Dr. Nasim Akhter

SUSTAINABLE FISHERIES

A Pakistan National Conservation Strategy Sector Paper

5

SUSTAINABLE FISHERIES

Dr. Nasim Akhter

ENVIRONMENT & URBAN AFFAIRS DIVISION, GOVERNMENT OF PAKISTAN

IUCN
The World Conservation Union

The sector papers were commissioned from mid-1988 to mid-1990 and
printed in 1992, 1993, 1994 and 1995

The Pakistan National Conservation Strategy was prepared by the
Government of Pakistan (Environment and Urban Affairs Division)
in collaboration with IUCN – The World Conservation Union

It was supported by the Canadian International Development Agency

Additional sector activities were supported by
the United Nations Development Programme

IUCN – The World Conservation Union, Pakistan
1 Bath Island Road, Karachi 75530

Editors: Tehmina Ahmed & Yasmin Qureshi
Editorial Advisors: Dhunmai Cowasjee & Saneeya Hussain

ISBN 969-8141-09-X

Design: Creative Unit (Pvt) Ltd
Formatting: Umer Gul Afridi, Journalists' Resource Centre for the Environment
Printed in Pakistan by Rosette

CONTENTS

PREFACE

This monograph is one of the 29 sectoral and programme papers produced to support the preparation of the Pakistan National Conservation Strategy. The NCS is a comprehensive review of the state of the country's environment, and of government and corporate policies, the voluntary sector, community and individual practices, which support or hinder sustainable development. The objective of the NCS is to identify strategic initiatives to conserve the country's natural resources which are the base for lasting improvements in the quality of life.

Environmental impacts do not respect sectoral or administrative boundaries. Yet, conventional development planning is frequently focused on narrow performance criteria and associated financial requirements, ignoring huge costs on downstream ecosystems and economic activities dependent on them. These costs cannot be avoided and must be paid by society; the only questions are when and by which group.

To facilitate an understanding of such 'externalities', one of the first steps of the National Conservation Strategy was to undertake assessments of cross-sectoral impacts from the point of view of each major activity sector. In order to facilitate comparison, the reports were prepared according to common terms of reference. Subsequently, major programme areas that must be given priority in the transition to a sustainable society were identified. The list of economic, environment and programme areas is given overleaf.

A paper on each sector was produced by a well recognized expert supported by peer reviewers in related specialities. The key insights have been incorporated into the Strategy. Since the papers are the reference base of the strategy and contain special interest material, a decision was taken to publish them serially in the form of monographs. It is hoped they will be found useful by researchers of sustainable development in various facets of national life as well as by the interested lay reader.

The sectors are:

1. Economic sectors:

- Agriculture, forestry, livestock, fisheries.

- Mining, energy, industries, transport.
- Human settlements and recreation.

2. Environmental impact sectors:

- Soil degradation, loss of biodiversity, and over harvesting of renewable resources.
- Municipal and industrial discharges, environmental health effects, and misuse of water resources.
- Destruction of cultural heritage.

3. Programme areas:

- Incorporation of environment in education, communication, and research; enforcement of laws and regulations; improved administration; use of economic instruments to align market forces with sustainability; promotion of conservation ethics.
- Programmes to promote population planning, women in development, and regional equity.
- Creation of grassroots institutions, with participative management.

SUSTAINABLE FISHERIES

1. INTRODUCTION

Pakistan is endowed with fishery resources that have an immense potential for development. At present, this sector's contribution to the overall gross domestic product (GDP) is about 0.8%, which is relatively small in comparison to other Asian countries. But there is much scope for growth.

Marine fisheries play an important role in coastal Balochistan and in Karachi, where they are a major source of income and employment. Pakistan also has substantial areas of inland waters — reservoirs, canals, swamps, lakes, streams and rivers — since this region acts as a drainage basin for the Himalayan mountain range. However, fish production from inland rivers and lakes has always been low, while reservoir fishery and aquaculture are still in their infancy.

The development and management of fisheries and aquaculture have faced several technical and non-technical problems. These problems are reflected in the relatively low increases in marine catch over the years and in the low fish yields from inland fishery.

The Government of Pakistan appreciates the importance of fisheries. This is reflected in its Sixth and Seventh Five-Year Plans. But factors such as the lack of a strong research programme, the unreliability of baseline data and an inadequate extension and conservation programme have hindered development. The basic goal of fishery and aquaculture management in Pakistan should, therefore, be aimed at increasing fish production while conserving this re-source as part of an attempt towards the coordinated use of water bodies by multiple users.

This paper analyses the status of the fishery sector in Pakistan and addresses those critical constraints that affect its promotion on scientific lines. The strategy and programme presented here is meant to serve as a guide to help in the formulation of a National Conservation Strategy.

2. THE FISHERY SECTOR

FISH STOCK

Marine Resources

With the declaration of an exclusive economic zone (EEZ) in 1976, Pakistan's fishing limits were extended to 200 nautical miles from the shore, providing the country with a fishing area of approximately 196,600 square kilometres,

with shoreline areas of less than 200 metres in depth estimated at around 50,000 square kilometres.

The entire coastline, of about 1,100 kilometres (km) bordering the Arabian Sea, lies within the subtropical zone and is divided into the coasts of Sindh, and Makran in Balochistan. The continental shelf off the Makran coast is steep, rough and very narrow, i.e., between 12-32 km wide. The Sindh coast, on the other hand, has an extended 40-120 km shelf area. Mostly flat, it forms good trawlable ground. The coast protrudes into the sea in the form of capes and peninsulas and is, at a few sites, cut off into several small and large bays. There are only a few islands along the coast.

The large estuarine delta of the river Indus provides good nurseries for fin-fish, shrimp and other marine life.

Demersal Fish

Recent information on demersal fish stock indicate that the total biomass within the EEZ, upto a depth of 200 metres, is around 380,700 tonnes. This would mean that the potential yield would be about 123,000 tonnes. The present yield is about 94,000 tonnes indicating a surplus of 29,000 tonnes.

Shrimp

Shrimp constitute the backbone of the marine fishery industry in Pakistan, contributing about 80% to the foreign exchange earned through exports. The Indus Delta provides a large nursery for the shrimp.

Shrimp stocks, however, are already overexploited. Recent increases in catch are deceptive and were due partly to a ban on fishing being observed, and partly the result of a ship building boom that began in 1982. Analyses of catch and effort data suggest that present shrimp catch levels are somewhat below their biological potential because the resource is being over-exploited at all stages of its life cycle. Based on extensive trawl surveys, the estimated shrimp biomass is 88,000 tonnes and the annual maximum (not sustainable) yield 37,000 tonnes. However, current levels of production are already beyond sustainable levels.

Small Pelagic Fish

Information regarding small pelagic fish is limited. The research vessel *Dr. Fridtj Nansen* executed three acoustic surveys in 1983-84. From the results, estimates of a biomass ranging from 408,000-580,000 tonnes with an annual potential yield of about 250,000 tonnes, were made. However, the validity of these acoustic surveys is debatable as the surveys neither covered the entire fishing zone nor a full year.

Large Pelagic Fish

Very little is known about large pelagic fish in Pakistan. However, it is estimated that the potential annual yield could be close to 20,000 tonnes.

Cephalopods and Other Marine Resources

Squid and cuttlefish, found on the continental shelf, constitute a substantial portion of the inshore fishery catch. Their estimated biomass is 10,000 tonnes with a potential annual yield of 2,000 tonnes.

There are also considerable stocks of crabs, crayfish, lobsters, clams, sea urchins, etc., which have good commercial potential.

Inland Resources

Pakistan possesses an extensive lake, river and canal system. Natural lakes cover an area of 109,780 hectares. Some are high-altitude lakes suitable for cold water fish e.g., Saif-ul-Mulook in the North West Frontier Province (NWFP), Satpara in the Northern Areas and Hanna in Balochistan. Warm water lakes are mostly located in Sindh, and two such lakes are Manchar and Kalri. There are several small lakes also, mostly in the Thatta and Sanghar districts of Sindh.

The Indus and its tributaries are the major freshwater fisheries of the country. The Indus flows from the Northern Areas through the NWFP and the Punjab, where it is joined by five large

rivers — Kabul, Jhelum, Chenab, Ravi, and Sutlaj — before passing through Sindh and finally draining into the Arabian Sea. Along the course of the Indus are a number of dams and reservoirs which provide water to an extensive irrigation network in the Punjab and upper Sindh regions, representing one of the world's largest canal systems. These running and still waters cover about 4.57 million hectares, while waterlogging covers about 2.225 million hectares.

Of the reservoirs, six — Mangla, Tarbela, Chashma, Hab, Khanpur and Warsak — cover an area of 80,613 hectares and play an important role in freshwater fisheries. Besides these, more than a hundred small and mini-dams (in the *barani* (rain-fed) tract of the country, particularly in the Potwar Plateau) built for the storage of water, hold an immense potential for aquaculture. At present only a few of these multiple use water resources are being used to raise fish.

Although aquaculture is a fairly new activity in the country, dug-out ponds for fish farming have been constructed in the private sector. There are approximately 3,300 fish farms in the country. The area under pond fishery is estimated at about 5,000 hectares, most of which is located in the Punjab and Sindh. However, aquaculture is characterized by low production per unit area, mainly because of low inputs.

Freshwater Fish

The major freshwater species include carp *Catla catla*, *Cirrhina mrigala*, *C. reba, Labeo dero, L. dyocheilus*, *L. rohita*, *Tor putitora* and catfish *Mystus aor*, *M. seenghala*, *Rita rita*, *Bagarius bagarius*, *Wallago attu* and an anadromous fish *Hilsa ilisha*. Of these species, three — *C. catla*, *L. rohita* and *C. mrigala* — enjoy premium prices in the market because of consumer preferences. Of the latter species, *C. catla* is found in the lower reaches while *L. rohita* is found in upper reaches of the Indus river system. Since these three species can be cultivated, they have a special significance for fisheries and aquaculture in Pakistan. Another species *Tor tor,* known locally as mahaseer, is a famous freshwater sport fish. But stocks are on the verge of being depleted due to breeding ground loss through the building of the Mangla and Tarbela dams on the Jhelum and Indus rivers.

Beside these indigenous species, several exotic species have been bred successfully also. The performance of the grass carp *Ctenophary - godon idella*, silver carp *Hypopthalmichthys molitrix* and the common carp *Cyprinus carpio* indicate that these species can be used successfully in aquaculture projects.

Inland Capture Fishery

Harvesting fish from natural riverine and estuarine stocks is termed capture fishery and in Pakistan this method dominates.

Inland capture fishery is poorly developed, being mostly of an artisanal and small-scale character. Much of it is subsistence fishing and thus statistically poorly assessed. The bulk of its production comes from the Indus River and its major tributaries, and from the large reservoirs, Mangla, Warsak, Tarbela and Hub. Catches from natural lakes are generally of secondary importance.

Cold water stream and riverine catches are insignificant as far as total production is concerned, although these waters have considerable attraction for anglers and tourists. Both the rainbow and the brown trout, known game fish, have been introduced into cold water lakes and streams and their adjustment has been excellent. Besides the trout, the indigenous *Schizothrox* species also plays an important role in cold water fish catch. In addition, the waters of the NWFP, the Northern Areas, the Federally Administered Tribal Areas (FATA) and Azad Jammu and Kashmir, provide local fishermen with fish for home and general consumption, though this is unaccounted for.

About 132,000 fishermen are actively involved in inland capture fishery. However, it is difficult to assess the number of full-time versus part-time workers. A wide variety of netting methods and boats are used in this fishery.

RESEARCH

Fisheries research and development in Pakistan is carried out by a number of federal and provincial institutions, as well as by autonomous bodies and the private sector. In the public sector, the Fisheries Departments of the Punjab, Sindh, Balochistan and the NWFP are responsible for planning and management work, for licensing and leasing public waters, for data collection, for training fisherfolk and fish farmers, and for extension services. The Punjab Department of Fisheries also conducts freshwater aquaculture research. The Arabian Sea fishery is under the jurisdiction of three agencies: the Sindh and Balochistan fisheries departments manage the 12-mile territorial water zone; while the federal Marine Fisheries Department is responsible for administering activities beyond the territorial zone and for compiling statistics on national fisheries.

Cold water fishery in the FATA is taken care of by a Department of Fisheries functioning under the federal Ministry of Kashmir and Northern Areas. In Azad Jammu and Kashmir, a small fishery unit for inland fishery development has been established by the Forest Department.

The federal Water and Power Development Agency (WAPDA) has a Directorate of Fisheries to develop and manage fisheries in Tarbela, Mangla, Hub, Khanpur, Chashma and Warsak.

The Pakistan Agricultural Research Council is an autonomous body, which co-ordinates and sponsors fisheries research at the national level. It also conducts in-house research at its National Agricultural Research Centre. Several other institutions are involved in research e.g., the Centre of Excellence in Marine Biology and the Marine Reference Collection Centre at the University of Karachi, and the Zoological Survey of Pakistan under the Ministry of Food, Agriculture and Co-operatives (MinFa).

Financial credit to the fishery sector is provided by a range of sources. For Karachi-based vessel operators and fish/shrimp catchers, the *mols* (fish auctioneers; money lenders) are the main source of credit. Along the Balochistan coast, fish buyers and middlemen also provide money. Institutional credit is available from the five public sector commercial banks and the Agriculture Development Bank of Pakistan.

The boat-building industry is well established and the main boat-building yard is situated alongside the Karachi Fish Harbour. Other yards are situated in Ibrahim Hyderi and Rehri in Sindh, and in Gwadar, Ormara, Pasni and Pisho Khan in Balochistan.

Streamlining the procurement and processing of shell/fish once the catch is landed, and renovating and expanding the harbour is taken care of by the Fish Harbour Authorities of Karachi and Pasni. Plans are underway to establish proper fish harbours or miniports at Gwadar and Korangi.

DEVELOPMENT OF THE FISHERY SECTOR

Inland Fishery and Aquaculture

Inland fishery and aquaculture were neglected in the first two decades after Independence. Actual progress began in the late 1970s with most of the development seen today being achieved in the past decade. In the last ten years, inland fisheries in all four provinces have received substantial government assistance.

Recently, the Asian Development Bank (ADB) has invested US$ 22.1 million in aquaculture in the Punjab, the NWFP and Sindh. In the Punjab, this includes the improvement of fish hatcheries, nurseries, the procurement of nursery equipment and technical knowledge, foreign training, the provision of consultants and the upgrading of existing physical and biological facilities. The NWFP component includes the establishment of a pilot project to determine the feasibility and economics of commercial trout farming, improvement of facilities at the Madyan Trout Hatchery, assistance in establishing commercial trout farming units in other areas and training of local staff through the provision of consultants, and fellowships for foreign training. Sindh's project includes the development of two big hatcheries in Chilya and Sukkur, lake fishery

development, a cage and culture pilot project, fish pond development, the establishment of demonstration and experimental fish farms, and training and extension services.

The project started in late 1979 and was for a 5-year duration. Most of the goals have been achieved and the project provided the initial thrust that the industry required. As a result, seed production capabilities have been increased for both warm and cold water species and this has been an incentive to potential fish farmers. The adoption and introduction of new technology will have a far reaching impact on fisheries development in the country.

During the last several years much attention has been paid to the development of reservoir fishery. WAPDA created an independent directorate to develop this sector in the reservoirs controlled by the agency. Several approaches to improve fish stocks in the reservoirs have been suggested. The UN Food and Agriculture Organization (FAO) assisted through a feasibility study followed by an 18-month pilot programme. Under this project, a limnological and fisheries study was commissioned, which was supposed to form the basis for reservoir management.

Marine Fishery

Pakistan has received technical assistance for fisheries development from the United Nations Development Programme, FAO and various bilateral sources. However, no substantial capital has been provided to this sector except by the ADB, which provided US$ 86 million in loans for three marine and one aquaculture project. In addition, the European Community (EC) has provided US$12 million for the rehabilitation of the Karachi Fish Harbour while ADB has funded the construction of a new harbour at Korangi near Karachi. One ADB project has been completed and others are in various stages of implementation.

One other port is under construction, at Pasni. Also funded by the ADB, this is to be completed at a cost of US$ 27 million. Thus after a long period of neglect, the government, the ADB and the EC have made a sizable commitment of resources to infrastructure development of the marine fishery. This should help expand fish landings.

ECONOMIC AND SOCIAL SIGNIFICANCE

Contribution to the National Economy

The fishery sector plays a relatively small, though by no means an insignificant role, in Pakistan's economy. In 1985 the total value of fish and fish products was approximately Rs. 4 billion or about 0.8% of the country's total GDP. Of this, about Rs. 1 billion was contributed by the shrimp fishing, processing and export sub-sector.

Employment in the fishery sector is relatively small. In 1987, about 250,000 full-time and part-time fisherfolk as well as fish farmers were employed. An additional 50,000 people are probably employed in fish handling, marketing, processing, boat-building and other related sectors. In toto, the fishery sector provides employment to about one per cent of Pakistan's labour force. In the coastal areas of Balochistan, however, marine fishery is the central economic activity and the largest employer.

While fishery contribution to the national GDP and employment is small, its export earnings are significant. Exports of fish and shrimp products in 1986-87 earned about Rs. 1,929 million, that is about 5% of overall export earnings. Continued expansion of exports from the fishery sector will, however, have to rely almost exclusively on fresh and frozen finfish as there appears to be little potential for expanded shrimp production from either marine fishery or aquaculture.

Socio-Economic Conditions of People Involved in Fisheries

Fish and fishing activities constitute the main source of income in the coastal belt of Pakistan. While bona fide fishermen are engaged

in fish catching, members of their families become engaged in activities such as boat-building, net-making, deheading and peeling, processing, marketing and transportation. A large number of women and children are involved, one way or another, in the handling and processing trade. Women are employed in the shrimp deheading and peeling process as well as in the shrimp freezing and canning plants. Permanent women employees are few and these are generally limited to the plants. Although labour below the age of 18 is forbidden by law, children are still employed on daily wages.

While there is no general estimate of the income of different categories of fisherfolk, in the Karachi area fisherfolk are better off financially than those working in the villages and towns of Sindh and Balochistan. Many fisherfolk migrated from the Gwadar area to Karachi after the expansion of the fishing fleet at Karachi. Also, there is a considerable drain in skilled labour from Pakistani fish processing plants to different countries of the Persian Gulf and the problem is becoming more acute with the passage of time.

The socio-economic conditions of villages in the coastal belt are, in general, poor in comparison to cities and towns inland. Fishing villages and towns are congested, dirty, and unhygienic. Most suffer from inadequate water supplies and medical facilities. The literacy rate is very low and there is a great paucity of school teachers. There is also little incentive for fisherfolk to send their children to school.

TRENDS

Pakistan is amongst those countries where the available protein per capita per day is very low, i.e., 14 grams a day, of which fish constitutes only 5.4 grams. Although fish should form an indispensable part of our daily diet, the majority of our rural population has been deprived of this food. This is because traditionally fish is not eaten in these areas. In urban areas also, fish is not a regular item on the table. It is, however, encouraging to note that with increasing awareness of the importance of a balanced diet, improved family income, and a rapid population growth rate (about 3% per annum) the per capita consumption of fish has been slowly increasing, and it is anticipated that by the year 2000 demand will be 50-70% more than what it is today.

Seventh Five-Year Plan and Perspective Plan Targets

The Government of Pakistan constituted a National Commission on Agriculture (NCA) in 1986. The Commission proposed a broad strategy for the years 1988-2000. It was aimed at maintaining self-sufficiency in all the basic commodities and in improving the productivity of crops, livestock, fishery and forestry. The Seventh Plan (1988/89-1992/93) has drawn its figures from the NCA: the production target is 493,000 tonnes of which 403,000 tonnes will come from marine waters and the remaining 9,000 tonnes from inland waters.

Fish production in 1982-83 stood at 343,000 tonnes. This gradually increased to 419,000 tonnes in 1986-87 registering an annual growth rate of 4.4% during the Sixth Five-Year Plan period. This increase was possible due to improvements in fishing techniques, in boats and in landing and storage facilities. The increase has largely been contributed by capture fisheries.

A rational approach together with a strong conservation programme, appropriate management of rivers and reservoirs, an increase in the area available to aquaculture, and effective exploitation of the EEZ will not only enable production targets set for the Seventh Plan to be reached, but should also help us push those figures to about 520,000 tonnes by the year 1992-93. The real impact of the adoption of a strategic national conservation policy for fisheries will be apparent by the year 2000, when we should reach the limits of sustainable yield at about 600,000 tonnes.

3. IMPACTS ON THE FISHERY SECTOR

HARVESTING BEYOND SUSTAINABLE YIELDS

Although data on fish landings is not of sufficient accuracy, it is believed that fish yields, both in the marine and freshwater sectors, have shown an upward trend over the past two decades. This can be attributed to improved fishing technology. While further technological advances should help increase the yield this can only happen up to a certain point before a decline sets in. If this sector is to show a marked improvement, it is essential to study this point, i.e., the sustainable production limit and how it should be achieved. It has to be remembered that marine and inland fisheries have different sustainable yield points.

It is also important that this sector, as a whole, should aim at maintaining a level of production which does not drastically reduce or in any way, wipe out the resource. To determine potential yields one would have to know stock size as well as its potential to renew itself i.e., breeding stock.

Determining Sustainable Yields

This is a difficult question to answer given the lack of a reliable database. No systematic study has been carried out to assess the levels of sustainable yields of fish in inland waters and no agency or institution is working on it. All the reports published so far, including those by provincial government departments, are based on estimates.

Inland Fishery and Aquaculture

At present, riverine fishery resources are being harvested close to optimum levels. These fisheries are based on stocks which are renewed by natural fertilization and recruitment. Hence, two strategies are possible. If the present yield is to be maintained then environmental problems need to be controlled: by preventing further degradation of the rivers through pollution and by halting the reduction of water resources through land reclamation projects or deforestation. This is essential if the habitat necessary for natural spawning and rearing is to be made available for fish stocks to renew seasonally. If this is not done, yields may decline. The second strategy would require regular transplantation of young fish, raised under controlled conditions, into the riverine system, so as to sustain the present level of catch. Production levels can be kept to an optimum by a combination of the two strategies in conjunction with a conservation programme restricting catch efforts to desirable species, size and time.

Reservoir fishery is a complex subject covering as it does a large variety of fish, reared in different ecosystems such as rivers or stagnant water bodies like impoundments. Fish yields are actually governed by a number of factors which affect one another e.g., species combination, natural and artificial recruitment, population balance, natality patterns and catch efforts, which in turn are subject to prevalent agro-ecological conditions, floods, etc. All said, a great deal is yet to be learnt, globally, about fish production patterns in reservoir ecosystems.

In Pakistan, the maximum sustainable yield from reservoirs will vary since, above all, production levels depend on the age of the reservoir and are higher in the initial years. An intensive investigation of each reservoir — which would include a biological, physio-chemical and socio-economical study over a period of time — will enable us to design an appropriate sustainable yield management model.

Given that reservoir fishery is a relatively new science in this country the sustainable yield, at present, is about 17 kilograms per acre per annum. In a country like the United States, the yield is 100 kilograms per acre or more. Now planners have to decide which of the two courses they would like to follow i.e., stick to a minimum production level or increase the yield through careful planning. In both cases, the figure would represent a sustainable yield. It needs to be restated that we have a reservoir area of

about 150,000 acres. Besides this, natural lakes cover an area of about 270,000 acres. Fish yields from these lakes are also very low, as are present sustainable yields. An improvement in management should increase productivity levels two to three fold, while continuous management would keep fish production at a fixed optimum level.

Aquaculture is also a relatively new activity and fish farms have been established on about 10,000 acres only. Aquaculture, i.e., raising fish under controlled conditions is characterized by a clear predictable yield which is easy to maintain. Present levels aim at producing about 700-1,000 kilograms per acre per year. Better utilization could increase yields as much as ten times present figures. Obviously, the country's total sustainable fish production can be well advanced through an integrated effort by aquaculture extensionists, researchers, investors and credit agencies.

The total inland sustainable yield can be further augmented by the utilization of waterlogged areas, by bringing suitable water under active fish culture. Though thousands of square kilometres of land is waterlogged, these areas do not contribute to production figures.

According to an assessment made by the NCA, sustainable production from inland waters can be increased by almost 200% in the coming two decades. However this is a conservative estimate and actual figures could be much higher.

Marine Fishery and Mariculture

Marine fishery is comparatively more developed capture fishery. Relatively more data is available and has been analyzed. Based on these figures we can safely say that we are reaching the sustainable yield limit for shrimp. This is mainly because of the introduction of a large number of fishing boats, which has resulted in increased fishing efforts. On the other hand, the shrimp stock situation and recruitment into the population (through natural increase only) indicate that we have reached the break-even point. Hence, we should restrict catch efforts to the present level for the next two to three years, till we can determine sustainable yield levels in the shrimp fishery.

With the introduction of an EEZ, finfish fishery has acquired a different complexion. finfish yields are believed to be below sustainable levels. It is estimated that a modest increase in marine fish landings are possible without disturbing the population, balance and stock size. This rate of increase in production is envisaged at 1.8% per year up to 2000, when marine fish production will have reached its ceiling.

There are also 912,000 acres of brackish intertidal land in the Indus Delta, particularly the barren mudflats between the mangroves and dry land, with the potential for aquaculture development. Presently their contribution is nil. Overall, levels of sustainable yield can be substantially increased by the utilization of these deltaic lands for aquaculture.

The Government of Sindh has set aside 16,000 acres of land for potential shrimp farmers. About 10,000 acres of this land has already been allotted. Four private shrimp farmers have recently entered this field. The impact of these new developments are still awaited.

Forecasting Future Yields

This subject has been partially dealt with in the preceding section in the light of what is and what can be. Here, an attempt is being made to forecast future yields for each sub-sector for the year 1993. For inland fisheries the yield from reservoir fishery should increase considerably while riverine fishery will decline. The aquaculture industry should expand, but it will not contribute significantly to the total GDP. Although the use of waterlogged areas and brackish water for aquaculture will attract public and private institutions, these will have no significant impact on the status of fish production.

In marine fishery, fish and shrimp production will increase steadily in the next two to three years, after which shrimp landings may start declining. However, finfish production should witness a sharp growth due to the increase in territorial waters through the declaration of an EEZ. In quantifiable terms, after five years the

total inland fish production should be about 125,000 tonnes. Marine fish landing will register a yearly increase of 70,000 tonnes thereby bringing the production figure to 400,000 tonnes. This forecast, however, is based on the assumption that no conservatory charges or rational increases in developmental programmes, other than what is being practised today, occur.

HABITAT DEGRADATION

Inland Fishery

Irrigation System

Prior to the Indus Basin Development Project (IBDP) most fish came from existing reservoirs connected to the headworks of the irrigation system, while the Indus and its tributaries supported, largely, subsistence fishery. With the implementation of the IBDP, however, some drastic changes in habitat have taken place. This is because the project has regulated the flow of the river at various places for the creation of the Mangla and Tarbela dams. With the implementation of the project, forest cover has decreased in many places with a loss of catchment area, land that was a source of regular nutrient flow into the riverine system. There has also been a major shift in the type of fishery, i.e, from riverine to reservoir.

Dams have also been set up on small streams and in the intermediate or dry zones which receive a substantial volume of rain during the monsoon season, but remain dry for the greater part of the year. These small and mini-dams have been built at a far more rapid rate than large dams. This has resulted in a gradual increase in area under cultivation, and the rehabilitation of old and introduction of new irrigation facilities. The development of new land for cultivation has been at the expense of the natural habitat and its associated fauna and flora, and particularly the flood-plain fish population. Habitat degradation together with the changing attitude of people (with regard to fish as food) has provided a challenge to planners and managers in this sector.

The creation of the world's largest canal irrigation system, which is now more than a century old, must have had a short-term effect on inland fishery but there is no record of this. However, the long-term effect has begun to become apparent. One outcome is the tremendous loss of agricultural land, estimated at about 5.5 million acres, to waterlogging.

While the waterlogged areas are a threat to the country's agriculture sector, they do have a hidden potential: they can be used for aquaculture. Careful planning is needed to check the rapid rate of waterlogging, at one end, and for its judicious use for productive fish farming, at the other.

Erosion

Sedimentation in reservoirs is attributed to soil erosion caused by deforestation in the catchment areas. This is particularly serious in the case of Tarbela Dam, where the sedimentation rate is so high that some reservoir capacity has already been lost. Sedimentation has also affected the productivity of the benthic fauna, which serves as food for fish and constitutes an important link in the food chain. This is occurring in other reservoirs also, but at different rates. The threat it poses to inland fisheries needs to be assessed to find a timely solution.

Pollution

Chemical Pollution

Insecticides commonly used in agriculture are toxic to fish. However, toxicity varies with the chemical and its effect is either aggravated or lessened under various environmental conditions. Wastes from the Kala Shah Kaku industrial estate near Lahore have wiped out the fauna and flora of the water body into which the effluents are dumped, before it outfalls into the river Ravi.

Organic Pollution

Although organic pollution is generally useful for fish and aquaculture, if low oxygen or anaerobic conditions occur, it can arrest fish growth or cause mortalities.

Marine Fishery

Ghulam Mohammed Barrage

The building of the Ghulam Mohammad Barrage on the Indus has created a unique problem for the fishery of the anadromous *Hilsa ilisha*, a choice fish for consumers in Sindh. The fish is migratory, swimming upstream from the sea during the spawning season. The barrage's ineffective fish ladder has reduced migration, leading to a fall in breeding and young stock, and a considerable decline in total catch.

Reduction of Mangrove Cover

Mangrove forests along the coast of Sindh and parts of Balochistan form part of a unique ecosystem. Found in the intertidal zones of tropical and subtropical shores, the trees colonize about a quarter of the world's shoreline. The mudflats adjoining the mangroves are high in salt and hydrogen sulphide, and low in oxygen. The soil is inhabited by animals that have adjusted to high salinity and periods of desiccation e.g., the mud-skipper fish.

Mangroves and their associated mudflats are erroneously regarded as waste land. The ecosystem serves as nursery grounds for juvenile fish and shrimp, providing food and shelter to the fingerlings. The trees act as natural windbreaks reducing the intensity of coastal storms and stabilizing the coastline.

Fishing yields from the area per se are insignificant. It is the mangrove's role in the life cycle of the many species of marine fish and shrimp that make it so important; reducing mangrove cover would have a negative effect on the stock of commercially important fish and shellfish.

The major threats to the mangroves are urban expansion and fuelwood extraction. These are rapidly degrading the ecosystem and pose a potential threat to the future of the shrimp industry in Pakistan. Deforestation, from extraction for fuelwood, must be prevented to benefit from the mangrove's multiple roles in maintaining the environment.

The benefits that can accrue to coastal communities, as well as to the nation as a whole, from the management of the mangrove ecosystem, have not been conveyed effectively to the public.

Pollution

Industrial Pollution

Industrial pollution along the coast of Pakistan is found mostly on Karachi's shoreline. Wastes from the Sindh Industrial Trading Estate (SITE) are brought via the Lyari River to the Manora Channel. Industrial and domestic wastes from the Landhi Industrial Trading Estate (LITE) including Korangi, outfall into the Malir River before being discharged on the tidal flats of Gizri Creek and being passed through the adjoining creeks into the Arabian Sea.

In the Karachi area, the biological oxygen demand (BOD) load is found to exceed 1,000 tonnes per day. Industrial waste forms 84% and organic wastes 12-16% of the total. The SITE area contributes about 51% to the total industrial pollution. Of this, 89% is by the textile and 8% by the chemical industry. In all, 615 tonnes and 550 tonnes of BOD are contributed by the SITE and the LITE areas respectively per day.

It has been pointed out that industrial waste contains organic solvents like benzene and toluene as well as chlorides, acids and alkalies. The Lyari River is known to carry sulphates, calcium, alum, magnesium and arsenic in significant amounts and the suspended matter is said to reach the coast at an average rate of 30 tonnes a day, creating dredging problems in the Manora Channel. In addition the Karachi Shipyard discharges considerable amounts of sulphuric acid in its waste water into the channel.

Some heavy metals, if present in high concentrations in sea water and in marine food chains, are toxic to both marine organisms and human beings. Organic mercury is believed to be about ten times as toxic as inorganic mercury. Zinc and copper follow mercury in its toxicity to marine organisms. Slightly less lethal are lead and cyanide. Arsenic, cadmium, chromi-

um and tin are less hazardous. There are also indications of heavy metal leaching from the Pakistan Steel Mills plant at Port Qasim.

Domestic Waste

The quantity of domestic waste per household in Pakistan varies from 80-280 litres per day. Most of this waste water is discharged into water bodies which eventually flow into the sea. Contaminated seawater poses health risks to swimmers and visitors to popular beaches.

The saltwater creeks of the coast of Sindh also receive garbage and raw sewage from several fishing villages. The intertidal mud and sand flats in these creeks serve as defecating grounds for the villagers.

However, organic pollution in the Manora Channel seems to have benefited the mangrove forests, which are thriving.

In Balochistan, all organic waste and pollutants reach the sea untreated. However, in view of the vastness of the coastline and the open-sea condition of the receiving waters, large-scale dilution occurs making these wastes less of a problem.

Human and domestic wastes can be sources of nutrients in coastal waters — nutrients increase the productivity of a body of water — and are a beneficial addition to the marine environment as they increase fish production. Upsloping, which occurs along the coast, transports nutrients from the lower levels of the sea to the surface. However, excessive nutrient loading can cause marine pollution through eutrophication — excessive phytoplankton production eventually leads to BOD problems as dead plants sink to the seabed and decay, depriving marine life of oxygen. Too many nutrients in coastal waters also lead to 'blooms' of toxic phytoplankton. Shellfish feeding on these blooms may absorb the toxic chemicals and be affected; if consumed by humans, the toxins in the seafood lead to paralysis, nervous disorders and respiratory disturbances. Fish kills have also been reported.

Air Pollution

Karachi and its suburbs suffer from acute air pollution, from dust and from the burning of kerosene oil, coal and sulphur along with firewood in residential and industrial areas. Carbon dioxide generation beyond the absorptive capacity of the city's environment can reduce the pH of adjoining waters, leading to an increase in the bicarbonate content of seawater, which is harmful to shellfish growth.

Thermal Pollution

Hot water discharges from power plants such as the Karachi Nuclear Power Plant (KANUPP), and plants owned by the Steel Mills and the Karachi Electric Supply Corporation affect the fauna and flora immediately around the outfall; but since the emission is relatively small compared to the receiving environment, the damage is localised.

Radioactive Waste

The major source of artificial radioactivity on the coast is KANUPP. It undertakes periodic monitoring of radioactivity in the environment through surveys of the surrounding grass and soil material. These have shown that radioactivity in the local waters has not increased. A second, much larger, nuclear power plant is being built upcountry near Chashma in the Mianwali district. Some radioactivity may reach the coastal waters of Pakistan through this source, via the Indu, but the levels are expected to be insignificant.

Oil Pollution

Evidence of oil pollution is found in the form of tar-balls on certain beaches all along the coast. The sandy and rocky intertidal zones at Gadani are smeared with oil which flow from the oil tanks of vessels scrapped at the ship-breaking yard. The intertidal area in the vicinity of the oil refineries along Korangi and Gizri creeks are also blackened with oil.

Although a great deal of oil pollution is present in the Manora Channel (flushed daily by the tide) virtually no trace can be found along the beaches in the vicinity of the channel. This may be due to the large-scale dilution which occurs along the water course before the effluent reaches the Arabian Sea and/or because of the direction of the current.

The Indus Delta is located at a safe distance

from another source of oil pollution: mechanized fishing boats that are still relatively small in number.

No information is available for the southeast coast. Tar-balls from the west coast of India may, nevertheless, reach the delta before any other part of Pakistan's coast.

It is generally believed that oil spilled at sea, in small or large quantities, does not immediately affect stocks of fish and shellfish. However, current evidence suggests that oil spills in inland and coastal waters can be extremely hazardous. Pollution may be gradual and chronic, resulting in the long-term reduction of fish production. Light refined oil is known to be more toxic to adult fish than crude and heavy fuel oil. In addition, spills covering large areas can disrupt fishing activities almost to the extent of paralyzing the industry. On all fish-landing centres, except Karachi, catches of marine fish are landed directly on sandy or muddy beaches. The indirect effects of oil pollution in such cases are numerous, such as the oiling of fish and gear.

4. INTERACTION AMONG COMPETING USERS OF WATER BODIES

INLAND FISHERIES

Water Resources

The major users of the Indus and its allied water resources have been identified as agriculture (both dryland, barani and irrigated agriculture), forestry, mining, hydropower production, aquaculture and capture fisheries. They are all interrelated in one way or another, either directly affecting the quantity or quality of water or requiring water as a medium.

Our perspective is inland fisheries. From this standpoint, the river basin is under stress from deforestation resulting in heavy soil erosion, with the situation further aggravated by improper land use and cultivation practices.

Pressure on our water resources have also been increasing with the growth in population and the rising demand for water for drinking and domestic use. While there may be no apparent connection between human consumption and inland fisheries, this is really not so. The competition for water between the two is evident at the communal level, especially during hot, dry summers when the small reservoirs, particularly in the barani areas, are drawn down. At such times there is a tremendous shift in water-use priority, with fisheries coming at the bottom of the list. Aquaculture in the plains of Pakistan can only be developed if this sector gets its share of water from the canals, and in turn, from the rivers — where competition between the various users is acutely felt. Much of the low-lying barren land of the plains could be developed for aquaculture with water from tubewells. Given the present level of small farm holdings, the average aquaculture farm would, at the most, be between 1-2 acres per family. For such small farms, tubewells are economically not feasible; given this constraint, it would be a good idea to develop communal or co-operative fish farms.

Floods have a negative impact on fisheries although fluvial conditions are considered to be a triggering agent for natural spawning in a majority of edible fish species. The floods are followed by the opening of spillway gates at reservoirs, to let excess water pass without damage to the dams, bunds or *pushtas* (embankment). This free flow of water allows fish stock out of the reservoirs and into tailwater streams. When the flood recedes and the tailwater stream starts drying up, the fish are stranded in water pockets where a large number die as the water dries up. In this way, a sizeable stock of fish is lost through a natural calamity. Reservoirs and flood management come under the agriculture and irrigation departments with fisheries being given a low priority in such conditions. What is needed is a comprehensive programme to reduce fish population losses due to inevitable reservoir manipulation.

Water bodies with multiple-users also impact on fisheries when therapeutic agents or medicines for fish cannot be put in the water

because it is being used for drinking purposes. Thus, preventing disease outbreaks in fish reared in such water bodies is not really possible. Supplemental feed to overcome nutritional paucity in reservoirs is also not possible..

This remains the biggest factor limiting intensive aquaculture in reservoirs. Massive levels of fish mortality in dams also pollute the water, making it unfit for domestic use. The major constraints on fisheries because of the multiple use of water bodies and environmental mismanagement of resources have been organized in a matrix in which the level of each stress on a particular type of fishery is given. (See Table 1).

Inputs Used in the Aquaculture Industry

Besides competition for the use of water by various sectors, the aquaculture industry faces another problem: its inputs are common to other industries. The most serious problem that will confront this industry as it grows, will be the availability of feed items such as fish meal, which constitute a major dietary requirement, and which is used by the poultry industry also. The availability of ingredients for the production of fish meal in the country can become a limiting factor for the expansion of both the aquaculture and the poultry industry. Unless an alternative is worked out, the problem is bound to be further aggravated when the production of meal from trash fish will be reduced. At present, the bulk of marine fish landings are considered non-edible and trash. With the modernization and adoption of new fish processing technology, trash fish will probably be converted into a more useful product than meal, part of which could be made available for human consumption as well. The availability of fish meal, therefore, is expected to decrease in the coming years as competition between fish for food and fish for meal increases.

If aquaculture continues to depend on fertilizers rather than on feed, then the main competition for fertilizer input would be between crops in agriculture and aquaculture. If aquaculture systems start using artificial feed, than the competition would be between poultry industry and aquaculture.

The conflict for land for aquaculture or agriculture use already exists as does competition among other sectors such as livestock, poultry, industry, and human settlements.

Commercial and recreational users often compete for the same fishery resource. As in other countries, the two frequently come in conflict when anglers — who look for calm and natural conditions — request limitations on commercial fishing, which is sometimes difficult to consider.

MARINE FISHERY

Marine water-use competition is quite different from that of inland waters, with the major users being fisherfolk and navigators. It is the dumping of pollutants into the marine environment by industries, municipal sewage corporations and others which causes considerable problems. This issue will be discussed in detail later in this paper.

CONFLICT REDUCTION

As seen, there are many uses of water which can limit fish production. Such factors tend to subtract from the resources available to the fishery sector. Thus, when considering fishery resource allocation, we are obliged to keep two points in mind: the amounts that are lost to production because water bodies have other users — householders, farmers, flood controllers, power generators, industrialists, shippers, etc — and the division of harvestable resources among the fishing community — subsistence, commercial, and recreational. In this, we must not lose sight of the opportunities to correct misallocations or to ameliorate mismanagement. Fisheries will have to rely on residual aquatic resources while recognizing the fact that what resources exist will continue to shrink.

However, the potential for augmenting

TABLE 1

IMPACT OF THE MULTIPLE USE OF WATER BODIES ON FISHERIES

TYPE OF FISHERY	IMPACT ON WATER BODIES								Constraints Imposed by Natural Catastrophes		
	High sediment load through large-scale deforestation in the upper catchment	Improper agriculture practices, leading to a high sediment load	Mining waste and tailing disposal	Urban sewage outlets	Water for irrigation or other uses	Regulation by damming	Heavy metals leaching from sediments	Pesticide and herbicide run-off from agriculture		Floodwater impact on mining waste/tailings store	Floodwater wash of eroded soils
Upper Reaches of the Indus and its Tributaries											
Traditional fishery	H	H	H	M	H	—	H	—		H	H
In-stream aquaculture	H	H	H	M	H	—	H	—		H	H
Pond aquaculture	—	—	L	—	—	—	H	—		—	—
Reservoirs on major rivers											
Capture fisheries	L	L	L	L	H	—	M	L		H	M
Stocking	L	L	L	L	H	—	M	L		H	M
Cage culture	L	L	L	L	H	—	M	L		H	M
Stocking	M	M	M	L	—	—	M	M		H	H
Aquaculture	M	M	M	L	—	—	M	M		H	H
Irrigation System											
Capture fisheries (stream and flood-plain)	M	M	M	L	M	L	L	L		M	M
In-stream fisheries (including macrobrachium)	M	M	M	L	M	L	L	L		M	M
Aquaculture in ponds	—	—	—	—	—	—	—	L		L	—
Lower Reaches of the Indus											
Capture fisheries (estuary and delta)	M	M	M	L	—	L	L	L		L	—
Coastal											
Brackish-water Fishery	—	—	—	—	—	—	—	L		—	—

Note: Conflict level H: High; M: Medium; L: Low; —: None.

inland fishery resources does exist. This can be done by creation of new bodies of water e.g., man-made lakes and ponds, and by increasing the fish yield per unit area through intensive management of the aquatic production system. By seizing the manifold opportunities existent in aquaculture, we can recognize and develop emerging aquatic resources, in addition to fully utilizing the resources mentioned earlier. (See Figure 1).

In light of the preceding discussion it becomes obvious that a more active and focused dialogue is needed between the fishery sector and organizations responsible for agriculture, forest exploitation, irrigation, hydroelectricity production, etc. A more comprehensive approach has to evolve to resolve conflicts. This would assist in the development of a programme that would ensure the optimum use of land and water resources, and closely monitor and maintain a high standard of water quality.

5. ACHIEVING SUSTAINABLE USE

FORMAL EDUCATION

An unfortunate factor which adversely affects the development of fisheries and aquaculture is the lack of specialization/specialists in this field. Most of those involved in fishery research and management are primarily zoologists by profession. They might have used fish as an experimental animal during their M.Sc. or Ph.D. level research without a sound understanding of the subject.

The essential key to self sufficiency in aquaculture is the initiation of a strong Master of Science programme in fisheries and aquaculture. Such a programme should include the principles of aquaculture; nutrition; disease; breeding and genetics; river and reservoir fisheries; pond construction and design; management of ponds, reservoirs, brackish waters and estuaries; mariculture and aquacultural economics. The Agriculture University at Faisalabad and certain other institutions have plans to institute such a programme.

Doctorate-level personnel should be trained abroad. This is essential for maintaining quality in advanced academic programmes and for generating the technology necessary for sustaining growth of fisheries and aquaculture.

Besides degree level courses there is an urgent need to introduce short courses for in-service personnel, for those involved in extension, research and development. These courses could include subjects such as pollution, aquaculture engineering, conservation approaches, appropriate resource utilization, production models, and other related topics.

AWARENESS

There is little awareness of fisheries and its related problems. What needs to be highlighted is:

- The hazards of pollution. Delivered through the media to the public, industrialists, agriculturists and administrators.
- The importance of fish as part of the staple diet. Awareness of the high protein value of fish would encourage people to eat fish regularly.
- Composting of domestic garbage to be used as feed for fish ponds. In the rural areas, composting techniques should be demonstrated to villagers while in urban settlements, city, municipality or development authorities should arrange small demonstrations highlighting the recycling process.
- The importance of natural resources to people. This should be publicized through films in cinema houses and on television. The public must also be made aware of the hazards associated with the degradation of resources.
- Activities that harm fish and fishery resources. Highlighted through pamphlets and thought-provoking posters. These should be widely displayed through advertisements in newspapers and periodicals, particularly through the popular Urdu digests.
- A stock assessment programme through the tagging of fish in reservoirs. The programme

should seek to reward anybody, fisherfolk or angler, who reports catching a tagged fish. Such a programme would be given wide publicity through signboards at prominent places. These methods should assist in creating public awareness of the importance of fish conservation.

- Conservatory rules and regulations. They should be displayed prominently near fishing or landing sites, clearly indicating the fines or penalties that could be otherwise imposed.

RESEARCH

Generally, research on fisheries in Pakistan has been conducted by the universities. These activities, however, remain limited because of the shortage of facilities, staff, equipment and programmes in applied and adaptive research in fisheries and fish farming. The few hundred publications since Independence in 1947 are based mostly on academic or basic research. There is, therefore, an extreme paucity of information on improving yields, on a sustainable basis, from various types of water bodies. The paucity of research in aquaculture has also affected the growth of the overall industry.

There is a need to institutionalize fisheries and aquaculture research programmes. Such research can only be streamlined if present institutions are strengthened. This would mean better equipment, trained labour, more finances, and added incentives for better and more productive work.

Several exercises have been carried out in the past five years by the Pakistan Agriculture Research Council (PARC), in conjunction with local as well as foreign fishery experts, to delineate the priority research areas in both inland and marine fisheries. As a result, PARC has been able to prepare a National Agriculture Research Plan which included fisheries and a National Agriculture Research Centre Master Research Plan. It has also compiled a priority list with possible research subjects. These lists alongwith the NCA's recommendations on research areas for fisheries provide a sound basis for future research.

Aquaculture Research

Site Specificity

Pakistan is divisible into several agro-ecological zones. It is essential that a full characterization of both the experimental site and the actual environment, to which the results are to be transferred, be identified. It should be noted that such a selection and characterization procedure, however thorough, cannot replace the adaptive research and on-farm testing which should remain the basis for validation and extension of improved techniques. Knowledge of different agro-environments will add a geographical dimension to aquaculture management research that would have a far-reaching impact.

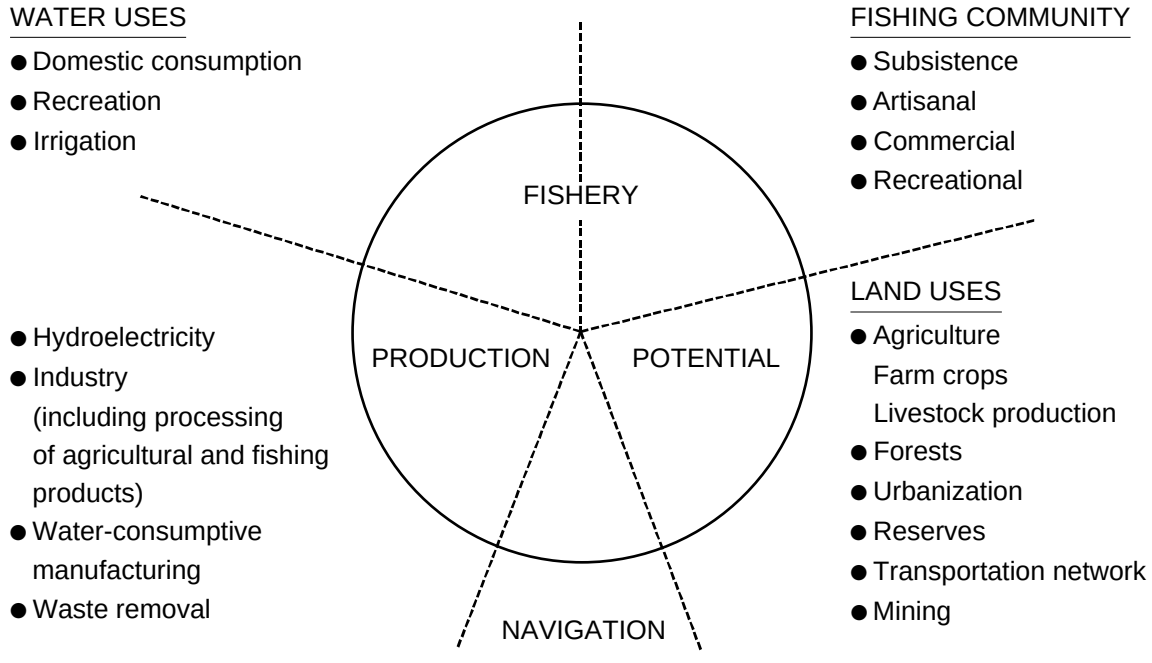
Management

Research for management is of two types: strategic research, generating new knowledge mainly on discrete components affecting pond dynamics and management; and adaptive research, using general knowledge. The former is a long procedure which generates new or improved technology; while the latter can be conducted on fish-farms in real-life conditions. In Pakistan, priority should be given to adaptive research to promote the use of existing knowledge to cope with the need for increased fish production.

Good adaptive research must provide a range of options to farmers. Cash-intensive technology has often been promoted by scientists as they generate higher and more spectacular yields as compared to traditional practices. Farmers, on the other hand, need adequate cash or credit to be able to use this technology and their preference is for better results under poor economic conditions. Adaptive research, therefore, should be aimed at improving fish-farm yields under different agro-ecological conditions and with different levels of inputs.

FIGURE 1

HYPOTHETICAL ALLOCATION OF WATER RESOURCES AMONG COMPETING USERS



ADMINISTRATIVE AND LEGISLATIVE CHANGES

National Fisheries and Aquaculture Policy

A National Fisheries Policy should be developed as soon as possible for the rapid growth of this sector, allowing fisheries to play an appropriate role in the national economy.

At present, there is no separate department at the national level to deal with fisheries. At the Federal level, this sector is under the Animal Husbandry Commissioner in MinFa. The NCA has stressed the need for a Fisheries Development Commissioner in the Ministry. The same point is endorsed here. This office should be the focal point for the development of a National Fisheries Policy and then for a National Fisheries Plan. The Commissioner should also establish linkages between national and international agencies to promote fisheries in the country.

National Nutrition Council

A National Nutrition Council should be set-up to formulate a food and nutrition policy and plan; the council should be the country's principal policy-making and co-ordinating body for nutrition from both conventional and non-conventional sources. A food and nutrition policy should aim at eliminating malnutrition in the country; it should be rational with achievable goals.

The council should develop policies for using fish and other seafood more effectively, of making them a substantive part of our daily diet.

Shell/Fish Stock Assessment

At the national level an agency should be created under the auspices of MinFa, which should be responsible for conducting in-depth surveys of the stock situation, species combination, population dynamics and catch analysis of annual landings. Initially, the agency should seek the technical and financial assistance of international donor agencies, while simultaneously conducting corollary training programmes for local scientists. The agency should also, through its yearly publication, guide the various fisheries research and development institutions on how to use their statistics for future programming.

Fishery Database and Information System

The database, on which most cold and warm water fish bioengineers rely on, is lacking for most of the freshwater species that can be cultured. It is only now that we are investigating the basic physiology of various species, and defining the biological parameters necessary to design efficient and economical culture systems. In contrast to the poultry industry, which is based on a limited number of species with a large database on each, aquaculture has a large number of species with limited data on most. Intensive culture systems for warm and cold water fish have not been standardized; instead systems have been custom-made to fit the requirements of a species in a particular location. A large number of cultivable species have also impeded the development of a standard system appropriate for all locations. It is important to remember that the success of any system will be enhanced by the magnitude of the available data.

Proper planning is needed to harness the extensive information on fisheries in international and regional agricultural and fishery information systems and databanks. The setting up of a Fisheries Information System (FIS) can help do so. National libraries and documentation centres attached to fisheries research institutes should focus on an FIS with the following objectives:

- To monitor and process local/national fisheries information for input into the Aquatic Sciences and Fisheries Information System.
- To publish a national fisheries bibliography and special bibliographies.
- To prepare and circulate a list of abstracts of local and foreign periodical articles related to fisheries.
- To prepare directories, inventories, etc., of fisheries research projects and scientists with their fields of interest.
- To upgrade expertise through a series of training courses.
- To equip network libraries to enable them to carry out tasks related to provision of information on the fisheries and aquaculture sector of Pakistan.

Maps

Marine Fishery

National planning of resource development is becoming increasingly dependent on geographical resource-use maps not only to catalyze the process but also to promote efficient and economical management. This necessitates the preparation of accurate charts and maps showing coastline configurations and bathymetry of coastal waters. The latter should also include geographical information on fisheries, areas reserved for marine aquaculture, underwater parks, demarcation of fishery access and closure zones for various purposes. Specialized maps can also be made for each. The demarcation of the EEZ has further emphasized the need for the preparation of an accurate geographical map for various purposes. As a matter of fact, the preparation of accurate maps is essential for planning the multiple use of maritime resources within national waters.

Inland Fishery and Aquaculture

Here, also, there is a need for accurate maps delineating the various types of inland fishery resources, geographical distribution of fisheries, fish breeding grounds, reserve areas, commercial fishing areas, recreational waters, etc. Pre-

cise supporting maps and charts on the various inputs useful to aquaculture are urgently needed for the promotion of inland fisheries. Principal fishery institutions, the services they render, their location and availability are yet other areas which need to be highlighted through maps and posters.

Official maps delineating the proposed primary and secondary stream sections should be drafted and the termini of designated streams and rivers should be defined by easily identifiable features such as bridges on stream mouths.

A list of primary and secondary waters should be developed in conjunction with the trout management people, utilizing their knowledge of the resource, historical data, stocking records, and incorporating any recent fish population and temperature data. Primary trout streams, by definition, contain naturally reproducing populations of trout. Secondary trout streams, on the other hand, contain no such populations.

Legislation

In the past, under the British, laws were enacted to conserve resources and to protect the rights of the rulers and the rich rather than the common person. But despite the amendments made to legislation associated with fishing and water bodies since Independence, the changes have not kept abreast with the growth in the industry and in the socio-economic conditions of people.

Regulatory measures to conserve fish stock, are based on two principles: one, identifying a closed season for fishing, and two, restricting catch to fish above a given size. There is no mention of the other conservation techniques practised in fisheries and the legislation is silent about several conservatory and regulatory measures which have proven effective in other countries. Under these circumstances, changes in the legislation would serve no purpose, as it would be no better than a stop-gap arrangement. It is therefore recommended, that a completely new fisheries act be prepared by a group of experts from federal, provincial and other such institutions in conjunction with the Ministry of Law and that this act be adopted after clearance from the appropriate bodies.

Also, a lack of regulations on the import of exotic shell/fish from abroad have had, in some cases, an adverse effect on indigenous stocks. Regulatory agencies in Pakistan should be encouraged to use the strongest possible measures to prevent unauthorized or unapproved introduction of fish. In this regard there should be a code of practice to reduce the risk of adverse effects arising from the introduction or transfer of inland aquatic organisms. The code should detail the procedure that needs to be followed for each proposed introduction. The appropriate authorities at the federal level (the Fisheries Development Commissioner) should examine the biology and associated pathogenic organisms and parasites of each species to be introduced into Pakistani waters, to assess the implications for the local ecosystem. The authorities should also assess the probable effects of the species' introduction into new areas, including the effects of any previous introduction of this or similar species in other areas. An accurate prediction of the final range of the species would be essential, particularly if the exotic fish has the potential to breed in confined waters as well.

IMPROVING THE MULTIPLE USE OF COASTAL AND MARINE RESOURCES

There is growing concern that critical habitats are being allowed to decline as society finds even more use for coastal resources. Furthermore, newer and more efficient methods of exploitation place 'traditional' resources under even greater pressure. multiple use management requires a better understanding of the effects of exploitation on the system as a whole.

As the multi-purpose use of marine areas expand, the conflicts between the competing users will inevitably increase. To develop ecologically sound and cost-effective programmes,

managers need better and more timely, though not necessarily more, data. Scientists, fisherfolk, industrialists, politicians, the public and the government must come together to decide what research is to be done, and to make decisions on the allocation of resources after the requisite data has been gathered and analyzed.

Assessments of heavily fished stocks may not be enough to evaluate the impacts of allocation. The task of maintaining and enhancing marine and estuarine resources is vital. Co-operation among users is the only viable option, because as coastal populations increase and resources diminish, new demands will exacerbate existing conflicts among user groups.

Conflicting Demands on the Resource

The conflict between land for development and for estuarine fish-nursery grounds must be balanced, for at stake is the future of valuable stocks of commercial and sport fish.

Aquaculture and husbandry of certain coastal fish stocks — through habitat enhancement — have shown positive results, indicating that stocks for food and angling can be increased. However, this is not possible when estuaries are heavily polluted.

It is difficult to document the effects of ocean dumping on fish stocks — to gauge a specific cause and effect relationship. The degree to which oceans can safely assimilate waste must be understood to prevent a decline in seafood availability. It is worth noting that the fishing industry can also pollute waters by discarding fishing gear — that entangles fish — and by releasing fish processing waste in restricted areas.

Port development is an important, but controversial, use of the coastal zones. While some aquatic habitat loss is unavoidable, losses can be mitigated. To make mitigation work, projects for port development must be environmentally sound, realistically cost-effective, and must deal with critical needs. Better communication and relevant data, well in advance of project deadlines, are crucial.

Merchant shipping issues, such as problems with navigation and safety, and fisheries have not led to any major conflicts.

Co-Operation Among Users

Certain industries, such as oil and gas, which build structures in the marine environment can actually enhance fisheries. These artificial reefs encourage fish aggregations, enhancing fishing. Constructing petroleum platforms with an eye to their future use as reefs can ensure their continued benefit even after their initial use is over.

Co-operation between industry and public agencies can lead to efficiency on many levels. The commercial feasibility of a project should be determined at an early stage; this would avoid costly mistakes or polarized positions.

A creative use of an energy by-product to enhance fisheries involves using waste heat from power plants. With this heated water, fish culturists have been able to boost production and cut costs. New ways for the management of biodegradable waste from fish processing plants should be also developed.

Many anglers would welcome a fishing licence if they can be assured that their money would be earmarked for fisheries research and management. This could result in further control over the system.

Allocating Resources

The question is, how should limited resources be allocated and by whom. Selecting the appropriate criteria for allocations is the key issue: it is a difficult task, made more so because of the common property nature of fisheries. Fair and cost-effective decisions must be made which will ensure the renewability of the resource. Assuming that allocations are made judiciously, they must be socially and politically feasible as well as perceived to be reasonable and enforceable.

The important societal functions of water bodies provide serious constraints to implementing optimal allocation schemes. Society can either accept the existing system and be content with its limited benefits, or it can alter its institutions to increase benefits.

One recommendation is to grant private property rights through licences. The right to fish would be personal property and the licence would come with catch limitations; more important, one would be able to trade or sell part of the licence, particularly the amount that could be caught. This simple allocation scheme could satisfy social and economic objectives, yet effectively protect stocks.

Allocation of resources is the final product of any marine resource management regime. It can be simplified through an understanding of the basic concepts of some form of private property rights, and the application of minimal but relevant data to support the decision making process. Yet this very simplification can produce a sophisticated allocation scheme which truly addresses the important factors necessary in an optimum yield equation. The goals to keep in mind are allocations that are equitable for all, understood by all, and beneficial to fisheries resources. Other than marine mammals and endangered species, the management of living marine resources is generally for the benefit of all. The bottom line is that all human activity involves some kind of allocation decisions, be it time, money or fish.

USE OF ECONOMIC INSTRUMENTS

Credit Mobilization and Incentives

The development of fisheries is linked to capital and supply. Capital requirements include funds for investment in assets (infrastructure, boat, gear, etc.) and for operation (payroll and inventory financing). Generally fishing enterprises are often unattractive to private sources of funding such as banks and financial institutions. Also, fish farmers, processors, and other allied industries tend to borrow less from these institutions because of the high interest rate and perceived cumbersome procedure for acquiring loans. *mols*, middlemen and non-conventional lending sources thus gain importance.

The issues that confront credit for fisheries cannot be differentiated from the issues that are inherent in the development of efficient financial processes. Credit subsidies need to be reviewed in the face of emerging resource constraints and the alternative use of capital. Another problem which needs to be resolved is the tendency of formal lending agencies to lend to large borrowers with well-known track records, rather than to small borrowers for whom the cost of search and verification of credit-worthiness are higher. Unless credit facilities and terms are made more accessible and attractive, the industry cannot be expected to expand rapidly.

Besides loans, certain inputs need to be subsidized in both fisheries and aquaculture. The government will have to come forward if resources are to be mobilized.

Import Incentives

The fishing equipment and other ancillary industries should be encouraged to produce quality equipment to make a headway in modernizing fisheries and aquaculture. Till such industries are established, fishing equipment should be imported duty free.

Exemption from Income Tax

Incentives, in the form of tax holidays for the fishing industry, can help promote fisheries and end current illegal practices. Investments made in fish farming and fisheries should be exempted from tax.

Provision of Electricity and Subsidy for Tube-Wells

For aquaculture promotion it is necessary for tube-well installation to be subsidized, as it is for other agricultural uses. Electricity for operating tube-wells should also be subsidized.

CONSERVATION

A conservation strategy to safeguard endangered species and to maintain optimum yields will require a multidisciplinary approach in which biologists, fish managers, administrators and policy-makers, all will have to play a role. This can be through the enforcement of rules and regulations within the industry itself or through a multi-sectoral approach.

To re-emphasize, the conservation of fish stocks calls for an approach that goes beyond conserving conventional resources such as oceans, rivers and reservoirs, to include unconventional resources such as fish ponds.

Conservation Across the Board

Long- and short-term conservation programmes need to be prepared for each species of commercial and economic value, based on reliable data. This is important because unlike poultry or livestock, fish species are very diverse in habit and habitat requirements. Conservation approaches feasible for one species, or a group of species, may not be effective for other species. As a first step, therefore, it is essential that the requirements of important fish, particularly those most effected by habitat degradation, be identified.

Conventional conservation techniques such as restriction on catch in terms of space, size and fishing methods should be adopted after a careful study of the efficacy of these techniques. A constant feedback loop would also have to be evolved. Conservation of stock through these methods would have to be supplemented by a realistic programme of habitat conservation, particularly when there are many competing users.

Resource-Oriented Conservation

Shrimp

There is a dire need to limit unchecked access to shrimping areas and this can be only be done by imposing restrictions. The government should immediately announce the areas subject to this form of management and these areas should then be clearly demarcated.

In view of the need to restrict the number of shrimping boats licenced to operate, only those entitled to operate during the 1987-88 season should be allowed to apply to operate after 1989 in the managed areas.

License Fees

There should be a substantial increase in boat fees. Holders of entitlements to fish in managed areas are in a privileged position and should be required to pay a greater fee than those fisherfolk who do not hold such entitlements. The fees should be calculated on a sliding scale, reflecting the size of the vessel and its catch potential

Management

A national working group consisting of experts on fisheries and professionals drawn from the Marine Fisheries Department, the Sindh Fisheries Department, the Pakistan Agriculture Research Council, the Zoological Survey Department, the Centre of Excellence in Marine Biology at the University of Karachi, the Harbour Authorities, representatives of vessel operators and primary fishing industries should be formed under the umbrella of MinFa, to study and review existing management practices. The tasks assigned to the working group should be to:

- Provide the mechanism whereby research and monitoring of the Pakistani shrimp fishery can be co-ordinated.
- Provide scientific advice on the optimum utilization of shrimp stock.
- Provide analyses of current data, make recommendations for future needs and lay down the procedures for monitoring the resource and evaluating any management systems that are implemented.
- Recommend what existing or new biological and economic research would be necessary to monitor the utilization of the resource and to improve management advice.

Genetic Diversity

There is an immediate need to maintain breeding populations of an effective size: of at least 50 for short term fitness, and of at least 500 for long term survival, at the government fish hatcheries responsible for fish seed production for utilization at large in aquaculture systems. This is essential if we are to overcome the genetic constraints created by a reduction in breeding stock to one or more generations.

- It is recommended that a conservative approach to translocations of native fish be adopted, as there are several dangers associated with it. For instance, translocation

augments destruction of an ecotypic form below the species level because of hybridization, competition, direct predation, etc. Because ecotypes comprise the total range of genetic variability available for future use by commercial fisheries and aquaculture, any reduction in this genetic potential is a loss to the future.

- Well established natural gene pools should be protected as they are the prerequisites of any successful breeding programme. Artificially produced hybrids are likely to destroy the ecology of existing systems; strict supervision of their production should be exercised by the federal and provincial fisheries department. This may not appear to be a problem, for at this stage almost all the breeding is being carried out in the public sector. But, with the planned expansion of the aquaculture industry, this will pose a big threat to future commercial fisheries.
- As mentioned earlier, aquatic ecosystems are subject to natural and man-induced stresses which have adversely affected fish populations. Destruction of habitats have been identified as a particular problem, as it affects genetic thresholds of fish; fish are prone to rapid evolution in response to environmental change more than other invertebrates. There is a need to establish a Bureau of Fish Genetic Resources like the one in India. This bureau may be created under PARC as has been done by the Indian Council for Agricultural Research. It should start collecting basic information to evaluate the diversity, genetic and ecological vulnerability of important fish and shellfish species.

Pollution Control

Some of the measures suggested for pollution control are:

- Changes in the engineering curricula at the tertiary level to include topics on waste management.
- Establishment of institutions where people can be trained in modern, low-cost pollution control technology.
- Promotion of cheap treatment plants for sewage and industrial effluent.
- Improvement in the maintenance of industrial plants to minimize effluent discharge.
- Introduction of modern town planning methodology.
- Formulation of a national policy for the establishment of industrial estates at appropriate locations to minimize problems.
- Formulation and enforcement of national legislation for the control of environmental pollution.
- Launching of campaigns to enhance public awareness of the hazards of pollution.
- Exchange of information on pollution and its control among developing and developed nations.

River Management

It is essential that the successional or developmental stages of rivers in the country be determined. All need to be classified under the following categories: unmodified, slightly modified, extensively modified and completely modified. The degree of modification could be the result of a single or several factors including increased pressure on fluvial and adjacent resources. Research, development and management strategies should be clearly linked to the developmental stages of the river.

- For unmodified rivers, research should aim at studying species composition, the biology of important species, and the identification of major resources. The main activities should focus on establishing simple regulatory measures for the protection of major stocks, and on improving access and marketing networks.
- For slightly modified rivers, research should focus on population dynamics, the biology of important fish and species interaction. Conservation and management plans should be directed towards strict monitoring to prevent the overfishing of major stocks complemented by aquaculture development, and the improvement of fish landing and preservation techniques.

- For extensively modified rivers, research should concentrate on the population dynamics of the fish particularly in relation to various sources of landing. The conservation and development approach should be directed towards better control of catch methods through licensing and legislation. There is also a need to evaluate the impact of resource utilization by users other than the fishing industry, in an attempt to preserve and maintain suitable conditions for fishing. Allied aquaculture should be given due attention to augment and sustain fish production in drainable ponds and in regularized depressions. The development of reservoir fisheries also needs further attention.
- For completely modified rivers, the research priorities would be in investigating pollution and other management impacts on fish stocks, and to control the discharge of effluent and waste into the river.

The management regime should strictly enforce regulations on catch size, fishing season and stock replenishment programmes to support threatened species. Allied aquaculture and reservoir fisheries development should be intensified for maximum resource utilization.

Riverine Fisheries: An Integrated Model

For the development of riverine fisheries an integrated transdisciplinary model should be set-up. This should be capable of predicting the effects of a variety of development strategies and activities on rural populations inhabiting river margins and flood plains, as well as the overall impact of such schemes on national programmes. A major focus of the work could be the application of system analyses to key river basins.

In order to command the attention of the river basin and water management planners, it is necessary for fisheries, agriculture, wildlife and other disciplines concerned with rural development to join forces. A first step should be to present the findings and recommendations of each group to a working group. Joint attempts can then be made to define alternatives for river basin development. To determine what information is likely to be required for the development of a systems model, the government may have to work in conjunction with an international agency such as FAO and/or other river basin groups abroad. During the development of the model, attention should be given to the development of various types of water bodies under a given set of environmental conditions.

Reservoirs

- Baseline studies of the physio-chemical and biological characteristics of the water of main reservoirs is essential prior to the development of a rational fisheries manage ment/conservation programme for reservoirs. Likewise, there is a need for more precise data collection on fish yields in reservoirs currently managed and for the impact evaluation of fingerling stocks on total reservoir fish yield.
- Fry should reach a suitable size before being released into the reservoir. If ponds in the vicinity of the reservoir are not available, then fry should be raised for a short period in ponds elsewhere and then transferred to net cages and/or coves within or near the reservoir before being released.
- The development of aquaculture using cages for the intensive rearing of some marketable herbivorous and omnivorous carp species, with supplementary feeding, holds potential. This technique should be demonstrated for wider acceptance by farmers.
- More efficient utilization of benthic biomass could be achieved by increasing the stock of demersal fish through an increased rate of stocking.
- Measures should be taken to increase the natural spawning of original riverine species.
- The protection of fish stock should be enhanced by the application and enforcement of fisheries management measures in agreement with modified fisheries laws.
- A synthesis and evaluation of data accumulated from post-impoundment studies in the

field of limnology and biology of fish in reservoirs needs to be done. Such data should then be used for more precise planning of reservoir fishery development.

Aquaculture

Pakistan has a sizeable area of land and water suitable for the development of aquaculture along the coastline, in the estuarine areas and in the flood plains where many species of shrimp and fish can be cultured. There is also scope for the establishment of rearing farms for the commercial production of fish and shrimp in both fresh and marine waters. This needs to be complemented by a comprehensive extension programme with incentives and subsidies for the promotion of the industry.

Stocking Public Waters/Utilization of Wetlands

Stocking fish in commonly owned water bodies in villages and town (village ponds, etc.) can play a significant role in fish production for the poor, especially in inland areas. This would considerably improve the nutritional value of the diet of poorer sections of society. Poor villages, particularly in the remote areas, should be given priority by the government when stocking is being considered. Subsequent management should be handed over to a village management committee. The fish should be harvested at a particular time of the year followed by immediate restocking. The product should be sold to the public at subsidized rates. The government should fund the project completely in the first and second years, 50% in the third and fourth years and upto 25% in the fifth year. Thereafter, the government should provide only technical advice. This use will add a new dimension to community resources generally used for washing clothes, and for the bathing of both human beings and cattle. The Punjab government has started such a pilot project in a village and the lessons learnt from this can provide guidelines for the future.

The right approach would be to prepare a map of stockable waters and overlay this with a map showing areas of extreme poverty in order to estimate where the benefits, in terms of nutrition, will be the most.

Mangroves: Designation of Areas for Conservation

Although biosphere reserves have been designated for terrestial forests and plantations, no such reserves have as yet been created for mangroves.

Mangrove forests provide a link between marine and terrestial ecosystems. There is generally an import of nutrients from the land to the mangroves, and then an export of nutrients from the mangroves to the sea. In the mangrove swamps most primary production is by the trees.

Coast Conservation Department

A coastal zone management plan should be formulated through the creation of a Coast Conservation Department. The following objectives, with respect to estuaries, lagoons and mangroves should be kept in mind.

- To safeguard the coast to protect these ecosystems.
- To enhance fishery production from these ecosystems.
- To utilize these ecosystems for mineral extraction in a manner that does not conflict with the above points.

National Conservation Databank

A national conservation databank project should be established at the federal level to facilitate the analyses, interpretation and dissemination of data on various aspects pertaining to the conservation of sectors identified by the NCS. This database should link with an international database.

In the past, fisheries managers have accorded the economic and social aspects of their work a lower priority than biological data collection. Today, the need is for multi-disciplinary data for decision-makers.

SOCIAL AND DEMOGRAPHIC APPROACHES

Non-Governmental Organizations

Besides governmental departments, NGOs can play an important role in the conservation of natural resources. There are many dimensions to conservation, and NGOs can be effective in creating awareness about the need for conservation. Several NGOs have adequate resources to build up a system for feedback that would allow the impact of their programmes to be evaluated and to point out any discrepancies that may exist. For example, for the fisheries sector, NGOs concerned with the welfare of the fishing community can be asked to play a more effective role. The government, in this case, should be approached to provide special funds for such NGOs.

People's Participation

People are one of the most important components of a conservation programme. Since all programmes are for the general public, none can succeed unless people participate in or, at least, endorse the main objectives. The problem is a general lack of awareness. The first step, therefore, should be to create greater awareness about the major aspects of a national conservation policy. Public participation is possible either through their representatives, voluntary societies or even at an individual level.

Rewards

Rewards to outstanding conservators, in the public or the private sector should be considered a key to the success of any conservation policy. The rewards may be in cash or kind; but they should be given publicity, to be an inspiration for others.

Discouraging Over-Exploitation

The major cause of the destruction of our fishery resources is illegal fishing — which include dynamiting, overfishing, poaching etc. At the root of the problem lies poverty. This is a subject which requires in-depth study, if we are to find a way out of this problem. Society will also have to undergo attitudinal and behavioural changes if this issue is to be tackled successfully. This also requires an enhancement in the capacity of the fisheries law-enforcing agencies to monitor the resource in the way it ought to be.

CONCLUSION

Fishery resources are very sensitive to changes in the environment arising from activities such as river basin development, deforestation, and pollution. But the problems are especially complex as they all arise from the multiple use of aquatic resources. The reason why these problems persist is because of the practical difficulties encountered in implementing their solutions. Implementation is frequently hampered, not only by technical difficulties but by adverse political and economic forces also. In addition, the fishery sector is considered the least important.

Fishery resource management in multi-use water bodies calls for strong conservatory measures in conjunction and co-operation with other users and the development of aquaculture techniques to most profitably augment fish yields. Measures taken to control other problems such as pollution, deforestation, improvement of the quality of water for domestic use, and so on, will positively affect fisheries.

REFERENCES

Ahmad, A. 1983. Toxic Wastes of Industrial Effluents in Karachi. In *Hazards of Toxic Wastes and Water Pollution, Proceedings of the World Environment Day Seminar, 5 June 1983,* 12-15. Karachi: Institute of Environmental Studies, University of Karachi.

Ahmad, M. 1970. *Bioecological Survey of the Indus Delta Estuary.* Annual Research Report, Pakistan Science Foundation. 108 p.

Ahmad, M. 1977. An Assessment of the Magnitude of Coastal Pollution in Pakistan through a Study of its Fauna and Fisheries. *Thalassia Jugosalavica* 13, no. 2-4: 395-412.

Ahmad, M. 1979. The Present Status of Marine Pollution in Pakistan. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems.* Karachi: Pakistan Council for Scientific and Industrial Research.

Ahmad, S. 1979. Combating Pollution in Karachi Port. *In Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 57-58. Karachi: Pakistan Council for Scientific and Industrial Research.

Alabaster, J.S. 1986. *Review of the State of Water Pollution Affecting Inland Fisheries in Southeast Asia.* FAO Fisheries Technical Paper 260. Rome: Food and Agriculture Organisation. 25 p.

Asian Development Bank (ADB) and International Bank for Reconstruction and Development (IBRD). 1983. *Indonesia Fisheries Sector Study*. Manila: ADB and IBRD. 168 p.

Asian Development Bank. 1987. *Second Pakistan Aquaculture Development Project Feasibility Study.* Honolulu: Aquatic Farm Ltd. 238 p.

Asian Development Bank. 1987. *Pakistan Fisheries Sector Study.* Manila: ADB. 168 p.

Beg, M.A.A., S.N. Mahmood and A.H.K. Yusufzai. 1975. Industrial Effluents, their Nature and Disposal in Karachi Region, Part I, Survey of the Polluted Lyari River.

Proceedings of the Pakistan Academy of Sciences 12 no. 2: 115-131.

Beg, M.A.A., M.A. Siddiqui, R.B. Qadri, N. Basit, F. Siddiqui and I. Mahmood. 1979. Microbiological Aspects of Land Based Pollution in the Marine Environment. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 59-62. Karachi: Pakistan Council for Scientific and Industrial Research.

Beg, M.A.A., S. N. Mahmood, N. Sitwat, and A.H.K. Yusufzai. 1984. Land Based Pollution and the Marine Environment of Karachi. *Pakistan Journal of Scientific and Industrial Research* 27 no. 4: 199-205.

Beg, M.A.A., N. Basit, F. Siddiqui, I. Mahmood and M.A. Siddiqui. 1984. Studies on the Biological Contamination of the Coastal Environment of Karachi. *Pakistan Journal of Scientific and Industrial Research* 27 no. 4: 206-210.

Bernacsek, G.M. and M. Shoaib. 1986. An Outline of Principal Fisheries Development Policy Issues Suggested for Discussion for the Seventh Five-Year Plan of Pakistan. In *Report of the National Seminar on Fisheries Policy and Planning.* Karachi: Marine Fisheries Department.

Bochet, J.J. 1983. *Management of Upland Watersheds: Participation of the Mountain Communities.* FAO Conservation Guide 8. Rome: Food and Agriculture Organisation. 199 p.

Butler, M.J.A., et al. 1986. *Marine Resource Mapping: an Introductory Manual.* FAO Fisheries Technical Paper 274. Rome: Food and Agriculture Organisation. 256 p.

Campbell, J.S. 1978. *Type of Parastatal Bodies Concerned with Fisheries Development and their Financial Responsibilities.* FAO Fisheries Technical Paper 179. Rome: Food and Agriculture Organisation. 39 p.

Coche, A.G., comp. 1987. *Selected Aquaculture Publications: Serials, Newsletters, Meeting Proceedings, and Bibliographies/Directories/ Glossaries.* FAO Fisheries Circular 808. Rome: Food and Agriculture Organisation. 108 p.

Comisión de Pesca Continental para América Latina (COPESCAL). 1979. *Report of the First Session of the Commission for Inland Fisheries of Latin America, Mar del Plata, Argentina, 19-23 March 1979.* FAO Fisheries Report 222. Rome: Food and Agriculture Organisation. 22 p.

Cushing, D.H. 1977. *Marine Ecology and Fisheries.* London: Cambridge University Press. 278 p.

External Affairs Canada. 1984. *Fisheries and Oceans: The Canadian Experience.* Ottawa: Ministry of Supply and Service. 15 p.

Regional Office for Asia and the Pacific, FAO (RAPA). 1984. *National Development Plan. Strategies of Developing Countries in Asia-Pacific Region.* RAPA Monograph 10. Bangkok: RAPA. 32 p.

Food and Agriculture Organisation (FAO). 1973. The Pakistan Shrimp Resources. Report to the Government of Pakistan on the Pakistan Shrimp Resources. Rome: UNDP-FAO. 77 p.

Food and Agriculture Organisation. 1976. *FAO Technical Conference on Aquaculture, Koyoto, Japan, 26 May - 2 June 1976.* FAO Fisheries Report 193. Rome: Food and Agriculture Organisation. 93 p.

Food and Agriculture Organisation. 1985. *Report of the Sixteenth Session of the*

Committee on Fisheries. Rome, 22-26 April 1985. FAO Fisheries Report 339. Rome: Food and Agriculture Organisation. 46 p.

GESAMP (IMO/FAO/UNESCO/WMO/WHO/ IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution). 1986. *An Approach to Marine Pollution Prevention.* FAO Report and Studies (24) 6. Rome: GESAMP. 47 p.

Government of Pakistan (GOP). 1986a. Korangi Fisheries Harbour Project. Preliminary Design Report. Stage 1, Phase II. Karachi: Korangi Fisheries Harbour Authority, GOP. 134 p.

Government of Pakistan. 1986b. Korangi Fisheries Harbour Project. Initial Management Advisory Report. Karachi: Korangi Fisheries Harbour Authority, GOP. 45 p.

Grover, H.H., ed. 1984. *Allocation of Fishery Resources. Proceedings of the Technical Consultation on Allocation of Fishery Resources held in Vichy, France, 20-23 April 1980.* Rome: FAO in co-operation with the American Fish Society. 623 p.

Haq, S.M. 1976. Overview of Pollution in the Coastal Environment of Pakistan and its Possible Implication for the Marine Ecosystem. In *Proceedings of International Symposium Marine Pollution Resources*, ed. S.P. Meyers, 33-53 Baton Rouge: Centre for Wetland Studies, Louisiana State University.

Indian Ocean Fishery Commission and Indo-Pacific Fishery Commission. 1983. *Report of the Joint Session of the Seventh Session of the Indian Ocean Fishery Commission and the Twentieth Session of the Indo-Pacific Fishery Commission, Bali, Indonesia, 11-18 November 1982*. FAO Fisheries Report 281. Rome: Food and Agriculture Organisation. 190 p.

Indian Ocean Fishery Commission. 1985. *Report of the Third Session of the Committee for the Development and Management of Fisheries in the Bay of Bengal and the Ninth Meeting of the Advisory Committee for the Development of Small-Scale Fisheries of the Bay of Bengal Programme. Bangkok, Thailand, 25 February - 1 March 1985*. FAO Fisheries Report 330. Rome: Food and Agriculture Organisation. 26 p.

Indo-Pacific Fishery Commission. 1985. *Report of the Fourth Session of the Committee for the Development and Management of Fisheries in the South China Sea, Kuala Lumpur, Malaysia, 6-8 December 1984*. FAO Fisheries Report 342. Rome: Food and Agriculture Organisation. 17 p.

Indo-Pacific Fishery Commission. 1986. *Report of the Third Session of the Indo-Pacific Fishery Commission Working Party of Experts on Inland Fisheries, Bangkok, Thailand, 19-27 June 1986, and Report of the Workshop on Strategies for the Management of Fisheries and Aquaculture in Mangrove Ecosystems, Bangkok, Thailand, 23-25 June 1986* FAO Fisheries Report 370. Rome: Food and Agriculture Organisation. 42 p.

Japan Information Centre of Science and Technology (JICST). 1987. *Abstract of Science and Technology in Japan Agriculture, Forestry and Fisheries*. Tokyo: JICST. 112 p.

Jawaid, M.Y. 1985. Position Paper on Fisheries Sector. Directorate of Fisheries, Punjab. 16 p.

Kapetsky, J.M., ed. 1981. Seminar on River Basin Management and Development, 8-10 December 1980, Blantyre, Malawi. CIFA Technical Paper. Rome: Food and Agriculture Organisation. 302 p.

Khaisqhi, M.H.K. 1979. Marine Pollution by Ships. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 29-32.

Karachi: Pakistan Council for Scientific and Industrial Research.

Khan, A.A. 1983. Determination of Organo-chlorine Pesticides in Sessile Animals from Karachi Coast, Master's thesis, Centre of Excellence in Marine Biology, University of Karachi. 99 p.

Khan, M.Y. 1986. Fishing Techniques in Coastal Waters of Pakistan. In *Report of the National Seminar on Fisheries Policy and Planning.* Karachi: Marine Fisheries Department.

King, M.G. 1986. *The Fishery Resources of Pacific Island Countries. Part 1. Deep-Water Shrimps.* FAO Fisheries Technical Paper 272. Rome: Food and Agriculture Organisation.

Lander, I. 1978. Industrial Organic Wastes. In *Fifth FAO/SIDA Workshop on Aquatic Pollution in Relation to Protection of Living Resources*, 153-174. Rome: FAO.

Lu, X., comp. 1986. *A Review on Reservoir Fisheries in China.* FAO Fisheries Circular 803. Rome: Food and Agriculture Organisation. 37 p.

Maccrimmon, H.R., J.E.F. Stewart, and J.R. Breett. 1974. Aquaculture in Canada. *Bulletin of the Fisheries Res. Board of Canada*, vol. 188. 85 p.

Marine Fisheries Department (MFD). 1985. *Handbook of Fisheries Statistics of Pakistan,* Vol. 14. Karachi: MFD, Ministry of Food, Agriculture and Cooperatives. 105 p.

Medina-Pizzali, A.F. 1988. *Small-Scale Fish Landing and Marketing Facilities.* FAO Fisheries Technical Paper 291. Rome: Food and Agriculture Organisation. 68 p.

Mian, H.A. 1979. Pakistan Shores and Oil Pollution. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 25-28. Karachi: Pakistan Council for Scientific and Industrial Research.

Moazzam, M. and S.H.N. Rizvi. 1979. An Overview of Oil Pollution along the Coast of Pakistan. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 33-39. Karachi: Pakistan Council for Scientific and Industrial Research.

National Commission on Agriculture, Ministry of Food and Agriculture. 1987. *Report of Committee IX (Fisheries).* Islamabad: Government of Pakistan.

Pakistan Agriculture Research Council (PARC). 1985. Mangroves of Pakistan. In *Proceedings of National Workshop on Mangroves, 8-10 August 1983, Karachi.* Islamabad: PARC. 63 p.

Petr, T., ed. 1985. *Inland Fisheries in Multi-purpose River Basin Planning and Development in Tropical Asian Countries: Three Case Studies.* FAO Fisheries Technical Paper 265. Rome: Food and Agriculture Organisation. 166 p.

Pillay, T.V.R. 1997. *Planning of Aquaculture Development and Introductory Guide.* Surrey, England: Fishery News Books Ltd. by arrangement with the Food and Agriculture Organisation of the United Nations. 71 p.

Ploskey, G.R. 1985. *Impacts of Terrestrial Vegetation and Preimpoundment Clearing on Reservoir Ecology and Fisheries in USA and Canada.* FAO Fisheries Technical Paper 258. Rome: Food and Agriculture Organisation. 35 p.

Quraishe, G.S. 1985 (a). Influence of the Indus River on the Marine Environment. In

International Conference on Management of Environment, Part I. Pakistan Academy of Sciences, Islamabad.

Quraishe, G.S.. 1985 (b). Influence of the Indus River on Marine Environment. In *International Conference on Management of Environment, Part II*. Pakistan Academy of Sciences, Islamabad.

Saifullah, S.M. 1982. Mangrove Ecosystem of Pakistan. Third Research on Mangroves in the Middle East, Japanese Co-operation Centre for Middle East, Publication no. 137:69-80.

Siddiqui A.A. and Mirza, K.F. 1979. Disposal of Radioactive Waste from Karachi Nuclear Power Plant. In *Protection of Marine Environment. Proceedings of National and Regional Seminar for the Protection of Marine Environment and Related Ecosystems*, 67-70. Karachi: Pakistan Council for Scientific and Industrial Research.

Sinha, V.R.P. 1988. Indian Aquaculture. Souvenir at the USDA/ICAR International Symposium on Aquaculture Research Needs for the Year 2000, New Delhi. Cent. Inst. of Fish Edu. Versova, Bombay, no. 15-18. 18 p.

Soyosa, C., L.S. Chia, and W.L. Collier. 1982. *Man, Land and Sea: Coastal Resource Use and Management in Asia and the Pacific.* Bangkok: The Agriculture Development Council. 320 p.

USDA and ICA. 1988. Report of the USDA Aquaculture Team Visit to India, Indo-US Subcommission on Agriculture, New Delhi, India. 71 p.

USDA. 1988. Aquaculture: Situation and Outlook Report. USDA Economic Research Service report, Aqua 1. 39 p.

Veloze, R.C. 1987. *Incentives for Community Involvement in Conservation Programmes.* FAO Conservation Guide 12. Rome: Food and Agriculture Organisation. 159 p.

Zain-ul-Abedin. 1978. Domestic Sewage and Sewage Treatment. In *Fifth FAO/SIDA Workshop on Aquatic Pollution in Relation to Protection of Living Resources*, 30-58. Rome: Food and Agriculture Organisation.