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Man in the Mangroves

The Socio-economic Situation of Human Settlements in Mangrove Forests

Edited by Peter Kunstadter, Eric C. F. Bird, and Sanga Sabhasri

THE UNITED NATIONS UNIVERSITY

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Proceedings of a workshop held at Nong Nuch Village, Pattaya, Thailand, 27-31 May 1985, sponsored by the United Nations University and the National Research Council of Thailand

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More than half the world's people live in coastal regions, utilizing such resources as salt, minerals, fish, and crustaceans, the products of mangroves, salt marsh, seagrass, and kelp, energy from wind, waves, and tides, and such materials as sand, gravel, clay, and limestone, all obtained from the coast or the adjacent sea. Moreover, the coast provides sites for settlement, agriculture and aquaculture, ports and harbours, industry, commerce, and recreation. The management of coastal environments and their resources has raised many problems in both developed and developing countries, and it was felt appropriate that the United Nations University should give emphasis to this field of study.

The Coastal Resources Management Project was initiated as part of the University's Natural Resources Programme. It was decided that the coastal environment — comprising the foreshore (between high and low tide lines), backshore (above high tide line to the landward limit of marine influences), and nearshore (from low tide line out to a depth of 20 metres) zones — was a distinctive field for research and training that merited its own project within the programme.

A number of research studies and workshops were commissioned under this theme. *Man in the Mangroves* contains papers presented at a UNU-sponsored workshop. Three of the papers result from UNU research. The remainder were submitted by independent researchers. They focus on the socio-economic aspects of the use, development, and management of mangrove areas in relation to environmental and ecological factors.

Although the Coastal Resources Management Project has now been concluded, the University's new programme on Resource Policy and Management has undertaken to maintain an international dimension in research, training, and dissemination, stressing the interaction of resource management, conservation, and development.

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PREFACE

The papers which follow are edited versions of presentations given at the Workshop on the Socio-economic Situation of Human Settlements in Mangrove Forests, held at Nong Nuch Village, Pattaya, Thailand, 27–31 May 1985, under the auspices of the United Nations University and the National Research Council of Thailand.

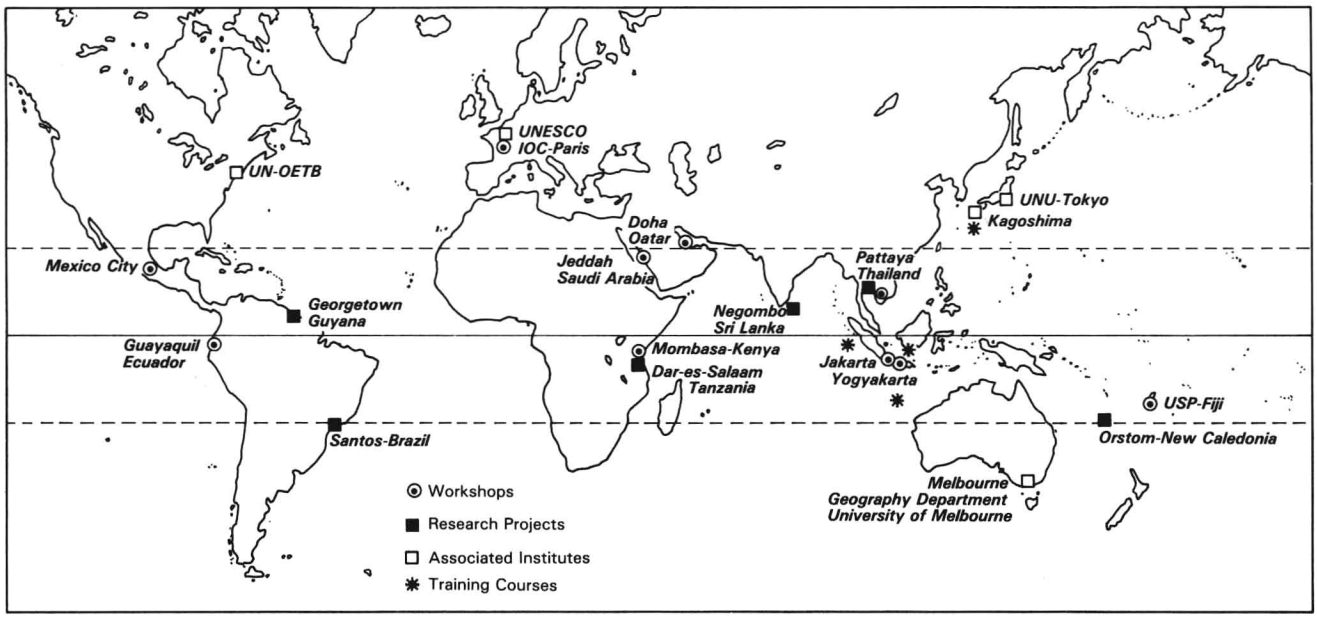
Following the introductory addresses, the results of studies on socio-economic aspects of the use, development, and management of mangrove areas were considered in relation to ecological and environmental factors. A general introduction (Kunstadter) is followed by case studies of the situation in Thailand (Aksornkoae et al., and Puckprink), Malaysia (Chan), Indonesia (Mantra), Australia (Bird), Sri Lanka (Silva), Tanzania (Mainoya et al.), Japan (Miyawaki), and South America (Snedaker). The papers are followed by a set of recommendations based on a review of the situation in Thailand by the workshop participants in the perspective of the other case studies.

These case studies fall short of a global review (notable omissions include the Philippines, Papua New Guinea, New Zealand and other Pacific island nations, Burma, Bangladesh, India, Pakistan, the Arabian peninsula, parts of Africa, and Central America). They nevertheless represent a reasonably comprehensive range of environmental, ecological, and socio-economic variations in human–mangrove relationships and the associated problems of development.

Many generalizations emerged from the diverse national settings described in the papers and from the ensuing discussion. Many of these are mentioned in the introductory chapter, and others are included in recommendations, which, although they refer specifically to Thailand, may have wider applicability.

The workshop was part of the activity of the United Nations University within a wider programme area on Resource Policy and Management (originally initiated in 1976 under the designation ''Use and Management of Natural Resources''). One important bottleneck impeding the development of the right resource-use systems in the tropics is the need for further research. Thus the UNU Resource Policy and Management programme has focused on a number of issues in projects such as Assessment Studies on Arid Lands Management (1977–1984), Water–Land Interactive Systems (1977–1984), Highland–Lowland Interactive Systems (since 1977), Agro-forestry Systems (since 1977), and Coastal Resources Management (1977–1985) (United Nations University 1982). The objectives of these projects are connected with an international discussion on the interaction between population, resources, environment, and development, known by the acronym PRED.

As an example of the PRED interaction, one could mention the well-known phenomenon of shifting cultivation, or land-rotation with bush fallow. This land-use system can be regarded as stable if the fallow periods are long enough for the regeneration of soil and vegetation. If, however, the pressure of population increases and the fallow intervals are shortened, the vegetation growth is reduced and soils are degraded. The system loses its productivity, and the subsistence of the population is no longer ensured. Previous solutions to this problem have been to introduce irrigated agriculture or tree crops, both of which have been successful in South-East Asia. However, a vision of the tropical zone as an exporter of tree crops and an importer of food is not realistic, particularly as the demand for tropical products is rather stagnant and land resources are becoming increasingly scarce. Also, even if countries earn a considerable amount of foreign exchange through exports of cash crops, they often need these earnings for other essential imports (e.g. in the field of technology) and not for food alone (Waller 1984). These considerations are part of the rationale for a land- and resource-use system such as agro-forestry, which combines the production of food and wood (including firewood) and at the same time is useful as a tool for management of resources and conservation of the environment. It can be considered a nearly closed system, because it requires few



Global network of the UNU Coastal Resources Management project, 1978–1985

costly inputs such as chemical fertilizers and pesticides.

Because of the food crises, especially now in tropical Africa, further research, training, and dissemination of information on system requiring low external input are very important. One of the greatest weaknesses in new and appropriate forms of resource-use systems such as agroforestry, eco-farming, and aquaculture is the lack of management packages that can be implemented under specific conditions of climate, soil, and vegetation (Ruddle and Manshard 1981). This weakness is also characteristic of the mangrove ecosystem in the tropical and subtropical world.

The UNU work on mangroves is part of the Coastal Resources Management project, (coordinated by Eric Bird, of the University of Melbourne). Several studies on the use and management of coastal and near-shore resources in tropical environments were initiated under this project. A number of graduate research and training courses were sponsored in Indonesia (Jakarta, Yogyakarta, Sunda Strait) by the UNU. Several UNU fellowships to universities and research institutions were awarded, notably in Japan and the United States, and a series of international workshops in Fiji, Jeddah, Mombasa, and Paris was organized. Work started in 1983 on the traditional uses and socio-economic implications of ecosystem changes in tropical mangrove areas. Case studies were prepared in Thailand, Tanzania, and Sri Lanka, results of which are discussed in papers in this volume. The locations of activities and institutions associated with this project are shown on the map above.

Work on coastal resources is also linked to the newly established UNU project on Climatic, Biotic, and Human Interactions in the Humid Tropics, which was started in 1983. While this project concentrates mainly on bio-physical and geophysiological problems (e.g. the effects of deforestation and land use on soil, hydrology, microclimate, and productivity), the human side is reflected in seven case studies on the resource uses of pioneer settlements in frontier zones of the humid tropics.

In sum, it is felt that there is not nearly enough applied and pure research on the very complex development thresholds of tropical countries. A combined effort of many institutions and organizations is needed for improved policy implementation. It is in this sense that this workshop is a contribution, as mandated in the Charter of the United Nations University, to solving some of "the pressing global problems of human survival, development and welfare."

— Walther Manshard
Programme Director
Development Studies Division
The United Nations University

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WELCOME AND OPENING ADDRESS

WELCOME

Mr. Sombhan Panateuk
Director, Sriracha Regional Forest Office, Royal Forest Department

Professor Sanga Sabhasri, Professor Walther Manshard, and distinguished guests, on behalf of the Eastern Regional Forest Office here in Sriracha, I would like to welcome all of you from overseas and from Thailand.

I am very pleased that the United Nations University and the National Research Council of Thailand have arranged this Workshop on the Socio-economic Situation of Human Settlements in Mangrove Forests, at Pattaya in our region.

We have about 40,000 hectares of mangrove forest growing in estuaries in this region. The mangrove forest has been used for many years, mostly for charcoal production. We now face problems with people who live in and near the mangrove area. They still cut the mangrove for firewood and charcoal production on a sustained-yield basis, but now some of them have cleared the forest for aquaculture, especially for shrimp farms. This raises questions about the possibility of sustained use of the mangrove forest resources.

I have learned from Dr. Sanit Aksornkoae that excellent mangrove ecologists, both from overseas and from Thailand, have come to this workshop. The knowledge obtained from this workshop will be very useful to us, and also to our friends from neighbouring countries, for mangrove resource management and development. I hope that the workshop will be very fruitful and that all of you will enjoy your stay.

OPENING ADDRESS

Professor Sanga Sabhasri
Permanent Secretary, Ministry of Science, Technology, and Energy, Government of Thailand

It is a great honour for me to have the opportunity to participate in the Workshop on the Socio-economic Situation of Human Settlements in Mangrove Forests, which is jointly organized by the United Nations University and the National Research Council of Thailand.

When we speak about mangrove forests, everyone now agrees that these forests provide us with important natural resources extremely beneficial to people living along the coastal areas and nearby. Mangrove forests make up only about 15.8 million hectares, or 0.6 per cent of all inland forests in the world. About 6.5 million hectares, or 41.4 per cent of the world total, are found in tropical Asia. Although small in comparison with the world's total forests, they play a very important role in the ecosystem of the region. They prevent soil erosion by acting as a wind and water break. They maintain moisture and breeding grounds for many plants and animals both on land and in the sea. They also provide food, construction materials, fibres, and medicinal plants to dwellers in and near the coastal zones.

Problems of exploitation of mangrove resources are increasing due to the rapid recent growth of the population. In the late 1960s the complex

pressures resulting from population growth, urban expansion, and economic development brought about heavy exploitation and destruction of mangrove resources. Detrimental activities included poorly executed logging operations, alluvial mining, road construction, and conversion of mangrove forests into shrimp farms, fish ponds, and salt pans. In addition, many mangrove forests near big cities have been reclaimed for real estate developments. It has recently been noted that many mangrove areas have been manipulated beyond their environmental tolerance. The over-exploitation of mangrove resources, without concern for their maintenance, reflects the outmoded view that mangroves are an inexhaustible resource. The time has come to realize that such an attitude towards the mangrove environment needs to be changed, and a sense of responsibility to protect the mangroves must be restored.

Public awareness of these problems began in the early 1970s. There were several incidents which first drew the attention of Thai scientists. Among them were the effects of military use of herbicides on mangroves in South Viet Nam. This attracted the attention of American, European, and Vietnamese scientists to questions of productivity and regeneration of mangroves. Thai scientists were invited by the US National Academy of Sciences to join in the study of these problems. Mangrove areas in Thailand were used as a baseline for study of the ecosystem of relatively undisturbed mangroves. Plants in undisturbed mangrove forests were investigated to determine their ecological role, as a comparison with mangroves destroyed by military use of herbicides [*The effects of herbicides in South Vietnam,* National Academy of Sciences, Washington, D.C., 1974].

Coinciding with the study of effects of herbicides was the conversion of mangroves to fish ponds at an alarming rate. This drew attention from Thai conservationists and scientists. A group of Thai scientists who were deeply concerned with the loss of mangrove forests met in the early 1970s. They produced a message to the public that over-exploitation and misuse of the mangrove ecosystem could lead to detrimental effects on economically important aquatic species along the coastline such as fish, prawns, shrimp, crabs, and oysters. An appeal was issued stating that a symbiotic relationship in which humans are equal partners with nature must be recognized, mangrove resources had to be renewed, and a better management system had to be developed quickly to restore stability to the mangrove ecosystem. To achieve these objectives, the scientists asked that basic information should be collected and understood and that this information should be used as a basis for improved management and utilization. In order to mobilize resources for this purpose, support was sought from international organizations such as Unesco and the United Nations University in addition to bilateral organizations.

Problems in the management and conservation of mangrove resources can be classified into three key needs. The first is to re-establish a stable mangrove ecosystem after the exploitation of the forest area; the second, to maintain the relationship between forest and fisheries; and the third, to enhance the function of mangrove forests in erosion control. Both information on human uses and scientific knowledge of the natural ecosystem are required in order to develop effective management and conservation of the mangrove ecosystem. Education and training for public appreciation of the mangrove system must be increased, and awareness and consciousness of the importance of the mangrove ecosystem must be established among high-level decision-makers.

As the mangrove area is losing ground to fish ponds, shrimp farms, and other uses, it is recommended that the carrying capacity of the mangrove area should be determined before converting it to other resource development projects. The socio-economic aspects of human activities in mangrove areas should be taken into account. The socio-economic consequences of a decision by the state to allow a few private entrepreneurs to take control of the area should be taken into account. In general, the mangrove resources in South-East Asia are owned and managed by the state, and it is considered that the general public has an interest in this property, but mangrove dwellers depend specifically on mangrove resources for their livelihood. The decision to give ownership of concessions to a few entrepreneurs would eventually cause great hardship for mangrove dwellers, most of whom are poor. Therefore, a balanced relationship between fishery production and forest production in mangrove areas is necessary in order to benefit the largest number of people. It is essential that countries which possess these valuable coastal resources should concentrate their political will and aim their highest policies at sustained yield from the mangrove resources, while moving toward greater equity and a more even distribution of the income and other benefits from these resources among rural people.

Successful policy planning for the development and management of mangrove resources depends on many factors. Policy planning and implementation cannot be successful without basic data on dwellers in the mangrove forest and on the dynamics of the watershed areas and the coastline.

This workshop is a great occasion for experts and policy-makers from different corners of the world to have an opportunity to meet and share their views and experience. I believe that the four days of the workshop will yield pertinent knowledge which can be applied to successful policy planning for the management of mangrove forests. I believe this workshop, attended by distinguished researchers, will produce appropriate recommendations for policy planning to develop, manage, and maintain mangrove resources. I am sure that, as long as we are aware of the significance of mangrove resources, mangrove forests will continue to exist and will be preserved as useful natural resources not only for all of us today but also for future generations.

Finally, I want to take this opportunity to express my appreciation to the United Nations University, to the National Research Council of Thailand, and to all those who made this workshop possible, and to welcome all the participants.

CONTENTS

1. SOCIO-ECONOMIC AND DEMOGRAPHIC ASPECTS OF MANGROVE SETTLEMENTS

Peter Kunstadter

Introduction

This paper reviews some of the progress made over the past 15 years in studies of socio-economic and demographic aspects of human use of mangrove areas, with emphasis on South-East Asia. Mangroves are usually defined in terms of the distribution of characteristic tree species. Mangrove forests are found growing in brackish water on the margin between land and sea in tropical and subtropical areas, but, as with other definitions of ecological zones, this is not completely satisfactory because the exchange of individual organisms, nutrients, and energy between this margin and both the sea and upstream areas is at least as important as what goes on within the geographic limits of mangrove tree species (fig. 1).

Discussions of the socio-economic aspects of human settlements in the mangroves are difficult for several reasons. Mangrove forest ecosystems and the socio-economic systems of mangrove settlers are not coterminous, and, as compared with the natural ecosystem, information on the socio-economic systems of mangrove dwellers is sparse. Most of it deals with economics (e.g. yields of forestry and fisheries), and relatively little describes the social and human ecological systems of the human residents.

Long-term residents of mangrove areas are generally similar ethnically to the inland populations (see, e.g., Aksornkoae et al. 1984, 34ff.), but their way of life often involves adaptation to mangrove environmental conditions, and economic exploitation of several distinct ecological zones. Thus mangrove dwellers have many different socio-economic systems, some of which are primarily focused on subsistence activities (including both agriculture and fishing) and some are primarily commercial (including agriculture, fishing, and forestry).

Traditional mangrove dwellers often combine the use of land, sea, and inter-tidal resources. Even with limited economic development and modernization, the boundaries of the social and economic systems that influence mangroves spread well beyond the ecological limits of the zone itself. For example, charcoal from mangroves has long been an item of international trade, as have fish and shellfish. With increasing economic development, the boundaries of the socio-economic systems that use mangrove resources spread even further. The future fate of the mangroves (e.g. with respect to extractive forest harvest or the hazards of pollution from oil transported by sea, or the spread of industrial development to and along the coastline, or the development of seaside resorts or condominiums) may be decided in the air-conditioned board rooms of temperate-zone businesses. Thus the proper study of the socio-economics of mangroves must include some attention to national and even international social, economic, and demographic processes (fig. 2).

Although rich in many resources, mangrove forests have traditionally been sparsely settled and unintensively exploited by humans. In South-East Asia this has probably been the result of the scarcity of fresh water for domestic use and the unsuitability of mangrove soils for long-term agricultural exploitation; in Papua New Guinea it may have been the consequence of the presence of highly effective mosquito vectors of malaria. Modernization (e.g. development of motorized transportation or the extension of modern urban water supplies) has allowed the spread of human populations into mangrove areas without requiring that the newcomers adapt to mangrove ecological conditions. At the same time, modern technology has made the clearing of mangroves and their conversion to other uses such as shrimp ponds or urban dwelling sites relatively inexpensive, thereby opening mangrove areas for more intensive exploitation, with rapid environmental change and rapid expansion of the human population.

Because forests are one of the major mangrove resources, studies of mangroves have often been conducted as forestry research. Fifteen years ago the emphasis in studies of all aspects of forestry

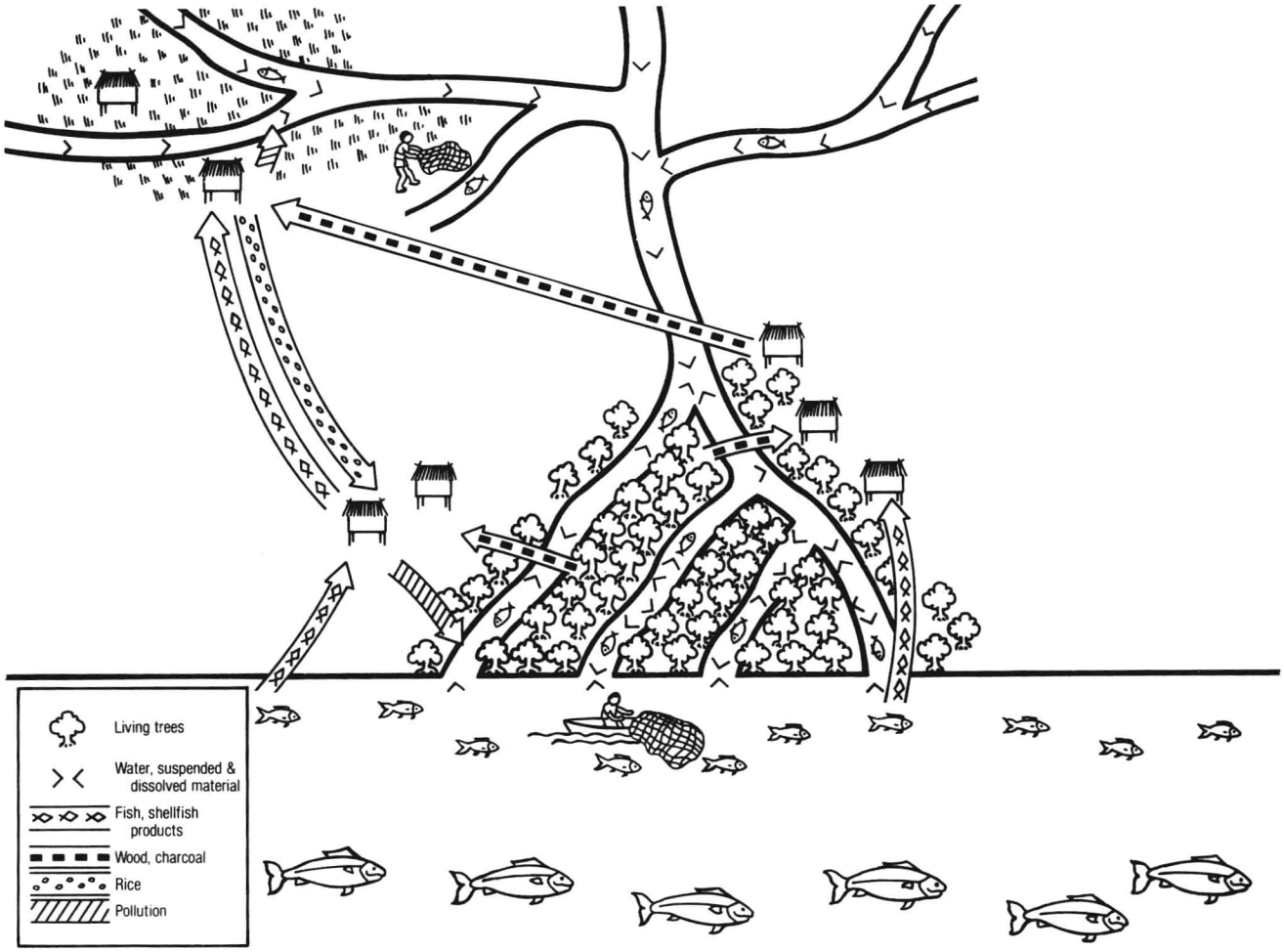

FIG. 1. Characteristics of mangrove management systems: traditional subsistence economies

was on the upland forests, while mangroves were "the forgotten forests." Following the massive destruction of mangroves associated with the military use of herbicides in Viet Nam, and the attention focused on those forests by the American Association for the Advancement of Science and the National Academy of Sciences (e.g. Committee on the Effects of Herbicides in Vietnam 1974, sec. IV C), scientists from Thailand were drawn into studies of their own, relatively well preserved mangroves. Largely as a result of the efforts of Sabhasri (1979) and Aksornkoae (e.g. Aksornkoae et al. 1984), mangrove forests in Thailand are now among the best studied and best known in the world. As attention was being drawn to mangrove forests, the importance of mangrove fisheries and spawning grounds was also being recognized (see, e.g., MacNae 1974; Martosubroto and Naamin 1977).

Several ecological and economic characteristics of mangroves are now relatively well understood:

- Mangrove forests perform multiple ecological functions (e.g. production of woody trees; provision of habitat, food, and spawning grounds for fish and shellfish; provision of habitat for birds and other valuable fauna; protection of coastlines and accretion of sediment to form new land), and some of these functions have benefits far beyond the geographical limits of the mangrove zone itself (Hamilton and Snedaker 1984; MacNae 1974; Saenger, Hegerl, and Davie 1983).
- Mangrove areas have high biological productivity associated with heavy leaf production and leaf fall, and rapid decomposition of the detritus (see, e.g., Christensen 1978; Knox and Miyabara 1984, app. 1).
- The mangrove ecosystem is dynamic, changing

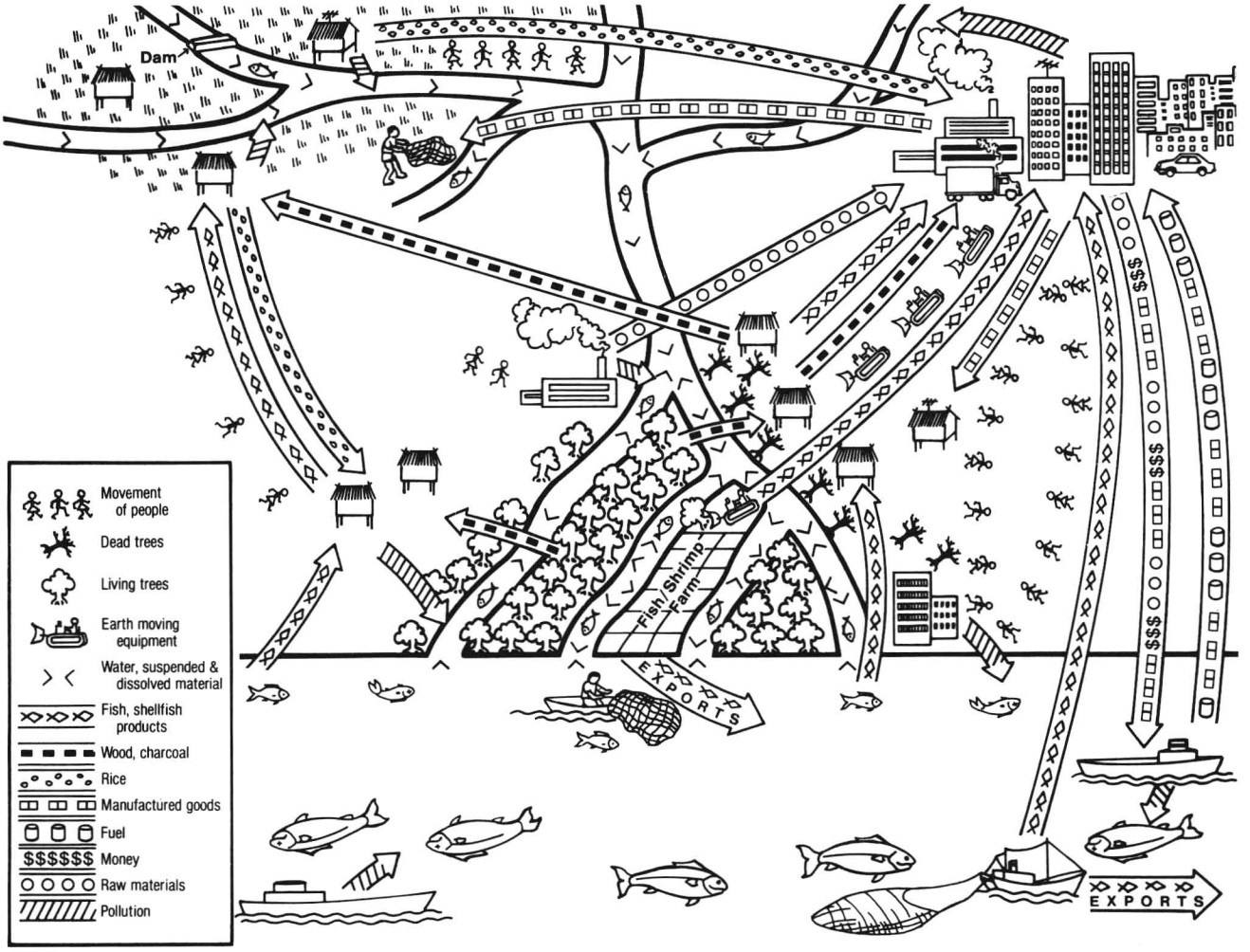

FIG. 2. Characteristics of mangrove management systems: modern market economies

in both location and composition, and has great resilience with the ability to restore itself after heavy damage, as long as seed sources and water flow are maintained (Committee on the Effects of Herbicides in Vietnam 1984; Lai and Feng 1984).

- There are many direct economic benefits from mangrove resources (mangroves may be, e.g., a source of firewood and charcoal, self-renewing sites for collecting fish and shellfish, sites for collecting honey, an attraction for tourism) (Hamilton and Snedaker 1984, chs. 3, 5, 6, 9).
- In comparison with irrigated farms and upland forests, the relatively undisturbed mangrove forests in South-East Asia provide a salubrious environment for people, associated with the absence of vectors for important diseases (Kunstadter, in press). In the relatively undisturbed state, mangrove forests do not support the reproduction of the local brackish-water malarial mosquito *Anopheles sundaicus* (Arwati 1977; Boschi 1975, 1976; Desowitz et al. 1974). This is in contrast with New Guinea, where highly effective malaria vectors (*A. farauti*) breed in undisturbed mangrove areas (Smithurst 1970; Spencer 1964, 1976), so that malaria inhibits human settlement in these zones (Petr 1977).
- Mangrove zones are useful for a great variety of human settlements, ranging from villages for near-subsistence fisherfolk to housing and industrial developments (Hamilton and Snedaker 1984, ch. 10).

Despite their natural resilience, mangroves are threatened on a worldwide scale with unprecedented widespread and long-term damage or destruction. The harmful consequences of human activities upstream (e.g. due to various forms of

agricultural and industrial pollution) and downstream (e.g. due to oil spills) are now widely recognized (Lai and Feng 1984; Chia and Charles 1984; Gomez 1980; Piyakarnchana 1980; Saenger, Hegerl, and Davie 1983, ch. 5; Soegiarto 1980; Zoology Department 1980). The most serious threats, however, seem not to be the indirect effects of human activities but rather the more direct consequences of human efforts aimed at rapid commercial exploitation of raw materials from the mangroves (e.g. for cellulose as in Kalimantan and Papua New Guinea) or converting the ecosystem to some use which is not compatible with regeneration of the forest, as in land "reclamation" for agriculture, aquaculture, housing, or industry (Kunstadter and Tiwari 1977, 3; Sabhasri 1979, 5, 14ff.).

Mangrove forests now appear to be affected by the same processes associated with modernization and economic development that have led to the rapid loss of other types of forest in Thailand and elsewhere in the tropics (Kunstadter, Chapman, and Sabhasri, in press). These include rapid growth of human population (but see below), expansion of agricultural land-use associated with both growth of population and commercialization of agriculture, use of modern earth-moving machinery and other modern technology, growing demands for raw materials and for food (especially high-quality animal protein), and an increase in urbanization and industrialization. Associated with these changes has been a tendency away from traditional patterns of sustained multiple use and toward increased specialization of use of land in ways that, for at least the short run, reduce the options for (or greatly increase the costs of) other uses (e.g., once a mangrove forest is converted to salt farms, the area is generally unsuitable for agriculture or regeneration to forest).

Mangroves, like highland forests, are generally considered "marginal," not in the sense of being unproductive but in the sense of being relatively remote and quite different from cities and farms. Even the terminology applied to mangrove forests (at least in English) tends to be derogatory (mangroves are generally termed "swamps" rather than forests or fish hatcheries), whereas the discussion of mangrove destruction ("reclamation") tends to be euphemistic, implying or stating that the mangroves are wasted in their uncleared or undrained state.

The implications of research on population change, as well as of research on pollution, are that the major socio-economic, demographic, and ecological pressures on mangroves and other forest types come primarily from outside these zones, not inside. For example, although mangrove areas are not segregated in national censuses, it appears in Thailand that the human fertility of coastal districts where mangroves are found is no higher than the average for the province or region in which they are found (Pejaranonda 1985), and therefore natural population increase within the mangroves is unlikely to be the prime cause of pressure on mangrove resources. Other important causes of damage to mangroves that originate outside the mangrove zone include reduction of fresh-water flow associated with large-scale irrigation projects upstream (as in Bangladesh and India), central-government resettlement schemes which send people to settle in mangrove areas (e.g. in Indonesia), hydraulic mining which results in silt deposition in mangroves (e.g. in Malaysia and Thailand), urban growth, including the siting of large electric generators (e.g. in Australia, Indonesia, the Philippines, Singapore, and Thailand), and pollution from oil transport (e.g. in Indonesia, Malaysia, and Singapore).

Human Use of Forests: Mangroves and Uplands

Traditional patterns of human occupancy and use of mangrove forests in many ways resembles those of traditional swidden agriculturalists in the hills. Population density was low and settlements were relatively small. Technology was based on simple materials, minimal use of fossil fuels, and small numbers of tools. The use of the technology (e.g. in terms of fishing gear) was often ingenious and reflected an intimate knowledge of the environment. The traditional economy was largely self-contained. Long-term settlers in general had developed a conservative, self-sustaining adaptaion to the local environment. Studies of contemporary mangrove communites (e.g. Aksornkoae et al. 1984) suggest the continuing importance of subsistence production and home consumption of local products even in mangrove communities that are at least partially integrated into the market economy.

Social controls were based on a moral community, that is, consensus of the villagers regarding desirable goals, the appropriate ways of achieving them, and sanctions against those who violated norms. These norms tended to perpetuate the long-term

conservation of the environment within which the people expected their descendants to live a life similar to the one they experienced.

Traditional use systems in the highlands as well as in the mangroves involved clear-cutting of patches. Under more conservative systems that did not destroy seed stock for regeneration and involved short periods of use followed by long fallow, there was natural regeneration of the forest when it was abandoned (Kunstadter, Chapman, and Sabhasri 1978; Saenger, Hegerl, and Davie 1983, chs. 4 and 5). Similar patterns were followed in mangrove forests that were carefully managed for long-term commercial exploitation, e.g. in Malaysia.

In the highlands wood from the cut forest was used as fuel to convert above-ground biomass to fertilizer for agriculture; in the mangroves, wood cut from the forest was used and often sold as fuel or as building material, and soil fertility was restored by infusions from upstream. Under conditions of low population density and a subsistence-oriented economy, both systems provided long-term sustained yield. Both systems generally involved multiple use of the varied forest environment at least for subsistence (e.g. hunting or fishing for food, collecting for minor food resources, building materials, and medicines).

In both systems the existence of a transitional zone between forested and non-forested areas is associated with increased species diversity, to the benefit of the human residents. In the highlands this is accomplished by successional forest regrowth after the swidden is abandoned or fallowed (Kunstadter 1979). The mangrove forest is itself a transitional zone between dry land and open ocean, which contains a richly varied environment.

Several socio-economic and ecological problems associated with economic development are common to highlanders and sea-margin dwellers. These include failure to protect the traditional inhabitants' interest in the land, damage to the environment as a result of the physical processes of development, harvest at rates far higher than natural replacement, emphasis on single uses that restrict employment rather than on multiple uses, and, in general, loss of traditional life-style.

Traditional patterns of land ownership and land use are often unrecognized by the authorities. The government claims the land as "forest" or "wasteland" which may be turned over to new owners or concessionaires for commercial exploitation or settlement. Although this may provide wage-labour opportunities for traditional inhabitants, commercial use as forest (which emphasizes short-run economic efficiency and profit) may not support as many people as were supported by traditional land-use systems. Aksornkoae et al. (1984, 110–111), for example, show that the number of people employed in mangrove concessions is only about 17 per cent of those who actually live in mangrove areas. Moreover, the beneficiaries from jobs created by the commercialized exploitation of the mangrove forest are often outsiders, not the local people whose habitat is being destroyed (cf. Aksornkoae et al. 1984, 66).

Unless carefully controlled, the physical development processes (e.g. road-building) and large-scale logging or farming of forested land, both in the highlands and on the coast, may greatly reduce the ability of the forest to regenerate and may selectively change the character of the vegetation in favour of weedier (less useful) species. Overcultivation in the highlands has sometimes resulted in replacement of forest by grasses (*Imperata* or *Saccharum*) or bracken that inhibit forest regeneration and greatly increase costs of further cultivation. The analogous development in overused mangroves may be the spread of the fern *Acrostichum,* which inhibits the reseeding and regeneration of mangrove-tree species (Gan 1982; Srivastava and Khamis 1973; Srivastava and Sani 1979). Ecological problems (e.g. erosion) in the highlands are often associated with use of earth-moving machinery. In the mangrove forest, earth-moving projects which block water-flow patterns kill the mangroves as a result of change of water quality (see, e.g., Saenger, Hegerl, and Davie 1983, 35). Drying of the mangrove soils associated with some types of agricultural development may result in diminishing crop yields and virtually irreversible acid sulphate buildup (Hamilton and Snedaker 1984, 94–95; Saenger, Hegerl, and Davie 1983, 38).

There seems to be a strong association between commercialization of land use and costly, destructive ecological changes that generally do not occur under traditional subsistence uses. Great damage often occurs during the early stages of development, when the economy shifts from a sustainable subsistence system to an extractive commercial basis. In the highlands opium cultivators are generally much more destructive of forest resources and much less able to maintain yields

on a given site than are subsistence cultivators (Kunstadter and Chapman 1978). In upland forests, commercialized timber harvesting has often been by high-grading (selective cutting of valuable species) without replanting, leaving vast tracts of low-quality forest. In the mangroves, large-block cutting without systematic replanting greatly increases the time needed for natural reforestation. Also in the mangroves the commercialization of fishing often leads to over-fishing. The problem of assessing the costs and controlling the damage may be more difficult in the mangroves because the consequences are often geographically and socially remote from the places where the decisions are made and the environmental interventions take place. It is the fishermen, not the mangrove developers, who suffer directly from the loss of spawning grounds. This is a special example of "the tragedy of the commons" — i.e. the difficulty of exerting control for widespread public benefit over a resource that may be exploited for localized gain (Bromley 1985; Hardin 1973).

It is apparent that, once the pressures of modernization (e.g. in demands for cash and the material goods money can buy) spread from outside to the mangrove dwellers, the resulting changes take on a momentum of their own. In seeking the better things of modern life through commercialization, the descendants of the traditional mangrove settlers themselves may actively participate in the forces that destroy their environment. Community ethics break down, local inhabitants are no longer able to control the use and changes of their environment, the users (or despoilers) of the environment do not have to live with the immediate or long-term consequences of the changes, and the mangrove dwellers themselves can exert little or no influence over these changes.

The overall rate at which mangrove forest is being converted to other uses or made unsuitable for continued forest use may be on the order of 2 to 8 per cent per year (Sabhasri 1982). This rate is about the same as that for upland forests. If sustained, it leads to very rapid disappearance of the forests. About 40 per cent of the mangrove area of the Philippines was reported to have been converted to fish ponds between 1967 and 1978 (Hamilton and Snedaker 1984, 25–26; Saenger, Hegerl, and Davie 1983, 36ff.). About 200,000 ha of mangroves were reclaimed for agriculture in Indonesia in 1969–1974, with a much larger area reclaimed in 1974–1979 (Bird and Ongkosongo 1980). The potential for continued loss of mangroves is great because less than 1 per cent of the total world mangrove area is under some degree of preservation status (Hamliton and Snedaker 1984, 9). Because of the special problems of agricultural development in coastal zones (e.g. acid sulphate buildup), the "reclaimed" mangrove areas may become unsuitable for agriculture after a few years of cultivation.

Pressure on the remaining mangrove forest areas is often very great because they may appear to be relatively low-cost sites for construction of a variety of facilities, from salt farms, fish ponds, and rice fields to housing estates and industrial sites. If present socio-economic and demographic trends outside the mangroves continue, these pressures can be expected to increase.

Management of the Mangroves

Most of these problems are now well recognized, and in recent years there has been a shift in research emphasis from basic descriptive studies to studies of management systems. Recent studies have often proceeded from several basic assumptions about the aims of management. These include combining some of the virtues of the traditional systems with the benefits of modern use — long-term sustainable yield, multiple use, reduction of environmental damage, and maintenance of the ecological benefits of the mangrove forest at the same time as economic goods are being taken from them for human use — and, in some areas, deliberate protection of mangroves in a relatively unmodified state (Burbridge and Koesoebiono 1980; Hamilton and Snedaker 1984; Knox and Miyabara 1984, chs. 6 and 7; Nature Conservation Council 1984; Philippine Council for Agriculture and Resources Research 1978, 71–128; Saenger, Hegerl, and Davie 1983, ch. 6). Management of mangroves may pose special problems, as compared with other ecological systems, for reasons already given, especially because of the important linkages of mangroves to other ecological zones.

Probably the most detailed integrated research on ecology, traditional patterns of human use, and modern management of mangrove areas for higher yields has been in Indonesia (e.g. Collier 1979; Hanson 1981; Hanson and Koesoebiono 1979; Koescebiono et al. 1979). Indonesia is a particularly appropriate place for this research because of the pressing need for agricultural land due to rapid population increase. Indonesia's long-term

Characteristics of mangrove management systems

	Traditional systems	Transitional systems	Ideal developed systems
Population	Small; slow growth; little net migration	Rapid growth; net in-migration	Large; slow growth; little net migration
Technology	Simple; low use of machinery and chemicals	Increasing use of machinery and chemicals	High use of machinery and chemicals
Use of resources	Largely local	Increasingly national and international	Local, national, and international
Employment	Self-employed; local	Corporate; remote	Self-employed and corporate
Economic-system boundaries	Largely self-contained, involving trade and barter	National and international; commercial	National and international; commercial
Yield	Relatively low	Temporarily high, then declining	Moderate to high
Net productivity	Self-sustaining	Extractive	Self-sustaining, with inputs for restoration
Purposes	Multi-purpose	Often single-purpose	Multi-purpose
Knowledge used for management	Local, detailed, traditional	Technical; general	Scientific, local, detailed, and general
Management objectives	Subsistence in perpetuity	Profit	Profit and sustainability
Method of control of exploitation	Customary behaviour and values supported by local moral community	Poorly enforced laws and regulations; loss of moral community	National and international regulation, and international moral community (e.g. control of trade in endangered species)
Pollution	Local, biodegradable, chemically non-toxic, minor, micro-biological pollution may be effectively controlled by dilution	Local and regional; biodegradable and non-biodegrable; non-toxic and toxic; major (oil; agricultural and industrial chemicals); poorly controlled, with danger of secondary spread by marketing	Full range of potential sources and types; actively controlled

transmigration programme has sought, with mixed success, to relieve population pressures in Java through government-sponsored migration to less-populated islands, especially Kalimantan and Sumatra. The destination has often been lands that are marginal for agriculture and poorly suited for traditional Javanese farming techniques. The work of scholars in Indonesia has described ecological problems, management issues, and some successful adaptations of traditional solutions, such as those of the Buginese, to coastal conditions. These studies can serve as a model for other areas in which there is a general lack of similar integrated research.

Discussion

Ecological characteristics of mangroves are in general fairly well known, but detailed information is needed on local and regional variations. This is important in discussing socio-economic aspects of human settlements because mangroves have hinterlands with a great diversity of natural and