LIVING OFF THE TIDES

J.L. FISELIER

With contributions by

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ENVIRONMENTAL DATABASE ON WETLAND INTERVENTIONS

G.J. Schiereck

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strategies for the integration of conservation and sustainable resource utilization along mangrove coasts

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Cover photo: A. Spaans

FOREWORD

When the EDWIN project started some years ago, it mainly focused on interventions that threatened the integrity of wetland ecosystems. Then, the EDWIN project gradually shifted towards a new approach as the EDWIN team felt that answers to the question "How can we preserve and manage these vulnerable ecosystems?" were increasingly needed. Wise use of wetlands became the main goal for all those who dealt with wetlands in one way or another. It is now recognized that in many parts of the world new methods for sustainable use of wetland resources have emerged, some of them being based on experience acquired by local wetland communities throughout the years. This report presents an overview of these methods pertaining to one of the most complex and interesting wetland types, the mangrove. Of course the ideas and concepts discussed in the report need adaptation as every region or situation is different. But I hope - and I am confident - that local wetland managers as well as scientists and policy makers will find it a useful guide to enhance the well being of both the mangrove and the people who depend on it.

Marcel Marchand

Leiden, April 1990

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During the production of the reports, I heavily depended upon Gerhard van den Top (EDWIN-staff member), Ger Geertsma (information officer EDWIN) who handled most of the information, and Henri Roggeri for the final editing. For any incorrect information and unwise opinion left I am solely responsible. I hope this report will encourage the wise use of mangroves as a natural resource and splendid ecosystem.

Jasper L. Fiselier

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CONTENTS

ACRONYMS

AWB	: Asian Wetland Bureau
CBA	: Cost-Benefit Analysis
CML	: Centre for Environmental Studies, Leiden University
SECA	: Société d'Eco-Aménagement
EDWIN	: Environmental Database on Wetland Interventions
EIA	: Environmental Impact Assessment
ESCAP	: (United Nations) Economic and Social Commission for Asia and the Pacific
FAO	: Food and Agriculture Organization of the United Nations
ICLARM	: International Center for Living Aquatic Resource Management
ICPB	: International Council for Bird Preservation
IUCN	: International Union for the Conservation of Nature and Natural resources
RSPB	: Royal Society for the Protection of Birds
UNEP	: United Nations Environment Programme
UNESCO	: United Nations Educational, Scientific and Cultural Organization
WHSRN	: Western Hemisphere Shorebird Reserve Network
WIWO	: Foundation Dutch Working Group for International Wader and Waterfowl Research
WWF	: World Wildlife Fund

0. EXECUTIVE SUMMARY AND CONCLUSIONS

0.1. SUMMARY

mangroves, a valuable natural resource
Mangroves are productive ecosystems, that sustain important fisheries, provide a variety of forest products and harbour millions of resident and migratory birds as well as endangered mammals and reptiles. Reclamation for aquaculture and agriculture is currently considered the main way to achieve development of mangrove areas. These types of reclamation are costly, often unsustainable, and have adverse environmental effects. They mainly benefit outsiders, and to a lesser extent local communities, to the prejudice of those traditionally engaged in fisheries and the gathering of forest products. Partial reclamation may be beneficial and cause limited environmental damage provided that activities are properly designed, judiciously located (i.e. largely outside the mangroves, and on suitable soils), implemented on a small scale and controlled by the local population.

However, reclamation is certainly not the only option available and priority should be given to the development of mangrove-related activities such as fisheries, forestry, open water aquaculture and nature-orientated tourism. These activities require less investments, are easily taken over by local communities and offer more opportunities for conservation. However, most of them may induce environmental risks and need proper management and control.

Integrating sustainable development of mangrove coasts with conservation may take place along three different lines:

- optimising mangrove-related activities, while maintaining the integrity of mangrove ecosystems as wildlife habitat and naturally functioning ecosystems,
- optimising reclamation activities while maintaining the integrity of adjacent mangrove ecosystems,
- integrating conservation into coastal development.

optimising mangrove-related activities
Mangrove-related activities have considerable economic value that often exceeds the benefits accrued from reclamation. Traditional activities can often be optimised and mangrove-related activities can be introduced at low costs, and for the benefit of the entire coastal community. When aiming at the development of mangrove coasts, these possibilities should always be examined before reclamation is considered. Most mangrove-related activities are compatible with conservation.

optimising reclamation activities
Reclamation of mangroves often failed because it was poorly designed and unwisely located, thereby generating more environmental costs than economic benefits. Partial reclamation can enhance the diversity of economic activities, create additional employment opportunities and improve security of daily subsistence if carried out wisely and to a limited extent. Reclamation can be made more beneficial through its integration into the life system of local communities.

integrating conservation
Wildlife utilization can be an important source of food and income for local communities. National parks and nature reserves can generate local employment opportunities and increase local incomes. However, these opportunities are seldom seized. Park management costs can be decreased by involving local communities. Controlled hunting by local people forms an important incentive for counteracting poaching and illegal fishing by outsiders. Opportunities for conservation also exist outside protected areas; these include habitat improvement and, provided that unsustainable forms of hunting are controlled, creation of breeding and roosting sites.

integrated strategies
The formulation of realistic strategies will depend upon demographic pressure, level of conversion and characteristics of the existing mangroves, and the current state of the wildlife. When demographic pressure is high, the emphasis may be put on creating employment opportunities and increasing production. When demographic pressure is low, labour-extensive forms of cultivation may be envisaged.

- wildlife utilization strategy, with nature reserves, national parks, nature-orientated tourism and possibly rearing of wild animals (e.g. crocodiles, turtles) as most important components together with compatible and sustainable forms of forestry and fisheries.

- mangrove utilization strategy, with mangrove forestry and associated economic activities (e.g. charcoal production), shellfish cultivation (open water culture) and fisheries as major activities. In this strategy, opportunities for wildlife conservation remain, provided that hunting is controlled.

- partial reclamation strategy, consisting of all aforementioned forms of mangrove utilization, combined with limited reclamation for aquaculture and agriculture on suitable soils only. Wildlife can be supported by improving roosting and nesting sites and controlling hunting.

- innovation strategy. This strategy puts the emphasis on improving existing aquaculture and agricultural activities and allowing no further reclamation; possibly, to be combined with mangrove restoration in unsuccessful reclamation schemes.

enhancing people's participation
When counteracting poaching, control of fisheries and forestry activities will have to be supported by local communities, especially when classic means of law enforcement are lacking or limited. Environmentally sound activities can often be achieved by making sustainable utilization beneficial to and the responsibility of local people.

planning tools
Decisions related to coastal development should involve the implementation of environmental impact assessments and cost-benefit analyses that include all production and regulation functions of mangrove forests. Coastal zoning as a means to ensure the optimal allocation of non-compatible forms of utilization, is an important tool for achieving envi-

ronmentally sound development. Within a regional framework, reclamation zones, conservation areas, coastal protection zones and preservation areas for fisheries should be delineated.

The implementation of environmental profiles of coastal areas may constitute a first step towards the identification of sustainable resource utilization strategies. These profiles should include an inventory and an analysis of the functions and values of the areas under consideration and current and planned economic activities. Environmental profiles should also identify possibilities and constraints with respect to the sustainable utilization of resources. Environmental projects that aim at maintaining and rehabilitating mangrove functions and values should be promoted.

0.2. RECOMMENDATIONS FOR FURTHER RESEARCH AND ACTION

recommendations for further research

The ecological functioning and optimal living conditions of many mangrove and mangrove-related wildlife species are not fully understood. Many opportunities for optimising mangrove-related activities deserve further research and development of proper design and management guidelines. Areas for further research and action are indicated hereafter.

ecology of mangrove ecosystems

- productivity of mangrove forests under different environmental and management conditions and optimal conditions for natural regeneration;
- living conditions of plant and animal species of mangrove forests that are of (potential) economic interest or endangered, or those that support important food webs or ecological processes;
- potential impact of global climatic change;

mangrove-related development options and strategies

- optimal site conditions and management of different forms of open water aquaculture (e.g. different forms of shellfish cultivation, cage culture);
- management schemes for wildlife utilization (e.g. rearing of turtles and crocodiles);
- cost-effective techniques for mangrove restoration (e.g. planting techniques) and "brackish water reclamation" (e.g. improvement of fish breeding sites);
- environmentally sound intensification of aquaculture;
- environmentally sound intensification of existing agricultural activities through the introduction of polyculture (mixed farming), fast-growing and salt-tolerant crop varieties, and alternative forms of water management that can be based on indigenous knowledge;
- socioeconomic integration of partial reclamation schemes when and where these are socially desirable and ecologically benign;
- strengthening of existing forms of risk avoidance strategies and formulation of alternatives whenever appropriate;

methodologies for inventories and planning tools

- techniques that enable rapid inventories and monitoring of mangrove resources, especially by means of remote sensing;
- development of methods and techniques for the implementation of environmental profiles that involves local participation;
- methods for Environmental Impact Assessment and Cost-Benefit Analysis that take all costs and benefits into account, especially the value of traditional forms of resource utilization and off-site functions of ecosystems and effects of interventions; rapid rural appraisal techniques are needed for the implementation of preliminary assessments;
- environmental zoning that involves local participation and that can be successfully implemented in developing countries with limited institutional capacity;
- rapid rural appraisal methods for the identification of possible ecological threats and development options;

recommendations for further action

establishing proper organizations and regulations

- establishment of (intersectorial) coastal management authorities and mangrove resource committees whenever and wherever they are lacking, and build-up of the capacity that is necessary for the planning, implementation and control of coastal activities;
- establishment of independent and interdisciplinary bodies that can advise these management authorities;
- projects involving mangrove conversion or those expected to alter coastal dynamics should be formulated and evaluated within the framework of the entire coast and should involve an Environmental Impact Statement;
- it is recommended that all countries join the Ramsar convention and register their important coastal areas as Ramsar wetlands;
- it is recommended that Central and South-American countries that have tropical coastal wetlands with important shorebird concentrations join the Western Hemisphere Shorebird Reserve Network; reserve-twinning for areas within the same waterfowl flyway can be used as a means to generate financial and technical assistance;
- a similar reserve network should be developed for the Palearctic flyway system (Europe-Africa, Asia-Australia) with a reserve-twinning system similar to the one that is proposed for the lowland peat areas of the Netherlands and the coast of Guinea Bissau in relation to the Black-tailed Godwit (Limosa limosa);
- formulation and implementation of regulations (legislation as well as economic incentives) that prevent destructive activities, and control activities that are potentially harmful and stimulate environmentally sound development activities;

conducting inventories and formulating coastal management plans

- implementation of coastal environmental profiles, with high priority for mangrove coasts under high demographic pressure and rapidly changing conditions; these profiles should focus on economic activities and their trends, and should identify possible threats and available development options; furthermore, they should reveal the information, legislation and organizational needs

that are felt at the planning and implementation level;
- inventory of all mangrove resources, important fish breeding areas and zones that ensure natural coastal protection;
- identification of important roosting, breeding and feeding grounds for birds and formulation of recommendations for their delineation and management, with high priority for mangrove coasts that are relatively undisturbed and currently lack protection;
- as far as possible and as long as the main conservation objectives are served, proposed and existing protected areas should be integrated into the socioeconomic life of local communities;
- development projects should be designed and implemented within the framework of coastal management plans; such plans should include zoning of areas with respect to resource uses, and pertinent regulations;
- formulation of (participatory) environmental projects in key areas that are seriously threatened by environmental degradation.

In order to emphasize the importance of issues and recommendations involving participation of local people in wetland management, the conclusions of the International Conference of People's Role in Wetland Management, held in June 1989 in Leiden, The Netherlands, are included in Appendix 3.

1. MANGROVES, A VALUABLE NATURAL RESOURCE

1.1. MANGROVES, SOURCE OF LIFE FOR MAN AND NATURE

mangroves, source of life for man and nature

Along the tropical and subtropical coasts of most continents, a brackish water forest is found that consists of mangroves. Mangroves, a combination of the Portuguese word *mangue* and the English *grove*, are trees that are physiologically adapted to regular inundations by sea water. Most ooze the excess of salts taken in with brackish water, through special pores. Growing on the edge of sea and land and benefiting from the inflow of nutritious (sediment-laden) river waters, mangroves are characterized by high levels of biological production and stunning structural diversity and scenery. Their importance to man and wildlife has long been recognized. The trees give valuable timber and firewood, their leaves are used as manure and fodder, and tannin and medicines are extracted from their bark.

Among their dense root system, a multitude of life forms spawn, breed and feed, many of which are of commercial interest. Coastal communities have found means to exploit these resources and have thus woven mangroves into their very existence. Communities dwelling in mangroves often reach a high degree of self-reliance. Mangroves provide nearly all basic necessities: food (proteins and carbohydrates), building materials, firewood and medicines. Traditional resource utilization and indigenous knowledge often are environmentally sound. Leaving mangrove fringes untouched (as natural protection) and respecting restricted areas and seasons for fishing and woodcutting, these local communities have been sustained by mangroves for hundreds of years.

Coastal areas are generally densely populated and the limited accessibility of mangroves often ensures that threatened animals, such as Bengal tigers, manatees (or dugongs) and otters can take refuge. Mangroves are extremely important for resident and migratory birds. Mangroves such as those of Suriname, Indonesia and Guinea Bissau harbour large flocks of threatened bird species. Tourists are attracted by the scenic beauty of mangroves and their wildlife. Large numbers watch the reddish, radiating flocks of ibis on their way to roosting sites in the mangroves of the Caroni Mangrove Swamp in Puerto Rico or fish on the spectacular tarpon in Costa Rica. Mangroves are an important gene reservoir and some crabs, now unnoticed, may find themselves becoming a trendy dish or a crucial protein source in the near future.

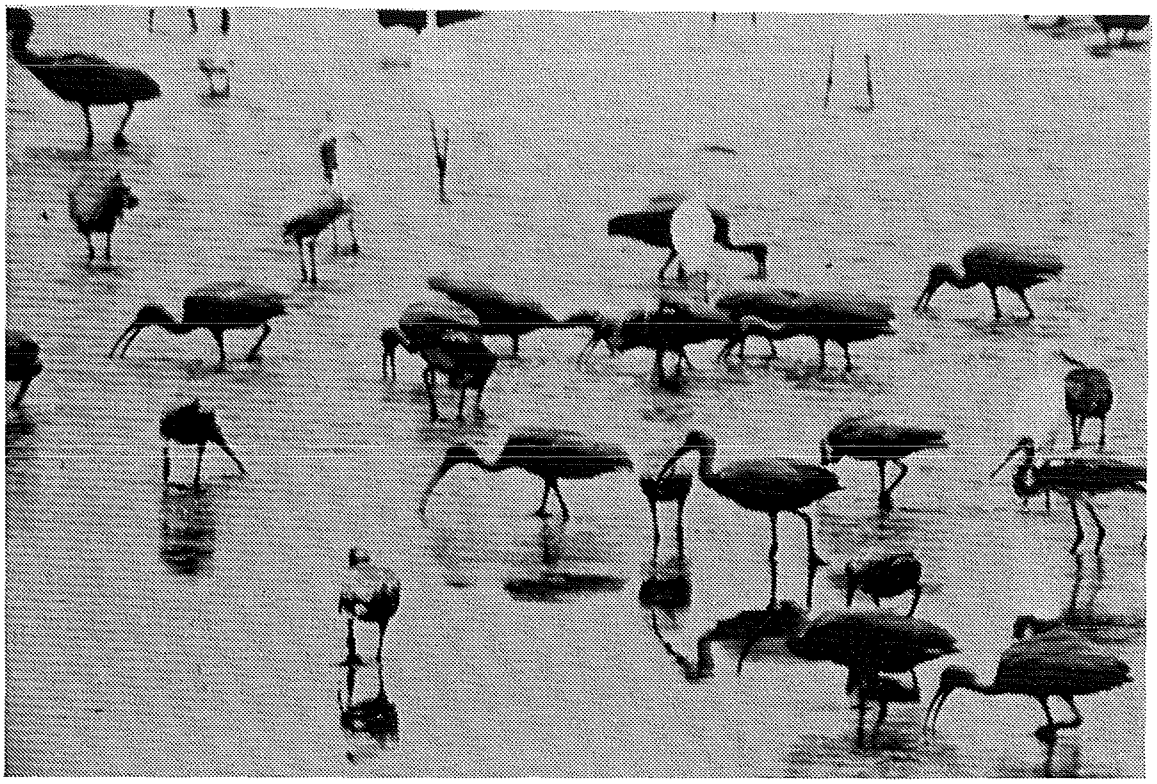


Photo 1.1. A colony of Scarlet Ibis, Suriname (A. Spaans).

mangroves, a dwindling natural resource and wildlife habitat

Notwithstanding their usefulness these swamps are threatened in many ways. Mangroves are increasingly being utilized beyond sustainable levels. Logging of mangroves and reclamation occur along most coasts of the tropical region, while nearly everywhere estuarine fish communities are overexploited. Oil pollution, reclamation for agriculture, urban housing, port construction and aquaculture ponds have already caused the loss of thousands of hectares of valuable mangrove forests. In many places, upstream dam construction, has deprived mangroves of nutrients and freshwater supply, thereby aggravating their degradation. Loss of mangroves deprives, adjacent freshwater swamps and agricultural lands of their coastal protection and exposes them to high floods and storms. Without the Sundarbans, a several kilometers wide mangrove forest in the Gulf of Bengal, even a moderate storm would be disastrous to the deltaic lowlands of Bangladesh. Without mangroves filtering out silt and sand, adjacent sea grass beds and coral reefs would be buried under sediments.

sustainable utilization of resources, peoples priorities and conservation

The establishment of nature reserves and national parks has often been considered the only way to achieve the conservation of natural resources. This complete segregation (protected area vs. local people) has not always been the most adequate solution; it meant the loss of important resources to local communities, while park administration and law enforcement are very costly. In recent years the necessity to integrate the basic needs of the local poor into park management, thereby making park management less costly and more beneficial to the local communities, has been increasingly recognized.

1.2. OBJECTIVES AND JUSTIFICATION

aim and objectives

The aim of this report is to show in what way conservation and sustainable utilization of mangroves may be integrated while taking into account the needs of local communities. It will therefore describe ways to optimize mangrove-related production while maintaining the quality of mangroves as a wildlife habitat, and attempt to illustrate the integration of conservation with socioeconomic development. It will also stress the necessity to integrate people's priorities into conservation and development activities, and illustrate approaches for achieving this integration.

It is hoped that this report will provide useful ideas and concepts to those who are responsible for the formulation of development options for mangrove ecosystems. It does not pretend to discuss all important environmental issues, it merely tries to generate new ideas for the environmentally sound development of mangrove coasts. Examples have been taken from mangrove areas all over the world and four areas have been described in more detail in case studies prepared by contributors to this report.

1.3. CRITERIA FOR SUSTAINABLE UTILIZATION OF RESOURCES AND CONSERVATION

sustainable utilization and environmentally sound development of mangroves

The sustainable utilization of resources is not a new concept. It is however very difficult to translate this concept into sharp cut guidelines for development projects and programmes, answer questions regarding carrying capacities and environmental thresholds, or determine the number of trees that can be cut and the area of mangroves that should be left aside as coastal protection. Although mangroves are generally very productive, it remains to be seen if they can, in their natural state, continue to fulfil the changing and increasing needs of coastal communities. In several areas, the needs of local people and the utilization of resources already exceed by far sustainable levels of production.

Sustainable utilization of resources is not only an ecological concept that can be expressed in terms of carrying capacities, it also addresses sociological and economical issues. Production (i.e. resource utilization) systems can only be sustainable if they remain feasible and attractive to those who manage them. When dikes are no longer maintained and clear-felled forests no longer replanted because such activities are not considered feasible and attractive, dikes will be carried off by floods and forests will not regenerate, and valuable resources will be lost. However, attractive and easily adaptable forms of resource utilization, such as the conversion of mangroves into fish ponds, can become difficult to control and may result in environmental degradation. Development of sustainable forms of resource utilization should therefore be based on reliable control mechanisms that may be safeguarded by both governmental bodies and local communities.

Taking into account people's capacities and preferences

In the past, the design and implementation of agricultural development projects seemed to be governed only by water availability, soil fertility and commodity prices. Many of these projects have failed because they could not be taken over by the local population, for technological or organizational reasons, or arouse sufficient local interest and participation. The history of irrigation projects bears an important lesson with respect to projects aiming at the conservation and the sustainable utilization of natural resources: whenever projects fail to take into account the capacities and preferences of rural communities, they fail in nearly every objective that was set.

preserving biological diversity

In general, conservation aims at preserving biological diversity. It is increasingly being realized that in order to achieve the conservation of flora and fauna species, it is necessary to preserve the integrity of the ecosystems upon which these species depend during different stages of their lives. This is clearly shown in the case of migratory birds that winter and breed in areas sometimes more than 10.000 kilometers apart. The integrity of mangrove ecosystems can only be guaranteed if tidal activity and inflow of nutrients and sediments are maintained; sustainability is a prerequisite for conservation.

integrating different objectives

Not all objectives mentioned above are compatible. "The goal of preserving the structural integrity of ecosystems should not be conferred with preserving species or habitat diversity" (TURNER, 1988). Sustainability does not automatically include conservation of natural resources; however, it should be repeated that sustainability is a prerequisite for conservation. Daily food and firewood needs have caused overfishing and deforestation in many mangrove areas. Rural and coastal communities often have no alternative and resource degradation can only be halted if they are provided with suitable alternatives. Although many endangered species require full protection, wildlife utilization and moderate use of mangroves may be compatible with some conservation objectives. Wildlife and natural parks can also be managed so as to generate more benefits to local communities. Conservation may thus be an important development option for rural areas.

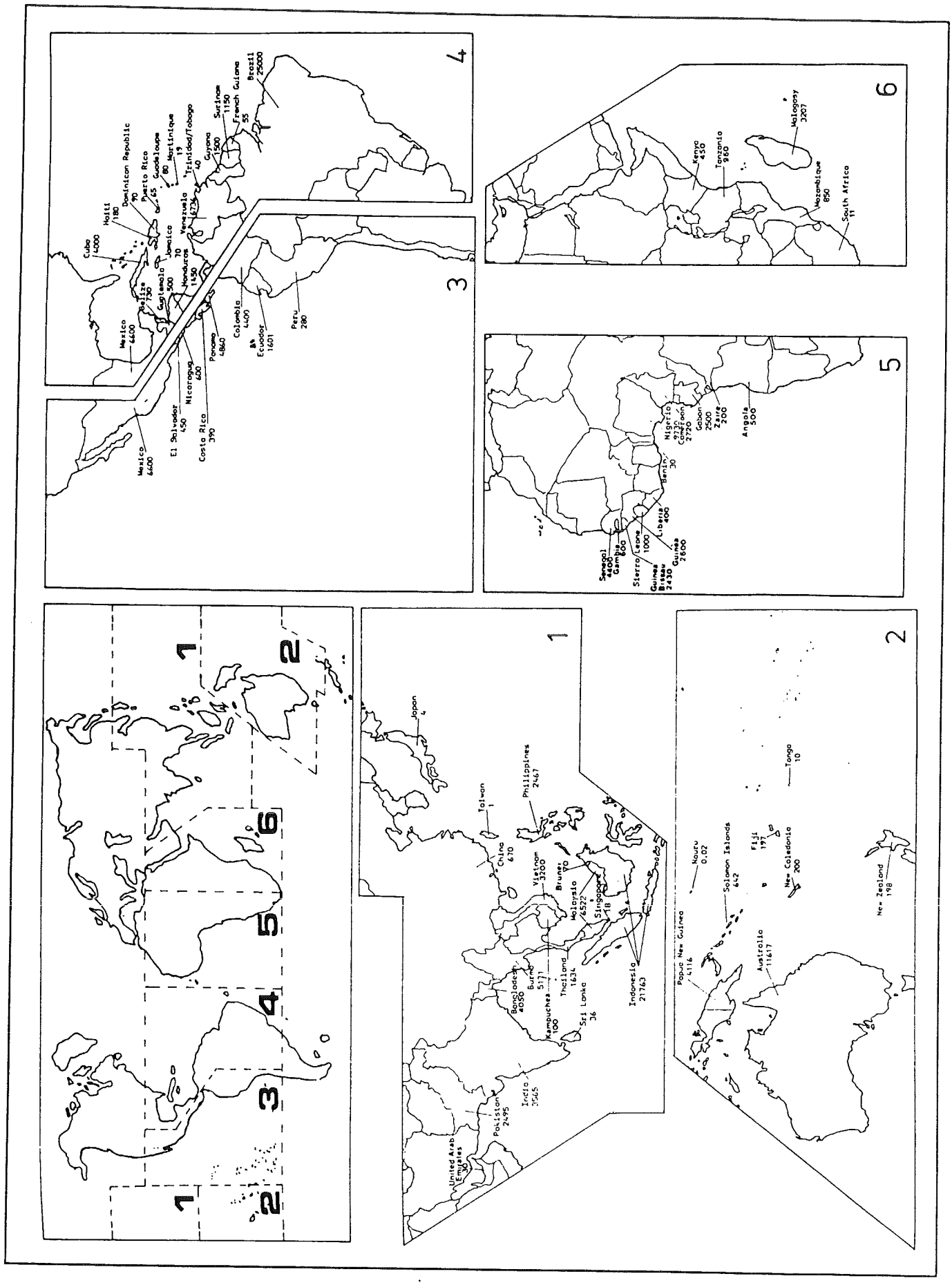


Figure 2.1. Distribution of mangroves in different geographical zones of the world (areal extent is given in km2):**1**, Asia; **2**, Oceania; **3**, West Coast of thee Americas; **4**, East Coast of the Americas; **5**, West Coast of Africa; **6**, East Coast of Africa and the Middle East. (Saenger et al, 1983).

2. MANGROVES: FUNCTIONING, FUNCTIONS AND VALUES

2.1. MANGROVES, A DYNAMIC ECOSYSTEM

2.1.1. Mangrove types and distribution

Mangroves are a form of vegetation adapted to brackish water. They largely consist of a limited number of tree species and associated shrubs and herbaceous plants. According to Benessalah (1988), mangrove forests cover approximately 7.540.000 ha in Asia where the most extensive forests can be found along the coasts of Australia (1.162.000 ha) and Indonesia (2.500.000 ha), 3.258.000 ha in Africa where mangroves mainly occur along the coast of West Africa, and 5.831.000 ha in America with large forests in Brazil (2.500.000 ha) and Mexico (660.000 ha).

Mangrove types are generally distinguished on the basis of site characteristics as riverine, fringe and basin mangroves, or deltaic/coastal, estuarine/lagoon and island mangroves (ONG, 1982). Biologists distinguish them according to their species composition. Their environment is characterized with respect to the balance between marine and fluvial processes and, by coastal engineers, according to tidal and wave energy. All these factors play an important role in the functioning of mangroves. Considering the wildlife they harbour (especially birds), a pragmatic distinction between mud flats, 'mangal rice fields' and salt ponds in mangrove areas is useful.

On a global scale, a distinction can be made between 5 different biogeographical zones. Each zone contains a variety of mangrove species, some of which can be found in several zones (e.g. Rhizophora spp. and Avicennia spp.). In sharp contrast with tropical rainforests, mangroves do not abound in plant diversity. Most tree species belong to 7 different families. The greatest diversity in mangrove species is found in Asia, where they probably originated.

The zonation of mangrove vegetation is largely controlled by salinity levels and substrate stability. The width of the different zones depends to a large extent upon tidal activity and climatic conditions. In semi-arid West Africa the zone of the more salt-tolerant Avicennia species is very broad compared to the Rhizophora zone. In the humid Gulf of Guinea, Rhizophora accounts for more than 80 % of the forest.

The regional diversity in mangrove ecosystems is large and general descriptions may easily lead to misconceptions among planners and policy-makers. It is therefore advisable to treat each mangrove forest as a unique ecosystem and to make generalizations only with great caution, on the basis of a sufficiently detailed classification.

2.1.2. Tidal dynamics, river discharge and mangrove-related production

sea level rise and tidal flat formation

At the end of the last Ice Age, sea levels were considerably

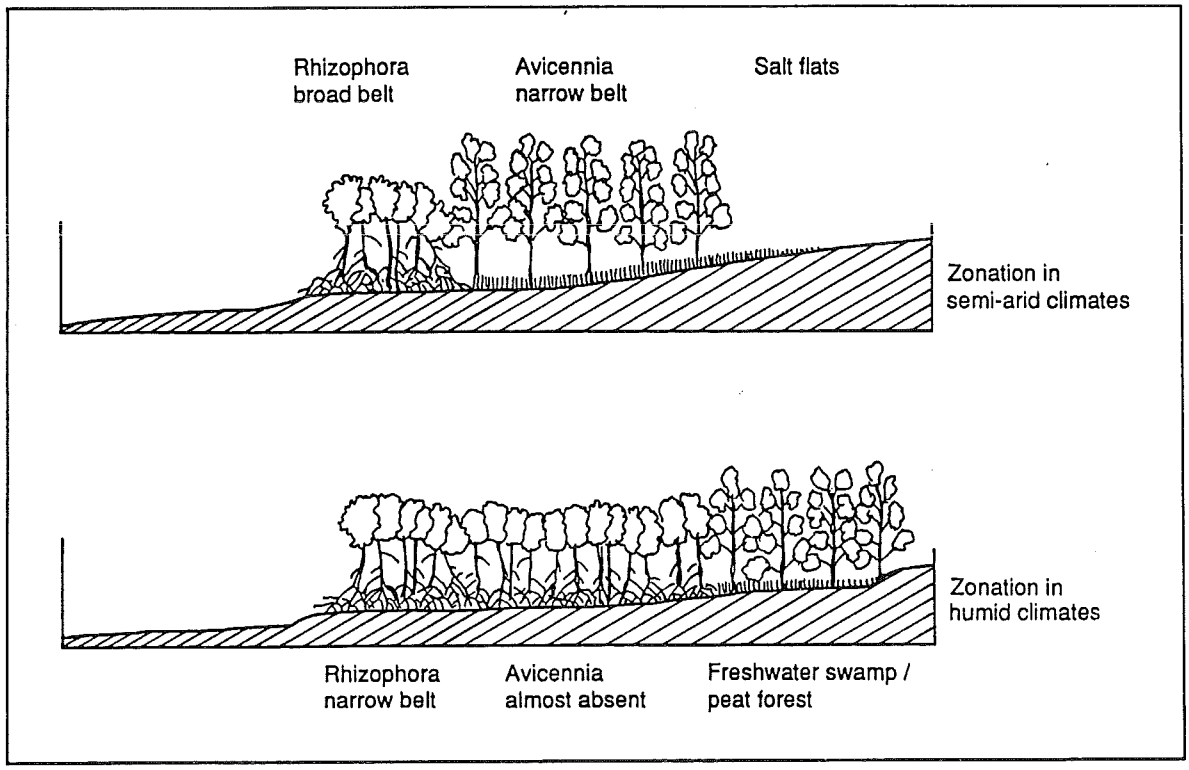


Figure 2.2. Vegetation zones under semi-arid and humid conditions. A. Semi-arid West Africa (steppe estuarine mangroves): a small fringe of Rhizophora is followed inland by a relatively broad zone of the more salt tolerant Avicennia, the latter is backed up by salt flats or rice fields under more humid conditions. B. Humid Gulf of Benin (tropical rain forest, estuarine mangroves): a relatively broad zone of Rhizophora gradually changes into an inland freshwater swamp; a distinct zone of Avicennia trees is nearly non-existent.

BOX 2.1. CLASSIFICATION OF MANGROVE ECOSYSTEMS

The salinity of intertidal water in the mangrove soil (which is governed by deficits in rainfall, and tidal inundations), the stability of the substrate (which depends upon sediment budgets, and wave and tidal energy) and nutrient availability are the key factors for mangrove forest ecology and production. On a regional scale, climate and coastal morphology may serve as differentiating parameters. Tidal activity, wave energy, soil characteristics and vegetation types can be used to distinguish growing conditions within a mangrove swamp.

climate (after Köppen)
Steppe, tropical savanna, marine west coast, humid subtropical, desert and tropical rainforest.

coastal dynamics (water chemistry, sediment budget, tidal and wave activity)
- riverine mangroves and fringing mangroves salinity seasonally dominated by river discharge, limited tidal activity and wave energy
- estuarine mangroves, dominantly brackish water governed by the continuous interplay of fresh and salt water
- lacustrine mangroves, dominantly brackish water with low wave energy and tidal activity
- closed lacustrine mangroves, no wave energy or tidal activity, occasional inflow of saline water
- deltaic mangroves, dominantly accreting, river-dominated shores
- coastal lowland mangroves, mainly saline water gradually changing (inland) into freshwater swamps (in humid conditions) or salt flats (in more arid conditions)
- basin mangroves, characterized by very limited tidal activity and strong influence of rainwater; often sheltered by extensive sand barriers and barrier-islands
- mud flat mangroves, dominated by saline water and active shore accretion.

lower. They rose quickly till about 7.000 years ago. Then, the rate at which these levels rose decreased (PONS AND VAN BREEMEN, 1982). Along coasts where sedimentation could keep pace with the rising sea (e.g. in Indonesia), extensive deltas, sand barriers, coastal dunes and tidal flats were formed. Today, the most extensive mangrove forests occur on these coasts.

Mangrove trees colonize newly formed tidal flats in places where wave energy is low. Zones with low wave energy are found in the wind- and wave shadow of promontories and islands, and behind wave-absorbing sand bars and sea grass beds. Where the substrate is stable enough, the seeds (these often are elongated propagules) can settle and develop roots that thrive into the soft mud. Mangroves are not so much land builders as land maintainers. Their root system may however enhance sediment deposition and stabilization.

coastal and fluvial dynamics

Coasts are very dynamic and shifts in longshore currents and river channels, or an increase in storm frequency, may considerably alter the area and shape of the mangroves. Along the coasts of Guinea Conakry, shifting mud flats occasionally block river mouths (SALOMON, 1987). Along the coast of Suriname, mud flats shift at a speed of about 1 km/year, thereby generating a cycle of coastal erosion and accretion (see the case study on Suriname).

Without regular inundations, salinity would soon impede metabolism. On the other hand, continuous low salinity levels (below 5 ppm, depending on the species) favour the growth of riverine vegetation at the cost of mangroves. The broadest and most luxuriant mangrove forests can be found in the estuaries of rivers with large seasonal peak flows (e.g. Niger Delta, Nigeria, and the Sundarbans, India and Bangladesh) and along coasts with extensive coastal lowlands and large tidal amplitude (e.g. the Banyuasin Delta, Indonesia, with its 35 km wide mangrove belt).

During droughts, river flows are considerably reduced and the salinity of estuarine waters and tidal flat soils increases. In the Casamance estuary (Senegal), a series of dry years has led to a net inflow of seawater and salinity exceeded than 100 ppm in the dry season. As a consequence, Rhizophora trees were gradually replaced by the more salt-tolerant Avicennia while former Avicennia forests changed into salt flats ('tannes').

Understanding the seasonal and long-term dynamics of tidal flats and salinity is crucial in coastal zone and mangrove management.

biological productivity and diversity

The primary productivity of mangrove forests consists of mangrove benthic productivity, mangrove aquatic primary productivity and mangrove tree productivity. They all represent considerable quantities that vary according to site and mangrove species. Few studies have been carried out so far. Nevertheless, available data indicate that benthic primary productivity and tree primary productivity are considerable. For instance, the gross primary tree productivity ranges from 38,7 to 100 t/ha/yr (net primary productivity ranges from 0 to 54,8 t/ha/yr). Available data also suggests that the aquatic primary productivity is relatively low because of shaded conditions under mangrove canopy (GONG, 1984).

BOX 2.2. THE POTENTIAL IMPACT OF GLOBAL CLIMATIC CHANGE IN GENERAL AND ON THE SUNDARBANS, BANGLADESH, IN PARTICULAR

A: Possible effects of global climatic change (various sources)

primary effect	secondary effect
- increased temperature	- increased cycling of nutrients and biomass production; increased risks of drought conditions and salinization; shift in species composition; risks of lower oxygen content in water; increased risks of algae bloom and eutrophication
- increased sea level rise with	- increased tidal flooding, longer period and higher amplitudes; increased and earlier salt intrusion and therefore altered estuarine conditions for fauna and flora species and sedimentation processes such as flocculation; increased flooding of coastal flood-plains by river waters; decreased drainage conditions for coastal plains generating more salinization; changing longshore currents generating modified patterns of coastal erosion and accretion
- changing local rainfall	- increase or decrease in rainfall quantity and variability, and length of rainy season with risks of increase in drought conditions and salinization, or increase in waterlogged conditions
- changing river discharge	- altered flood dynamics of coastal plains and seasonal shift in salinity with effects on estuarine conditions; upstream climatic change may induce various land use changes with consequences for river discharge, water quality and sediment budgets
- increased storm frequency and and intensity wind	- increased erosion of shoreline sand mud flats and larger damage due to storm surges

B: Predicted conditions in the Bengal delta in 2050 and 2100 due to sea level rise only. The best case scenario assumes minimal rise in sea level: natural subsidence is offset by river / deltaic sedimentation. The medium case assumes maximal rise in sea level and uncompensated natural subsidence. The worst case assumes enhanced subsidence due to groundwater withdrawal (from: Milliman et al, 1987).

	2050			2100		
	best case	**medium case**	**worst case**	**best case**	**medium case**	**worst case**
Total sea level rise	13cm	144cm	209cm	28cm	332cm	447cm
worldwide	13cm	79cm	79cm	28cm	217cm	217cm
local subsidence	0	65cm	130cm	0	115cm	230cm
Shoreline erosion	0	1 km	1,5 km	0	2 km	3 km
%Loss habitable land	-	16	18	-	26	34
%Population displaced	-	13	15	-	27	35
%GDP	-	10	13	-	22	31

BOX 2.3 SEASONAL CHANGES IN SALINITY IN THE NIGER DELTA

From CML/SECA (1987).

The Niger delta is fed by the Niger, a large river that originates in the highlands of Guinea. Its regime is strongly seasonal; river discharges vary between 15.200 m^3/s during peak floods and 2.000 m^3/s during the dry season resulting in a seasonal shift of saline and fresh water. The delta consists of four distinct ecological zones: the fresh water swamp, the brackish water swamp and mangroves, the coastal barrier islands and shallow coastal waters. It comprises also different mangrove ecosystems; the western part, strongly influenced by tributaries of the Niger, changes from deltaic to more riverine mangroves, the eastern part is at present more estuarine of character, while the mangroves situated behind the protective barrier island may be called basin mangroves and gradually change into freshwater peat swamps. Mangroves cover the area comprised between the sea and the zone with a salinity of 5 ppm during the dry season.

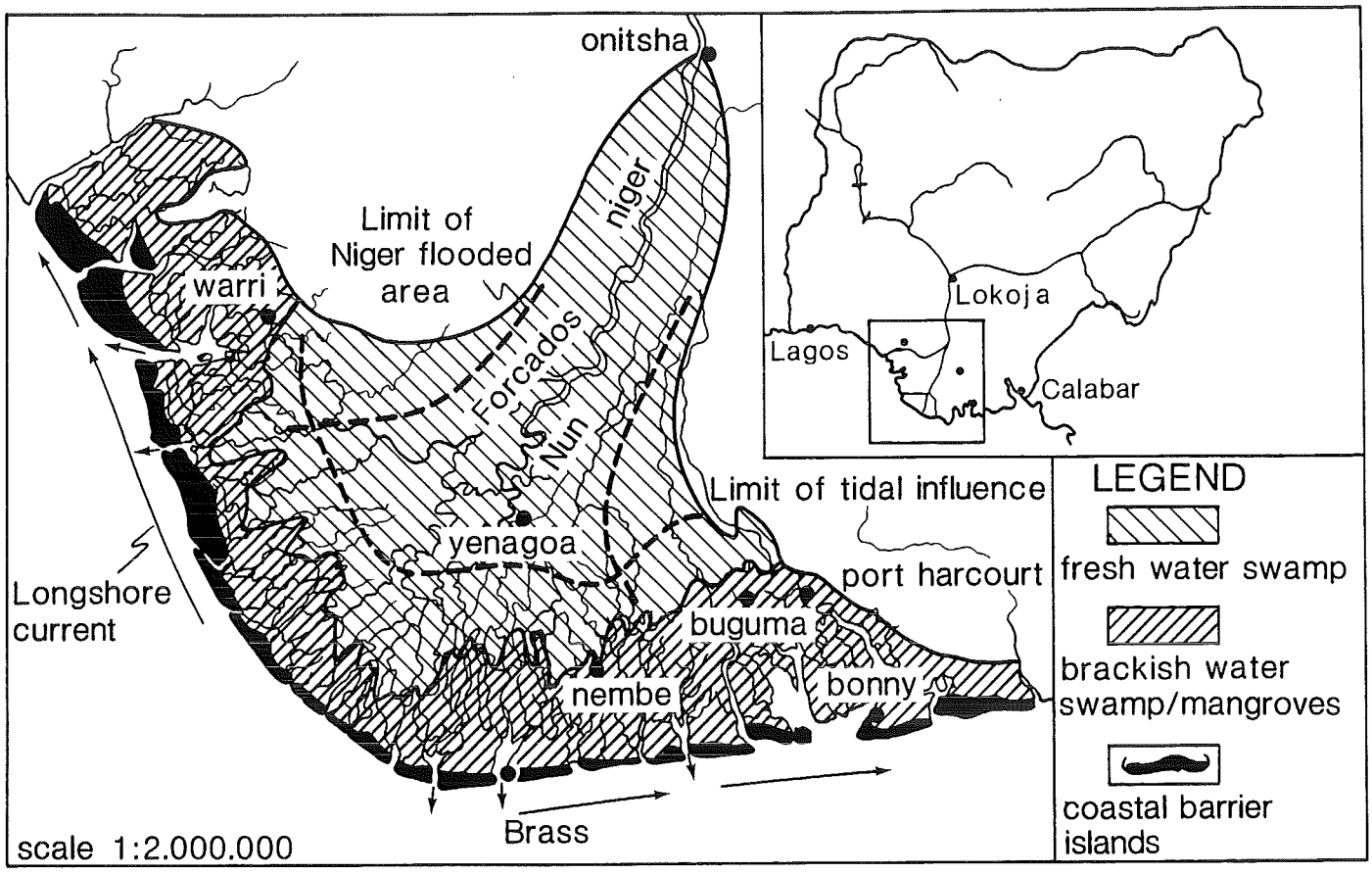


Figure A: The main ecological zones of the Niger Delta.

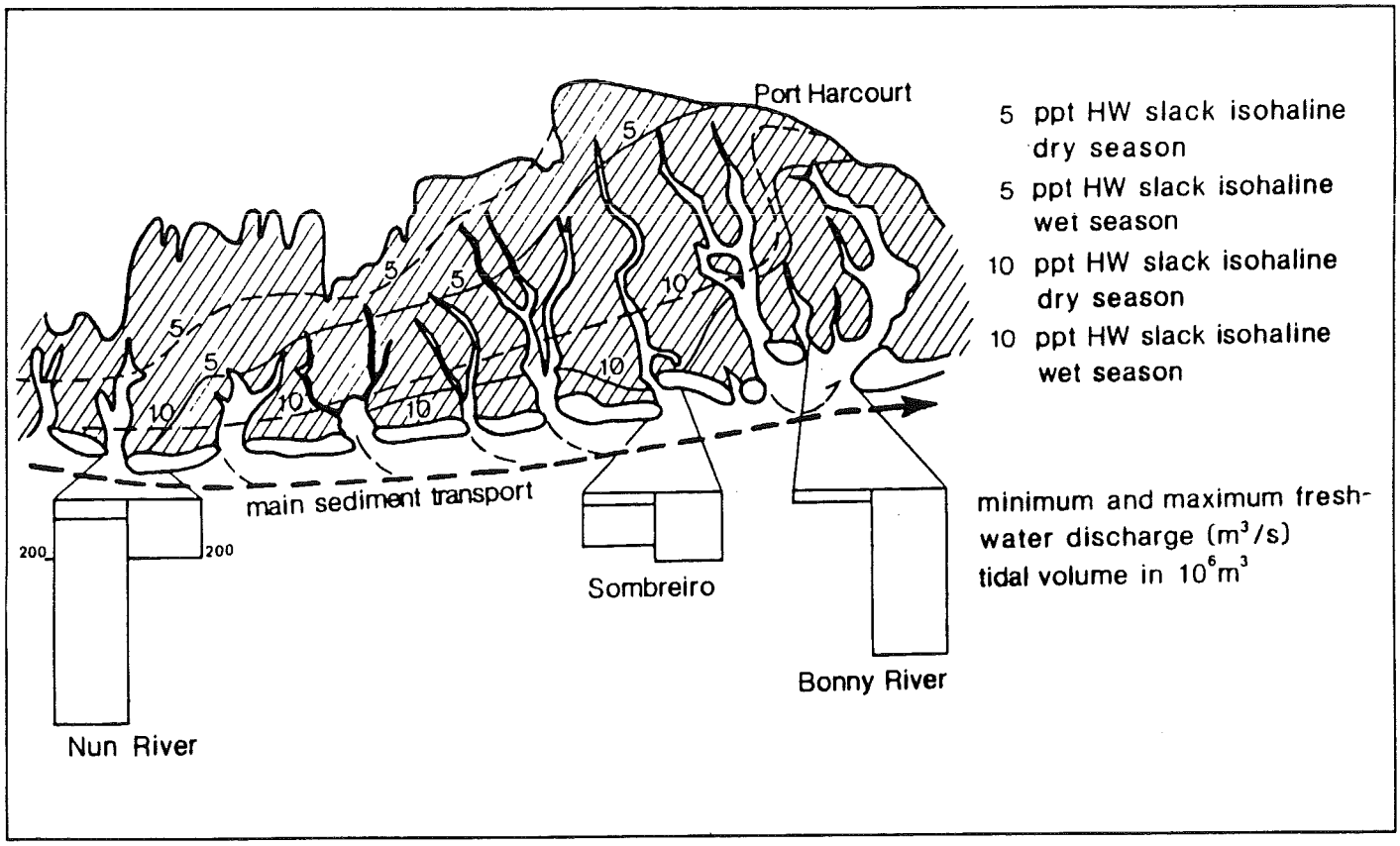


Figure B: Different estuarine systems in the eastern part of the Niger Delta.

Mangroves trap nutritious sediments with their stilt roots where decomposition can take place. Litterfall production ranges in general between 8 and 12 t/ha/yr for Rhizophora forests and between 3 and 8 t/ha/yr for Avicennia forests (CHANSANG, 1984). Slightly higher and considerably lower litter productions have also been observed; the net productivity of mangroves varies between 0 and 20 t/ha/yr depending on salinity, nutrient availability and other factors.

The litter is rapidly decomposed by micro-organisms such as fungi and bacteria followed by small invertebrates and worms. This dish of organic debris and debris consumers is relished by molluscs, prawns and crabs, the latter playing an importnat part in the recycling of nutrients. Many shrimps and fish depend upon mangroves for at least a part of thier life cycle (KIENER, 1978). Part of the organic debris is thought to be exported towards the open sea by the tides ('outwelling') but scientific evidence is lacking or points at a very small percentage of the primary production. Other evidence pictures the mangroves mainly as a sink for nutrients provided by rivers and tides (ONG, 1984).

The aforementioned variability in mangrove productivity and soil conditions imposes special demands on coastal zoning an dmangrove management.

BOX 2.4. THE IMPACT OF SAHELIAN DROUGHT ON THE CASAMANCE ESTUARY

The Casamance estuary has always received a seasonal inflow of freshwater from the Casamance River. This results in a seasonal shift of the saline water zone. Since the beginning of the Sahelian drought, the fresh water inflow has decreased dramatically. The climatic zone to which the estuary belongs, became a zone of annual net evapotranspiration. As a result, the estuary has received a net inflow of seawater for the past years. Salinity levels have risen consequently and salinity now varies between 30 and 150 ppm according to seasons. This change in salinity has altered the migration pattern of shrimps in the estuary and forced them to shift their breeding grounds. Relocation of the most suitable fishing grounds has led to social conflicts on issues related to fishing territories. Furthermore, most adjacent rice fields have been abandoned owing to the lack of rain.

The increased salinity of the estuarine water has had consequences for the soils of tidal flats and mangrove forests as these were temporarily submerged in hypersaline water. Leaching of salt by rainwater was greatly reduced and this has led to a high salt content in most soils. The increased salinity impeded the growth of mangrove trees (some were even killed) and the salt flats ('tannes') enlarged substantially. At present, only a very narrow fringe of vital mangroves is left. Salinity levels are so high that only a long series of above average wet years could allow the rehabilitation of mangroves forests and soils.

Photo Aerial view of the Casamance showing saline flats, abandoned rice fields and a narrow fringe of mangroves.

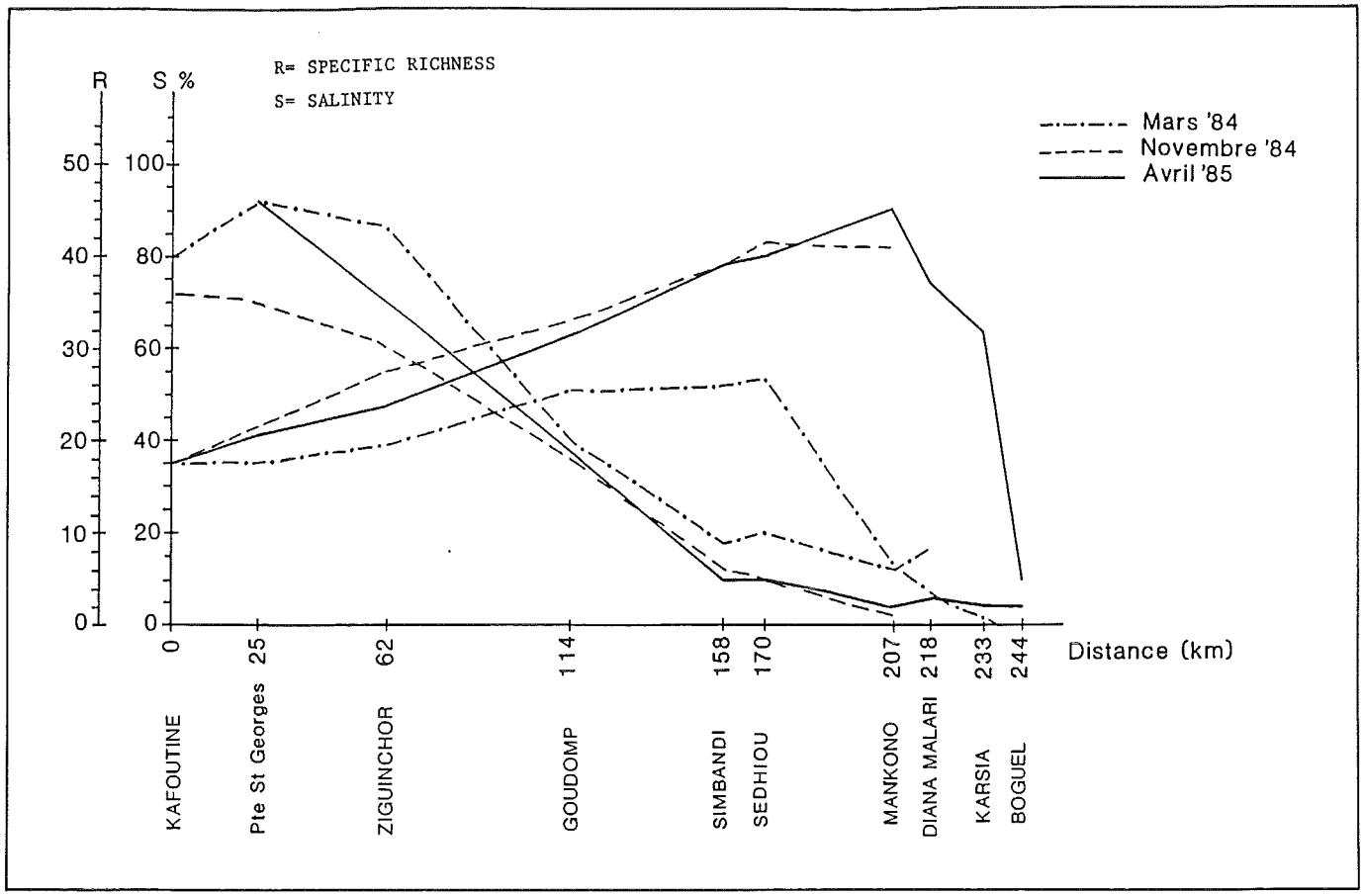


Figure Salinity levels in the Casamance estuary (Albaret, 1986).

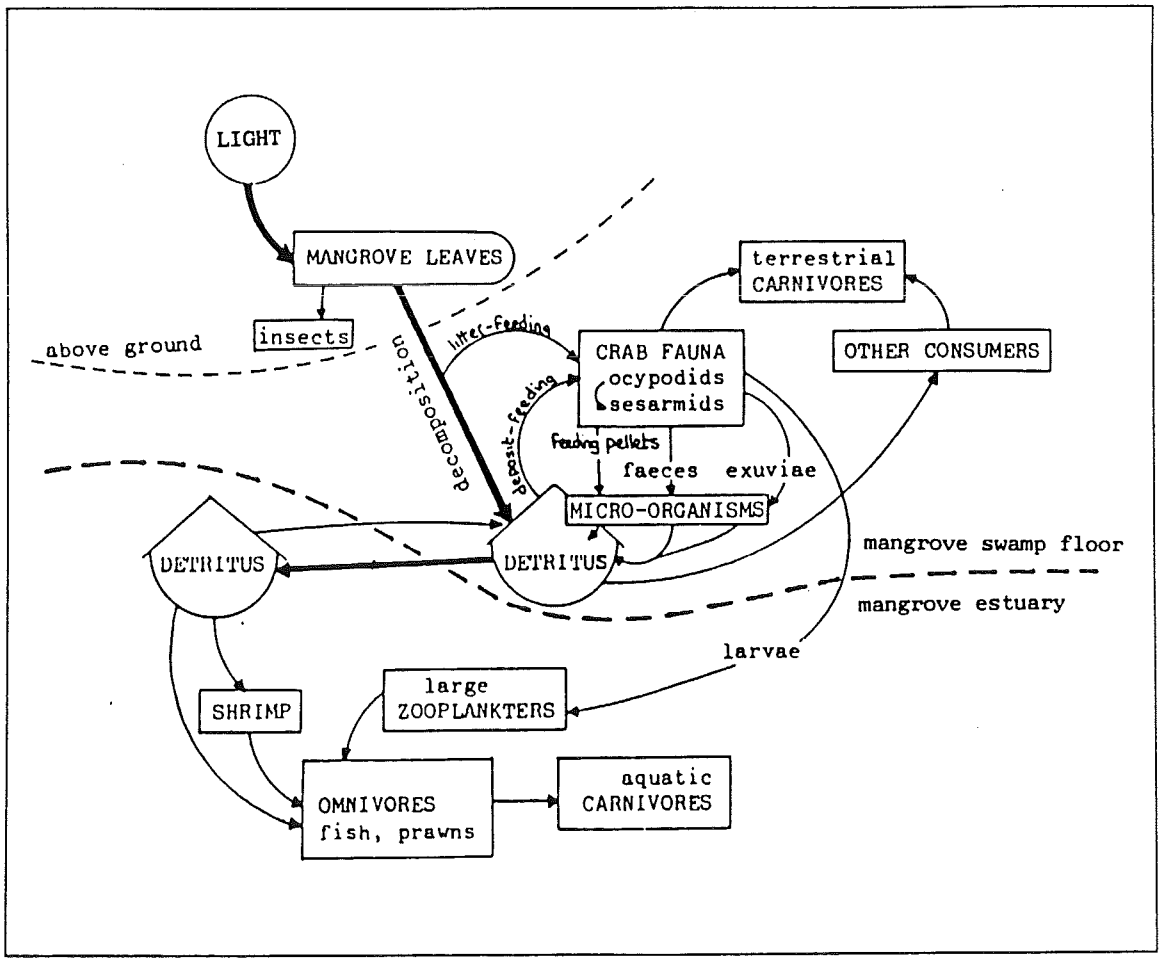


Figure 2.3. Food chain relations in a mangrove swamp (MacIntosh, 1984).

2.2. REGULATION AND PRODUCTION FUNCTIONS OF MANGROVES

2.2.1. Introduction

Several authors have tried to categorize different values of wetlands, discriminating between production, regulation, information and support functions (VAN DER MAAREL AND DAUVELLIER, 1978; DE GROOT, 1986), or on-site and off-site functions (MARCHAND AND DE GROOT, 1988), distinguishing store, sink, pathway, buffer and production functions (HOLLIS, 1988) or more pragmatically between different useful functions (ADAMUS AND STOCKWELL, 1983; SATHER AND SMITH, 1984; NOWICKI AND NOWICKI-CAUPIN, 1984). Whatever categorization is used, it is important to put special emphasis on mangrove functions that are often forgotten in cost-benefit analyses and decision-making. Non-marketable products, non-tangible functions and off-site functions are among the most neglected, although their value - this value can often be considered from an economic point of view - is often substantial. Table 2.1 gives an overview of mangrove functions that include different off-site and on-site regulation, production, information and support functions.

TABLE 2.1. FUNCTIONS OF MANGROVE ECOSYSTEMS

	external (seaward)	internal (on-site)	external (inland)
REGULATION FUNCTIONS			
- attenuation of peaks in nutrient discharge and sediments	x		
- neutralization of potential sulphuric acids by frequent flooding		x	
- maintenance of coasts, river banks and tidal flats	x	x	x
- shelter from storms and surges			x
- maintenance of groundwater levels			x
PRODUCTION FUNCTIONS			
- enhancement of sedimentation	x	x	
- transformation of nutrients into vegetation and organic food	x	x	
- production of shell and finfish (breeding and feeding grounds)	x	x	
- enhancement of biological diversity (wildlife habitat)		x	
INFORMATION FUNCTIONS			
- genetic resources and evolution		x	
- aesthetic and recreational values		x	
- scientific and educational values		x	
- cultural values		x	
SUPPORT FUNCTIONS			
- waterways for transportation and communication		x	
- tidal flats as sites for agriculture and urban housing		x	

2.2.2. Neglected functions

non-marketable production

Economists tend to focus on marketable products and forget the production of basic commodities that are necessary for the daily subsistence of the local people. When full reclamation of mangroves for rice cultivation is achieved, local communities are deprived of their source of tannins, medicines, firewood and timber that were formerly provided by the mangroves. Obtaining similar products on local markets may be time-consuming and involve considerable costs; local people may not be in a position to buy products that were once provided free of charge by the mangroves.

non-tangible functions

Coastal protection against storms and erosion is one of the most important non-tangible functions of mangroves. The construction of a sugar factory near Conakry (Guinea) led to mangrove deforestation. As a result, the coast eroded rapidly, thereby threatening a large area of rice fields (LEBIGRE, 1987). Similar problems were encountered along the West Coast of Malaysia. While in Western countries economists try to calculate recreational, option and bequest values, cultural values are completely neglected in the developing world. The cultural identity derived from the mangroves, 'their land', strongly motivates rural communities in Irian Jaya to protest against clear-felling for woodchip production (VAN DIEPEN AND FISELIER, 1990).

off-site functions

There are strong correlations between the area of mangroves and shrimp catches (KAPETSKY, 1987) and it is widely accepted that mangroves contribute to off-shore fish production by providing breeding grounds to commercially interesting species and by 'outwelling' organic nutrients. Trapping of sediments contributes to the stability of coastlines and clears the water; this last function is vital for sea grass beds and coral reefs.

2.2.3. Mangrove utilization

utilization of mangroves at the ecosystem level

Man has searched various ways to utilize mangroves. Gathering of oysters and crabs, fishing and the utilization of mangrove firewood and timber are among the most important activities. In West Africa, a traditional form of 'mangal' agriculture has emerged. In Indonesia, artisanal forms of aquaculture ('tambak') have been practiced for more than two thousand years. Most of the aforementioned activities have been intensified during the last decades in order to meet a rising food demand. Other relatively recent interventions such as the construction of reservoirs and anti-salt barriers, the impoldering of large areas of mangrove swamps for agriculture and urban housing, and the conversion of mangroves into fishing ponds, have accelerated the overexploitation of mangroves. An extensive overview of interventions in and utilization of mangroves is presented in the 'Global Status of Mangrove Ecosystems' (SAENGER ET AL, 1983).

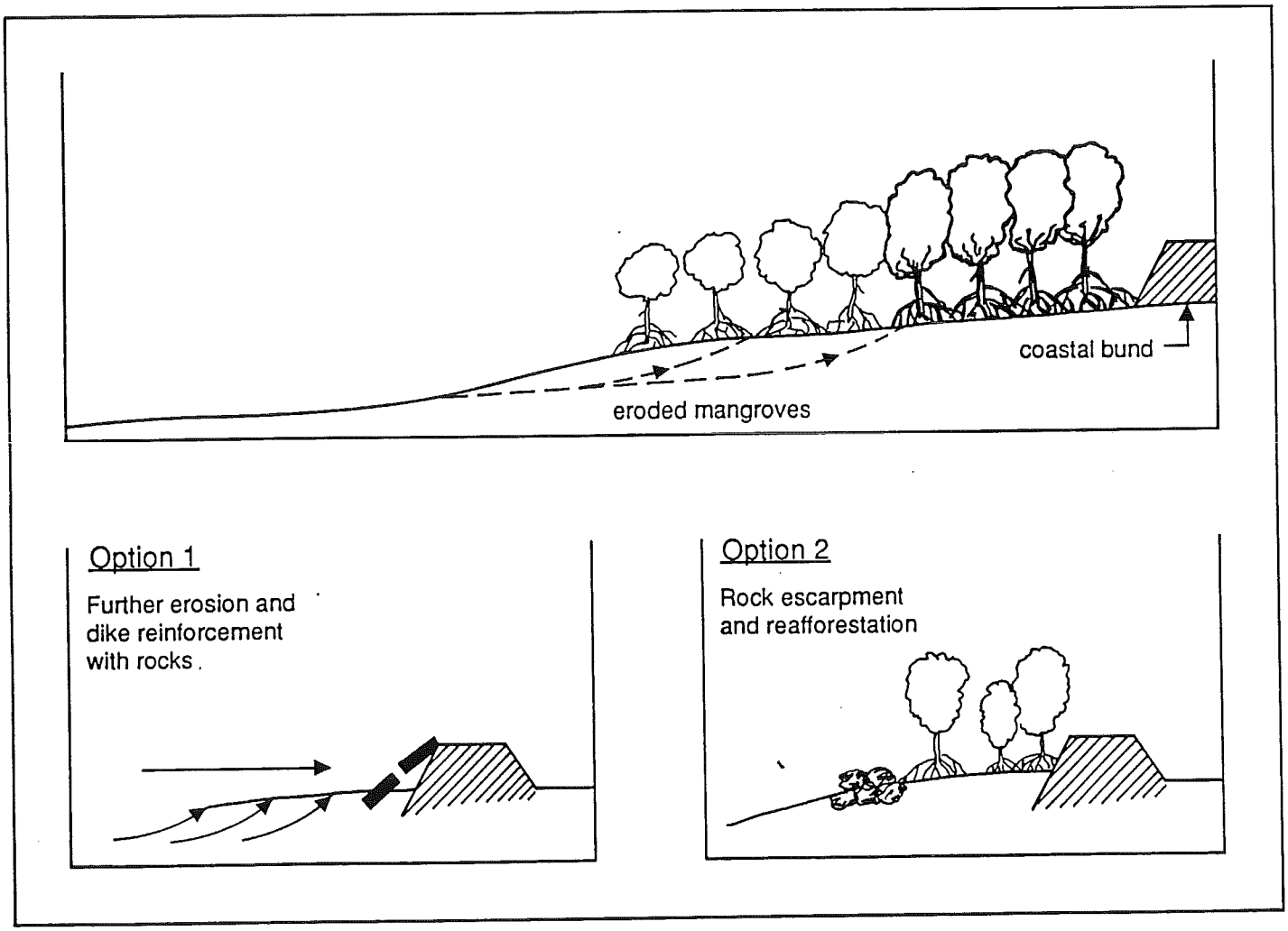
utilization at the household level

Different types of mangrove utilization can be observed among distinct ethic groups and among the households of

BOX 2.5. COASTAL PROTECTION IN MALAYSIA.

Early this century, hundreds of hectares of mangroves have been reclaimed along the West Coast of Malaysia. The reclaimed agricultural lands, mostly rice fields and palm plantations, are protected from seawater by a bund. Both erosion and accretion occur owing to natural processes but man-induced erosion also plays an important role. Along the eroding coast, tidal flats are first cut back; then, mangrove erosion begins. Once they are fully exposed to wave action, mangroves offer little resistance and the vegetation fringe may quickly disappear leaving the coastal bund open to the sea. Regulations require the preservation of a fringe of mangroves that is 100 metres wide along stable coasts and 400 metres along eroding coasts. The latter however is sometimes cut back within a decade. The bund itself is often constructed simply by buldozering clay and has little resistance. Without rock protection, it is soon eroded away. This has already been the case in several places.

The current policy consists in reinforcing the existing bunds with concrete blocks and rocks as soon as the wave-absorbing mangrove fringe has been eroded away. Lately a new technique has been adopted: a rock escarpment is built as soon as the mangrove fringe is reduced to 100 metres or less. This escarpment is less costly (about 700.000 MS/km, i.e. about 300.000 US$) than traditional bund reinforcement (1.300.000 MS/km) but has the advantage of maintaining a fringe of productive mangrove forests. However, its effectiveness has still to be proven. Nevertheless, coastal protection is extremely costly. Whenever erosion is stopped, it tends to move down the coast, thereby making it a continuous problem. Retreat bunds may well be the only feasible option in the future. Reforestation is undertaken together with coastal protection. Seedlings grow well in the shelter of escarpments.



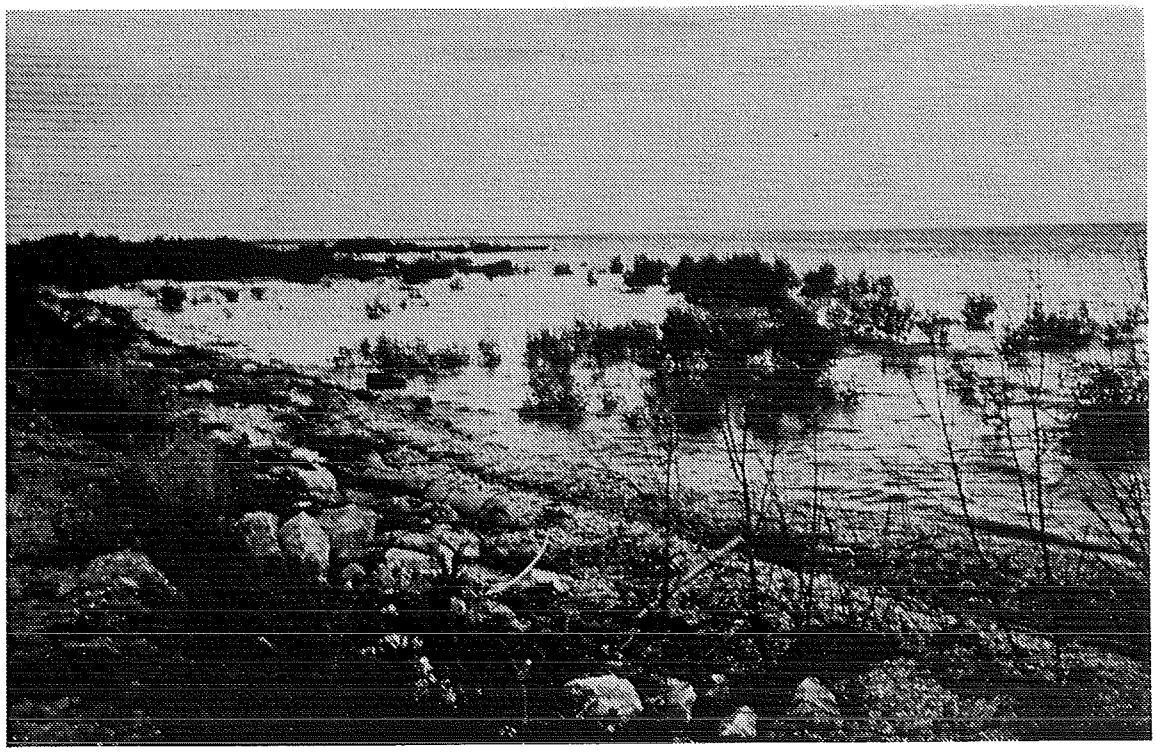


Photo Mangrove reforestation in the shelter of rock escarpments.

BOX 2.6. CULTURAL VALUES, BINTUNI BAY

Adapted from van Diepen and Fiselier (1990).

The Bintuni Bay area (Irian Jaya, Indonesia) belongs to the Irarutu tribe. In their perception, the land has been created by tribal heroes and handed over to them by the ancestors as a sacred legacy. This notion of ownership by-passes legal documents and land is not negotiable in the real sense; selling land is strange to them. Under the Indonesian Agricultural Law, traditional landownership is acknowledged; unfortunately there is no appropriate state institution that handles transfers of traditionally owned land.
'The various interests listed above [cultural values, values of forestry and fishery products] may not all of them sound equally important if taken separately. However, it is the sum of them that makes them momentous for the Irarutu tribe. What habitat is for flora and fauna is environment for the Papuan'.

At present, large timber companies have started to exploit this mangrove area for wood-chip production. They destroy a valuable resource while offering no compensation or jobs to the local inhabitants who, compared with people from elsewhere in Indonesia, are on the whole less skilled and enjoy different daily rhythm and work discipline. What springs to the fore is the poor adaptation capacity of the local communities when big business opens up in their neighborhood, and vice versa (i.e. the poor adaptation capacity of big industries when dealing with tribal communities). Van Diepen described the social disruption of the Irarutu tribe as observed during the first stages of logging activities, in these terms:

'The negation of their rightful landownership by intruding companies; the loss of resources for their daily living; their sacred traditions and scale of values being trampled; the great events 'in the beginning' and their annual feasts, constituting and regenerating reality, now being thwarted by devastating forces; their world, so painstakingly put into order by the tribal heroes, now, on the appearance of the greedy, all devouring foreigner, under their eyes falling apart into the original chaos; it's too much to bear! The loss of their world brings with it the loss of self, the loss of his identity.'

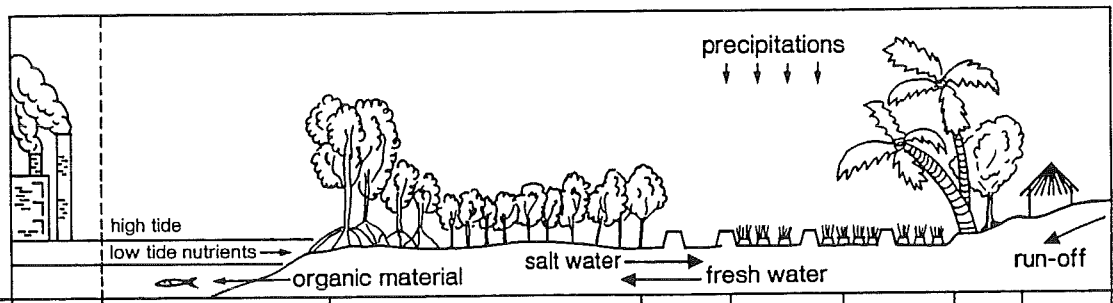
BOX 2.7. SOCIOECONOMIC DIFFERENTIATION IN MANGROVE UTILIZATION IN GUINEA BISSAU

Adapted from Fiselier and Toornstra (1987).

The land use system of the coastal communities in Guinea-Bissau consists basically of rice cultivation, fishing, gathering of natural products, rain-fed agriculture and off-farm activities. These various activities are divided between men and women, and between the old and the young; they are also carried out in different seasons. They are woven into a social network which enables households to overcome seasonal labour shortage, crop failures and even drought periods. Whenever environmental conditions deteriorate, more off-farm activities are developed in order to obtain the funds needed to purchase food.

The core activity is rice cultivation in reclaimed mangrove areas. The cultivation system is very labour-intensive since the extensive infrastructure (dikes, bunds and canals) has to be maintained and all ploughing is carried out by hand. Youngsters who are engaged in seasonal labour migration return to their village during agricultural labour peaks. However, rural life is less fulfilling and young people increasingly tend to remain in the city.

Figure Production systems and socioeconomic differentiation in mangrove utilization in Guinea Bissau (adapted from Fiselier and Toornstra, 1987).



Activities	Season wet	Season dry	Functions
dryland, rain-dependent agriculture	m		
housing	m	m	
palm trees, fruit trees vegetable gardens	w w	w	
rice fields with livestock	m/w	y/w	
fish ponds		w	buffer zone for brackish water
hunting		m	habitat for flora and fauna); genetic pool
mangroves and natural products such as wood, honey and medicinal products	w	w	trapping of nutrients; coastal protection
collection of oysters	w	w	
local fisheries	w	m/w	transportation of nutrients and organic material
industrial fisheries transportation			
labour (migrants), non-agricultural activities	y		

m = man w = woman y = youth

each group. Members of a household also use mangrove in different ways as men, women and youth usually perform different tasks. In Guinea Bissau, the farming system consists of mangrove utilization (wood, fish, oysters), 'mangal' rice cultivation, upland farming (mainly peanuts) and off-farm activities. While women are mainly involved in the gathering of wood, fish and oysters, the men engage in agricultural activities. Young men often are labour-migrants who only spend 2-4 months in their home area in order to help during labour peaks (VAN DER KLEI, 1986; CML/SECA, 1987). The integration of upland agriculture and off-farm activities is a common practice that is not limited to African coastal communities. Mangroves development should reckon not only with ecological aspects but also with socioeconomic relations that exist between these ecosystems and their users.

2.3. MANGROVES AS WILDLIFE HABITAT

2.3.1. Introduction

Mangroves provide important breeding and feeding grounds, and roosting sites to many wildlife species. Few of them, mainly birds but also species such as the Probiscus monkey (Nasalus larvatus), are strictly restricted to mangrove ecosystems. Many birds use mangroves as a roosting and breeding place and feed on adjacent tidal flats, shallow seas and rice fields.
Few thorough studies on mangrove wildlife are available; all have been carried out in protected areas. This explains why new studies carried out in other areas often reveal important wintering sites, bird colonies and even species that were unknown. For instance, a WIWO expedition to the Bijagos Archipelago discovered important wintering areas for the Black-tailed Godwit (Limosa limosa) (ALTENBURG, 1987); major colonies of Milky Stork (mycteria cinerea) were found breeding in the tidal swamps of Sumatra where an inventory was being carried out (SILVIUS ET AL, 1987); new species of shrimps and crabs have been found by teams investigating the extensive mangrove swamps of the Niger Delta (POWELL, 1985). This chapter gives a brief account of the importance of mangroves as a wildlife habitat. It only considers resident and migratory birds, reptiles and mammals.

2.3.2. Mangroves as a habitat for reptiles and mammals

Estuarine species such as the American alligator (Alligator mississippiensis), the Bata (Caiman crocodiles), the American crocodile (Crocodylus acutus) and the saltwater crocodile (Crocodylus porosus) are among the most threatened reptiles which are nowadays almost entirely restricted to mangrove environments (HAMILTON AND SNEDAKER, 1984). The highly endangered Manatee can still be found in small numbers in the estuaries of America (Trichechus manatus) and Africa (T. senegalensis). Different species of monkeys such as the Long-tailed macaque (Macaca fascicularis) and the Probiscus monkey (Nasalus larvatus), depend for their diet upon mangrove fruits and leaves and are therefore exclusively found in mangrove forests. For other mammals, mangroves constitute a last refuge. The Bengal tiger (Panthera tigris tigris) still rooms the extensive mangrove swamps of the Ganges Delta. Marsh antelopes (Sitatunga Tragelaphus spekei) still abound in the Bijagos Archipelago (Guinea Bissau). One of the remaining populations of hippos in West Africa is to be found in the mangrove forest of Guinea Bissau.

2.3.3. Mangroves as a habitat for resident and migratory birds

The presence of birds in mangrove areas is closely related to the proximity of adjacent lagoons, tidal flats, freshwater swamps, rice fields and salt pans that provide food to a variety of ducks, herons and waders.

migration routes
Tropical wetlands, and among them mangroves, are essential as wintering habitats to millions of migratory birds, especially waders. Their migration routes stretch along shores and strings of wetlands that function as stepping stones. Several flyways can be distinguished between breeding grounds and African, Asian/Australian and Central and South-American wintering quarters.

Some birds make long intercontinental flights while others seem to use several 'stepping stones' before reaching wintering and summering quarters (PIERSMA ET AL 1987). Normally, short-distance travellers are late in going to and coming from their winter quarters (KWAK AND STORTELDER, 1981). Before taking off for their winter or spring migration, birds have to store fat reserves in order to be able to fly considerable distances. Birds like the Bar-tailed Godwit (Limosa Lapponica) may gain 80 grammes in weight and loose them in 3 days of flight. This weight gain is barely enough to reach breeding areas or the next stepping stone (PIERSMA, 1987). If conditions are less favorable, fattening may take more time and birds will arrive late in their breeding quarters; this might affect breeding (CURRY-LINDAHL, 1981). Small, strategically located wetlands may be crucial for the wintering and breeding of these birds. What all water birds have in common is that they concentrate in few and relatively small wetlands during their migration and wintering. This makes them very vulnerable compared to other groups of birds.

The availability of food in January, February and March is thought to be vital to Palearctic birds as they have to fatten before flying northwards again. During this period, birds in the Sahel are joined by those that have their winter quarters in southern Africa and use the Sahelian wetlands to gain weight before crossing the Sahara and the Mediterranean. In dry years, the flood duration is shorter (ROUX AND JARRY, 1987) and rice fields which often are the only remaining wetlands, become more attractive (BALK AND KOEMAN, 1984).

rice fields
Research by Altenburg & Van der Kamp (1985 and 1986) and Tye & Tye (1987) conducted along the West coast of Africa, revealed the importance of 'mangal' rice fields as a foraging ground for many waders, especially the Black-tailed Godwit and Ruffs (Philomachus pugnax). The largest bird numbers were observed in slightly brackish rice fields that had a relatively open rice vegetation. Numbers were much lower in more densely vegetated rice fields. These results reflect similar research conducted in other rice fields (TRECA,1975) and observations made in Asia.

The attractiveness of rice fields to waders is mainly due to the availability of rice grains and the presence of invertebrates, which are apparently very vulnerable to the use of pesticides (VERWEY ET AL, 1986). An intensification of rice cultivation, resulting in dense stands of rice will lead to lower bird numbers. This will especially affect larger herons and waders.

tidal flats
Wolff (1989) calculated an average of 200.000 waders/day/km² for the tidal flats of Africa that have an average dry biomass productivity of 5 to 10 grammes/m². The comparison with European tidal flats, with an average of 120.000 waders/day/km² and a dry biomass productivity of about 25 grammes/m², stresses the importance of African tidal flats. Tidal flats such as those occurring in the Bijagos Archipelago (Guinea Bissau) harbour large numbers of waders although food availability is relatively low (ZWARTS, 1988). While in Guinea Bissau waders stayed at 100 to 200 metres from people gathering oysters and snails, Tye & Tye (1987) noted that in Sierra Leone this distance was reduced to 20-40 metres probably because of a lower hunting pressure.

salt ponds
Several authors mention salt ponds as important feeding grounds for waders. According to Hussain (1987), shallow lagoons with low salinity levels provide the best feeding opportunities in the Vedarranyam Swamp in Tamil Nadu (India). Two of the three most important wader sites in Ghana consist of a combination of mangroves and active salt pans (NTIAMOA-BAIDU AND GRIEVE, 1987). In southern Thailand, salt pans are temporarily taken out of production in order to attract birds for hunting purposes.

BOX 2.8. HABITAT OF BIRDS IN WEST AFRICAN MANGROVES

The West Coast of Africa, which is characterised by the presence of mangrove forests in combination with extensive tidal flats and rice fields, is among the most important wintering quarters in Africa. The mangrove ecosystem of West Africa consists of the following components:

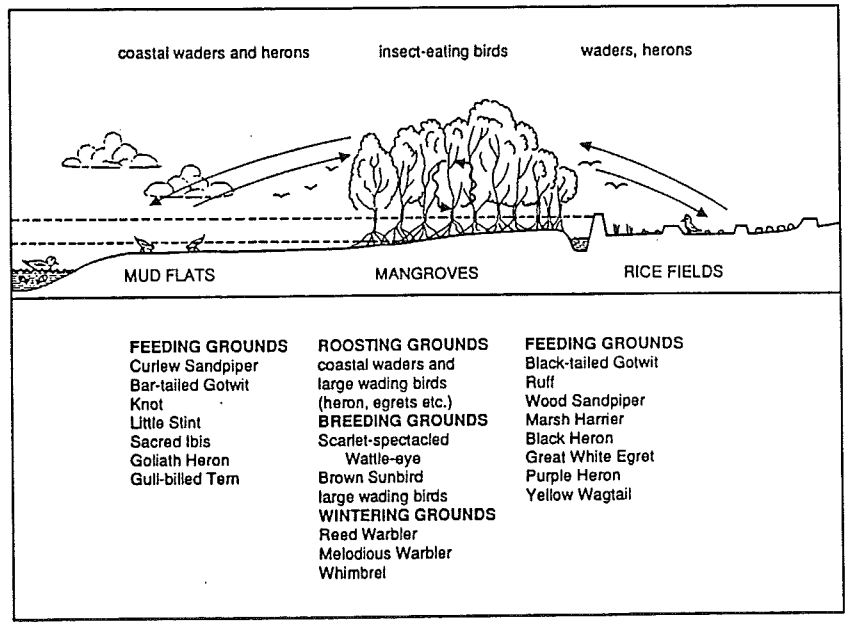
1. **tidal flats** function as a feeding ground for resident and migratory waders. Examples of resident birds that can be found foraging on tidal flats are the Long-tailed Cormorant (Phalacrocorax africanus), the White-necked Stork (Ciconia episcopus), the Wood Ibis (Mycteria ibis) and the Sacred Ibis (Threskiornis aethiopicus).

2. **mangrove forests** function as a breeding and roosting site for birds that feed on tidal flats and rice fields; few birds are restricted to the mangrove itself and these mainly are insect-eaters. Examples of resident birds that fish in mangroves are the Green Heron (Butorides striatus), the White-backed Night heron (Nycticorax leuconotus), the African River Eagle (Haliaeetus vocifer) and the Kingfisher (Ceryle rudis). Insect-eaters such as the Mangrove King Fisher (Halcyon senegaloides), Shrikes (Laniidae), Sunbirds - e.g. Brown Sunbird (Anthreptes gabonicus) - and Flycatchers such as the Scarlet-spectacled Wattle-eye (Platysteira cyanea) are also found breeding and foraging in African mangroves.

3. **rice fields** function as a feeding ground for waders that feed on either small invertebrates or rice grains; during the dry season these fields dry out and become unattractive to birds. The (grey) Pink-backed Pelican (Pelecanus rufescens), the Hammerkop (Scopus umbretta) and the African Spoonbill (Platalea alba) mainly fish in adjacent rice fields and freshwater swamps, but roost within the mangroves. Rice field constitute the most important feeding grounds for the migratory Black-tailed Godwit (Limosa limosa).

4. **salt flats** mainly function as a high water roosting site for waders.

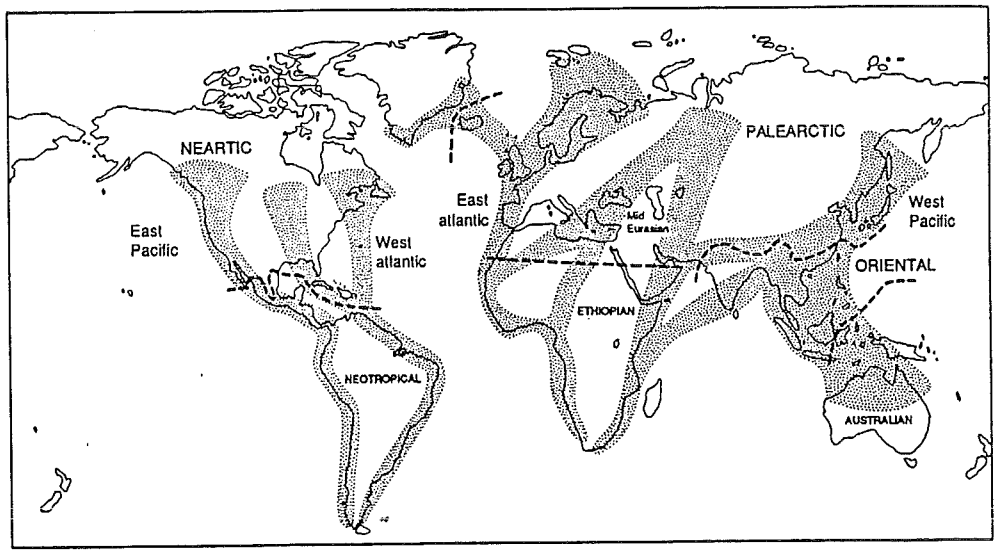
Figure The essential role of mangroves with respect to resident and migratory birds (Altenburg and Fiselier, in this report).



BOX 2.9. MAJOR FLYWAYS

Several flyways can be distinguished. The Indo-Asian Flyway connects northern India with the Indian Peninsula; the Eastern Asia Flyway stretches from Siberia and Japan to southeast Asia (PARISH ET AL, 1987; CURRY-LINDAHL, 1981; McCLURE, 1974). Among the main wintering quarters in Asia are the river valleys of the Red River, the Mekong, the Chao Phraya, the Irrawaddy and mangrove areas in Indonesia, Thailand and Malaysia. Most shorebird species breeding in northern America have their wintering sites in Central and South America. These sites are connected by different flyways stretching along the west and east coasts (MYERS ET AL, 1987; MORRISON AND MYERS, 1987). In America, the coasts of Mexico and Suriname are important wintering areas (MYERS ET AL, 1987). The Western Atlantic flyways cross the Mediterranean at Gibraltar following the coast of West Africa and proceeding along the coast as far as South Africa, or come over Sicily and cross the Sahara in direction of Lake Chad, eventually reaching the Gulf of Guinea. In West Africa, the flyway stretches along a string of coastal wetlands. Among these, the Banc d'Arguin (Mauritania), the Senegal Delta, the Sine Saloum, the estuaries of the Gambia and Casamance rivers, and the Coast of Guinea Bissau are the most important. Further south, the coast changes in appearance and a multitude of lagoons in Sierra Leone, Liberia, Ivory Coast, Ghana and Nigeria are important stepping stones and wintering quarters to herons and sterns. Another major route follows the eastern coast of the Mediterranean and then the Nile Valley and the lakes of the Rift Valley (SUMMERS ET AL 1987). While many migratory birds remain in the wetlands of West Africa, some birds fly further south, as far as southern Africa. In West Africa the floodplains of the Senegal Delta and Valley, the Niger Inner Delta, the Logone floodplain, Lake Chad, Lake Fitri, the Banc d'Arguin and tidal flats and mangroves of Senegal and Guinea Bissau are the most important wintering areas (JARRY ET AL, 1987).

Figure Flyways and zoogeographical regions (NOME, 1982).



2.3.4. Present status and protection

Ramsar and other wildlife conventions

The Ramsar Convention was created for the preservation of wetlands of international importance, especially as a waterfowl habitat. In 1986, it had 43 contracting parties and 352 listed sites covering a total of 21 million hectares (SMART, 1987); the Convention now counts 52 contracting parties that have designated 445 sites (covering 29.510.841 ha) for the Ramsar list (pers. com. J. Harrison). Within the framework of the Ramsar convention, criteria were developed for the selection of 'Ramsar sites'. According to these criteria, a 'Ramsar site' should at least contain 20.000 water birds or at least 1 % of the total population (ATKINSON-WILLES, 1976: PRATER, 1976). Unfortunately these criteria do not take into account the size of the wetland in question (SAEIJS & BAPTIST, 1977) and the duration of the period during which the birds stay in this wetland (WOLFF, 1989).

Other conventions that contribute to the protection of wetlands and wetland species are CITES (Convention on International Trade in Endangered Species of wild flora and fauna), the World Heritage Convention and the Bonn Convention. In the future, these two last conventions may play a more important role in the protection of mangroves (SMART, 1987).

the status of African mangroves

Areas of virtually virgin mangrove forests still exist in West Africa, the Gulf of Benin and along the coast of Madagascar. Many mangroves are however threatened by impoldering, anti-salt barriers, deforestation, mining and pollution (CML/SECA, 1987). Impoldering and the construction of anti-salt barriers have already led to the conversion of thousands of hectares of mangroves in Senegal, Guinea Bissau, and Guinea Conakry. The mangroves of the Gulf of Guinea are the scene of intensive oil exploration; large tracts of mangroves are destroyed by dredging and oil-pollution resulting

from shipping activities and occasional tanker incidents. Deforestation in mangrove areas is serious near urban centres such as Banjul (The Gambia), Lagos and Port Harcourt (Nigeria) and in regions where, owing to domestic salt production, firewood demand is high (Benin, Ghana) or where other forest resources are scarce (Senegal).
Many African countries with important mangrove forests (e.g. Guinea Bissau) have not signed the Ramsar Convention yet. The very important coast of Guinea Bissau is not protected at all and a similar situation prevails along the entire West Coast. Only a small acreage of mangroves are protected within national parks and nature reserves e.g. Parc National de Casamance and Parc National du Delta du Saloum (Senegal), the Sankwen River estuary in the Cestos-Sankwen National Park (Liberia), and the Parc National du Banc d'Arguin (Mauritania) or other Forest Reserves where Avicennia africana is present (CML/SECA, 1987).

A protection network such as the Western Hemisphere Shorebird Protection Network (see box 2.10.) is unfortunately still missing in the Eastern Hemisphere. There are however two examples of twinning that resulted from cooperation between WWF, the French Ministry of the Environment and the Mauritanian Government - these three parties cooperate within the framework of the Fonds International du Banc d'Arguin - and between the RSPB, ICBP and the

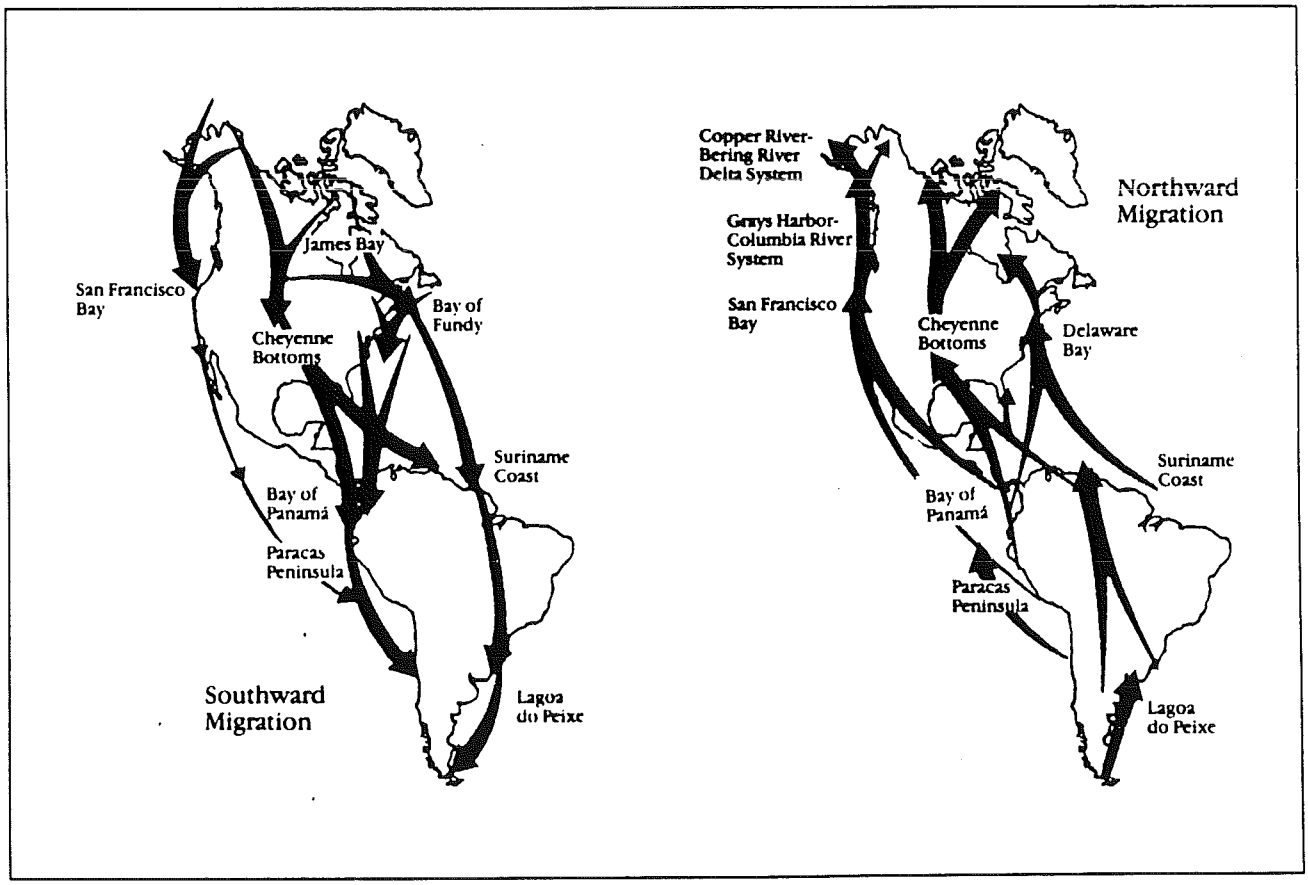
BOX 2.10. THE WESTERN HEMISPHERE SHOREBIRD RESERVE NETWORK (WHSRN)
Based on WHSRN (n.d.) and WHSRN (1988).

WHSRN is a voluntary collaboration of government and private organizations that are committed to shorebird preservation. The network was launched in 1985. In 1987, 5 national agencies as well as 32 state or provincial wildlife agencies from North and South America made commitments to support the network.

The WHRSN gives international recognition to critically important shorebird habitats and promotes cooperative management and protection of these sites by linking them into a chain stretching from the breeding grounds in the Arctic to the wintering grounds near the southern tip of South America. When becoming a part of a the network, a site gains international recognition; this may in turn generate support to local wetland management efforts.

Sites can be nominated by wildlife agencies, resource managers and landowners. The WHSRN council reviews these nominations and evaluates their importance to shorebird populations. Membership in the network and participation in its projects are wholly voluntary, and management authority and priorities remain the prerogative of the land administrator.

Figure Important sites in the reserve network (adapted from WHSRN, n.d.).



Government of Ghana that joined forces in the conservation of seabirds and shorebirds (HEPBURN, 1987).

the status of Asian mangroves

Asian mangrove forests are under heavy pressure from pollution, conversion for agriculture and aquaculture, and deforestation. The severe pollution problem due to heavy shipping in the Strait of Malacca calls for international action. Aquaculture and rice cultivation are among the most important forms of mangrove conversion in most Asian countries, especially in the Philippines, Thailand and Indonesia. Deforestation has already devastated large mangrove forests in Malaysia and Indonesia. Clear-felling for woodchip production is one of the main causes of deforestation and concessions still are being given in one of the last remaining extensive Asian mangrove forests in Bintuni Bay (Irian Jaya) (VAN DIEPEN AND FISELIER, 1990; AWB, 1989). The effects of fresh water diversion by dikes is less documented. The construction of the Farakka dam on the Ganges may have reduced the vitality of the Sundarbans mangroves in Bangladesh (POTKIN, 1987, 1988).

The protection status of mangroves in Asia is slightly better than in Africa. Although there are few strict nature reserves, most mangroves have been designated as Protection Forests (e.g. Indonesia) or Forest Reserves (e.g. Malaysia) and fall under the responsibility of Forest Departments.

The status of American mangroves

In America, conversion of mangroves for aquaculture is the most important threat to mangrove forests, especially in Ecuador and Venezuela. Large tracts of untouched mangroves still exist in Mexico, Costa Rica, Panama, Suriname and Brazil.

In 1985, on the initiative of the International Association of Fish and Wildlife Agencies and the World Wildlife Fund, the Western Hemisphere Shorebird Reserve Network (WHSRN) was established. WHSRN provides a framework in which many public and private organizations collaborate. Its purpose is to safeguard all necessary breeding, wintering and migration habitats (MYERS ET AL, 1987). Within the network, important breeding and wintering habitats are twinned and the mutual protection of the twinned areas is promoted. So far the network has proved to be very successful and a substantial part of all relevant American wetlands, including important mangrove areas, has been brought within the network.

3. OVERVIEW OF MANGROVE RESOURCES AND THEIR USE

This chapter gives an overview of all known forms of mangrove utilization, both in reclaimed and non-reclaimed areas. These activities are briefly described and compared in terms of sustainability, suitability to people's priorities and potential with respect to the preservation of biological diversity.

3.1. MANGROVE RESOURCES

3.1.1. Forest resources

general

The wood of most Rhizophora and Avicennia species is used as firewood. Taller trees such as Rhizophora, Bruguiera and Ceriops are used as timber; most Avicennia trees are too small and too vulnerable to fungi and therefore, not suitable for timber production. The use of mangrove wood for pulp production is limited to Asian countries where it has recently appeared. The leaves of mangroves are used as dry-season fodder and green manure especially in semi-arid regions such as Senegal, Guinea Bissau (BLASCO, 1975) and the Gulf of Kutch, where other sources of fodder are lacking. Mangrove fruits and seeds form part of the diet of rural communities and tannins and medicines are extracted from the bark of Rhizophora. Honey production is found in areas with blossoming Avicennia trees.

Wood production varies according to environmental conditions, logging activity and mangrove species. Average annual increments vary between 4 and 7 m^3/ha/yr (e.g. Matang forest, Malaysia; Ranong area, southern Thailand), the lowest figures being obtained under semi-arid climates in areas with limited supply of fresh water and nutrient-rich sediments, and low tidal activity.

mangrove forestry

Forest management is absent in Africa and relatively new in Central and South America but well established in many Asian mangrove forests (e.g. Malaysia, Thailand, Bangladesh). In Africa, forestry practices are usually based on the selection and felling of the most suitable trees, which leaves gaps of variable size in the mangrove forest. Only the main stems of the trees are taken away. The remaining slash makes the mangroves almost inaccessible, thereby hindering future use and natural regeneration. In Thailand, forestry is practiced in strips of Rhizophora stands with a rotation cycle of 30 years; in Malaysia (Matang), thinning is carried out twice within a period of 30 years (FRISK, 1984) and trimming of Avicennia occurs every 3-10 years.

Natural regeneration is poor when seed bearers (mother trees) are absent, the soil has dried out, or when Acrostichum ferns invade the available space. Regeneration is also poor in sites with high wave energy. Large tracts of Sabah mangroves never recovered after being clear-felled for wood-chip production (FAO, 1985). The Government of Sabah banned the export of wood-chips in 1986 after clear-felled mangroves did not show any sign of recovery. Artificial reforestation needs seed collection, storage, planting and is therefore costly. In Indonesia concessions consist of a production zone and a protection zone, the width of the latter being 200 metres on the coast and 50 metres along inland creeks and rivers. Regulations require that 40 seed trees should be left per hectare and that 2.500 seedlings be planted after felling (FAO, 1985).

In the Matang forest, after three rotations (each of 25 - 30 years) of pure Rhizophora stands, a drop in yields and poor natural regeneration have been observed (TANG ET AL, 1984). There are however no problems with natural regeneration in the Sungai Merbok Mangrove Forest Reserve (Peninsular Malaysia) where no mono-specific stands are planted (ONG, 1982).

Deforestation of mangroves is frequently observed near urban centres and along semi-arid coasts where inland wood resources are scarce. In Benin and Ghana, the use of mangrove wood for salt extraction nearly led to the complete disappearance of mangroves (CML/SECA, 1987). Deforestation is however also a problem in the more humid parts of Asia as a result of clear-felling by national and multinational timber companies. Law enforcement in these remote areas is often poor and forest regulations meant to ensure regeneration often are neglected.

The interests of local mangrove dwellers and timber companies are often conflicting (see also VAN DIEPEN AND FISELIER, 1990). The delineation of commercial forestry concessions fails to reckon with the traditional use rights of local communities. Designation of traditional use zones such as the 'bagan' areas in the Matang mangrove, Malaysia, has occurred in few cases only.

Although mangrove forestry can be carried out at an ecologically sustainable level, it should be noted that, for some birds, mono-specific stands of comparatively young mangrove trees are less suitable as roosting and breeding sites.

mangrove wood utilization

timber and logs

Logs in Indonesia are mostly derived from Heritiera littoralis, Ceriops spp. and Xylocarpus spp. (SOEGIARTO AND POLUNIN, 1980). Timber in Africa is usually provided by Rhizophora spp. Poles are used for building houses and walkways but also for furniture, and larger trees for the building of canoes.

charcoal production

Charcoal production is important in most Asian countries but nearly absent in Africa (CML/SECA, 1987). For the production of one cubic metre of charcoal, more that 2 m^3 of mangrove wood are needed. The efficiency of kilns in Malaysia was reported to be only 27% and may be improved (MAHMUD, 1984). In Thailand, 387.000 m^3 of charcoal is produced annually (HAMILTON AND SNEDAKER, 1984). Mangrove species used are Rhizophora spp., Bruguiera spp., Avicennia spp. and Ceriops spp. Charcoal manufacturing is labour-intensive and occurs on a small scale but it is often controlled by entrepreneurs who bid on forest concessions. Charcoal production is profitable, but initial costs are high owing to the construction of kilns that are reported to pay off only after 8 years (FAO, 1985). The production of charcoal also needs management and technology.

wood-chip production

The felling of mangroves for the production of wood-chips is a new phenomenon in South-East Asia. The clear-felling, a sort of mining, of (mainly) Rhizophora apiculata has already caused the destruction of large mangrove forests in Sabah (LIEW, 1977) and Sarawak (CHAI, 1980). Regeneration after clear-felling is very poor. Other species used are Sonneratia spp. and Excoecaria agallocha. At the moment, large concessions have been given to national and multinational timber companies for wood-chip production in Irian Jaya. These companies often employ people from outside and create considerable social unrest among coastal communities, or only offer temporary employment.

BOX 3.1. MATANG FORESTRY

Partly after Chan (1986).

The 40.000 ha of the Matang Forest Reserve are at present in their third rotation cycle of 30 years. Each cycle includes the following steps:
- after felling the trees, the slash is left for 2 years to rot; mother trees and fringes of mangroves that have been left aside, allow natural generation;
- Agrorostis ferns may have to be destroyed using chemicals before seedlings can be planted in order to fill in the gaps where no natural regeneration occurs; Rhizophora conjungata is preferred for the good quality of its wood, but R. mucronata is also used in deep water sites;
- after 15 years, a first thinning is carried out (with a 1,20 m long stick); a second thinning occurs after 20 years (with a 1,80m long stick);
- after 30 years all trees are felled with the exception of some mother trees and a fringe of mangroves along the creeks.

The trees are felled by small teams consisting of 3 men equipped with a boat. In deep water sites, the trees are cut at low water and loaded into boats at higher water levels. In higher parts that remain dry for longer periods, a wooden pathway is constructed and the poles are wheeled to the boat using wheelbarrows. The workers (i.e. pole contractors) receive 0,40 to 0,60 US$ for each pole. Poles are sold at a price of 0,70 - 1,50 US$ a piece. A worker can collect 30 to 40 poles a day and work 15 to 20 days a month. In the case of charcoal contractors, each worker needs about 2 days to load a boat with a capacity of 150 pieces to be used for charcoal production. For this he is paid 60 US$. Considering that he works more or less 2 weeks in a month, he can earn about 420 US$. There are at present 75 registered pole contractors and 55 charcoal contractors in the Matang mangroves.

PHOTO A Mangrove poles ready for transport after the first thinning (15 years after the beginning of operations).

PHOTO B Felling and loading of mangroves in a deep water site.

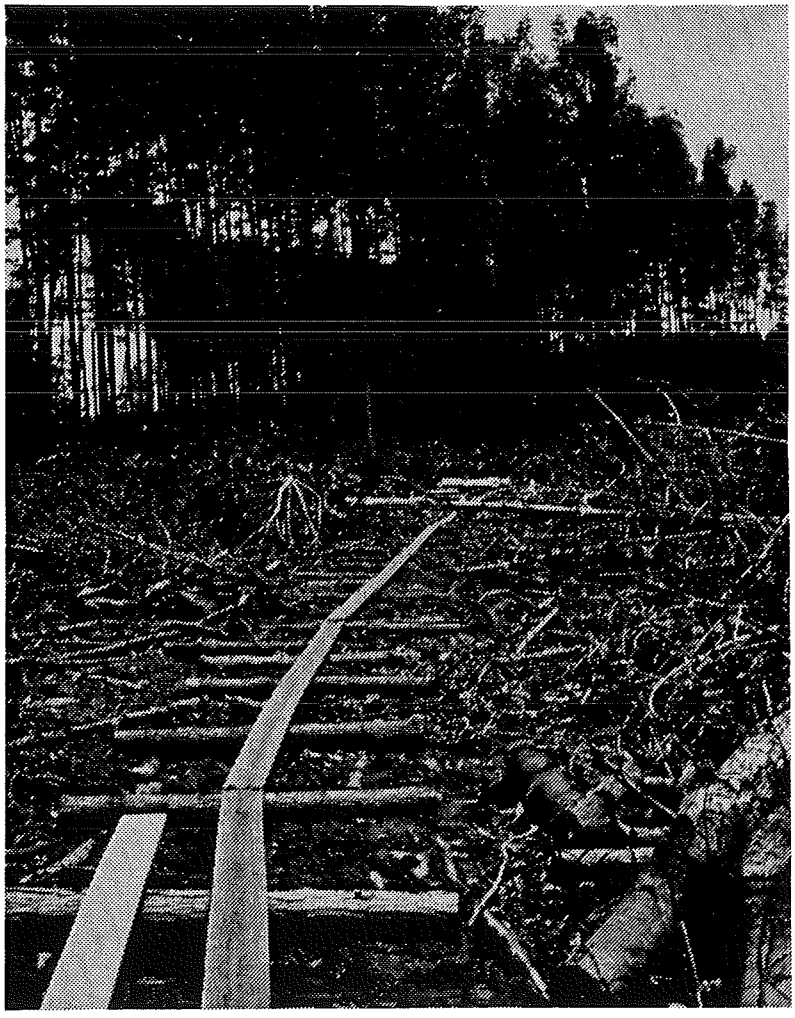


PHOTO C Felling of mangroves in a shallow water site, using wheelbarrows and wooden pathways.

BOX 3.2. MATANG CHARCOAL MANUFACTURING

Partly after Chan (1986).

Most of the wood cut in the final felling is used for the manufacturing of charcoal. Large kilns - usually 6,7 metres in diameter - are filled with up to 40 tons of wood and heated for 4-5 days. Kilns are then closed for 20 to 25 days to allow carbonization of the wood. Thus, 40 tons of green mangrove wood generate 10 tons of charcoal. The Matang charcoal is exported as far as Singapore and Hongkong; its market price is about 150 US$/ton.

PHOTO A Charcoal kiln.

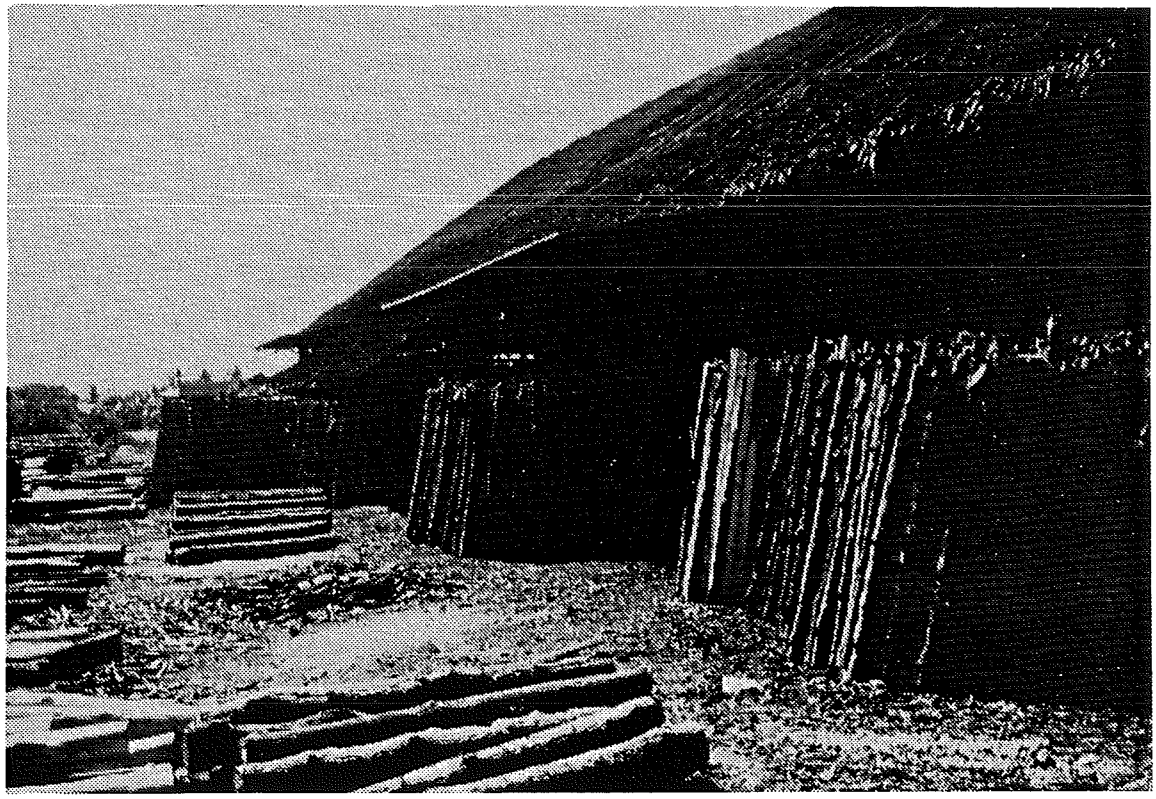


PHOTO B Mangrove wood ready for charcoal manufacturing.

non-wood utilization

tannins

Rhizophora barks produce tannins that are not broken down by ferments and consequently are suitable for the tanning of hides. Tannins are produced in virtually all mangrove areas. In Costa Rica, 'mangleros' only fell the largest Rhizophora trees with the thickest bark causing substantial damage (FAO, 1988). Instead, barks should be seen as an additional side-product of forest operations.

Nipa palm cultivation

Nipa palm (Nypa fruticans) is extensively used and cultivated in Asia. The leafs are used for the construction of walls and baskets. It was introduced early this century in West Africa where it is however considered a nuisance instead of a blessing. In addition to not being used by the local people, it competes with Rhizophora which provides a better substrate to oysters and a better protection to riverbanks (CML/SECA, 1987). However, nipa alcohol production in plantations can amount to as much as 18.000 l/ha/yr under optimal conditions and management, more than thrice the alcohol production of sugarcane (HAMILTON AND SNEDAKER, 1984; JARA, 1987). Nipa leaves are also used for producing cigarette-wrappers in Peninsular Malaysia (CHAN, 1986).

honey production

Most mangrove forests have a potential for honey production if they include flowering species like Ceriops, Aegialitis rotundifolia and Cynometra ramiflora (HAMILTON AND SNEDAKER, 1984). According to the FAO (1982), the average annual production of the Bangladesh Sundarbans reached 177 tons of honey and 49 tons of beeswax between 1957 and 1977. Local honey production in West Africa is based on Avicennia sp. (CML/SECA, 1987). In Coronie, near the mouth of the Suriname River, and at Matapica approximately 50 beekeepers harvest a total of 30.000-35.000 litres of honey per year (see case study on Suriname). Sophisticated forms of honey production in the southwest of Florida are based on black mangroves (Avicennia germinans) and yields amounting to 0,2 and 0,5 kg/ha/yr make it a profitable enterprise. Implemented on a small scale, it may provide food and income, while involving limited investments and causing no damage to the mangrove ecosystem. It can be practiced by both man and woman.

mangrove fodder and grazing

Mangrove foliage is used as stall feeding and mangrove forests as dry-season pasture. Mangrove foliage equals alfalfa in fodder quality (JANICK et al, 1981; MALIK et al, 1966). It is rich in proteins and contains all necessary minerals. Although grazing of mangroves is quite rare, examples of serious overgrazing do occur along the coast near the Indus Delta in Pakistan. Here a large herd of camels uses the mangroves (Avicennia marina) as dry-season grazing. Mangroves that once consisted of medium-sized trees have meanwhile been reduced to partly defoliated forests and shrub lands (HAMILTON AND SNEDAKER, 1984).

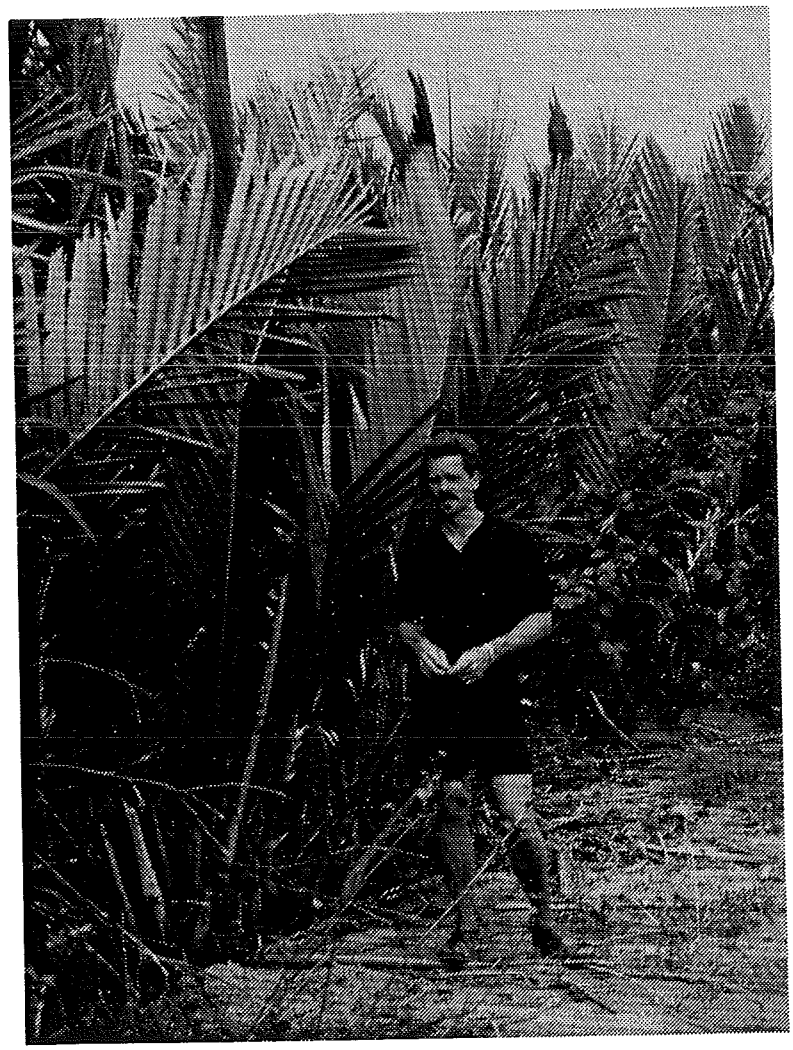


PHOTO Nipa palm Malaysia.

3.1.2. Aquatic resources

general

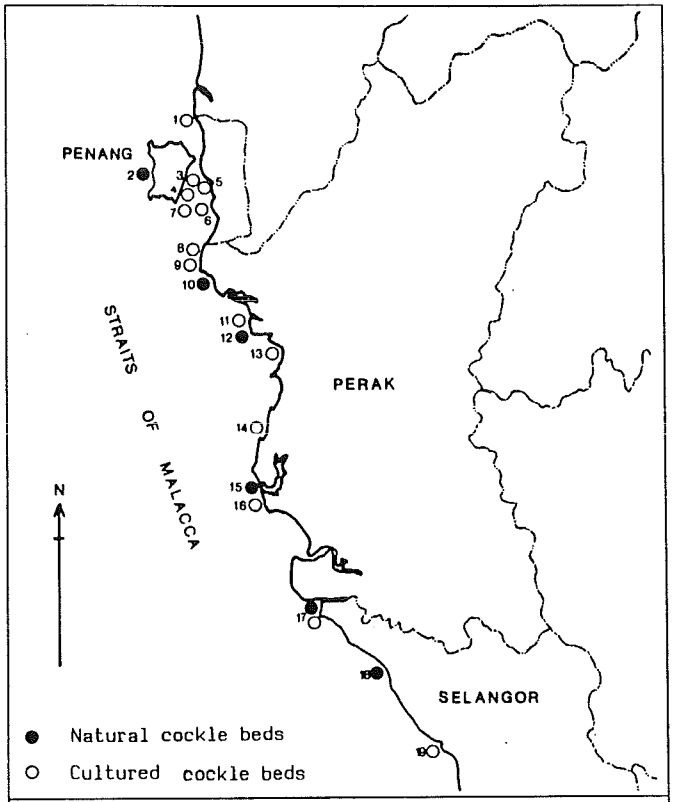
The exploitation of aquatic resources knows a great variety in level of inputs, technology, management and conversion of mangroves. Gathering of oysters, crabs and cockles, and artisanal fisheries and open water aquaculture leave mangroves untouched. Artisanal fishponds require mangrove conversion but depend upon food and fry provided by the mangroves. Pump-equipped modern aquaculture ponds are stocked with artificially bred fry and do not depend on mangroves.

Shallow water bodies within mangrove swamps are the most important fish habitats. Kapetsky (1985, 1987) noted an average fish production of 91 kg/ha/yr with a highest production that can reach 225 kg/ha/yr in mangrove-associated coastal lagoons and estuaries. Mangroves are vital not only to estuarine fisheries but also to ocean fisheries. It is estimated that 80% of all marine species of commercial and recreational value depend upon mangroves for at least a part of their life cycle (HAMILTON AND SNEDAKER, 1984).

BOX 3.3. COCKLE CULTURE IN MALAYSIA

Adapted from Chan and Sallah Mohd. Nor (1987).

Since 1948, the cultivation of cockles has evolved into the most important coastal aquaculture industry in Malaysia and is essentially practiced along the West coast of Peninsular Malaysia. Cockles are harvested from natural and artificial cockle beds. The latter are sown with spat collected from natural spatfall areas. Spats are collected when they have attained a diameter of 4 to 10 mm. A skilful worker can collect seven to eight tins of about 120 kg of spat per day, each worth 6 US$. After 10 to 12 months, the cockles have attained a size of 24 to 34 mm and they are collected with a scoop. Within a period of 5 - 6 hours a man can harvest 10 to 12 bags, each weighing 65-70 kg and being worth 1,20 US$. In 1979, the total production exceeded 63.000 tons.



1. Kuala Muda
2. Sg. Pinang
3. Glugor
4. Batu Maung
5. Kuala Juru
6. Kuala Jejawi
7. Pulau Aman
8. Sg. Udang
9. Tg. Piandang
10. Kuala Kurau
11. Kuala Gula
12. Tg. Kuang
13. Matang
14. Sg. Triang
15. Kuala Jarum Mas
16. Pantai Renis
17. Bagan Pasir Laut
18. Tg. Karang
19. Kuala Selangor

FIGURE Location of major natural and artificial cockle beds, West coast of Malaysia.

gathering and rearing of shellfish

The gathering of crabs, oysters and cockles is an important source of protein and income. Most crabs are edible but few actually are eaten owing to inadequate size, parasites or taboos (GUINOT, 1966). Scylla serrata and Callinectes latimanus are much appreciated in Africa (CML/SECA, 1987). In the Philippines, 16 species of sea cucumbers are harvested (ALCALA, 1982). Jelly-fish are also appreciated by some communities.

Shellfish are normally restricted to locations with limited variation in salinity. Oysters grow on stilt roots and are easily collected at low tide. Crassostrea gasar in West Africa and C.sucullata in East Africa are gathered and sold in small amounts (CML/SECA, 1987) but nevertheless represent an important economic activity, especially for women. In most countries, cockles are harvested on mud flats at low tide.

shellfish cultivation

In Asia (e.g. Thailand and Malaysia) the spat of some cockles (Anadara granosa) is collected and sown on mud flats without natural spat (FAO, 1985). The culture of cockles is practiced in small farms. The cultivation of oysters on fences (Crassostrea lugubris and Saccostrea commercialis) covers more than 7.100 ha in Chanthaburi Province (Thailand) alone.

In Thailand, Green mussel farming is practiced on more than 10.000 ha with an average yield of 62,5 tons/ha (POTAROS ET AL, 1987). Occasionally, crabs are artificially bred, e.g. in the Philippines and Thailand (Scylla serrata), but their digging activity presents management problems. In Africa, shellfish cultivation is nearly absent.

The farming of oysters is practiced only in South-East Asia and in South America although all mangrove coasts do have a potential (KAMARA, 1982; VAN SOMMEREN AND WHITEHEAD, 1961). In Asia (Philippines), America (Brazil, Venezuela) and Australia, oysters are cultivated on an artificial substrate (ropes, rafts). The cultivation of molluscs, e.g. Crassostrea lugubris and C.commercialis, might be interesting for human consumption (POWELL, 1985).

artisanal fisheries

Most forms of artisanal fisheries are adapted to the rhythm of the tides, and based on the corresponding movements of fish populations. Gill nets, beach seine nets, bow nets, drag and cast nets and fishing lines are used. Fixed fish traps, normally baskets or a set of nets, are build into creeks (SAMARAKOON, 1987). On mud flats, trenches (Cameroon) are dug or stone walls (Guinea Bissau) erected to trap the fish. Catches mainly consist of Cichlidae (Tilapias) and Clupeidae. Locations equipped with fixed gears are often individually owned while open water belongs to communal village grounds.

PHOTO Fixed gear.

industrial fisheries
Industrial fishing with trawlers started in the 60s and 70s in most developing countries. They can be specialized in shrimps or pelagic fisheries. Using modern technology and high capacity catching devices, industrial fisheries put a tremendous pressure on resources. In almost every country, this has led to overfishing and coastal trawlers often have fished themselves out of business.

Owing to depleting fish resources, trawlers start roaming estuarine and shallow coastal areas that have always been the traditional fishing grounds of coastal communities. Serious conflicts occur nowadays between artisanal estuarine fisheries and trawlers who come close to the shore. Often local communities are impoverished when the fishing industry takes off. Modernization will benefit coastal communities only if boats are owned and manned by these communities itself.

artisanal "open water" fish culture
Traditional forms of aquaculture ("in open water") do not involve any form of mangrove conversion. Instead, they use creeks and estuaries within the mangroves. In its most basic form, this type of culture depends upon the fry and food produced by the mangroves. Gears are preferably constructed in wave-sheltered places with moderate tidal flows. Some techniques merely consist of blocking the upper reaches of creeks with nets, others involve additional feeding. The "acadjas" in Western Africa (Benin and Ghana) are enclosures of branches and fishing gear; they function as a shelter against predators, provide substratum for periphytic algae and form suitable spawning grounds (WELCOMME, 1971; BALARIN, 1985).

In Asian countries, notably Malaysia, Thailand and Sri Lanka, floating cages are used for growing fish of high market value (e.g. sea bass and grouper). Although their construction costs are lower than those of ponds, they remain substantial. With high stocking densities and supplementary feeding, yields of 130 - 150 kg/m^3 can be obtained (POTAROS ET AL, 1987). However, cage culture is not free of environmental effects. The continuous feeding and, consequently, the spilling of fish trash may enhance the formation of anaerobic sediments under the cages. Furthermore, cultures with a high density of fish are vulnerable to diseases that might rapidly spread around.

Whenever fixed gears and cage cultures occupy former fishing grounds or block navigation routes, conflicts arise. Since cage cultures require substantial investments, they are mainly owned by entrepreneurs who employ local labour. Nevertheless, collectively-owned cage cultures also exist.

artisanal pond aquaculture
conversion into aquaculture ponds and natural fry production
Cutting of mangroves and construction of ponds decrease the area of mangroves that contributes to aquatic production by producing litter and providing shelter to juvenile fish, shrimps and crabs or substrate to shellfish. Raised dikes may generate sulphuric acids that constitute a major obstacle to high fish production. Large quantities of lime have to be supplied in order to create more favorable conditions. Fertilizers and agrochemicals, commonly used in intensive aquaculture, adversely affect the aquatic ecosystem into which they are drained. The increased retention of water results in higher water temperature and salinity, and reduced flood-buffering capacity (GONG AND ONG, 1984). Full water control is obtained by means of pumping devices that increase the risk of oil spilling.

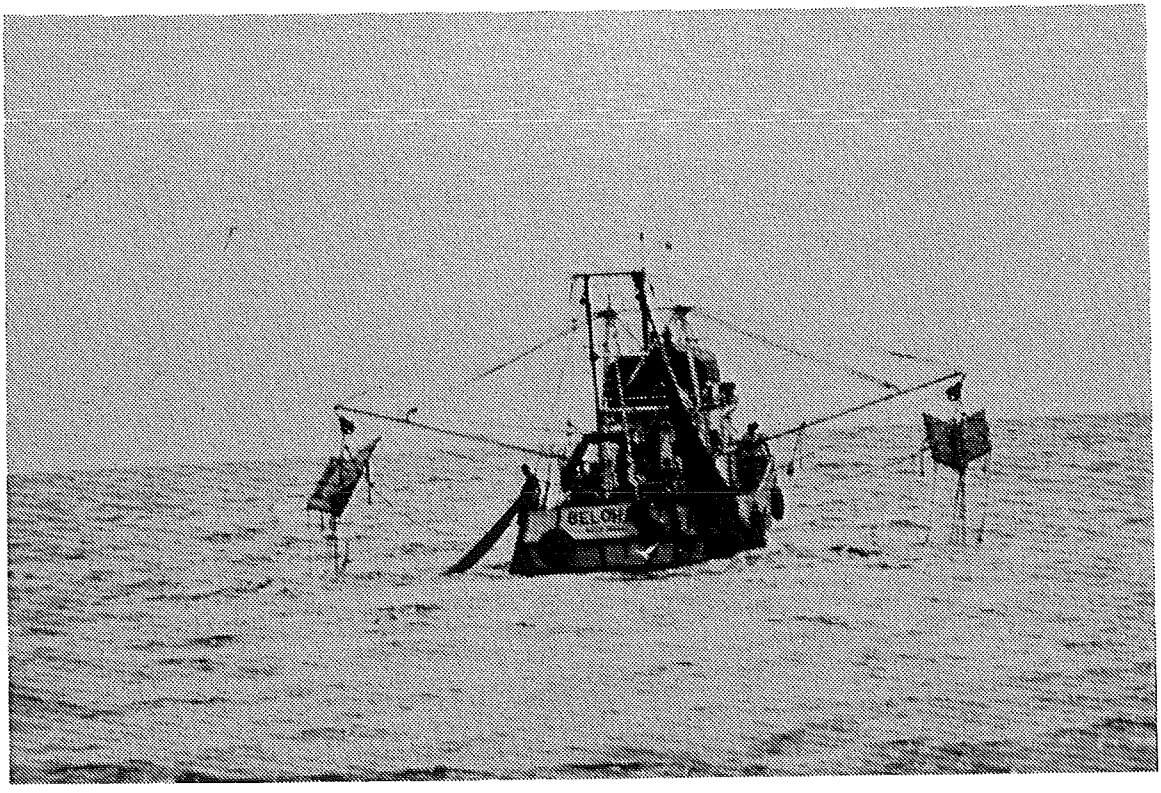


PHOTO Trawler fisheries.

In some mangrove areas (Ecuador, Bangladesh), natural fry supply - that is essential to artisanal aquaculture - has been reduced as a result of reclamation. Decreased production induces further reclamation as the loss has to be compensated. This, in turn, causes further decline and degradation of the mangroves (KAPETSKY, 1987). The gathering of fry constitutes a serious threat to fish and shrimp production but it creates employment. There are over 20.000 fry-collectors in the coastal provinces of Khulna and Chittagong (Thailand) alone accounting for half the total employment in aquaculture (MAHMOOD, 1987). However, intensive forms of aquaculture are generally less labour-intensive than extensive forms.

fish and shrimps

Artisanal ponds appeared more than 2000 years ago in Indonesia (SUKARDJO AND AKHMAD, 1982). They usually consist of a nursery and several small rearing ponds (SOEGIARTO AND POLUNIN, 1980). The conversion of mangrove into artisanal aquaculture ponds is the single most important factor of wetland loss, especially in Thailand (32.000 ha), The Philippines (196.000 ha) and Indonesia (250.000 ha); (SIMPSON AND PEDINI, 1985). It is also fairly common in Central America where it has known a spectacular increase, especially in Ecuador. The species most often bred in Asia are milkfish (Chanos chanos) (SMITH AND CHONG, 1984), tilapias and mullet. Average yields range from 400-800 kg/ha/yr while under optimal conditions 3-4 t/ha/yr is considered possible.

The breeding of shrimps is often commercially more interesting than fish cultivation and the world annual production is rapidly increasing (SIMPSON AND PEDINI, 1985). Natural fry-dependent shrimp ponds produce 300 - 500 kg/ha/yr; with higher stocking densities and supplementary feeding, production figures vary between 1.000 and 2.000 kg/ha/yr.

BOX 3.4. CAGE CULTURE IN ASIA

Cage culture was almost unknown in the Asian region before 1980 (except in Japan), but has rapidly developed since; today Thailand has more than 20.000 marine fish cages (Indian Ocean Fishery Commission, 1989). Fish cages are often found in wave-sheltered locations nearby major fish markets (as fish trash is used for this kind of culture). Cage culture is exclusively practiced for fish with a high market value; it will therefore never be an alternative to the production of cheaper finfish in coastal aquaculture. Cages in the Matang and Pulau Ketam areas, Malaysia, are stocked with fingerlings imported from Thailand at the cost of 0,5 US$ each. Cage cultures are often owned by entrepreneurs as initial investment costs are high; in this case the feeding of the fish is done by workers. Co-operative cage cultures or even individually owned, small-scale cage cultures can be found locally.

PHOTO A Cage culture (floating farms) near Krabi, southern Thailand.

PHOTO B Cage culture in the Matang area, Malaysia.

Many fishponds are used on a subsistence basis and yields could be improved by means of better water control, stocking, feeding and pest control. However, such improvements are expensive. A special type of pond culture is the "tambak tumpangsari", a form of reforestation of illegally constructed tambaks in Java; in this system, yields range between 200 and 300 kg/ha per crop (CHOLIK AND POERNOMO, 1987).

mangrove-independent aquaculture

Modern aquaculture requires full conversion and water control. The shrimp fry is artificially bred and sometimes exotic species are raised. The ponds are fertilized and even pesticides might be used. These systems require high direct and recurrent investments, and a high level of know-how and management.

Modern aquaculture ponds can also be constructed on adjacent, higher lands. A study of Gedney et al (1983) shows that the latter option is more profitable; pumping costs are increased but maintenance of the dikes is less expensive.

Shrimp hatcheries are often large, highly sophisticated enterprises that rely on constant water temperatures and salinity, and balanced feeding. In Thailand, an important part of the shrimp fry is successfully produced in "back yard hatcheries" that often cover less than an acre and benefit from the technical assistance provided by governmental institutions. Nevertheless, hatcheries require less labour and consequently, their introduction is detrimental to fry collectors.

Because the legal ownership of mangroves is often claimed by the State, entrepreneurs who have better access to capital and technology purchase large areas and push out local inhabitants. As Bailey (1988) puts it "Stripped to its essence, the expansion of shrimp mariculture into mangrove habitat generally involves the transformation of a multi-use/multi-user coastal resource into a privately owned single-purpose resource. In many tropical developing countries policies which encourage development of privately owned shrimp ponds involve expropriation of resources over which local residents have traditional rights based on long-standing patterns of usage. However, because these people do not have legally recognized property rights, the resources upon which their communities depend can be allocated to outside investors". In areas where small holders have legal ownership, e.g. in Bangladesh, they still can be forced to let their holdings to larger landowners and shrimp entrepreneurs at meager rents.

agriculture combined with aquaculture

A combination of agriculture in the rainy season and aquaculture in the dry season within the same pond is found in Asia (VINCKE, 1979; HUAT AND TAN, 1980; CAMACHO,

1985). Such systems are called "beri" or "gher" in Bangladesh. This alternation has several advantages, it increases benefits per hectare and allows better pest control. However, the management of these mixed systems is more complicated than the management of systems based on a single production (i.e. rice cultivation only or aquaculture only).

BOX 3.5. INPUTS AND YIELDS IN MONOCULTURE SYSTEMS AND MIXED SYSTEMS BASED ON SHRIMPS, RICE AND SALT PRODUCTION IN BANGLADESH

Adapted from ESCAP (n.d.)

	shrimp + fish	shrimp +fish +rice	shrimp +fish +salt	shrimps semi-intensive	shrimps intensive	shrimps +rice improved	shrimps +salt improved
stocking of post-larvae (ha/yr)							
a.brackish shrimps	20.000	11.700	wild entry	60.000	100.000	30.000	30.000
b.fresh-water shrimps	520	1.154					
c.finfish							
lime application (kg/ha/yr)	-	-	-	250	500	250	250
fertilization (kg/ha/yr)							
a. cow dung	-	-	-	3.000	6.000	3.000	3.000
b. urea				375	750	375	375
c. TSP				125	250	125	125
supply of feed (kg/ha/yr)	-	-	-	-	3.000	-	-
labour (days/ha/yr)	99	69	40	110	150	82	82
output (kg/ha/yr)							
1.brackish water shrimp	210	215	56	1.000	2.000	500	500
2.fresh water shrimps	12	39	-	-	-	-	-
3.finfish	84	44	135	-	-	-	-

Total employment (days/ha) for shrimp farming amounts to 232 days, of which 112 days on the farm, 113 days for fry collection and transport and 7 days for deheading. The combination of shrimp and rice cultivation increases labour by 30% (75 days for shrimp cultivation and 115 days for rice farming, 66 days for fry collection and transport, and 6 days for deheading). In summary, early stages of shrimp cultivation adversely affect the subsistence economy. The level of employment is reduced and the income of workers declines in relative as well as absolute terms while the income of landowners and entrepreneurs increases. With improved methods, all incomes increase although the income of workers evolves at a slower pace.

3.1.3. Salt exploitation

Salt extraction is mainly found along semi-arid and arid coasts. Depending upon evapotranspiration and duration of the dry season, different artisanal techniques are used. In its most simple form, salt is gathered from the bare, saline flats in the backswamps. When the sun alone provides insufficient energy to crystallize the salt, the soil is boiled and purified in a process that involves repeated percolation with water and a considerable amount of firewood. This system is a common practice in Benin, Ghana and Ivory Coast (CML/SECA; 1987).

Industrial salt exploitation is found near Sal Sal and Kalack in Senegal, where artificial salt pans similar to those found in the Mediterranean region have been constructed. Salt production on a large scale is also practiced in Thailand, India and Eastern Indonesia (Gulf of Kutch).

salt exploitation combined with aquaculture or agriculture

Salt production in the dry season can be alternated with fish or agricultural production in the rainy season. The combination of salt production and aquaculture is widespread in the Chittagong region of Bangladesh where it has gained momentum as a result of raising shrimp prices (MAHMOOD, 1987).

BOX 3.6. TRADITIONAL SALT EXTRACTION IN AFRICA

After CML/SECA (1987).

Salt extraction is mainly found along coasts where a pronounced dry season prevails, e.g. in Benin, Ghana, Senegal, Gambia, Guinea Bissau and Mozambique. Traditional extraction techniques, as practiced in West Africa, include several steps that are briefly described hereafter.

1. Site preparation. This involves weeding and ploughing of the uppermost topsoil in order to increase the capillary uplifting of salts.
2. Soil processing. When salt efflorescence appears, the salty topsoil is collected in baskets or steel basins and percolated with water in order to obtain a very saline filtrate.
3. Filtrate processing. The filtrate is boiled in iron pots until the salt crystallizes; it is then bleached in the sun.

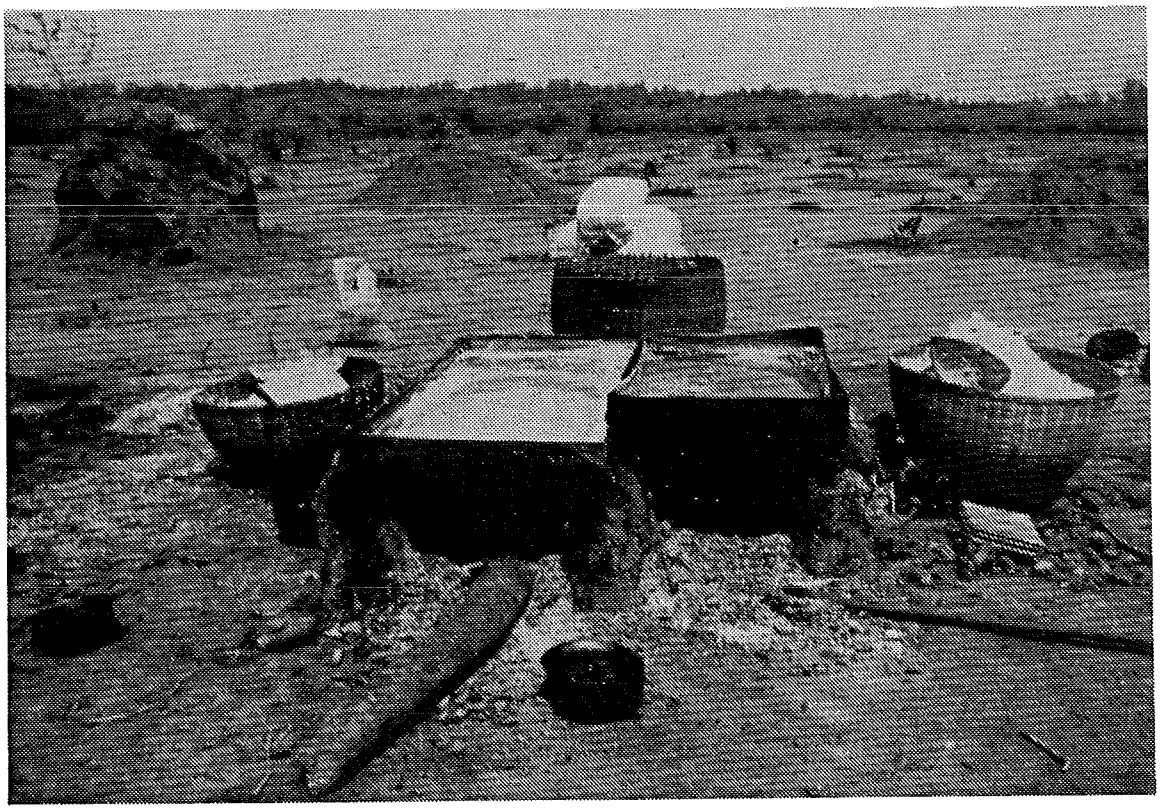


PHOTO Boiling of the brine (Benin).

3.1.4. **Agricultural resources**

reclamation and potential acid sulphate soils

Mangrove soils are generally flat, fertile, often within reach of freshwater sources and situated along densely populated coasts. They have therefore always "attracted" reclamation activities. In many African and Asian countries, the conversion of mangroves into rice fields began millennia ago. On good mangrove soils, i.e. soils that are not potentially acid, yields of 2t/ha can be obtained. During this century, mangroves have increasingly been reclaimed for the purpose of palm plantation.

Mangrove soils are difficult to manage. Failures are reported from all over the world, throughout Asia and West Africa. Water and flood control is needed to prevent saline water intrusion; water table control is necessary to check acidification and salinization, and water pollution control to drain acids. An important factor in cultivating mangrove soils is the formation of sulphuric acid following drainage. It also is the main reason for failures. Potential acid sulphate soils are difficult to detect without detailed mapping.

Reclamation results in a decrease of mangrove-related production (forest products, fish and shrimps). Several studies established a relation between mangrove area and fish and shrimp landings. These studies show that mangroves play an important role. Agricultural schemes are often associated with storage dams, anti-salt barriers and water pollution that also have adverse environmental effects on mangroves.

BOX 3.7. FORMATION OF ACID SULPHATE SOILS

The substrate of mangroves has been formed by the deposition of riverine and marine sediments, and continuous litterfall production. Under anaerobic conditions, sulphate is reduced to pyrites (FeS, FeS_2) by bacteria that extract energy from organic material provided by the mangroves. Sulphuric acids are formed by the oxidation of pyrite. In the absence of calcium carbonates, this leads to acidification as the pH drops to low values (pH 3 and less). Such low pH values cause aluminium to be dissolved (see DOST, 1986 and DENT, 1986). Aluminium is very toxic to plants. Consequently root growth is restricted to the non-acid upper-soil. This results in water and nutrient deficiencies and meager crop production. For instance, rice yields usually remain below 2-3 ton/ha, even after liming and fertilization (HAMILTON AND SNEDAKER, 1984). In America, Asia and Africa, acidification has been identified as the cause of major failures of mangrove conversion into rice fields.
Full reclamation of potential acid sulphate soils requires leaching of sulphuric acids during several years in order to gradually make more soil available to the plants. In traditional "mangal" rice fields, e.g in Guinea Bissau, brackish water is used to neutralize and leach the sulphuric acids that formed during the growing season. Because of its high buffering capacity, brackish water can check and leach sulphuric acids more effectively than fresh water. Salts can easily be leached with fresh water just before the following growing season. By then, pyrites on the higher parts of tidal flats (which are only inundated by high tides) usually have been leached.

BOX 3.8 ENVIRONMENTAL EFFECTS OF STORAGE DAMS AND ANTI-SALT BARRIERS

Storage dams adversely affect the downstream estuarine environment in many ways. Decreased peak flows and increased base flows result in smaller seasonal variation of salinity levels, thereby reducing the extent of the estuarine environment. Gradually, mangroves in the upper reaches of the estuary are replaced by riverine forests. Diversion of fresh water also leads to a rise in average salinity and a reduction of mangrove growth. Reservoirs withhold sediments that are vital to mangrove regeneration and growth; this eventually leads to coastal and shoreline erosion. Many of these downstream effects can be mitigated by proper design and operation of dams.

In addition to the aforementioned effects, anti-salt barriers prevent salt intrusion and tidal activity which leads to the conversion of a brackish estuarine system into a freshwater lake. Mangroves die and are replaced by riparian forests. Lands that were formerly inundated daily now remain above the sea level and may become acid, and soils within the capillary reach of salt/brackish ground water may become saline (BARRY AND POSNER, 1986; HESSELINK AND VAN SLOBBE, 1987). Anti-salt barriers block migration routes of euryhaline fish and shrimp species (University of Michigan, 1985). Downstream of the dam, salinity levels and tidal amplitude increase. Possibilities to mitigate the aforementioned effects by alternative sluice gate management are often available. In the case of some locally managed small-scale anti-salt barriers in Guinea Bissau, salt water is let in at the end of the dry season (after the harvest); it neutralizes sulphuric acids which formed during the growing season, thereby preventing acidification.

Agrochemicals are a necessary component in high-input cultivation of vulnerable mono-specific crops such as cotton and rice, and their use is likely to increase in the future. These agrochemicals often kill non-target organisms (VAN DER VALK AND KOEMAN, 1988; BALK AND KOEMAN, 1984). Fish production and wildlife are affected directly, by poisoning, or indirectly, by a decrease in (invertebrate) organisms on which fish and wildlife may feed (VERWEY ET AL 1986).

tidal rice

Tidal rice cultivation is based on the utilization of fresh waters blocked in the upper reaches of estuarine rivers during months of peak flow. These waters irrigate rice fields that are laid out in former mangroves forests. One well-known example is found along the Gambia river, a river with strong seasonal peak flows. Tidal rice also covers extensive areas in Asian coastal floodplains, such as the Mekong and Irrawaddy deltas. In the Gambia this cultivation system flourishes when freshwater discharges push back the salt-water front for more than 100 (preferably 120) consecutive days. The droughts of the last decade resulted in an early upstream move of the saltwater front along the Gambia River and an inundation of the rice fields with brackish water. Success of the tidal rice cultivation depends strongly on the reliability of the river discharge.

In its original form, it is one of the most easily adoptable rice cultivation technique. It involves low costs and has moderate environmental impact. Tidal rice fields do not need large dikes. Instead, small bunds are used for water control within the fields. In fact, much of the natural hydrology remains unaltered. This technique requires the transplantation of seedlings. The rice fields also act as hydrologic buffers, and breeding and feeding grounds for fish. It is successful even in places where acid sulphate soils occur in the first 20 cm below the surface.

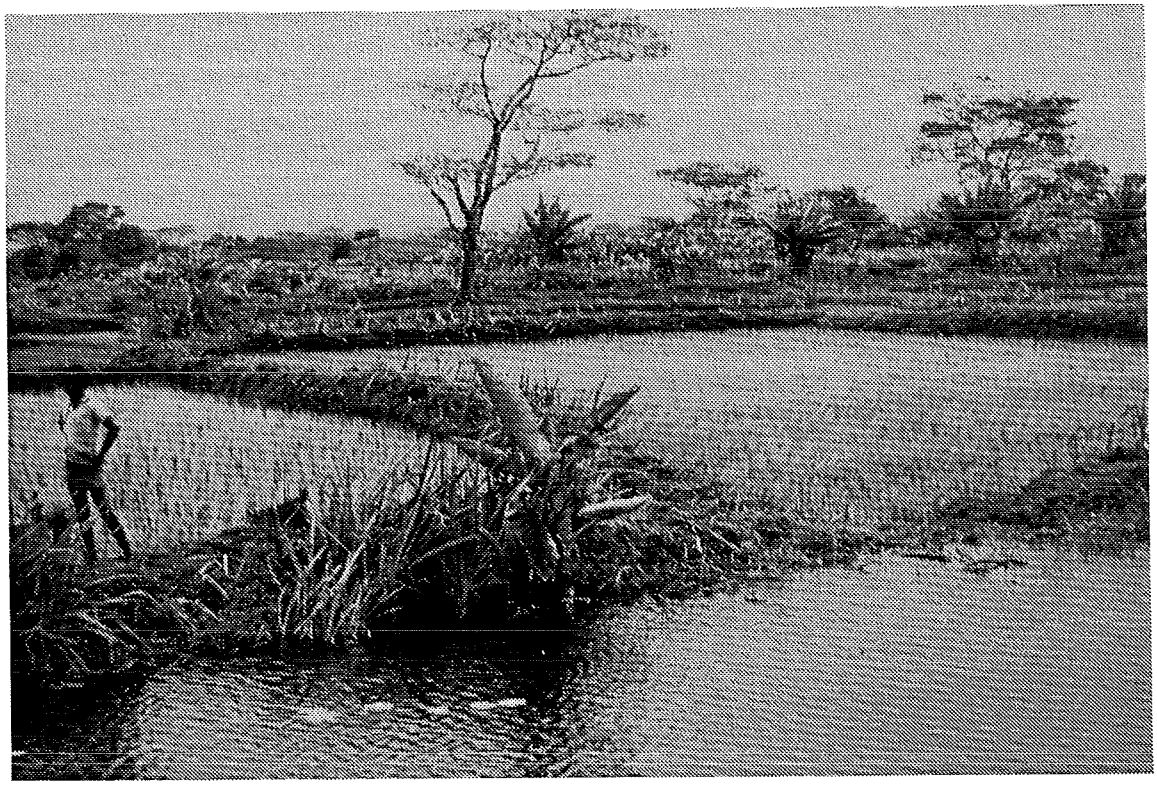


PHOTO Tidal rice

seasonally flooded rice

Coastal floodplains may be flooded for several months during the rainy season while brackish water prevails during the dry season. Seasonally flooded rice depends upon sufficient floods, i.e. floods that are able to inundate rice fields. In the Mekong Delta, floating rice varieties yield 4,6 - 6 tons/ha; the rice is transplanted after the flooding (XUAN ET AL, 1982).

reclamation by intensive shallow drainage

In the Mekong Delta 45-60 days old seedlings of floating rice are planted on flooded beds intersected with shallow ditches. Yields obtained can reach 4 tons/ha (DENT, 1986).

"rainwater polders"

This form of rice cultivation is found in Senegal, Guinea Bissau and Guinea. During the rainy season, impoldered mangrove and tidal areas are filled with rainwater. The rice is cultivated on small ridges, which are laboriously re-erected every year. During the dry season the polders are flooded again with brackish water in order to neutralize and leach sulphuric acids. In some systems, a ring of small polders is used as fishponds, device for water level control and buffer against saltwater.

Improvements are mainly sought in the form of anti-salt barriers. Although tides are still used for occasional inundations, rainwater polders do not contribute to the regulative and productive estuarine/mangrove functions.

rain-fed coastal rice

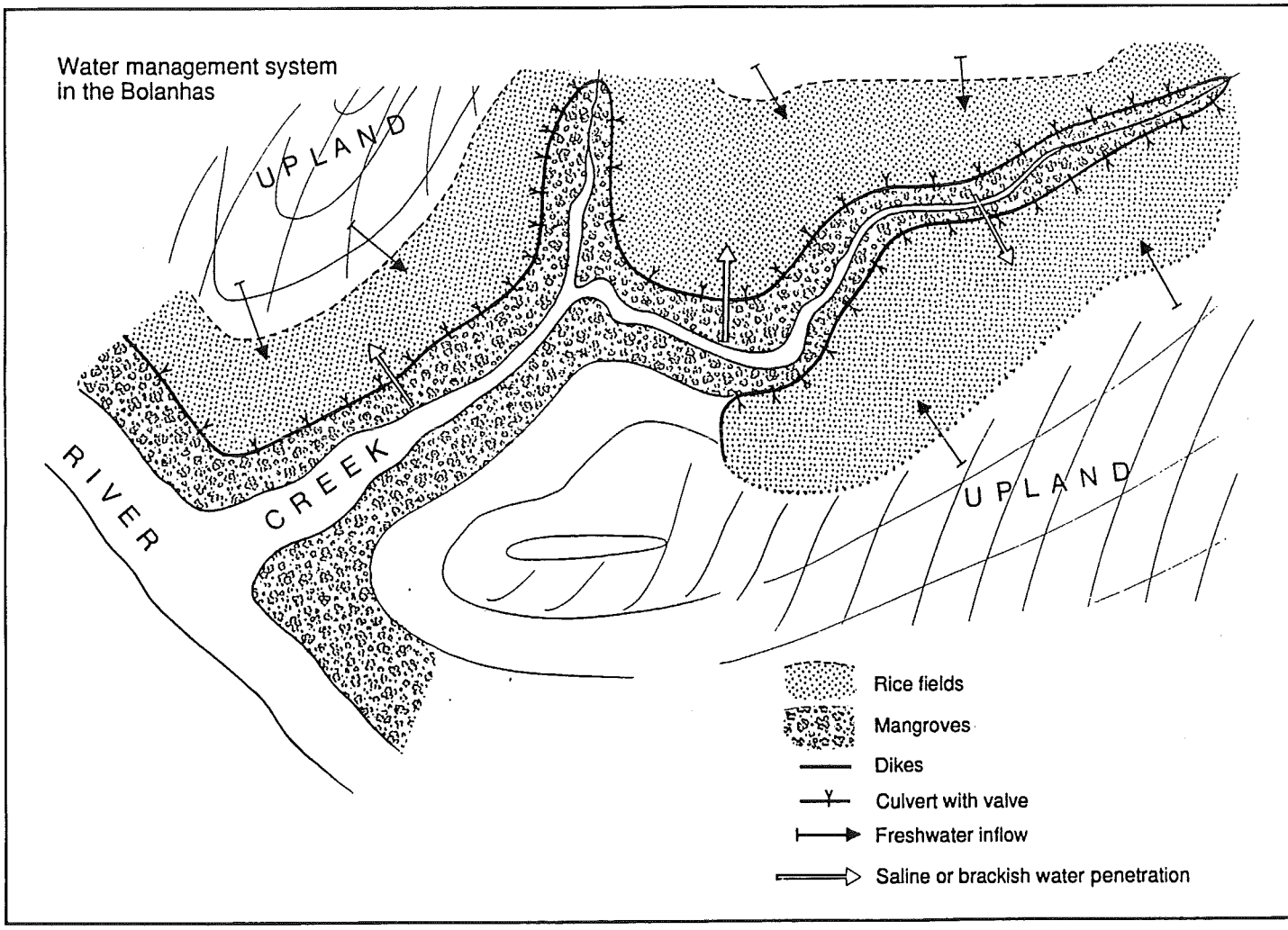
In the more humid areas in Asia, a form of rice cultivation is found that is very similar to upland rice; this type of coastal rice cultivation depends on rainfall that is retained by a

BOX 3.9. RAINWATER POLDERS AND ANTI-SALT BARRIERS, GUINEA BISSAU

Rainwater polders consist of several small basins surrounded by an outer bund. The basins form cascading systems that follow the slope and are filled with rainwater. No irrigation is used. The outer bund includes a gate that is closed at the beginning of the rainy season and opened again in the dry season. Inundation of the rice fields with salt water neutralizes acids and hampers the growth of weeds. Between the outer bunds and the first rice plots, an additional basin may function as a buffer against water. This additional basin is often used as a fishpond.

Within the basins, the rice is grown on small ridges. These ridges are annually reconstructed by hand; the soil is turned with a specially adapted shovel. The construction of the entire system - especially of the outer bund - requires special skills and indigenous knowledge. Yields vary between 0,5 and 1,5 t/ha/yr but may amount to 2-3 t/ha/yr when small quantities of phosphate and nitrate are applied (CML/SECA, 1987). Reaction to fertilizers is normally poor and the best yields are obtained on good soils (i.e. soils that are not potentially acid).

The rice is transplanted from nurseries and many different varieties are used. These have been selected on the basis of local, long-term experimentation. Rice cultivation requires about 1.000 mm of rainfall within 4 consecutive months. The drought years of the 70s and 80s were therefore disastrous to this type of cultivation, especially in the northern part of Guinea Bissau. Many small anti-salt barriers have been constructed in order to extend the growing season. However, most of these dams failed to induce an increase in rice production.



FIGURES The traditional pattern of 'bolanhas' adjacent to creek system, and the region after the construction of an anti-salt barrier (FISELIER AND TOORNSTRA, 1987).

system of bunds. In this case however, no brackish water is let in during the dry season, neither is the rice cultivated on ridges.

controlled high water table management
Controlled high water table cultivation occurs in regions of the humid tropics where there is no pronounced dry season. Dikes protect the reclaimed mangrove area but high water tables are maintained using rainfall and other sources of fresh water. Shallow field drains are necessary to remove excess of rainfall. Only the uppermost decimeters of the soils are fully reclaimed with respect to soil acidity and salinity. This form is normally used for the cultivation of oil palms and coconuts, and can have yields approaching those obtained on non-mangrove soils (LAW, 1984); costs for reclamation and water management are higher. Shallow-rooted vegetables can also be grown, e.g. tapioca, sugarcane and oil palm in Malaysia and Senegal (HAMILTON AND SNEDAKER, 1984), and cotton and coconut palms in El Salvador (DAUGHERTY, 1975).

total reclamation
As already mentioned, mangrove reclamation has often failed as a result of acidification. Successful reclamation has only been observed on non-potentially acid soils. In situations with abundant water supply, an alternation of draining and leaching may completely check soil acidity (see DENT, 1986).

socioeconomic aspects of reclamation
As the ownership of mangrove areas is not stated in written documents or vested in the State, entrepreneurs enjoy an easy access to permits, licences and money needed for reclamation activities. Trends similar to those described in the case of shrimp ponds can also be observed in the case of reclamation for agriculture. Coastal communities who in fact 'owned' the resource, are driven out and impoverished or become landless workers on endless oil palm plantations and large rice schemes. Traditional small-scale rainwater polders and tidal rice plots are on the contrary individually owned since they are the result of continuous manual labour efforts made within a framework of customary rules and obligations.

3.1.5. Wildlife resources

introduction
Unlike national parks in western and eastern Africa, mangroves do not contain large herds of mammals that would be suitable for game cropping and game viewing. Nevertheless, their scenic qualities give most mangrove swamps important touristic and recreational potentials in the form of bird-watching, sport fishing and the enjoyment of sandy beaches that may be found close by.

game cropping
Birds are hunted in most mangrove swamps and adjacent tidal flats. They constitute an important source of proteins. Cropping of crocodiles and varans is practiced in Asia, e.g. in Sumatra (see the Sumatra case study), and provides local people with an income; cropping of these species - as it is currently practiced - is not sustainable.

game rearing
In several countries, the raising of crocodiles in mangroves is a profitable enterprise. Crocodiles (Crocodylus niloticus) are reared near Libreville, Gabon (CML/SECA, 1987), but crocodile farming is much more widespread in America and Asia (HAMILTON AND SNEDAKER, 1975). There are plans for intensive rearing of crocodiles (C. porosus and C. novaeguineae) in Irian Jaya (COX, 1987) and Sumatra, the latter being supported by a FAO project (pers. com. W. Verheugt, 1990). Turtle farming is practiced in Bali and Sulawesi and plans have been drawn by a private company to hatch eggs and provide hatchlings to local people who would rear them and sell them back (SILVIUS ET AL, 1987).

tourism and recreation
Except for a few examples in the industrialized world, mangrove swamps do not yet attract large numbers of tourists. Occasionally, e.g. in the Casamance (Senegal), Krabi (Thailand) and Segarai Anakam (Indonesia), a boat trip into the mangrove is added to a beach-holiday. Extensive walkways and numerous birds in nature reserves such as the Coronie swamps attract large numbers of tourists. Nevertheless, the potential for educational nature tourism and bird watching remains largely unexploited. In countries such as Costa Rica, individual landowners have declared their property a nature park and attract tourists by proposing bird watching excursions. Sport fishing on tarpon and snook is popular in Caribbean and Central American mangrove swamps where first class accommodation mainly attract North American tourists. Sport fishing generates local income through the creation of jobs (e.g. boatman and waiter), boat rentals and, in some cases, local licence fees.

3.1.6. Other activities

port construction, channelization and shipping
Creeks and rivers within mangrove swamps are important transport ways; they often constitute the only communication means between different coastal communities. Continuous navigation by fishing boats may cause serious shoreline erosion and oil pollution. Dredging of canals may considerably upset the local tidal activity as canals may constitute shortcuts for tidal currents, thereby leading to raised tidal velocities and shoreline erosion. Pollution of water and sediments due to combustibles (gasoline, kerosine) used by motor boats of all sizes, is often a serious problem near coastal cities. These refined oils are highly soluble and toxic for shrimps, oysters and crabs (BAKER, 1981). Frequent navigation in estuaries and creeks may thus constitute a serious threat to the aquatic environment.

dike and road construction
In mangrove areas, coastal roads often block tidal creeks. Mangroves on the inland side of the road die off owing to the lack of tidal activity. Seaward, the tidal amplitude increases which may result in erosion of the dike while mangroves dwindle owing to a lack of fresh water inflow. Upheaval of mangrove soils generates large quantities of sulphuric acids that affect aquatic production and corrode concrete and metal structures.

BOX 3.10. KRABI MANGROVE TOURISM

After Parr (1988).

The town of Krabi (southern Thailand) is situated amidst mangrove forests of high biological diversity consisting of mature trees adorned with epiphytes. The number of bird species is also very high. These species include the Mangrove Blue Flycatcher Cyornis rufigastra which (within Thailand) was only observed in this area, Mangrove Pittas Pitta megarhyncha and the Masked Finfoot (Heliopais personata).

The scenic beauty of the Krabi mangroves is further enhanced by limestone islands and cliffs. In order to probe the touristic potential of these mangrove swamps, boat trips have been organized during which tourists were given a broad insight into the mangrove ecosystem and its utilization by coastal communities. Reactions were very enthusiastic. Nevertheless, the activity slowed down owing to insufficient efforts in the field of public relations.

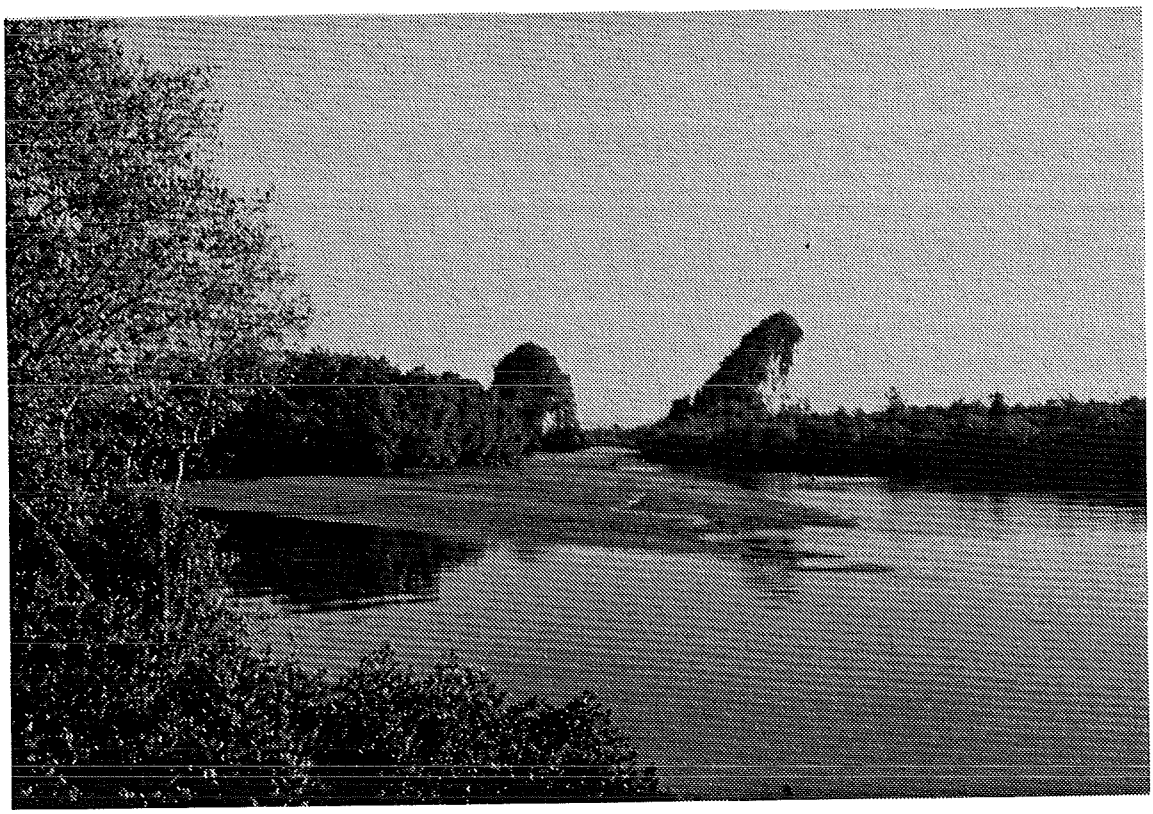


PHOTO Krabi mangroves.

industrial and urban sewage and effluents
Many large cities are located along coasts and major rivers, some are even erected within mangrove swamps, e.g. Lagos and Banjul. Their sewage is often not or insufficiently treated before being drained into estuaries and mangrove swamps. The effects of untreated sewage discharge on the estuarine ecosystem are more important when temperatures and salinity are high and tidal flushing is insufficient. On the other hand, tidal currents easily spread pollutants far inland. Important producers of organic wastes are agro-industries (palm-oil factories), pulp mills and slaughterhouses. Organic wastes are most common and may result in oxygen depletion killing juvenile fish and shrimps that are very vulnerable to low oxygen levels (CLOUGH ET AL, 1983).

mining
Oil exploitation in coastal areas and mangrove swamps such as the Niger Delta has frequently led to oil-spills of catastrophic proportions (EKEKWE, 1981; ODU AND IMEVBORE, 1985). Crude oil suffocates aquatic life and mangrove leaves, and the complete regeneration of the ecosystem may take several years (HASKONING, 1983). The death of mangroves on shorelines that are heavily exposed to wind and waves may induce irreversible erosion. Occasionally, drinking water sources are also contaminated (OTERI, 1981). Tin mining in Thailand stirs up sediments and the increased turbidity lessens aquatic production (POTAROS ET AL, 1987).

Most of the aforementioned reclamation activities fail to reckon with traditional land use rights.

3.2. COMPARISON BETWEEN MANGROVE-DEPENDENT ACTIVITIES AND ACTIVITIES IN RECLAIMED AREAS

general

Table 3.1. summarizes the performances of all aforementioned activities with respect to their ecological and economic sustainability, the way in which they may cater for the needs of local people and the conservation opportunities that they may offer. Such an assessment can only be made in general terms that indicate the potential performances of activities. It should be remembered that these performances largely depend on and vary according to site characteristics, prevailing socioeconomic conditions and management types. A thorough assessment of the different resource utilization options should involve the comparison of all compatible activities in non-reclaimed conditions with all compatible activities in reclaimed conditions.

TABLE 3.1. COMPARISON BETWEEN DIFFERENT MANGROVE EXPLOITATION OPTIONS

	sustainability		people's priorities		nature
	ecol.	econ.	poss.	pref.	values
A. NON-RECLAIMED AREAS					
forest resources					
-timber	ss	mmm	ll	cc	nnn
-charcoal	ss	mm	ll	cc	nnn
-wood-chip	ss	mm	l	c	nn
-nipa palm	ss	mm	ll	cc	nn
-fodder	ss	mmm	lll	ccc	nn
-honey	sss	mmm	lll	ccc	nnn
aquatic resources					
-gathering	sss	mmm	lll	ccc	nnn
-shellfish cultivation	sss	mm	lll	ccc	nnn
-artisanal fisheries	sss	mm	lll	ccc	nnn
-industrial fisheries	s	mm	l	c	nn
-cage farming	ss	mm	ll	cc	nnn
wildlife resources					
-game cropping + hunting	ss	m	lll	ccc	nn
-game raising	ss	mm	ll	cc	nn
-tourism	sss	mm	ll	cc	nnn
B. RECLAIMED AREAS					
aquaculture					
-extensive	ss	mm	ll	cc	nn
-semi-intensive	ss	mm	l	cc	nn
-intensive	s	m	l	c	n
-multipurpose rice and fish/shrimps	s	mm	ll	cc	nn
salt production					
-small scale	ss	mmm	lll	ccc	nn
-industrial	ss	mm	l	c	nn
-multipurpose salt and fish/shrimps	ss	mm	ll	ccc	nn
agriculture					
-tidal rice	ss	mmm	lll	cc	nnn
-seasonal flooded rice	ss	mmm	lll	cc	nnn
-shallow drainage	ss	mm	ll	cc	n
-rainwater polders	ss	mm	ll	cc	nn
-rain-fed coastal rice	ss	mm	ll	cc	nn
-high water table	ss	mm	ll	cc	nn
-total reclamation	s	m	l	cc	n

s = high risks of being unsustainable and having adverse effects
ss = sustainability depends very much on proper management and control
sss = nearly always sustainable
m = high maintenance costs in terms of money and labour
mm = moderately high maintenance costs
mmm = low maintenance costs
l = high level of organization and technology
ll = moderate high level
lll = low level of organization and technology
c = often not catering for local food and income needs
cc = potentially catering (depending on ownership)
ccc = nearly always catering
n = nearly no opportunities for conservation
nn = conservation potential depends upon management
nnn = good opportunities for conservation

ecological and socioeconomic sustainability
Reclamation nearly always has adverse environmental effects that lead to a decrease in mangrove-related production. Reclamation for agriculture often fails owing to unanticipated acidification, water management problems and maladjustment to coastal dynamics. Examples of feasible forms of reclamation are mainly encountered on soils with no acidification potential, and under conditions of sufficient freshwater supply. Aquaculture is in itself often more sustainable. Reclamation for agriculture and aquaculture requires high investment and maintenance costs (in terms of both money and labour); it is therefore vulnerable to unexpected economic and environmental drawbacks. However, if reclamation is economically attractive, its unbridled growth can only be prevented through very strict regulation and law enforcement.

Artisanal fisheries and shellfish culture or gathering are often ecologically and economically sustainable. Cage culture is prone to market price fluctuations. Although forestry and fisheries are basically sustainable, they need proper management regulations and law enforcement. This is especially true for forestry as strict regulations are needed in order to prevent "wood mining" and favour replanting. Industrial fisheries seem difficult to control and often lead to overfishing.

taking into account people's needs, priorities and capacities
Socioeconomic conditions differ widely between America, Africa and Asia. In Africa, opportunity costs of labour are usually very high owing to farming systems that are largely based on off-farm activities. In Asia, these costs are low and labour abounds. Compared to the situation in Africa, conditions in Asia are, in general terms, much more conducive to labour-intensive and market-oriented activities.

Most forms of reclamation need higher levels of organization, technology and market infrastructure than existing, traditional forms of fisheries and forestry. Intensive aquaculture and plantation are difficult to adapt to local conditions. Although they are considered more feasible from an economic point of view, semi-intensive and intensive forms of aquaculture are largely out of reach of local communities (CHOLIK AND POERNOMO, 1987). Investment costs are high and licences difficult to obtain by local people. Therefore, reclamation is often dominated by entrepreneurs. Partial conversion can be beneficial as it ensures more diversity and generates more employment and income opportunities, but it has to be properly integrated.

Introduction of industrial fisheries seldom benefits coastal communities. For instance, cage culture involves high investment costs that cannot be met by local people, although co-operative forms of cage culture exist. Shellfish cultivation and improved artisanal fisheries more easily fit local socioeconomic conditions. Forestry activities, and especially timber extraction and charcoal production, require more organization and investments. However, they can easily be carried out by coastal communities with the assistance of and under coordination by governmental services.

with respect to conservation
Most forms of reclamation destroy natural values associated with mangrove swamps; especially wildlife that uses the swamps as feeding and breeding habitat will be affected. However, some forms of reclamation generate opportunities in terms of feeding grounds for waders, e.g. salt pans in the rainy season and rice fields in the dry season. In Guinea Bissau, rice fields have contributed to biological diversity. Nevertheless, the remaining mangroves still play a crucial role as roosting and breeding sites. When rice fields are densely cultivated with high yielding varieties, fertilizers and especially pesticides, they loose their attractiveness. Plantations offer no opportunities to wildlife.

Among mangrove-related activities, gathering of shellfish, fishing and beekeeping have no or little adverse effect on the wildlife. Forestry activities that are based on monospecific stands, lead to an impoverishment in terms of biological diversity, thereby decreasing the attractiveness of the forest as a breeding and roosting site for birds.

comparing options in reclaimed and non-reclaimed conditions
Several studies have looked into the productivity and economic value of mangrove swamps and have compared these with reclamation alternatives. The general picture emerging from these studies shows that benefits accrued from mangrove-dependent options exceed the benefits of reclamation. Revenues derived from mangrove-dependent fisheries were the most substantial and were followed by forestry revenues. It should be stressed however that these studies had great difficulty in assessing the values of non-tangible, regulation functions and artisanal utilization of mangroves (nor do they account for small-scale variations).

Anwar et al (1986) compared forestry, aquaculture and "tambak timpangsari", and found out that the latter had a negative net present value (NPV) while aquaculture was the most profitable activity with a NPV of 12%. Aquaculture also generated more employment than forestry. Jara (1987) compared the benefits accrued from fishponds (1500 pesos/ha) and mangrove wood (1450 pesos /ha). A study on milkfish (Chanos chanos) farming in the Philippines showed that only semi-intensive and intensive shrimp cultivation is economically feasible. It also requires less surface area. Therefore, one should stimulate the intensification of existing ponds rather than an increase in surface area (CHOLIK AND POERNOMO, 1987). Milkfish however caters for local fish demands while shrimps are largely exported. Kapetsky (1987) gives an overview, based on several studies, of the gross economic value of mangroves for fisheries. This gross economic value varies between 133 - 426 US$ /km^2 yr and more than 280.000 US$/km^2/yr; therefore, it often exceeds reclamation benefits, especially when investment costs are accounted for.

conclusions
The integration of conservation and sustainable utilization of resources may be achieved along three different lines, namely: optimising mangrove-related activities as well as activities in reclaimed areas, maintaining the integrity of the mangrove ecosystem and making conservation beneficial to local communities by integrating it into their life systems.

optimising mangrove-related activities

Mangrove-related activities have considerable economic value that often exceeds reclamation benefits, especially when reclamation requires high investment costs. Traditional activities can often be optimised, and mangrove-related activities introduced, at low costs and for the benefit of the entire coastal community. When developing mangrove coasts, these options should be screened before reclamation is considered. Most mangrove-related activities can be carried out without diminishing conservation possibilities.

optimising activities in reclaimed conditions

Reclamation of mangroves often failed owing to improper design and location that have induced more environmental costs than economic benefits. Limited reclamation can enhance diversity in economic activities, create additional employment and secure daily subsistence if carried out wisely. Reclamation should be more integrated into the life system of local communities.

integrating conservation

National parks and nature reserves can generate employment and income opportunities for local communities. Wildlife utilization can be beneficial to local people and constitute an important incentive for counteracting poaching and illegal fishing by outsiders. Conservation opportunities also exist beyond the boundaries of protected areas, provided that hunting is controlled (habitat improvement, creation of new breeding and roosting sites etc.).

people's participation

Activities aiming at checking poaching, and controlling fisheries and forestry activities will have to be supported by local communities, especially when other means of law enforcement are limited. This can often only be achieved when the sustainable utilization of resources benefits local people and can be controlled by them.

4. FORMULATION OF INTEGRATED STRATEGIES

4.1. INTRODUCTION

The preceding chapters have shown that pressure on mangroves is increasing while mangrove-related production and activities are more profitable in terms of benefits accrued to coastal communities, sustainable utilization of resources and natural values. Development of mangrove resources to their full capacity will often be necessary and a diversification in production, based on partial reclamation, might even be envisaged. Nevertheless, intensification in existing rice fields and aquaculture ponds appears to be more feasible than new reclamation schemes. However, intensification must benefit local communities and be adapted to their needs, interests and capacities; it therefore requires proper implementation procedures.

The choice of development options depends to a great extent upon site characteristics, demographic pressure, natural values and socioeconomic context. In former chapters, it has been argued that the benefits of mangrove-related production may outweigh those of conversion and reclamation but that opportunities to optimize mangrove-related production are often overlooked. It has been shown that the management of wildlife resources and protected areas may benefit local communities and involve lower costs. This chapter consequently discusses options for optimising mangrove-related activities as well as activities in reclaimed areas, and opportunities for integrating conservation into development.

4.2. OPTIMISING MANGROVE-RELATED PRODUCTION

4.2.1. Mangrove afforestation, restoration and enhancement

Most mangrove coasts are dynamic and continuously changing, the erosion of some can be stopped and the accretion of others enhanced and secured by dikes or vegetal groins and afforestation. This should be done at strategic locations in order to reduce tidal activity and wave energy, and enhance sedimentation, thereby facilitating colonization by and growth of mangroves. Non-vegetated, seasonally formed mud flats might be planted and protected with groins of living mangroves. The fencing of mud flats for shell-fish production also increases sedimentation.

BOX 4.1. MANGROVE AFFORESTATION IN THE SUNDARBANS, BANGLADESH

Adapted from ESCAP (n.d.).

The Ganges-Brahmaputra-Meghna delta is characterized by low wave energy, high tidal range, deposition of sediments and seaward extension and a tropical rainforest climate. Parts of the coast have known rapid accretion in recent years; about 400 km^2 have been formed and 186 km2 eroded in 45 years. Cyclones with storm surges of 3 to 6 metres in height are most destructive.

The newly formed land would be unstable without the development of deep-rooted vegetation, which is often hampered by cattle grazing. Afforestation can help consolidating newly accreted land. By 1980, about 40.000 ha of plantation had been completed and 37.000 ha have been planted between 1980 and June 1985.

The objectives of coastal afforestation are:
a. to accelerate the process of siltation and the stabilization of the soil
b. to create forest shelter-belts to protect life and property inland from tidal bores
c. to create an urgently needed resource to add to the national wealth
d. to create job opportunities for the rural communities
e. to create an environment for wildlife, fishes and other estuarine and marine fauna.

The species used are Acacia arabica and A. catechu on higher land, and Sonneratia apatala, Avicennia officinalis, Bruguiera gymnorhiza and Nypa fruticans in new accretion areas.

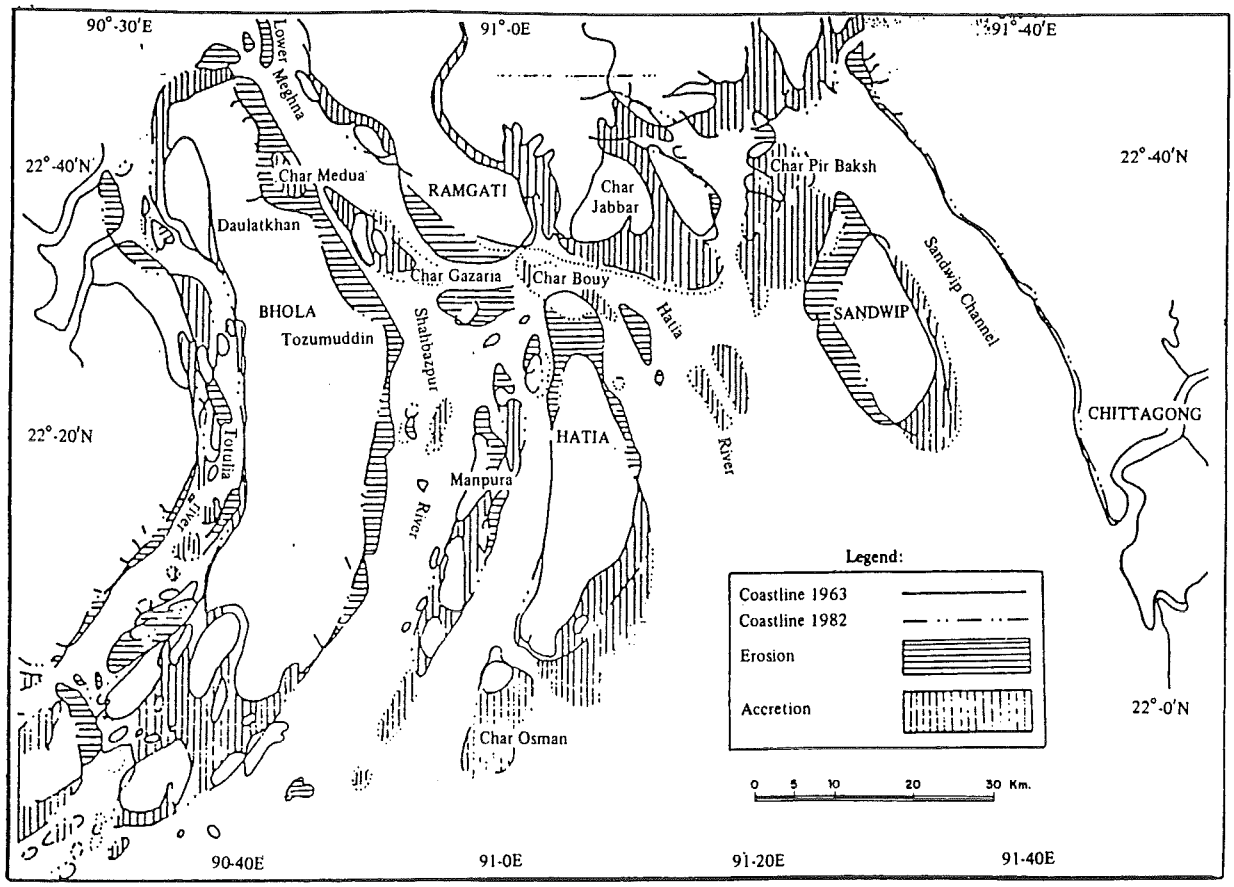


FIGURE A Coastal accretion and erosion (1963-1982)

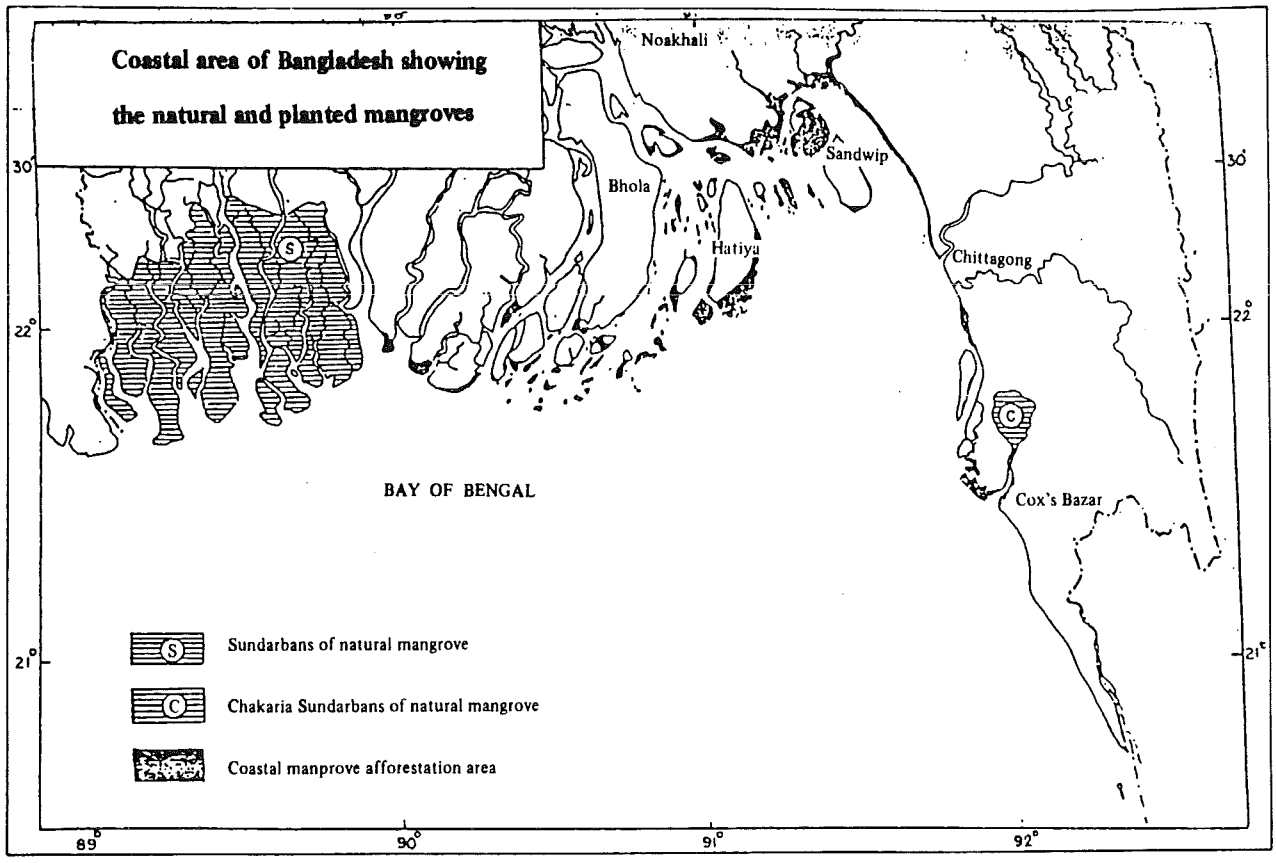


FIGURE B Natural and planted (afforestation) mangrove areas.

Large areas of mud flats have been planted with mangroves in the Bay of Bengal and in several Asian countries, notably in the Philippines. The costs of afforestation and planting are usually smaller than the expected benefits (THORHAUG, 1987). Planting seeds and propagules is the most cost-effective option in low energy zones (450 to 1800 hr/ha are needed for collecting and planting seeds and propagules); transplanting smaller or larger trees is suitable for zones with higher wave energy but, in this case, costs are at least doubled. Mangrove poles, rock bunds (370 -580 US$/m) and rubber tyres (100 US$/m) are used for the restoration of mangroves in Peninsula Malaysia (CHAS, 1984).

The planting of sea grass beds may also be an interesting alternative as it stimulates the formation of wave-absorbing sandbanks. In Bangladesh, it is hoped that the formation of mud flats will be stimulated in the wave shadow of a major dike, the Sandwip dike (BWDB, 1987).

Study of wave and tidal dynamics, and sediment budgets (sources, supply) will be necessary to determine relatively long-term stable accretion and better select sites where the aforementioned measures can be implemented (see NORDSTROM AND TERICH, 1985). Characteristics of the longshore current will determine optimal objectives with respect to the ideal coastline alignment and the corresponding mangrove afforestation measures. Coasts which are prone to occasional storms may need more important and expensive forms of protection or permanent restoration efforts.

Afforestation activities, i.e. collection and planting of seedlings, are labour-intensive and can easily be carried out by local communities in the form of environmental projects.

mangrove restoration
The coasts of West Africa and Asia include thousands of hectares of abandoned rice fields, salt pans and aquaculture ponds, and large areas of clear-felled mangroves with poor natural regrowth. Hundreds of hectares of mangroves have been lost behind roads that now isolate former forests from the sea.

If environmental conditions are favorable, breaching dikes and bunds - thus reestablishing tidal activity - is sufficient to stimulate natural regrowth. Natural regeneration of Avicennia spp and Excoecaria spp in abandoned rice fields is a common feature in Sri Lanka (JAYASEKARA, 1987). In the Casamance, isolated salt flats that formed during the drought could sometimes be rehabilitated by breaching creek levees, hence increasing tidal activity (pers. com. Prof. Pons). A culvert may suffice to stimulate mangrove growth behind dikes and roads. If however the soil has become acid or dry, or the plots are infested with Agrofestus ferns, or in the absence of suitable mother trees, planting is necessary and reforestation can be costly.

However, the rehabilitation of mangroves may not always be desirable. Rice fields could be converted into profitable aquaculture ponds. Abandoned rice fields and salt pans are very attractive to the waterfowl; their incorporation into a conservation plan may also be considered. Abandoned rice fields are often individually owned and their owners may prefer to wait for sufficient rains and be opposed to mangrove rehabilitation. In some places, e.g. near Conakry (Guinea), there is almost no mangrove fringe left between the sea and rice fields; under these circumstances, it may be necessary to rehabilitate mangroves with the help of retreat bunds.

maintaining and enhancing tidal activity
Brackish water estuaries are very productive and function as a spawning, breeding and feeding ground to shell- and finfish. Possibilities for creating, maintaining or even optimising estuarine conditions should be fully explored and developed whenever possible.

Plans have been developed for the creation of an artificial estuary in the Senegal Delta which no longer benefits from the influence of tides owing to the presence of the Dagana anti-salt barrier (see DE GEORGE, 1984; GERSAR/SONADER, 1987). This estuary will consist of several compartments with seawater and freshwater intake that are expected to reestablish the seasonal migration of euryhaline species for the purpose of increasing fish production.

Several types of interventions often, and unnecessarily, restrict tidal influence, e.g. roads and anti-salt barriers. Anti-salt barriers often block estuarine systems. Thereby, large part of these systems become unsuitable for agriculture; large areas of formerly productive mangrove and creeks are lost as a result of salinization and acidification which also contaminates adjacent open water. Anti-salt barriers should preferably be constructed in the upper estuarine zone, downstream of areas that include no or few potential acid sulphate soils. This will involve the creation of more but smaller dams that will maintain maximal estuarine productivity and can be more easily controlled and managed by the local population (HESSELINK AND VAN SLOBBE, 1987).

The operation of anti-salt barriers and sluice gates should allow tides to inundate mangrove rice fields during the dry season. In this way, weed control is optimal and sulphuric acid that formed during the period of cultivation is neutralised. The fish production potential of these seasonally flooded fields should be fully explored and exploited.

4.2.2. Optimising mangrove-related production

better use of forest resources
Proper management could substantially increase the productivity of mangrove forests. However, most forests are not properly managed, especially in Africa. Mangrove poles and charcoal could be produced on a sustainable basis in many mangrove forests. Non-wood products also have a considerable potential (e.g. beekeeping and extraction of tannin). The efficiency of charcoal production can be substantially increased.

better use of aquatic resources
In the preceding chapter, it has been shown that the potential for improving fisheries without modifying the physical environment is considerable. The introduction of open water fish and shellfish culture is one of the main means that

could be used in order to take advantage of this potential. Such activities should be developed whenever possible and feasible. Improved management of fisheries will increase catches in areas where overfishing currently occurs. Fish preservation techniques are very often inadequate and a large percentage of the catch is lost; improved processing and storage facilities can substantially contribute to the solving of this problem.

socioeconomic integration
Along semi-arid coasts that are prone to drought and where farming systems combine upland cultivation and "mangal" rice fields, mangrove-related forestry products and fisheries provide local people with a stable and secure subsistence. Along coasts where fisheries are largely seasonal, diversification will guarantee a more regular income. Storage will be needed to overcome temporary food shortages in case of large variations in annual production. Such facilities have traditionally been developed in many cases, they may however need improvement.

Newly introduced activities should, whenever possible, be adapted to village-based organizations and involve equitable local participation. When introducing capital-intensive activities, e.g. cage culture, cooperation should be stimulated. Examples exist of industries supplying turtle hatchlings to local households for rearing. Commercial forestry needs proper coordination and organization but it can absorb much local labour.

Different incentives can be instrumental in stimulating environmentally sound activities. Subsidies for replanting or the free supply of mangrove seedlings will stimulate reforestation; fines may prevent clear-felling of essential mangrove fringes (for other incentives, see chapter 5.1).

4.3. OPTIMISING RECLAIMED BENEFITS

This report cannot thoroughly discuss all possibilities for optimising reclaimed benefits. This chapter will only indicate some opportunities for environmentally sound innovation and its socioeconomic integration. Although reclamation should never be considered as the only or major development option, it may contribute to the diversification of activities, provide income and employment opportunities, and increase food production, if carried out wisely. Existing reclamation techniques can often be innovated and proper management can mitigate their adverse effects.

BOX 4.2. OPTIMISING MANGROVE-RELATED PRODUCTION

better use of forest resources
- improving forest management and production, including artificial replanting, zonation etc.
- introducing new forest-related activities, such as tannin production, nipa plantation, beekeeping and charcoal production
- improving processing and storage facilities for forest products (e.g. improved charcoal kilns)

better use of aquatic resources
- improving fisheries management, including delineation of fish breeding grounds etc.
- introducing open water culture (e.g. shellfish cultivation and cage culture)
- improving processing and storage facilities for shell- and finfish

socioeconomic integration
- combining different activities such as forestry and fisheries, with agricultural activities, thus attenuating seasonal unemployment
- adaptation to local organization structures
- economic incentives for environmentally sound behaviour.

BOX 4.3. INNOVATION AND INTEGRATION OF RECLAMATION ACTIVITIES

environmentally sound innovation
- reclamation design adapted to tidal flushing, the pattern of potential acid sulphate soils and the maintenance of mangroves for coastal protection, fish breeding areas etc.
- water management, using high water table management techniques, flushing with saline waters in order to control weeds
- crop varieties that are salt-tolerant or fast-growing
- combining fish farming with raising of poultry, sewage processing and rice cultivation

socioeconomic integration
- design adapted to local organization
- management by local communities
- crop diversification in order to meet people's needs
- combination with other activities
- economic incentives that stimulate environmentally sound reclamation and innovation in existing polders

environmentally sound innovation
Agricultural and (intensive) aquaculture scheme should be located outside mangrove areas. If reclamation is inevitable, e.g. in the case of high demographic pressure, only non-acid sulphate soils should be considered for reclamation and a minimum area of mangroves should be maintained as fish breeding ground and for the purpose of protecting the coast (see chapter 5.3). Impoldering should be restricted to suitable soils only, while tidal activity and fresh water inflow should be fully maintained in adjacent non-reclaimed areas. Reclamation along eroding coasts should be avoided.

Drainage waters from agricultural and aquaculture schemes should be kept out of mangrove swamps and estuarine areas that are insufficiently flushed. When the use of agrochemicals is inevitable, drainage should not take place before these chemicals have lost their effectiveness. Preferably, crops should be salt-tolerant and adapted to high water tables and waterlogged conditions. In the case of limited fresh water supply and short growing seasons, short and fast-growing rice varieties can be considered for cultivation. Aquaculture production can be greatly improved by higher stocking densities and combination with poultry farming. In areas with a pronounced dry season, rice cultivation can be combined with aquaculture or salt production. Fertilization should be minimal and the application of pesticides should be avoided. The growth of weeds can be prevented successfully by occasional saltwater inundation.

socioeconomic integration
Reclaimed activities are often implemented on a large scale and need substantial investments and licences that are not easily obtained by local people. Reclamation should preferably be attuned to local village organizations or be based on cooperatives. In the 'backyard hatcheries' of Thailand, fry is produced by local households with the assistance of governmental institutions. Instead of being based on cash-crops and monoculture of rice, reclamation schemes should also include cultivation of food crops. Partial and environmentally sound reclamation can enhance the diversification of economic activities and daily diet, and increase employment.

Economic incentives can be a powerful tool in steering developments. In the Philippines, subsidies are given for the conversion of mangroves into shrimp ponds; this has caused unnecessary destruction of mangroves by unsound forms of aquaculture. Subsidies for the intensification of aquaculture will increase the production, stimulate feasible forms of aquaculture and maintain mangrove forests. Sometimes, agrochemicals are provided free of charge in order to stimulate production. As a result weeds and insects are killed by an overdose, and so are adjacent ecosystems. Pesticides with adverse environmental effects should be forbidden or only available at high prices in order to insure their efficient use.

4.4. INTEGRATION OF CONSERVATION

4.4.1. Making conservation more beneficial

There are many ways in which protected areas can benefit local communities. Indirectly protected mangroves support fisheries and provide coastal protection to agricultural lands. In bufferzones, fishing and gathering of minor wood products and shellfish can be allowed. Bufferzones may even function as zones of traditional resource utilization. Local control can stop illegal felling of mangroves and illegal fishing.

National parks and nature reserves may employ local people as game wardens and maintenance staff. Poaching was successfully halted by involving local village scouts in several African parks. National Parks can support tourism industries, which creates employment opportunities. In Costa Rica, tourism is an attractive commercial enterprise and landowners have started to designate their lands as nature reserves. Many mangrove areas are suitable for bird watching and fishing trips, that can be locally organized. Entrance and hunting fees can be (partly) returned to local communities through revolving funds.

The aforementioned benefits of protected areas are not always fully explored and exploited. Minor forms of resource utilization are often forbidden although they are compatible with the conservation objectives of parks. At present, hotels and restaurants employ people and bring in supplies from outside the area, and their facilities are being used by tourists only. Entrance fees of national parks are minimal and not returned to local communities.

Wildlife species also can constitute sources of income and food. Along the coast of Suriname, local people collect turtle eggs under the control of the Foundation for Nature Preservation in Suriname (STINASU). Eggs are removed mainly from threatened sections of the coast and transferred to more suitable places or nesting boxes. Since 1960, the number of nesting sea turtles has increased, and so have the number of eggs collected and the number of young turtles that went to sea (see the case study on Suriname).

BOX 4.4. THE BENEFITS OF PROTECTED HABITATS

Adapted from McNeely (1988).

- Stabilization of hydrological functions; when inundated, protected habitats buffer floods and sediments, and allow recharge of groundwater reservoirs.
- Soil protection; yearly inundations prevent salinization and fertilize soils.
- Contribution to climate stability.
- Conservation of renewable resources that can be harvested; limited grazing, gathering of wood, fishing and even agriculture can take place in protected areas without competing with conservation objectives.
- protection of genetic resources.
- preservation of breeding stocks and biological diversity; protection of areas that are essential to crucial life stages of species, and protection of species that are widely and profitably harvested outside reserves.
- maintenance of the natural environmental balance; for instance, the balance between insect and bird populations is maintained as a lack of insects (i.e. food) limits the number of birds present in the area.
- support to tourism and recreational activities; protected areas are sources of foreign currencies while their existence stimulates local industries (hotels, restaurants, transport system, souvenirs and handicrafts, and guide services).
- creation of employment opportunities related to the protected area itself and additional employment related to auxiliary services, road construction, tourism development etc.
- provision of facilities for research, education and monitoring, thereby generating direct benefits through the purchase of supplies, hire of local assistance and other contributions to the economy.

4.4.2. Creating opportunities for wildlife

better control of hunting

Coastal protection zones and preservation areas for fisheries, but also forest reserves, commercial forestry and even rice fields and salt flats may give ample opportunities for wildlife, provided that hunting pressure is low. In many areas, hunting is the single most important factor responsible for the decrease in wildlife populations. In most cases, poaching can only be stopped through local control. For this purpose, wildlife cropping can be an important incentive.

habitat improvement

Bird populations can be supported by providing roosting and nesting sites. Along coasts with extensive mud flats and rice fields, e.g. in Guinea Bissau, the protection of small but important roosting and breeding sites will strongly support bird populations without hampering agriculture. The Matang forest contains two small lakes, Stork lake I and II, that are very important to many endangered bird species such as the Milky Stork. It has been proposed to attune forest management and regulations to the requirements of this bird population. A slightly altered management of salt ponds will increase their attractiveness to waders and waterfowl.

rearing of endangered species

Species such as estuarine crocodiles and marine turtles can be reared in order to reduce hunting pressure on wild populations. When wild species are important for sustaining farms, incentives are created for their protection.

4.5. INTEGRATED STRATEGIES

Various objectives can be set for the development of mangrove coasts, e.g. self-reliance in food supply, creation of job opportunities or generation of revenues in foreign currencies. Therefore the formulation of 'wise-use' strategies will very much depend upon:

- the actual status of the mangrove coast, whether the mangrove ecosystem is still in its natural virgin state, already modified or fully reclaimed will largely determine in what way and to which extent biological diversity can be preserved and what forms of water control and mangrove-dependent activities may be envisaged;
- the demographic pressure, whether the mangrove coast is the resource base for many or for few people will determine if the activities should be labour-intensive or highly productive;
- the socioeconomic reality, whether the area is market oriented, situated in a more or less developed economy and organized society, and which other economic activities are being carried out will determine if activities can be capital-intensive, technologically advanced, demanding high levels of organization or labour-effective (i.e. giving high benefits at low levels of labour-input).

The following integrated strategies can be distinguished (also see Table 4.1):

wildlife utilization strategy

Whenever demographic pressure is comparatively low and the mangrove forest relatively untouched, a wildlife utilization strategy may be envisaged. It basically consists of the creation and management of nature reserves and national parks combined with sustainable forms of game cropping and game raising. Income for local communities is generated by jobs in park management, ecotourism, sport fishing, game farming and other compatible and sustainable forms of mangrove utilization such as fisheries and open water aquaculture.

Since potentials for tourism development depend upon accessibility, touristic infrastructure, natural scenery, beaches and enjoyable climate, a limited number of coasts are prone to the development of nature-oriented tourism. Exam-

ples of tourism development activities can be found in Puerto Rico, Costa Rica and Suriname. Such activities could be developed in many other areas, for instance in Senegal, Gambia, Thailand and Indonesia.

mangrove utilization strategy
This strategy focusses on forms of sustainable mangrove utilization, namely forestry and collection of forest products, fisheries and open water aquaculture. Such activities leave the mangrove ecosystem largely untouched. Small nature reserves may have to be created as breeding sites, and hunting regulations may need enforcement. Forest management should also incorporate conservation-oriented regulations such as the preservation of a limited number of high nesting trees. Various forms of nature-oriented tourism may also be included in this strategy.

This strategy can allow employment of large numbers of workers who can be active in the forest (and related) industries, and engaged in fisheries and open water aquaculture. The Matang mangrove reserve in Malaysia and the Sundarbans in Bangladesh provide good examples of this kind of integrated strategy. It may involve the control and guidance by a forest department that issues licences for all kind of exploitable natural resources. Replanting and other restoration activities should preferably be carried out by the forest department itself, and royalties should ensure the necessary financing. Several of these activities are strongly market-oriented, e.g. timber, charcoal and fish production, but most activities require limited investments. The production of expensive fish in open water aquaculture systems can only occur in the vicinity of markets. Mangrove areas propitious to such strategies can be found along African and Asian coasts.

partial reclamation strategy
This strategy involves the partial reclamation of a limited percentage of mangroves on condition that no environmental thresholds are surpassed and mangrove soils considered for reclamation are not potential acid sulphate soils. The utilization of mangrove resources and various forms of fishery and aquaculture are important as well.

When demographic pressure is high, land suitable for cultivation is scarce and opportunities for developing market-oriented timber and fisheries are limited, partial reclamation may be a suitable strategy. Small-scale rice cultivation may increase the diversity in daily diet, enable a better distribution of labour peaks throughout the year and absorb a large part of labour. Partial reclamation should be based on soil surveys, embedded in a sound coastal management plan, and controlled and monitored in order to prevent excessive and illegal reclamation activities. The use of agrochemicals and hunting should be restricted so that rice fields can act as feeding grounds for waders. Small, fully protected core areas should be designated in the mangrove zone in order to allow undisturbed breeding and roosting.

innovation strategy
Along coasts with extensive reclamation where low-input aquaculture and agriculture prevail, innovation can be the most viable and economically feasible development option, especially as an alternative to further reclamation. Innovation may consist of improving the efficiency of labour, increasing the production by introducing new technologies and improving inputs, and combining activities such as aquaculture, agriculture and salt production. Mangrove restoration and afforestation may also constitute an important component of this strategy.

Conservation activities consist mainly of controlled hunting, prohibition of dangerous agrochemicals and full protection of relatively isolated and small roosting and breeding areas.

TABLE 4.1. DIFFERENT INTEGRATED STRATEGIES AND THEIR COMPONENTS

STRATEGY	wildlife utilization	mangrove utilization	partial reclamation	innovation
OPTIMISING MANGROVE-RELATED ACTIVITIES				
mangrove afforestation etc.				
-afforestation	p	+	+	+
-restoration	p	+	+	+
-maintaining tidal activity	.	.	+	+
optimising mangrove-related production				
-better use of forest resources	p	+	+	+
*improving forest management				
*introducing non-wood activities				
*improving processing and storage				
-better use of aquatic resources	p	+	+	+
*improving fisheries management				
*introducing open water cultivation				
*improving processing and storage				
socioeconomic integration				
*combining	.	p	+	+
*adaption to local organizations				
*economic incentives for environmental sound behaviour				
OPTIMISING RECLAIMED ACTIVITIES				
environmentally sound innovation				
-adapted reclamation design	.	.	+	p
-improved water management	.	.	+	+
-adapted crop varieties	.	.	+	+
-combinations	.	.	+	+
socioeconomic integration				
-design adapted to local organization	.	.	+	p
-management by local communities	.	.	+	p
-crop diversification	.	.	+	+
-combination	.	.	+	+
-economic incentives	.	.	+	+
OPTIMISING CONSERVATION				
making conservation more beneficial				
-creating job opportunities in park management	+	+	p	p
-tourism development	+	+	p	p
-allowing for sustainable utilization	+	p	.	.
creating opportunities for wildlife				
-better control of hunting	+	+	+	+
-habitat improvement	p	p	+	+
-rearing of endangered species	+	p	p	p

. = minor component; p = possible component; + = dominant component

5. PLANNING, DECISION AND IMPLEMENTATION

5.1. ENHANCING PEOPLE'S PARTICIPATION

identifying strategies

As it has been emphasized in the preceding chapters, the ultimate success of a project aiming at the integration of conservation and sustainable resource utilization, will largely depend upon the willingness of local communities to support it. These communities will only be inclined to do so if the project caters for their needs. Therefore, people's priorities must be known in order to properly identify and formulate projects. Uncovering these priorities requires the participation of the relevant communities from the very first beginning.

opposed objectives and strategies

While national governments may aim at self-sufficiency and generation of revenues by means of large, high-input irrigation schemes, local people aim at minimizing risks that threaten their daily subsistence, and optimising individual net profit. In order to do so, local people base their strategies on crop diversification, and low-input and labour-efficient productions. They also prefer to control land and water resources themselves. Objectives and strategies of national governments and local communities seem to oppose each other although they should be integrated. Identifying people's needs may involve long-term commitment.

coastal zone planning

Many decisions concerning the allocation of water, the building of dams, and the reclamation of areas for agriculture and aquaculture cannot be taken at the local level. However, these decisions should be made at the level of the entire coast. The identification of coastal development options still has to start at the local level.

TABLE 5.1. PEOPLE'S PRIORITIES AND STRATEGIES IN GENERAL

PEOPLES PRIORITIES

OBJECTIVES	STRATEGIES
daily subsistence	gathering and cultivation (food crops) are the first priorities, followed by non-food basic needs such as firewood and timber.
minimized risks	low-input forms of agriculture using different varieties; control over resources; diversification of agricultural activities including off-farm activities; storage as buffer and family ties as insurance.
net profit	preference for net profit with low inputs and minimal risk after basic amenities are satisfied; when these are absent, there is a need for cash-income

dislocation of environmental costs and benefits

Most interventions increase the benefits accrued to one group while the costs they induce are often paid by another group owing to the dislocation of resources such as water and land. The dislocation of environmental costs and benefits, whereby benefits are accrued to some group at the cost of others, is one of the major causes of environmental degradation. The different ways in which dislocation occurs, i.e. dislocation paths, are summarized in table 5.2. In order to meet today's needs, environmental costs are allocated to other areas, other resources, other resource users and future forms of resource utilization. Local people tend to put emphasis on local and current production, ignoring its effects on downstream pollution and future productivity. Many environmental degradation problems in developing countries have their origin in the industrialized world.

TABLE 5.2. CAUSES AND FORMS OF DISLOCATION OF ENVIRONMENTAL COSTS AND BENEFITS

DISLOCATION PATHS			
in time	-short term benefits for present users	versus	long term costs for future generations
in river basins	-upstream benefits for upstream users	versus	downstream costs for downstream users
between sectors	-land use benefits for farmers	versus	aquatic costs for fishermen
in trading	-first world benefits for first world inhabitants	versus	third world costs for third world inhabitants
	-cash crops benefits	versus	subsistence costs
in social hierarchy	-rich people benefits	versus	poor people's costs
	-man's benefits	versus	woman's costs
	-individual benefits	versus	collective costs

ORIGIN OF DISLOCATION	
unawareness	-environmental effects are not known to actors
unwillingness	-effects are known but actors do not care
unavoidable	-effects are known but can not be avoided owing to a lack of alternatives ("poverty-caused degradation")

using incentives

Most forms of environmental degradation caused by dislocation mechanisms can only be stopped by redirecting dislocation paths and having costs paid by those who get the benefits, or eliminating the causes of dislocation. Giving land ownership to farmers and setting up revolving funds are but two examples of ways through which dislocation paths can be redirected. Awareness building and research are ways to reduce and eventually eliminate dislocation. Checking environmental degradation in the coastal areas of developing countries requires the development of alternatives that can provide the local poor with a secure income.

Economic and socioeconomic incentives can be instrumental in stimulating environmentally sound behaviour. Incentives can operate at community level, national level (mainly by using taxes) or international level (by using international package-deals). Some require sophisticated control mechanisms and are therefore unsuitable for countries with insufficient enforcement capacity. The most effective and cost-efficient incentives are those which provide resource users with control over relevant resources. In this context, the use of traditional (customary) laws and organizational structures or the stimulation of village-based organizations can be powerful tools.

BOX 5.1. PEOPLE'S PARTICIPATION AND INSTITUTIONAL MANAGEMENT SYSTEMS

In principle three different institutional wildlife management systems can be distinguished in Africa (after Udo de Haes and Fiselier, 1990):

	main characteristics
SENEGAL	wildlife vested in the state law enforcement and hunting quota set by government officials benefits of hunting accrue to the state deprivation of local communities **law enforcement is costly and inadequate; high incidence of poaching**
ZAMBIA	wildlife vested in the state llaw enforcement and quota set by government officials benefits of hunting to state and local communities **law enforcement is cheap and adequate; low incidence of poaching**
ZIMBABWE	wildlife partially vested in commercial farms and communal grounds, wildlife in national park is still vested in the state law enforcement and determination of quota by individuals benefits of hunting accrue to individuals and communities **law enforcement is cheap and adequate; low incidence of poaching**

In the case of Senegal, which is representative of most African countries, the benefits of hunting accrue only to the state and privately run safari-hunting operators, while local communities are deprived from an important source of food, animal products and income. Hunting fees are however insufficient to maintain the extremely costly law enforcement. In Zambia and Zimbabwe the benefits of hunting accrue also to the local communities, thereby providing an economic incentive for locally based wildlife protection and management.

BOX 5.2. ECONOMIC INCENTIVES AT THE COMMUNITY LEVEL

After McNeely (1988).

- direct incentives in cash; examples are (entrance) fees to be returned to the village, rewards for control and proper use, fines on illegal activities, compensation for damages caused by wildlife or restricted resource use, grants, subsidies for environmentally sound activities, land banks, loans, revolving funds and daily wages for reforestation activities,
- direct incentives in kind; examples are food (for work), animals, access to resources (especially equitable access) in buffer/ multiple use zones
- indirect fiscal incentives; tax incentives such as tax exemptions for environmentally sound activities, security, guaranties, and insurance to less pressure on resources in times of droughts, economic recession etc.
- indirect service incentives; community development activities, agricultural inputs such as mangrove seedlings, improved use of resources (especially efficient stoves etc.), reduced pressure, rural development projects that make use of native biological diversity, education and training
- social incentives; community organization, the establishment of strong village level institutions can be a very effective incentive; land tenure, employment e.g. jobs in tourism; information.

Apart from these locally based incentives, incentives at the national level (e.g. regulations for EIA, Cost-Benefit Analysis and conservation strategies) and international level, such as institution building and "debt for nature swaps" also can be effective in preserving biological resources.

Some forms of dislocation cannot be locally controlled. This is especially true for activities that affect downstream areas, or benefit a village or an ethnic group while being detrimental to another. Solving such conflicts requires arbitration by an organization or institution operating at the regional level.

5.2. ENVIRONMENTAL IMPACT ASSESSMENT AND COST-BENEFIT ANALYSIS

the necessity for the implementation of environmental impact assessments

In the past, construction of anti-salt barriers and reclamation for irrigation schemes and aquaculture have taken place without (proper) environmental impact assessments (EIA). When considered individually, small interventions may have little effects; nevertheless, these effects may interact with 'minor' effects of other interventions and cause considerable damage. Such interventions still pass unnoticed. EIAs now carried out in developing countries suffer from a lack of basic data, uncertain predictions with respect to the effects of interventions and inadequate participation of local people in assessment procedures. Most EIAs tend to look at the effects of an intervention that is already agreed upon, and merely produce guidelines for the mitigation of (expected) adverse environmental effects. The formulation of alternative options suffers from a lack of creativity and mainly promotes traditional forms of expensive engineering works and full conversion of land.

In order to promote environmentally sound alternatives, the Congress of the USA adopted a law (Public Law 99-662) requiring the formulation of a predominantly non-structural alternative for each new water project that is recommended for authorization (BLACKWELDER ET AL, 1987). Similar requirements would considerably improve the quality of EIAs and plans implemented in developing countries.

forgotten environmental effects

For most interventions in wetlands, the implementation of an EIA is a rather complex operation. The basic information necessary to make valid predictions is nearly always lacking or incomplete. In most cases, EIAs only take into account and put emphasis on single, direct, obvious, easily measurable and short-term effects on marketable productions, while other effects are ignored or underestimated. However, effects on non-marketable productions essentially affect subsistence systems, while effects on non-tangible regulatory functions performed by coastal areas can be disastrous.

In classic civil engineering, effects that can be predicted by calculations are thought to be fairly reliable. This often proved to be wrong as these predictions are based on blueprints according to which market mechanisms function perfectly, market prices are stable and human behaviour is predictable. Tiffen (1987) evaluated a number of major irrigation schemes and showed that in most projects the internal rate of return was less than half the rate originally predicted. Poor predictions in Sub-Saharan Africa were mainly due to benefits unexpectedly accruing to groups falling beyond the target groups of projects, unreliable marketing factors, labour (shortages during labour peaks), land tenure, consolidation, compensation and resettlement, conflicts between the objectives of the State and those of farmers, and managerial problems. She concludes that operation and management costs should be kept as low as possible; this should be a major guideline in the design of interventions while flexibility should be used as an independent criteria in evaluations.

Most cost-benefit analyses only consider costs and benefits in absolute terms without paying attention to their final allocation (who benefits from interventions and who pays the costs). However, development activities can only be properly implemented and managed if the actual distribution of costs and benefits is known. In developing countries, particular attention should be paid to the distribution of environmental costs and benefits, and the sustainability of development options with respect to vital resources such as water, land and energy.

5.3. COASTAL ZONING

introduction

Environmental zoning, the optimal spatial allocation of non-compatible activities, is one of the most powerful tools for sustainable development.

Delineation of different environmental zones should be done with regard to:

- **people's priorities**: minimum required surface of mangroves, aquaculture and agriculture; maximum distance to the village and minimum required access to resources; maximum size of interventions that can be supported and taken over by local organizations;
- **sustainable development**: minimum mangrove fringe needed for coastal protection and the spawning and breeding of fin- and shellfish;
- **conservation**: minimum required surface of undisturbed habitat and its optimal position with respect to other forms of resource utilization; possibly, habitats can be improved.

different forms of environmental zones

Several categories of environmental zones can be distinguished:

protection zones

Location and size of protection zones are largely determined by ecological factors. Because mangrove coasts are so dynamic, it is advisable to systematically designate an outer **afforestation and restoration** zone. The afforestation zone is meant as a buffer for the coastal and shoreline protection zone, but can also favour mangrove enhancement. Both zones can be combined with moderate forms of open water aquaculture especially cockle farming, fishery and gathering of minor forest products.

The width of the **coastal protection** zone depends largely upon the expected erosion. Under natural conditions, erosion depends on sand-budgets and sources, exposition to longshore currents, winds and waves, occurrence of tropical cyclones, tidal amplitude, navigation and presence of

wave energy-absorbing coral reefs, sandbanks, mud flats and sea grass beds. Along rivers one may add flood amplitudes and storm surges. Most of these factors change continuously and a coastal protection zone can seldom be wide enough since dike construction and maintenance are very expensive. This zone may tolerate moderate forest utilization but certainly no clear-felling and fisheries; it can also function as a breeding area for shell- and finfish. In this zone, mature mangroves can be protected as breeding and roosting trees.

Most fin- and shellfish are sensitive to salinity and their **spawning and breeding grounds** shift with salinity levels. In the Casamance estuary the breeding and migration of shrimps has been extensively studied by Le Reste (1986). He noted that in dry years, spatial shifts of breeding grounds and migration routes of shrimps occur. Therefore, fish preservation areas should be wide enough.

mangrove utilization zones

The designation of mangrove utilization zones should be mainly governed by local needs and the levels at which the exploitation of resources is sustainable. It is advisable to distinguish between **traditional use** areas, wherein access is restricted to local communities and **commercial exploitation** zones.

Different zones for **fisheries** can be distinguished that correspond to activities such as gathering and cultivation of shellfish, open water fisheries, fisheries with fixed gear in creeks and on mud flats, and cage cultures. Zones can be accordingly allocated. Many mangrove soils are not suitable for **forestry** owing to a poor regeneration capacity; they should preferably be used for the gathering of minor forest products. Other areas can have rotational felling of tree for pole, firewood and charcoal production.
Navigation routes should also be delineated in order to prevent conflicts with shellfish cultivation, fixed-gear fisheries and cage culture development. In the vicinity of large cities, special zones for **sewage disposal** can be delineated; they should preferably be located in areas with intense tidal flushing.

mangrove reclamation zones

When reclamation of mangroves is the only feasible option, it should be restricted to areas where only suitable, non-potentially acid soils occur. Nevertheless, mangrove protection zones always have the highest priority. Reclamation for **agriculture** should preferably occur as far as possible inland, on the highest lands. As stated before, modern **aquaculture** should preferably be situated outside the mangrove area. When there is not much competition for land, the conversion of rice fields into temporary or permanent shrimp ponds may be envisaged.

conservation zones

Conservation zones are designated in order to maintain habitats and ecological relations that are crucial to endangered species. There are many different types of conservation zones; this chapter only considers core areas that are exclusively restricted to wildlife, and multiple use zones where conservation is combined with moderate forms of land use. Normally, conservation zones will not be limited to mangrove forests, they may also include all relevant feeding and breeding grounds. Multiple use zones, that act in fact as buffers, can be divided into **marine bufferzones** with limited gathering of shellfish and artisanal fisheries, and **terrestrial bufferzones** with limited gathering of forest products. Normally, feeding areas may be designated as multiple use zones, while breeding and roosting areas need full protection as **core areas**.

implementation of environmental zonation

The delineation of environmental zones requires research as well as political decisions. Extensive mapping of available resources is essential. Mapping should be implemented not only for the different mangrove zones, but also for tidal flats and the most relevant fluvial and marine systems that characterize the coast under consideration.

Decisions have to be made at different levels; this requires different forms of organization, and the use of ecological and socioeconomic criteria. At the highest level, protection of particular stretches of mangrove coast may be found desirable because of their role as crucial breeding grounds for resident birds, or as wintering habitats and stepping stones for migratory birds. Protecting wintering quarters may involve international co-ordination and require international package-deals. Although river basin development authorities are widespread in most developing countries, "coast development authorities" are often lacking. Regional authorities are needed to decide upon the allocation of mangrove forests for traditional uses, commercial exploitation and possibly reclamation, urban development and navigation.

Coastal management zoning as practiced in the western world is often not appropriate for developing countries that lack institutional capacity in the fields of monitoring and the enforcement of regulations. Instead, zoning - and its enforcement - may have to be based on public participation and commitment, and traditional organizations and procedures, as it has been recommended for the American Samoa (see Box 5.5).

It is advisable that irreversible decisions be made at the highest political level, and reversible decisions at the local level as proposed for the Fiji Islands (see Box 5.6).

BOX 5.3. PROPOSED ENVIRONMENTAL ZONING, BANYUASIN-SEMBILANG SWAMPS, INDONESIA

Adapted from Verheugt et al (in this report).

The Banyuasin-Sembilang swamps complex lies in the northern corner of the South Sumatra Province, Indonesia. These tropical rainforest, coastal lowland mangrove swamps gradually change inland into a freshwater swamp. The mangroves mainly consist of an association of Rhizophora and Bruguiera. The complex of mangroves and associated freshwater peat swamp forests harbour over 330 species of birds, either resident or transient. Twenty eight species of migratory waders that mainly forage on the tidal mud flats have been recorded.

The swamps are sparsely inhabited by traditional forest dwellers (Kubu) and Malay fishermen. The swamps are not intensively used and there still exist considerable potential for mangrove-related activities such as forestry activities and fisheries. In order to safeguard the natural values of the area, an environmental zoning was proposed consisting of:

1) an inland (terrestrial) bufferzone, for forestry activities such as the gathering of minor forest products;
2) an inter-tidal (marine) bufferzone where artisanal fisheries and gathering of invertebrates is permitted;
3) a Wildlife Reserve, where only collection for scientific purposes will be allowed.

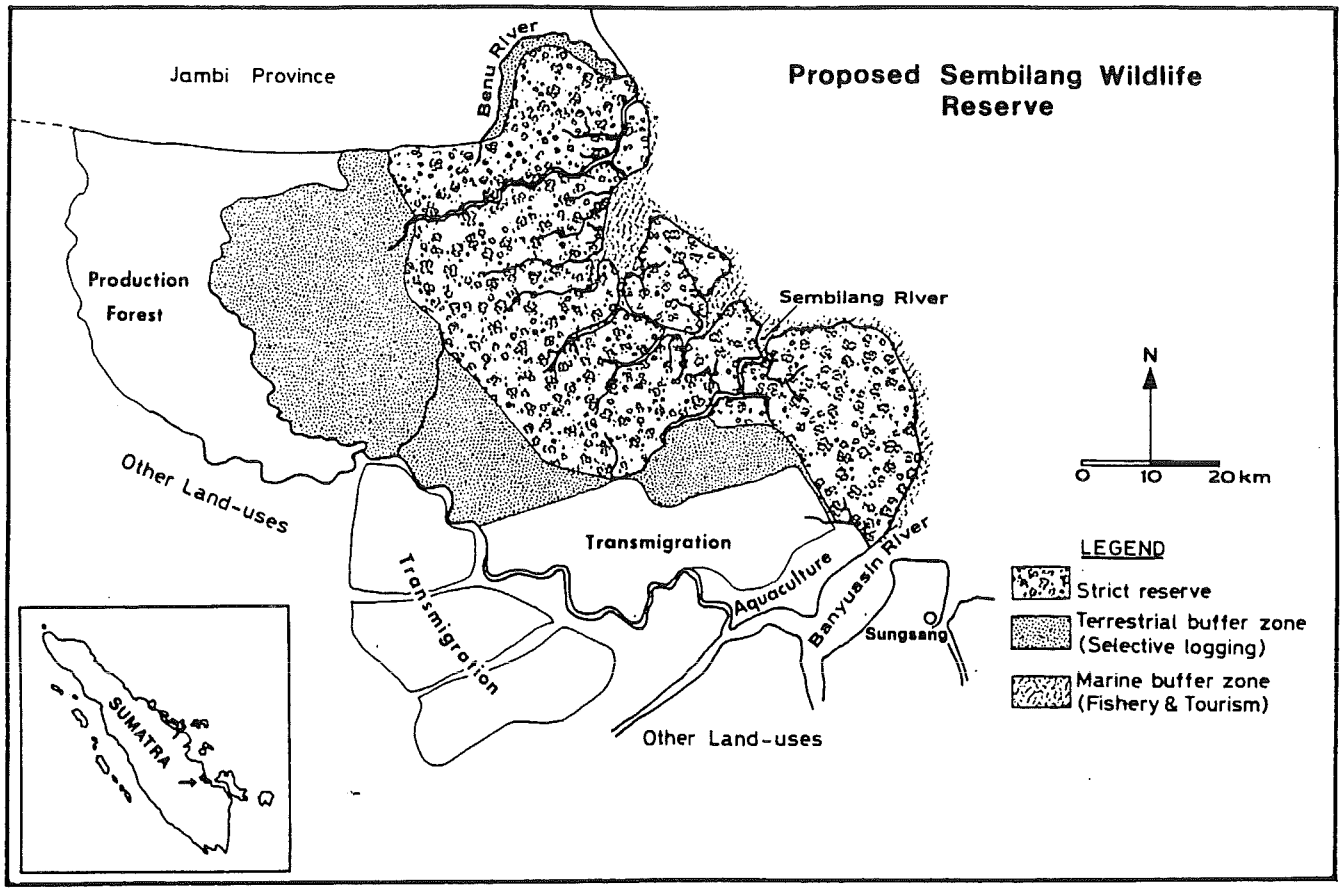


Figure Proposed Sembilang Wildlife Reserve

BOX 5.4. ECUADOR SHRIMP CULTURE AND TRANSFER OF COASTAL ZONE MANAGEMENT POLICIES DEVELOPED IN THE INDUSTRIALIZED WORLD

From Meltzoff and LiPuma (1986).

Ecuador is a country where shrimp cultivation has become a major economic activity, its export revenues are second to that of oil. In 1984, earnings were estimated to be US$ 225 million supporting 150.000 jobs, of which 90.000 'semilleros' (fishermen of post-larvae). The ponds cover more than 100.000 hectares, of which 70% are constructed in former mangroves, 15% on salt flats and 15 % on agricultural land. Both in 1981 and 1985, 12 billion semilla were caught, of which 6 billion are Penaeus vannamei (the preferred cultured species), although the number of semilleros had doubled between 1981 and 1985.

Basically three different types of shrimp ponds can be distinguished:
- **highly extensive ponds** (about 35%) with only human inputs and low stocking densities (20.000 'semilla' per hectare), and a production of 400 to 600 lbs/ha; begun in the late 60s and is often individually owned by men from the local banana industry;
- **moderately extensive ponds** (about 55%) combining natural and man-made inputs, medium stocking densities (40.000 and 60.000 semilla per ha); production of 600 to 900 lbs/ha; mainly owned by an association of Ecuadorian businessmen and bankers;
- **semi-intensive ponds** (about 10%) mainly under professional management and owned by foreign companies.

The interest groups of established owners are opposed to further reclamation of mangroves as this will decrease the natural availability of semillas, and are consequently in favour of Coastal Zone Management. However, coastal zone management in the industrialized world is based on:
- long-term viewpoints and commitments that emphasize sustained maximum economic return; however business and government policies in Ecuador are placed in a short-term perspective;
- impartial, equitable means of policy formulation; this is however not possible in a system based on a duality of interests and where individuals and the different sectors strive for their own interests and power;
- implementation of coastal zone management through enforceable laws, regulations and permits; in Ecuador, law enforcement is largely absent and corruption undermines the system of regulations and permits.

"This implies that the shift towards a more intensive production stressing capital-intensive, long-term ponds productivity will require not only more technology, capital and skilled labour, but basic revisions in the Ecuadorian view of what business is about". According to Meltzoff and LiPuma (1986), a three-step approach is needed; firstly, 'the identification of environmental problems in relationship to their socioeconomic causes and implications', secondly, 'to discover what are possible solutions given the prevailing structure of that social and political economy', and thirdly 'to examine coastal zone policies and institutional arrangements which address similar problems and determine which elements of these policies and arrangements can be combined with local solutions and adapted to the situation in question'.

BOX 5.5 GUIDELINES FOR THE IMPLEMENTATION OF COASTAL ZONE MANAGEMENT IN AMERICAN SAMOA

From Templet (1986).

1. Strong involvement with the local government (villages) through their traditional procedures is important in creating linkages, and the use of surveys, plans, and self-help projects for the villages gains their help and trust.
2. Public participation and consensus-building efforts should work at appropriate levels. In American Samoa, this was the village level, although schools and television (public education) were later used.
3. Use of coastal management to reinforce territorial aspirations and goals ensures a high level of cooperation. In American Samoa, appropriate economic development is being promoted through coastal area management policies and objectives.
4. The use of traditional cultural experience, by appealing to local customs, ethics, and folk wisdom, reinforces aspects of the program, instills an ecological understanding, and adds traditional strengths to the program.
5. The use of visually formatted information (the Atlas) to convey technical information to the villages, agencies, and governmental personnel is effective.
6. Coastal management programs are useful in guiding technical assistance from outside the territory or country. A well-focused resource management program with clearly defined policies and goals can be a very useful conduit for guiding and coordinating outside assistance, both fiscal and personnel, into areas where help is needed while minimizing adverse impacts.
7. The program must be flexible and operate at a level of bureaucratic and fiscal checks and balances which is compatible with territorial experience. For example, in a territory which values its extended family structure very highly and where families are large, nepotism is inevitable. While this is a problem to Americans, it may be an asset to American Samoa.
8. Experience with program implementation in American Samoa indicates that the U.S. system of checks and balances and resulting bureaucracies to control money is inappropriate in other countries. Traditional infrastructures generally cannot cope with extensive bureaucratic and fiscal procedures, and the creation of massive infrastructure causes unnecessary and counterproductive burdens which will work against any program associated with them.

BOX 5.6. MANGROVE ZONATION, FIJI ISLANDS

From Watling (n.d.)

As shown in the matrix, the zonation assumes traditional use zones and different levels of decision with respect to designation changes.

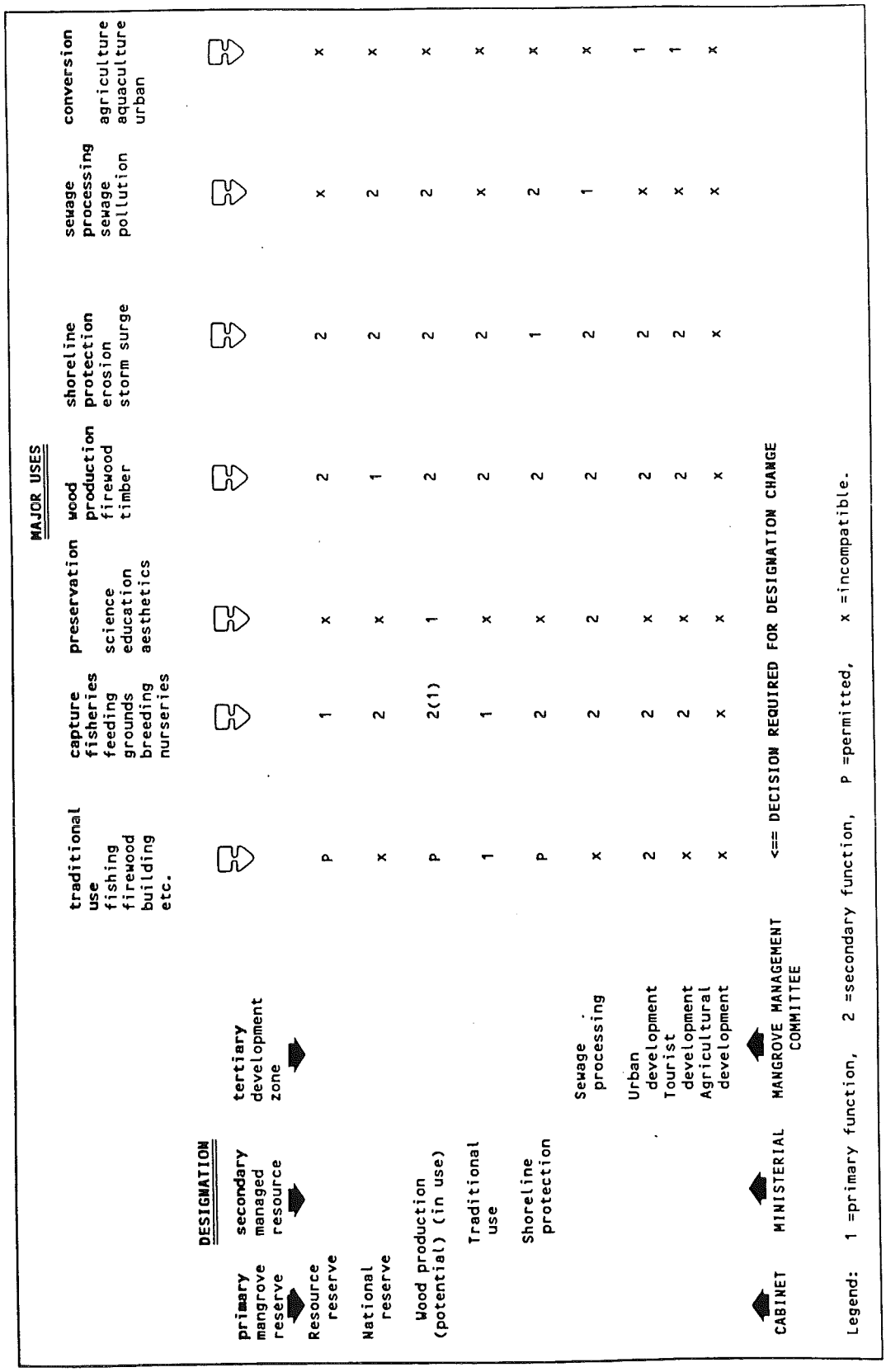


Figure: Mangrove-uses compatibility and decision levels

5.4. COASTAL ENVIRONMENTAL PROFILES AND PROJECTS

implementing integrated strategies
Various strategies for the integration of conservation and sustainable resource utilization have been formerly discussed. An environmental profile can identify pertinent strategies that can be implemented in the form of environmental projects.

coastal environmental profiles
For a country such as Guinea Bissau, the production of an environmental profile is the first step that should be made. Such a profile gives an overview of environmental resources in their socioeconomic context, their current utilization and the related environmental problems. It often provides a first integration of sector studies and reports.

A coastal environmental profile should reveal:
- information gaps, and formulate priorities for inventories and related research,
- insufficient institutional capacity and, make proposals for the strengthening of crucial departments or the creation of new ones,
- deficiencies in environmental legislation and law enforcement, and give recommendations for altered or additional legislation, control mechanisms and enforcement capacity,
- short-term and long-term environmental problems, and indicate priorities with respect to actions that should be undertaken,
- opportunities for the sustainable use of resources, and suggest development projects.

In South-East Asia, coastal environmental profiles have been made as part of the Coastal Resources Management Project (ICLARM, UNESCO) for Singapore, the Lingayen Gulf (Philippines), the Ban Don Bay and the Phangnga Bay (Thailand), South Johor (Malaysia) and Brunei. Others exist such as the Coastal Environmental Management Plan for Bangladesh and the Regional Environmental Management Plan of Eastern Seaboard (Thailand). This last plan has not been implemented since relevant institutions that had not been involved in its preparation were reluctant to give follow-up to the recommendations. Involving implementing institutions is a key-factor in the elaboration of a realistic and successful coastal environmental plan. Coastal environmental profiles are new tools that are yet to be fully developed and used in most parts of Africa, the Pacific, the Caribbean and Central and South-America.

environmental projects
Within the framework of a coastal environmental profile, first steps can be set for the formulation of environmental projects, e.g. projects aiming at maintaining or rehabilitating the environment. These projects can be formulated in order to solve local environmental problems in cooperation with local communities. Examples of potential environmental projects are:
- mangrove restoration plans, involving local communities in seed collection, planting, site selection, and management,
- rehabilitation of abandoned rice fields and their combination with aquaculture, involving local communities in rebuilding and maintenance as well as site selection and management,
- establishment of nature reserves and national parks, involving local communities especially in the delineation of the park and in its management.

The identification of possible environmental projects should preferably be done with the local inhabitants. According to Drijver (1989), the following factors are crucial when aiming at people's participation in environmental projects:

- the extent to which the project has adopted a step-by-step approach involving local people in design and management procedures and leading to decentralization of decision power and responsibility, and recognition of local people's priorities.

- the extent to which the project has recognized different interest groups and their possible conflict in relation to the social distribution of rights and benefits and the security of these benefits for local participants.

- the extent to which the project has made use of a specific combination of complementary instruments such as:
  *regulation and enforcement
  *financial incentives and revolving funds
  *awareness building and extension
  *linking rights and restrictions
  *social control.

- the extent to which a realistic assessment was made of ecological factors that determine the rehabilitation capacity and sustainable production capacity of ecosystems in the project area.

- the extent to which the project has taken into account the specific factors of the administrative and political context, e.g. the gap between traditional and modern legislation, the land tenure and the institutional development.

APPENDIX

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THE ESTUARINE ZONE OF SURINAME: TOWARDS A SYMBIOSIS BETWEEN CONSERVATION AND DEVELOPMENT OF A COASTAL WETLAND AREA

by

A.L. Spaans & F.L.J. Baal

INTRODUCTION

Mangrove swamps constitute highly productive ecosystems, which provide many products that can be harvested by local people. Moreover, these wetlands have some other functions that are beneficial to man. They are often also important breeding sites for resident waterbirds, and staging areas for non-breeding migrant waterfowl, particularly arctic and sub-arctic shorebirds. Nevertheless, coastal wetlands are often considered wastelands that either should be used for the discharge of polluted water and the dumping of waste or reclaimed for agricultural and industrial purposes. Such developments are detrimental to nature and wildlife, and in the long run often also to the local human population. This case study shows how Suriname attempts to integrate nature conservation and sustainable development of its estuarine ecosystem.

Suriname (just over 160.000 km² and approximately 400.000 inhabitants) is located on the northeastern coast of South America (figure 1).

Ninety-five per cent of the human population is concentrated in and around the capital, Paramaribo, and the smaller settlements in the coastal plain. In the interior there are only small, scattered settlements of Amerindians and Bush-negroes, mainly concentrated along the rivers.

Geologically, the country can be divided into four regions (figure 1): (1) the young coastal plain (16.200 km², 8 km wide in the east and broadening to 50 km wide in the west, 0-4 m above mean sea level), consisting of Holocene marine swamp clays, at several places dissected by sand and shell ridges; (2) the old coastal plain (4.300 km², approximately 20 km wide, 4-11 m above mean sea level), consisting of swamp clays of marine origin and sand ridges of both marine and riverine origin; (3) the savanna belt (10.000 km², several tens of metres above mean sea level), consisting of coarse sands and loams, and characterized by white sand savannas; and (4) the interior, or crystalline basement (132.000 km², over 30 m above mean sea level), consisting of a gently sloping dissected peneplain (up to 300 m above mean sea level in the south) with hill and mountain ranges of up to 1.230 m, and predominantly covered with undisturbed Neotropical rain forest.

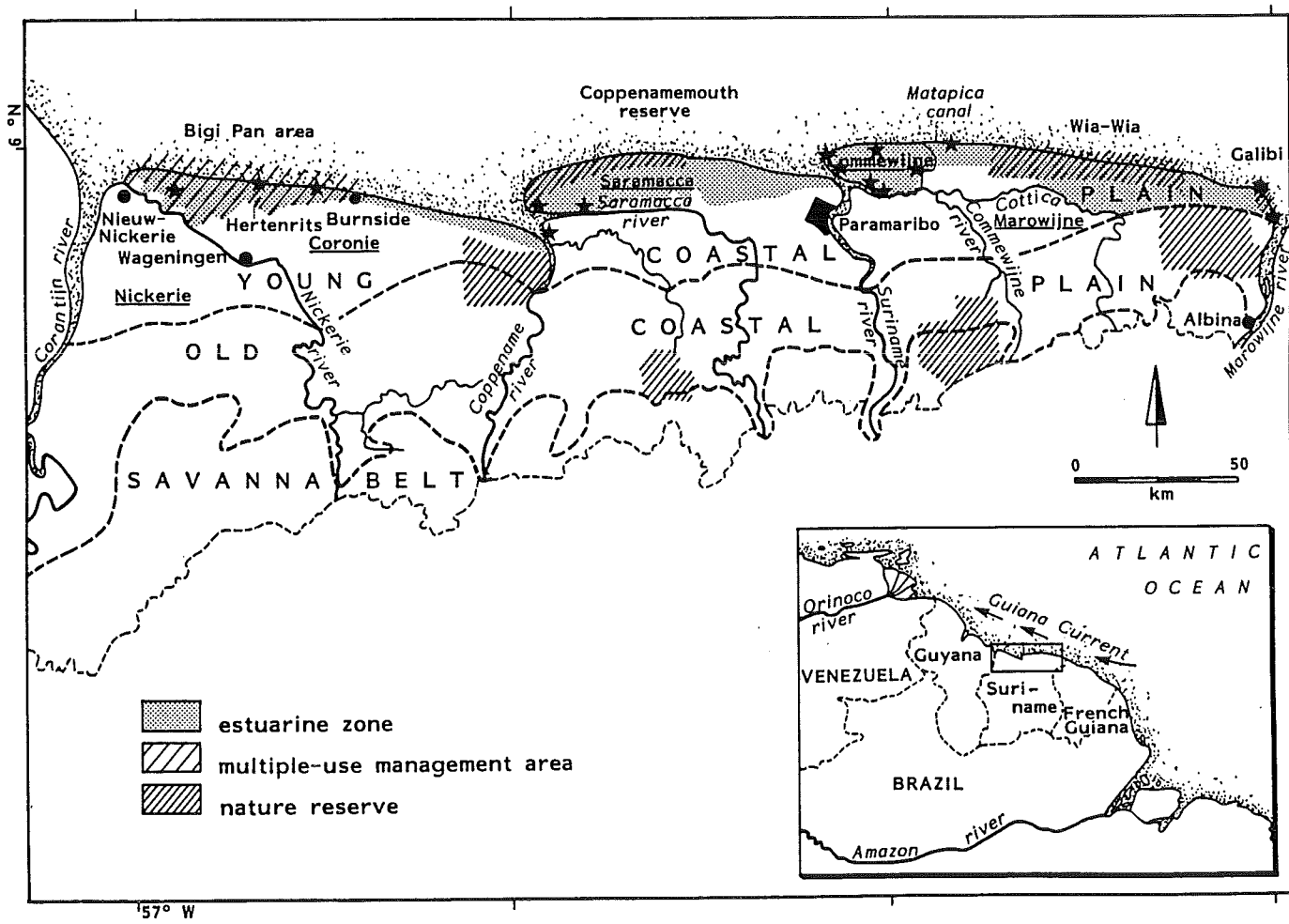

Figure 1. Map of lowland of Suriname (young and old coastal plain, savanna belt) with geographical names mentioned in the text (stars from left to right: Bigi Pan, Bladholo creek, Bucklesburg, Pralala creek, Boskamp, Hildesheim, Braamspunt, Pomona, Johanna Margaretha, Beripan, Kroonenburg, Reynsdorp, Krofajapasi, Eilanti, Baboensanti) and location of estuarine zone, Bigi Pan multiple-use management area, and nature reserves.

ECOLOGICAL PROCESSES AND PATTERNS

Climate Suriname has a humid tropical climate influenced by the NE trade wind. Temperature is uniformly high (average of 27°c in Paramaribo) and rain falls throughout the year (average of 2.200 mm in Paramaribo). However, the amount of rainfall varies seasonally. Four seasons can be distinguished: (1) a short dry season from early February to late April; (2) a long rainy season from late April to the middle of August; (3) a long dry season from the middle of August to early December; and (4) a short rainy season from early December to early February (Stichting Planbureau Suriname 1988). There is, however, much variation in the amount of precipitation and in the onset of the seasons from year to year. There are also regional differences in the amount of precipitation, the coastal fringe receiving less rain than areas a few tens of kilometers inland.

Tidal amplitude There is a marked tidal difference along the coast. At neap tides, the tidal amplitude is 1,00 m; at spring tides 2,80 m. The average is 1,80 m (Nedeco 1962).

Coastal landscape The estuarine zone of Suriname comprises vast tidal mud flats, narrow sand and shell beaches, and mangrove swamps that are bordered inland by shallow saline and brackish lagoons, and swamps with some mangrove forests. Further inland the marshes become fresh, with patches of swamp forest, and mixed dryland forests on the sandy ridges (Teunissen 1978).

Geomorphology The clay swamps along the coast consist of mud that originates from the Amazon river in Brazil. Sand and shell beaches, and ridges are of local origin. The Amazon discharges a large amount of fine sediments into the Atlantic Ocean, of which an estimated yearly load of 1-2 x 10^8 tons is carried along the continent's coast by the WNW moving Guiana Current (Nedeco 1962). This mud gives rise to a wide band of very turbid water along the coast of the three Guianas, with silt contents of up to a few grams per litre; Secchi-disc visibility varies from 1 to 30 cm (Augustinus 1978). Owing to the influence of freshwater from the rivers, the salinity of the near-shore surface water is locally lowered to well below 35o/oo. At places with a significant river runoff during the long rainy season, the water near the seashore can even be almost fresh.

The silt is deposited along the coast as a watery sediment called sling mud (Diephuis 1966). The settling of the sling mud results in the development of very soft tidal mud flats that can be up to a few kilometers wide.

Under the influence of the Guiana Current, and the waves generated by the NE trade wind, the mud flats are eroded on the east side and silted up on the west side with a speed of approximately 1 km per year (Augustinus 1978). The succession of accretion and erosion has a cyclic character. Diephuis (1966) established that such a cycle takes approximately 30 years.

In a few places along the coast, narrow sand and shell debris beaches are built up. Like the mud flats, the beaches move westward along the coast, resulting from a westward movement of the sand due to beach drift in a narrow zone around the high water line. When the supply of sand and shells is too small, erosion occurs. Where a mud flat is located in front of the beach, the development of the beach comes to a standstill because the waves cannot reach the shore due to the dampening effect of the sling mud. The tidal zone of coastal stretches that are in erosion consists mainly of an up to 100 m wide, firm and tough bank of clay layers eroded from older deposits.

In 1989, 32% of the coast was in accretion, 40% was being eroded, while 17% was more or less stable, the remaining 11% consisted of sandy beaches (J. van der Steege). The continuous alteration of the shoreline gives the coastal fringe a very dynamic character. Today, processes are probably the same as they were in the past. This is a valuable situation for geomorphological studies (cf. Augustinus 1978).

Vegetation (see fig. 2) On the parts of the soft mud flats above mean high water level, mono-specific black mangrove Avicennia germinans forests develop. The red mangrove Rhizophora mangle dominates the higher portions of the intertidal zone of the river banks. The latter species is absent as a pioneer species on the tidal mud flats along the ocean, probably due to the low viscosity of the sling mud which prevents seedlings from settling (Augustinus 1978), and/or to the extremely dynamic nature of the coast of Suriname (Cintron Molero 1986). In river mouths, the black mangroves may be fringed by Spartina brasiliensis. Since the mangroves are only found on the highest parts of the tidal mud flats, almost the entire intertidal zone of the flats is completely bare. Suriname has some of the most impressive mangrove forests in South America with a high degree of structural development, with canopy heights of up to 20 metres and basal areas of 15-20 m^2/ ha (Cintron Molero 1986). During periods of erosion, most black mangroves are uprooted and transported westward by the sea, and drifted ashore elsewhere along the coast.

The coastal fringe is bordered by a wide zone of shallow saline and brackish lagoons and swamps with some mangrove forests. The lagoons are former black mangrove forests in which the mangroves have died in situ after prolonged inundation by sea water. This occurs when the natural drainage system of the mangrove forest is temporarily impeded by a beach platform or a high muddy creek bank. The water in these areas becomes hypersaline as a result of evaporation, especially during the long dry season. For many years the mangrove trunks remain a dominant feature of the vast, bare salt pans. After some time, the lagoons are covered with halophytes such as Sesuvium portulacastrum, Batis maritima and Sporobolus virginicus. When mud is again deposited by the sea in the lagoon, Avicennia re-establish in these areas. Swamps characterized by a lower salinity are dominated by short grasses such as Eleocharis mutata, Cyperus articulatus, Paspalum vaginatum, and the huge fern Acrostichum aureum. In the coastal swamps between Wageningen and Burnside, and in those north of the Commewijne river, large areas of open water occur. Further inland, the marshes become fresh. These freshwater marshes are dominated by Cyperus articulatus, Leersia hexandra, Typha angustifolia, and there are patches of swamp forests dominated by Erythrina glauca, and mixed dryland and marsh forests on the sandy ridges.

During the last three centuries, large areas of the estuarine zone have been converted into plantations, pastures, and rice fields. However, many plantations were

abandoned. Although former plantations are now covered with a natural vegetation, they still are easily recognizable due to the difference of the vegetation on the dams and in the areas in-between. At the moment, agricultural activities are carried out only in the southern, freshwater parts of the estuarine zone.

The alternation of accretion and erosion affects the vegetation of the estuarine zone to a great extent. In fact, the situation is rather stable only near Galibi, in the eastern part of the country. This is the only place along the coast where savannas are found on young sand ridges, as well as forests on sand ridges rich with the cactus Cereus hexagonus and Astrocaryum vulgare palms. There are also some rare types of freshwater swamp (Teunissen 1979).

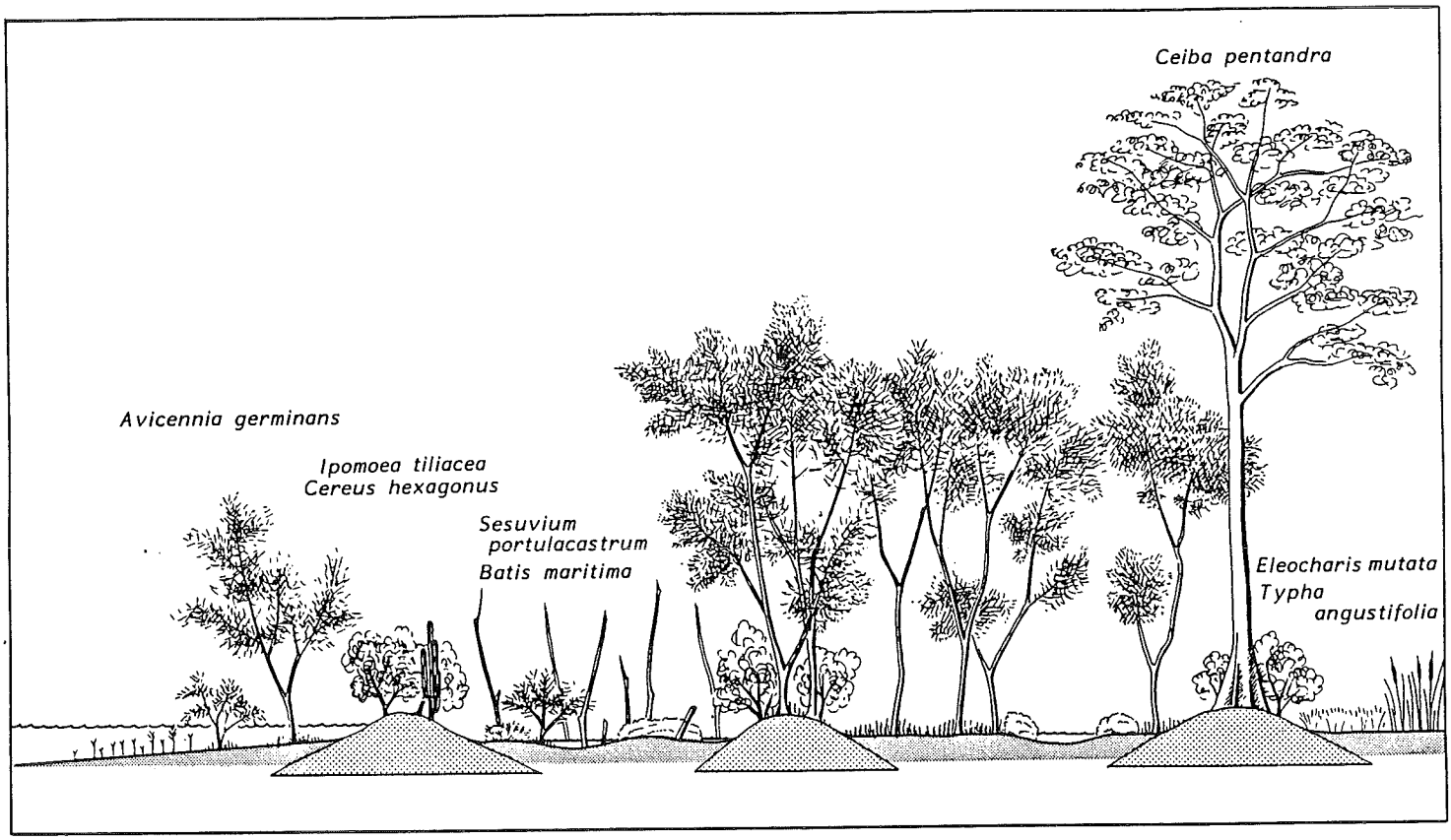

Figure 2. Outline of zonal partition of Suriname's coastal landscape.
From left to right: mud flat during high water with young mangrove forest, young sand ridge, saline lagoon with trunks of dead mangroves and re-establishing mangroves, sand ridge, mature mangrove forest with brackish water pan, sand ridge, and grass swamp.

Production Primary production in the near-shore zone is low because light penetration into the muddy water is poor. Yet this zone has high nutrient concentrations resulting from an active mineralization of organic matter, largely originating from terrestrial vegetation. A belt of high primary production is situated just outside the muddy coastal water (Cadee 1975).

On the soft tidal mud flats many species of benthic diatoms are found in high densities, probably resulting in a high primary production (Swennen et al. 1982). Three zones are conspicuous on the flats (Swennen et al. 1982): (1) the zone above mean high water level covered with mangroves and inhabited by several crab species, with the fiddler crabs Uca rapax and U. vocator in densities of up to 100 individuals/m^2; (2) a zone beyond the vegetation, around and just below mean high water level, dominated by U. maracoani (sometimes mixed with U. rapax) up to densities of over 200 individuals/m^2 and a total biomass of over 30 g ash-free dry weight (AFDW)/m^2; and (3) a zone of wet mud with high densities of tanaids (up to 6.000 individuals/m2), but a low total biomass (on average 2-4 g AFDW/m2, depending on the age of the flat and the time the flat is exposed during low and high tide). Soft mud flats along tidal creeks have higher tanaid densities (up to 13.000 individuals/m2) than flats directly exposed to the sea, but approximately the same total biomass as the latter. Tanaids constitute the staple food of most species of shorebirds feeding on the tidal mud flats. The firm and tough clay banks along erosion coasts are characterized by the occurrence of some relatively large, hole-dwelling decapods (Swennen et al., 1982).

Mammals So far, no complete inventory for any mammal species has been undertaken in Suriname. Occurrence and abundance of mammals are therefore not well-known. The

following species inhabit the estuarine zone and their occurrence should be mentioned: the Guiana White or River Dolphin Sotalia guianensis (mouths of main rivers), the American Manatee Trichechus manatus (main rivers and swamp creeks), the Crab-eating Raccoon Procyon cancrivorus (from littoral mangrove swamps up to cultivated land, common), the Red Howler Monkey Alouatta seniculus (forested sand ridges, still common, even in the neighborhood of Paramaribo), and the Jaguar Panthera onca (swamps, ridges, sea turtle beaches, common) and other felids. Locally, there are also good populations of White-tailed Deer Odocoileus virginianus.

Birds De Jong & Spaans (1984) list 118 bird species that can be found regularly in Suriname and are ecologically dependent on coastal wetlands. Seventy-seven of these are genuine waterfowl as defined by the Ramsar Convention, and they represent a total number of over 5 million birds in the saline and brackish zone (more than 4.000.000 shorebirds, 600.000 ciconiiform birds, 100.000 ducks, 100.000 larids and skimmers, and 30.000 others; figures obtained by addition of recorded or estimated maximum numbers for each species).

For 21 out of the 118 species (3 ardeids, the Scarlet Ibis Eudocimus ruber, 2 raptors, 3 ducks, 9 shorebirds, 2 terns, and the Black Skimmer Rynchops niger one or more of the five sectors into which the coastal area is subdivided by De Jong & Spaans (1984), are of international importance (criterion: 10.000 or more individuals or at least 1% of biogeographic population, as suggested by Scott & Carbonell 1986). Numbers of species for which a sector qualifies range from 7 to 17 (average 12,6). For five species (Tricolored Heron Egretta tricolor, Rufous Crab-Hawk Buteogallus aequinoctialis, Lesser Yellowlegs Tringa flavipes, Short-billed Dowitcher Limnodromus griseus, Semipalmated Sandpiper Calidris pusilla) all five sectors qualify as internationally important.

The coast of Suriname holds more colonies of ciconiiform birds than any other coast of the same length between the Amazon and Orinoco rivers (Spaans 1974, 1990). Suriname is of critical importance as a nesting area for the South American endemic Scarlet Ibis, with up to almost 35.000 pairs breeding in the country's coastal mangroves in top years, being over two thirds of the species' coastal population and almost one third of the total population, respectively. The Wageningen breeding colony (30.000 pairs in 1986) in the Nickerie-Coronie swamp area is the second most important colony known for the species.

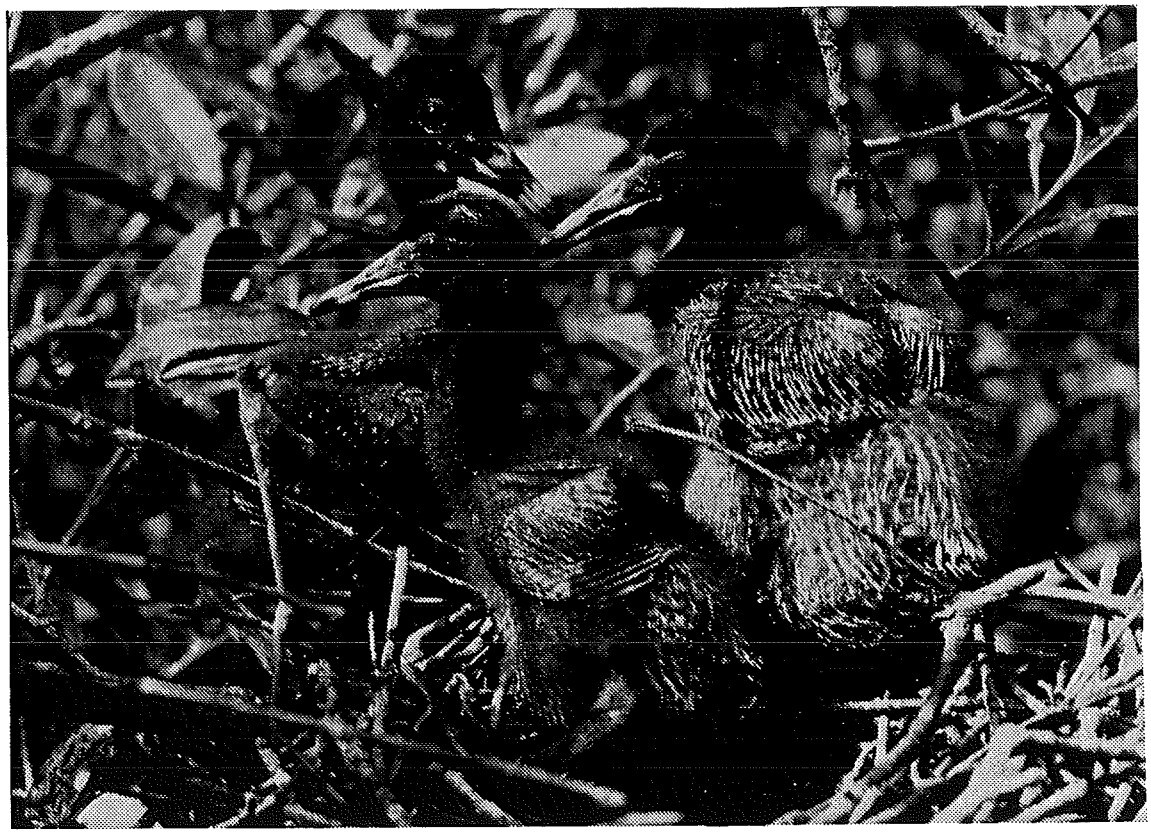

Photo 1. Young Scarlet Ibises nesting, Suriname coast (J.P. Schulz).

Suriname is by far the most important wintering area within South America for shorebirds breeding in the boreal and arctic regions of North America (Morrison & Ross 1989). Fifty-two per cent of the more than 2,9 million Nearctic shorebirds Morrison & Ross counted during aerial surveys conducted along the entire South American coastline (28.000 km) during the months January-February in 1982-1986, were observed in Suriname (370 km). The coast of Suriname is of special importance for Greater Yellowlegs T. melanoleuca and Lesser Yellowlegs (species not separated; 80,3% of continental north coast total and 72,8% of South American total, respectively), Semipalmated Sandpiper (64,5% of north coast total), Short-billed Dowitcher (46,1% and 44,7%), Willet Catoptrophorus semipalmatus (39,5% and 35,3%), Whimbrel Numenius phaeopus (21,7% and 13,3%), Black-bellied Plover Pluvialis squatarola (16,6% and 14,5%), and Ruddy Turnstone Arenaria interpres (3,1% and 2,1%). During the southward and northward migration periods, percentages might be even higher. This holds especially for Short-billed Dowitcher, Willet, and Semipalmated Sandpiper (cf. migration patterns in Spaans 1978). Maximum numbers estimated for the five most abundant species of shorebirds are: Semipalmated Sandpiper 2-5 million, Short-billed Dowitcher and Lesser Yellowlegs 200.000 each, Greater Yellowlegs and Least Sandpiper C. minutilla 50.000-100.000 each (Spaans 1978).

Comparable data for waterfowl other than ciconiiform birds and shorebirds are lacking. Among the landbirds using the estuarine zone, the Orange-winged Parrot Amazona amazonica is paid special attention here. Thousands of birds that feed inland, use communal night roosts in the coastal area.

Sea turtles The few high sandy beaches of Suriname (Baboensanti, Eilanti, and beaches between Matapica and the mouth of the Suriname river) are important nesting places for several species of sea turtles. In 1988, for instance, there were 6.776 nests of the Green Turtle Chelonia mydas (approximately the same numbers as in the 1960s), 11.436 of the Leatherback Turtle Dermochelys coriacea (numbers very much increased since the 1960s and 1970s), 563 of the Olive Ridley Lepidochelys olivacea (numbers very much decreased since the 1960s and early 1970s), and 24 of the Hawksbill Eretmochelys imbricata. Based on the number of clutches a female lays during one season, and the average interseasonal breeding intervals (Schulz 1975), the numbers of females making up the entire female population nesting in Suriname amounts to 7.600 Leatherbacks, 3.900-5.200 Green Turtles, and 400-560 Olive Ridleys.

Photo 2. Olive Ridley, nesting beach Eilanti, Suriname (A.L. Spaans).

Other reptiles The sandy beaches and ridges are also good habitats for the Iguana Iguana iguana (diminishing in numbers in areas inhabited by man).

Archeology Important archeological sites are located in the estuarine zone of eastern Suriname, east of Matapica creek (Boomert 1976), and in the coastal swamps of Nickerie and Coronie (Hertenrits, Bucklesburg, Burnside) in the west (Versteeg 1985).

HUMAN UTILIZATION AND OCCUPATION

Suriname is a multi-ethnic society. In prehistoric times Amerindians lived along the coast and rivers. Since the middle of the 17th century colonists from European origin undertook systematic efforts to exploit the country. This resulted in the conversion of large areas of the coastal plain into plantations. As the Amerindians refused to work on the plantations, the landowners brought slaves from Western Africa. After the abolition of slavery in 1863, most of the slaves left the plantations. Their places were taken over predominantly by immigrants from India and Java, Indonesia. Therefore, the various ethnic groups are not equally distributed over the country: rural portions of the coastal area have relatively more East Indians and Javanese, and the urban area of Paramaribo more Creole people, while the interior is mainly inhabited by Bush-negroes, descendants of runaway slaves, and Amerindians.

Most people inhabiting the coastal area live along the southern border of the estuarine zone or just south of it, either in large towns (Paramaribo, Nieuw-Nickerie), small villages along lower reaches of rivers (Nickerie, Coppename, Saramacca, Suriname, Commewijne, and Marowijne rivers) and on sand ridges (e.g. Coronie), or scattered on polder dams and in swampy areas along recently constructed roads such as the East-West road between Albina, Paramaribo, and Nieuw-Nickerie.

Large-scale and small-scale agriculture, animal husbandry, and fishery are the main means of support of people living in the rural portions of the coastal area, with fishing being practiced largely in the estuarine zone. Means of support of the Carib Amerindians of Galibi - near the mouth of the Marowijne river - are agriculture (shifting-cultivation, with clearing of the forests entirely carried out by men, and planting, weeding, and harvesting of crops by women), hunting (now less important than in former times because of over-hunting of game and of differentiation of hunting and fishing technologies in the 19th century: Kloos, 1971), fishing (with only a minor part going to markets in other villages or cities), and collecting of animals, wild fruits, and non-edible materials for boat, house and household, in which husband and wife often co-operate (Kloos 1971).

Local fishermen working along the Surinam coast (full-time or part-time) are from almost all ethnic groups living in the country. Most live in Paramaribo or in small settlements in the coastal plain (Galibi, Matapica, Reynsdorp, Kroonenburg, Johanna Margaretha, Pomona, Braamspunt, Hildesheim, Boskamp, Coronie, Nieuw-Nickerie and surrounding polders). When fishing, people operate either from temporary camps at Eilanti, Krofajapasi, Matapica canal, Beripan, Pralala creek, Bladholo creek, and several lagoons in the Bigi Pan area, or directly from their homes. In addition to local fisheries, a foreign fleet (mainly originating from Guyana, Venezuela, Japan, and South Korea) fishes in the territorial waters, further off the coast than the local fishermen, and in the adjacent Economic Zone. Most of the work in the fisheries is done by men, although women sometimes assist their husbands with the cleaning and selling of fish and shrimps.

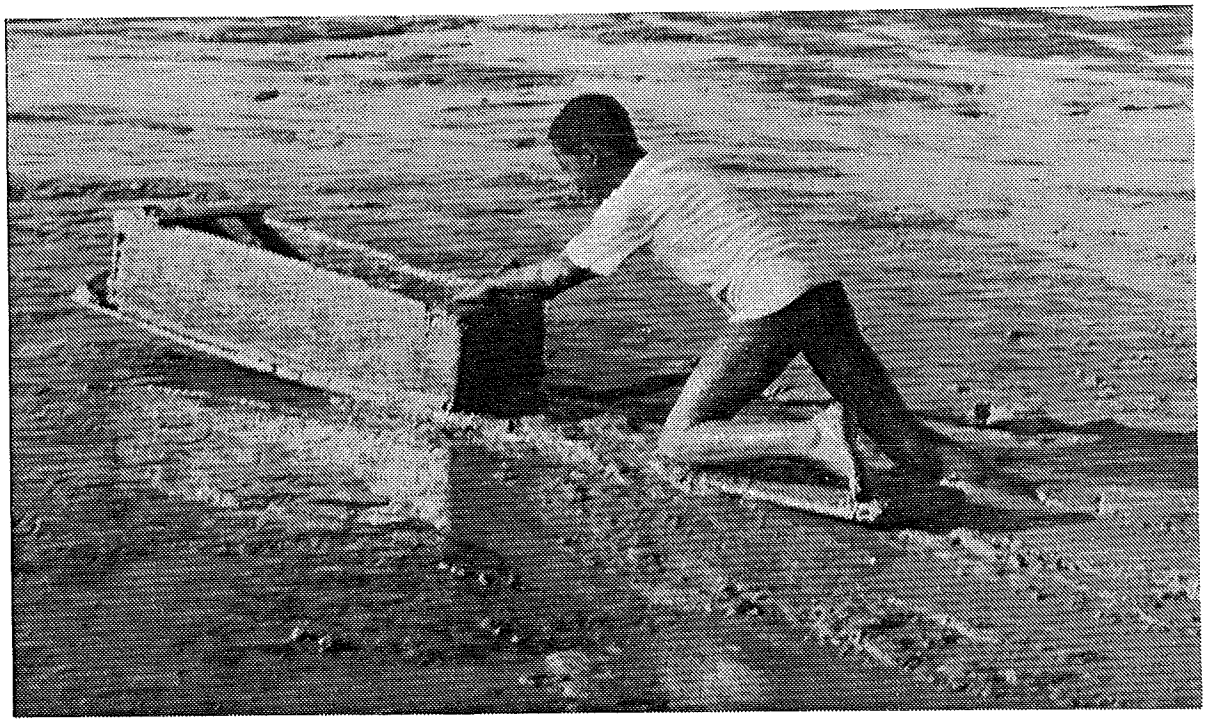

Photo 3. Man going out for fishing with a 'mud horse', tidal mud flats, Suriname (J.P. Schultz).

INTEGRATING CONSERVATION AND DEVELOPMENT

Excessive hunting of wildlife and exploitation of other natural resources led authorities to take several conservation measures since the 1950s. At first, measures taken involved legislative enactment of the protection of natural ecosystems, i.e. establishment of nature reserves (based on the Nature Protection Law of 1954) and protection of many wildlife species (based on the Game Law of 1954 and the Fish Protection Law of 1961). Since the 1970s, when people became aware of the economic benefits that the estuarine zone provides, greater emphasis was placed on the integration of conservation and development. The recognition by the Government of the international importance of coastal wetlands for sea turtles and birds has led to the signature and the ratification of several international conventions and agreements.

Conservation and protection Since 1954, four nature reserves have been established in the estuarine zone: Wia Wia reserve (1961; extended in 1966 to 36.000 ha), Coppenamemouth reserve (1966; 12.000 ha), Galibi reserve (1969; 4.000 ha), and the archaeologically interesting Hertenrits reserve (1972; 100 ha). Within the reserves, wildlife is fully protected. However, camps can be built by fishermen with a special permit and sea turtle eggs can be collected under co-ordination by the Foundation for Nature Preservation in Suriname (STINASU) under well-defined conditions. In 1985, the Coppenamemouth reserve was accepted as a wetland of international importance under the Ramsar Convention. Other areas that might be nominated in the near future include the Wia Wia reserve and the Bigi Pan area.

Outside the reserves, species of mammals, birds, sea turtles, and some other animals belonging to the wild fauna are protected under the Game Law. An exception is made for 'game species', 'cage-animal species' (pets), and 'predominantly harmful species'. At present, the game legislation applies to the entire northern part of the country, with the exception of the traditional hunting grounds of the Carib Amerindians of Galibi in the northeast. However, future game legislation will cover the entire territory of Suriname with inclusion of the Economic Zone.

From an international point of view an important step forward was made on 4 March 1989, when three coastal areas important for waterfowl (Bigi Pan area, Coppenamemouth reserve, Wia Wia reserve) were officially dedicated as 'hemispheric reserves' within the Western Hemisphere Shorebird Reserve Network. They were subsequently twinned with two protected areas in the Bay of Fundy, Canada, which are used by the same flyway population to which the Nearctic shorebirds along the coast of Suriname belong (Spaans 1989). The reserve-twinning was a result of the Memorandum of Understanding of 8 August 1987 concerning co-operation in the field of conservation by the Canadian Wildlife Service and the Suriname Forest Service.

STINASU was established in 1969 to increase public awareness, to stimulate and co-ordinate scientific (nowadays restricted to sea turtles) and touristic exploitation of the nature reserves, and to manage the Brownsberg Nature Park in the interior (Schulz 1971).

Ecological integration Besides its intrinsic value as an unspoiled area, the estuarine zone has several values that are directly or indirectly beneficial to man. Thus, the mangrove forests along the coast, both within and outside the reserves, provide a significant natural protection of the hinterland against the sea. For neighboring Guyana, which has a coastline of approximately the same length as Suriname, the inherent value of this protection amounts to 4 milliard US dollars (1 US dollar = Sfl. 1,77) based on a 1987 EEC report (De West, 4 February 1988). To this amount the maintenance costs for the dikes still have to be added. Rehabilitation and maintenance of the present dikes (69 km long, 4-6 feet high) in Guyana cost 30 million US dollars for the period 1966-1987, while for 1988-1991 an additional 15 million US dollars will be needed. The estuarine zone is also a natural breeding and nursery ground for many commercially valuable swamp and marine fish, and crustacean species, and it has the capability to process organic material, including waste products from upland areas. However, in some parts of the Bigi Pan area, productivity has been negatively affected by pollution (pesticides) and changes in hydrology, both resulting from the recent expansion of rice cultivation in the area.

Furthermore, the estuarine area can be considered an open air laboratory. Biological field-trips to the area are made by students, especially from educational establishments, as part of their training. Research conducted in the estuarine zone during the last 25 years includes studies related to various disciplines. A summary of biological research conducted in this zone during the last few decades has been given by De Jong & Spaans (1984).

Spatial integration Plans for converting coastal wetlands into rice polders and other uses of the estuarine zone in the middle of the 1970s prompted local experts to plea for a well-grounded management plan for the estuarine zone, and to support the designation of the entire zone as a 'multiple-use management area'. The Plan Law of 1974 defines such an area as an area where special management by, or on behalf of, the Government is needed for a rational exploitation of the resources (Schulz 1976, Baal 1981). A first step was taken by the Government in 1987 when the Bigi Pan area, the most western part of the estuarine zone, with a coastal length of 70 km, comprising 68.320 ha of land and approximately an equal area of the adjacent sea body, was placed at the disposal of the Ministry of Natural Resources for general management by the Suriname Forest Service. In 1989, a management plan was drafted to optimize the area's long-term natural productivity and sustainable use by man (Canadian Wildlife Service & Suriname Forest Service 1990). The management plan was subsequently approved by the Board of Ministers on 16 February 1990. Management strategies involve (1) clear demarcation of area boundaries; (2) formal protection of all archeological sites within the area; (3) measures to prevent flow of polluted drainage waters into the area, withdrawal of swamp water from the area for irrigation purposes, establishment of additional rice polders in the watershed that drains into the Bigi Pan, and measures to ensure that domestic animals no longer roam through the area; (4) encouragement of ecological research, particularly studies that consider management-related issues such as determination of numbers of hunters and of hunting pressure, and the ecological impact of public

works and agricultural chemicals (pesticides, fertilizers) outside the Bigi Pan on the area; (5) education programmes to increase public awareness; and (6) development of an adequate infrastructure to take advantage of the touristic potential of the area, particularly with regard to ecotourism.

Actions to address administrative requirements of the area include: (1) establishment of an advisory committee, including representatives of all ministries that have management responsibilities relevant to the area, to facilitate and co-ordinate the management of the area; (2) appointment of sufficient, trained personnel; (3) acquisition of proper equipment for adequate surveillance; and (4) approach of external funding sources with proposals for support when local resources are inadequate to implement the management plan. Management and administrative strategies are now awaiting implementation. Other areas expected to be placed at the disposal of the Ministry of Natural Resources, to allow management by the Suriname Forest Service, in the near future include the estuarine zone north of the Saramacca river in the centre of the coastal strip and the area north of the Commewijne and Cottica rivers in the eastern part of the country.

Economic integration The coastal wetlands of Suriname provide several commercially valuable products that can be harvested by man without a depletion of these natural resources.

Coastal lagoons, lower reaches of rivers, tidal mud flats, and inshore waters constitute very productive areas for small-scale commercial fisheries. The coastal fishery is semi-primitive in techniques and semi-commercial in organization. These fishery types have traditionally met local needs for fish. Particularly important areas include the four river mouths, Wia Wia flat to the mouth of the Suriname river, and Coronie to the mouth of the Nickerie river, including creeks and lagoons behind the shoreline. In addition to coastal fisheries, there is a modern and export-oriented deep-sea trawling fishery (over 30 m deep waters), largely dominated by foreign companies. Most trawlers sail under Surinamese, Venezuelan, Panamanian, South Korean, or Japanese flags. According to the official registration data of the Fisheries Service for 1988, coastal fisheries yielded 2.487 tons of fish, shrimps, and crabs (only part of the actual catch: Charlier 1988) with a wholesale value of Sfl. 24.900.000 and a retail value of Sfl. 29.700.000. The deep-sea shrimp fishing produced 2.690 tons of shrimps, with a wholesale value of Sfl. 60.000.000, of which 2.337 tons were exported i.e. a value of Sfl. 53.000.000. In addition, a small quantity of fish is extracted from the sea by shrimp trawlers and converted shrimpers. The fisheries industry gives employment to a lot of people in Suriname. In 1988, for instance, 879 permits were issued for coastal fishery boats, involving 2.382 fishermen. In the same year, 148 trawlers were operating in offshore waters.

The maximum sustainable yield per year is estimated at 32.000 - 35.000 tons of demersal fish, 210.000 tons of pelagic fish, and 5.000 tons of peneid shrimp. At present, approximately half of the potential catch per year of demersal fish is caught, while the pelagic fish stocks have hardly been touched yet (Charlier 1988). The under-utilization of this natural resource is attributed to inadequate facilities (Stichting Planbureau 1988). Peneid shrimps are considered fully exploited. For this reason aquaculture is being introduced. In the northern area of the Commewijne district an aquaculture farm (breeding of freshwater shrimps) is already operating, while another pilot project for marine shrimps is planned.

Eggs of sea turtles constitute a source of protein that is highly appreciated by both urban and rural people in Suriname. Till the middle of the 1960s, eggs of all species were unscrupulously collected by local fishermen, and nesting turtles sometimes killed for their meat. Since then, main nesting beaches are guarded and the harvest of eggs is regulated as to species (only eggs of Green Turtle and Leatherback may be collected now), status of nests (only eggs from 'doomed' nests may be collected), maximum numbers (the last few years up to 250.000 to 300.000 eggs per year), and season (only from 1 March to 31 May, i.e. before the endangered Olive Ridley nest). The organization of collection, transport, and sale of the eggs has been delegated to STINASU. Eggs are collected either by local Carib Amerindians (Galibi reserve) or by employees of STINASU (other main beaches). During the nesting season all main nesting beaches are regularly patrolled by employees of the Suriname Forest Service and of STINASU to prevent poaching of eggs.

Most eggs are collected in the parts of beaches which are endangered by erosion or where eggs have been laid below the high water level (and where, therefore, eggs have no chance to survive). During the closed season, such eggs are transferred to beach areas where survival of the eggs is high (formerly also to artificial (styroform) nesting boxes). In this manner the sea turtle egg harvest does not negatively affect the population. In fact, since the 1960s, the total number of nesting sea turtles increased on Suriname's beaches as did the numbers of baby turtles that went to sea.

Egg collecting provides the Caribs with a supplementary income that completes earnings obtained from fishing. In 1989, STINASU paid the Caribs Sfl. 55 for each 1.000 eggs they collected, and an additional Sfl. 66,60 per 1.000 eggs for transport to the STINASU landing station near Paramaribo. For each 1.000 eggs landed, another Sfl. 24 is donated to a relief-fund of the local Amerindian society from which fishermen are paid when sea turtles have damaged their nets. The employees on the beaches outside the reserves are earning Sfl. 10 per 1.000 eggs collected (in addition to their normal wages).

The eggs are sold by STINASU in Paramaribo and surroundings for Sfl. 0,28 each (price of 1989). Last year, the total revenue for STINASU amounted to Sfl. 84.000, of which the costs have to be subtracted. The profits of the egg collecting are returned to turtle conservation activities, allowing STINASU to cover the expenses for patrolling the main nesting beaches, i.e. protecting the sea turtle nests against poachers, and to stimulate relevant research.

Contrarily to the situation observed during the 1970s, hunting of waterfowl and deer has been hardly practiced during the last few years as socioeconomic conditions prevailing in the country have resulted in very high prices for ammunition and transportation.

Black mangrove flowers constitute an important source of honey. In Coronie, around the mouth of the Suriname river, and at Matapica approximately 50 beekeepers harvest a total of 30.000 to 35.000 l of honey per year, with a total market-value varying between Sfl. 750.000 and

Sfl. 1.600.000 (Ministry of Agriculture, Beekeeping Division).

Other products used in the local economy include logs for the building of base camps by fishermen, fuel wood for the smoking of fish, leaves of Cyperaceae for mats and hats (Commewijne area), and clay for pottery (Caribs of Galibi).

At present, nature conservation activities in the coastal area give employment to a number of people: approximately 15 persons are employed at the main offices of the Suriname Forest Service and STINASU in Paramaribo, and an additional 10 (20 during the sea turtle nesting season) in the field, mainly at Galibi and Matapica.

The unspoiled nature along the coast, with its overwhelming number of nesting sea turtles, breeding ciconiiform birds, and migrant shorebirds attracts both local and foreign tourists. The tour-programme of STINASU (leaded mainly by local guides) includes wildlife-orientated tours to Galibi, Matapica, Coppenamemouth reserve, and the Bigi Pan area. The first two offer good opportunities for observing nesting sea turtles during the nesting season, and all four are good areas for bird-watching. The estuarine zone is used further for individual sport-fishing, sport-hunting, camping, and picnicking.

CONCLUSIONS AND RECOMMENDATIONS

The estuarine zone of Suriname, with a coastal length of almost 400 km, a land surface area of more than 300.000 ha, and at least an equal area of marine waters, comprises a highly productive coastal wetland complex. The importance of the coastal area as a natural breeding and nursery ground for commercially valuable species of fish and shrimps, as a breeding area for resident ciconiiform birds, and a staging ground for non-breeding migratory waterfowl is closely related to the high natural productivity of the area. Except for some local problems, the estuarine ecosystem shows a pristine, undamaged condition throughout the area. This is of great ecological value. It enables the area to optimally perform functions that are directly or indirectly beneficial to man. In areas that have both great natural and economical value such as the coast of Suriname, integration of the two values (by setting up a proper management strategy optimising the ecological and economical outputs) seems to be the best way to enhance the natural productivity of the area in the long run and ensure a sustainable use of its resources. The harvest of sea turtle eggs such as practiced in Suriname shows that wildlife utilization and nature conservation can be compatible. Like wildlife-orientated tour programmes, wildlife utilization can cover some of the costs related to nature conservation activities.

The concept of a 'multiple-use management area' seems a successful means for the integration of economic development of the area and conservation of its natural value. Since most land in the estuarine zone of Suriname is public land, the establishment of multiple-use management areas is relatively easy to implement. In areas with many private landowners, the establishment of such areas will of course be more difficult. Optimal functioning of a multiple-use management area requires a clear demarcation, sound management planning, environmental zoning of area, implementation of management plans, setting up of an authority that oversees implementation and co-ordination of management goals, and systems, research, feed-back of research results to management policy, and public awareness campaigns.

The designation of parts of Suriname's estuarine zone as hemispheric reserves within the Western Hemisphere Shorebird Reserve Network gives them international recognition as important shorebird areas, which in turn may give strength to local wetland management efforts. Twinning of these reserves with reserves in Canada used by the same flyway populations of shorebirds was followed by a Canadian-Surinamese agreement with respect to co-operation to conservation initiatives of mutual interest. This has resulted in financial and technical support by Canada for the preparation of a management plan for the Bigi Pan area, and for several conservation-related studies on shorebirds and their habitats along the coast of Suriname.

It is recommended that other Central and South American countries that have tropical coastal wetlands with internationally important shorebird concentrations join the Western Hemisphere Shorebird Reserve Network. The concept of hemispheric reserve network systems could possibly also be developed within the Palearctic flyway systems of waterfowl (Europe-Africa, Asia-Australia). Special attention should be paid to the possibility of reserve-twinning for areas situated within the same flyway of waterfowl. When conservation and development activities in such areas are integrated, financial support to waterfowl habitat conservation also assists local people in using the resources of the area in a sustainable way.

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INTEGRATING MANGROVE AND SWAMP FORESTS CONSERVATION WITH COASTAL LOWLAND DEVELOPMENT

The Banyuasin-Sembilang swamps' case study, South Sumatra Province, Indonesia

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1. METHODS

The study forms part of a project executed by the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) and the Asian Wetland Bureau in South Sumatra Province. Called Integrating Wetlands Conservation with Land use Development in South Sumatra Province, the project started in August 1988 and is due to be completed by August 1989. Under this project, the Danish Ornithological Society and Ornis Consult in collaboration with staff of the Program Penelitian Lingkungan Hidup (PPLH, the Environmental Study Centre of the Sriwijaya University at Palembang) joined the above agencies. The overall project seeks to provide land zoning maps of South Sumatra, identifying sites of importance for protection or sustainable utilization. The project was funded by Danish International Development Agency (Danida) and World Wide Fund for Nature, Danish Branch (WWF-Denmark).

In order to obtain data on natural resources utilization and the services derived from wetland resources, a questionnaire was designed by PPLH. During 2 weeks in April and May 1989, 3 temporary staff of PPLH and 1 staff of the local PHPA interviewed 75 farmers and fishermen in the coastal wetlands throughout the province. Of these 75, 32 interviewees live in the Banyuasin Sembilang swamps. In addition, data were obtained through group interviews and meetings with heads of the various settlements. Data on forest utilization obtained from the interviews has been analyzed already and is presented in this paper.

2. STUDY AREA

Situated between 03.50 - 02.20 N and 104.00 - 105.00 E, the mangrove/swamp forest complex of Banyuasin-Sembilang lies in the northern corner of South Sumatra Province, Indonesia. It has a land area of about 5.000 square km. In the north it borders the Province of Jambi, in the east the South China Sea and the Bangka Strait. These lowland swamps form part of an approximate area of 100.000 square km of continuous tidal lands, stretching from Aceh Province in the northern tip of Sumatra, to Lampung in the South (Land Resources Department 1988). Eastwards from the Barisan mountains, towards the South China Sea and the Strait of Malacca, a huge extent of flat alluvial land unfolds. Following the length of the Barisan Range, this plain covers almost one-fifth of the island. Narrow at its extremities, it is almost 100 km. wide in the central section, covering greater parts of the provinces of Riau and Jambi. Immense impenetrable swamps cover large portions of the lowlands; they are intersected at regular intervals by Sumatra's main rivers and their tributaries.
The area is unusually uniform and flat; by far the greater part of the area has an altitude of less than a few meters. Tides moving between the Indian Ocean and the Java sea / South China sea are funneled between Sumatra and Malaysia. As a result, tidal variation reaches a range of 3 meters at spring tides. On the Musi River, the saline intrusion is therefore felt up to 60 km up streams, the tidal influence even up to 110 km from the sea. (Anon. 1976).

2.1. Climate

The area is within the equatorial monsoon belt. The climate is tropical, with temperatures varying a little during the year (daily high range around 33°C) and with an average rainfall figure of 2.200 mm. During the rainy season the area receives four wet months (more than 200 mm rain per month); while in the dry season prolonged dry spells (less than 100 mm rainfall) occur of up to one or two months. Such droughts of many months are of considerable ecological significance. Some recent dry spells struck the area in 1983 and 1987. Several peat swamp forests were set ablaze as a result of careless burning of farmland after the rice harvest.

3. BIOLOGICAL RESOURCES

3.1. FOREST RESOURCES

The forest formations in the study area can be grouped according to prevailing hydrological and edaphic conditions. Four major types can be found.

3.1.1. Mangrove forest

This habitat type has the widest occurrence in the study area. Skirting the sea, on soft mud deposits, a belt of tidal forest, mainly of the Rhizophora/Bruguiera association occurs, described in detail by a number of authors; Sukardjo et al (1984), Yamada & Sukardjo (1980) and Silvius (1986). Here, the mangrove forest reaches the widest belt on the

island of Sumatra, and must be considered one of the last undisturbed coastal forests in South East Asia.

3.1.2. Freshwater swamp forest

Inland where the tidal influence is limited, a rich freshwater swamp forest has developed. This vegetation type is found along the main rivers and is adapted to occasional inundation by freshwater from rivers flooding during the rainy season. The forest may remain inundated for periods of up to 8 months. This forest formation has been developed on rich freshwater alluvium, i.e. on sites possessing considerable agricultural potential. The forest is rich in tree species similar to the lowland diptocarp forest. It contains numerous commercial exploitable hardwoods such as Shorea species. Not less than 1082 plant species are known from this habitat, representing almost 15 % of the species known from the entire Malaysian floral realm (Corner 1978). The vegetation is luxuriant with some emergents reaching heights up to 70 meters. Most common species are Gonystylus bancanus, Dyera costulata and Kompassia malaccensis and a number of Shorea sp.

3.1.3. Peat swamp forest

Away from the rivers in the hinterland, peat swamp forests thrive on 1-10 meters deep peat. This vegetation type has the most extensive distribution in the eastern Sumatran coastal plain. Most of the peat is of an ombrogenous type meaning that the surface of the land is above the tidal limits and the water input is derived solely from rainwater. The corresponding increasing infertility of the soil towards the peat dome is reflected by a decreased canopy height. Under such extreme conditions only a few tree species occur, which are rarely higher than 20 meters. A striking associated feature of this forest type is the black water of the rivers which bear a high humic acid content. In the rainy season these back swamps are regularly flooded with fresh water.

3.1.4. Lowland rain forest

Throughout the study area sandy small levees, locally called pematangs, are found with a maximum elevation of 20 m. On these soils lowland rainforest have developed. These pematangs are of high importance for large mammals such as Elephants, as they will not become inundated during the rainy season.

3.2. FAUNA

The Banyuasin-Sembilang lowlands are characterised by their great biological diversity. The Sumatran lowlands as such harbour a fauna which has a close Asian affinity due to the historical linkage with the Asian mainland. three large mammal species present here are found which have a limited distribution in Indonesia, including Tapir, Siamang and Tiger: species considered endangered by the International Union for Conservation of Nature and Natural Resources (IUCN) (Table 1). Sumatra supports approximately 600 species of birds of which over 330 occur in the Banyuasin-Sembilang area, either as resident or as transient (Verheugt et al, 1989).
The fauna associated with mangrove forests is dominated by crustaceans and other invertebrates. The forest canopy and exposed mud flats provide habitat for a great many species of birds. The tidal mud flats of eastern Sumatra, in particular those of the Banyuasin-Sembilang, play a vital role in the annual migration patterns of waterbirds. Twenty eight species of migratory waders have been recorded, including several Red Data Book species such as the Asian Dowitcher and Nordmann's Greenshank. Recent surveys, revealed the importance of this region for some of the worlds rarest waterbirds, including 90 % of the world population of Milky Stork, and possibly the only breeding population of the Spot-billed Pelican in Indonesia and Malaysia (Silvius 1986).

TABLE 1 RED DATA BOOK SPECIES OCCURRING IN THE BANYUASIN-SEMBILANG AREA

Scientific name	Common name	Category
Mammals		
Panthera tigris	Sumatran tiger	endangered
Tapirus indicus	Tapir	endangered
Hylobates syndactylus	Siamang	endangered
Orcaella brevirostris	Irrawaddy Dolphin	endangered
Birds		
Pelicanus philippensis	Spot-billed Pelican	endangered
Ciconia stormi	Storm's Stork	endangered
Mycteria cinerea	Milky Stork	vulnerable
Leptoptilus javanicus	Lesser Adjutant	vulnerable
Cairina scutulata	White-winged Wood Duck	endangered
Spizateus nanus	Wallace's Hawk-eagle	rare
Tringa guttifer	Nordmann's Greenshank	rare
Limnodromus semipalmatus	Asian Dowitcher	rare
Rhinoplax vigil	Helmeted Hornbill	indeterminate
Aceros subruficollis	Plain-pouched Hornbill	indeterminate
Aceros corrugatus	Wrinckled Hornbill	vulnerable
Reptiles		
Crocodiles porosus	Estuarine crocodile	endangered
Tomistoma schlegeli	False gavial	endangered

Source: IUCN 1974, Collar & Andrew 1988

Photo 1. Milky Stork (W. Verheugt).

4. POPULATION

Until recently, the interior of the swamps was never permanently inhabited, the only settlements found were the houses of Malay fishermen along the river fronts. Nearer the foothills of the Barisan mountains, the Kubu lived and may still live in the interior. A remnant group of forest dwellers, they live off collecting forest products. Although the Indonesian policy is towards facilitating their settling in government sponsored villages, an unknown number is still said to live in the Banyuasin-Sembilang swamps in the western corner and to practice their traditional way of life. Reliable population figures are notoriously difficult to obtain, but it is not inconceivable that their numbers may have dwindled to less than 200 (Provincial Social Affairs Office, pers com. 1989). With nearly all the remaining forested land under forest concession schemes, except land classified as protection and conservation forest , the Kubu may well find one of their last refuges in the Banyuasin-Sembilang area.

Beside the villages of Sungsang and Sungai Benu, with respectively around 15.000 and 1.000 inhabitants, none of the other settlements, such as Dusun Sembilang, have village (desa) status. The majority of the settlements are found on stilted houses, along the river banks and coast. These settlements are temporary in nature, especially the bagans which are found up to 2 km off the coast on the mud flats. These fishermen occupy their shelters during the fishing season, lasting from May to October.

No official data exist on the number of settlers in the swamps, but their total is estimated at 5.600. The majority of the people newly arrived, were attracted by the upsurge in fisheries production and the arrival of fishmongers from Jambi Province, who established cold storage warehouses and provide credit systems for the purchase of boats. Since 1988 at least 1.500 settlers have moved in along the S. Marang and S. Kepayhang, collecting the latex of Dyera costulata. According to the questionnaire survey, the majority of the new settlers previously lived in other parts of South Sumatra Province.

5. COASTAL SWAMP FORESTS OF BANYUASIN-SEMBILANG: THEIR IMPORTANCE FOR SUSTAINABLE DEVELOPMENT

The mangrove and peat swamp forest performs important sustainable socioeconomic functions, which support the livelihood of the rural community. These forests are of value both for their commercial hardwoods as for their non-timber products, including important herbs and drugs (and wild ancestors of fruits such as durian Durio sp.). Many of the natural resources of the mangrove and peat swamp forest have actual or potential economic values in support of such activities as fisheries, aquaculture, forestry and transportation.

5.1. SMALL SCALE NATURAL RESOURCE UTILIZATION

The majority of the settlers of the Banyuasin-Sembilang are engaged in fishing, with agricultural activities undertaken during the west monsoon season, when coastal fishing comes almost to a complete stand. The people are thus directly dependent on the conditions of such natural resources as land (soil fertility) and fresh water (quality) for their livelihood.

5.1.1. Husbandry of minor forest products

Mangrove and swamp forests provide many products of benefit to the rural communities. Some tree and herb species have horticultural or pharmaceutical potentials. Other trees are known for their latex (Jelutung Dyera costulata) or essential oils (Melaleuca). The mangrove palm Nibung Oncosperma tigillarium is much favoured as it provides the durable poles for the stilted houses, found so abundantly along the main rivers and coast. While the leaves of another mangrove palm Nipa Nypa fructicans are used as thatching material.

Indeed additional income is derived from the husbandry of these minor mangrove forest products. Out of 32 fishermen interviewed, 22 (or 75%) said they regularly collect forest products. This is normally done by the people individually during the west monsoon season, when fishery activities almost entirely cease. Seven main products are gathered (Table 2).

TABLE 2 MINOR FOREST PRODUCTS GATHERED FROM THE BANYUASIN-SEMBILANG MANGROVE SWAMPS

Product	Scientific Name	Number of respondent	Use	Value in Rp	Total trade value. In million Rp. 1988 prices
Nibung	Oncosperma tiggilarium	5	Scaffolding	1.500	24
Rattan	Korthalsia/Calamus	4	Furniture	1.250	4.8
Nipa	Nypa fructicans	6	Thatching	60 per sheet	n.a.
Bakau	Rhizophora sp.	13	Firewood	400 per 100	n.a.
Fruits	mainly Eugenia sp.	1	Food	500	n.a.

Source: various interviews, 1989
n.a.: not available

In the majority of the cases, these mangrove forest products are used by the people themselves, who pay a small fee to the lease owner of a particular forest product; only 2 respondents mentioned the sale of these products at local markets (including Palembang).

5.1.2. Trade in Wildlife

Trade in wildlife from the mangroves in the Banyuasin-Sembilang is mainly centred around two reptiles species: the Estuarine Crocodile and Monitor Lizard Varanus salvator. Around ten families are believed to be engaged full time in Monitor lizard trapping during a three months season (June - December). Along the Sembilang river up to 1.300 Lizards were trapped in 1988 (Erdelen 1988). Although under the CITES Convention regulations for Indonesia, officially no crocodiles skins from the wild are allowed to be processed, still up to 50 fishermen are poaching these rare animals during the months June - August. The fishermen mainly collect young crocodiles from crocodile nests in the swamp forest. They are sold when they reach the length of 40 cm and above to a number of exporters based in Palembang. Crocodile hunters from the Sembilang river said that they do not kill adult female crocodiles, so as not to endanger a sustainable harvesting of young. However, the population of crocodiles in the Banyuasin - Sembilang is now believed to be at the verge of extinction. Trade figures are given in table 3.

TABLE 3 TRADE FIGURES IN CROCODILES AND MONITOR LIZARDS, BANYUASIN - SEMBILANG MANGROVES, 1988

species	unit price in Rp per piece	number caught	total value in Mil. Rp
Estuarine Crocodile	225.000 (adults)	30	6.8
	40.000 (young)	1.200	48.0
Monitor Lizard	6.500	3.000	19.5

Source: various interviews, 1989

5.1.3. Artisanal Fisheries

Capture fisheries in the Banyuasin-Sembilang area centres mainly on the harvest of shrimp, demersal fish and the collection of shells on the intertidal mud flats. Especially shrimp is a valuable commodity. One kilogram of large tiger shrimp Penaeus monodon can fetch up to Rp 15.000. The shrimp fisheries core area is located around the Banyuasin peninsula. Mainly traditional gear, such as beach seines and tidal traps, are used.

The South China Sea close to the Sumatran coast and the Strait of Bangka in particular is a highly productive ecosystem due to the shallow condition (less than 30 m) and the continuous input of nutrient rich sediments from the discharge of the Musi and Banyuasin Rivers. Both demersal fish and shrimp catches in this area are high and yielded an estimated Rp 6.470 million in 1988 (Table 4).

TABLE 4 FISHERY PRODUCTION FIGURES BANYUASIN-SEMBILANG AREA 1988

Species		Volume in ton	Value in mil. Rp
Shrimp	Penaeus sp.	1.166	5.830
Sea fish	variety of species	700	640

Sales price of shrimps based on average Rp 5.000 per kg; for sea fish, Rp 900.

Source: 1986 Statistics Office Musi Banyuasin Recency and interviews 1989.

6. A PLAN FOR SUSTAINABLE DEVELOPMENT OF THE BANYUASIN SEMBILANG AREA

The mangroves of the Sembilang area, which are the widest still occurring in their natural condition throughout western Indonesia, are currently classified as Protection Forest, with a total acreage of 77.500 ha (Hutan Lindung). However, this status needs to be upgraded to allow for more effective control and wardening.

Although the project has not yet been finalized, the team is proposing to PHPA to consider a large area of 247.500 ha to be set aside as Wildlife Reserve (Suaka Margasatwa), excluding two buffer zone areas. The area also includes one of the last remaining primary swamp forest in South Sumatra Province. The area under consideration is in need for immediate protection measures and negotiations would need to be started with a number of logging companies which have logging rights within the proposed area, and by which 108.700 ha of fresh-water and peat swamp forest would be logged within the next 8 years.

6.1. ECONOMIC INCENTIVES

The Sembilang Wildlife Reserve must be seen to be in the regional/provincial interest so that its establishment will constitute benefits to the local populations. These spin-offs are:

1: The protection of the core spawning areas for shrimp and demersal fish. The reserve has a major function in supporting the potential sustainable development of a marine fishery industry, with spin-offs for the greater part of the Province's coastal inhabitants. Through regular implementation of control and monitoring of fishery activities and stock inventories, maximum sustainable yield levels can be established;

2: Protection of the natural resource base, which can be utilized, within delineated bufferzones only, by the local communities;

3: Job opportunities created by local (wildlife) tourism industry.

4: Increased attention by the national and international scientific community. Applied research for the furtherance of the local economy may be undertaken in such fields as sustainable crocodile harvesting, bee-keeping in mangrove forest.

6.2. ENVIRONMENTAL ZONING

The project team proposes to delineate 2 buffer zone areas, totaling 121.400 ha. It will allow the present inhabitants to continue their living inside the reserve boundaries, with restriction on further immigration. The buffer zones provide the local population with traditional harvesting areas for essential products (firewood, house construction materials). Under the Indonesian Forestry Act of 1967, the term buffer zone is not described or defined. Instead the wording traditional use zones has been established. According to the law, such area is the land belonging to the reserve (Suaka Margasatwa) which will be managed by the authorities for the benefit of the local communities to ensure that minor forest products can be gathered in a non-destructive way.

As mentioned above for the Sembilang Wildlife Reserve, two buffer zones are proposed (Fig 1):

1) An inland buffer zone: an area currently being used by two forestry concessionaires. When their permits expire for selective logging operations, this area could be used for collection of minor forest products, under strict control by the reserve authorities;

2) Inter-tidal (marine) buffer zone: an area up to 3 km from the outward mangrove forest's edge, including the rivers' mouths, where artisanal fisheries are permitted; including the rights to collect invertebrates (shells) from the exposed mud banks.

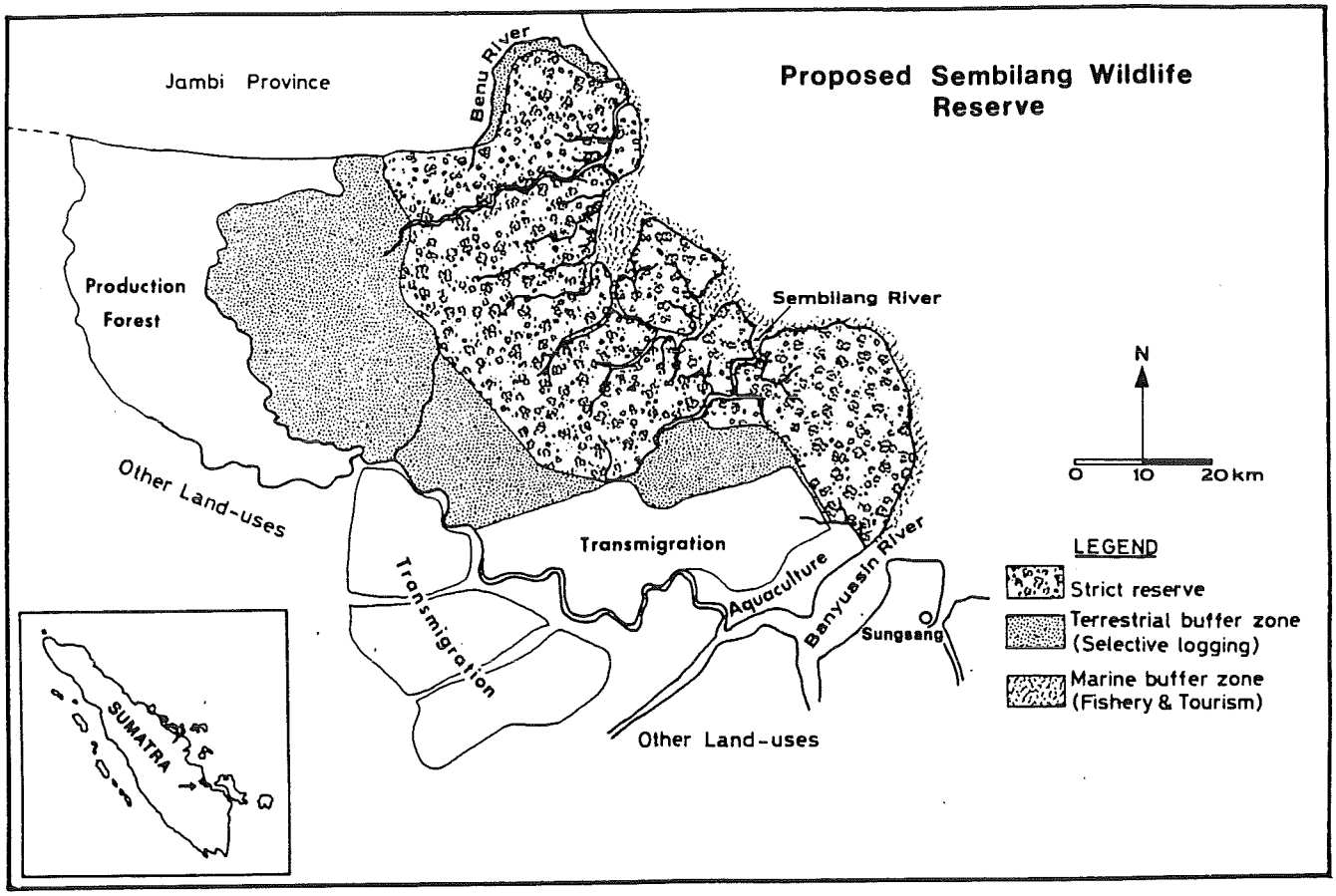

Figure 1. Proposed Sambilang Wildlife Reserve.

The area proposed as Strict Reserve (or Wilderness Zone according to the current Forestry regulations) has been delineated because of its present largely undisturbed state of mangrove and freshwater swamp forest. As such it is the largest remaining example of the Indo-Malayan swamp forest ecosystem, with an undisturbed gradient between coastal mangrove and inland forest. The area under consideration supports 16 globally endangered wildlife species.

Under the Indonesian traditional zone concept, as defined in the current Forestry Act, settlements and enclaves within the reserve are not allowed (Table 5).

A new act on Protection and Conservation of Natural Resources has been drafted which includes modifications pertaining to the settlements inside protected areas and resource exploitation. The act is awaiting approval by Parliament.

Natural resource utilization used to be controlled under the old Marga system. A Marga was a central village including smaller satellite settlements and their lands plus waters (van Rooyen 1927). Resource exploitation rights were leased in auctions annually to the highest bidder. It was generally felt that the Adat law was an effective element in preventing over- exploitation (Hanson & Koesobiono 1979). Since 1983, the Marga system has ceased to operate and the District (Kecamatan level) offices of the Fishery, Agriculture and Forestry Provincial Agencies are now in control of leasing the rights for the collection of minor forest products. The controll of minor forest utilization inside the reserve area is the sole responsibility of the Indonesian Nature Conservation Agency PHPA.

6.3. IMPLEMENTATION

Once PHPA approves the proposals for the Sembilang area as prepared by the team, establishment of the area requires endorsement by the provincial authorities (Governor), upon which the Minister of Forestry might decide to change the status of the forested land into Wildlife Reserve.

International recognition is needed to support PHPA in its efforts to establish the reserve. To this effect the authors propose the area for submission as UNESCO Man and Biosphere reserve. Beside, if the Government of Indonesia accedes to the Ramsar convention, the reserve could be listed as wetland area of international importance.

TABLE 5 ACTIVITIES ALLOWED OR RESTRICTED IN THREE DIFFERENT CLASSES OF CONSERVATION ZONES

ACTIVITIES	WILDLIFE RESERVE		NATURE RESERVE
	traditional use marine & terrestrial bufferzones	wilderness zone	
human settlement	-	-	-
conversion to logging	-	-	-
conversion to farmland	-	-	-
commercial logging	-	-	-
collection of rattan	+	-	-
collection of bamboo, fruits	+	-	-
collection of firewood & timber (dead wood)	+	-	-
traditional hunting	?	-	-
traditional fishing	+	-	-
planting of tree crops	-	-	-
habitat management	+	+	-
construction of tourist facilities	-	-	-
scientific collection	+	+	+
tourist visiting	+	-	-

Legend:
+ permitted
- Not permitted
? sometimes permitted

Source: FAO 1981

Photo 2. Nypa palms along a S. Sembilang tributary. The proposed Sembilang Wildlife Reserve represents a large and undisturbed example of the Indo-Malayan swamp forest ecosystem (W. Verheugt).

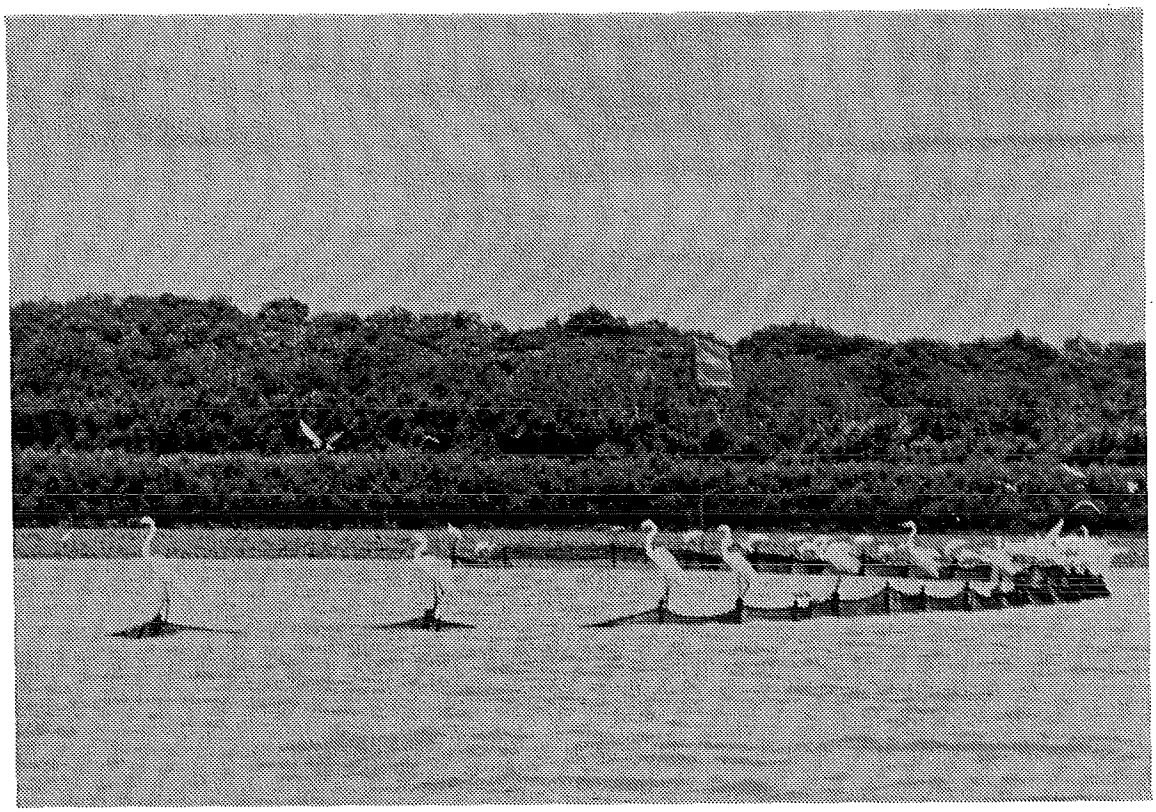

Photo 3. The proposed Sembilang Wildlife Reserve is one of the most important wetland areas in South East Asia for it supports a large number of globally endangered wildlife species, which occur in viable numbers (W. Verheugt).

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MANGROVE COASTS OF GUINEA BISSAU

by

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1. INTRODUCTION

Guinea Bissau (36.125 km²) is situated on the West coast of Africa. Its population of about 768.000 inhabitants (census 1979) is largely concentrated in the coastal areas and in the capital Bissau (129.000 inhabitants, census 1979). Urbanization rate is 4 to 6 % per year, almost 2 to 3 times the average population growth, and largely due to a rural exodus (SAWA, 1987). Most inhabitants are engaged in agriculture, mainly rice cultivation on a subsistence level. There are no major industries, and fisheries and forestry are still in a state of development. The coast is the major rice producing region, but the country's rice production does not meet the current national demand; in 1981, roughly one third of the rice consumed was imported (about 35.000 tons). Most of it is bought on external markets instead of purchasing rice in the regional surplus producing areas in the south. However, market prices for rice are low, and economic incentives for surplus production are lacking.

The mangroves and tannes cover about 11% of the area: a total of 347.000 ha of which a quarter has been reclaimed for agriculture in the past centuries; tidal flats cover 157.000 ha (ZWARTS, 1988).

2. ECOLOGICAL PROCESSES AND PATTERNS

climate and coastal processes
Generally, rainfall amounts to 1.200 - 1.400 mm between June and October in the northern part and more than 2.000 mm between May and November in the southern part of the country. Evapotranspiration in the North exceeds precipitation, leading to conditions of temporary and permanent increase in salt content of soils and estuarine waters.

The entire coast consists of large funnel-shaped permanent brackish to saline estuaries which are fed by rivers with relatively small catchment areas. The Rio Geba is the only river with a significant discharge. The tidal amplitude ranges between 2,5 and 5,7 metres on the coast and its influence reaches far inland. In some estuaries, the tidal amplitude may exceed 7 metres (e.g. Rio Geba).

mud flats, mangroves and rice fields
The mud flats form a dominant feature of the entire coast. Extensive mud flats are present along the Rio Geba, Rio Grande de Buba and in the Archipelago dos Bijagos. It is not known if they are stable or migrate as those that can be observed along the coast of Guinea Conakry (CHENEAU-LOQUAY & USSELMAN, 1990; SALOMON, 1987); however, topographical maps of 1956 - 1972 still appeared to be fairly accurate in 1983 and 1986/87 (ZWARTS, 1988) showing the mud flats to be relatively stable. Biomass production has been measured and calculated by Zwarts (1988) and is in general between 5 - 10 gr/m² compared to about 25 gr/m² for temperate European mud flats, while feeding intensity of waders for both regions is 200.000 and 120.000 days/km² respectively (WOLFF, 1989).

The mangroves of Guinea Bissau consist predominantly of Rhizophora harrisonii, R. mangle and Avicennia nitida, the latter being more extensive in the northern parts. Generally Rhizophora mangroves are tallest along creeks and river channels but luxuriant growth of Avicennia spp. can also be observed along creeks and tidal channels thriving on abundant nutritious sediments supplied by the sea (PONS & FISELIER, 1990). Biomass production is unknown but an average of 13 tons of litter per ha per year has been reported from mangroves in the Casamance under less favorable conditions (ISRA, 1985). However, litter production under similar climatic conditions in the Asian region is between 8 - 12 tons for Rhizophora forests (CHANSANG, 1983).

Rice fields are mainly situated in former mangrove areas and consist of small-scale embankments. The rice is grown on ridges and entirely dependent upon rainfall. The amount of rainfall and labour force determines to a large extent the cultivated acreage. Traditionally, the fields are flooded with seawater in the dry season in order to control weeds and neutralize sulphuric acids which are formed in the growing season.

3. THE IMPORTANCE OF MANGROVE COASTS TO WILDLIFE

The estuaries of Guinea Bissau probably still harbour small populations of the African Manatee (Trichechus senegalensis), Hippopotamus (H. amphibius) and crocodile (Crocodylus niloticus). The Sitatunga (Tragelaphus spekei) still rooms the islands of the Archipelago dos Bijagos in large numbers (CML/SECA, 1987).

For waterbirds, especially waders and large wading birds such as herons and egrets, mangroves in Guinea-Bissau play a vital role in the system of coastal wetlands, which consists besides mangroves of extensive mud flats (1.570 km²; POORTER & ZWARTS, 1984), rice fields (1.800 km²;

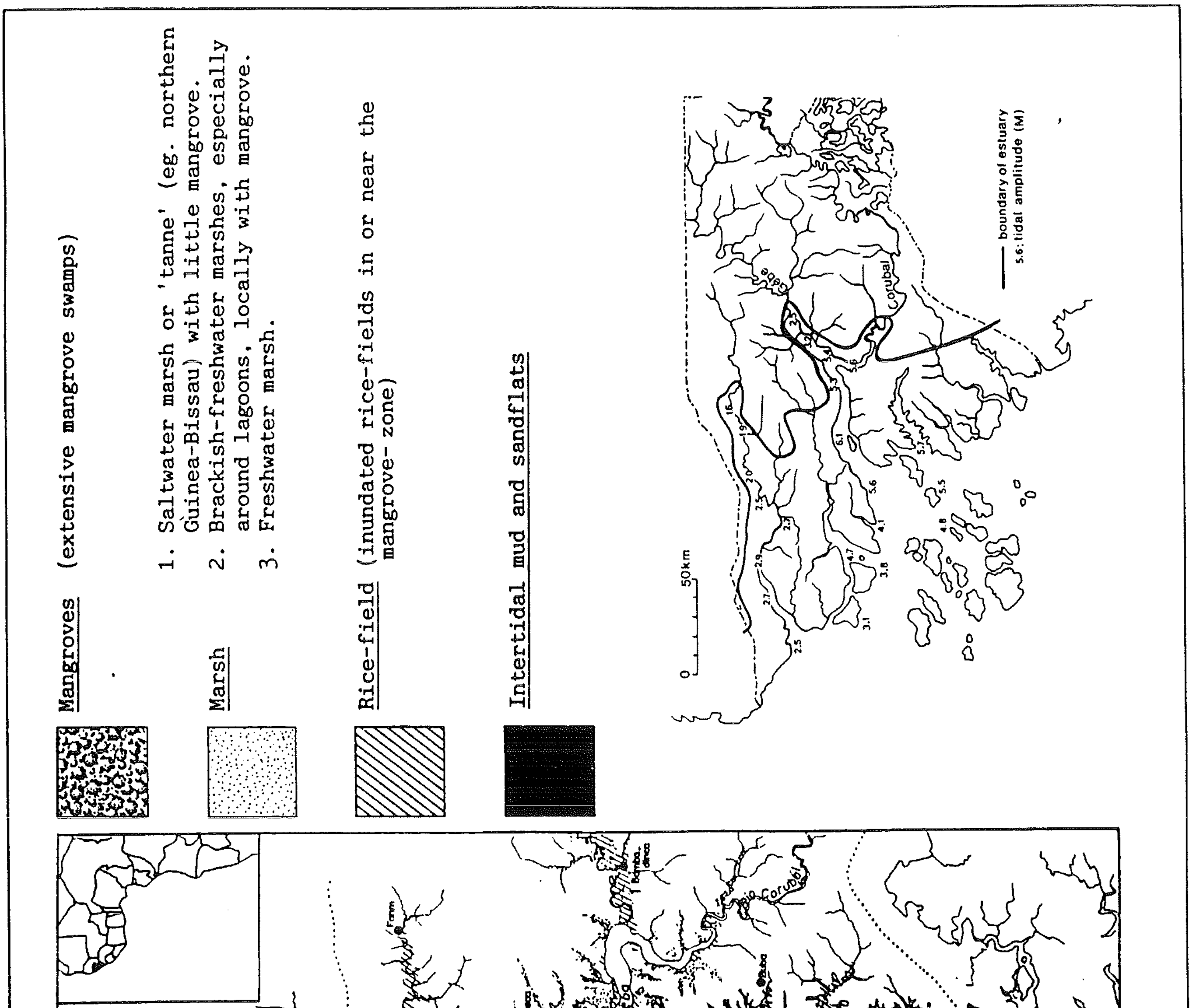


Figure 1. Distribution of tidal areas, rice fields and mangrove forest in Guinea Bissau and the boundary of the estuarine systems (adapted from ALTENBURG, 1987 and CML/SECA, 1987).

ALTENBURG & VAN DER KAMP, 1985) and a relatively small area of salt flats or "tannes" (380 km²; SCET, 1978). Mangroves might be considered as "key-habitat" in this system (ALTENBURG & VAN DER KAMP, 1989), being essential to its very existence and acting as a pivot in bird movements to and from mud flats and rice fields (Fig. 2).

mangroves as food source and feeding grounds

Apart from ensuring coastal stability and accelerating shore development, which in a way affect the position and size of mud flats and coastal marshes, an important function of mangroves is to support the marine food web by producing organic debris. Mangrove swamps enhance the productivity of mud flats and shallow coastal waters, promoting nursery conditions for invertebrates, crabs and fish, and are thus essential, though indirectly, for birds depending on these food sources (cf. ALTENBURG & VAN SPANJE, in press; macrobenthos: coastal waders; crabs: coastal waders, at least partly Sacred Ibis Threskiornis aethiopica and Gull-billed Tern Gelochelidon nilotica; fish: wading birds (cormorants, herons, egrets etc.), terns, kingfishers, Osprey Pandion haliaetus, African Fish Eagle Haliaetus vocifer).

Many species of these groups occur in large numbers on the mud flats and in the mangroves of Guinea-Bissau in winter. For most of these, especially the afro-tropical species, the relative importance of their numbers is unknown because data on breeding populations, and migration or wintering grounds are lacking. For some groups of palearctic migrants the international importance is clear (cf. ALTENBURG & VAN SPANJE, in press). This is especially true for palearctic coastal waders: 1 million in winter, Curlew Sandpiper Calidris ferruginea (250.000), Bar-tailed Godwit Limosa lapponica (156.000), Knot Calidris canutus (144.000) and Little Stint Calidris minutus (123.000) being the most numerous species (ZWARTS, 1988). Osprey and Gull-billed Tern also seem to occur in (internationally) important numbers.

mangroves as roosting grounds

Another important function of mangrove swamps is to provide a roosting place for birds which largely feed outside the mangroves, on mud flats (waders, wading birds), rice fields, coastal marshes and areas further inland (mostly wading birds). Waders usually roost on stilt roots, but also in tree tops (especially Whimbrel Numenius phaeopus), while wading birds predominantly use tree tops. Although the majority of coastal wader species roost in considerable numbers in mangroves, part of them seem to prefer open grounds (tannes and, to a lesser extent, beaches and rice fields), particularly Oyster-catcher Haematopus ostralegus, Sanderling Calidris alba, Knot Calidris canutus and Curlew Numenius arquata. The numbers roosting in mangroves increase when the tannes and lower beaches flood at spring tide (ZWARTS, 1988).

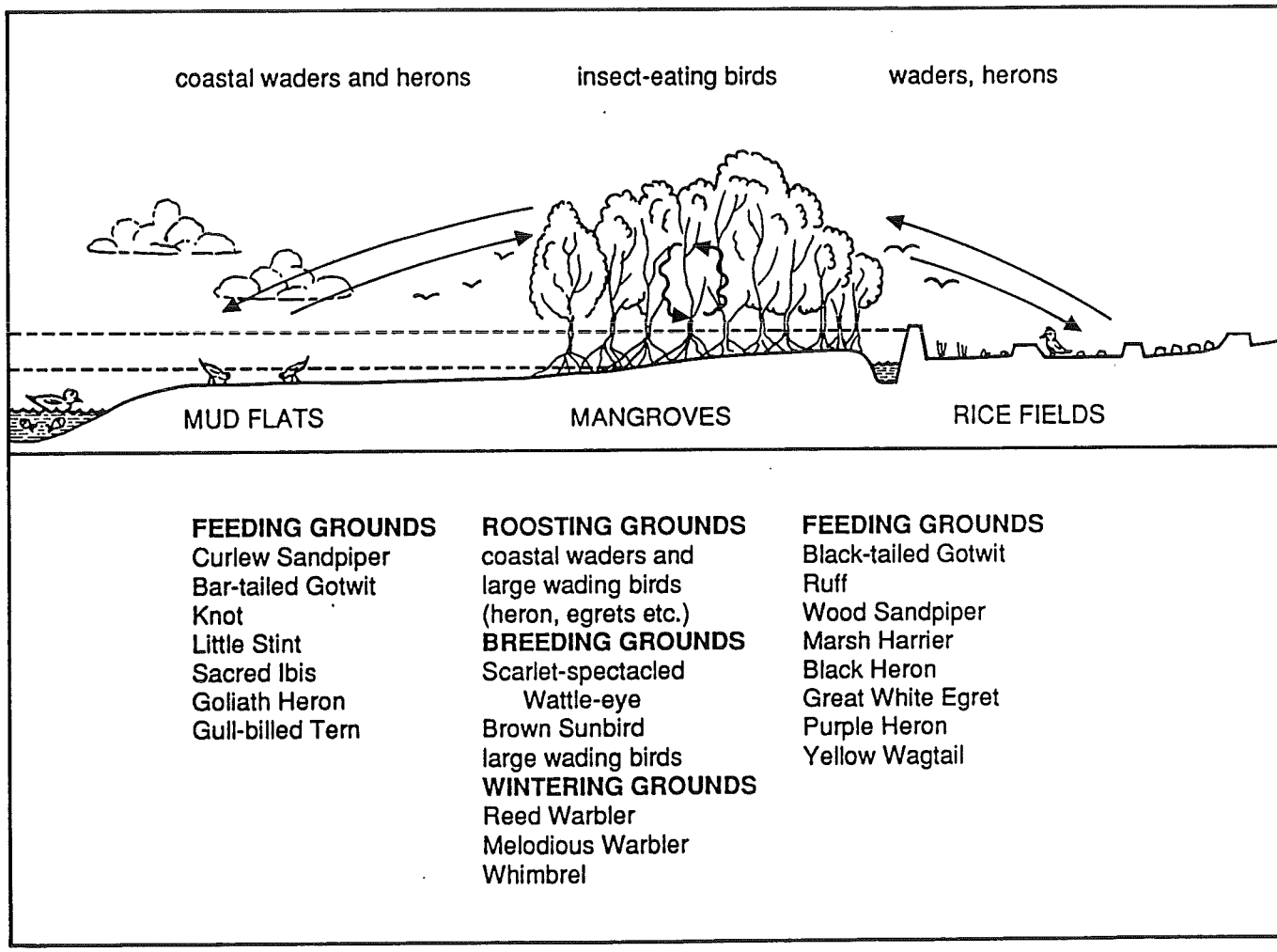


Figure 2 Bird habitats and movements in the coastal ecosystem of Guinea Bissau.

According to data of Altenburg & van Spanje (in press), of the 1 million wintering coastal waders in Guinea-Bissau several hundred thousands will use mangrove trees as a high tide roost, while most of the remaining birds roost on tannes within the mangroves and a much smaller number on beaches. Most of the terns also roost on tannes and beaches. The greater part of the large wading birds which feed on the mud flats have their high-tide roost in the mangroves. This applies to several thousands of birds, while their night roosts in mangroves (probably mostly isolated mangrove islets) may hold tens of thousands, containing both birds coming from the mud flats and from rice fields. A night roost on Ilheu dos Passaros ("bird-islet") near the capital Bissau held over 15.000 birds on 9-12-1986, of which Bubulcus ibis (9.841), Egretta gularis (2.244), E. ardesiaca (1.354) and Phalacrocorax africanus(1.098) were the most numerous species. The same authors estimate the number of roosting birds of prey at several thousands for the Palm-nut Vulture Gypohierax angolensis and several hundreds for Osprey and African Fish Eagle.

The poor accessibility of the mangroves and part of the tannes, and the tangle of stilt roots of Rhizophora, partly inundated at high tide and under a thick cover of leaves and branches, offers waders and wading birds a safe roosting place. It protects them from the Marsh Mongoose Atilax paludinosus (of which Altenburg & van Spanje (in press) report numerous traces along the mangrove edge), from a number of birds of prey and from hunters. In many parts of Guinea-Bissau, no such refuges exist outside the mangrove area. Both waders and wading birds would presumably be subject to greater predation if they attempted to roost elsewhere.

mangroves as breeding grounds

The thick cover and relative safety from predators of any sort, probably also confer importance to the mangroves as a breeding ground for those birds which nest inside but feed outside the mangroves. This is true especially of wading birds; in Guinea-Bissau, as far as is known, breeding species of this group include cormorants, herons, egrets, darters, spoonbills and ibises (DE NAUROIS, 1969 and ALTENBURG & VAN DER KAMP, 1986). Colonies of most of the large wading birds are scarce in West Africa.

rice fields as feeding grounds

The wet rice fields in reclaimed mangrove areas are an important habitat for both afro-tropical and palearctic waterbirds. Altenburg & van der Kamp (1986) mention internationally important numbers of palearctic migrants, eg. Black-tailed Godwit Limosa limosa (110-120.000), Ruff Philomachus pugnax (50-75.000), Black-winged Stilt Himantopus himantopus (2-4.000) and Marsh Harrier Circus aeruginosus (1.000-1.500). Of the afro-tropical species, especially herons and egrets occur in large numbers, e.g. Cattle Egret Bubulcus ibis, 15-25.000, Black Heron Egretta ardesiaca (10-20.000), Great White/Intermediate Egret Egretta alba/intermedia (5-10.000), feeding in the rice fields and using the mangroves as night roost and (locally) breeding place.

According to Altenburg & van der Kamp (1985, 1986), the numbers of many species are highest in wet rice fields with a relatively open vegetation, and lowest in dry fields with dense stands of rice. A relatively open structure is particularly encountered in wet and slightly brackish rice fields close to the tidal river or the sea. Bird numbers probably change during the growing season as a result of the modification of the vegetation structure and the gradually drying fields.

birds restricted to mangrove forests

Despite being a key-habitat for birds in the coastal wetland system, mangroves themselves are a suitable habitat for only a restricted number of bird species. The nature of the visits of a large number of species is probably casual on most occasions, though some of them may breed in the mangroves. Casual visitors include many passerine species of semi-open country, less so of forested areas. Altenburg & van Spanje (in press) mention 18 bird species which are abundant in mangroves of Guinea-Bissau apart from roosting birds, at least during the palearctic winter, most of them being insectivorous passerines and insectivorous/piscivorous kingfishers. Of these, the afro-tropical species (12) occur in considerable numbers, especially the Scarlet-spectacled Wattle-eye Platysteira cyanea and the Brown Sunbird Anthreptes gabonicus. The relative importance of the mangroves for these species is unknown. All of them are widely and for the most part commonly distributed in a large part of West Africa (SERLE & MOREL, 1977; FRY ET AL, 1988). Only for the Brown Sunbird, whose coastal distribution area extends from Gambia to the mouth of the Zaire river, do mangroves constitute the main habitat.

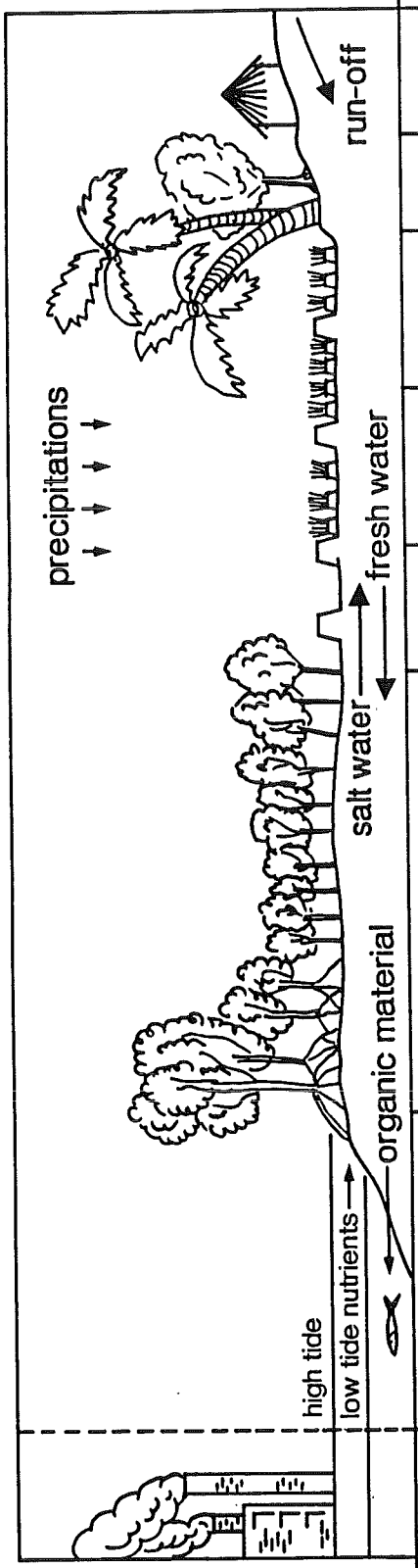
The abundant palearctic migrants (6) probably occur in internationally important numbers. This will be true for Subalpine warbler Sylvia cantillans and Common Sandpiper Actitis hypoleucos, and even more likely for Whimbrel, Willow Warbler Phylloscopus trochilus, Reed Warbler Acrocephalus scirpaceus and Melodious Warbler Hippolais polyglotta. Wintering in mangroves, which are much less affected by drought than other Sahelian habitats, could well account for the fact that the latter two species show no decline in West European breeding areas in contrast with many other palearctic passerines wintering in the Sahel.

4. THE IMPORTANCE OF MANGROVES TO FARMING SYSTEMS

farming systems

The mangroves play also a vital role in the economy of the coastal communities. The farming system of these communities consists roughly of three groups of activities (see figure 3);

- mangrove-related activities such as fisheries, gathering of oysters and crabs, hunting and wood extraction;
- agriculture: rice 'bolanha' cultivation in former mangrove areas and cultivation of groundnut, sorg hum and millet in the uplands, while within the zone between mangroves and upland horticulture cás - sava, yam, okra, sugar cane and fruit trees like papaya, mango, banana and citrus are grown; in most areas, cattle farming constitutes an important economic activity;



Activities	Season wet	Season dry	Functions
dryland, rain-dependent agriculture	m		
housing	m	m	
palm trees, fruit trees	w	w	
vegetable gardens	w		
rice fields	m/w		
with livestock		y/w	
fish ponds		w	bufferzone for brackish water
hunting		m	habitat for flora and fauna); genetic pool
mangroves and natural products such as wood, honey and medicinal products	w	w	trapping of nutrients; coastal protection
collection of oysters	w	w	
local fisheries	w	m/w	transportation of nutrients and organic material
industrial fisheries			
transportation			
labour (migrants), non-agricultural activities	y		

m = man w = woman y = youth

Figure 3. Farming system in Guinea Bissau consisting of mangrove-related activities, agriculture and off-farm activities, performed by different sexes, age groups and in different seasons (adapted from: FISELIER AND TOORNSTRA, 1987).

- off-farm activities: mainly labour migration to Bissau and the Casamance (Senegal).

The Balantas and the Manjacos are the most important ethnic groups along the coast. Both groups practice rice cultivation and rice takes a special place within their society as a source of food, as a medium for the exchange of commodities, as a storage buffer and as part of their ceremonies (SAWA, 1987). Labour organization is patrilineal and land is owned and controlled by older men. The Balanta organization is largely horizontal and decisions are taken at the local level by the council of old men. The Manjacos have a hierarchical organization of king, local rulers and village headman (CML/SECA, 1987). Labour division within the Balantas is strict; women weed rice fields and cultivate food crops while men cultivate rice and upland millet, and plant and attend to fruit trees. Among the Manjacos, the women grow upland rice. In many households, especially in the northern parts of Guinea Bissau, the income is supplemented by wages obtained through paid labour mainly in the Casamance.

mangrove-related activities

Fisheries are not well developed in Guinea Bissau. Fixed gears are used only in few places and few people are engaged in coastal fisheries on a full-time basis. Large foreign trawler fleets roam the coastal waters for fish and shrimps on the basis of bilateral contracts. Considerable potential for further development of the fishery sector has been recognized. Shellfish constitutes an important part of the diet and oysters are mainly gathered by women.

There is no commercial forestry in Guinea Bissau, although mangroves are exploited by coastal communities for timber and firewood and even mangroves leaves are reported to be used as fodder. Some charcoal is manufactured near Bissau (VERVOORT, 1985). Trees are more or less cut at random, no replanting is done and pressure on wood resources is generally low.

Hunting is not an important activity. Guns and ammunition are too expensive and out of reach of most people. Traps are however used.

mangrove rice cultivation

Throughout the ages, the Balantas developed a special way of cultivating rice in mangrove areas, the 'bolanhas' or so-called rainwater polders. The system consists of larger polders incorporating smaller embankments; rice is mainly cultivated on ridges. Historically, bolanhas where constructed on higher tidal forelands with few potential acid sulphate soils. From the higher to the lower parts of the system, shallow rice fields gradually change into larger, deep water rice fields. The system also comprises nursery fields (see Fig. 4). The Diola in the Basse Casamance have added an outer buffer, situated between two ring-dikes and used as fishpond (VAN DER ZAAG, 1986).

The lower fields normally have a water level of more than 50 cm and slightly brackish water; in the upper fields, the water level seldom exceeds 15 cm.

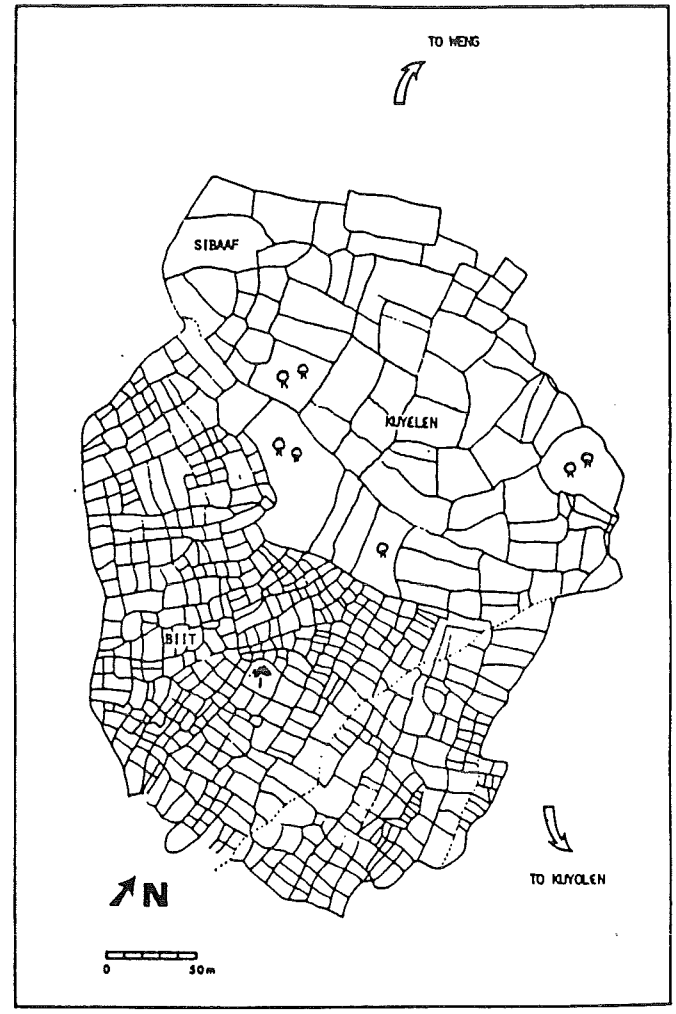


Figure 4. Bolanha rice field pattern (LINARES, 1981): nurseries (kuyolen), shallow rain-fed fields (biit), deeper rain-fed fields (kuyelen), sandy and shallow rain-fed fields (sibaaf) and deep fields bathed with marigots (weng).

The highest fields are the first to be cultivated and require less labour. When labour is scarce, planting is often late which leaves less time for the ripening of the rice. The highest fields are planted with short-cycle varieties. Richards (1985) noted that farmers, especially women, are constantly experimenting with rice varieties, while Pellissier (1966) estimated that the Diola used more than 100 different rice varieties (63 Oryza sativa, 36 Oryza glaberrima). According to Linares (1981), a Diola household (Basse Casamance) consisting of 3 adults and 2 children manages to cultivate between 0,6 and 1,1 ha of rice fields (about 150 workdays - at 6 h/day - per hectare). This means that 50 to 75 persons per km^2 can be supported. The rice is cultivated on ridges that are re-erected every year.

This type of cultivation has some advantages: salts and sulphuric acids are easily drained (DENT, 1986), rice cultivation in deeper fields is possible, capillary rise of salt groundwater is hampered by the residues of former crops - mulching is practiced - (VAN DER ZAAG, 1986) and ridges increase the water that is available to plants and water storage in the fields.

Recent reclamations are often situated on less suitable, potential acid sulphate soils. The average rice production amounts to 800 kg/ha per year and yields are generally higher in the south: 1.300 kg with occasional yields of more than 2 tons on good mangrove soils (pers. com. Pons). Fertilization occurs through the mulching of crop residues and weeds and some sedimentation in the lower fields under temporary tidal influence. Often, no other fertilizers are used. The cattle grazes the residues and fertilizes the fields. This is often the only form of fertilization that nursery beds receive. Many mangrove soils react favorably to small applications of phosphate and nitrate; this might double the yields (CML/SECA, 1987; UKKERMAN, 1988).

droughts, migration and dams

Compared to the 1960s, precipitations dropped from 2.000 mm (Bissau) and 2.400 mm (Bolama, South Guinea-Bissau) to 1.500 mm and 1.800 mm respectively (5 year-average) and the growing season is now shorter. In the North, salinization has become a serious problem, and crop failures and abandoned rice fields common phenomena. As a reaction, more than 40 small anti-salt barriers have already been built downstream of a mangrove area of about 100.000 ha and 40 other barriers have been planned (SAWA, 1987). Their purpose is to lengthen the growing season by storing rainwater and avoid premature salt penetration. The dams are also meant to reduce the labour-intensive dike maintenance.

Many dams have failed owing to problems of a technical and socioeconomic nature (SLABBERS ET AL, 1990); upstream of the barriers, the cultivation percentage of most fields ranges between 10 and 60 % (SAWA, 1987). Reasons for this failure include: non-adaptation to local organizational structures, imperfect technology and design, and insufficient participation of local communities. Most dams have been planned without adequate research on soil and hydrological conditions while organizational and socioeconomic factors were largely neglected. The decision to build a dam is normally taken at the highest level.

The dams also fail because they do not remove the main existing constraints to rice cultivation. These often are of socioeconomic rather than climatic origin. The abandonment of fields already started during the liberation war as a result of eroding traditional societies. Droughts only have accelerated the phenomenon. Owing to migration, labour becomes scarcer and dikes are poorly maintained; while low market prices for rice tempered any surplus production, most marginal fields have been abandoned, especially in the north.

Besides the fact that they do not meet their own objectives, many dams have adverse environmental effects. The mangroves upstream of the barrier die off due to absence of tidal activity, and fish migration routes are obstructed. An important part of the resource base of the local communities has thus been diminished. In certain areas, e.g. Biombo, the situation is critical as the failure of a large number of anti-salt barriers deprived the region of almost all lands that are suitable for traditional forms of bolanha cultivation.

5. INTEGRATING CONSERVATION AND DEVELOPMENT

sustainable coastal development

The coastal area of Guinea Bissau is and will remain the region with the most important economic activities; the economic development of the country as a whole will largely depend upon the sustainable development of its coastal resources. Many natural resources are still in a state of under-exploitation, e.g. fishery and forestry resources. Existing production systems can be innovated and new forms of sustainable resource utilization may be introduced. On the other hand, marginal rice fields and tidal flats remain among the most important wintering areas for palearctic migratory birds. The sustainable utilization of coastal resources does not necessarily imply the conservation of important wildlife habitats. Nevertheless, more productive rice fields will provide less opportunities for the feeding of waterbirds. It is therefore advisable to designate national parks in order to safeguard the most important roosting, breeding and feeding areas for waterbirds, manatees and other threatened mammals.

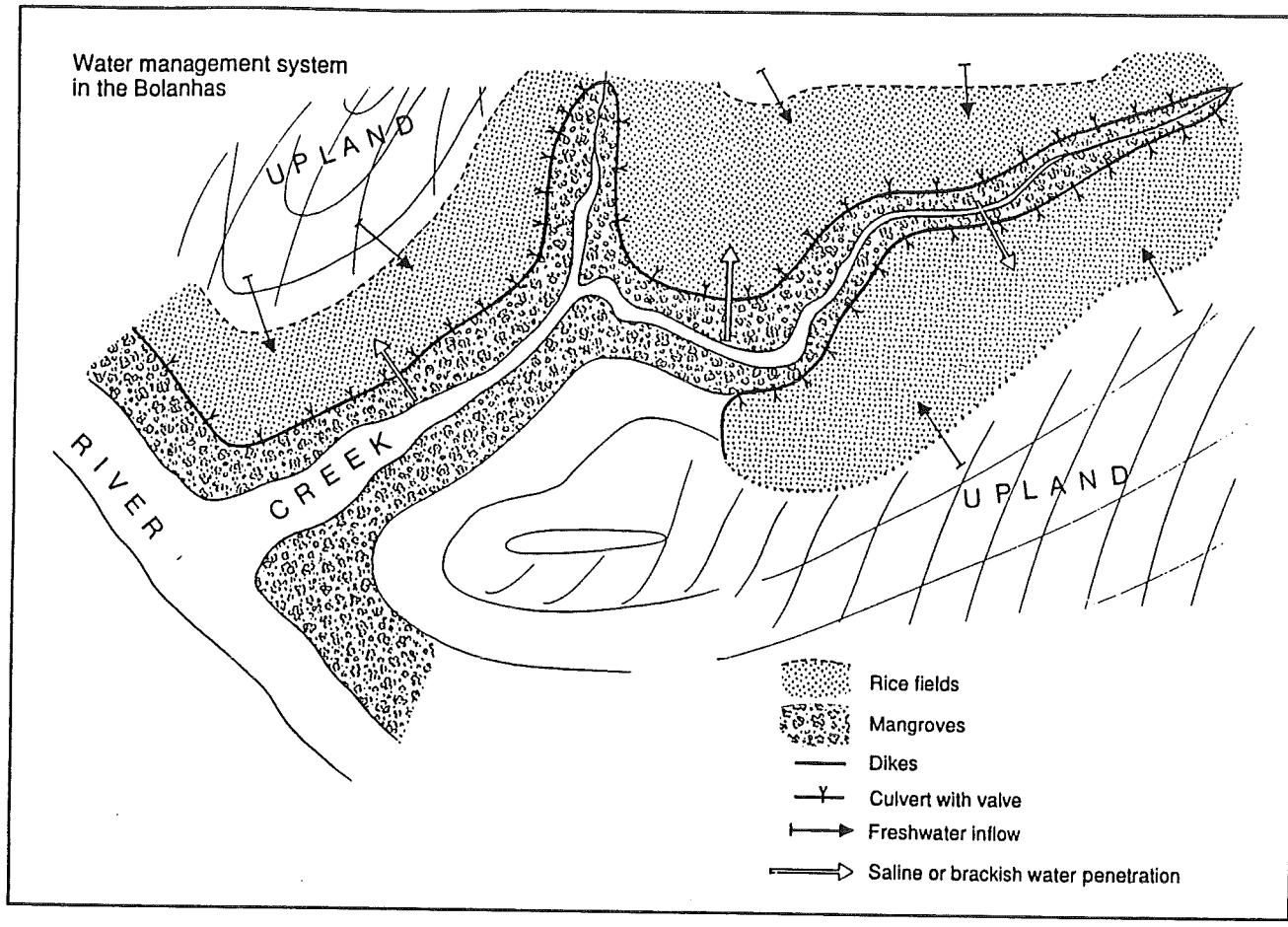
optimising mangrove-related production

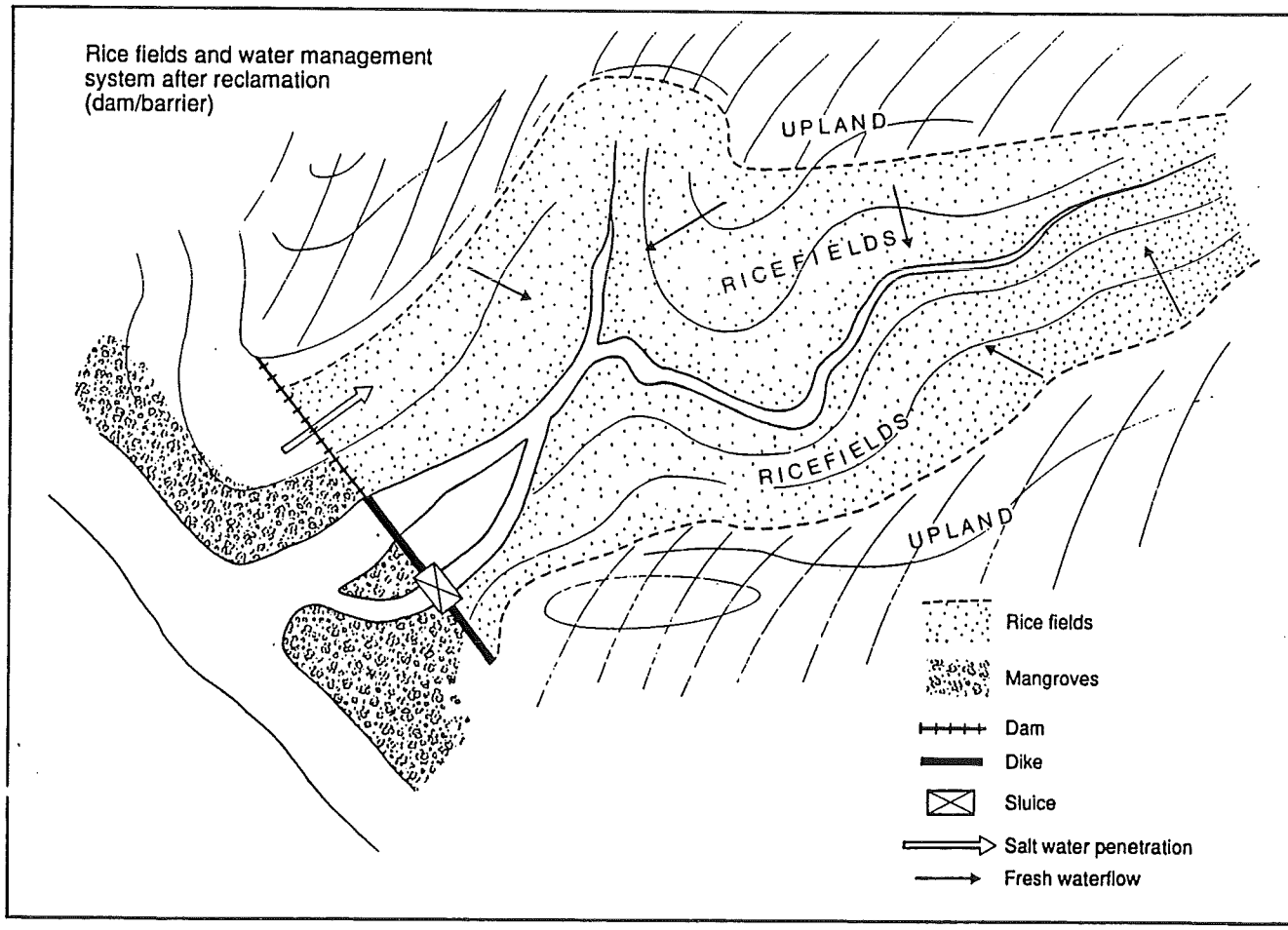
For many of the existing anti-salt barriers, a re-establishment of the tidal activity in upstream areas might be envisaged as well as the reforestation of abandoned rice fields.

There is also a potential for commercial forestry on a sustainable basis. However, this requires proper organization and control, and preferably the existence of local or regional markets (e.g. Senegal). The delineation of commercial mangrove plots should reckon with minimal requi-

TABLE 1. POTENTIAL DEVELOPMENT OPTIONS FOR THE COASTS OF GUINEA BISSAU

A. optimising mangrove-related benefits	
- afforestation	not relevant
- restoration	mainly of abandoned rice fields and salt flats by improved tidal flushing and replanting;
- tidal activity	in constructing anti-salt barriers, reopening of barriers and coastal roads;
- better use of forest resources	development of forestry for timber and improved charcoal manufacturing;
- better use of aquatic resources	development of artisanal fisheries open water cultures e.g. near Bissau
- socio-economic integration	based upon the entire farming system
B. optimising reclaimed benefits	
- environmentally sound innovation	mechanization mainly animal traction; fast growing and salt tolerant varieties; moderate applications of fertilizers; improved water management by sluices; combination with aquaculture in rice fields and in ditches and canals; combination with cattle keeping for manure and traction whenever absent;
- socio-economic integration	augmenting rice prices; integration into the farming system
C. integrating conservation	
- making conservation beneficial	establishment of National Parks, nature reserves and roosting areas; stimulating tourism development in the North and around Bissau
- creating opportunities for wildlife	maintaining roosting sites in and near agricultural areas; very limited use of herbicides; improved hunting control
D. planning, decision and implementation	
- identification of development options	village-based
- environmental zoning	is lacking but may be envisaged including nature reserves, commercial and traditional fishery and forestry zones, and delineation of potential reclamation and anti-salt barrier sites
- environmental profile	coastal environmental profile discussing integrating sectoral information and giving zoning priorities for fisheries, forestry, nature conservation identification of environmental problems and first development options
- environmental projects	environmental projects for mangrove restoration, rehabilitation of rice cultivation, introduction of aquaculture, development of tourism, establishment of national parks may be envisaged





Figures 5A and 5B. The traditional system of 'bolanha' rice cultivation and the region after the construction of an anti-salt barrier (adapted from FISELIER AND TOORNSTRA, 1987).

red traditional mangrove use areas. It is also advisable to set aside important roosting and breeding areas of birds.

Considering the socioeconomic situation of most coastal communities, innovation of fisheries should be labour-extensive and involve low costs. Improved fixed fishing gears, small fishing boats and equipment constitute practical development possibilities. There may be opportunities for the development of small-scale bottom cultures of oysters and cage culture near large markets such as Bissau.

The potential for sustainable wildlife utilization (e.g. sitatungas, raising of crocodiles etc.) should be investigated.

optimising 'bolanha' rice cultivation
The bolanha rice cultivation is very labour-intensive and its productivity is low. Improvements could be achieved through an increase in labour efficiency (mechanization), rice production and rice prices. There are indications that yields can be raised by fertilization, especially small applications of phosphate. Short growing varieties might also improve rice yields, especially in the north. If planned properly, anti-salt barriers may have positive effects on rice cultivation by reducing maintenance needs and prolonging the growing season.

More sophisticated forms of aquaculture are not easily adopted by local people, but there may be opportunities to raise the production of traditional fishpond that is part of the rice-growing system. An alternation of rice cultivation and fish production might be an interesting option for the semi-arid northern part of the country.

national parks and the potential for nature-oriented tourism
At the moment, there are no major threats to conservation, large virgin mangrove areas still exist. No mangroves are currently being protected. There is considerable potential for delineating national parks and nature reserves without displacing coastal communities.

Tourism is now negligeable; attractive sand beaches are nearly absent. There might be a potential for the development of tourism, but such development will require considerable upgrading of a (now) nearly absent infrastructure. Attracting tourists that visit the nearby Casamance by offering them the possibility of joining short (2-3 days) trips in the mangrove, could possibly create the necessary momentum.

people's participation
Most development issues will require considerable socioeconomic studies as since the coastal communities belong to different ethnic groups with different organizational structures. Farmers tend to experiment with different rice varieties and cultivation schemes. The innovation of both rice cultivation and mangrove-related activities may therefore greatly benefit from indigenous knowledge. All options should be properly screened within the context of the farming system.

6. CONCLUSIONS AND RECOMMENDATIONS

The coastal area of Guinea Bissau is among the most important wintering quarters of palearctic migratory birds. It will probably remain the country's economic backbone. Augmenting rice production is one of the most important objectives of the Government. This will however only succeed if rice production is made more attractive to local farmers by increasing rice prices and by innovating rice production. Most of these improvements may prove detrimental to birds that depend upon rice fields for their sustenance, especially if herbicides are to be used. Besides rice cultivation, the coast has a potential for forestry, fisheries, aquaculture and, to a limited extent, nature-based tourism.

Elements mentioned above should preferably be integrated into coastal development programmes and environmental projects that can be directed towards sustainable forms of mangrove utilization in combination with rice cultivation and upland agriculture, horticulture and off-farm activities. However, baseline data are largely lacking; extensive surveys of the coastal resources and in-depth studies of coastal farming systems will be necessary before programmes and projects can be developed. Several sectorial studies have been carried out, e.g. studies on fisheries, forestry and rice cultivation, but the necessary integrated, intersectorial view is still lacking.

A coastal environmental profile should constitute the first step. This profile should integrate existing knowledge, fill in remaining gaps, identify key-areas for environmental zoning and planning, and propose long-term policies for coastal development. Special attention should be paid to:

- inventories of areas that can be delineated as national parks and nature reserves, or should be designated as fish breeding areas and coastal protection areas;
- inventories of anti-salt barriers that can be rehabilitated, i.e. where tidal action can be re-established, and potential new locations;
- inventories of existing and potential traditional use zones and commercial fishing and forestry zones.

Considering the importance of Guinea Bissau to (especially) Dutch meadow birds such as the Black-tailed Godwit, a "twinning" of coastal areas in Guinea Bissau and Dutch meadow areas in Netherlands is proposed. The main objectives of this twinning is to create development opportunities for the local communities and secure parts of the coast as wintering habitats.

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THE SUNDARBANS, BANGLADESH

by

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COUNTRY SETTING

Location	-	Bangladesh lies between latitudes 20o34'N and 26o38'N and longitudes 88o01'E and 92o41'E. It is bordered by India in the West and North, by India and Burma in the East and by the Bay of Bengal in the South. The Sundarbans forest reserve lies on the Bangladesh/India border and stretches eastward. Bangladesh contains the largest river delta in the world. It comprises the Ganges, the Brahmaputra, the Meghna and the Karnaphuly rivers.
Surface	-	144.000 km2
Land use	-	crop land / pasture / forest and woodland / other
(km2)		92.270 / 6.000 / 21.310 / 15.330
Climate	-	Tropical monsoon climate with heavy summer rains from June to September, generally accompanied by hurricanes. Average winter temperature 15-20 °C, summer temperature 26-30°C.
Population	-	104 millions (1987), with a urban population representing 13% Population density: 672 inhabitants/km^2 Population growth 1970-1982: 2.6% Expected population by 2000: 157 millions.
Labour force	-	32.382.000; 74% agriculture, 11% industry, 15% services
GNP (1986)	-	16.070 million US$. Annual Income per Capita 160 US$ Agriculture 47%; Industry 14%; Services 39%
Membership International Wildlife Conventions		
	-	World Heritage (Parts of the Sundarbans were inscribed in 1987) CITES (1973)

1 INTRODUCTION

The Bangladesh Sundarbans lies on the juncture of two vast river basins. Melting snows in the Himalayas and the Tibetan Plateau join the runoff of monsoon rains in rivulets, streams and rivers that flow down to the world's largest delta, covering a surface of 80.000 km^2 (Leong, 1971 in Seidensticker and Hai, 1983). The entire floodplain of Bangladesh was once well forested but much of the forest has disappeared in recent decades owing to an increasing demographic pressure. In 1980, the remaining natural forest was estimated to be 4.782 km^2 (3.3%) and that of scrub forest 9.260 km^2 (6.5%); (IUCN, 1987b).

With a total land area of 4.020 km^2 in Bangladesh (and nearly as much in India), the Sundarbans are the largest remaining mangrove forest in the world. The Sundarbans include vast areas of tidal marshes and innumerable thickly forested islands with a network of rivers and channels. These forests derive their name from the tree 'sund'ri' Heritiera fomes (H. minor), which is the chief species (Ahmad, 1964). Although serving as habitat for one-fourth of Asia's remaining wild tigers, the Sundarbans are no wilderness but a strictly controlled and scientifically managed reserve since the mid-nineteenth century. This reserve yields a rich and (so far) sustainable stream of wood and fisheries products, the extraction of which provides direct employment to a half million Bangladeshis, and food, fuel and fibre for scores of millions more (Potkin, 1988).

A relatively small portion of this huge mangrove forest is protected by a National Law of 1977. The Sundarbans West, South and East Wildlife sanctuaries altogether comprise 32.386 hectares (see fig. 1).

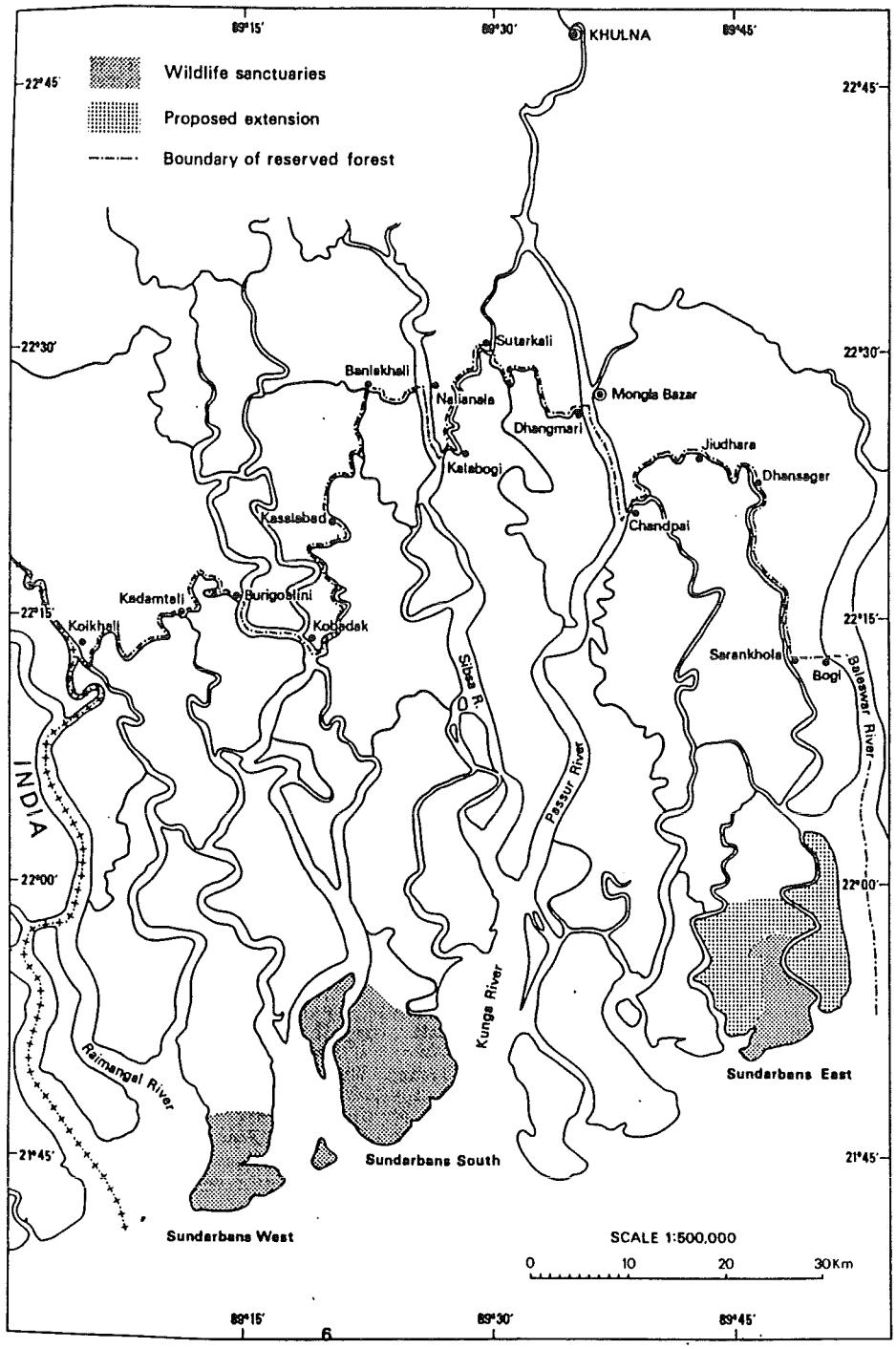

Figure 1. The Sundarbans (source Chaffey et al, 1985).

This case study is meant to illustrate the following aspects:
- the implications of sea level rise;
- the need for integrated river basin management and coastal environmental zoning;
- coastal afforestation programme.

2 ECOLOGICAL PROCESSES AND PATTERNS

physiography and ecology

The whole area is intersected by an intricate network of interconnecting waterways. Innumerable khals (i.e. small drainage canals) drain the land at each ebb. Easily eroded sands collect at the river mouths and form banks and chars, which are blown into dunes above the high-water mark by the strong south-west monsoon. Finer silts are washed out into the Bay of Bengal but, where these are protected from wave action, mud flats form. These are overlaid with sand from the dunes and develop into grassy middens, which spread until they are stopped by a khal or an early forest growth. The process of coastal accretion and erosion continuously changes the shape of the coast and coastal islands (see figure 2). Parts of the coast have known rapid accretion in recent years; about 400 km^2 had been formed and 186 km^2 eroded in different places in the course of 45 years.

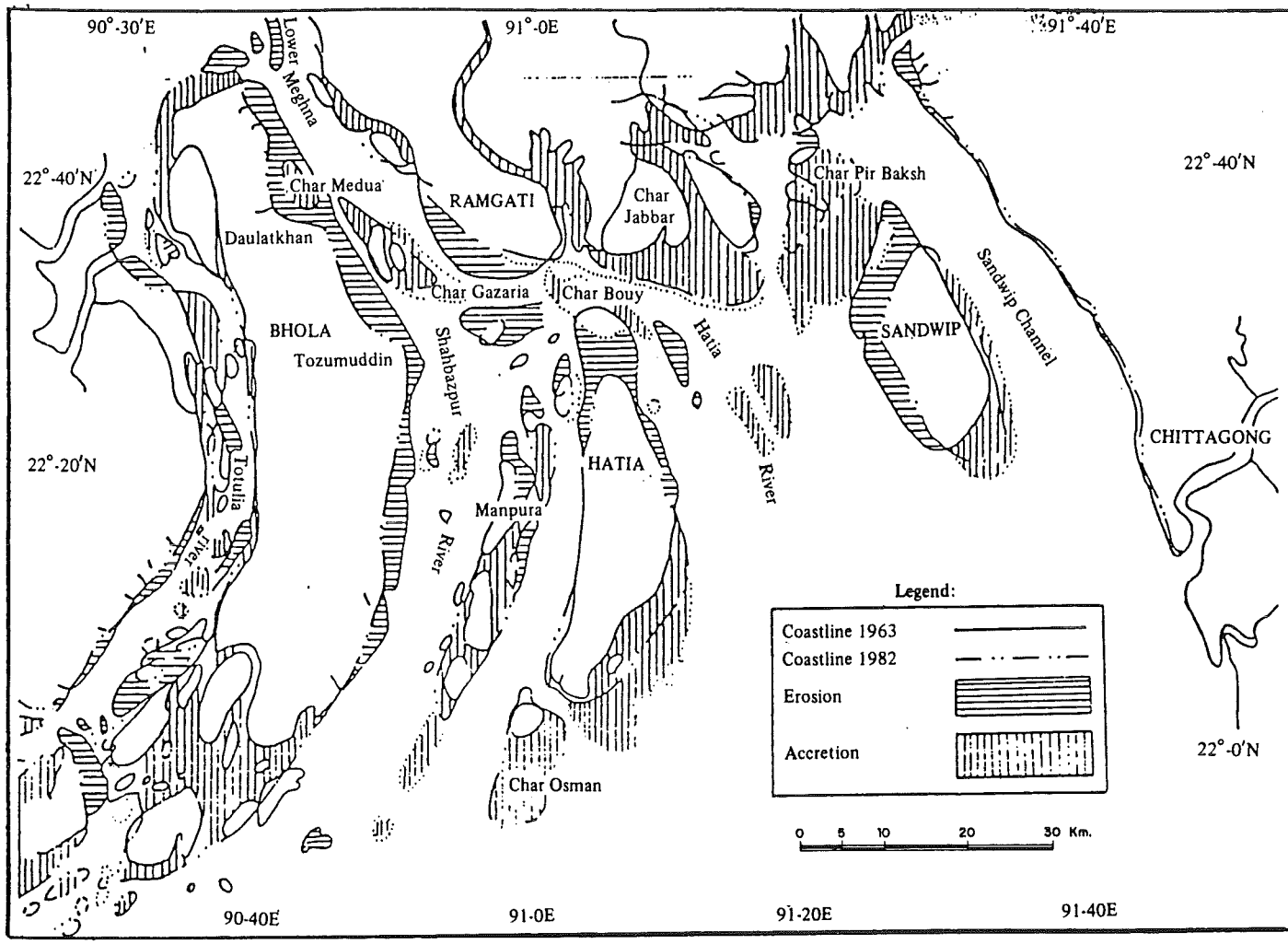

Figure 2. Coastal accretion and erosion (ESCAP, n.d.).

Most rivers and streams which dissect the Sundarbans are, or once were, distributories of the Ganges. They divide the area into five main estuaries which form major ways of salt intrusion. The vertical tidal range is three to four metres. The area is flooded by a 1,5 to 2 meters tide twice a day for up to six hours. The salinity increases from east to west. Studies carried out in the past stressed the importance of fresh water and alluvium in maintaining soil-fertility in the Sundarbans (FEC 1989).

climate and storm surges

About 80% of the rain falls in the monsoon season, which lasts from June to October. Mean annual rainfall varies between 1.800 mm at Khulna, north of the Sundarbans, to 2.790 mm on the coast. There is a six-month dry season during which evaporation exceeds precipitation. Conditions are most saline in February-April, the depletion of soil moisture being coupled with reduced freshwater flow from upstream areas. The funnel-shaped, 730 km long coast of Bangladesh is frequently reached by cyclones and is conducive to the development of tidal surges. Storms are common in May and October/November, and may develop into cyclones which are usually accompanied by tidal waves of 3 to 6 metres in height. Theoretically, surges that can be as high as 7,5 metres can be expected (Seidensticker and Hai, 1983). The severe impact of storms on the area is mainly the result of storm surges; the direct impact of wind on property and flooding due to exceptional rainfall is less destructive.

In the last days of November 1988, a cyclonic surge caused another disaster in the south of Bangladesh. A cyclonic (or storm) surge is the result of a low air pressure field in the centre of the cyclone. Due to the low pressure, the water surface rises significantly (a hundred millibars equals one metre water pressure/level rise). The rise takes the shape of a wave, which travels with the storm and continues even after the storm ceases or changes course. It happens very fast, taking coastal inhabitants by surprise. Dikes often fail, as the surge is usually accompanied by strong winds and waves (Van Duin, 1988).

global climatic change

The expected global climatic change may have a serious impact on the Bay of Bengal; it may lead to sea level rise, increased storm frequency and intensity and it may alter river discharge and flooding as a result of shifting rainfall patterns, rapid snow melting and blocking of river by higher sea levels (Brammer, 1989 in Huq and Rahman, 1989). It may also lead to earlier and deeper intrusion (Table 1).

TABLE 1. POSSIBLE EFFECTS OF GLOBAL CLIMATIC CHANGE (various sources)

primary effect	secondary effect
- increased temperature	- increased cycling of nutrients and biomass production; increased risks of drought conditions and salinization; shift in species composition; risks of lower oxygen content in water; increased risks of algae bloom and eutrophication
- increased sea level rise	- increased tidal flooding, longer period and with higher amplitudes; increased and earlier salt intrusion and therefore altered estuarine conditions for fauna and flora species and sedimentation processes such as flocculation; increased flooding of coastal floodplains by river waters; decreased drainage conditions for coastal plains generating more salinization; changing longshore currents generating modified patterns of coastal erosion and accretion
- changing local rainfall	- increase or decrease in rainfall quantity and variability, and length of rainy season with risks of increase in drought conditions and salinization, or increase in waterlogged conditions
- changing river discharge	- altered flood dynamics of coastal plains and seasonal shift in salinity with effects on estuarine conditions; upstream climatic change may induce various land use changes with consequences for river discharge, water quality and sediment budgets
- increased storm frequency and intensity	- increased erosion of shoreline sand mud flats and larger damage due to storm surges and wind

The relative sea level rise, caused by a combination of absolute sea level rise and land subsidence, may amount to as much as 144 cm in 2050 and 332 cm in 2100 in the worst case, thereby leading to the loss of respectively 16% and 26% of the inhabitable land (see Table 2). It may also induce a substantial loss (50% - 75%) of the mangrove forests (Woods Hole Oceanographic Institution, 1986 in ESCAP, n.d.; Milliman et al, 1989). Local land subsidence is an important contributing factor and may locally be increased by recently introduced groundwater pumping. Sedimentation may strongly counteract subsidence and sea level rise. By then however, sedimentation rates may have been reduced owing to upstream damming and water diversion works. Reclaimed land within areas protected by dikes tends to lower due to drainage and shrinking of the soil.

TABLE 2. PREDICTED CONDITIONS IN THE BENGAL DELTA IN 2050 AND 2100 DUE TO SEA LEVEL RISE ONLY.

From Milliman et al (1987).

The best case scenario assumes minimal rise in sea level: natural subsidence is offset by river / deltaic sedimentation. The medium case assumes maximal rise in sea level and uncompensated natural subsidence. The worst case assumes enhanced subsidence due to groundwater withdrawal.

	2050			2100		
	best case	medium case	worst case	best case	medium case	worst case
Total sea level rise	13cm	144cm	209cm	28cm	332cm	447cm
worldwide	13cm	79cm	79cm	28cm	217cm	217cm
local subsidence	0	65cm	130cm	0	115cm	230cm
Shoreline erosion	0	1 km	1,5 km	0	2 km	3 km
%Loss habitable land	-	16	18	-	26	34
%Population displaced	-	13	15	-	27	35
%GDP	-	10	13	-	22	31

<<TABLE .

Predictions are at the moment very rough, detailed analysis of the interaction of changing river and tidal dynamics is completely lacking as well as trends and magnitudes of local subsidence caused by geological, pedological and man-induced factors.

vegetation
Generally three different ecological zones can be distinguished in the delta: a freshwater zone with as most characteristic tree species Heritiera fomes, a moderately saltwater zone with Excoecaria agallocha, and a saltwater zone with Ceriops dicandra. There are about 25 other tree species which are common but occur less frequently. The trees seldom reach heights of more than 10 metres.

3. THE IMPORTANCE OF THE SUNDARBANS TO WILD LIFE

importance to birds
The Sundarbans is the only remaining habitat in the lower Bengal Basin for a great variety of faunal species. It harbors a varied and colorful bird-life with at least 186 species so far recorded (Salter, 1984), among which no less than nine species of Kingfisher, including the brown-winged and stork-billed Kingfishers, Pelargopsis amauroptera and P. capensis. The mud flats and sandbanks provide feeding grounds to herons, egrets, storks, sandpipers, whimbrel, curlew and other waders (IUCN, 1987b).

Six species of the ICBP World Checklist of Threatened Birds have been observed in the Sundarbans and adjacent areas (Seidensticker and Hai, 1983; Collar and Andrew, 1988). These include the Spot-billed Pelican (Pelecanus philippensis), the Greater Adjudant (Leptoptilos dubius), the Lesser Adjudant (Leptoptilos javanicus), the Swamp Partridge (Francolinus gularis); two pairs of the Pallas's Fish Eagle (Haliaeetus Leucoryphus) have also been observed. The Sundarbans are an important breeding area to the White-bellied Sea Eagle (Haliaeetus Leucogaster), with 62 birds recorded in 1983 (population density: one bird per 53 km^2. Breeding success is however very low. Most of their nests are in high keora trees Sonneratia apetala.

Lately, a flock of over 250 Spoon-billed Sandpipers (Eurynorhynchus pygmeus), an endangered species with a world breeding population estimated at only 2.000-2.800 pairs (Kosolov, 1983 in Collar and Andrew, 1988) has been sighted on newly accreted chars in the Meghna estuary. The same team also counted three Nordmann's Greenshanks, including a juvenile, and nine Asian Dowitchers, that are listed among the critically endangered species in the world (Anonymous, 1989).

importance to mammals and reptiles
The area supports one of the largest populations of Panthera tigris, the Royal Bengal Tiger, now living in much reduced numbers in what may well be its last refuge in the country. The tiger is on the list of endangered species and its survival depends upon the provision of sufficient protected area as a habitat for itself and for its prey, e.g. the spotted deer (Cervus axis) and the wild boar (Sus scrofa). Other mammals include three species of wild cat, Felis bengalensis, F. chaus and F. viverrina and the Gangetic dolphin Platanista gangetica, which occurs in some of the larger waterways.

At least 35 reptile and eight amphibian species have been recorded (Salter, 1984 in IUCN, 1987b). The mugger Crocodylus palustris has become extinct probably due to over-exploitation. The estuarine crocodile C. pororus still survives but its population has been considerably depleted through hunting and trapping for skins. So have the population of monitor lizard (Varanus spp.), rock python (Python molurus), and species of marine and freshwater turtles and snakes.

Wildlife conservation has a low priority and there is no organization or funds available for it. Illegal hunting is a serious problem and the relevant departments lack personnel, logistics and funds for adequate law enforcement.

4 HUMAN UTILIZATION AND OCCUPATION

forestry, wood production and logging
For the past 50 years, the forest reserve has been managed under a selection-cum-improvement felling system with a 20 year felling cycle. The exploitation of all natural resources from the Sundarbans is managed through a system of auction, licenses and permits on the basis of work plans. The highest bidder is permitted to fell the trees within an identified coupe. All boats, boatmen and woodcutters are registered by name at the Forestry Department, which facilitates control.

Heritiera is the main timber species and it is the primary resource base for 221 saw mills, 350 pitsaw units and a hardboard mill. Other species cut for timber and wood processing are 'baen' (Avicennia officinalis), 'kankra' (Bruguiera gymnorrhiza) and 'keora' (Sonneratia apetala). Bobbins for the textile industry are made from 'keora' wood as well. The quality of Passur (Xylocarpus mekongensis), a protected species, makes it a valuable species for the production of furniture. Excoecaria provides wood for a newsprint mill and two match factories. The total amount of extracted round timber in the 1982/83 season amounted to 201.500 m^3.

The upper parts of felled trees are exploited as fuelwood in the case of 'sund'ri' and are sold separately through the issuance of permits by local offices of the Forestry Department. The other major fuelwood species is goran (Ceriops decandra), a shrub. In the 1982/83 season a total of 317.700 tons of fuelwood was extracted from the Sundarbans.

The exploitation of the Sundarbans forest resources provides direct industrial employment to 10.014 persons. The number of permits issued by the Forest Department for the gathering of forest products suggests an average of 45.000 people working each day in the Sundarbans, amounting to a total of 300.000 per year (ESCAP, n.d.).

gathering of mangrove products
There are no villages in the Sundarbans, but the area seasonally provides a basis for the livelihood of woodcutters, fishermen, honey-gatherers and collectors of gol-

patta palm leaves (Nipa fruticans) for thatching and tiger ferns for under-thatching material.

Apart from the large numbers of people employed by contractors in the commercial exploitation of sund'ri and other tree species, the local people are themselves dependent on the forest and waterways for such necessities as firewood, timber for boats, poles for house posts and rafters, golpatta leaf for roofing, grass for matting, reeds for fencing and fish for their own consumption.

Table 3. Extraction of minor forest products from the Sundarbans, 1973-1983

Year	Golpatta (1,000 tons)	Hental (1,000 tons)	Grass (1,000 tons)	Fish (1,000 tons)	Honey (tons)	Beeswax (tons)	Shells (1,000 tons)	Others (millions of taka)
1973/74	72.4	111	4.9	1.0	117	29	5.1	1.17
1974/75	66.3	73	7.0	0.6	202	50	7.6	2.14
1975/76	72.4	178	4.2	1.2	155	37	5.3	3.87
1976/77	68.5	425	7.6	6.3	239	60	6.0	1.50
1977/78	65.2	873	4.4	7.0	177	53	4.0	2.04
1978/79	68.1	228	8.4	9.3	176	42	5.2	2.64
1979/80	69.9	263	9.1	8.8	213	54	5.1	2.68
1980/81	67.5	166	13.6	7.8	299	74	3.0	4.34
1981/82	68.2	125	8.9	9.3	244	53	3.3	3.46
1982/83	62.0	154	4.5	9.1	232	58	2.2	5.53

Source: ESCAP (n.d.).

Thousands of people engage in the collection of honey and wax during a period of 2,5 months beginning in April. This activity can only be carried out with permits issued by the Forest Department. The total quantity of these commodities collected during the 1983 season was 232 tons, which at a market price of 30 Taka per 'ser' (approximately 0,9 kg) represents an appreciable source of income to local communities (Blower, 1985).

Shells are collected throughout the Sundarbans. They are burnt in order to produce the lime that is used with betel leaves or in the construction of buildings. The average yearly quantity of shells gathered in the Sundarbans from 1979 to 1983 amounts to 3,5 tons but this volume is declining (FEC, 1989).

The royalties set and charged by the Forest Department for most natural resources are very low compared to the market price of the products.

fisheries

Coastal fisheries and off-shore fisheries both depend heavily upon the mangroves as breeding and feeding area. The force of the current and the degree of salinity vary from khal to khal in different months of the year and have a direct influence on the production of phytoplankton, which form, directly or indirectly, the food of fish (Ghani in UNESCO, 1964). Sometimes the plankton multiplies so rapidly that it forms a red or yellow scum during high tide.

Bangladesh is endowed with vast offshore waters having a high fishery potential. This area is considered one of the most productive fishery zones in the world, because of the presence of the Sundarbans mangrove forest. The Bangladesh Government has conducted several surveys and has identified three major fishing grounds in the Bay of Bengal and recorded more than 475 species of fish belonging to 133 families, 10 species of marine shrimps of commercial importance, 108 species of shellfish, molluscs and crabs, and 2 species of lobsters from the Bay of Bengal (FEC, 1989).

The demand for fish is high in Bangladesh as the population prefers fish to meat. Nevertheless, the fish available per capita has strongly declined; between 1972/73 and 1984/85, the fish availability per capita decreased by 35%. In 1982/83, 9.100 tons of fish were landed, a third of which consisted of dried fish that was equivalent to about 15.000 tons of fresh fish, by an estimated number of 100.000 fishermen (ESCAP, n.d.).

Of the three species of otter living in the area, the smooth Indian otter Lutra perspicillata is domesticated by fishermen to drive fish into their nets (Blower, 1985). Over 120 species of fish are commonly caught by commercial fishermen in the Sundarbans, and shrimps, prawns, lobsters and crabs have a predominant place in the estuarine-dependent catch (Seidensticker and Hai, 1983).

aquaculture

For ages, the local population has been reclaiming land for aquaculture and agriculture. Normally, reclamation involves the building of strong embankments on the banks of tidal rivers and the raising of bunds around lands to be reclaimed. The construction material is taken from the enclosed area and excavation is done in such a way that one or more channels or canals are created. The impoundment communicates with the stream by one or more sluice gates, mostly made out of wood. In this way, certain areas are raised while others become shallow. For the first few years, the enclosed area is used for fish culture.

The practice followed is that during the high tide, in April and May when the water contains millions of young fish and prawns, the sluice gates are opened till a sufficient number of young fish and crustaceans have entered the enclosed area, locally known as 'bheries'. Bamboo traps are placed in the mouth of the sluices, in this manner only opening inward. After short intervals, the captured fish and prawns are sorted out, suitable ones returned to the bheries while the others are discarded. If there is a shortage of fish food, the sluices are opened at intervals in order to allow food-organisms into the ponds where fish and crustaceans are kept until they attain a marketable size. After several cycles of leaching, the land is fit for agriculture. In this way, landowners earn a sufficient income even during the first year of reclamation. In 1964, in the (then Pakistani) Sundarbans zone only, there were about 200 such bheries, some suitable for fish cultivation, others for paddy and paddy-cum-fish agriculture (Ahmad, 1964). Combination with salt production during the dry season also exists.

Lately, more intensive forms of aquaculture have been developed in the region. High-input aquaculture involves artificial stocking with fish and shrimp species such as Penaeus monoton and possibly, supplementary feeding. Some shrimp ponds are used all the year round and alternation with rice cultivation or salt production no longer occurs. Table 4 shows inputs needed and yields obtained in different aquaculture systems that can be found in the coastal area of Bangladesh.

TABLE 4. **Inputs and yields of mono- and multicultures of shrimp, rice and salt production in Bangladesh.**

Input/output	Shrimp/fish only (present)	Shrimp/fish and rice (present)	Shrimp/fish and salt (present)	Shrimp only (semi-intensive)	Shrimp only (intensive)	Shrimp/rice (improved)	Shrimp/salt (improved)	ADB 2nd AQ. Report (semi-intensive
INPUT								
1. Earthen dikes	Low traditional	Low traditional	Low traditional	Strong, properly designed	Strong with proper height, base and creast	Strong, properly designed	Strong, properly designed	Bike repair, drying of ponds in Oct.-Dec.
2. Water control structures	Wooden box sluice	Wooden box sluice	Wooden box sluice	Concrete sluices	Concrete, properly designed sluices	Concrete sluices	Concrete sluices	Repair and screening of sluice gates
3. Buildings	Very ordinary makeshift shed	Very ordinary makeshift shed	Ordinary shed	Proper residence and store building	Residence, store, etc., improved building	Proper residence, store building	Proper residence, store, etc., building	
4. Equipment	Traditional	Traditional	Traditional	Improved	Improved and varied	Improved	Improved	
5. Stocking of post-larvae (No/ha/year):								
(a) Brackish-water shrimp	20 000	11 700	Wild entry	60 000	100 000	30 000	30 000	10 000 30 000
(b) Fresh-water shrimp	520	1 154	–	–	–	–	–	–
(c) Fin fish	–	–	–	–	–	–	–	–
6. Application of lime (kg/ha/year)	–	–	–	250	500	250	250	100
7. Application of ratenone (kg/ha/year)	–	–	–	15	30	15	15	–
8. Application of fertilizer (kg/ha/year):								
(a) Cow dung	–	–	–	3 000	6 000	3 000	3 000	250
(b) Urea	–	–	–	375	750	375	375	5-10 kg/ha/week
(c) TSP	–	–	–	125	250	125	125	5-10 kg/ha/week
9. Supply of feed (kg/ha/year)	–	–	–	–	3 000	–	–	–
10. Labour (man-days/ha/year)	99	69	40	110	150	82	82	
OUTPUT								
1. Brackish-water shrimp (kg/ha/year)	210	215	56	1 000	2 000	500	500	250
2. Fresh-water shrimp (kg/ha/year)	12	39	–	–	–	–	–	–
3. Fin fish (kg/ha/year)	84	44	135	–	–	–	–	–

Source: ESCAP (n.d.).

Aquaculture and agriculture development has led to the reclamation of mangroves with adverse effects upon the aquatic production of estuarine, coastal and off-shore waters (Khan and Sanwar, 1989). The rapid expansion of the farming areas coupled with the selective shrimp monoculture has resulted in a tremendous demand for tiger shrimp post-larvae. Rough estimates suggest that in 1986 over 3 billion wild post-larvae of P. monodon were collected, of which about 40% died owing to improper handling and inadequate transport (Bashirullah et al, 1989). It is expected that the demand for seed will increase due to uncontrolled collection of post-larvae in the estuaries and heavy trawler fishing on the adult population. At the moment, only one private farmer is planning to establish the first hatchery for P. monodon in the country.

agriculture

As already indicated, aquaculture is often the first step towards the reclamation of land for rice cultivation. Successive washings for several years remove the salt and the bheries become fit for paddy cultivation. Almost 50% of the area reclaimed for aquaculture is used in the bheri system as outlined above (Bashirullah et al, 1989).

Rice yields vary between 0,7 and 2,8 ton/ha. Many rice fields are subject to salinization in the dry season or can only be irrigated with fresh water due to early saltwater intrusion. In many places, coastal embankment projects have blocked former tidal creeks in order to lengthen the availability of fresh water. Potential acid sulphate soils constitute a problem only in some places.

The aforementioned activities have led to the clearing of substantial areas of mangroves for the purpose of agriculture and aquaculture development. After subsidence due to drying out, these areas become situated below mean tide level. Because of the large tidal range and the cyclonic tidal surges, catastrophic flooding and heavy loss of life regularly occur in the area. It is believed that at least 1.300-1.500 km^2 of West Bengal mangrove forest (Indian Sundarbans) have been reclaimed in the last 100 years (Saenger et al, 1983). The coastal embankment projects have removed more than 2,1 million hectares of floodlands from fishery production (Siddique, 1986 in ESCAP, n.d.), to which losses due to cross-dam construction should be added. Furthermore, high-input agriculture induces risks of contamination of freshwater bodies by chemical fertilizers and pesticides. High mortalities of fish, turtles and aquatic mammals resulting from these environmental impacts have been reported.

5 INTEGRATING CONSERVATION AND DEVELOPMENT

introduction

As described in the preceding chapter, the Sundarbans support not only hundreds of thousands of people but also large populations of highly endangered wildlife species. Demographic pressure is increasing, thereby demanding higher levels of production, while there are indications that forestry and fisheries activities already exceed levels of sustainable production. The Sundarbans are adversely affected by upstream water diversion, pollution and reclamation and may be exposed to additional environmental stress from global climatic change in the future. This chapter will briefly discuss a few aspects related to the integration of conservation and development.

the need for integrated watershed management

Integrated river basin management and coastal zoning of activities are necessary for several reasons:

- river and coastal systems are functionally related; the coast is influenced by upstream activities, notably dams and water diversion that affect seasonal shifts in salinity, sediment budgets and therefore mangrove productivity and the stability of the coast; the coast itself and foremost the mangroves attenuate storm surges and tides and influence flood dynamics in the coastal floodplain;
- many activities take place that will influence the functioning of both systems; the flood protection measures pleaded for since the last 1988 floods will greatly alter ecological conditions in the estuary, and so have and will all other reclamation activities on the coast, some of which are incompatible with mangrove-related activities;
- the expected sea level rise will require additional measures and activities in a large area that will be affected by increased flooding, salt intrusion and impeded drainage.

the influence of upstream water diversion upon the mangroves

A long term ecological change is taking place in the Sundarbans due to the eastward migration of the Ganges, the loss of some distributories, and water diversion and withdrawal for irrigation. Up to 40% of the dry season flow of the Ganges has been diverted upstream, following the completion of the Farakka barrage in India in 1974. Decreased freshwater flushing of the Sundarbans results in increased saline intrusion, particularly in the dry season. Salt water has progressed inland from 170 miles normally to 270 miles now (FEC, 1989).

The increase in salinity and the intrusion of saline water affect soil and plant nutrients. Concern has been expressed about recent indications of apparent deterioration in the flora, including the die-back of Heretiera fomes or sund'ri, the most desirable and robust mangrove species, prized for its quality timber and its excellent fuelwood. With the increasing salinity of the ecosystem, the sund'ri species is replaced by the more salt-tolerant but less valuable "newsprint tree" gewa or Excoecaria agallocha. An estimated 50 million cubic feet of valuable sund'ri wood was lost as a result of top-dying since 1976 (FEC 1989) which is most likely to be associated with the decrease in freshwater flow, either as a direct effect of increasing salinity or other associated edaphic changes. Recent inventories show that approximately 17% of Heretiera fomes stems are moderately to severely affected by top-dying.

While an ODA inventory in 1983-84 surmised that the reduced stocking of sund'ri was caused in part by petty tree poaching or possibly by larger scale corrupt practices (so that the actual timber volume annually extracted exceeded the authorized and recorded cut), the report concluded that to a degree as yet unascertained, the decline of the sund'ri forest was "almost certainly caused by a major recent alteration of the regional hydrological regime" (Blower in Potkin, 1988).

While deterioration of the vegetation is already well documented and further studies are being carried on this subject, no attention has yet been given to the possible effects these changes might have on the fauna (IUCN, 1987).

Safeguarding the productivity of the Sundarbans ecosystem necessitates the preservation of its freshwater and sediment source. In principle, rehabilitation may, to some extent, be possible but it requires freshwater and therefore international action since the Farrakka scheme as well as most of the river basin lies outside Bangladesh, in India and Nepal. A study to determine the feasibility of ecological restoration of the Sundarbans would have to provide the following outputs (Potkin, 1988):

1) an explicit statement of the quantifiable and non-quantifiable benefits of a minimally degraded southwest Ganges estuary and of the cost of a no-action alternative;
2) a credible estimate—spatial, temporal and volumetric—of the conservation flows required to maintain these benefits and,
3) a descriptive ranking of each of the present proposals for reallocating existing freshwater supplies or for low flow augmentation through storage, inter-basin transfer and groundwater extraction as a possible supplier of necessary inflow.

flood protection works and mangroves

For many years, flood-control plans have been drafted and partly implemented. The recent, catastrophic flooding has triggered the development of more plans of the same kind. Basically, envisaged flood protection works consist in raising dikes along major rivers and around vulnerable areas such as settlements and cities, but also controlling floods (pers. com. Atiq Rahman). Most of these measures will have a profound impact upon flood dynamics. In general, they will lead to the obstruction of floodwaters because they narrow the floodway and therefore create higher water levels upstream. Downstream too, higher water levels and more profound flooding have to be feared as less floodwater can be stored. Studies or hydrological models confirming or predicting the effects of flood control measures are lacking. These may have to include:

1) a detailed analysis of the flood dynamics in relation to local rainfall, river discharge and tidal action;
2) the development of a flood dynamic model with which effects can be predicted.

optimising mangrove related production

coastal afforestation

The Government of Bangladesh has undertaken a large-scale planting programme in order to protect the coast from storms and reclaim accreted land. In 1976, the management of about 497.750 hectares of land in newly formed chars, in estuaries and at the confluence of rivers in the Districts of Chittagong, Noakhali, Barisal and Patuakhali, was given by the Ministry of Land Administration and Land Reform to the Forestry Department. The forest areas would be released for agricultural settlement after 20 years instead of 10 years as agreed earlier. In 1985, 75.000 ha of land had been planted, while for the next 5 years another 40.500 ha are required. Coastal afforestation projects had already been undertaken by the Bangladesh Forest Department before 1976. Between 1966 and 1973, within the framework of this programme, shelter-belt plantations had been raised with Acacia spp, Phoneir spp, Nypa fructicans, and Sonneratia apetala in several coastal districts.

The objectives of coastal afforestation are (ESCAP n.d.):

a. to accelerate the process of siltation and the stabilization of the soil.
b. to create forest shelter-belts to protect life and property in land from tidal bores
c. to create an urgently needed resource to add to the national wealth
d. to create job opportunities for the rural communities
e. to create an environment for wildlife, fishes and other estuarine and marine fauna.

Indeed, numerous publications have stated that the people living behind the Sundarbans mangrove belt have suffered much less from cyclones than those in the coastal areas more to the East, where hardly any mangroves occur.

Man-made mangrove plantations are raised by transplanting naked-rooted seedlings raised in nurseries and seedlings raised in polybags, by direct sowing of pre-germinated seeds etc. The principal species planted is Sonneratia apetala, with Avicennia officinalis, A. alba and A. tomentosa limited to areas of high salinity (FEC 1989). The World Bank Coastal Afforestation Programme involves only mangroves. The main objective of coastal afforestation carried out by the World Bank is to provide firewood and, to a lesser extent, construction wood.

These plantations are to be established only in areas in which accretion has almost come to a standstill. As soon as the mangroves have reached their mature size, they are planned for clear-felling and the plantation land is converted into agricultural land. A maximum of 20 years has been set for any forested coastal area. After the clear-felling, the wood is sold by the Forestry Department, mainly to paper mills and brick factories.

sustainable exploitation

At the moment, the rate of extraction exceeds sustainable levels. This is partly due to illegal exploitation but also to improper management implemented in the absence of increment and regrowth studies and upset by poor regeneration that partly results from upstream water diversion.

At present, the Forest Department lacks the means for adequate law enforcement. Nevertheless, the level of royalties might be doubled, thereby creating more funds for the Forest Department. More co-ordination may also be needed between customs, police and forest department officers.

The Sundarbans forest is to be managed under a system where the existing forest cover is not removed drastically. At the same time, the process of ecological succession has to be stopped when the sub-climax stage is reached so that the reproduction of the economically important wood-production stage is ensured.

Clear-cutting and replanting of the forest with "genwa" (Excoecaria agallocha) — which is the raw material for the

paper industry — is hazardous as removing the forest cover in areas not subject to daily inundation may bring too much salt to the surface and result in increased physiological stress, retarded growth and hampered natural regeneration.

This factor also has consequences on the utilization of some of these tidal areas for agricultural purposes, as premature colonization of these lands for agriculture may disturb the delicate salt-water relationship and induce greater upward salt movement, thereby making the land unfit for tree growth. More data on the increment of mangroves are needed for the elaboration of proper management plans.

With respect to fisheries, the first signs of overexploitation have already been observed. One main factor is the uncontrolled collection of shrimp fry, half of which is lost due to improper handling. A survey of important spawning and breeding areas is necessary for the establishment of fish preservation zones.

optimising reclaimed benefits

The production of and benefits accrued from most of the existing agricultural lands and ponds can be greatly improved by higher inputs, combinations and improved water management. Current rice yields seldom exceed 2 tons/ha and can be substantially increased through better water management and the use of fertilizers. The combination of different dry season and rain season cultures may even be more beneficial. Most of the land is owned by big landowners, especially in the newly reclaimed polders as smallholders only have a limited access to credit facilities.

integrating nature conservation

nature reserves

The problem of animals invading areas where they do not belong has increasingly been observed. These animals threaten the survival of forest animals through competition for food or competitive exclusion in a number of forms. This is a new development. In the past, animals living in the forest were buffered by a broad transitional belt of habitats. These have been destroyed by man in the process of reclamation. During this process, a considerable segment of the fauna of the Basin has been lost, including the more spectacular forms - the Javan Rhinoceros (Rhinoceros sondaicus), wild water buffalo (Bubalus bubalis), swamp deer (Cervus duvauceli), Hog deer (Axia porcinus) and gaur (Bibos gaurus). Additional buffer areas may be needed; some have already been proposed.

Managing and harvesting the resources of the Bangladesh Sundarbans in a manner allowing the maintenance of wildlife in the area would require:

- avoiding disturbance of inter-specific and intra-specific relationships (crocodile-fisheries, monkeys-deer, tiger-deer and boars);
- avoiding the fragmentation of habitats;
- maintaining habitat quality (Seidensticker and Hai, 1983).

Chaffey et al (1985) have already indicated the need for and the possible location of new wildlife reserves. The designation of new conservation areas should not unnecessarily hinder sustainable forms of exploitation; possibilities of creating job opportunities and generating incomes through the management of protected areas should not be left unexplored. The maintenance of large trees (Sonneratia apetala) in areas suitable for eagles is essential as the height of these trees is crucial for the nesting of this endangered bird (ICBP, 1985).

wildlife utilization and controlled hunting

Hunting licences are to be issued by the Bangladesh Government, but in practice none is issued, and the Sundarbans is thus officially closed to legal hunting. Under the provision of the 1973 Wildlife Preservation Act, various activities are prohibited within the wildlife sanctuaries, including (inter alia) residence, cultivation of land, damage to vegetation, hunting, introduction of domestic animals and setting of fires. However, any of these interdictions may be relaxed for scientific purposes, aesthetic enjoyment or scenery 'improvement' (IUCN, 1987b).

In practice however, several species have become extinct and many more endangered due to illegal hunting and cropping. Law enforcement is evidently insufficient and proper enforcement in an area of more than 4.000 km^2 close to the Indian border may involve high costs, many men, unbeatable logistics and co-ordinated action with local customs.

An alternative way may be to reduce pressure on poached and endangered species. Some of the endangered animals may be suitable for raising, e.g. the estuarine crocodile which is at present under high hunting pressure, and marine and freshwater turtles. The Spotted Deer and wild boars may also offer opportunities.

The Sundarbans has been notorious for its man-eating tigers since the 17th century. Since much of the killing occurs in the more saline south and west parts of the Sundarbans, a possible relation with the salinity factor is assumed by some researchers (Hendrichs 1975 in IUCN 1987b). However, other evidence suggests that the frequency of man-tiger interactions is mainly determined by the availability of easy preys, i.e. human beings. The incidence of man-killing has decreased as an average of 15,5 persons have been killed each year between 1980 and 1983 (Blower, 1985).

tourism

The area has no potential for mass tourism but it does offer obvious possibilities for limited special-interest tourism from October to April or May. The use of launches equipped with catering and sleeping facilities is considered more practicable than permanent land-based facilities and would provide greater flexibility. There is, however, a large well-equipped rest house belonging to the Port Authority at Hiron Point, and a smaller one belonging to the Forest Department at Katka in the Sundarbans East Wildlife Sanctuary (Blower, 1985).

the need for environmental zoning

Adverse and non-compatible activities must be segregated in such a way that all can be optimally carried out. Decisions on nature reserves, coastal protection zones and the delineation between mangrove forests and reclamation must be decided upon at the regional level. Different zones will be allocated to different activities and involve different regulations. The success of zoning will therefore also depends upon its proper enforcement.

reclamation and effects on mangroves

Conversion of the mangroves for aquaculture and agriculture is in several ways in direct conflict with the objectives of conservation and sustainable utilization of the mangrove ecosystem as it eliminates coastal protection, renewable timber and fuelwood resources, and the biological diversity and richness of the area. Furthermore, it causes major changes in drainage conditions, tidal inundation frequency and nutrient availability; it results in the formation of highly pyritic soils and inhibits the efficiency of phosphate fertilizers which leads to the inadequate growth of algae on which fish ponds depend for their high yields. Eventually, this causes high acidity and high aluminium concentrations resulting in the killing of fish or, in less severe cases, their increased vulnerability to parasites or diseases. During rains, the sudden influx of these toxins from the sides of the dikes creates concentrations that are lethal to a large proportion of the remaining fish. Finally, divided ferric hydroxide subsequently appears in the pond water and clogs the gills of the survivors, killing some and weakening others. Prawns grown in aquaculture ponds appear to be even more vulnerable to the toxins of acid sulphate soils.

Rabanal (1984, cited in Bashirullah et al, 1989) suggested the creation of buffer strips that would be 100 meters wide along the coast and along the banks of the principal waterways, and 30-50 meters wide along secondary tributaries.

6 CONCLUSION AND RECOMMENDATIONS

Population density is high and growing at about 2% per year. While Bangladesh does not have the industry that could provide employment to these generations, economic necessity is forcing millions to work and live on a seasonal basis in the low lying coastal areas despite the risk of natural calamities and the lack of minimal living conditions (Bashirullah et al, 1989). The entire coastal zone is subject to violent storms and tropical cyclones during the pre-monsoon (March-April) and post-monsoon (October-November) seasons. Cyclones are often associated with huge tidal waves causing enormous loss of human lives and extensive damage to property and agricultural crops. Nevertheless, the coastal zone of Bangladesh and the Sundarbans will continue to play an important role in the livelihood of many people.

For centuries the Sundarbans have been intensively exploited and thousands of people are engaged in forestry, collection of forest products, and fisheries. At the same time, the Sundarbans harbour large numbers of endangered bird and mammal species. The Sundarbans have been adequately managed but first indications of over-exploitation can be noted while there is an increasing conflict between conservation and economic activities. Furthermore, the integrity of the system has been affected by upstream water diversion, notably the Farakka scheme, and may now be threatened by the consequences of global climatic change, especially the potential sea level rise and the increased frequency and intensity of tropical storms. The productivity of activities in existing reclaimed areas might be improved, open water aquaculture may be stimulated and wildlife utilization schemes and rehabilitation of the Sundarbans may be introduced.

Coastal zone management and river basin management are needed to address the aforementioned conflicts and potentials for development. At the moment, flood-protection and reclamation is undertaken without knowing their potential environmental effects. Management plans should however be based on a complete understanding of the functioning of the Sundarbans. Generally speaking, it can be said that the ecology of the Sundarbans has been studied only casually. Hence, it is difficult to estimate the effects of immediate environmental changes in terms of how the flora and fauna may be affected. Several combined studies will be needed in order to thoroughly assess the effects of activities and implement a proper environmental zoning possible:

- development of a hydrological and geomorphological model of the delta that will include river and tidal dynamics;
- inventories of breeding and foraging areas of all relevant species, and essential mangrove resources; propositions for their protection and management;
- studies on the population dynamics of (potentially commercially important) animal and mangrove species and their management.

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CONCLUSIONS OF THE CONFERENCE 'THE PEOPLE'S ROLE IN WETLAND MANAGEMENT', LEIDEN 5-8 JUNE 1989

In this section the conclusions of the conference will be outlined, based on the workshops and the general discussions. These conclusions are mainly substantiated by experience in Third World countries, but most of them will apply to developed countries as well.

A. GENERAL

Wetlands are ecosystems of great value. They often play a pivotal role in regional economies, and they may be even more important if their functions are considered on a larger scale, ranging from water and element recycling to the sustaining of natural processes and gene pools for the benefit of future generations. Moreover, many wetlands are key habitats for ensuring the survival of birds and other species that have a right to exist on this earth independent of their instrumental value.

The wise use of wetlands implies the safeguarding and enhancement of these functions on a sustainable basis, thereby safeguarding the continuation of their more vulnerable elements and guaranteeing their unique qualities.

Local people in and around wetlands may be a threat to the wise use of these areas and national policies may not serve their best interests. However, local people can form a powerful force in the safeguarding of wetland values. Consequently, wetland management strategies within or outside the RAMSAR framework should pay due attention to enhancing local people's willingness and improving their capacity to contribute to wise wetland use, both for themselves and for the whole of society, for the good of future generations and for the promotion of nature as an intrinsic value.

Wetland policies and programmes that build on the capacities of the local people are as yet sparse. There is therefore a great need for more adequately documented case-studies, dealing with both the successes and the failures. Experience gained so far, combined with experience in other participatory programmes, show that success in this field does not only depend on education and information, but also on matters like the legal setting, the regional planning process, economic considerations and programme organization. The conference 'The People's Role in Wetland Management' has enabled the following conclusions with regard to these matters.

B. LEGAL CONSIDERATIONS

1. Security of rights is a major condition for the wise use of wetlands by local communities. In many countries present legislation does not provide incentives for local people to participate in conservation measures, as they are not given any assurance of their sharing in the long term benefits of their investments. Through innovative legislation and a process of decentralization of management responsibilities, governments should enhance the likelihood of secure rights for local users within the framework of wise use and conservation plans. Donor agencies can play a stimulating role in this too.

2. In participatory management there is also a strong need for a sound legal framework which sets the conditions under which a management programme will function and which makes allowances for the possible use of coercive measures (e.g. for the purposes of nature conservation). The likelihood of this type of framework meeting with approval will be greatly increased through:
   - a decentralization of responsibilities (where possible);
   - the accruing of local benefits where possible;
   - sound procedures which guarantee equality of the different interests before the law;
   - adequate information.

3. In view of the necessity of a sound legal base for the wise use of wetlands, it is essential that there be a sound accordance between statutory law and customary law if the success of a management programme is to be guaranteed.

4. Preferably, wise use should be based on legal agreements at a local level between local people, their organizations and the authorities. These agreements should regulate projected activities bearing in mind on the one side the socio-economic aims of the local people and the conditions required for their sustainability, and nature conservation aims on the other.

C. PLANNING CONSIDERATIONS

5. Sound wetland planning necessitates the identification of both the conservation and the socio-economic aims and potentials. The planning process should recognise people's priorities and potential, thereby differentiating between different forms of utilization. In a single wetland there may well be a number of types of wise use. Furthermore the differential role of men and women should be recognized with a view to enhancing their mutual socio-economic opportunities.

6. Environmental zoning of a wetland area in one form (multiple use areas, nature core areas) or another (preservation, utilization and reclamation zones) may be necessary or advisable in order to reconcile the different forms of use and conservation. This zoning should not be structured in a standard way but should be dealt with in a specific way for different ecological and economic conditions.

7. Participatory planning includes the involvement of local people and organizations in all phases of a planning process, starting from a shared analysis of the problems up to the implementation of management measures.

8. Enhancing participation is a long-term process, therefore it would be preferable to replace projects by long-term programmes. The present situation is that projects are often overfunded in the short term, whereas in the long term there is a great need for more continuity.

9. The fact that both the ecological and socio-economic reality is complex and subject to change means that the programmes should not contain fixed blueprints, but consist of strategic aims and flexible operational principles. The process should include learning by doing and the method is just as important as the content of the programme. The planning guidelines in a programme should not be too specific, because that may hamper participation at a local level.

D. ECONOMIC CONSIDERATIONS

10 The economic returns on conversions of wetlands are often overestimated, due to the underestimation of costs, mismanagement and the resulting loss of existing values, and to the initial overestimation of the economic benefits. In addition, after implementation, large interventions may give rise to critical conflicts of interests which can only be resolved at a great cost.

11 Local communities should be involved in socio-economic analysis for wetland management. In this manner the local (potential) economic wetland values can be fully taken into account, thus widening the scope of products, including high grade products like medicaments, tannins and the like.

12 Financial support from external agencies may produce an undesired effect running contrary to the initial aims. It is of prime importance that the motivation of people participating in management is founded on the benefits (for themselves) brought about by a better environment and not on the money the agency provides. Income generation, not gifts should be the economic core.

13 Indigenous practices and resource uses should be regarded as potential elements to be adopted in wetland management programmes. These practices can be of great value due to the empirical knowledge contained in them, their adapted technologies which may be put to good use and their regulation mechanisms which may be adopted. Although traditional uses may not be sustainable, they are community-based activities and hence starting points in enhancing people's participation in wetland management.

E. ORGANIZATIONAL CONSIDERATIONS

14 In participatory wetland management it should be recognized that the costs and benefits of wetland use concern not only the people living in the wetland itself, but the entire population dependent on the wetland and on whom the wetland depends. Governments and aid agencies have a specific responsibility to initiate an open dialogue with the different groups in question.

15 In the management process an awareness of potential conflicts between conservation and utilization aims and between different types of utilization aims is essential, and should be acknowledged by the use of sound procedures. The allocation of responsibilities to the parties involved should reflect the arena of perceptions and interests, including possible off-site functions and interests which are not directly linked to local user groups (e.g. coastal protection, nature conservation). In the case of huge gaps in values an independent strong party is indispensable to act as a mediator in the process.

16 It may be important to make a distinction between local users of a wetland, who directly depend on the resources, and outside users who are basically independent thereof (logging companies, cattle breeding companies). Although the first type of users may cause overexploitation, they may at the same time constitute a basis for protection and wise use. The second type is intrinsically more threatening to the integrity of a wetland. In such a situation an organization made up of the local group of users may be essential in order to counterbalance destructive influences from the outside users' group.

17 This type of organization may include coalitions with outside users, in as far as the latter take explicit responsibility for the conservation of the integrity of the wetland (e.g. fishing companies, hunting companies, tourist organizations etc.). The latter may even take the initiative for conservation and wise use.

18 An important instrument for solving conflicts can be found in agreements between the interest groups at a local level. Local communities may have an active role in enforcing the agreements, provided that the local people have an interest in this. This role can also prevent people from outside taking the lion's share of the resources preserved by local people; it is better to have a social fence than an iron fence.

19 A management authority at a local level should have a central place in the organization. Preferably, the authority may be closely linked to the traditional local organization. At the same time it is essential that the authority has a close relationship with higher levels of administration as well.

20 Non-Governmental Organizations (NGO's) can play a powerful role in enhancing people's participation in wetland management. Their position, being independent of governments, may create the momentum to enhance negotiation and debate. They may also help to create more direct links between donor agencies and the local management authorities, thus helping to fulfil the responsibilities of the programme. On the other hand, NGO's can make use of opportunities that may be created by Governmental Organizations for participation in decision-taking and hence be active participants within the management process.

F. INFORMATION, EDUCATION AND RESEARCH CONSIDERATIONS

21 An essential tool for enhancing participatory management is education. Education is important at two levels: at a local level, linked to a specific programme, and at a level of the project-manager or those responsible for policy decisions regarding development programmes.

22 Education at a local level should be as specific as possible, thus differentiating between target groups (farmers, fishermen, hunters, officials, commercial enterprises) and should be directly linked to both income generating activities and to management aims. In the education programme, information should be included about indigenous practices, beliefs and taboos, because of their potential value for wise use.

23 High quality ecological, social, technical and medical expertise on wetlands is an essential precondition if participatory wetland management is to be effective. In this respect, there is a specific need for in depth problem oriented research aimed at:

- the existing survival strategies and resource use in wetlands;
- the people's perceptions of natural resources;
- the evaluation of sustainable economic values of wetlands and of the impacts of interventions in wetlands;
- the evaluation of participative management approaches and the distinctive role of women and men therein;
- the generalization, design and testing in the field of these results and methodologies.

In connection with this, specific methods for cost-benefit analysis for wetland interventions should be developed, that include non-marketable, non tangible and off-site functions.

24 It is imperative for all parties involved in wetland management that may be (positively or adversely) affected by developments to know the facts. In all management phases, there is a need for open access to information in order to enable all participants to correctly align their positions in the debate. In relation to this, monitoring of the effectivity of wetland management with respect to the different functions is crucial and should be an integrated part of the management process. This will include censuses on wildlife and other resources, and indicators of the social results (income, organization, medical and welfare aspects).

25 It is of great importance for wetland management institutes and authorities to review the cases presented and the outcomes of the discussions of this conference in relation to their own programmes. This may also have the effect of enhancing the awareness and involvement of communities and action groups in the realization of wise use through more institutionalized influence.

G. RAMSAR CONVENTION

26 The RAMSAR Convention and its Contracting Parties should give leadership in wetland conservation at a global level, in partnership with other participating organizations and the people involved. Therefore all countries should join the convention. The convention should pay special attention to the "wise use" and the "international cooperation" obligations, whilst in addition public involvement should be added as one of the primary requirements.

27 As to the wise use-obligation the importance is stressed of:

- the need to coordinate wetland policies between different authorities in one country, taking into account the views of local people;
- the need to relate indigenous uses (not all of which are positive) to the wise use concept;
- the potentially damaging effect on wetlands caused by a high density of human populations and concomitant intensive use, whether in developed countries (reclamation, recreation), or in developing countries (overexploitation); there is hence a need for zoning of activities;
- the importance of small wetlands as representatives of unique ecological types, used as breeding or stopover sites for migratory birds;
- the exploitation of wetland productivity at a community level.

28 As to the international cooperation-obligation the importance is stressed of:

- the need to promote North/South collaboration particularly with respect to the Northern agencies' funding wetland projects in countries with limited resources;
- the possibility of re-establishing geopolitical contacts with countries following political rupture or isolation;
- the need to strengthen national and international wetland networks and linkages of both North/South and South/South character, to foster more effective scientific knowledge of wetland functions and management techniques.

CRITERIA FOR IDENTIFYING WETLANDS OF INTERNATIONAL IMPORTANCE FOR DESIGNATION FOR THE LIST UNDER ARTICLE 2 OF THE RAMSAR CONVENTION

as revised at the Third Meeting of the Conference of the Contracting Parties in Regina

A wetland is suitable for inclusion in the List if it meets any one of the criteria set out below:

1. Criteria for assessing the value of representative or unique wetlands.

   A wetland should be considered internationally important if it is a particularly good example of a specific type of wetland characteristic of its region.

2. General criteria for using plants or animals to identify wetlands of importance.

   A wetland should be considered internationally important if

   a. it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species;

or b. it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna;

or c. it is of special value as the habitat of plants or animals at a critical stage of their biological cycles;

or d. it is of special value for its endemic plant or animal species or communities.

3. Specific criteria for using waterfowl to identify wetlands of importance

   A wetland should be considered internationally important if

   a. it regularly supports 20.000 waterfowl;

or b. it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity;

or c. where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

Guidelines

A wetland could be considered for selection under Criterion 1 if:

   a. it is an example of a type rare or unusual in the appropriate biogeographical region;

or b. it is a particularly good representative example of a wetland characteristic of the appropriate region;

or c. it is a particularly good representative of a common type where the site also qualifies for consideration under criteria 2a, 2b or 2c;

or d. it is representative of a type by virtue of being part of a complex of high quality wetland habitats. A wetland of national value could be considered of international importance if it has a substantial hydrological, biological or ecological role in the functioning of an international river basin or coastal system;

or e. in developing countries, it is a wetland which, because of its outstanding hydrological, biological or ecological role, is of substantial socio-economic and cultural value within the framework of sustainable use and habitat conservation.

(Source: Ramsar Convention Bureau, 1988)