Incorporating Ecosystem Perspective in River Basin Planning Illustrated by Case Studies on Wetland Ecosystems

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INTRODUCTION

Shifting Paradigms

The last few decades have witnessed the recognition that the Earth's resources are finite and call for implementation strategies which ensure the maintenance of these resources for future generations. At the same time, development is undoubtedly a desirable economic and social objective which seems to achieve or maximize a number of attributes such as: increased income, improvements in health and nutrition status, educational achievements, access to resources and a 'fairer' distribution of income (Pearce et al, 1990). The World Conservation Strategy (WCS) acknowledged that 'development and conservation are equally necessary for our survival' (IUCN, 1980). The strategies outlined by WCS include: (i) the maintenance of essential ecological processes within 'life support ecosystems' such as agricultural land and soil, forests, and coastal and freshwater wetlands; (ii) the preservation of genetic diversity; and (iii) the promotion of sustainable utilisation of species and ecosystems. The concept of 'ecodevelopment' advanced by the WCS was brought into the realm of political development by the establishment of the World Commission on Environment and Development in 1983. The Commission's report *Our Common Future* renewed the debate over sustainable development, defining it as "development that meets the needs of present without compromising the ability of future generations to meet their own needs'.

Several new paradigms are being propounded to achieve the goal of sustainable development of natural resources, one such being 'ecosystem' approach. The concept of a 'holistic approach' is relatively easy to preach but difficult to practise, mainly because it encompasses not only the domains of physical and natural sciences but also that of social sciences. To achieve success in natural resources management for sustainability, it is necessary to carefully plan for bringing together the two important components, namely (i) the complex web of interactions in nature, and (ii) still more complex web of interrelationships among human needs, expectations and value systems. In such an approach, sustainability calls for due consideration of economic, social, environmental and institutional aspects.

It is worthwhile to note that the UN General Assembly held in June 1997, while examining the progress on sustainable development, made a call for the formulation and implementation of policies and programmes for integrated watershed (basin) management. In such a river basin management, it is essential to ensure the involvement of all stakeholders, encourage the public participation, raise public awareness, build capacity and develop appropriate institutional structures. All these will help in building a consensus and resolving conflicts of interests; such exercises are essential for effective natural resources management.

Significance of Water Management

The management of freshwater has been one of the greatest challenges faced by the present generation. It is estimated that one-sixth of humanity does not have access to freshwater and twice that number lack sanitation facilities. Moreover, freshwater is needed for sustaining the environment with all its biodiversity. As the population increases and people resort to unsustainable development activities, pollution and environmental degradation take place, bringing down the quality and quantity of available freshwater. All these are expected to have their impact on health and economic and social status of people.

Most of the freshwater is used to grow food. While the daily drinking water requirement of a person is a few litres, around 2000-5000 litres of water are needed to produce the daily food requirements of an individual. Agriculture now accounts for over 80 per cent of the water consumed in the world. It is estimated that about 15 per cent more water would be needed to meet the food requirement in 2030. Presently, 60 per cent of water used for irrigation is wasted and a 10 per cent improvement in irrigation efficiency could double the water supply for the poor.

There are some limitations in achieving equity as far as water is concerned. In the past, water has been taken for granted and it has been an 'open access' resource. As it becomes scarce, it goes mainly to those who have the political power and economic capital to appropriate it by controlling the sources and distribution channels. For water as well as for other resources, the following three pillars ensure sustainable development:

- People- nature issues – management of resources
- People- machine issues – technologies for water
- People- people interactions – institutional mechanisms

These are some of aspects to be considered in the context of sustainable development of water resources.

NEED FOR INTEGRATED RIVER BASIN MANAGEMENT

In line with the recommendations of the International Conference on Water and Environment - 1992, Chapter 18 of Agenda 21 of Rio Conference stressed the need for integrated water management. The emphasis was also on the need for water resources assessment, protecting freshwater from over-exploitation and pollution, improvements in drinking water supply and sanitation, impact of urban development, water for food security and implications of climatic change.

The integrated water resources management is based on the concept of water being an integral part of an ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilisation (UN, 1992). The World Bank (1996) states that degrading the quantity and quality of water in rivers, lakes, wetlands and aquifers can inextricably alter the water resources system and its associated biota, affecting present and future generations. The holistic management of freshwater as a finate and vulnerable resource, and the integration of sectoral water plans and programmes within the framework of national economic and social policy, are of paramount importance to ensure sustainable use of water.

The inter-connected nature of river systems means that successful water management requires the adoption of methodologies which consider all the activities within an area instead of focusing on only one or perhaps a small number of limited objectives. The river basin provides the natural unit for such an approach. According to Young et al (1994), the fact that water interacts with and, to a large extent, controls other natural components within a basin such as soils, vegetation and wildlife suggests that human activities, which are so strongly influenced by water availability and quality, might best be coordinated within administrative structure which reflect river basins. This management approach should enable the incorporation of both upstream and downstream considerations into decision making and subsequently the management of water resources. It should also help to avoid the problems associated with the isolated, often short-slighted, use of water- land resources in one area which often have knock on impacts elsewhere within the river basins. In the context of a river basin, it is a natural integrator of all hydrologic processes within its boundaries and therefore a rational and ideal unit for soil, water and biomass management. These resources are closely linked and can be rightly designated as a 'trinity' in the context of a basin/watershed. If one among this trinity, namely, the bioresources is overexploited by deforestation, more soil erosion and degradation will take place; this in turn will have its impact on water balance and *flora* and *fauna* as such.

Water resources and river basin management in Asia can be viewed at a range of scales. Some of the local level water management practices followed for hundreds of years include:

- Small dykes with simple sluice gates covering 2-4 ha of rice fields in the mangroves of Vietnam;
- Lined tanks of Thar Desert in India and the k*undi* consisting of a tank surrounded by hardened surface with mud that funnels rainwater;
- Contour bunds constructed in the hillslopes at different parts of India and Pakistan;
- Wells dug in the downstream portion of the bunds to provide water for the livestock; etc.

These types of local scale integration rarely grew into river basin scales in Asia, though several major hydraulic structures were constructed in the later half of the twentieth century.

One of the attempts made in Philippines to achieve basin-wide management is worth mentioning. The National Power Corporation of Philippines is in full control of Angat River Basin, and has succeeded in achieving multiple objectives. These include: (i) maintenance of the watershed's capacity to support and sustain the generation of electricity by maintaining adequate forest cover and minimize, if not control, soil erosion; (ii) regulating land use activities and controlling exploitation of forest resources; (iii) improving socio-economic conditions of human population within the river basin and ensuring their participation in watershed management and protection; and (iv) generating income from agricultural plantations to partially subsidise the cost of watershed management and development.

Another attempt towards achieving integrated river basin management in Asia has been done in the Mekong basin of 7,95,000 km^2 area; the river is the longest in Southeast Asia and twelth longest in the world. The six riparian countries of the river include China, Cambodia, Vietnam, Laos, Thailand and Myanmar. The governments of Cambodia, Laos, Thailand and Vietnam gave birth to Mekong Secretariat. In 1995, an international agreement was signed by the lower riparian countries, brokered by UNDP. The Council of Ministers of Mekong River Commission is supported by senior water officials in a Joint-Committee, who are in turn, aided by experts and technical staff of the Mekong River Commission Secretariat. The diagnostic study carried out has helped in coming out with Mekong Basin Development Plan.

COMPONENTS OF ECOSYSEM MANAGEMENT

Forest Ecosystem

Forest ecosystems contribute to soil and water conservation and some of them have their own unique micro-climate within the system. Several forestry and silvicultural practices have been evolved for protecting and conserving these 'environmental reserves'. However, the following procedures are found to be useful in evaluating the land-treatment programmes in the forest ecosystem:

- The soils, vegetation, use, and condition of the forest watershed is surveyed to determine the area of all existing complexes of soil cover
- Estimates are made of the areas of exploitation with and without a land-treatment programme in effect
- Estimates of streamflow from the watershed are made for vegetative conditions with and without the proposed land-treatment programme and the differences between the streamflow for the two conditions is a measure of the effect of land-treatment measures.

The techniques used to quantify the benefits include:

- Evaluation by infiltration procedure
- Evaluation by multiple regression (considering a set of dependent and independent variables)

- Evaluation by regional analysis (effect of peak discharge and effect of fire on erosion rates)
- Evaluation by hydrographic analysis
- Evaluation by runoff number procedure

Some of these procedures are illustrated during the lecture.

Agricultural Ecosystem

The watershed is a natural integrator of all hydrologic processes within its boundaries, and as such, it is a logical unit for planning optimal development of soil, water and bio-resources. The management of agricultural watersheds, arising at appropriate development of land, water and bio-resources within their capability and treated according to their needs, has the following objectives:

- To protect land against all forms of soil deterioration
- To rebuild eroded and depleted soil
- To build up soil fertility
- To stabilize critical runoff and sediment producing areas
- To improve grass lands, wood lands, and wildlife lands
- To conserve water for beneficial use
- To provide necessary drainage and irrigation
- To reduce floods and sediment damage (Chow, 1964).

Urban Ecosystem

The watershed or the watershed within which the urban area falls may be considered as a unique ecosystem, and in most of the cases such a watershed may have high population pressure and subsequent anthropogenic activities. The management of such watersheds not only calls for comprehensive policies but also valid and reliable indicators and appropriate models. The interacting issues and crisis in the context of such an integrated approach may be listed as: (i) water supply and demand crisis representing a predominantly engineering dimension; (ii) deteriorating water quality crisis that can be considered as an ecological dimension; (iii) transboundary dependencies representing a geo-political dimension; (iv) organisation crisis exemplified in a management dimension; and (v) data and information crisis, not only in terms of availability and validity but also as part of combining data and judgment, modelling, and the establishment of useful Decision Support Systems.

In urban water, sustainability is perhaps best supported by the total management of the water cycle in the affected areas. For this, the most appropriate unit for planning is a watershed. Urban water management categories representing components of a total water cycle can be defined as: (i) reuse of treated wastewater; (ii) integrated stormwater, groundwater, water supply and wastewater based flow management; and (iii) water conservation based approaches. A diagram showing different components of integrated catchment management is given in Fig 1.

Typical urban watershed plans provide policies and directions for a wide range of issues including the following:

Management of water quantity and quality (both surface water and groundwater)
Ecological integrity and carrying capacity
The protection of valley systems and green space planning
Fisheries management
Rehabilitation/enhancement programmes
A framework for implementation
Regional opportunities and constraints
Documented servicing needs/availability of water/sewerage
Delineation of sub-watershed planning areas
Present targets, goals and objectives for individual sub-watersheds.

An integrated water management plan follows a systems approach, starting with problem definition, development of solutions, selection of the best alternative, and post audits (Fig 1). Water supply is a part of the overall water services cycle which is bridging the gap through an artificial 'water cycle' (Fig 2).

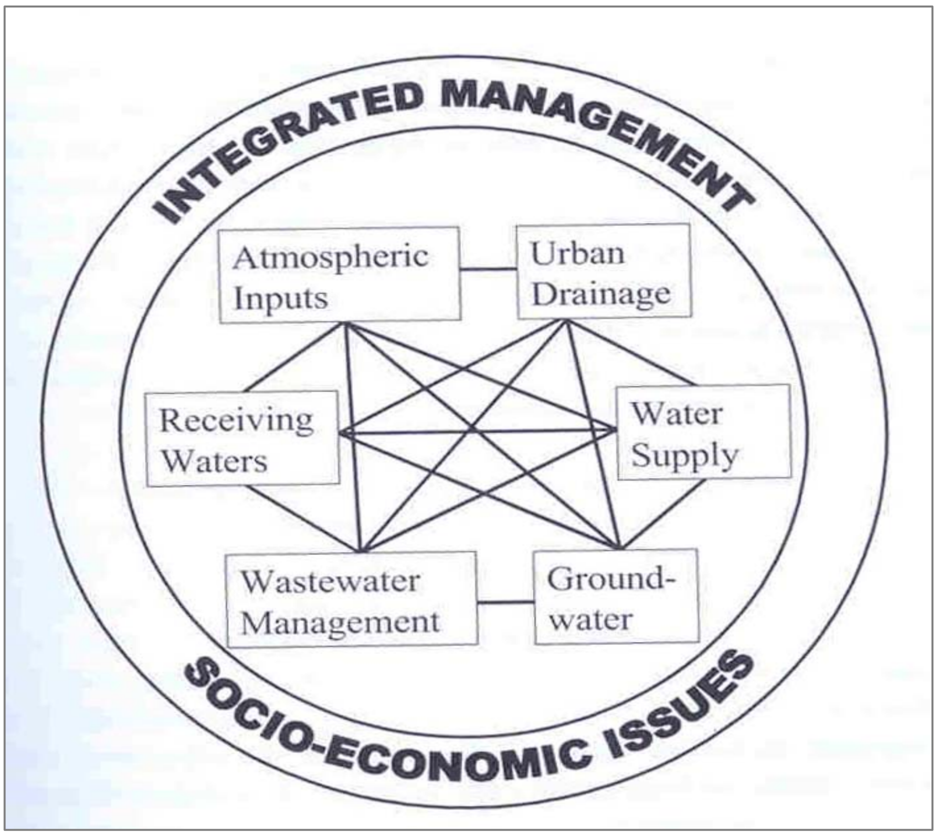

Fig 1 Different components of urban water management system

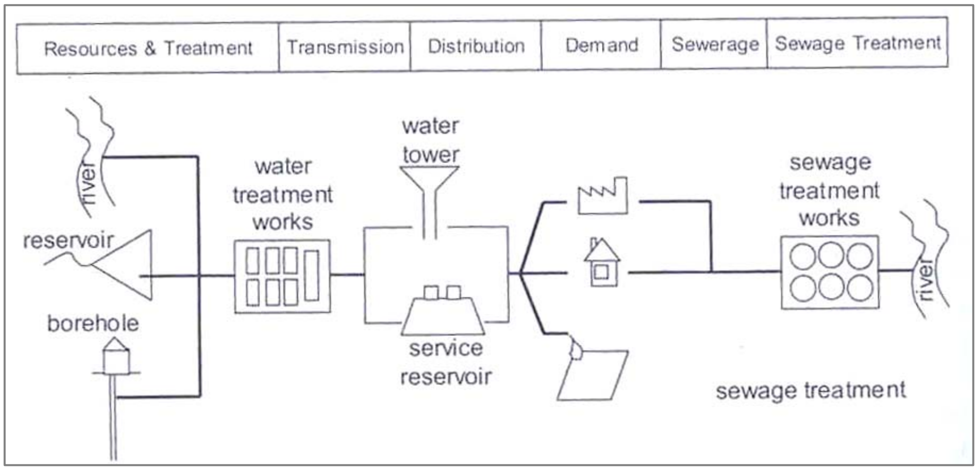

Fig 2 Urban water services cycle

Wetland Ecosystem

Wetlands are managed for environmental protection, water conservation, production of renewable resources, wildlife, recreation, aesthetics and tourism. The important goals of wetland management are listed below:

- Maintain water quality
- Reduce erosion
- Protect from floods
- Provide a natural system to process airborne pollutants
- Provide a buffer between urban residential and industrial segments
- Maintain a gene pool of marsh plants and provide examples of complete natural communities
- Provide aesthetic and psychological support for human beings
- Produce wildlife
- Control insect populations
- Provide habitats for fish spawning and other food organisms
- Produce food, fiber, and fodder
- Facilitate scientific inquiry.

The need for integrated management of river basins to achieve the wise use of wetlands is discussed in this lecture with the help of case studies.

Coral Island Ecosystem

Many of these small islands depend on ground water from the shallow aquifers. There is a fresh water prism floating over the brackish water and over-exploitation of fresh water will lead to mixing of brackish water and loss of fresh water sources of this ecosystem. Moreover, some of the thickly populated coral islands in the Lakshadweep are facing bacterial contamination of the groundwater sources mainly because of lack of proper sanitation facilities. Several water-borne diseases are reported from these islands. In the light of the severe problems related to water management of these islands, a few strategies have to be worked out for the conservation and management of water in these fragile ecosystems. Some of the suggested measures are:

- Creation of awareness among the islanders on the limitations of groundwater sources
- Mechanized water lifting devices should not be permitted in the islands
- Existing tanks/ponds should be cleaned, protected and properly managed
- Land use should be properly planned and controlled
- Sanitation programmes suitable for the islands should be introduced
- Disinfection of water bodies should be undertaken frequently
- People should be encouraged in activities related to recharging the groundwater, rainwater harvesting and water quality monitoring
- Regulatory mechanisms should be introduced to avoid overexploitation of limited groundwater sources of these islands

The predicted sea level rise would pose additional threat to these fragile ecosystems and their fresh water sources. Therefore, IWRM is all the more relevant for these island ecosystems.

RIVER SYSTEMS IN RELATION TO WETLANDS

River systems can be considered as 'interconnected transport systems'. They are open systems in which energy and chemical and biological matter are exchanged with an external environment (Knighton, 1984). Within drainage basins numerous exchanges between different water stores (vegetation, soil, groundwater, etc) take place and water will often follow many pathways before it reaches the channel system. The erosional, transportational and depositional roles played by river systems create an enormous variety of river network, channel forms and wetland environments. These ecological systems are sustained by the supply of water and nutrients maintained by river flows. The hydrological, geochemical, and ecological continuum in river basins is such that the character and behaviour of a river at any particular point is dependent upon the interaction of upstream controls including climate, geology and landuse. Similarly, downstream controls, such as baselevel, also have a controlling influence.

An integrated approach is required in which environmental, ecological, economic, social and political factors are considered on equal terms within the framework of the water system as a whole. Further, this approach enables the best use to be made of the functions and benefits provided by the basin resources, including its wetlands. Hydrology plays a key role in controlling the structure and functioning of any wetland. It is probably the single most important determinant responsible for the establishment and maintenance of specific types of wetlands and wetland processes. Integrating wetlands into river basin management and development is good not only for wetlands – for the biodiversity that they sustain and for the people who depend on them – but also for the river system as a whole, since in general wetlands perform functions that have an effect far beyond their place in the system.

WETLANDS – THE KIDNEYS OF THE EARTH

In the past, only the functions and values of the wetland pertaining to fisheries, agriculture and wildlife were well recognised. The role of wetlands in water conservation and management was recognized only in the recent times. Wetlands have a key role in natural flood control, groundwater recharge, water supply and purification. Furthermore, water allocation to wetlands is essential to enable these ecosystems to support the plants, fish and other animal species that, in turn, are often critical to the survival of local human settlements.

According to Mitch and Gosselink (1993), wetlands are distinguished by the presence of water, either at the surface or within the root zone, by the unique soil conditions that differ from the adjacent uplands, and by the hydrophytes within these systems. According to the Ramsar Convention (Ramsar Bureau, 1989), wetlands are: "areas of marsh, fen, peat land or water; whether natural or artificial, permanent or temporary, with water that is static or flowing , fresh, brackish or salt, including areas of marine waters, the depth of which at low tide does not exceed six meters" and may include "riparian and coastal zones adjacent to the wetlands or islands or bodies of marine water deeper than six meters at low tide lying within" .

The major determinant of a wetland functioning is the hydrological balance between inflows and outflows to the wetland, the soil contours in the wetland and the subsurface conditions. The important functions of wetlands are: groundwater recharge; groundwater discharge; flood storage and de-synchronisation; shoreline anchoring and dissipation of erosive forces; sediment trapping; nutrient retention and removal; food chain support; habitat of fisheries; habitat for wildlife; active recreation; passive recreation and heritage value. It is important to recognize that all wetland types perform the many functions which have been attributed to them while the degree to which any one function is performed varies between wetlands.

As with the elements within river basins, wetlands do not function in isolation. They are highly dependent on upstream conditions within their river basin. Changes in the hydrology of river feeding a particular wetland will inevitably have an impact on the wetland's water level regime. Similarly, water quality changes in an inflowing stream are likely to result in modifications in wetland *flora* and *fauna*, which in turn also will affect wetland hydrology. Wetlands generally provide benefits downstream; improving river flows downstream; controlling floods; groundwater recharge; etc. Inland wetlands often influence the coastal wetlands. On a global scale, wetlands have an influence on global nitrogen, sulphur and carbon cycles. Conversely, changes in the global environment such as sea level rise have its impact on coastal wetlands.

MANAGEMENT OF RIVER BASINS IN RELATION TO WETLANDS: CASE STUDIES FROM INDIA

Introductory

The large-scale population growth in India paved the way for great pressure on land, water, and bio-resources of the river basins. The landuse pattern underwent several changes, as manifested by deforestation, urbanisation, and distribution of infrastructure facilities. Several water resources development projects came into existence during the past five decades to meet the demand of water to cater to different requirements. However, all these changes and developments took place without giving due weightage to an integrated and sustainable management of the wetlands. The concept of river basin as a unit for planning and management of the resources did not receive due recognition. This has often resulted in the over-use and mismanagement of the water resources in the upstream sub-basins, while the downstream reaches often faced water shortage and even water quality problems. Uncontrolled water use upstream often adversely affected the ecology of the downstream wetlands, especially the coastal wetlands. In certain cases, the claim of upper riparians adversely affected the farmers in the delta region, who depended on their irrigated crops for many decades. Many of the river basins in the Indian subcontinent spread over more than one federal state of India and some of the rivers flowing through the north of India have their basins in more than one country. The interstate and international rivers add to the gravity of the problem, since there is no coordination among the upper and lower riparian federal states and countries. Even within a state, proper coordination of different departments and agencies and understanding among actual stakeholders do not exist. All these have led to imbalances in water availability, quality, and use pattern in different sub-basins within a river basin. Many stakeholders have come up with grievances and several agitations and disputes have resulted. Some such water disputes are referred to special tribunals and courts of the country.

Since hydrology is the single-most important characteristic of a wetland, it is necessary to consider the wetland together with the entire drainage basin for the purpose of management. This is also significant since the transport of various bio-geochemicals such as sediments and nutrients, waste materials and pollutants, and suspended and dissolved materials, into and out of the wetlands will have a marked impact on the system. Also, this movement of matter through the drainage basin depends mainly on the different phases of the hydrologic cycle. Therefore, an integrated approach, with due reference to the drainage basins, is important for the wise use of the wetland.

Need for Cross-Sectoral and Interdisciplinary Approach : Case Study of Ganges – Brahmaputra-Meghna Delta

The flood waters of the Ganges, Brahmaputra and Meghna provided multiple benefits to the people of the delta in the past (Hughes et al, 1994). These include agricultural production, fisheries, and grazing. Very often, different water management activities have a tendency to conflict with one another. Some stakeholders may have an upper hand over another, which can create hinderance to the wise use of the wetlands. These aspects are highlighted from the case study of the Ganges-Brahmaputra-Meghna delta.

Many of the international river basins of Asia do not have any form of international management organisation to ensure an integrated approach towards water management interventions. For example, Ganges-Brahmaputra–Meghna system has several water control interventions. According to Hughes et al (1994), these have played a major role in altering the hydrology of the basin and have been the subject of intense regional controversy. The large-scale water diversion from the upstream for irrigation and navigational purposes has contributed to the progressive drying out of a number of water bodies throughout the downstream reaches. Water shortages in the dry season have contributed to serious constraint to crop production. Therefore, there is a need for international cooperation to avoid upstream-downstream imbalances and for the wise-use of tidal areas. The Ganges-Brahmaputra-Meghna system is shared by India, People's Republic of China, Nepal, Bangladesh and Bhutan.

While managing the Ganges-Brahmaputra-Meghna system, necessary importance has to be given to the Sundarbans, situated in the deltaic region of these rivers in India and Bangladesh. The Saunderbans covers an area of 1,600,000 ha of land and water, and is the largest continuous block of mangroves in the world. There are 27 species of mangrove trees within the Sunderbans. The mangroves make up 45% of the productive forest in India and Bangladesh and constitute the single largest source of wood and other forest products (Dugan, 1993). The mangroves also provide other minor forest products, such as wood chips, crust leather, plywood, glues and honey. The mangroves support extremely important fisheries. It is reported that these wetlands have lost two species of reptiles, seven species of birds, and five species of mammals. In addition, several other mammal species are now considered threatened. Considering all these, there is a necessity to integrate the mangroves in the downstream reaches of the river basins into the river basin plans.

The deltaic and tidal zones are highly productive. Within the flood plains of Bangladesh, fish account for over three quarters of the daily animal protein intake of the people. Fisheries also play a major role in the country's economy. The annual catch of fish and crustaceans works out to about 750,000 tonnes. In order to maintain a congenial aquatic ecosystem for fishing activities, an integrated approach in river basin planning is called for.

During the wet season, rice is planted in the flooded areas of the delta in the Bangladesh. As the flooded areas begin to dry up in winter, farmers plant legumes, oilseeds, vegetables and tobacco. Drainage and irrigation schemes have now been initiated within the wetlands with the aim of increasing productivity (Zaman, 1994). The results of these schemes have been mixed. Increases in dry season productivity have been reported whilst elsewhere the failure to integrate projects with land tenure systems and local marketing, processing and transport systems have caused negative impact, on the income of farmers. The requirements of water for wetland cultivation in the coastal reaches have to be given due weightage while allocating water for different purposes. This is significant since the agriculture in wetlands can be a risky undertaking, since the area is susceptible to large-scale perturbations.

The Farraka barrage constructed just upstream of the border between India and Bangladesh diverted water from Bhagiradhi, helped in flushing silt and thereby improving navigation, provided water for drinking to the Calcutta corporation, and also for irrigation. However, the construction of the barrage and the diversion of dry (low) seasonal flows had a number of impacts downstream. The wetlands downstream experiences declining water supplies; the structure also adversely affected the wetland fisheries and increased the salinity intrusion problem. All these had a negative impact on the ecosystem, especially the downstream mangrove ecosystem. The groundwater level in the delta region either declined or the quality of this water deteriorated, especially due to salinity intrusion. This has also affected the rice cultivation in the alluvial plains.

Improvements to the Estuarine Ecosystem: Case Study of Chilika Wetland

The unscientific management of the river basins draining into the Chilika wetland has resulted in the degradation of this aquatic ecosystem, which is a Ramsar site. After the construction of Hirakud project for the purpose of irrigation in the Mahanadi river, which is the largest fresh water source draining into the Chilika, the wetland was not getting its full quota of fresh water. The Naraj barrage is expected to further deprive of this wetland from fresh water supply. Certain hydrological and biological investigations carried out have brought to light that the reduction in flows has changed the hydroperiod, increased the residence time, adversely affected the flushing phenomenon, modified the entire circulation and mixing characteristics and above all caused the partial blocking of the mouth to the Bay of Bengal. All these in turn have accelerated sediment deposition tendencies and have also affected the flora and fauna of this wetland. Over-exploitation of the watersheds on the western side of the wetland, especially deforestation, has also contributed to the increase in sediment load to the wetland.

An attempt has been made to cut open a new mouth to the sea, the consequences of which on this ecosystem are not yet properly understood. The artificial channel created, namely Magaramukh, is gradually stabilizing. Large quantum of sediment is flushed out into the Bay of Bengal due to the velocity of flow in the channel. The salinity levels in the estuary has improved and the fish catch has gone up. Chilika was included in the Montreux Record in 1993; this was lifted recently considering the positive signs observed based on the activities undertaken to conserve the ecosystem.

Salinity Problems in the Coastal Wetlands: Case Study of Indus Delta

The Indus delta covers an area of 6,000 km^2 and stretches from 200 km south of Karachi to the Kutch in India. The delta comprises of 17 major creeks, extensive mudflats and around 2,600 km^2 of mangrove forests. The annual rainfall in the area is of the order of 200 mm and the only other source of fresh water is the river flow. This is needed for the mangroves and also to maintain the sediment supply. The productivity of fish is high in the mangrove areas. It is estimated that now only 28% of the total annual flow of Indus reaches the delta and the dams upstream trap 75% of sediments (Ahmed et al 1993). This has resulted in increase in the salinity levels of creeks; the evaporation is also very high in the region. The salinity levels in many creeks are as high as 40-45 ppt, higher than that of sea water. The salinisation and water-logging are affecting more and more areas and some of these areas are not fit for crop production. A total area of 57,000 km^2 is affected by salinity. This case study brings to light how the diversion of water from the upstream areas with less rainfall will affect the flora and fauna in the coastal zone.

Wetlands and River Basin Management: Case Studies from South-West India

On the southwest coast of India, the estuarine stretch of the Periyar river is facing severe salinity intrusion and pollution concentration. This has adversely affected the drinking water project to the Greater Kochi and Alwaye urban areas, industrial water requirements of Udyogamandal complex and also the entire ecology of this estuarine ecosystem. The barrages constructed during summer to prevent salinity intrusion from the sea add to the problems faced by the estuarine ecosystem. All these are caused by the transfer of waters more than a century ago from the upper reaches of this river to the east-coast and another transfer to the Muvattupuzha basin on the south for power production arising out of the Idukki project, and also limitations of the operation rules of the upstream reservoirs.

A case study conducted in the ten river basins draining into the Vemebanad-Kol wetland system in south west India has shown several problems created due to the unscientific management of the river basins. Some of the measures suggested to improve the situation include diversion of waters from the river systems to the wetland during summer months. The existing and planned water resources projects can help in this task. Moreover, the hydroelectric projects have to be operated in such a manner that certain minimum required flows are maintained in them for meeting the requirements of the wetland (James et al 1997).

Ecosystem Degradation: Case Study of Loktak Wetland

The Manipur valley had several small wetlands in the past, known as *phats*. During 1980s, a barrage was constructed across the Manipur river to contain the waters in the valley for hydropower generation. All the *phats* in this area, including Loktak, became one large water body to cater to the requirement of a single sector development. The hydroperiod of these *phats* got completely changed; flushing got affected, sediments and pollutants were deposited in the wetland; the habitat of the endangered species of brow antlered deer, locally known as *Sanghai*, was disturbed. The vegetal growth floating in the habitat of the deers became thinner and polluted. Certain action plans have been recommended to improve the situation, including scientific operation of gates, considering the wise use of this wetland.

REQUIREMENTS FOR INTEGRATED RIVER BASIN MANAGEMENT

In order to accomplish the objectives of integrated river basin management there are a number of fundamental needs and requirements. Sustainable development of water environment requires a step-by-step approach which, by following a number of pathways and combining asset management , catchment management and land-use planning and control, will shift the emphasis from single function investment in water resource development to integrated river basin management. The pathways to sustainable development of water environment are given in Fig 3. Along these paths a series of approaches and actions can be adopted in order to most appropriately integrate wetlands into river basin management. Some of them are described hereunder.

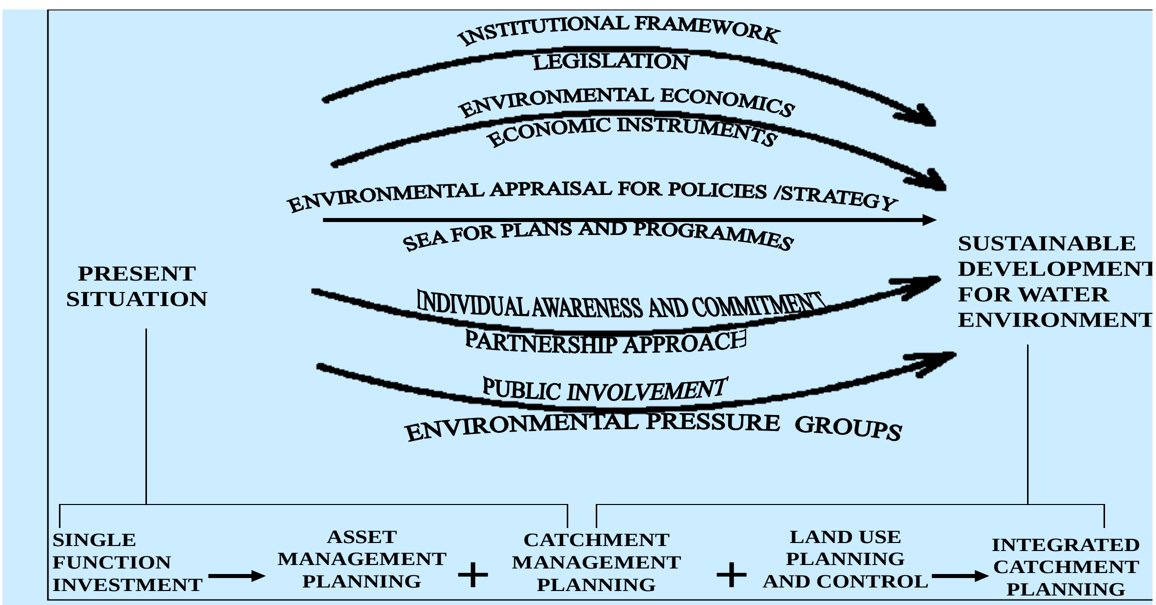

Fig 3 Pathways to sustainable development of water environment

The Environmental Impact assessment (EIA), which is relevant in the context of river basin management, is a method of identifying (i) the impacts of human activities on human and natural environment; and (ii) option to reduce or mitigate adverse impacts. The main objectives of EIA are: (i) to disclose significant environmental effects to the decision-makers and public; (ii) to identify ways to avoid or reduce the damage; (iii) to prevent environmental damage by requiring implementation of feasible alternatives or mitigation measures; (iv) to disclose to the public reasons for agency approval of projects with significant environmental effects; (v) to foster inter-agency coordination; and (vi) to enhance public participation. The EIA now includes also social impact assessment, and risk analysis and a broader consideration of environmental management relevant to the project. Two questions deserve consideration in this context: (i) who are all responsible for the implementation of EIA recommendations? (ii) Can an impartial outside agency carrying out the EIA know all the implications of the project?

Cost Benefit Analysis (CBA) is a tool for calculating the net impact of the project on society and economic welfare by measuring all costs and benefits of the project. It is broader than a Financial Appraisal (FA), which identify the commercial return from the project. The results of CBA are almost always expressed in monitory terms. Most of the earlier water resources projects in developing countries were cleared by the Government of India considering the social benefits, presented in a qualitative manner in the proposals. In some cases, the command area of irrigation projects were exaggerated; later, it was found that water does not flow to some parts of these added-on command areas mostly at a higher elevation.

It is essential that the complementary nature of EIA and CBA is recognized: EIA is an integral part of the decision-making process; CBA includes cost and benefits of environmental impacts and options for mitigation. The decision-maker requires an analysis of the economic, environmental and social costs and benefits of policy and project options. The elements of such an integrated assessment are: (i) cost benefit analysis from the national perspective; (ii) cost benefit analysis from the regional perspective; (iii) environmental impact analysis; and (iv) social impact analysis. EIA has to be carried out at both the policy and project level. At the policy level, it is often referred to as Strategic Environmental Assessment (SEA).

Integrated river basin management calls for planners and environmental managers to work with, and for, the entire community of water users in the basin. To achieve this, one has to move away from past management structures and plans, which were meant to benefit limited population of the basin. Public awareness programmes should target at the general public, NGOs, government departments and others responsible for river basin management, such as farmers.

The present institutional structure and procedural patterns of the departments and agencies have to undergo a sea change to introduce integrated water resources management in Kerala.

Water policy statements form an integral part for the implementation of integrated river basin management. It may be difficult, if not impossible, to prescribe a single legal framework for integrated river basin management. However, water and environmental laws should: (i) base water management on river basins; (ii) incorporate sustainable management principles; (iii) require integrated water and environmental management planning; (iv) prevent fragmented departmental water allocation and use decisions; (v) ensure integrated economic and environmental policy and project appraisals; (vi) establish water management institutions as outlined in this paper; (vii) and establish enforceable incentives for environmentally sustainable water use.

CONCLUDING REMARKS

The need for integrated river basin management has been highlighted in the lecture. The role of integrated river basin management in conserving ecosystems, especially wetlands, has been brought to light. The management strategies for different ecosystems in a river basin has been discussed.

A few case studies have been presented from the Indian subcontinent to highlight the importance of integrated river basin management giving due weightage to the wise use of wetlands. The case study of Ganges-Brahmaputra-Meghna delta brings to light the need for international cooperation in managing these ecosystems so that their wise use from the angles of fisheries, biodiversity and agriculture can be achieved. The case study of the Chilika estuary brings out the problems created by over-exploitation of rivers draining into the wetland and how this adverse impact on the wetland was remedied to some extent. The study of Indus delta has clearly shown how the large-scale diversions upstream had adversely affected the downstream *flora* and *fauna*. The case studies from the south-west coast clearly bring out the necessity for river basin management keeping in view the downstream wetlands. Certain management strategies recommended for the coastal wetlands of south-west India have also been highlighted. The case study of Loktak in Manipur has highlighted the problems caused to the ecosystem by the development of a single sector, namely hydropower generation.

Most of the case studies point to the need for integrated river basin management to reduce the imbalances in water availability, quality, and use pattern in different upstream sub-basins and downstream reaches. An integrated river basin plan can be evolved only with the support of a strong data base and systems approach. Modern tools like remote sensing, GIS, and mathematical modelling can be of great use in arriving at decision support systems. The catchment treatment measures should become an integral part of the water resources development projects. Before the commencement of the projects, detailed environmental impact assessment has to be carried out. Often, appropriate cost-benefit analysis is not carried out before taking up large projects, and sometimes benefits are often exaggerated. Institutional support and capacity building are very important in achieving success in integrated water management. A two pronged approach is recommended for the institutional support. The local governments, known as Panchayats, are being empowered all over India. The small watersheds can be scientifically managed by these local level governments. The larger projects within a basin can be managed by a group of multi-disciplinary experts, answerable to a democratically elected group of representatives of people from the watershed committees of the Panchayats. This institutional setup will not only ensure coordination but also total participation of stakeholders. Interstate and international river basins should be managed by a river basin authority with representatives of the stakeholder states/countries.

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POINTS TO PONDER:

1 (a) Does your country/state have a water policy?
(b) If yes, does it emphasize river basin management?
(c) What are the regulatory mechanisms for conserving the wetlands of your country?

2 (a) What are your views on the EIA/CBA exercises carried out in your region?
(b) How far is participatory water management practical in your area? Can you suggest some case studies?
(c) Give your suggestions for improving the institutional and procedural mechanisms in your region.

3 (a) What are the laws in your country to protect the ecosystems?
(b) Are you satisfied with these laws?
(c) How can we implement the environmental laws effectively?

4 (a) What are the constraints in implementing IWRM?
(b) Are gender issues properly addressed in the water sector?
(c) Which are the government departments/ agencies involved in the water sector in your country? Who coordinates their works?

5 (a) What is the status of data management systems in the water sector?
(b) Do you have sufficient R&D support in the water sector in your country?
(c) Are the universities in your country involved in solving the practical problems in the water sector ?