Pauly, D. and Colleagues. 1989. Requirements for Environmentally Sound AquaticResources Management, p. 39-51. *In: Dryland, Wetlands, Croplands: Turning Liabilities into Assets.* Infoterra Programme Activity Centre, United Nation Environment Programme, Nairobi.

Requirements for Environmentally Sound Aquatic Resources Management

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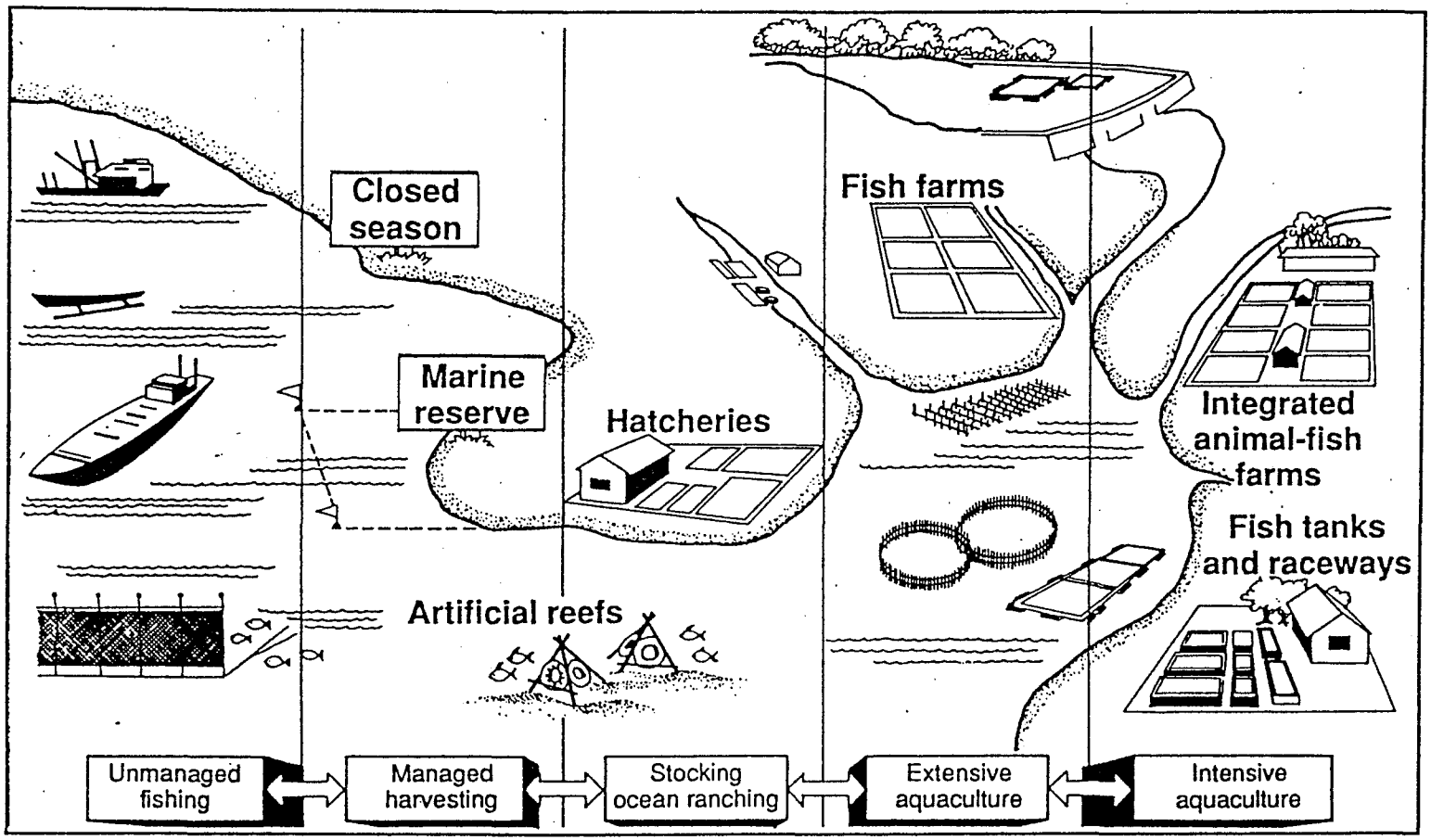
INTRODUCTION

Fresh water and table salt are the only products consumed by people which are not derived from the earth's biosphere. All other things that we drink and eat were either parts of plants or of animals which themselves directly or indirectly relied on plants. A similar situation exists for textiles and paper, essential elements of our material well-being and of our literacy, respectively, and for the various compounds that form the basis of the pharmaceutical industries. Thus, whether we live in countries that are industrialized or not, developed or not, we still depend totally, to meet our bodily and cultured needs, on photosynthetic processes and biological production.

This undisputable fact, one may think, should be reason enough for a major part of human activities and material research to be directed, worldwide, toward the management and improvement of the earth's productive capacity — especially in view of the rapid increases of the world's population. However, one does not need to be an alarmist to note that it is precisely the opposite which is happening. Worldwide, and particularly in tropical third-world countries, where population growth is most rapid, the very basis of the earth's biological production is being gradually and quite literally eroded away.

The major causes for this degradation, as far as terrestrial habitats are concerned, are large-scale monoculture, the resulting losses and/or impoverishment of top soil, overgrazing of rangeland and other marginal habitats, and deforestation and the resulting erosion.

Figure 1. Utilization of aquatic resources: a continuum of activities from open-sea fishing to intensive aquaculture. It is necessary to consider these interrelationships in management decisions concerning any one sector.



The open-access nature of most aquatic resources and their increasing overexploitation, particularly in the last decades, has turned much of the debate between conservationists and resource managers over rates of use into a sterile exercise. The point here is that "tapping of aquatic resources" is usually followed by rapid, totally uncontrolled expansion of "harvesters", leading to overexploitation and overcapitalization of the fisheries, past any rationally definable optimum.

This situation is documentable for the majority of fisheries throughout the world, tropical and otherwise, as well as for mangrove coastal zone areas, where aquaculture now competes with other land uses. The prevention of further environmental degradation, the rehabilitation of productive systems and habitats and the rebuilding of exploited resources and animal populations are commonly shared goals for these systems.

Most fisheries of the world, whether temperate or tropical, inshore or offshore, small-scale or commercial, may be described as "overcapitalized": there are too many fishermen and too many boats chasing too few fishes. However, politicians are often unable to acknowledge constraints resulting from resource limitations, and usually comply with the demands of the most vociferous segments of the fishing industry. This usually prevents long-term solutions to the overexploitation problem; rather, "quick fix" solutions, such as further subsidies and/or inconsequential legislation are implemented. Indeed, it is still rare for the overfishing problem to be generally recognized in tropical countries; more often views of "limitless" resources are maintained even in the face of declining annual national catches and scientific evidence to the contrary.

The widespread failure to address economic and social conflicts within the fishing industry, and even to organize fishing to provide a stable supply of fish, most often stems from the failure to fully understand the consequences of four interacting features of fisheries:

- **fisheries resources, although often bountiful, are always finite**; they do not respond, past a certain level, to further increase of fishing effort by a corresponding increase in yield;

- **entry into fishing is usually open, with the fish belonging to whomever catches them**; fishery resources are "common property" and fishing, unlike farming, is an open-access" activitiy;

- **demand for fish, for positive economic returns on boats and other capital investments and (in most third-world countries at least) for jobs in the fishing sector are steadily increasing**; if left on its own, this demand will always produce levels of fishing effort far beyond that needed to exploit a stock optimally;

- **there is a continuum of activities from open-sea fisheries to intensive aquaculture**; events in one sector always have repercussions on other sectors, whether at the resource or marketing level (**Figure 1**).

These four features are the essential reasons why, for example, the North Atlantic fisheries are overexploited and overcapitalized, with about US $1,000 million of potential resource rent dissipated annually. In Southeast Asia, they are the cause for declining catch and

fishermens' incomes in such countries as Thailand and the Philippines. The above-mentioned key features of fisheries are also the cause for recurring, often violent, conflicts between fishermen. For example, conflicts between Indonesian small-scale fishermen and trawl operators became so intense that the government in 1981 banned trawling in Indonesian waters altogether.

SMALL-SCALE FISHERIES

Recent interdisciplinary studies conducted in various parts of the world strongly support the suggestion that small-scale fisheries throughout most of the third world are economically more efficient than large-scale fisheries, besides usually exploiting resources in a way that guarantees their renewal. However, insufficient comprehensive interdisciplinary research has been carried out on small-scale fisheries. For example, a number of comprehensive studies exist on the (large-scale) demersal trawl fisheries of Thailand and the (large-scale) fishery for Peruvian anchovies, both by local (Thailand Peruvian) and by foreign researchers, but few exist on the small-scale sector of these two countries, although they employ far more people (in the case of Thailand) or provide the bulk of the fish for human consumption (in the case of Peru).

There are a number of obvious sociological and other reasons why research on small-scale fisheries is usually neglected. One of them is the simple fact that it is usually far more difficult to study small-scale than commercial fishermen. In the tropics, small-scale fishermen, operating a variety of gears which often change between seasons and are often modified as new construction materials become available, usually land their catches at the most unpredictable hours (to nonfishermen at least!), in faraway, inacessible places. Catches may in part be earmarked for consumption by their own families, with the rest sold in small batches to processors or middlemen with whom the fishermen are linked through complex ties of mutual dependence.

Obtaining reliable estimates of total catch, its composition and of other important statistics in these fisheries therefore is extremely difficult. Yet, making appropriate decisions concerning allocation of total available catches amongst small-scale and commercial fisheries, especially when they compete, requires that such data be available and analyzed.

The gathering and analysis of catch and biological data for use in managing fisheries, including that required for the more straightforward practice of stock assessment, is necessary because it is only through analysis of the performance of a fishery, of its catches and their trends that rational decisions can be taken. For example, when analyzed, such data, coupled with data on fleet economic performance, can help determine whether fleet expansion should be encouraged (the rarer case), or discouraged, or whether attention should be given to the development and deployment of new gears or to gear restrictions.

Fisheries economics research, long seen by many as only complementary to management schemes that were structured around the biology of fish stocks, is also extremely important in tropical fisheries, since fisheries economists, rather than fisheries biologists, are the ones most qualified to assess and compare the direct and indirect costs and benefits of various management schemes. In small-scale fisheries, economists also can help by quantify-

ing the costs and benefits of alternative employment schemes (including aquaculture), evaluating management options, and assessing the indirect costs incurred by developing economies when large segments of their population are kept out side the mainstream of society. Here again, methodologies need to be developed, tested, modified and disseminated.

Another important area, where resource economics can usefully intervene as far as fisheries in third-world countries are concerned, is the marketing aspect. Examples of relevant issues here are the cost/benefits of production for export *vs* domestic consumption, the competition of developed *vs* third-world countries on the international fish markets and related issues.

Finally, the analysis of resource economics increasingly will be needed to help formulate strategy and tactics of negotiations involving access by foreign nations to their exclusive economic zones (EEZ), as regulated by the new Law of the Sea.

Active programs of management of living aquatic resources in third-world countries are only now being considered by governments because seemingly irreparable damage to coastal ecosystems, of which such resources are a part, is occurring at an alarming rate. Traditional resource management measures by coastal communities in conserving their resources/ecosystems have been abandoned as a result of economic, political and population pressures, especially since World War II, and can no longer be counted upon to assure these resources are available for future generations. New approaches are desperately needed.

Existing management schemes in most nations, including those for fisheries, are unisectoral in approach and mainly directed towards conservation of the resources through various laws and regulations governing their use. However, these laws and regulations in most cases have not been effectively and scientifically managed.

The complexity and diversity in coastal resources use in the tropics call for integrated coastal resources management strategies involving various relevant economic sectors, the regulation of which requires the understanding and support of those affected. Despite their frequent inability to make hard decisions towards resource management, most governments today have become more aware recently of the need for rational, sustainable utilization of their nation's living resources. The problem is that these policymakers are confronted with national economic development priorities that may conflict with long-term resource management, and the absence of, or insufficient, relevant databases for policy decisions and management options.

One good example of this problem is the large-scale development of mangrove swamps for fish and shrimp ponds. While ecologists have strongly voiced the need to conserve mangrove swamps to help sustain the nursery grounds of certain species of shrimp and fish, they have failed to provide substantiated quantitative data on the potential loss of shrimp or fish stocks in the inshore waters, and of other relevant activities such as nipa palm production, if the mangroves were cut. Consequently, voices in favor of longer-term management have been drowned out by those favoring short-term experience; the race to develop coastal shrimp farms thus continues unabated. This is not to mention potential future market constraints for all the shrimp that will be produced.

The fact mentioned earlier that $1,000 million per year of potential resource rent is dissipated by overfishing the North Atlantic, means that forces other than biological and economic considerations (in the fisheries sector at least) are influencing the policymakers involved. The challenge facing those who would seek to recover the lost rent in this and many other fisheries is to formulate alternative management plans that take into consideration the many other factors involved, and that account for those factors quantitatively.

Sound management of aquatic living resources should be based on scientific databases containing basic resource information which is analyzed and synthesized for formulating management strategies. It is essential, if the management plan is to be workable, to adopt a holistic, integrated approach in resource management plan formulation. This approach must also be interdisciplinary in perspective. Not only regulatory measures are needed to form the basis for environment protection and resource conservation; possible enhancement measures, such as artificial reefs, that potentially rehabilitate resources and restore the environment should receive equal attention.

Fishermen themselves ought to be involved in management decisionmaking. If they do not understand the reasons for a management measure, they will most likely disregard it. An example of the result of such a situation in Peru is shown in **Figure 2.** Over 22% of the anchoveta catch was not reported during the 1970s. In 1972 the fishery collapsed from an annual harvest of about 12 million reported tonnes to 1.5 million tonnes in 1973.

AQUACULTURE

Many national laboratories, international agencies and private producers are now placing emphasis on aquaculture as an important future source of food. However, they mostly pursue short-term adaptive research and technology transfer, neglecting longer-term, more basic research. Frequent shifts in priorities by governmental groups and by international assistance agencies, their emphasis on 'quick development results', their focus on attention of poorly developed technology, and the scattered and disjointed nature of support for research efforts have all hampered the organization and funding of vital longer-term research, particularly for tropical species. Moreover, there is a general lack of well-trained aquaculture researchers in third-world countries. Hence, research methodologies and rigorous experimentation are poorly developed in many tropical aquaculture research institutions.

A further problem has been the tendency of researchers, educators and their supporting donors worldwide to view aquaculture as a 'part of fisheries' and therefore to isolate aquaculture research and training from agriculture. Aquaculture is a food producing system and must be seen in the broad context of food production by other systems - not only capture fisheries but also agriculture. This viewpoint is essential for the success of aquaculture development and the avoidance of failures. In particular, it makes no sense to separate freshwater aquaculture from agriculture. Agricultural research and extension are well developed. Aquaculture research and extention are not and can benefit from a close relationship with agriculture. This is a new perspective for aquaculture and aquaculturists, which needs more active promotion and evaluation.

Figure 2. Schematic representation of major causes of anchoveta catch under-reporting in the Peruvian reduction fishery; the under-reporting accounted for about 22% of the catch in the 1970s. From D. Pauly and I. Tsukayama (editors) 1987. The Peruvian anchoveta and its upwelling ecosystem: three decades of change. ICLARM Studies and Reviews 15, 351p.

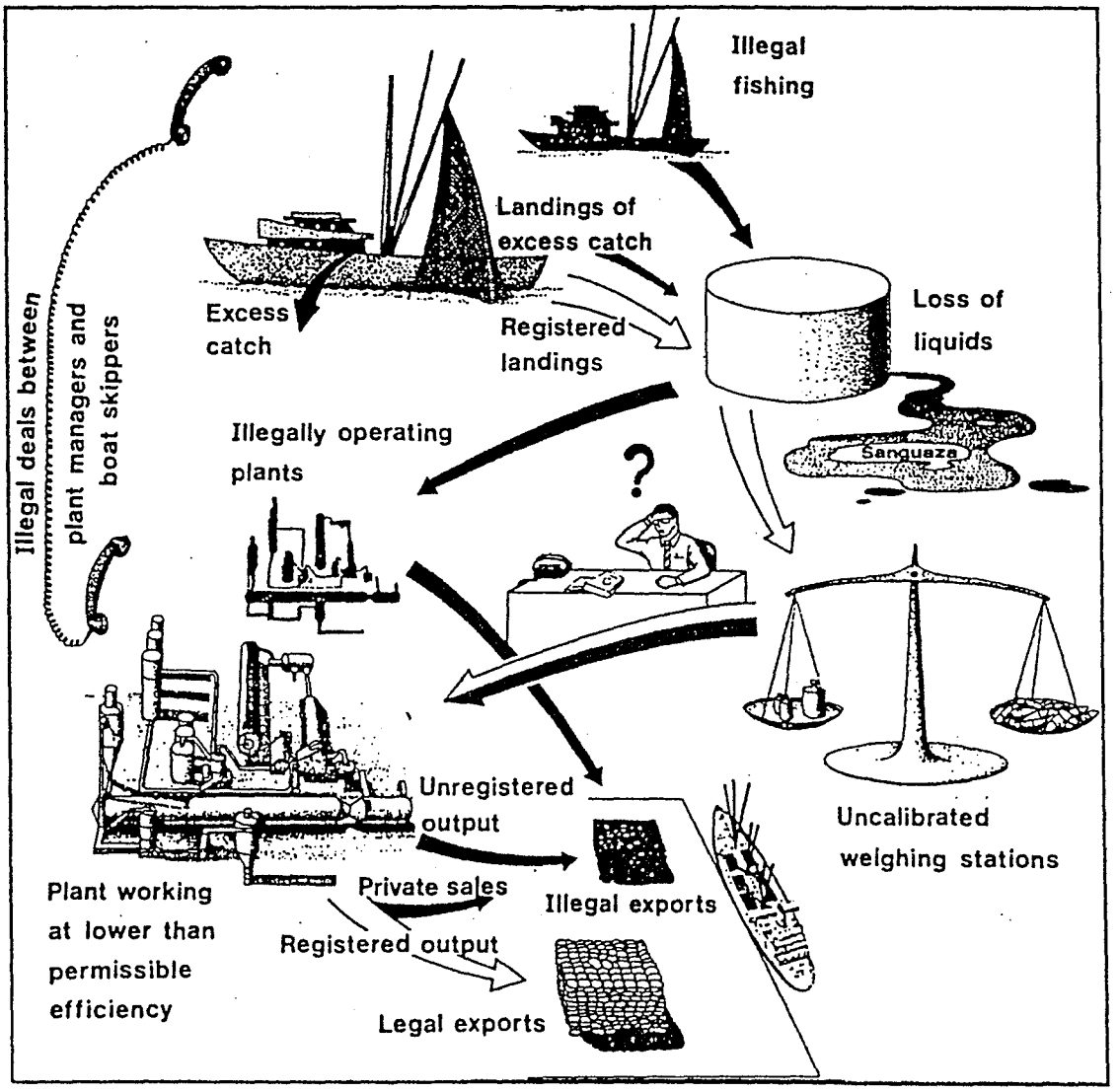


Figure 3. Schematic illustration of the relationship between the agricultural, aquacultural and capture fisheries sectors.

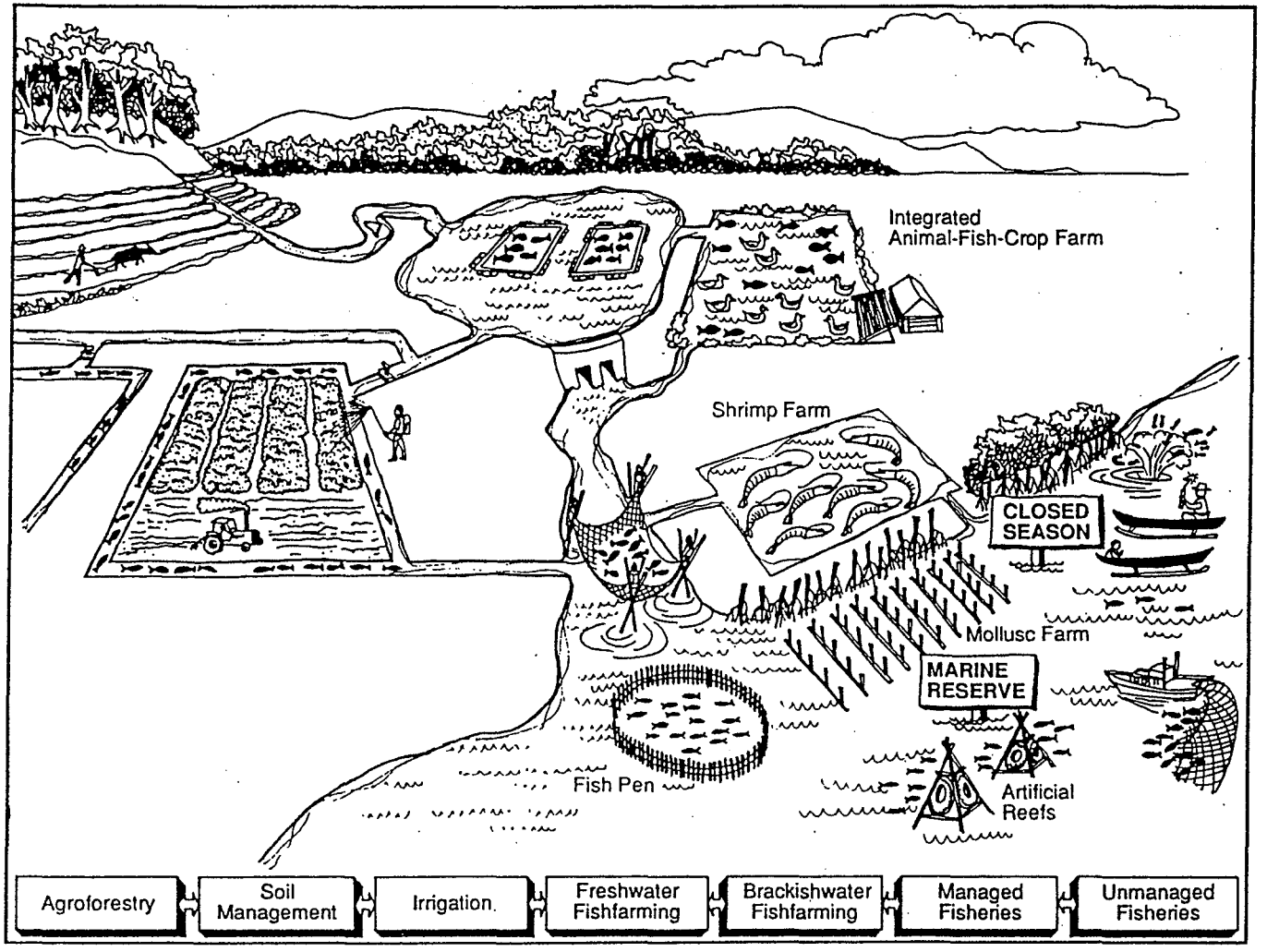


Figure 3 shows how this viewpoint increases the complexity of the overall system in which both agricultural and aquaculture scientists *and* managers operate. Compare with Figure 1, itself a daunting array of relationships within the aquatic sector.

Fish have many advantages as farm produce. They are a highly nutritious and valuable traditional food in much of Asia and Africa. They are excellent converters of low grade feeds into high quality animal protein because, unlike terrestrial livestock, they do not need to use dietary energy to maintain body temperature or posture. Finfish are better feed converters than any feedlot livestock apart from dairy cattle on a feed: whole product basis. Most attractive of all is the concept of producing natural fish food, like phytoplankton, in the fishpond. Tropical fishponds can produce up to 30 tonnes dry weight phytoplankton/hectare/year which can be converted into fish flesh at ratios as good as 2:1.

Another attraction of most aquaculture operations is that they are relatively nonpolluting. This is particularly true for Asian integrated agriculture-aquaculture farming systems which recycle organic wastes through ponds into valuable fish flesh.

COASTAL RESOURCES MANAGEMENT

The above considerations on the living aquatic sector, as illustrated in Figures 1 and 3, are still only a subset of the larger picture of coastal resources management. Viewed from this larger perspective, both capture fisheries and aquaculture are seen to be affected by decisions made in a variety of other sectors/industries. Earlier the conflicting demands on mangrove areas were cited as an example of this problem. In general terms, the coastal fisheries are literally at the downstream end of all human activities on land as well as being vulnerable to offshore activities such as oil exploration and shipping!

Case Study

It would be fair to say that coastal resources management in much of Southeast Asia has been neglected. Water pollution is widespread; most urban centers have inadequate sewage treatment facilities; canals and rivers have become open sewers which drain directly into nearby bays, lagoons and coastal waters. Pesticides are used indiscriminately and freely enter waterways, threatening both rural and urban consumers.

Management to date has been on an unisectoral basis. When addressing management of one sector, the effects on others have been more or less ignored.

An Association of Southeast Asian Nations (ASEAN) - USAID project, now in progress, has crystallized these issues and begun a series of steps that will culminate in integrated Coastal Resources Management (CRM) plans being incorporated into national development plans. The ASEAN countries are Brunei Darussalam, Malaysia, Indonesia, the Philippines, Singapore and Thailand.

The steps identified by this project, are shown in Figure 4. Research teams in each country are climbing the steps individually, but with coordinating workshops and activities of the technical experts to ensure uniformity of approach. Each country has chosen a pilot site on which to focus activities. The major steps are:

Figure 4. The process of CRM plan development

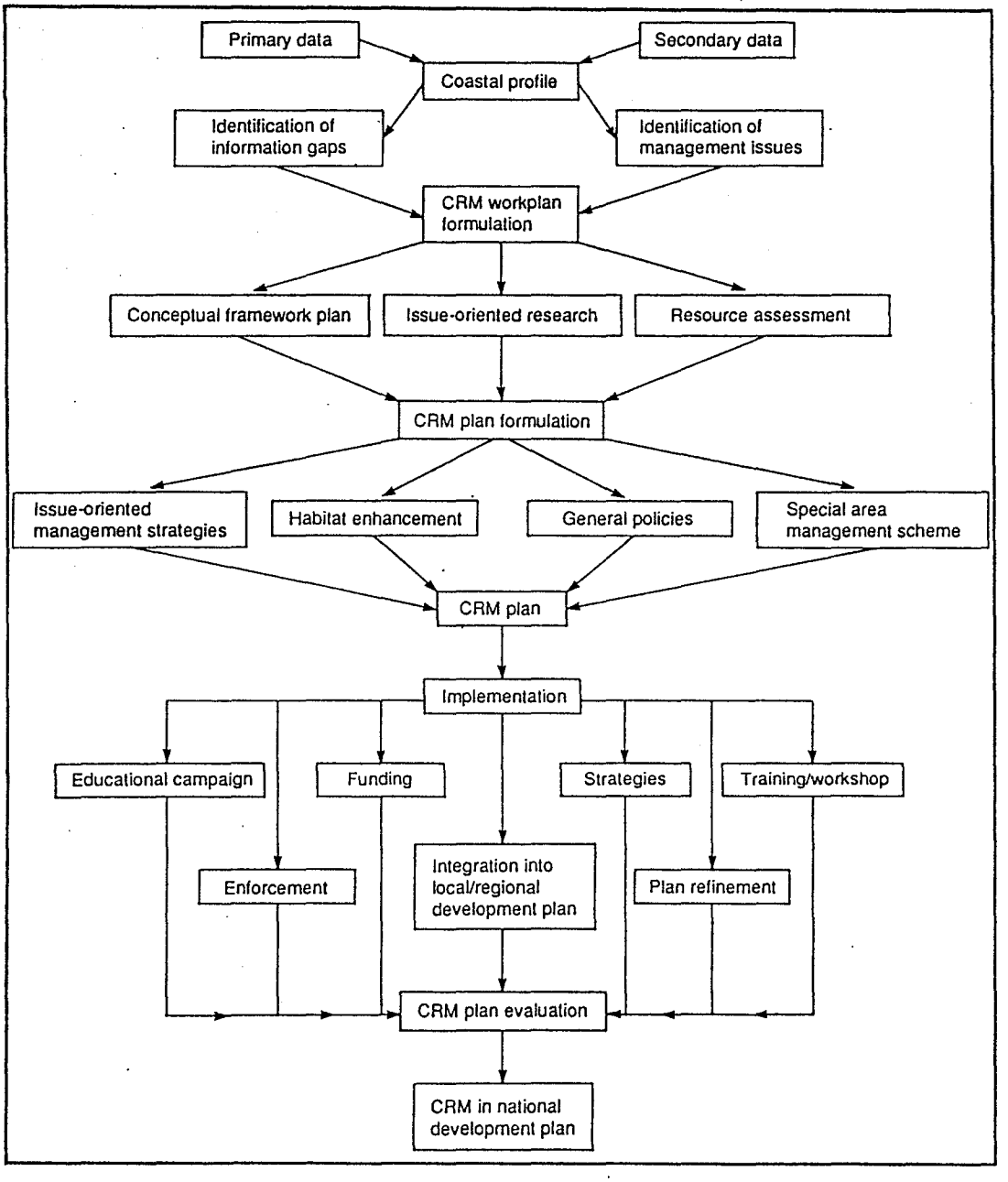


Figure 5. Coastal activities in Brunei Darussalam and their effect on marine resources and coastal development

	Fish resources	Mangroves	Coral reefs	Beaches	Estuarine and lagoons	Fisheries and aquaculture	Agriculture	Forestry	Energy	Transportation	Urbanization	Industry	Tourism
Trawling	●					◑							
Purse seining	○					◑							
Explosive fishing	●		●			◑							
Brackish pond construction		○				◑							
Mangrove harvesting		○				◑		◑			◑		
Sand dredging			○	●		◑							
Raft/long line aquaculture					●	◑				◑			
Cage/pen culture					●	◑				◑			
Sewage discharge	●		○	●		○					◑		◑
Factory discharge	○		○	●		○						◑	◑
Agricultural waste discharge	○			○		○	◑						◑
Ship discharge	○	○	○	○		◑			◑			◑	◑
Shipping/tanker traffic	○	○	○	○		◑				◑			
Oil/gas exploration	●		●	●		◑			◑			◑	
Road, rails, bridges							◑			◑	◑	◑	◑

Legend: ● Existing impact
○ Potential impact
◑ Relationship with coastal activities

Coastal Environmental Profile Preparation

There is a wealth of secondary data on the coastal zones of most sites chosen. However, much of this information is found in annual reports, mission reports, consultant reports, research reports/theses and departmental documentation. Very few are published. Some are classified or restricted to specific users only. This information was uncovered through the environmental profile preparation. In nations where baseline information was not available, preliminary on-site surveys were conducted to ensure completion of the profile.

As an example, **Figure 5** shows the outcome of data analysis in the environmental profile of Brunei Darussalam. The existing and potential impacts of the various sectors on each other indicate clearly the need for their integrated management.

CRM Workplan Formulation

The coastal environmental profiles provide direction for the development of activities on resource assessment, CRM conceptual framework plan formulation and issue-oriented research which form the core research program.

A series of tasks in each participating country, with well-defined beginning and end points, was derived and pilot sites selected to carry out the required research.

For example, Indonesia chose the Cilacap area, Central Java, as its pilot study site because it contains the largest mangrove forest (24,000 hectares) in Java, it supports various fisheries, it is influenced by several rivers, it has a natural habour, mining is an important industry, land use is changing. Thus, integrated management is seen as very pertinent to the area.

Issue-oriented Research

Multidisciplinary teams were formed to provide relevant information on the biogeography of the selected sites, socioeconomic conditions, existing governance of resource use and the institutional responsibility in resource management.

For example, such issues as blast fishing, overexploitation, mangrove-aquaculture conflicts and pollution were amongst the issues studied by the participating countries in the ASEAN project.

CRM Plan Formulation

This is the final stage of CRM plan development. The analysis and synthesis of data collected provide the basis on which general CRM policy is formulated; management strategies for special areas are developed; and specific management issues are addressed. The planning process requires the integration and coordination of multi-disciplinary teams made possible through small planning workshops and seminars.

The ASEAN project is at this stage now. As Figure 4 shows, several sets of data are included. *Management strategies* involve preparation of "action plans" for implementing measures to reduce e.g., pollution, and resolve conflicts. *Habitat enhancement* involves positive steps towards improving the environment, stocking waterways, artificial reefs, etc. *General policies* must be formulated through workshops and public hearings and agreed upon by government and participating coastal communities. Finally, *special area management schemes* are set up to deal with critical areas, such as coral reef islands. Again, community involvement is required. Some form of community association forms the core for the management structure, such that management is essentially within rather than outside the community involved.

All these elements comprise the draft Coastal Resource Management (CRM) plans for the ASEAN nations.

The lower part of Figure 4 shows the implementation of the draft CRM plans, through strategies involving training, workshops and educational campaigns. The plans are refined through successive evaluations in pilot sites. At that stage the CRM plans are to be taken up by the governments in their national planning.

CONCLUSION

The development of sound coastal resources management plans is a gradual process based largely on a reliable resource database and socioeconomic considerations. Appropriateness of the plans and whether they can be implemented depend greatly on the political will and participatation of the affected communities. The CRM plans have important consequences. Their main function is to ensure that the renewable (living) resources can be adequately conserved and protected so that they can withstand exploitation for generations to come. The role of resource managers is to identify the critical management issues and present management options for decisionmaking and implementation.