Transfer of Environmentally Sound Technologies for the Sustainable Management of Mangrove Forests: An Overview[1]

Background Document for the Ad Hoc Expert Group on Finance And Transfer of Environmentally Sound Technologies

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The views expressed in the paper are of the authors and are not necessarily the view of the UNFF or its Secretariat.

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Preface

This paper was submitted as a working document to the "Government-designated Expert Meeting on the Transfer of Environmentally-sound Technologies for the Sustainable Management of Mangrove Ecosystems in Latin America and the Wider Caribbean", held in Managua, Nicaragua, 3-5 March 2003, as part of an initiative lead by the Government of Nicaragua. The present version of the document incorporates the inputs and recommendations of that meeting. It was co-sponsored by ITTO, FAO, the UNFF Secretariat, the Secretariat of the Ramsar Convention on Wetlands, the Caribbean Environment Programme (CEP) and COCATRAM, with the participation of the World Bank, UNEP, the Central American Bank for Economic Integration, USAID and JICA. Government-designated experts participated from Colombia, Costa Rica, Cuba, Chile, the Dominican Republic, El Salvador, Honduras, Nicaragua, Surinam and Venezuela. Overall, the meeting was attended by 40 experts on mangrove forests. In addition to reviewing this paper, the meeting developed framework regional strategies for the sustainable management of mangrove forests for the Eastern Pacific and the Wider Caribbean. The full report of the Managua meeting (E/CN.18/2003/11) is available on the UNFF website under documents for UNFF 3 (http://www.un.org/esa/forests/documents-unff.html#3).

"*Technology cooperation involves joint efforts by enterprises and Governments, both suppliers of technologies and its recipients. Therefore, such cooperation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from the transfer of technology*." (Agenda 21)

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ABSTRACT

This document provides an overview of the status of forest-related environmentally sound technologies relevant to mangrove forests. It identifies main barriers to technology transfer, discusses enabling conditions for their successful and sustainable transfer, and assesses approaches for improving the transfer of environmentally sound technologies to and among developing countries for the sustainable management and utilization of mangrove forests. Most sections of this overview are geared towards facilitating implementation of the Intergovernmental Panel on Forests/Intergovernmental Forum on Forests proposals for action (which constitute the backbone of the Plan of Action of the United Nations Forum on Forests) relevant to international cooperation in capacity building, and access to and transfer of environmentally sound technologies relevant to mangrove forests. The document also briefly reviews the status of mangrove forests worldwide, with emphasis in Latin America and the Wider Caribbean, and considers the socioeconomic factors affecting the sustainability of these important – and grossly undervalued – forest ecosystems. Major and up-to-date sources of information are provided for the various topics discussed.

I. INTRODUCTION

Background

1. In Chapter 34 of Agenda 21 the international community recognized that the availability of scientific and technological information and the access by developing countries to, and transfer of, environmentally sound technologies (ESTs) are essential for achieving sustainable development. Ten years later, in 2002, the gap between developed and developing countries and the need for a dynamic and enabling international economic environment supportive of international cooperation, particularly in the area of, *inter alia*, technology transfer, were further underlined in the Plan of Implementation agreed at the Johannesburg World Summit on Sustainable Development[2]. Technology transfer is a cross-cutting issue and it is inseparable from capacity building: they have become "buzzwords" omnipresent in environmentally related conventions, agreements, programmes, plans, fora, project proposals, etc. Indeed, the efficiency and sustainability of the transfer of technology to developing countries rely on building the appropriate human and institutional capacities. In turn, technology transfer and capacity building depend on international cooperation and the provision of appropriate financial assistance. Over the last years, most efforts have focused not on developing new ESTs but rather on promoting access to them; however, the lack of assessment tools to identify technologies which are "environmentally sound" has hampered the efforts of many governments in developing countries to design and adopt environmental policies aimed at promoting the transfer of ESTs[3].

2. In this paper, the definitions of technology and environmentally sound technologies adhere to those given in Chapter 34 of Agenda 21. Technology is considered to cover the physical, human and organizational capacities, and also includes hardware, software, knowledge and approaches. Environmentally sound technologies (ESTs) encompass technologies that have the potential for significantly improved environmental performance relative to other technologies. ESTs are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment, as well as organizational and managerial procedures,

3. Improved technological capabilities are critical for the sustainable utilization of all types of forests. The acquisition of such capabilities in developing countries originates from either technology developed locally or from transfer of technology from elsewhere. However, it is widely recognized that local development of technology through national institutions has been significantly hampered by the lack of financial and human resources; thus, the transfer of technology acquires much more importance[4]. In spite of this, not much follow-up action has been taken over the last decade to follow-up on what was agreed at the 1992 United Nations Conference on Environment and Development with regard to the increase of technology transfer to developing countries, and countries with economies in transition, for sustainable forest management[5]. A renewed call for international cooperation on technology transfer was made at the 2002 World Summit on Sustainable Development[6].

4. In October 2000, the United Nations Economic and Social Council (ECOSOC) established the United Nations Forum on Forests (UNFF) with the main objective of promoting the management, conservation and sustainable development of all types of forests and to strengthen long-term political commitment[7]. As a means of achieving this end, the Forum was also mandated to take steps to devise approaches towards appropriate financial resources and technology transfer. At its first session (UNFF 1) in June 2001, the Forum stressed the fact that one of its main functions was to facilitate and promote the implementation of the Intergovernmental Panel on Forests (IPF)/Intergovernmental Forum on Forests (IFF) proposals for action and that their implementation will be a key basis for reviewing progress. With this in mind, the Forum adopted the Plan of Action of the UNFF[8], which includes 16 elements for the implementation of the IPF/IFF proposals for action. One of these elements focuses on the "international cooperation in capacity building, and access to and transfer of environmentally sound technologies." The members of the Collaborative Partnership on Forests (CPF), a new international partnership on forests established by ECOSOC in 2001 to support the work of the UNFF, were invited to contribute actively to the implementation of the IPF/IFF proposals for action, including through their technical and financial resources[9]. In fact, one of the main functions of the CPF is to facilitate and promote the implementation of those proposals for action. It was further agreed that in identifying the criteria for assessing/reviewing the effectiveness of the Forum, various actions should be taken into consideration, including addressing the means of implementation, finance, transfer of ESTs and capacity-building in developing countries.

5. To support the work of the Forum, UNFF 3 agreed to establish an *ad hoc* expert group on finance and transfer of ESTs. Regarding the transfer of environmentally sound technologies for sustainable forest management, it was asked to perform the following tasks:

> *(a)* *Review and assess existing initiatives on the transfer of environmentally sound technologies and knowledge diffusion for the promotion of sustainable forest management among countries and sectors and stakeholders, including through North-South, North-North and South-South cooperation and programmes of Collaborative Partnership on Forests members. This should include an analysis of incentives that promote and obstacles that inhibit the transfer of forest-related environmentally sound technologies between and/or within countries, in particular to developing countries and countries with economies in transition, in both the public and private sectors;*
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> *(b)* *Recommend approaches to improve transfer of forest-related environmentally sound technologies. The recommendations may include the role of various policy instruments, such as concessional and preferential terms, public-private partnerships and research cooperation, as well as capacity-building in the use and application of current and emerging environmentally sound technologies, including remote sensing.*

6. When further considering the issue of the *ad hoc* experts groups at its first meeting in May 2002, the UNFF 3 Bureau was of the view that country-led initiatives may facilitate clarification of the issues to be considered by the expert groups, as well as provide opportunities for informal consultations among countries[10]. On the basis of this and to facilitate the work of the expert group on transfer of ESTs, once it is established, the organization of a possible Government-led initiative for a global Expert Workshop on Transfer of Sustainable Forests Management Technologies is being explored by the UNFF Secretariat in consultation with the CPF members and countries.

7. In September 2002, the Government of Nicaragua expressed to the UNFF Secretariat its interest in leading an initiative on the transfer of ESTs for the sustainable management of mangrove ecosystems in Latin America and the Wider Caribbean. An Expert Meeting was hosted by the Government of Nicaragua as part of this initiative, which is cosponsored by the Government of Nicaragua, the UNFF, the Central American Commission of Maritime Transport (COCATRAM) as Executive Secretariat of the Convention on Cooperation for the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific (the Antigua Guatemala Convention), the International Tropical Timber Organization (ITTO), the Food and Agriculture Organisation of the United Nations (FAO), the Regional Coordinating Unit/Caribbean Environment Programme of the United Nations Environment Programme (UNEP) as Secretariat of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (the Cartagena Convention) and the Ramsar Convention on Wetlands. The World Bank and the Central American Bank on Economic Integration contributed technically to the Expert Meeting.

8. This overview was prepared as a background document for the Government-designated Expert Meeting on Transfer of Environmentally Sound Technologies for the Sustainable Management of Mangrove Ecosystems in Latin America and the Wider Caribbean, Managua, 3-5 March 2003, and provided the basis for drafting the regional strategies for the conservation and sustainable management of mangrove ecosystems in the region, which were prepared during the Nicaragua Expert Meeting (see the report of that meeting and the final report submitted by the Government of Nicaragua to the Secretary-General of the United Nations for consideration at the Third Session of the UNFF (Geneva, 26 May-6 June 2003). This present version incorporates the comments offered by the Expert Meeting, as well as information made available at the meeting, and will be submitted to the global expert meeting on transfer of environmentally-sound technologies for the sustainable management of forests being organized by the UNFF for early 2004. The main objectives of this overview are to:

(i) Review the status of mangrove ecosystems worldwide, with particular attention to Latin America and the Wider Caribbean, emphasizing the socioeconomic and technological factors affecting their sustainability;
(ii) Review the status of forest-related ESTs relevant to mangroves, including identification of barriers and recommendations on how to create enabling conditions for their successful transfer and sustainable use;
(iii) Assess approaches for improving the transfer of ESTs relevant to mangrove ecosystems; and
(iv) Identify opportunities for coordination and cooperation among regional and international partners to catalyze national and regional action to conserve and sustainably manage mangrove ecosystems.

9. In attempting the above, this document builds on all available relevant documents (e.g., reports, decisions and background papers of the IPF, IFF and UNFF processes, regional initiatives, programmes and documents) and all available published and unpublished literature. However, it must be kept in mind that the purpose of this overview is neither to provide a bulky volume on mangrove ecosystems nor on ESTs, but rather to identify and discuss the main issues of concern, key actors and provide major up-to-date sources of information

II. REVIEW OF THE IPF/IFF PROPOSALS FOR ACTION RELEVANT TO THE TRANSFER OF ENVIRONMENTALLY SOUND MANGROVE FOREST MANAGEMENT TECHNOLOGIES

10. The IPF/IFF proposals for action are the major and most concrete product of the work of the IPF (1995-1997) and its successor the IFF (1997-2000). Moreover, the Interagency Task Force on Forest (1995-2000) and its successor, the CPF, were established with the main purpose of facilitating the implementation of these proposals for action, which constitute the backbone of the work of the UNFF for the years to come. As mandated by ECOSOC resolution E/2000/35, one of the Forum's main functions is to facilitate and promote the implementation of these proposals for action by catalysing, mobilizing, generating and channelling the necessary financial, technical and scientific resources and expertise. Given that the IPF/IFF proposals for action focus on actions to be taken at the national and local level by governments and other stakeholders, the IFF and the UNFF agreed that implementation of these proposals should begin with their systematic assessment at the national level, in a process involving all concerned stakeholders so as to build consensus, clarify priorities and responsibilities, and bring new partners. In September 2002, the World Summit on Sustainable Development and its Plan of Implementation specifically called for the creation and strengthening of partnerships and international cooperation to facilitate the provision of increased financial resources, the transfer of environmentally sound technologies, trade, capacity-building, forest law enforcement and governance at all levels, and integrated land and resource management to implement sustainable forest management, including the IPF/IFF proposals for action.

11. To assist in the development of the UNFF Plan of Action, the UNFF Secretariat compiled a list of these 270 IPF/IFF proposals for action[11]. The proposals address a wide range of topics within the 16 elements comprising the UNFF Plan of Action. In addition, as result of a join effort of the government of Australia and the World Bank's Program on Forests (PROFOR), the IPF/IFF proposals for action were

summarized and consolidated to facilitate reporting on their implementation to the UNFF and to encourage greater collaboration between the UNFF and the Convention on Biological Diversity[12]. As pointed out in the latter report, these proposals for action not only greatly overlap, but their nature and content range from basic principles and guidelines to detailed specific recommendations. Thus, to be effective they need to be translated into country-specific actions that address national priorities and complement existing policy processes. This is particularly true for the proposals for action relevant to technology transfer and capacity building and information (IPF Programme Element II.B & IFF Programme Element II.C), which are clearly linked with those proposals for action dealing with international cooperation.

12. On the basis of the above-mentioned two compilations, the IPF/IFF proposals for action were screened in order to select those with direct relevance to the transfer of ESTs, capacity building and international cooperation for the sustainable management of forests, including mangroves. Table 1 is mainly the Australia/PROFOR compilation, but includes several additional proposals which were considered of relevance to the transfer of ESTs in the present document. Most sections of this overview are geared towards facilitating the implementation of these proposals for action.

Table 1. IPF/IFF proposals for action dealing with transfer of and access to environmentally sound technologies and international cooperation in capacity building in support of sustainable mangrove forest management

Main Topic	IPF	IFF
A. Technology Transfer and Capacity Building		
1. Support developing countries to expand their forest cover, increase downstream processing and community based processing of non-wood and timber forests products, including utilization of lesser used species	58c, 131b, 132c	
2. Assess, taking into account gender disaggregated data, the technological requirements necessary to achieve sustainable forest management	77b	56c, o
3. Enhance cooperation and financing to promote access to and transfer of environmentally sound technologies, including the enhancement of international cooperation and private sector investment in environmentally sound management technologies	69a, b, d, 71b, 77a,b, c, d, e, f, g	56a, e, g, h, i, l, 77d, 129e
4. Support national forest programs and capacity building to implement sustainable forest management and the IPF/IFF proposals for action, including strengthening and supporting institutions involved in forests, plantation and protected area management, forest research and supporting indigenous people, local forest dependent communities and forest owners	17g, 28a, 40f, j, m, r, 46g, 58b(vi), 70a,e, 77e, 89b, 115c	17a, 19b, 56d, 64e,i, 87,97b, 107d 143
5. Assist with the dissemination and interpretation of information on sustainable forest management to countries and stakeholders	78a, b, 94a(iii)	
6. Promote the dissemination and sharing of environmentally sound technologies to end-users, particularly in local communities, including though efficient use of extension services	77e	56f, h
7. Strengthen education and training for women in community development programs, including the growth and use of fuel wood and the use of energy efficient cooking technology and ensure women benefit from the transfer of environmentally sound technologies		56m, n
B. International Cooperation		
8. Support the forest work undertaken by international and regional organizations and under relevant international instruments and encourage them to contribute to forest policy dialogue and to support inter-agency cooperation on the implementation of the outcomes of UNCED and the IPF processes	146a, d, e	139a, b, 141a
9. Clarify the forest-related roles of international institutions and instruments to improve integration and coordination eliminate duplication of their efforts	146b, c	139c
10. Strengthen national arrangements to provide guidance to multilateral forest-related organizations		140b
11. Continue collaborative work to support the implementation of the IPF/IFF proposals for action, reporting and the provision of information to assist the forest sector	78c, 145	17e
12. Develop institutional synergies with other partners and prepare a comprehensive directory of organizations and instruments engaged in forest-related activities		141b, c

III. STATUS OF MANGROVE FORESTS AND A REVIEW OF THE SOCIECONOMIC FACTORS AFFECTING THEIR SUSTAINABILITY

A. Brief status of mangrove forests worldwide

13. Mangrove forest are restricted mainly to the tropics (between 30° S and 30° N) and extend beyond to the north in Bermuda and Japan, and to the south in Australia and New Zealand. There are two main centers of biodiversity: the eastern group, richer in species, occurs in the Indo-Pacific (Eastern Africa, South Asia and the Pacific), and the western group which is centered on the Caribbean and includes the west coast of the Americas and Africa[13]. The Food and Agriculture Organization (FAO) of the United Nations has recently established a mangrove area database, which currently contains more than 2,800 data sets (national as well as sub-national level data) with historical and recent references on the extent of mangrove areas in a total of 120 countries (Annex 1). Of these 120 countries, 18 have some 80% of the estimated 180,000 km² of world mangrove forests (Table 2). The four countries with most mangrove areas are Indonesia, Brazil, Australia and Nigeria. The major continuous strip of mangrove forests in the world, the Khulna Suderbans, lies in the west of the Brahmaputra-Meghna delta in Bangladesh, and covers an area of *ca*. 5770 km² (Bangladesh also has a further 1000 km² of planted mangroves)[14]. Presently, over 15 million ha of mangrove wetland are under protection and sustainable use as part of the Ramsar Convention on Wetlands[15] and a list of Ramsar sites containing mangroves is given in Annex 2.

Table 2. Estimates of mangrove areas (km²) from major mangrove holding countries[16]

South & Southeast Asia		Latin America		Africa		Oceania	
Indonesia	42,500	Brazil	13,800	Nigeria	10,500	Australia	11,700
India	6,700	Cuba	5,600	Madagascar	3,200	Papua NG	4,100
Malaysia	6,400	México	5,300	Guinea-Bissau	2,500		
Bangladesh	6,300	Colombia	3,700	Gabon	2,500		
Myanmar	5,200	Venezuela	2,500	Cameron	2,400		
Vietnam	2,500						
Total	69,600	Total	30,900	Total	21,100	Total	15,800

14. In other regions, although mangrove forests are not as extensive when compared to those illustrated in Table 2, they are indeed important relative to total national coast lengths (for instance, the Central American region, see Table 3). For these countries and regions, the socio-economic and environmental services (including protection against natural environmental disasters and coastal erosion) provided by mangrove forests acquire a much more important dimension.

Table 3. Estimates of mangrove forests (km²) relative to coast length (km) for Central American countries[17]

	Belize	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panamá	Total
Mangroves	115	160	1458	268	1550	410	1708	5669
Coast	250	403	844	307	923	1376	2500	6603

15. Increasing habitat destruction and ecosystem alterations either by physical, chemical or biological means constitutes the most widespread – frequently irreversible – human impact not only to mangrove forests but also to the whole coastal zone and its resources[18]. There are six main types of human activities which negatively impact on mangrove forests: (i) overexploitation by traditional users; (ii) conversion of mangrove land for agriculture and aquaculture; (iii) destruction caused by coastal development; (iv) changes in sediment flows; (v) pollution; and (vi) oil prospecting and exploitation. In addition, mangrove forest located at the periphery of metropolitan areas are being increasingly used for solid waste disposal, a very specific activity which is considered as one of the major causes of permanent destruction of mangrove forests[19]. The negative effects of all these activities have been documented in virtually all countries having major mangrove forests. A few examples are provided below.

16. Mangrove forests are directly harvested mainly for fuelwood - especially for charcoal making, in particular along the coasts of Southeast Asia, and Central and South America. Although timber production from mangrove forests continue to be minor in comparison to that from other types of forests, in a local scale it has been and remains to be important to local communities for house and boat building (mainly in South and Southeast Asia). Mangrove forests are heavily exploited for, *inter alia*, firewood (West Africa,

Latin America), fishing stakes/poles (Southeast Asia, Central America), wood chips and pulp (Bangladesh, Indonesia, Malaysia), and tannin (South and Southeast Asia, Latin America).

17. Particularly in Asia, large extensions of mangrove forests have been cleared for agriculture purposes (e.g., rice farming, coconut, oil palm). However, aquaculture expansion has played a major role in the destruction of mangrove forests all over the tropics and the conversion of mangrove areas into shrimp ponds represents one of the major threats to mangroves in many countries. An estimated 3 million ha of mangrove forests in Southeast Asia (particular in Bangladesh, the Philippines, Vietnam, Thailand, Japan and the Mekong basin) have been destroyed mainly by aquaculture-related activities[20]. It has been estimated that, to date, approximately 1-1.5 million ha of coastal lowlands worldwide (comprising mainly salt flats, mangrove areas, marshes and agricultural lands) have been converted into shrimp ponds[21]. For instance, although the decline of mangrove forests in the Philippines - from an estimated 500,000 ha in 1918 to an estimated 120,000 ha in 1994 - can be attributed to various factors (e.g., overexploitation for fuel wood and conversion to agriculture, salt beds, industry and settlements), aquaculture remains the major cause of mangrove destruction (nearly half of the 279,000 ha of mangroves lost from 1951 to 1988 were developed into culture ponds)[22]. The rapid development of the shrimp aquaculture in India (its production more than tripled from 30,000 tons of shrimp in 1990 to 102,000 tons in 1999), combined with a lack of adequate planning and regulations, brought together a series of environmental problems and social conflicts, including conversion of mangrove forests, water pollution and salinization of drinking water wells[23]. Similarly, aquaculture-related activities are cited as the major reason for the disappearance of half (some 1,800 km²) of southern Thailand's mangrove area between 1961 and 1996[24], and Malaysia lost 12% of its mangrove forests between 1980 and 1990 for this same reason[25]. The once luxuriant mangroves of the Mahakam River in Borneo (Indonesia) have lost in the last 10 years nearly half of their nipa stands due to conversion to aquaculture[26]. There are also many examples of destruction of mangrove forests at a local level, where the conservation of the mangroves were subordinated to commercial interests[27].

18. Poorly planned coastal urban and industrial development has changed and reduced areas previously covered by wetlands and mangroves all over the tropics and represent the single main threat to mangrove forest worldwide. The construction of harbours, tourism facilities, urban and industrial development, airports and power plants without proper planning and environmental impact assessment have destroyed extensive areas of mangrove forests. Also, deforestation, coastal erosion, increasing saline intrusion, nutrient depletion and sediment accretion caused by damming and diversion of rivers have a significant impact on mangrove forests and their resources[28]/[29]. Rivers are diverted for various purposes, such as preventing flooding of urban, agricultural and livestock-used lands, and for irrigation purposes. Pollution from untreated or inappropriately treated discharges of domestic and industrial wastewater, and chemicals used in agriculture not only affect mangroves but also threatens the health of coastal human populations. On the other hand, the construction and use of boardwalks (used in mangrove management since they are thought to solve problems of access by people while promoting recreational and educational opportunities) and the people using them may have negative impacts on the mangrove ecosystem[30].

19. Mangrove forests are particularly vulnerable to oils spills since floating oil settles with the tide and smothers breathing and feeder roots plus the associated resident fauna. Mangrove vulnerability is primarily based on the trees' vulnerability, since when the trees die the habitat lose its structure and protection from erosion. Oil deposited on the tree roots often result in the death of some trees but, perhaps more importantly, also results in depressed growth of survivors across the wider oiled area. The long-term effect can persist for several decades and can result in the partial collapse of the ecosystem[31]/[32].

B. Brief status of mangrove ecosystems in Latin America and the Wider Caribbean[33]

20. The most important threats to the mangrove forests of this region are land reclamation for aquaculture, agriculture and urban development, direct harvest for firewood, building material for construction of houses, tannin production and pollution from industries and from untreated or poorly treated municipal wastewater[34].

21. For instance, conversion of mangrove forests to croplands and grass lands for cattle grazing has increased in recent years in Latin America. In Cuba, the Dominican Republic and Puerto Rico the extension

of the agriculture frontier, particularly for sugar cane cultivation, occurred at the expense of mangroves. In Mexico and Central America extensive mangrove areas have been converted into grasslands for cattle, while in Ecuador they have been transformed into large coconut palm plantations. Similarly, the boom of the shrimp aquaculture of the past 30 years has had a great impact on the mangroves of this region. In many countries, most significantly in Ecuador, Honduras and Colombia, shrimp ponds have been excavated in mangroves or adjacent areas such as salinas. Since the beginning of shrimp aquaculture in Ecuador in the late 1960s, expansion of this industry eliminated at least 20% of mangrove areas and 80% of the salinas. In the early 1990s, Honduran shrimp farms covered 22,113 ha that once were largely occupied by mangroves and salinas. Shrimp farming started in Colombia in 1980 and, by 1991, 4,000 ha of mangroves forests were converted into shrimp ponds. Finally, construction of roads, urban areas, canals and dams has altered the mangrove ecosystems in essentially all countries in the region. In Puerto Rico, dredging and filling to create space for port expansion and industrial development destroyed large areas of mangroves. Activities that alter water flow, such as the construction of roads and drainage canals, have been predominant particularly in Mexico and Cuba. Tourism, industrial development and road construction have destroyed large areas of mangroves in Venezuela, Ecuador, Panama and Colombia.

22. The northern limit of mangrove forests in the eastern Pacific Ocean is near Puerto Lobos (30° 15'N) in the Gulf of California, Mexico, while the southern limit is at Punta Malpelo, Tumbes, near the Peruvian-Ecuador border (3° 40'S).[35] The mangroves of the Northeast Pacific[36] represented, in 1996, some 17% of the total Latin American mangroves, with the most extensive mangrove forests occurring along the coasts of Colombia, Panama, Costa Rica, Honduras, Guatemala[37] and Mexico. Mexico's mangrove-estuarine region of Teacapan-Agua Brava-Marismas Nacionales is the most extensive mangrove forest along the Pacific coast of Mexico and Central America[38] Only a small percentage of the mangrove areas in Northeast Pacific countries are presently protected: Colombia (22.2%), Costa Rica (1.9%), El Salvador (0%), Guatemala (16.7%), Honduras (42.2%), Nicaragua (14.8%), Mexico (not available) and Panama (2.1%). Of the 177 wetlands designated as Ramsar sites, 10 are located in the Northeast Pacific. Colombia and Panama have lost 60% of their mangrove forests: 5,000 ha of mangroves were cleared in Colombia in 1990 to be used on shrimp culture, while during the last 30 years Panama has lost 5,647 ha of mangroves that were cleared for agricultural and livestock-related purposes (1345 ha in Sona district, Veraguas Province, and 2157 ha in Chiriqui Province). In Costa Rica, deforestation is the major cause of mangrove destruction, as well as industrial pollution from pesticides and from untreated or poorly treated municipal wastewater in the area north of Punta Arenas and near the mouth of Rio Grande de Tarcoles. In Mexico, almost 65% of the original mangrove forests have disappeared in the last 20 years due mainly for land-reclamation for urban settlements. Guatemala and El Salvador have lost 20% of their original mangrove forests. The situation is similar in both Honduras and Nicaragua where the main threat to mangroves is land-reclamation for urban human settlements and for use in aquaculture activities. For instance, between 1973-1991 15,000 ha of mangrove forests and estuaries in the Honduran part of the Gulf of Fonseca were cleared for use in aquaculture.

23. Mangrove forests in the Southeast Pacific[39] are found from the northern border between Panama and Costa Rica to northern Peru. The most important species are *Rhizophora mangle*, *R. harrisonii* and *Avicenia germinans*. During the last 30 years, some 223,451 ha (40% of the original area) of the mangrove forests in this region have been lost due mainly to exploitation for firewood and for house construction, land-reclamation for agriculture, aquaculture and urban settlements: Colombia has lost 61.2% of its original mangrove area, Ecuador 20.4%, Peru 35.1% and Panama 3.4%. In Ecuador, in particular, shrimp aquaculture has played a very significant role in the destruction of mangrove forests. The situation is similar in Peru.

24. In the Atlantic Ocean, mangroves range from Bermuda (32°N, the world's most northerly location where mangroves occur) - throughout the wider Caribbean – to Laguna (28°30 S) In Santa Catarina, northern Brazil. The extensive mangrove forests of the Caribbean[40] are under acute threat mainly due to extraction for lumber and conversion to agriculture, aquaculture and coastal urban settlements, and mining. Among the Caribbean islands, Cuba has the largest extension on mangrove forests and they represent some 26% of the country's forests and 4.8% of the country's total area, and offer an important source of timber for fuel and charcoal. An estimated 30% of Cuba's original mangroves forests have been degraded during

the last 50 years, mainly due to socioeconomic development, road and dam construction, mining and conversion to agricultural and cattle-grazing lands.

25. Compounding this situation, since mangrove forests are the most prominent coastal ecosystem in tropical and many subtropical areas of Latin America and the Caribbean, the impact of, for instance, climate change on these areas is likely to have great environmental, economic and social significance[41]. Table 4 presents data on extension of mangrove forests en Latin America and the Wider Caribbean from 1980-2000[42] (FAO 2003).

Table 4. Mangroves in Latin America and the Wider Caribbean, 1980-2000 (FAO 2003)

Country/area	North and Central America						
	Extent						
	Most reliable recent mangrove area estimates		Mangrove area 1980	Mangrove area 1990	Annual change 1980-1990	Mangrove area 2000	Annual change 1990-2000
	ha	Reference Year	Ha	ha	%	ha	%
Anguilla	**90**	**1991**	90	90	n.s.	90	n.s.
Antigua and Barbuda	**1 175**	**1991**	1 570	1 200	-2.4	900	-2.5
Aruba	**420**	**1986**	420	420	n.s.	420	n.s.
Bahamas	**141 957**	**1991**	170 000	145 000	-1.5	140 000	-0.3
Barbados	**14**	**1991**	30	16	-4.7	10	-3.8
Belize	**65 767**	**1995**	75 000	68 800	-0.8	62 700	-0.9
Bermuda	**16**	**1992**	17	16	-0.6	15	-0.6
British Virgin Islands	**587**	**2001**	660	630	-0.5	590	-0.6
Cayman Islands	**7 268**	**1991**	7 300	7 300	n.s.	7 200	n.s.
Costa Rica	**41 330**	**1992**	41 000	41 000	n.s.	41 000	n.s.
Cuba	**529 700**	**1992**	530 500	529 800	n.s.	529 000	n.s.
Dominica	**10**	**1991**	40	13	-6.8	9	-3.1
Dominican Republic	**21 215**	**1998**	33 800	26 300	-2.2	18 700	-2.9
El Salvador	**26 800**	**1994**	47 200	35 600	-2.5	24 000	-3.3
Grenada	**255**	**1992**	295	262	-1.1	230	-1.2
Guadeloupe	**2 325**	**1997**	3 900	2 500	-3.5	2 300	-0.8
Guatemala	**17 727**	**1998**	19 800	17 800	-1.0	15 800	-1.1
Haiti	**15 000**	**1990**	17 800	15 000	-1.6	10 000	-3.3
Honduras	**54 300**	**1995**	156 400	103 300	-3.4	50 000	-5.2
Jamaica	**9 731**	**1997**	23 000	10 800	-5.3	9 300	-1.4
Martinique	**1 840**	**1998**	1 900	1 900	n.s.	1 800	n.s.
Mexico	**488 000**	**1994**	640 000	543 000	-1.5	440 000	-1.9
Montserrat	**5**	**1991**	5	5	n.s.	5	n.s.
Netherlands Antilles	**1 138**	**1980**	1 140	1 138	n.s.	1 130	n.s.
Nicaragua	**282 000**	**1992**	336 000	280 000	-1.7	214 300	-2.3
Panama	**158 100**	**2000**	230 000	166 000	-2.8	158 000	-0.5
Puerto Rico	**6 410**	**2001**	6 500	6 400	-0.2	6 400	n.s.
Saint Kitts and Nevis	**79**	**1991**	84	80	-0.5	75	-0.6
Saint Lucia	**200**	**2002**	200	200	n.s	200	n.s
Saint Vincent and Grenadines	**51**	**1991**	60	52	-1.3	45	-1.3
Trinidad and Tobago	**7 150**	**1991**	9 000	7 200	-2.0	6 600	-0.8
Turks and Caicos Islands	**23 600**	**1991**	23 600	23 600	n.s.	23 600	n.s.
United States	**197 648**	**2001**	263 000	260 000	-0.1	203 000	-2.2

United States Virgin Islands	**978**	**1991**	978	978	n.s.	978	n.s.
Total North and Central America	**2 102 886**	**1991**	**2 641 289**	**2 296 400**	-1.3	**1 968 397**	-1.4

South America

Country/area	**Extent**						
	Most reliable recent mangrove area estimates		**Mangrove area 1980**	**Mangrove area 1990**	**Annual change 1980-1990**	**Mangrove area 2000**	**Annual change 1990-2000**
	ha	**Reference Year**	**ha**	**ha**	**%**	**ha**	**%**
Brazil	1 012 376	1991	2640 000	1150 000	-5,6	1010 000	-1.2
Colombia	379 954	1996	440 000	396 600	-1,0	354 500	-1.1
Ecuador	149 688	1999	193 000	166 400	-1,4	147 800	-1.1
French Guiana	55 000	1980	55 000	55 000	n.s.	55 000	n.s.
Guyana	80 400	1994	91 000	83 400	-0,8	76 000	-0.9
Peru	4 791	1992	7 600	5 000	-3,4	4 700	-0.6
Suriname	98 121	1998	115 000	105 600	-0,8	96 300	-0.9
Venezuela	250 000	1986	260 000	240 000	-0,8	230 000	-0.4
Total South America	2 030 330	1992	3 801 600	2 202 000	-4,2	1 974 300	-1.0

C. Socioeconomic factors affecting the sustainability of mangrove forests and the cross-sectoral nature of mangrove management

26. The negative effects of human activities on the coastal environment primarily stem from two sources[43]: *poverty* (frequently associated with excessive population pressure on natural resources) and the negative effects of *economic and social change* (these changes increase the demand for scarce natural resources, while consumption patterns in industrialized countries add pressure to natural resources in less developed countries). Institutional failure allows these factors to have a much more powerful effect, particularly when governments are unwilling or unable to correct the market failures that occur when markets do not fully reflect the value of the resources. This is particularly true for mangrove forests (see below). Allocating resources through the establishment of property and use rights is thus fundamental to overcoming market failures.

27. About two thirds of the world's population lives within 100 km of the coast, about 45% of the population are within 150 km and two thirds of all cities with over 2.5 million inhabitants are located along the coast. All these are dramatically increasing the pressures on coastal habitats and their resources, and the negative effects of ill-planed tourism, urbanization, industry, agriculture, forestry, aquaculture, hydrological changes - and the concomitant commerce and transport-related activities which grow with them - all impact on the sustainability of mangrove forests around the world.

28. The need that coastal developing countries have for generating urgently economic revenues has led to an increase in activities/practices that negatively impact coastal ecosystems, including mangroves, but which also have serious socio-economic implications for local human populations in particular[44]. Increased internal human migration to the coast, coastal development, urbanization, tourism, aquaculture, among others, have not only increased the demand for more space, jobs, freshwater and food - many times at the expense of natural habitats and by displacing local inhabitants and altering their way of life - but they have also brought greater requirements for municipal and industrial wastewater treatment, augmented pollution and the destruction and modification of critical coastal habitats. All of these are compounded by

the economic hardship brought about to many poor countries by natural environmental disasters such as hurricanes and floods.

29. Thus, it is not surprising that the conservation and sustainable use of mangroves is heavily dependent on how successful we are in ensuring a cross-sectoral and integrated management approach involving all major sectors. Conflicts related to land/resource uses negatively affect the sustainability of the various sectoral plans using the coast and its resources. Box 1 illustrates the complexity of some of these conflicts for the world's major existing continuous strip of mangrove forest in Bangladesh.

Box 1. The Khulna Sunderbans[45]

With an area of 577,000 ha the Sunderbans, located in the west of the Brahmaputra-Meghna delta, is the world's largest compact single block of mangrove forest. It supports a very rich and diverse fauna, including 120 species of fish, 270 species of birds (offering an important staging and wintering area for many migratory species) and comprises the largest remaining habitat of the critically endangered royal Bengal tiger. The Suderbans mangrove reserve is also of great socio-economic importance to Bangladesh as a whole and provides livelihoods to some 300,000 people of which 160,000 are engaged in fishing activities. It also protects densely settled agricultural areas from periodic cyclonic storms and tidal waves. Here mangroves are exploited for timber, pulpwood, firewood, and for making matches, hardboard and pallets. In addition, leaves of *nipa* palm ("golpata") are used for thatching, mangrove trees yield large amounts of honey and wax from wild beehives and mollusc shells are gathered and burned to produce lime. Coastal renewable resources are primarily exploited in the fisheries sector by commercial, subsistence and recreational fishermen. Fishermen come to this area and establish temporary camps along the coast. Salt production and the aquaculture industries are also major players. The conversion of land to ponds and the resulting lost of agricultural land is a major issue, especially as in some areas the pond production is sustainable for a few years and the conversion of mangrove forests leads to loss of fish habitats. All of these different uses, plus other activities such as "reclamation" of mangrove areas for human settlements and for shrimp farming, have brought land and resource use conflicts and seriously impair the sustainability of the different sectors such as fisheries, aquaculture, shipping, industry and tourism. In some parts of the coast land use conflicts have even turned into battlegrounds.

30. Given the cross-sectoral nature of mangroves, coordination of efforts and clear distribution of responsibilities among the various concerned government authorities, both at the national and local level, are also critical to ensure the sustainable management of mangrove forest products and services. In many countries it is still not clear under which government department, ministry or institution mangrove forests are handled and the resulting overlaps in bureaucracy, competition for resources, power and sometime conflicting policies among these authorities have a great impact on how the sustainable use of mangrove goods and services is approached. A brief look at the institutional issues involved in the decline on mangrove forests in the Philippines helps illustrate the negative effects of lack or limited cross-sectoral coordination (Box 2).

Box 2. The role of institutional issues in the decline of mangrove forest in the Philippines[46]

The decline of mangrove forests from an estimated 500,000 ha in 1918 to 120,000 ha in 1994 in the Philippines can be attributed to various causes (e.g., overexploitation by local users, and conversion to agriculture, salt ponds, industry and settlements), but aquaculture is the major single cause: half of the 279,000 ha of mangroves lost from 1951 to 1998 were turned into culture ponds (95% of Philippine brackishwater ponds between 1952-1987 were derived from mangroves). Another widespread mechanism by which mangroves have been lost is when local residents, or even outsiders, "buy" mangrove areas by paying a real estate tax on such areas to municipal governments who are hard-pressed for cash and accept the taxes without much knowledge of the area (which can be protected reserves). The national policy encouraging brackishwater pond culture at the expense of mangrove forests has resulted from the belief that mangroves and other wetlands are "wastelands." There were even loans from national and international banks to promote conversion on mangrove areas into fishponds. In addition, the economic rent of mangroves converted into government-owned aquaculture ponds, under a Fishpond Lease Agreement (US$ 2/ha/year, in 2000), grossly underestimate the real value of mangroves and the right to harvest public forests and induce mangrove conversion to ponds. Government agencies with responsibilities over mangrove forest management and aquaculture had a long history of poor coordination which has lead to conflicting environmental policies even within the same agency. Besides, effective enforcement of many administrative decrees, orders and proclamations has been hampered by, *inter alia*, overlapping jurisdictions and bureaucratic corruption at many government levels. On the other hand, local initiatives prohibiting the sale of mangrove fuel wood have proved more effective in halting illegal cutting than a mangrove ban established by the central government.

D. The value of mangrove forests

31. There are many studies and publications on the value of consumptive and non-consumptive uses associated with mangrove forests[47]. These values are many and diverse, but four main categories can be identified[48]: economic, usefulness (ecological), intrinsic, and symbolic values. Only the first two categories can be quantified in monetary terms and only the economic values are readily recognizable and relatively easy to quantify. *Economic* values can be recognized in the direct and indirect products that can be obtained from mangroves (see Table 7) and they are discussed further below in the context of their importance in the local, national and international market. *Usefulness (ecological)* values are more difficult to recognize and quantify in monetary terms, but include functions that are undoubtedly much more economically important that the "economic" values, such as acting as buffer against natural phenomena[49] (typhoons, storm surge, tidal waves)[50]; preventing soil erosion and building land through soil and sediment accretion; minimizing water pollution; providing habitat, breeding and nursery grounds for marine fauna; playing an important role in the food chain in coastal and marine ecosystems; and minimizing global warming[51]. Table 5 lists the functions of the natural environment, most of which are performed by mangrove forests (there is a high degree of interconnection among these functions). *Intrinsic* values refer to the view that organisms, communities and ecosystems have an inherent right to exist independently of any human interest in them. *Symbolic* values are those attached to mangrove areas by indigenous people and include religious, totemic and mythical believes. Both intrinsic and symbolic values cannot be quantified, readily appreciated and thus are widely overlooked.

Table 5. Functions of the natural environment[52]

Regulation Functions	**Production Functions**	**Carrier Functions**	**Information Functions**
Protection against harmful cosmic influences Local and global energy balance Chemical composition of the atmosphere Chemical composition of the oceans Local and global climate Run-off and flood prevention Water catchment and groundwater recharge Prevention of soil erosion, sediment control Topsoil formation, maintenance of fertility Solar energy fixation, biomass production Storage/recycling of organic matter Storage/recycling of nutrients Storage/recycling of wastes and surpluses Biological control mechanisms Migration and nursery habitats Biologic (and genetic) diversity	Oxygen Water (drinking, irrigation, etc) Food and nutritious drinks Genetic resources Medicinal resources Raw materials for fabrics Raw materials for construction Fuel & energy Biochemical Fodder & fertilizer Ornamental resources	(providing space & a suitable substrate for) Human habitation, (indigenous) settlements Cultivation (e.g., of crops, cattle, fish) Energy conversion Recreation and tourism Nature protection	Aesthetic information Spiritual & religious information Historic information (heritage value) Cultural and artistic inspiration Scientific/educational information

32. Table 6 provides an illustrative list of estimates of the economic value of mangrove forests in selected countries.

Table 6. Estimates of the economic gains (or losses) of some mangrove products and services[53]

Country	Year	Value (US$/ha/yr)	Yield/benefit
Traditional goods			
Thailand	1982	230	Traditional products
Philippines	1984	650	Alcohol from nipa
Forest products			
Malaysia	1985	150	Charcoal
Malaysia	1986	566	Timber, fuel wood
Philippines	1996	151	Timber, fuel wood
Thailand	1982	230	nipa shingles
Thailand	1985	500	Timber, fuel wood
Aquaculture after mangrove conversion			
India			
Philippines	1986	- 145	Extensive shrimp products

Philippines	1978	- 180	Milkfish
Philippines	1979	- 1600	Intensive shrimp products
Thailand	1996	- 7124	Aquaculture
Thailand	1982	- 2106	Intensive shrimp products
Ecuador	1982	- 206	Extensive shrimp products
	1982	- 390	*Ibid*
Fisheries products			
Fiji	1976	100	Mangrove fisheries catch
Fiji	1985	166	Small-scale fisheries
Indonesia	1992	117	Mangrove fisheries catch
Indonesia	1977	1010	Wild-caught shrimps
Trinidad	1974	125	Small-scale fisheries
Thailand	1977	130	Wild-caught shrimps
Malaysia	1982	2770	Mangrove fisheries catch
Agriculture after mangrove conversion			
Senegal			
Thailand	1984	- 80	Rice
Indonesia	1983	- 165	Rice
	1992	- 220	Rice
Ecosystem services			
Indonesia			
Trinidad	1992	15	Biodiversity conservation
Fiji	1974	200	Ecotourism park fees
	1976	5820	Polishing treated sewage

33. Mangrove forests provide key inputs and support to aquaculture in general, in particular to shrimp farming, but these inputs (which include resources such as food, seed and broodstock, and services such as clean water supply) are not widely recognized nor appreciated. The following sequence of events is very familiar to many farmers throughout the world[54]. Shrimp farmers locate shrimp farms in mangrove areas mainly in order to reduce the costs of pumping water and buying land. However, the overexploitation of the mangrove exceeds the environment's carrying capacity for clean water and recycling of nutrient wastes, which may trigger the appearance of diseases. Also, the removal of the mangroves will eventually lead to a shortage of wild shrimp larvae and adult breeders. As a result, the farmers will have no option but to rely into capital-intensive high-technology solutions which means that they would have to turn into intensive and super-intensive farming methods. In the long run, this will cut all feed backs to the environment and makes the systems lose resilience, which greatly increase risks for diseases and collapse of the whole farm.

34. Other previously unsuspected benefits of mangrove forests, although difficult to estimate in monetary terms, should be considered when valuating mangroves. For instance, they are efficient biogeochemical barriers to the transfer of pollutants (in particular, heavy metals) generated in landfills to the coast: mangroves fix heavy metals under non-bioavailable forms and their large root systems retain and stabilize sediments more efficiently than bare sediments, thus avoiding the pollutant remobilisation by physical disturbance[55]. The use of mangroves in landfill management and the effective retention of heavy metals (such as mercury and zinc) by mangrove sediments have been successfully achieved at the Gramacho Metropolitan Landfill in Rio de Janeiro, Brazil, which receives some 5,000 tons of solid waste daily, and have reduced the transport of heavy metals to the heavily contaminated Guanabara Bay[56]. Also, the ascidian *Ecteinascidia turbinate* synthesizes some of the most promising substances against solid-type tumours, but the only available source are the natural population of this tunicate, which are well established on mangrove roots[57].

E. The importance of direct and indirect mangrove products on the local, national and international market

35. Both direct and indirect products can be obtained from mangroves forests (summarized in Table 7). The direct products are much more important at local level, although for some countries they are also a relatively important source of foreign exchange as part of the international market. However, the actual amounts of products - and thus their monetary value – at all levels (local, national, international) are probably underestimated since data collection procedures are inadequate[58].

36. Timber production from mangrove forests had and continues to be minor in comparison to other types of forests. Annex 3a provides timber production for selected countries and for various years, ranging from 1597 m³ per year (1995) in Fiji to 4,000,000 m³ per year (1990) in Nigeria. Some of these countries export relatively large quantities of mangrove products and others use them nationally or locally, thus there is a great deal of variation in the importance of mangrove-based products among both regions and countries. Indonesia, for instance, exported 11, 736 m³ of poles in 1977, 382,737 m³ of logs in 1978, 22,207 tons of charcoal in 1983 and 257,497 m³ of wood chips in 1991. Sumatra has been a center for charcoal production and other products exported to Singapore, Malaysia and Hong Kong, while logs from Sumatra and Kalimantan-Indonesia are exported to Japan and Taiwan to be converted to wood chips.

37. In Latin America and the Wider Caribbean[59] mangrove wood is a popular construction material for rural dwellings in Central American countries, particularly in Honduras, El Salvador and Guatemala. Its use as a firewood source is also common in Central America and overexploitation is a main treat. A high demand for mangrove firewood exists in El Salvador where wood supplies 64% of the energy consumption. In Costa Rica and Panama, family-operated mangrove charcoal industries supply part of the urban demand. El Salvador, Guatemala, Venezuela and Costa Rica produce charcoal mainly from *Rhizophora*. Extraction of tannin from *Rhizophora* sp. is another traditional mangrove use common in Honduras, Nicaragua, Ecuador and Panama. In these countries, lack of coordination between the people collecting firewood and those harvesting bark for tannin often results in great waste of mangrove resources. Tables 8 provides information on the use of mangrove wood in Honduras (in the Gulf of Fonseca and nearby areas, all wood used for house building comes from mangrove forests, i.e., *Rhyzophora*). Table 9 gives information on historical exports by Ecuador, and Table 10 illustrates the values of main products from mangroves forests in Panama.

Table 7. Indirect and direct products from mangrove forests[60]

A. Mangrove Forest Products

Fuel:
- Firewood, charcoal

Construction:
- Timber, scaffolds
- Heavy construction
- Railway sleepers
- Mining props
- Boat building
- Dock pilings
- Beams and poles
- Flooring, panelling
- Thatch, matting
- Fence posts, chipboards

Fishing
- Fishing stakes
- Fishing boats
- Wood for smoking fish
- Tannin for net/lines
- Fish attracting shelters

Textile, leather
- Synthetic fivers
- Dye for cloth
- Tanning for letter preservation

Food, drugs & beverages
- Sugar
- Alcohol
- Cooking oil
- Vinegar
- Tea substitutes
- Fermented drinks
- Dessert topping
- Condiment (bark)
- Sweetmeats (propagules)
- Vegetables (fruit/leaves)

Household items
- Glue
- Hairdressing oil
- Tool handles
- Rice mortar
- Toys
- Match sticks
- Incense

Agriculture
- Fodder

Paper products
- Paper-various

Other products
- Packing boxes
- Wood for smoking sheet rubber
- Fuelwood for:
  - salt making
  - brick kilns
  - bakeries
  - tobacco drying
- Medicines

B. Other Natural Products
- Fish/crustaceans
- Honey
- Wax
- Birds
- Mammals
- Reptiles
- Other fauna

Table 8. Utilization (m^3) of mangrove wood in the Gulf of Fonseca, Honduras 1983-1992

Year	Firewood	Bark	Timber
1983	11,370	792	813
1984	14,811	417	766
1985	4068	505	817
1986	2489	720	856
1987	1962	501	894
1988	1731	442	499
1989	1110	299	696
1990	1050	200	625
1991	2200	165	675
1992	2780	159	780
Total	**43,631**	**4200**	**7421**

Table 9. Mangrove bark exported historically by Ecuador for tannin production in nearbouring countries

Year	Amount (kg)
1879	90
1901	394,000
1904	316,000
1906	586,000

Table 10. Direct exploitation and uses of mangroves in Panama

Product	Location	Species	Tree diameter(cm)	Annual production	Price (US$)	Annual demand	Beneficiaries	Rentability
Woodchips	Chiriqui Azuero	*Laguncularia Pelliciera*	5-15	2.8 million	12/1000 chips	2.1 million chips	350	Subsistence
Charcoal	Azuero Chame Capira	*Rhizophora Laguncularia*	5-30	118,200 bags (1,087,440 kg)	1/bag	150 kg/ person	2060	Subsistence
Bark	Azuero Chiriqui	*Rhizophora*	40-70	9,480 qq 15,800 qq	1.8/qq 4.5/qq	10,000 qq (local) 16,000 qq (Costa Rica)	107	0.58/qq
Small logs (agriculture)	Azuero	*Rhizophora*	5-10	266,000 units	0.05/unit		375	Subsistence
Small logs (construction)	Chame Capira Azuero	*Rhyzophora*	10-20	8,780 units	1/unit		120	Subsistence
TOTAL REVENUE PER YEAR = US$ 170,000								

38. Similarly, the construction of salt evaporation ponds has contributed to the degradation of mangroves in Costa Rica and El Salvador. In Guatemala and Honduras, large volumes of mangrove wood are used to evaporate water and isolate salt in ovens. Fifteen percent of firewood consumed in the southern region of Honduras is used for salt production, and most of this wood comes from mangroves. At the local level, mangrove forest products are significant. For instance, the total revenues of products from mangroves extracted in 1984 from the Estero Real in Nicaragua were estimated at a minimum of US$ 244, 571. In Cuba, mangroves are considered a valuable resource both for their ecological functions and as source of fuelwood and charcoal. However, the production of timber products is very low due mainly to the lack of appropriate technology and equipment for the extraction of large trees and their transport along the coast. As a result, production on mangrove bark, which is still in great demand in the market, decreased from 2300 ton in 1976 to only 121 ton in 1991. Table 11 illustrates timber products from mangrove forest in Cuba.

Table 11. Production of mangrove wood products in Cuba 1987-1991

Product	1987	1988	1989	1990	1991
Fuelwood (m^3 x 10^3)	19.3	19.5	17.5	17.2	23.8
"Cujes" for tobacco drying	0.4	0.3	0.3	0.3	0.3
Charcoal (sacks x 10^3)	22.0	22.4	22.2	23.0	23.9
Bark (tons)	1027	711	608	351	121
Cross-ties (units x 10^3	4.4	3.6	3.4	2.6	1.2

39. On the other hand, mangrove-based fisheries have some importance in the national and international market (Annex 3b). For instance, in 1986 Panama's catch of anchovies was worth US$ 20 million and in 1980 catches of other fish totalled US$ 100,000; in 1989 Costa Rica's' artisanal fisheries catch was worth US$ 33 million; and in 1984 Nicaragua's shrimp and cockle catches was worth US$2,600,000. Similarly, shrimp production from mangrove areas in many countries has importance on the international market, totalling US$ 758 million in 1994 (Annex 3c). Finally, various countries also export non-wood mangrove products as illustrated in Annex 3d.

IV. REVIEW OF SOME PAST AND ONGOING INITIATIVES FOR THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF MANGROVE ECOSYSTEMS IN LATIN AMERICA AND THE WIDER CARIBBEAN

40. Unlike some parts of Asia, where mangrove forests have undergone experimentation with different silvicultural systems for most of the 20th century, American mangroves have received relatively little formal management[61]. Although cutting has been intensive enough to alter significantly the structure and composition of Caribbean mangroves, it has not led to the management of these areas. In addition, the principal commercial products (e.g., tannin, fuelwood and roundwood) have not been harvested in sufficient quantities to justify a concerted investment in careful silviculture (but see Tables 8-10, above). Moreover, hurricanes and other periodic natural disturbances have contributed to this situation by keeping trees below sawtimber size.

41. Probably one of the earliest efforts to specifically address the conservation and sustainable management of mangrove ecosystems in Latin America and the Wider Caribbean as a whole, were the Workshops on Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions, held in Niteroi, Brazil, 28-30 May 1993 and in Dakar, Senegal, 20-22 January 1993[62]. The workshops were cosponsored by the International Tropical Timber Organization (ITTO), the International Society for Mangrove Ecosystems (ISME) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

42. By March 2003, some 30 States and Territories in the Americas were Contracting Parties to the Ramsar Convention on Wetlands, the most important international agreement related to the conservation and sustainable management of wetlands and mangrove ecosystems. There are 161 Ramsar sites in this region, which cover almost 42 million ha and represent 40.6% of the world's wetlands of international importance[63]. Although all countries in the region recognized the environmental and socioeconomic importance of mangrove forests, with the notable exception of the International Tropical Timber Organization Mangrove Ecosystems Workplan 2002-2006 (addressed below), to date there are no regional agreements or programmes specifically designed to ensure their conservation and sustainable use. A list of projects related to mangrove ecosystems worldwide and sponsored by various organizations is given in section VII below.

Northeast Pacific

43. Various environmental initiatives and agreements, initiated particularly after the late 1980s, are of importance to the sustainable management of mangrove ecosystems in this region. Some of the most important are listed herein. In 1989, the Central American presidents agreed to create the Central American Commission on Environment and Development. The Commission is committed to evaluating and

protecting the region's rich biological diversity and, to this end, promotes coordinate action among governmental bodies in such areas as management of natural resources, particularly tropical forests, and the protection of watersheds and transboundary ecosystems[64]. In September 1991, experts from all Central American countries participated in the "Regional Workshop on the Management of Coastal Ecosystems" jointly organized by the Central American Commission for Environment and Development and the Coastal Resources Center of the University of Rhode Island, USA (through the Regional Natural Resources Project, sponsored by the United States Agency for International Development). Some of the recommendations of this workshop are relevant to the sustainable management of mangrove forests in the region[65]. In June 1992, the Presidents of Costa Rica, Guatemala, El Salvador, Honduras, Nicaragua and Panama met in Managua, Nicaragua, to sign the Agreement for Conservation of Biodiversity and Protection of Priority Wildlife Areas in Central America. The Agreement has provisions for the conservation and sustainable use of wetlands (and mangrove forest) in the region. In 1993, the Regional Convention for the Management and Conservation of Natural Forest Ecosystems and the Development of Forest Plantations was adopted. In 1994, the Alliance for Sustainable Development was established by mutual agreement between the government of the United States of America and the governments of the Central American countries, within the framework of the United Nations Conference on Environment and Development. In August 1995, the Tropical Agronomic Centre for Research and Training (Centro Agronomico Tropical de Investigacion y Enseñanza-CATIE) based in Costa Rica, the Rosenthial School of Marine and Atmospheric Conservation of the University of Miami, Florida, USA and the Mesoamerican Program of the IUCN-World Conservation Union jointly organized a Workshop on Productive Management of Mangroves, in Leon, Nicaragua. The workshop was coordinated by CATIE through research projects financed by the Norwegian Agency for International Development (NORAD), the Danish Agency for International Development (DANIDA) and the Swedish Agency for International Development (SIDA)[66]. In December 1995, 108 Governments (including those from the Northeast Pacific) adopted the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), which deals among others with the conservation of mangrove ecosystems [67].

44. Finally, in February 2001, after several years of intense negotiations, the governments of Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama signed the Antigua Guatemala the Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific. This Convention and its associated Plan of Action, which are the most important instruments for achieving the conservation and sustainable use of natural resources in this region, address mangrove ecosystems [68]. The Central American Commission on Maritime Transport (COCATRAM), located in Managua, is the Executive Secretariat of the Northeast Pacific Convention and its Plan of Action.

45. All countries of the Northeast Pacific are signatories to the Ramsar Convention on Wetlands and of the Convention on Biological Diversity, the most important environmental international agreements related to the conservation and sustainable use of mangrove forests and their resources. All these countries also participate in the United Nations Forum on Forests.

Southeast Pacific

46. The most important regional environmental agreement relevant to the conservation of mangrove ecosystems in this region is the Convention for the Protection of the Marine and Coastal Zone of the South-East Pacific, and its Action Plan, both adopted in Lima, Peru, in 1981. The Secretariat of the Southeast Pacific Action Plan is the Permanent Commission for the Southeast Pacific (CPPS), based in Quito, Ecuador. All Contracting Parties to the Lima Convention (Colombia, Chile, Ecuador, Panama and Peru) are Contracting Parties to the Ramsar Convention on Wetlands and to the Convention on Biological Diversity. They also participated in the negotiations and adoption of the GPA.

Wider Caribbean

47. The most important regional environmental agreement dealing with mangrove forests is the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, adopted in Cartagena, Colombia, in 1983. The Secretariat for the Caribbean Action Plan is the

Regional Coordinating Unit of the United Nations Environment Programme. In 1985, the Caribbean Coastal Marine Productivity (CARICOMP) programme was established; it has received funding from the John D. and Catherine T. MacArthur Foundation, the US Department of State and the United Nations Educational, Scientific and Cultural Organization (UNESCO). The programme is a regional scientific programme and network of marine laboratories, parks and reserves for coastal monitoring and scientific collaboration, focuses on understanding and comparing the structure and functions of mangroves, seagrasses and coral reefs. The CARICOMP network started in 1990 and in 1998 the CARICOMP - Caribbean Coral Reef, Seagrass and Mangrove Sites – a major compendium – was published by UNESCO[69]. Seventeen Caribbean countries (Bahamas, Belize, Colombia, Costa Rica, Cuba, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Dominican Republic, Saint Lucia, Suriname, Trinidad and Tobago, and Venezuela) are Contracting Parties to the Ramsar Convention on Wetlands, and many are Contracting Parties to the Convention on Biological Diversity. All Caribbean countries participated in the negotiations and adoption of the GPA.

Upper Southwest Atlantic

48. In this region, mangrove forests are restricted to the subtropical coast of Brazil. A tripartite collaboration for the protection of the marine and coastal environment of Argentina, Brazil and Uruguay is in place, and a regional workshop on the effects on land-based activities in this region was carried out in October 1998, in Manaus, Brazil. The three countries are Contracting Parties to the Ramsar Convention on Wetlands and the Convention on Biological Diversity, and participated in the negotiation and adoption of the GPA.

The Ramsar Convention on Wetlands

49. The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands (and, thus, those having mangroves) and their resources. The first obligation under the Convention is to designate at least one wetland for inclusion in the List of Wetlands of International Importance (the "Ramsar List") and to promote its conservation, including, where appropriate, its wise use. The Contracting Parties have adopted specific criteria and guidelines for identifying sites that qualify for inclusion in the List of Wetlands of International Importance. The Convention establishes that *"wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology*." There are presently 131 Contracting Parties to the Convention, with 1150 wetland sites, totalling 96.3 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance. Wetlands included in the List acquire a new status at the national level and are recognised by the international community as being of significant value not only for the country, or the countries, in which they are located, but for humanity as a whole. The Convention's mission is the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world.

50. Under the Convention there is a general obligation for the Contracting Parties to include wetland conservation considerations in their national land-use planning. They have undertaken to formulate and implement this planning so as to promote, as far as possible, "*the wise use of wetlands in their territory*" (Article 3.1 of the treaty). The Conference of the Contracting Parties has approved guidelines and additional guidance on how to achieve "wise use", which has been interpreted as being synonymous with "sustainable use". A Convention on Biological Diversity/Ramsar Joint Work Plan for 2002-2006 was adopted by the CBD and Ramsar Parties during early 2002. Joint actions on marine and coastal biodiversity focus on marine and coastal protected areas, development of guidance on integrated marine and coastal area management, and methodologies for the rapid assessment of marine and coastal biological diversity. This Latin American mangrove initiative directly supports the three pillars of the Ramsar Convention on Wetlands: the sustainable use of wetlands, the designation of new Ramsar sites and the international cooperation.

51. During the Eight Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands (Valencia, Spain, November 2002), a resolution (VIII.32) was adopted dealing specifically

with the conservation, integrated management and sustainable use of mangrove ecosystems and their resources (see the resolution in Appendix I). Most activities outlined below for preparing a regional strategy on mangrove ecosystems are in full concordance with this resolution.

V. OVERVIEW OF ENVIRONMENTALLY SOUND TECHNOLOGIES RELEVANT TO MANGROVE FORESTS

52. A brief review of technologies for the sustainable management of forests, with emphasis on those considered relevant to mangroves, is provided below. The intention is not to describe these technologies in great detail but mainly to identify them, highlight their pros and cons whenever possible and provide major relevant sources of additional information. An attempt has been made to arrange these technologies in a "taxonomic" manner by grouping them, in accordance with their intended use, in the following six main categories: (a) forest resource assessment and science; (b) management; (c) harvesting and transport; (d) wood processing and use; (e) non-wood forest products processing and use; and (f) marketing and trade.

A. Forest resource assessment and science

Remote sensing

53. A critical aspect of forest management is the availability of real (static or dynamic) geo-referenced data and information[70]. Geo-information, monitoring and assessment include all aspects of geo-information data, analysis and dissemination. Remote sensing covers all techniques related to the analysis and use of data from satellites (e.g., Meteosat, NOAA-AVHRR, Lansat Thematic Mapper, SPOT, ERS-SAR and Soyuz) and from aerial photographs. The main objective of remote sensing is to map and monitor natural resources. The following remote sensing technologies, which have relative advantages and disadvantages, have been applied with variable degrees of success in mangrove forest surveys, mapping, inventories and assessment in many countries[71]: aerial photography (e.g., panchromatic, colour and infrared colour); satellite imagery[72] (e.g., LAN sat using the Multi Spectral Scanner, Return Bean Vidicon and the Thematic Mapper; SPOT images) and radar imagery[73] (e.g., Side Looking Airborne Radar, Synthetic Aperture Radar, INTERA).

Geographical information systems

54. A GIS is a system of computerized information storage, processing and retrieval that has hardware and software specifically designed to handle geo-referenced spatial data and corresponding attribute information. The spatial data are commonly in the form of maps, which may depict topography, water availability, soil types, forests and grasslands, climate, geology, population, landownership, administrative boundaries and infrastructure (main roads, railways, power grids, communications networks). The possibility of merging several maps in a single operation, known as "overlaying", is a key GIS function. In essence, GIS is a data base management system (DBMS) specifically designed for simultaneous processing of spatial and related attribute data[74]. Although GIS differs from other tools, such as tabular data base management systems, computer graphics, and automated map making, each of these other systems is, in fact, a component of GIS. What GIS does is make it possible to integrate all of them in one operation. One of the primary sources of geographic data used in GIS is information about the Earth that is obtained through remote sensing. Remote sensing data are usually acquired either as digital satellite imagery or aerial photographs. After these images are geometrically corrected, enhanced, analysed and interpreted, the results can be fed into the GIS and integrated with other geographic databases. More information on GIS is provided in Annex 4.

Monitoring

55. Remote sensing is being increasingly used to quantify the decline of mangrove forests. However, it is equally important to link the analyses of remote sensing to fieldwork that monitors qualitative changes which aims, for instance, at the selective unsustainable utilization or exploitation of certain mangrove species or at the patterns of succession, both of which can lead to a change in floristic composition or vegetation structure[75]. Thus, research on changes in mangrove forests and on the regeneration potential,

including solutions to keep the latter at a level allowing forest rejuvenation, should be considered. A monitoring system is needed to decide whether human interference is desirable, since artificial restoration may be appreciated less than natural regeneration. A clear understanding of the nature and dynamics of local mangrove forests is the best guide to any restoration programme[76]. The first step is to collect information on the actual state of the mangrove forest, emphasizing different vegetation layers, but also about past changes in that particular vegetation[77]. The second step is to integrate such findings in the management and decision-making process.

Surveys[78]

56. A particular aspect to consider when planning a survey of mangrove forests is the change in area, which can be due to accreted land formed by coastal or riverine deposition or a decrease in land area caused by chronic erosion due to changes in coastal currents. There are various types of surveys that can be used for mangrove forests, depending on the level of application (Table 12).

Table 12. Surveys used for mangrove forests[79]

Type	Scope/purpose	Brief description	Advantages/limitations
National	Provide data for decision-making on national and regional forestry policy, and implementation of global development plans. For mangroves, the main interest of this survey is to know the extent of mangrove vegetation, its distribution and a broad classification of lands both for forest and non-forest uses.	There are two types of national level surveys. A cartographic survey, which is primarily based on image interpretation (e.g., small scale aerial photography, satellite imagery or a combination of both) and its objective is often limited to the production of thematic maps. It is suitable for use in classification of mangrove forests. The evaluation of map accuracy and correction of misinterpretation can be achieved by limited ground check in the field. Low flying plane surveys are also successful to rapidly check photo-interpretation and reduce the cost of ground surveys. The second type is multi-phase surveys, for which mapping may or may not be required. In these surveys, data are collected on sample plots, which are either randomly or systematically laid out over the image. Aerial photography is used to complement, adjust and check the interpretation obtained from satellite images. To reduce the survey cost, photo-interpretation of conventional photography is restricted to sample areas. The application of this method results in a multi-phase sampling design. A three-phase sampling (satellite imagery, aerial photography and direct field sampling) can be applied to mangrove forests.	Multi-phase surveys combine the positive aspects of satellite images (i.e., the possibility of having a synoptic view of the area of concern at low cost) with those of aerial photography (i.e., permits more details to be mapped).
Management planning	Provides managers with: (i) accurate estimates of the area, (ii) classification of the forest into cover types and their description; (iii) evaluation of the growing stock; (iv) regeneration assessment; and (v) assessment of tree and forest stand growth. This information cannot be obtained through remote sensing but through procedures combining statistical analysis with (limited) ground and aerial surveys	Combine statistical analysis, forest inventories, data obtained from ground and aerial surveys.	Usually restricted to forests in a district or smaller units.
Operational planning	Small areas. These surveys are used to complement national and forest management surveys, and to record changes since the last	Consisting more often of either field enumerations (and/or observations) or area surveying on the ground. Recent aerial photographs on a sufficiently large	Due to the constraints in conducting operational level surveys in mangrove areas (e.g., occurrence on many rivers and

	survey was undertaken.	scale to aid in mapping and area estimation need to be obtained.	streams, very soft ground, high tides, very high erosion and accretion rates), these surveys are only recommended for smaller areas.

Mapping

57. As indicated above, the final products of a survey are often maps: maps for planning more detailed surveys and/or to assist in taking decisions on the use and development of resources at different levels of application. Table 13 illustrates the information required for each application level and the technologies suitable for obtaining such information. At national level, mapping consists of presenting the general distribution of mangroves in a country or a region. Orbiting satellite imagery, combined with small to medium scale aerial photography, is suitable for this purpose[80]. At the management planning level, maps at medium scales can be produced on which the forest density and development conditions of various forest sites are shown, including (i) areas where mangrove forests are well preserved and can be allocated to timber production and some kind of intensive forest management could be imposed; and (ii) areas destined for conservation and protection purposes or allocated to other uses than timber production (due of the nature of the forest stand). At operational planning level, which deals with intensive forest management, forest stand classification should produce stand type maps with up-to-date information on certain parameters (e.g., tree species or species groups, age classes, regeneration, cutting activities, degree of stocking) and can only be obtained with aerial photography of high resolution and complemented with field ground observations.

Table 13. Mapping of mangrove forests: type of information, map scale requirements and suitable technologies for different application levels[81]

Application level	Information required	Scale range	Technology required
National	Geographical distribution Extent of area Broad land use	1:50,000 to 1:250,000	Satellite imagery combined with small-medium scale aerial photography & field ground surveys
Management planning	Mangrove sites Broad forest classes	1:25,000 to 1:50,000	Statistical analysis combined with (limited) field ground and aerial surveys
Operational planning	Mangrove forest resources Forest stands and types		Satellite imagery and aerial photography combined with field ground surveys

58. In mapping coastal habitats, remote sensing is more cost-effective (measured as overall map accuracy) than alternative field-survey based methods. Four types of cost are encountered in remote sensing: set-up costs, field survey costs, image acquisition costs and the time spent on analysis of field data and processing imagery[82]. The largest of these are set-up costs such as the acquisition of hardware and software which may comprise 48-78% of the total costs of a project (depending on specific objectives). For mapping small coastal areas (< 60 km in any direction) in coarse details, SPOT XS is the most cost-effective satellite sensor; while for larger areas LAN sat TM is the most cost-effective and accurate sensor.

Forest resource assessment[83]

59. As used by the FAO, forest resource assessment is understood as a rough estimate of the wood resources available, but this estimate (which can be useful to obtain a rapid assessment of the resource) is neither as accurate nor as detailed as the results from a forest inventory. This assessment can be based on measurements taken directly by remote sensing imagery (particularly aerial photography), on limited field ground sampling or on a combination of both techniques. However, although the estimates using field sampling are not very accurate and it is not possible to determine the error on the result, this method is

valuable in obtaining a first (rough) indication of the extent of the mangrove forests on a national or regional scale.

Inventories and sampling[84]

60. Since forest inventories provide more detailed and accurate estimates of specially the standing volume of wood, they are very useful in the preparation of forest management plans and in preparation and execution of operational plans where what is needed is a detailed knowledge on the quantity and quality of the wood available and a reliable estimate of the size of the area where logging operations will take place. This information can be obtained from field inventories with the aid of maps and aerial photography. The most commonly applied sampling techniques for tropical forests, including mangroves, are strip and line plot sampling, although other techniques such as stratified, multi-phase and cluster sampling are also of potential use.

Valuation

61. Many studies have been published in recent years demonstrating that goods and services by mangrove forests have a high value. Notwithstanding this fact, valuation has its limitations. The distribution of income is a key issue, especially in developing countries: for instance, benefits from fisheries are received by local (usually poor) fishermen; benefits from fishponds, due to their high investment costs, accrue to distant, rich investors. Conversion of mangrove forests to fish ponds therefore results in an unfavourable change in income distribution which is not reflected in total value and also creates areas that are not longer accessible by the local population[85]. Annex 5 briefly describes three generally accepted approaches to estimate economic values of ecosystem services[86], which can be applied to mangrove forests.

B. Management[87]

62. Some of the characteristics which make mangrove forests attractive for silviculture purposes include rapid growth, good regenerative potential (mangrove stands can recover rapidly from natural and human-induced disturbances, including logging), tendency to form homogeneous/even-age stands and diversity of forest products[88]. The major objectives for managing any mangrove plantation or restored area should be to (i) facilitate natural regeneration; (ii) enhance productivity through fertilization and weed or herbivore suppression; and (iii) select target areas where some assisted regeneration may be required. Some examples of management alternatives for mangrove forests in the Philippines are provided in Annex 6.

Mangrove silviculture

63. A silviculture system has been defined as the process by which the crops constituting a forest are tended, removed and replaced by new crops, resulting in the production of stands of distinctive form[89]. Some of the advantages and disadvantages of some silviculture systems applied to mangrove forests are summarized in Table 14.

Table 14. Some silviculture systems and their application to mangrove forests[90]

System and description	Advantages	Disadvantages/Risks
Clear-felling (in blocks or in alternate strips): Aim at establishing an even-aged stand by removing mature ones in a single operation. Cost-effective where the principal species are light demanding and can regenerate naturally, and sites are favourable. Due to its simplicity, this system is recommended where there is shortage of trained personnel/skilled workers; also suitable for countries where mangrove forest management is just	❖ Simple to implement and supervise ❖ Logging costs are lower, higher out-turn ❖ Over-mature stands are removed in one operation ❖ Comparatively less skills needed ❖ Create even-aged regulated forests in one rotation ❖ Affords complete overhead light, required by light demanders	❖ Erosion and site deterioration risks are higher ❖ Seedlings may be unevenly distributed ❖ Species must be able to withstand open conditions ❖ High damage to advance growth if logging not well conducted ❖ Reduces the aesthetic and amenity values of stands ❖ All trees, irrespective of species and merchantability, are cut

beginning.		❖ Creates a large amount of logging slash and debris
Selection systems: The stands are uneven-aged and the forest cover is never completely removed. The systems favour shade tolerant species, but the degree of canopy opening can be manipulated to also favour light demanding species. Environment-friendly since merchantable trees are harvested periodically and over all parts of the forests. A variant of this method is Group Selection, which creates larger felling gaps that favours regeneration of light demanding species and promotes formation of small groups of even-aged stands (consequently, harvesting costs are lower and wood extraction is simpler).	❖ Only system capable of maintaining an uneven-aged stand ❖ Reproduction of tolerant species easily obtained ❖ Site protection excellent ❖ Stands can be readily adapted to meet fluctuating market demands ❖ Capital returns at short intervals	❖ Require high level of technical skills and management control ❖ Extraction costs are higher and smaller removals/unit area ❖ Product dimensions more variable ❖ Crop trees are scattered throughout the stand ❖ Inventory data analysis and growth-yield forecasts are difficult ❖ Not favourable for growing intolerant species
Shelterwood systems: High forest systems in which the young crop is established under the shade or side-shelter of the old one (referred as the "overwood"). The overwood protects the site and sustains the forest microenvironment conducive to the regeneration and growth of the younger trees. The term is used to include some variants of the selection system using successive regeneration fellings.	❖ Provides protection to species with sensitive juvenile stage ❖ Excellent soil protection and reduce invasion by weeds ❖ Less risk of multiplication of injurious insects that breed in clearing ❖ Stands more wind-firm and better adapted to cyclonic areas ❖ Aesthetically more pleasing than clear-felling systems ❖ Selected trees can put on better increments through stand improvement treatments and gap openings	❖ Requires more skill ❖ Work dispersed, felling and extraction less profitable ❖ Higher logging damage to young crops ❖ Delayed regeneration response can be costly ❖ Yield regulation and silviculture more complex

64. The major objectives for managing a plantation (or restored area) are to facilitate natural regeneration, enhance productivity through fertilization and weed or herbivore suppression, and to select target areas where some assisted regeneration is required[91]. Nursery and planting techniques vary considerably among mangroves species[92]. Some of the advantages and disadvantages of natural regeneration used in mangrove silvicultural systems are summarized in Table 15 (see also the section on macro propagation of mangroves below)[93].

65. Although assisted regeneration is more expensive, there are difficulties in estimating the cost of the two approaches which depends on variables such as labour costs, site characteristics (e.g., accessibility, size) and proximity to propagule sources, and whether propagules, seedlings or transplants would be used[94]. Assisted regeneration is required to restock blanks and sites with insufficient natural regeneration. Propagules need to be collected and either planted out or rose in a nursery. For planting, propagules can be scattered over the target areas or alternatively pushed into the substrate. Some losses can be expected and it should be ensured that distribution of propagules to the site is repeated as necessary. Survival and propagule growth is higher if they are nursery grown before planting out. Propagule establishment success rate ranges from 30-90% depending on the site.

Table 15. Natural regeneration[95]

Advantages	Disadvantages
❖ Cheaper to establish and maintaining ❖ Less labour and heavy equipment required ❖ Origin of seed sources usually known ❖ Better early root developments by natural seedlings ❖ Usually less soil disturbance	❖ Less control over spacing, initial stocking and distribution of seedlings ❖ Risk of seed tree loss ❖ Genetically improved stock not easily introduced ❖ Regeneration delays and failures possible ❖ Greater need for non-commercial thinning ❖ Stands not suited to mechanized extraction ❖ Infestation of cleared areas by the mangrove fern *Acrostichum* and insect infestations are impediments ❖ May be affected by fauna (e.g., grazing of established seedlings and saplings may be locally significant)

Macro propagation of mangroves[96]

66. Mangroves can be planted for various purposes, including (i) timber production to support large commercial mangrove forestry operations; (ii) shoreline protection, channel stabilization and storm protection for coastal human settlements from cyclones and other extreme natural events, and for protection against seawater intrusion; (iii) fisheries, aquaculture and wildlife enhancement; (iv) legislative compliance to protective measures and compensatory requirements; (v) social enrichment (e.g., aesthetics, income generation through ecotourism); and (vi) ecological restoration. Whatever the objective (s), it is critical that they be clearly defined and prioritised from the onset of the planting process. Approaches for macro propagation of mangroves include:

(i) *Direct planting of propagules collected from the wild*. As propagules are generally available only during a few (2-3) months of the year, the direct planting of propagules needs to be scheduled accordingly to their seasonal availability. The high susceptibility of propagules to desiccation, dislodgement by waves and tides, and damage by predators and debris, make this approach unsuitable for areas subjected to medium and high energy[97].

(ii) *Outplanting of up to one-year-old nursery-raised propagules*. Propagules of different species are collected during the fruiting season and grown on freely drained sandy substrate. The pros of this approach are that year-round supplies of seeds are available, which is of particular importance in large-scale projects. Also, nursery-grown seedlings generally have higher success rates (survival rates, increases in height, number of leaves) than propagules collected from the wild. The cons are that nursery costs and planting difficulties, when compared to direct planting of propagules, are higher and may offset these advantages[98].

(iii) *Direct transplanting of seedlings and shrubs.* Young seedlings are removed from natural mangrove forests and transplanted to sites under rehabilitation. They should be kept moist and protected from direct heat and wind during collection and transportation. Also, young mangrove trees from natural forests can be transplanted. The pros are that extensive root system of these trees promise greater and faster success of establishment than from seedlings. The young trees have a higher resistance to wave erosion and debris and can be transplanted into areas of higher energy where propagules or seedlings are unlikely to survive.

(iv) *Outplanting after nursery-raising small seedlings collected from the wild*. In areas where propagules are not available, newly established seedlings can be replanted to establish nursery stock. In this approach, the advantages of both nursery-raised seedlings and small seedling transplantation are combined. Damage to the donor area can be avoided by using small seedlings. Another advantage of this technique is that it reduces the time required for propagules to grow to the height where a high survival rate is expected after transplantation[99].

(v) *Raising of air-layered material*. This involves the removal of short sections of bark and phloem of mature lateral branches until the cambium becomes exposed. The injured area of the stem is wrapped in aluminium foil to retain moisture. After roots have developed, the stem is then cut below the layering areas to form a new plant. The pros of this technique are that, unlike raising young seedlings, it reduces the risk of root damage by insects and crustaceans, especially in the early stages of establishment. The cons are that this technique is relatively expensive, and utilizes mature trees in the field and is thus subject to many variables that cannot be controlled (e.g., infections, fluctuation in temperature, rainfall and tide height)[100].

(vi) *Use of stem cuttings.* Mangrove stem cuttings can be induced to form roots after treatment with various hormones[101].

67. Air-layering, an artificial development technique, is an efficient technique for (i) increasing the production of roots from *Rhizophora mangle* branches; (ii) enhancing the development of viable seedlings for sowing; and (iii) decreasing the time required for propagules to develop into seedlings, thereby reducing the negative effects caused by the removal of mangroves from their native habitats[102].

Rehabilitation and restoration[103]

68. Mangrove reforestation is increasingly practiced in many parts of the world, particularly in Asia and Latin America and the Caribbean[104]. While it has been demonstrated that using a combination of ecological principles and engineering technologies for rehabilitation is feasible for the major tropical coastal ecosystems (coral reefs, seagrass beds and mangrove forests), mangrove forests are probably the easiest and most cost-effective habitats to restore in terms of level of difficulty and the associated cost of manpower and financial resources[105]. However, long-term success will be determined by the level of participation and involvement (understood in this context as co-management) of local communities and local governments[106].

69. The need for the rehabilitation of a mangrove ecosystem implies that the area under consideration has been altered or degraded in a way that conflicts with defined management or defined objectives. There are three main criteria for judging the success of mangrove rehabilitation: (a) the *effectiveness of the planting* (which can be considered as the closeness to which the new mangrove ecosystem meets the original goals of rehabilitation; (b) the *rate of recruitment* of flora and fauna (which can be considered to be a measure of how quickly the rehabilitated site recovers its integrity; and (c) the *efficiency of rehabilitation* (which can be measured in terms of the amount of labour, resources and material used).

70. There are three main reasons, or approaches, for the rehabilitation of mangrove ecosystems: conservation and landscaping, multiple use systems for high and sustainable yield, and protection of coastal areas[107]. Most examples of the first approach have occurred in the United States of America, while most examples of the second and third approaches have occurred in South and Southeast Asia[108]. Although it has been advocated rightly that the natural regeneration of mangroves should be the first choice of any rehabilitation program, there is already a great deal of knowledge and experience in rehabilitating mangroves by artificial means around the world; however, as underlined in section VI below, many of these efforts are being carried out without taking into consideration the experience and lessons learnt from similar projects which have lead to duplication of efforts and waste of resources.

71. Although all species of mangroves share common characteristics such as tolerance to salt and brackish water, survive long hydroperiods and anaerobic soil conditions, the conditions in a particular site (e.g., soil chemistry and salinity, sedimentation, frequency of tidal inundation, freshwater input) are critical. For instance, the more successful restoration projects (vegetation was established within 2-3 years) have been recorded in low-energy areas which experienced mechanical impact and which had an appropriate elevation within the intertidal zone[109]. Moreover, as noted recently for some estuaries along the coast of Sydney, Australia, genetic variation has implications for the rehabilitation and management of mangrove forests[110]. As coastal urban development is increasing throughout the world, many populations of mangroves have been removed leaving isolated remnant populations separated from one another by large breaks in distribution. This, in turn, causes a high level of heterozygote deficiencies which might render the mangrove populations less able to cope with future changes in the environment. Furthermore, since increasing levels of heavy metals in waterways threaten mangroves, the identification of metal-tolerant genotypes may also be of benefit in rehabilitating areas depleted of mangroves by human-induced stress. In other words, transplantation of mangrove propagules from one estuary to another could be of use in rehabilitating mangrove forest by increasing the genetic diversity of the mangroves of a given site. In several countries of Central America where reforestation of mangrove forests have been attempted (e.g., Panama, Guatemala and Nicaragua) the preferred species are from the genus *Rhizophora*[111]

72. At its 32nd session in May 2002, the International Tropical Timber Council (ITTC) adopted a set of guidelines to promote the restoration of degraded tropical forests, the management of secondary tropical forests and the rehabilitation of degraded tropical forestlands. The guidelines were developed in cooperation with IUCN-The World Conservation Union, the World Wildlife Fund (WWF), FAO and others[112]. For recommendations relevant to rehabilitation of mangroves, see section VIII below.

Indigenous technologies

73. Indigenous technologies can be environmentally sound technologies. However, not much is known about them, except that they would be local, "home-grown" or indigenous and would include traditional technologies. The traditional socio-economic systems that exploited mangrove resources were relatively small-scale and poor in technological equipment but often quite rich in intimate knowledge of the ecosystems[113]. As economic development has advanced, technological influences over the mangrove environment have increased, often with negative impact on mangrove forests. Except in Indonesia, few attempts have been made to describe traditional mangrove dwellers' knowledge and utilize it in designing management systems. This knowledge, together with the social organization by which it is implemented, is a valuable resource for reaching the management goals of sustained yield and multiple uses[114].

Protected areas

74. The most common approach for conserving mangrove forests is by establishing protected areas in undisturbed sites. There are various categories of protected or semi-protected areas[115], several of which could be applied to the sustainable management of mangrove forests, as follows:

75. *Nature reserve/wilderness area*. Managed mainly for science or wilderness protection. Public access is not generally permitted. Natural processes are allowed to take place in the absence of any direct human interference, tourism or recreation. *National park*. Managed mainly for ecosystem protection and recreation. Relative large areas managed and developed so as to sustain recreation and educational activities on a controlled basis. The visitor's uses are managed at a level which maintains the area in a natural or semi-natural state. *Natural monument*. Managed mainly for conservation of specific natural features. The area normally contains one or more natural features of outstanding national interest. These should be managed to remain relatively free of human disturbance, although they may be of recreational and touristic value. *Habitat/species management area*. Managed mainly for conservation through management intervention. The areas covered may consist of nesting areas of colonial bird species, marshes or lakes, estuaries, forests or grassland habitats, or fish spawning or seagrass feeding beds for marine animals. The production of harvestable renewable resources may play a secondary role in the management of the area. The area may require habitat manipulation. *Protected landscape/seascape*. Managed mainly for landscape/seascape conservation and recreation. Includes areas whose landscapes possess special aesthetic qualities which are a result of the interaction of humans and land or water, traditional practices associated with agriculture, grazing and fishing being dominant; and those that are primarily natural areas, such as coastline, lake or river shores, managed intensively by humans for recreation and tourism[116]. *Managed resource protection area*. Managed for the sustainable use of natural ecosystems. Normally covers extensive and relatively isolated and uninhabited areas having difficult access, or regions that are relatively sparsely populated but are under considerable pressure for colonization or greater utilization.

Biotechnology[117]

76. As defined by the Convention on Biological Diversity, the term biotechnology covers any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use. On the other hand, interpreted in a narrow sense, which considers only the new DNA techniques, molecular biology and reproductive technological applications, biotechnology covers a range of different technologies (e.g., gene manipulation and gene transfer, DNA typing and cloning of plants and animals). Modern biotechnologies currently used in forestry fall in three categories[118]: (i) biotechnologies based on molecular markers (e.g., to quantify genetic diversity between populations, locate genes affecting quantitative traits of economic importance); (ii) technologies that enhance vegetative propagation and support large-scale production of uniform materials (e.g., to select traits such as to tolerate metals, salt and low temperatures – high costs presently limit the direct use of micro-propagated material in forestry); and (iii) genetic modification of trees. Although very limited work on tissue culture of mangroves has been carried out to date, micro propagation is potentially an important area for improving mangrove germplasm[119].

77. Various Central American countries have valuable experiences in the management and participation of local communities in the sustainable use of mangrove forests and their products [120]

C. Harvesting and transport

78. The main methods in use for harvesting and transport of mangrove wood are (i) wheelbarrow, (ii) tramway, (iii) canals, (iv) high-lead cable; (v) portable cable winch; and (vi) manual (Table 16).

Table 16. Comparison of main methods used for harvesting and transporting mangrove wood in selected countries[121]

Method	Country	Description	Advantages	Disadvantages/ limitations
Wheelbarrow	Malaysia Thailand	Wooden planks *ca* 5 m long are laid across the felling coupe; billet or firewood loads of *ca* 300 kg are manually pushed to and loaded on boat landings using locally made wheelbarrows over 150 m average distance; a shoulder strap is often used to help lift and balance the wheelbarrow. Planks are replaced every six months; wheel and axle of the wheelbarrow is made of wood (to resist salt corrosion). Used to harvest *Rhizophora*.	Suitable for removal of billets (1.6. m long). Simple, practical, low cost	Labour intensive (which can be an advantage to rural settings where labour is plentiful but jobs are limited). Not suitable for frequently flooded areas (planks may be washed away by retreating tides).
Tramway	Indonesia	Used for mangrove forests in the elevated inter-terrestrial zone (species which generally do not have prominent aerial roots, e.g., *Bruguiera gymnorhiza* , *B. caryophylloides*)	Since these trees (which can grow to large sizes) are found in less frequently inundated areas, they can usually be accessed by light trolleys or small-wheeled carts on wooden rails or tramways.	Dragging of trees and logs remove topsoil, damage natural regeneration, compact soil. Skid rails are prone to deep flooding and affect natural regeneration.
Canals	Cuba Malaysia Vietnam	Extraction canals are constructed manually (Malaysia, Vietnam), mechanically (Vietnam) or using explosives (Cuba); felling is carried out by a combination of chainsaw and handsaw/axe; logs, posts and billets are manually carried, wheelbarrowed and loaded onto boats usually at high-tide. Used to harvest *Rizophora*.	Canals aligned parallel to felling strip (50 m x 200 m) facilitate rapid and orderly removals, reducing disturbance to advance growth. Minor canals can be temporarily adapted for shrimp farming. In Cuba, where canals are constructed using explosives, this method is very rapid, labour extensive and cost effective	It may not be environmentally sound. High damage to seedlings and saplings during logging. Alteration of tidal influence and draining patterns. Very labour intensive (which can be an advantage to rural settings where labour is plentiful but jobs are limited).
High-lead cable	Venezuela	Harvesting of stems and poles (used for telegraphic/telephone posts, mining pit-props and general utility timber) is organized into clear-felling strips (50 m wide, 300 m long) perpendicular to the river bank; a high-lead cable system mounted on to a barge towed by a tug-boat is used to haul the timber to stacking/loading sites along the river bank; logs and poles are transferred onto barges (manually or using small boats) and transported to the jetty; long-distance transport to the processing mills is carried out by floating platforms hauled by tug boats. The rivers and		Capital intensive to be used economically only in areas with high volume of commercial timber and/or where the wood has to be transported over long distances. It can only be used for clearcutting as the action of the high-lead cables destroys any remaining trees within the area.

		creeks have to be deep enough to permit the use of shallow draught barges. Used to harvest *Avicennia*.		
Portable cable winch	Costa Rica, Cuba	A portable winch powered by a small chainsaw motor is used to haul stems, poles, firewood and charcoal billets. First tested in the Sierpe-Terraba mangrove reserve (Pacific coast of Costa Rica) with the ultimate goal of transforming the irregular *Rhizophora* dominated forests into a series of even-aged equi-productive stands. A strip clear-felling method was used; a portable light winch is easy to move from place to place. Used to harvest *Rhizophora*, *Avicennia*.	Minimum disturbance to advance growth. Very practical, low costs, easy to apply, training is simple. More cost-effective than the manual method (described below).	
Manual	Sierra Leone Mali	Mangrove trees are cut with a local type of axe; the smaller firewood billets are normally bundled and carried manually to the dugouts. Directional felling is possible with proper axes, handsaws and wedges; removal of billets may be facilitated by the deliberate felling of convenient trees so that the topped trunks lie end to end forming a rough track across the swamp.		Big, heavy billets can only be carried out over short distances. Dragging of trees and logs remove topsoil, damage natural regeneration, compact soil. Skid rails are prone to deep flooding and affect natural regeneration.

79. With regard to forests in general, FAO is working on the promotion of environmentally sound forestry practices which involve the development, testing and promotion of the *Model Code of Forest Harvesting Practice* at the global, regional and national levels. Case studies are prepared by FAO for experimenting new environmentally sound forest harvesting practices. Information on reduced impact harvesting is collected, analysed and disseminated and a database is maintained on information on forest harvesting equipment[122]. FAO is also developing activities related to the development of guidelines on forest roads, which include the assessment of economic, environmental and social impacts of forest road infrastructure towards mitigation of impacts of forest road construction and utilization.

D. Wood processing and use

80. In general, large-scale capital-intensive operations of wood obtained from mangroves are not recommended. These operations involve clear felling of large mangrove areas for the production and export of chips which may generate some income in the short-term, but which may impact negatively local economies and ecologies in the long-term. Table 17 provides some examples on the utilization of wood from various species of mangroves.

Table 17. Examples of processing and utilization of mangrove wood[123]

Product	Species	Uses/comments
Timber	*Rhizophora*	Some species of *Rhizophora* can grow to over 40 m in height, although large trees are becoming scarce because they are cut before reaching such sizes. However, this genus is not valuable as timber due to their tendency to split and warp when dried; also, their wood is dense and difficult to work. Possible uses of *Rhizophora* wood includes agricultural implements, boat construction (knees and ribs), general heavy construction (rafters, beams, joists), marine and bridge construction (underwater, non-teredo infested waters), marine and bridge construction (above water since it is resistant to decay but not to marine borers), fence posts and poles, walling and flooring, and railways ties and posts (South East Asia).
	Avicennia germinans	Its wood has a lower density, good nail holding qualities and is used as railways ties (Cuba).
	A. nitida	Used as mining props, telegraph and transmission poles (Venezuela).
	Heritiera fomes	For house and boat construction (Bangladesh).
	Excoecaria	Bangladesh

	agalocha	
Charcoal	*Rhizophora*	The species of this genus are preferred for charcoal making because of their moisture content. Charcoal out-turn is improved when dry billets are used because less energy is needed to dry the wood. Charcoal is the main mangrove product in Thailand, Peninsular Malaysia, Indonesia, Myanmar and Southern Vietnam. Industries are well developed at the village and cottage industry levels in most Asian countries, where charcoal is mainly used for cooking and small-scale industries. In Indonesia (Matang) charcoal is produced in dome-shaped, masonry kilns located along small rivers or creeks to facilitate transport of billets. The battery of kilns is covered with nipa roofs and the roofing requires little attention as the tar-laden smoke emitted by the kilns preserves the nipa thatch. Masonry kilns are long-term, location specific and costly to construct; to be economically viable there must be an assured supply of billets and reasonably low land costs. The conversion efficiency of this method is low (in Matang, a standard 6.7 m diameter dome-shaped kiln operates at only 19% efficiency and about 55 tons of greenwood per kiln is required for an efficient burn). Costs to construct kilns of 5-7 m diameter and 3-7 m high have been estimated between US$ 2,000 – 7,000 in Indonesia and Thailand. On the other hand, in West Africa, Central America and the Caribbean islands, charcoal is mostly made using earth pits or earth mound methods. In general, these methods are less efficient, produce charcoal of variable quality and greater care is required in tending and controlling the carbonisation process. However, they are easy to build, costs are low and the structures are often temporary. In Cuba, billets of all sizes and lengths are arranged vertically to form a large circular stack which is the covered with fern fronds and sand and sealed with mud. In Costa Rica, the "carboneros" construct their charcoal-pits along the beach and are oriented perpendicular to the shoreline so that billets are easily rolled into the trenches to form stacks. Very low conversion efficiency is achieved (some 13%).
	Bruguiera gymnorhiza *Ceriops* sp.	Both species are used in smaller quantities.
Firewood	*Rhizophora*	These species are favoured as fuel wood for, *inter alia*, domestic use and are thus commercially exploited (e.g., Indonesia, Thailand), smoking fish (e.g., Sierra Leone) and boiling brine to produce salt.
	Heritiera fomes	Bangladesh.
Fishing stakes/poles		An established demand for mangrove piling pole (imported from Indonesia and Thailand) exists in Singapore, Hong Kong and Malaysia.
	Oncosperma filamentosa	It is normally used as fishing stakes in Southeast Asia
Pulp	*Excoecaria agalocha*	This is the main species used in Bangladesh.
	Rhizophora *Bruguiera*	Large mangrove concessions have been granted for chipping operations in Malaysia and Indonesia. The chips are exported mainly to Japan for making dissolved pulp and cellulose derivatives (e.g., rayon) used in the textile industry. These activities have led to clear felling of large areas in Indonesia, the regeneration on many of which has been unsuccessful.
Matchwood	*Excoecaria agalocha*	Bangladesh
Tannin	*Rhizophora*	The barks of species of this genus produce very fine tannin, which is not broken down by ferments and is thus very suitable for leatherwork. Tannin as also been used for curing and dyeing of fishing nets made of natural fibre. The amount of tannin varies with bark thickness and species of mangrove; the bark must be fresh and transported to the tanneries rapidly in a moist condition. Bark for tannin is collected in Southeast Asia, and Latin America (mainly Panama and Costa Rica), but its production has declined greatly since local demand have been reduced after the introduction of nylon fishing nets and the use of chrome as the predominant agent for leather curing.

E. *Non-wood forest products processing and use* (e.g., nipa palm, food, beverages, pharmaceutical, oils, gums, fishing, mangrove honey, household items, other products**)**

81. No detailed information was found on processing and use of non-wood mangrove products such as nipa palm, food, beverages, pharmaceutical, oils, gums, fishing, mangrove honey, household items, etc. Most sources merely refer to these products (see, FAO. 1994. Mangrove forest management guidelines. FAO Forest Paper 117, 319 pp).

F. Marketing and trade

82. The market and trade for wood and non-wood mangrove products varies between and within regions and this has a direct impact on both the market and the sustainable management of mangrove forests. For instance, it has been reported that a large internal market and a lucrative export market of charcoal produced from mangroves support large charcoal industries in Southeast Asia and has made the management of mangrove forests economically viable in some countries in that region[124]. Trade liberalization is no panacea. Trade liberalization measures in the forestry sector (e.g., elimination of official prices and introduction of market-based prices, abolition of export tax) which can result in price increases of forest products and thus turn into an incentive for increase production, better distribution and marketing, can also accelerate deforestation, as demonstrated recently in Tanzania [125].

83. Trade tools such as certification and ecolabelling are inextricably a part of the technology transfer landscape. These are tools that can point timber users and consumers to primary and secondary forest products that are the product of sustainable forest management, including the utilization of environmentally sound technologies.

Certification[126]

84. The direct purpose of any form of certification is to provide verification that something – a product, service or process – has been done as prescribed. Forest certification involves a certifier (i.e., a third-party inspector) giving a forest enterprise a written assurance that the quality of forest management practiced by the enterprise conforms to specified standards. Certification is often accompanied by a verification of the "chain of custody" of the products that come from certified forests, together with the labelling of those products - so that they can be proven not to have been mixed with, or substituted by, products from other forests. In this way, certification attempts to link the demand for forest products produced to high environmental and social standards, with producers who can meet such demands. In other words, forest certification aims at creating a credible system that could assure the market that forest products made available to consumers were produced under environmentally sound management practices and technologies and in conformity with internationally agreed criteria. Although in practice Governments are supposed to be doing that[127], the reason for requiring an additional certificate of origin is said to be the lack of credibility of Governments and failures in the official control and monitoring system.

85. Any system of forest certification comprises four essential elements: (i) a set of "standards" which represent "good" or "acceptable" practice. These must be locally relevant but also compatible with international standards or definitions of good practice, including the utilization of environmentally sound technologies and scientific knowledge, in order for the standards to have credibility and widespread acceptability; (b) a formal auditing process which, in an independent and objective manner, compares the systems and activities of an enterprise with the standards. In the case of forest certification this involves matching the management of a forest with the appropriate "production standards" or a forest processor (sawmill, pulp mill, furniture manufacturer etc.) with "processing standards"; (iii) a system for identifying the source of a product (i.e., being able to trace the forest from which wood or another product originates - commonly called a chain of custody audit); and (d) a foolproof system for applying a certificate and labelling any product. To judge whether certification is effective and efficient, four criteria have been proposed. Certification programs should be: (i) positive and sustainable in their impact on forest management; (ii) acceptable to stakeholders, credible in the marketplace, and able to impact on the market; (iii) non-discriminatory in terms of types of forest, forest owner or country, and trade distortions; and (iv) able to cover their costs, in terms of extra benefits produced. Annex 7 lists available forest-related certification schemes and initiatives

Ecolabelling[128]

86. Ecolabelling is a voluntary method of environmental performance certification and labelling that is practiced around the world. An ecolabel is a label which identifies overall environmental preference of a product or service within a specific product/service category based on life cycle considerations. In contrast to "green" symbols or claim statements developed by manufacturers and service providers, an ecolabel is

awarded by an impartial third-party in relation to certain products or services that are independently determined to meet environmental leadership criteria. There are many different voluntary (and mandatory) environmental performance labels and declarations. The International Organization for Standardization (ISO) has identified three broad types of voluntary labels, with ecolabelling fitting under the Type I designation: Voluntary Environmental Performance Labelling: A voluntary, multiple-criteria based, third party program that awards a license that authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations.

87. The global ecolabelling network (GEN) is an association of worldwide ecolabelling organizations. The GEN promotes and develops ecolabelling of products and services. The Centre for Environmental Labelling (CEL) is active in policy analysis and the evaluation of environmental labelling programmes. It works with the GEN and the United Nations Taskforce on environmental labelling to obtain knowledge and understanding on ecolabelling programmes worldwide. It has an information center in Canada where ecolabelling programmes are evaluated and the criteria are set. Factors for a successful labelling programme include: (i) previous consumer awareness; (ii) third party certification; (iii) market structure; (iv) consumer willingness to pay for the products; and (v) clear, inexpensive label format.

VI. BARRIERS AND ENABLING CONDITIONS FOR THE SUCESSFUL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES FOR SUSTAINABLE MANAGEMENT OF MANGROVE FORESTS

88. Technology transfer aims at addressing three main types of gaps[129]: (i) between innovation and commercialisation; (ii) between technologies used in developed and developing countries; and (iii) among technologies available to different developing countries. The major sources of technology transfer to developing countries are: foreign investors (including equipment suppliers), official development assistance (provided bilaterally by donor countries and multilateral international agencies, programmes and mechanisms), non-governmental organizations, foundations and South-South cooperation. The important technologies for sustainable forestry are those that foster better communication among stakeholders and allow informed decisions spanning scales from the gene to the ecosystem[130].

Barriers

89. As discussed in the previous sections of this overview, it is clear that the major barriers for the successful transfer of environmentally sound technologies for the sustainable management of mangrove forests involve primarily a combination of problems/difficulties dealing with the following areas[131]:

- *Suitability of conservation and protection policies/laws*
- *Lack of effective management*
- *Lack of adequate institutions to support sustainable mangrove forest management, human resources, public involvement, etc*
- *Lack of databases for individual mangrove ecosystems*
- *Lack of coordination among agencies*
- *Lack or limited participation of local communities*[132]/[133]
- *Limited investment in mangrove management, research and human resource development (= limited number of scientists) from governments, donors, private sources domestic or foreign, international contributions*
- *Costs to acquire, use and maintain technologies (e.g., hardware, software)*

- *Limited information on the flow of mangrove forest products*
- *Lack or limited participation of the private sector*
- *Lack or limited awareness on the value of mangrove ecosystems*[134]/[135]/[136]/[137]
- *Land tenure and property rights*[138]/[139]

Enabling conditions

90. As considered in this document, technology transfer means a system under which various inter-related components of technology, such as *hardware* (materials such as a variety of equipment and machines), *software* (technique, know-how, information), *humanware* (human ability), *orgaware* (organizational, management aspects) and the *final product* (including marketing) are rendered accessible to the end-users[140]. The system also includes institutional capacity for technology adoption, adaptation or rejection, constituting a matrix of technology component and institutional capacities for absorbing technologies (Table 18). Thus, barriers and enabling conditions for successful technology transfer deal with this wide range of issues.

91. Moreover, as pointed out in the introduction of this document, technology transfer has both functional and institutional meanings. A technology transfer programme would be considered effective when there is minimal or no gap between the potential and realized impacts of the technology. It means that monitoring of the adoption or adaptation of technologies is an integral part of the technology transfer system. Transfer of technology must therefore be preceded and succeeded by technology assessment, reasserting that technology transfer and assessment are complementary processes[141]. There is a need to ensure that ESTs are compatible with nationally determined socio-economic, cultural and environmental priorities and development goals. Otherwise, the might not be successfully transferred.

Table 18. Technology transfer and adaptation matrix for a given objective[142]

Institutional capacity for technology	**Technology components**				
	Hardware, Tangibles	Techniques, Software	Knowledge, "Humanware"	Organization, Management	Product, Commercialisation
Choice, Identification					
Acquisition, Negotiation and Transfer					
Generation, Upgrading, Adaptation, Invention					
Reproduction, Capital goods, Manufacture					
Application, Maintenance					

92. At the national level, three goals have been identified as critical for creating enabling conditions/strategies to promoting the successful technology transfer for forest management[143]. If implemented, they could address most, if not all, of the major barriers/impediments identified above for the transfer of environmentally sound technologies for the sustainable management of mangrove forests[144]. These goals, which stress the need for the establishment of long-term partnerships involving the public and private sectors and local communities, are to:

(a) Build industries that are competitive in domestic and international markets and that contribute to sustainable development;

(b) Establish business conditions attractive to technology-oriented investment, including foreign investment, technology transfer and managerial know-how; and

(c) Promote public-private research and develop partnerships to promote adaptation, commercialisation and spin-off of cleaner technologies.

VII. APPROACHES FOR IMPROVING THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES FOR THE SUSTAINABLE MANAGEMENT OF MANGROVE FORESTS

93. It as been rightly pointed out that technology will help in addressing the challenges for sustainable forestry in the 21st century, including the shift of production from native forests to plantations in areas of comparative advantage, more efficient processing delinking end-use products from raw wood characteristics, increased demand, better information technologies to support decision makers, and more options for conserving biodiversity[145]. All these challenges are relevant to the sustainable management of mangrove forests. One of the prerequisites for effective technology transfer is the appropriateness of the technology. Appropriate technology refers to a technology package which must be technically feasible, economically viable, socially acceptable, environment-friendly, consistent with household endowments, and relevant to the needs of users. The concept is a dynamic one and the elements of appropriateness will vary over time and space. Thus, technologies are subject to adjustment, change and evolution[146].

94. A brief discussion on ways and means to improve the transfer of selected technologies relevant to mangrove forests, as well as of the expected benefits, is provided below.

A. Forest resource assessment and science

95. Remote sensing is being increasingly used to quantify the decline of mangrove forests. Satellite imagery and GIS can play an important role in the management of mangrove forests and of other natural resources, by assisting in acquiring and processing data which allows the mapping of large areas, preparation of inventories and for addressing key issues. These data, combined with geo-referenced data from other sources (e.g., socio-economic) allow more comprehensive, multi-sectoral analyses in support of management decisions. Satellite imagery is a cost-effective technique. It provides access to synoptic and up-to-date information for the mapping, illustration and modelling of natural and human-induced events (e.g., regular felling, illicit felling, forest fires, reforestation and regeneration). GIS can be used to monitor the impacts of deforestation, and to plan the timing and type of timber management practices based on information on soil types, species requirements, growth and yield.

96. Compared with information acquired by traditional methods, data obtained from remote sensing offer a number of advantages, including: (i) satellite imagery can cover vast expanses of land (thousands to tens of thousands of km² on one image) and it can be acquired regularly over the same area and recorded in different wavelengths, thus tracking the state of forest resources; and (ii) satellite data can be acquired without encountering administrative restrictions. GIS provides a means of converting spatial data into digital form that can then be displayed, manipulated, modified and analysed and reproduced quickly in a new format, available for either visual display or hard copy reproduction. Conventional (paper) maps, in contrast, are time-consuming to prepare manually, and the display and analysis of changed data or the comparison of more than one set of map data (e.g., soil and vegetation) requires additional manual labour. The digital data can also be easily transmitted from one user to another or from one GIS to another merely on disk, tape or by the Internet. As digital maps come into wider use, many users can share the cost of digitising. In fact, some digitised maps on CD-ROMs cost less than the same maps on paper. As networks and libraries of databases grow, information exchange should reduce the need for redigitising regional or national maps and other geographic databases than are in common use.

97. In summary, remote sensing and GIS-based forestry studies can generate results that can be directly used in forest management planning[147]. Applicable findings (when focusing on vegetation layers of different age) can for instance include the prediction of future changes in mangrove forests. In addition,

combination of these data with local and global ecosystem data (e.g., biological, hydrological, physicochemical, geographical), socio-economic or socio-geographical data allows to assess future changes under different scenarios (e.g., exploitation, conversion, natural catastrophes, sea level rise) and to adopt conservation strategies by interfering appropriately.

98. Given that its widely recognized that the natural regeneration of mangrove forests should be the first choice of any rehabilitation program unless there is irrefutable evidence that it will be unsuccessful[148], the understanding of mangrove vegetation structure dynamics in a particular area is a prerequisite to the development and successful implementation of conservation and management measures, such as the establishment**,** protection and management of re-afforestation plots in the framework of regeneration projects. There is a need for a methodology that allows to express reliable predictions about the state of mangroves using a relatively small input from vegetation field work, and to decide whether a mangrove stand at a certain location has the potential to successfully renew and rejuvenate or whether anthropogenic pressure renders human interference such as restoration imperative[149]. Baseline ecological studies, monitoring and assessment of undisturbed mangrove forests and their comparison with more degraded and rehabilitated mangroves remain important to support management and conservation strategies, including the valuation of mangrove ecosystem good and services.

99. Considering the cost, time constraints and logistics involved in surveying and monitoring mangroves in the field, the most appropriate approach is to take advantage of both field surveys and remote sensing technologies[150]. There are considerable difficulties to evaluate the potential and sustainability of wetlands and mangrove areas. They are a dynamic environment affected both seasonally and annually by variable climatic conditions and, consequently, their surface area is also in a dynamic state and, therefore, difficult to calculate accurately. A second problem is one of accessibility. The very nature of wetlands provides a problem of marshy ground and dense reed beds. Access via foot, land transport or boats is often restricted by such circumstances. In addition, wetlands are often quite large, covering areas of tens of thousands of square kilometres. This, combined with the above factors, leads to the conclusion that a ground survey can often be difficult, time consuming and economically prohibitive. Thus, the use of satellite data, combined with field surveys, facilitates the monitoring of wetlands[151].

B. Management

100. Table 19 illustrates the advantages and disadvantages of various mangrove management systems. Given their cross-sectoral nature, any envisioned management strategy of mangrove forests should take into accounts the present and potential uses and users. Those alternatives include: preservation (extraction of forest products is not allowed), subsistence forestry (which recognizes the dependence of coastal communities on mangrove products such as fuel wood, charcoal and timber for fences and posts, and the management of the forest will be the responsibility of the communities themselves), and commercial forestry. Ecological characteristics of mangroves are in general fairly well known, but detailed information is needed on local and regional variations. This is important in discussing socio-economic aspects of human settlements because mangroves have hinterlands with a great diversity of natural and socio-economic environments which exert a strong influence on ecological processes and human activities within the mangroves[152].

Table 19. Characteristics of mangrove management systems[153]

	Traditional systems	**Transitional systems**	**Ideal developed systems**
Population	Small, slow growth, little net migration	Rapid growth, net in-migration	Large, slow growth, little net migration
Technology	Simple, low use of machinery and chemicals	Increasing use of machinery and chemicals	High use of machinery and chemicals
Use of resources	Largely local	Increasingly national and international	Local, national, international
Employment	Self-employed, local	Corporate, remote	Self-employed and corporate

Economic-system boundaries	Largely self-contained, involving trade and barter	National and international, commercial	National and international, commercial
Yield	Relatively low	Temporarily high, then declining	Moderate to high
Net productivity	Self-sustaining	Extractive	Self-sustaining, with inputs for restoration
Purposes	Multi-purpose	Often single-purpose	Multi-purpose
Knowledge used for management	Local, detailed, traditional	Technical, general	Scientific, local, detailed, general
Management objectives Method of control of exploitation	Subsistence in perpetuity Customary behaviour and values supported by local moral community	Profit, poorly enforced laws and regulations, loss of moral community	Profit and sustainability, national and international regulation, and international moral community (e.g. control of trade in endangered species)
Pollution	Local, biodegradable, chemically non-toxic, minor, micro-biological pollution may be effectively controlled by dilution	Local and regional, bio-degradable and non-biodegrable, non-toxic and toxic, major (oil, agricultural and industrial chemicals), poorly controlled, with danger of secondary spread by marketing	Full range of potential sources and types, actively controlled

101. Given the rapid and increasing rate of destruction of mangrove forests throughout the world, the development of effective replanting techniques and procedures are becoming increasingly important[154]. Mangrove forests can be considered as a particular case of an estuarine environment and the continuity and interdependence of riverine, estuarine and marine environments is a biological reality for coastal fish resources; thus, the management of their resources has to be integrated and go beyond the frequent division of responsibilities between inland and marine/coastal fisheries management bodies[155].

102. Restoration and impact mitigation projects have become one of the main ways to cope with destruction or degradation of wetlands, in particular, of mangrove forests, and the number of these initiatives has increased in recent years[156]. Between 1970 and 1998, only 20 of the 121 countries with mangrove forests have attempted the rehabilitation of mangroves, and only nine countries have planted more than 10 km², and they have done so with various degrees of success (Annex 6) [157]. However, few of these projects have been sufficiently well monitored limiting the availability and thus the use and transfer of lessons learnt. There is already a great deal of knowledge and experience in rehabilitating mangroves by artificial means around the world; however, many of these efforts are being carried out without taking into consideration the experience and lessons learnt from similar projects which have lead to duplication of efforts and waste of resources.

C. Marketing and trade

103. Well-managed charcoal industries using mangrove wood (e.g., based on sustainable supplies) can contribute to the well being of coastal rural populations. If charcoal is produced efficiently and marketed competitively it can serve the needs of local consumers (e.g., by contributing to reduce their over-dependence of rural populations on non-renewable fossil fuels) and even be exported. Access to credit and finance (through, for instance, the establishment of partnerships with the private sector) to improve carbonisation methods and capacity building of personal are needed[158].

104. Certification cannot work effectively without government support and input. However, certification was developed as a mechanism to substitute for national and international processes, which had failed, and these were the responsibility of national Governments[159]. Governments can play a significant role in improving the system or certification and in making it more efficient, by *inter alia*: (i) facilitating multi-stakeholder involvement in defining standards and procedures; (ii) ensuring consistency within government (e.g., between different departments or Ministries); (iii) ensuring compatibility with law and international obligations, and contributing to the framework for international compatibility of certification; (iv) supporting research and trials in certification; (v) monitoring the impacts of certification

on forests, stakeholders and trade – especially as there is very little evidence of this impact; (vi) submitting government forest enterprises to certification; and (vii) using government monitoring and audit systems in certification.

D. What makes (or can make) mangrove forest sustainable exploitation an attractive investment?

105. Mangrove forest stakeholders can be, in principle, divided into three categories[160]: primary stakeholders (those whose livelihoods are directly dependent on mangrove resources, e.g., fishermen, paddy farmers, charcoal makers), key stakeholders (those whose actions directly affect decision-making in the mangrove forests, e.g., developers, government officials) and secondary stakeholders (those who have an interest in the mangrove forests, but no direct involvement, such as tourists and traders). Cooperation and trust among all these three categories of stakeholders is essential for any sustainable exploitation scheme to succeed on a long-term basis.

106. Although limited and mostly concentrated in forest-based processing, private sector participation in reforestation/reafforestation programmes in developing countries have been successful[161]. International private-sector investment in developing countries in forest management, products industries and related trade is considered to be growing; however, much of this investment flows to a very limited number of countries and mostly for plantations and industries[162]. The participation of the private sector in the transfer of ESTs relevant to mangrove forests is still meagre. Given the long gestation and risks associated with forest-resources investment, attractive incentives are needed to stimulate the active participation and involvement of the private sector. Improving the enabling environment to encourage private sector investments in all aspects related to sustainable forest management, including transfer of ESTs, would require efforts by the public sector to, *inter alia*[163]:

- ✓ Avoid excessive and inappropriate regulations and bureaucracy which increase costs;
- ✓ Ensure stable and clear policies, institutional and operational environments;
- ✓ Have adequate government commitments to, and support for, the forestry sector, and provide public incentives and investment in public infrastructure;
- ✓ Seek ways for a augmenting the competitiveness of forestry as an investing option;
- ✓ Develop instruments to hedge excessive market fluctuations and seek mechanisms for achieving better prices in international markets;
- ✓ Seek ways to deter major markets from buying low-priced products supplied from unsustainable sources that unfairly undermine responsible suppliers committed to achieving sustainable forest management;
- ✓ Ensure training and skills development and research in the forestry sector;
- ✓ Seek the political stability necessary to assure investors.

E. North-South, South-South & North-South-South cooperation & institutional/human capacity-building in the use/application of current and emerging environmentally sound technologies

107. There is presently an unprecedented accumulation of technology knowledge; however, much of it is still unrecognised and inadequately shared[164]. As noted previously, the transfer of technology from developed to developing countries can be achieved through, *inter alia*, private entrepreneurs, bilateral and multilateral assistance agencies, regional and international research institutions, non-governmental organizations and foundations. Foreign investment in developing countries is often associated with a technology package which includes management and marketing contracts, foreign equipment and patented technology. All these conditions apply to mangrove forests as well.

108. A number of countries, regional development banks, funds and international organizations have programs aiming at promoting and assisting on the transfer of ESTs to developing countries or have made technology transfer for sustainable development a focus of existing assistance. Since information on most of these programmes is not readily available or has not been properly disseminated, the prerequisites (e.g., geographic or thematic focus, selection criteria) are not well known and this has made it difficult for developing countries to identify sources of assistance for particular projects, including those related to forests[165]. A compilation of many of these programmes, prepared in 1999 by the United Nations Division for Sustainable Development and the United Nations Industrial Development Organization, was reviewed and those of potential importance for mangrove forests were selected (Annex 9).

109. Transfer of ESTs among developing countries is becoming increasingly important but, in the particular case of mangrove forests, is still very limited. For instance, there is a great wealth of knowledge on ESTs in South and Southeast Asia and in many Latin American countries which could be made available within and outside these regions. Consequently, technical cooperation among developing countries needs a much more coordinated effort and stronger national, regional and international support so that its potential can be properly used.

F. Role of economic policy instruments (direct and indirect) and appropriate conditions for their implementation

110. Economic instruments for environmental protection are policy approaches that encourage behaviour through their impact on market signals rather than through explicit directives regarding pollution control levels or methods or resource use. They encompass a range of policy tools from pollution taxes and marketable permits to deposit-refund systems and performance bonds. If implemented properly, and often in combination with so-called "command and control" approaches, they can help to[166]: (i) increase prices of environmentally-damaging goods and services, as well as increase the returns to more sustainable production and consumption patterns; (ii) reduce compliance costs by providing flexibility to polluters or users of natural resources to choose the most cost-efficient and environmentally effective measures; (iii) minimize the overall costs of achieving a given pollution control target; **(**iv) create dynamic incentives for investments to innovate and continually improve environmental technology, generating both environmental and financial benefits (so-called "win-win"); (v) allocate property rights and responsibilities of firms, groups or individuals so that they have both the incentive and the power to act in a more environmentally-responsible manner; and (vi) raise revenues that can be used for environmental purposes or for social benefits (e.g., decreasing income taxes)

VIII. INITIATIVES ON THE TRANSFER OF ENVIRONMENTALLY SOUND MANGROVE-RELATED TECHNOLOGIES

111. As illustrated in a previous section of this overview, initiatives on the transfer of ESTs can involve, *inter alia*, individual governments or groups of governments, indigenous peoples' organizations, private sector, bilateral and multilateral assistance agencies, international and regional research institutions, non-governmental organizations and foundations. In preparing the present overview, it was difficult to find initiatives or projects specifically dealing with the transfer of ESTs relevant to the management of mangrove forests.

112. Thus, in this section a compilation of past and ongoing projects dealing with various aspects of mangrove forest management, conservation and scientific research (many of which are relevant to the transfer of ESTs and, thus, are of interest to the purpose of this overview) prepared by the International Society for Mangrove Ecosystems and supported by the International Tropical Timber Organization and other organizations and various funding agencies is provided (Tables 20 & 23)[167]. Lists and details of additional projects supported by FAO and the World Bank are given in Tables 21 and 22 respectively. In addition, a list of projects supported by the Secretariat of the Ramsar Convention on Wetlands is given in Annex 10. Those interested in finding more details of any particular project should contact the respective organization directly.

Table 20. Projects on mangrove forest management funded by the International Tropical Timber Organization (ITTO) worldwide since 1990

REGION/ COUNTRY/YEAR	TITLE OF PROJECT	BRIEF SUMMARY
ASIA-PACIFIC Thailand 1993-1997	Development and dissemination of re-afforestation techniques of mangrove forests	Surveyed existing mangrove forests and developed mangrove afforestation techniques to promote large scale reforestation for the restoration of mangrove forests.
Thailand, Malaysia, Indonesia, Fiji 1991-1992	The economic and environmental value of mangrove forests and present state of conservation	Collected and analysed available information, field visits of mangrove forests and agencies engaged in Asia-Pacific region for their management and utilization.
LATIN AMERICA Colombia 1995-2000	Conservation and management for multiple use and development of Colombian mangrove swamps Phase I, Phase II, Stage I and II	Incorporate the management of mangrove forests into sustainable development strategies for the coastal communities.
Colombia 2001-2003	Sustainable management and rehabilitation of mangrove forests by local communities of the Caribbean coast of Colombia	Sustainable management and rehabilitation of degraded mangrove forests for local communities in Caribbean regions of Colombia.
Honduras 1999-	Management and conservation of mangroves in the Gulf of Fonseca, Honduras-Phase I and II	Reduce pressure of local communities on mangrove forests by establishing and protecting fast-growing plantations for energy purposes and raise the awareness of the communities to the importance of mangrove ecosystems.
Panama 1992-1995	Management, conservation and development of mangrove forests in Panama	Achievement of sustained utilization and improved efficiency in exploitation of mangroves, improved conditions for local communities, and the maintenance of breeding and harvesting fisheries in the mangrove ecosystems.
Venezuela (not signed yet)	Evaluation of mangrove forests in the north-west of the Orinoco delta region in Venezuela with a view to sustainable forest utilization	Evaluate all aspects related to mangrove species to develop management plan and determine socio-economic aspects for sustainable used of mangrove forests in the Delta Amacuro State.
AFRICA Gabon 1996-1998	Multiple resources stratification, mapping and inventory for the first forest zone in Gabon-Phase I	Development of a land-use plan proposal to allocate the National Permanent Forest estate within the first forest zone of Gabon.
GLOBAL Latin America and Africa 1992	Workshop on conservation and sustainable utilisation of mangrove forests in the Latin American and African regions	Collected information on mangrove forests in ITTO member courtiers in Latin America and Africa to create regional program for sustainable utilization, conservation and management of mangrove forests.
All regions 1991-1992	Establishment of an international network for the conservation and sustainable utilisation of mangrove forest genetic resources	Established global network to assist coastal communities by the sustainable management and wise use of mangrove ecosystems and to make gene pool through bio-diversity conservation at national regional and global levels.
All regions 1993-1995	Manual and world natural mangrove atlas for mangrove system restoration	Compiled relevant information and produced three books to enhance public awareness of the importance of mangrove ecosystems and to provide planting, restoration, rational management techniques of mangrove communities.
All regions 1997-2003	Global mangrove database and information system (GLOMIS)-Phase I, II	Establish database of all published and unpublished data on the mangroves and it ecosystems to provide researcher, planners, policy and decision makers and coastal zone managers for sustainable utilisation of mangroves for timber, fisheries and other users.
All regions 1996 (6 months)	Mangrove resource information system of the scope and content of existing databases	Evaluated the scope and content of existing database (Pre-project to the GLOMIS project).

Note: In addition, the following projects and pre-projects (to be supported by the ITTO) were awaiting an implementation agreement in late 2002 following the recommendations of the ITTO's Expert Panel for the Technical Appraisal of Project Proposals at its 24th Meeting in Yokohama, Japan (29 July-2 August 2002):

PD 55/98 Rev.3 (F)	Evaluation of Mangrove forests in the North-East of the Orinoco Delta Region in Venezuela with a View to Sustainable Forest Utilization (Venezuela)
PD 63/01 Rev.2 (F)	Assessment and Management of Mangrove Forests in Egypt for Sustainable Utilization and Development (Egypt)

PPD 40/02 Rev.1 (F)	Conservation and Sustainable Management of Mangroves in the Kouilou Coastal Area with the Participation of Local Communities Established in the Area - South Congo (Congo)
PD 152/02 (F)	Demonstration Project for the Rehabilitation and Multipurpose Sustainable Management of Mangrove Forest Ecosystems on the Coast of Ecuador

Table 21. FAO projects on mangrove forests worldwide[168]

REGIONAL PROJECTS

REGION	TITLE	DURATION	MAIN OBJECTIVES
Africa (Gambia, Guinea, Guinea-Bissau, Senegal)	*Conservation des écosystèmes de mangrove en Afrique de l'Ouest (Gambia, Guinea, Guinea-Bissau, Senegal) (Project proposal)*	2002 -2006 (proposed)	La conservation des ressources en mangroves des 4 zones prioritaires dans trois pays en Afrique de l'Ouest (le delta du Siné-Saloum, Basse Casamance (au Sénégal), Rio Cacheu (Guinée-Bissau), Lower Gambia River District (Gambie) à travers l'élaboration et la mise en oeuvre des plans de gestion.
Africa (Gambia, Guinea, Guinea-Bissau, Senegal)	Formulation of Tropical Mangrove Eco-Systems In West Africa GCP/INT/483/NET	Mar 1996 - Dec 1998	Mission to formulate regional project (see above)
Africa	Aquaculture for Local Community Development Programme INT/436/SWE	1987 - 1997	Among other objectives this project focused on the relationship between mangrove ecosystem and fishery/aquaculture.
Asia and Pacific (Bangladesh & India)	Biodiversity Management in the Sundarbans World Heritage Sites: An Integrated Two-Country Approach in India and Bangladesh RAS/01/H01/A/IV/99 UNFIP	2002	Develop a full project proposal for the conservation and management of biodiversity and regeneration of degraded eco-biological condition of the Sunderbans World Heritage Sites and the surrounding areas.
Asia and Pacific (Myanmar & Pakistan)	Regional Wood Energy Development Programme in Asia (Phase II) FAO-FO--GCP/RAS/154/NET	Jul 1994 - Apr 1999	1. To contribute to an improved data base on wood energy at regional and national level 2. To contribute to the development and adoption of improved wood energy polices plans and strategies in member countries 3. To improve capabilities of Government, private and community based organizations in implementing wood energy strategies and programmes. Countries covered in relation with mangroves: Myanmar and Pakistan.
Asia and Pacific (Vietnam)	Regional Wood Energy Development Programme. FAO-FO--GCP/RAS/131/NET	Jun 1989 - May 1993	1. Strengthening regional co-operative network on wood energy. 2. Development and improvement of planning and implementation of wood energy development. 3. Development of wood energy strategies. 4. Enhancement of contribution of wood energy for household use. 5. Development of required manpower skills. The mangroves have been studied under protection (case study in Can Gio District) and charcoal point of view. The project is extended to Vietnam and Thailand.
Asia and Pacific (Fiji, India, Indonesia, Malaysia, Myanmar, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand)	Forestry Research Support Programme for Asia and the Pacific FAO-FO--GCP/RAS/134/ADB	Nov 1991 - Dec 1994	1. To Improve forestry research capabilities in the Asia-Pacific region in order to respond more effectively to the needs of the sector 2. To contribute to the enhancement of the socio economic well-being of the populations. The mangrove ecosystem aspects covered by the studies developed in this project were: management, ecology, reforestation and conservation.

Asia and Pacific	Agroforestry Systems Research and Development in the Asia and Pacific Region. FAO-FO--GCP/RAS/133/JPN	Sep 1990 - May 1992	Mangrove-related objectives: Identify, synthesize and present information from Southeast Asian countries on mangrove silvofishery systems, in order to improve the collective knowledge base; Strengthen the national agroforestry programme in the countries in order to further develop activities in mangrove silvofishery.
Asia and Pacific (Bangladesh, Cook Islands, Fiji, Indonesia, Malaysia, Myanmar, Papua New Guinea, The Philippines, Samoa, Thailand, Tonga, Vanuatu and Vietnam.	Special Study on Forest Management, Afforestation and Utilization of Forest Resources in Developing Regions FAO-FO--GCP/RAS/106/JPN	Feb 1984 - Jun 1987	Assist the countries to enhance their own capacity to safeguard the forest resources and the environment for present and future generations by adopting appropriate methods of conservation, development and utilization. This project also supplied available information on mangrove forests in Asia-Pacific region
Asia and Pacific (Bangladesh, India, Sri Lanka)	Small-Scale Fisherfolk Communities in the Bay of Bengal, Asia FAO-FI–GCP/RAS/118/MUL FAO-FI–BOBP/REP/67	1983 - 1995	The socio-economic betterment of small-scale fisherfolk infishing communities of the Bay of Bengal Region. The immediate project goals were: the development and demonstrations of methodologies and technologies by which the ultimate objectives were to be achieved, and the assistance to the participating countries in applying them on a wider scale by means of integrating them into their respective programmes for rural development of coastal areas. Some of the studies conducted on mangroves included the assessment of the resource and the analysis of silvi-pisciculture in these forests.
Asia and Pacific (Indonesia, Malaysia, Philippines, Singapore and Thailand)	South China Sea fisheries development and co-ordinating programme FAO-FI–SCS/80/WP/94a(Rev.) FAO-FI–RAS/74/013	1974 - 1983	Several mangrove characteristics have been studied during this project such as the relation between aquaculture and mangrove and its ecological consequences and the impact of pollution on different countries. Some proposal for research related to the utilization of mangrove have been also given. The countries covered by this project are: Indonesia, Malaysia, Philippines, Singapore and Thailand
Central America	Reseña del estado actual de los manglares en Honduras FAO-FO--HON/82/008	Jan 1982 - Dec 1986	1. La ordenación de pinares en las lajas, Rancho grande, Siguatepeque y la Paz; la iniciación de la segunda fase del plan comayagua 2. La ordenación forestal unidades teupasenti, campamento y guaimaca 3. El desarrollo del aprovechamiento de trozos de pequeño diametro y de plantas defectuosas 4. Capacitar personal en ordenación forestal y planificación desarrollo industrial 5. Reglamentar decreto ley 103 de la ley forestal. Los manglares se estudiaron en distintos niveles, los principales son: a. fauna silvestre (tanto terrestre como marina); b. manejo Los paises analizados fueron: El Salvador, Guatemala, Honduras. Algunas referencia también para Malaysia.
South America	*Gestión Participativa en Areas de Manglares (Proposal)*	*2002 - 2003 (fecha propuesta)*	*El objetivo principal del proyecto es suscitar la partecipación de algunas comunidades, que dependen para su subsistencia de la explo tación del manglar, en la gestión del manejo sustenible y del manejo compartido entre Estado-usuarios-sociedad. Los países incluidos en el proyecto son: Colombia, Ecuador, Panamá y Venezuela.*

INDIVIDUAL COUNTRY PROJECTS

COUNTRY	TITLE	STARTING DATE	MAIN OBJECTIVES
Bangladesh	Overseas Training Component for the Sundarbans Biodiversity Project	2002-2003	This project represents the training component of the overall GEF/ADB project. The subjects to be covered include: 1. Topics related to Forest Resources Assessment; 2. Mangrove conservation and management; 3. Economic Development and Income-Generating Activities; 4. Participatory Forestry; 5. Management Information Systems, Communications and Media

Bangladesh	Integrated Resource Development of the Sundarbans Reserved Forest FAO-FO--DP/BGD/84/056	Jan 1992 - sep 1995	1. The monitoring for the Sundarbans ecosystem, focusing on spatial and temporal changes and the effects of different treatments on the long-term sustainable management of the system; 2. The planning for integrated resources management ; 3. The construction of an enhanced institutional framework to facilitate the integrated management of the Sundarbans. Physiology, pathology and harvesting aspects of mangrove forests are also been studied.
Bangladesh	Assistance to the Forestry Sector (Phase II) FAO-FO--BGD/85/085	Jan 1987 - Dec 1990	1.Develop a Forest resources Management system which incorporates socio economic, environmental and investment consideration; 2. Apply silvicultural research findings to the field; 3.Develop basic Forestry education and training at the Sylhet Forestry school and Chittagong Forestry college. The studies developed on mangroves were especially focused on coastal afforestation and plantation techniques and methodology.
Bangladesh	Assistance to the Second Agricultural Research Project FAO-AG–BGD/83/010	1985 - 1990	Strengthen forest research institute Chittagong by assisting the forest management branch of the institute in: A) designing, implementing, and evaluating research programmes; B) development of a site classification methodology for selected species (including training).
Bangladesh	UNDP/ESCAP Regional Remote Sensing Programme, Asia, RAS/81/034	1985 - 1986	In the framework of this project several reports on the analysis of mangrove forests extent and on the relation between shrimp/fish farms and mangrove ecosystem using remote sensing techniques have been carried out.
Bangladesh	Remote sensing application to accretion and erosion studies and their effects on mangroves. FAO-AGO–BGD/81/009	1983 - 1984	The principal studies that have been carried out during this project focused on the use of remote sensing techniques to analyze the impact of storms on mangrove.
Bangladesh	Fisheries Resources Survey System FAO-FI–BGD/79/015	1982 - 1985	
Bangladesh	Assistance to the Forestry Sector FAO-FO--BGD/79/017	May 1981 - Nov 1984	1. To maximise production of forest products; 2. To develop the forest resources in the Government and private homestead forests; 3. To provide protection against cyclones, tidal bore and soil erosion; 4. To provide outdoor recreation. Specific actions on mangrove forests have been carried out during the development of this project.
Bangladesh	Applied Remote Sensing Technology FAO-AGL--DP/BGD/75/029	Aug 1977 - Aug 1979	1. To evaluate the extent to which Landsat and other satellite data can be applied for development and planning purposes in Bangladesh 2. To develop the capacity of the Landsat Task Force to improve and analyse existing data and to provide new additional data for identifying vegetation types, forests (mangroves), and water resources by different computer systems and visual interpretation methods of Landsat data 3. To determine the appropriatenes and effectivened of various satellite data interpretation techniques, and subsequently to apply those techniques in country-wide use in various sectors, i.e., agriculture, forestry, water reosurces, cartography, oceanography, fisheries, geology and metheorology 4. To develop in-country training for scientists and engineers in the application of satellite data to agricultural and natural resources surveys and management, and to identify specialized international training sessions in which Bengali scientists should participate.

Bangladesh	Development of the Forest Research Institute, Chittagong. FAO-FO--BGD/72/005	Nov 1976	The project at long term was intended to provide the Government with the technical knowledge required to implement its forest policy and make maximum use of the country's forest resources. The immediate objectives were: 1. To establish (or strengthen) research units at the FRI in the silviculture and forest management disciplines 2. To formulate a research programme for these units paying rigid attention to the FD's development plans and problems 3. To initiate, guide and assess research activities 4. To train counterpart personnel in research planning, organization and evaluation through on-the-job training and a fellowship programme 5. To advice and assist the government as required in establishing a forestry training programme. The project also supply proposals and studies on mangrove artificial regeneration and on coastal afforestation. Some studies on Pakistan mangroves are also included in this project.
Bangladesh	Sundarbans Forest Development Planning Mission, FAO-FO--TCP/BGD/2309(Mf) FAO-FO--TCP/BGD/2309	1984	Several aspects of the Sundarbans mangrove have been studied in the framework of this project, among these the principal are: the morphological, ecological, silvicultural and management aspects.
Costa Rica	Manejo Integral de una Area de Manglar, Costa Rica FAO-FO--TCP/COS/6652	1988 - 1991	Fortalecer la acción del Gobierno en la planificación del manejo y en el aprovechamiento sostenido de los ecosistemas de manglares, a fin de contribuir eficazmente a un incremento de los beneficios a largo plazo y reducir los efectos negativos de deterioro del medio, aumentando la contribución de los manglares al mejoramiento de las condiciones de vida de los pobladores de la zona y manteniendo la alta productividad y diversidad biológica del área.
Cuba	Manejo Integrado del Ecosistema de Manglares FAO-FO--TCP/CUB/8851	Apr 1988 - Apr 1989	1. Fortalecer la acción del gobierno en la planificación de manejo/aprovechamiento de ecosistemas de manglares 2. Desarrollar técnicas practicas para zonificar, manejar y regenerar manglares en una área piloto 3. Preparar plan investigación uso multiple del mangle y estudiar los efectos en la conservación del ecosistema.
Egypt	Rehabilitation, Conservation and Sustainable Utilization of Mangroves in Egypt TCP/EGY/0168 (A)	Jan 2002 - Jun 2003	To assist the Government of Egypt to rehabilitate, conserve and sustainably utilise the mangrove resources in the country by assisting the Government : 1. Assessing the present situation on mangrove ecology and carrying out a complete inventory for the country 2. Conducting studies and pilot activities on mangrove conservation, rehabilitation and sustainable utilization, in order to develop a national mangrove conservation and development programme 3. Formulating a full-fledged National Development Programme for the rehabilitation, conservation and sustainable utilization of mangrove resources in Egypt within the overall framework of the existing Integrated Coastal Zone Management Action Plan for the Egyptian Red Sea 4. Strengthening the national capacity in all aspects of mangrove rehabilitation, conservation, utilization and management and raise awareness on the crucial role of mangroves for the sustainability of the Red Sea ecosystem.
Fiji	Forestry Sector Development Study FAO-FO--FIJ/88/006	May 1988 - Apr 1990	Prepare development strategy, action plan and investment proposal for forestry sector. There are several references to the mangrove forests within the framework of this project.
Gambia	Integrated Coastal Fisheries Management FAO-FI--DP/INT/91/007	June 1992 - June 1996	To develop and improve methodologies and coordinating mechanisms for integrated coastal fisheries management and to prepare a detailed document for an enlarged programme phase. A specific study on ecology of mangroves in Gambia has been conducted during the development of this project.
Guinea	Elaboration d'un Plan d'Amenagement de la Mangrove FAO-FO--TCP/GUI/6654	1986	Formulation d'un document de projet visant a l'elaboration d'un plan d'amenagement de la mangrove
Guinea-Bissau	Development of Mangrove Lands for Rice Cultivation in Tombali and Quinara (formerly Buba) Regions FAO-AG--TCP/GBS/2307	Jan 1983 - Jun 1988	1. Reclamation of mangrove lands for rice cultivation 2. Reconstruction of existing rice field protection dykes. This project could be considered an extension of the GCP/GBS/006/BAD.

Guinea-Bissau	Assistance d'Urgence pour l'Archipel de Bijagos en Vue de la Relance de la Production Vivriere FAO-OSRO–TCP/GBS/0105 FAO-OSRO–GBS/101	1981 - 1983	Organiser le contrôle des apports fournis par le projet à Bissau et leur transport à l'archipel de Bijagos; superviser la distribution des facteurs de production auprès des agriculteurs; organiser et mettre en place des parcelles de démonstration aux fermes d'Etat de Bolama et Bubaque; vulgariser des techniques culturales améliorées; assister le Gouvernement dans la récupération des semences de variétés améliorées distribuées, et établir un stock de réserve pour la prochaine campagne agricole; evaluer l'impact du project sur l'amélioration du rendement des rizières couvertes par le projet et sur le bilan de la productin de semences réalisée dans les fermes d'Etat de Bolama et Bubaque.
Guinea-Bissau	Reclamation of Mangrove Lands for Rice Cultivation in the Tombali and Quinara Southern Regions of Guinea-Bissau FAO-AG-GCP/GBS/006/BDA	Dec 1979 Jan 1983	The main objective of the project was the reclamation of mangrove lands for rice cultivation.
Guinea-Bissau	BADEA project formulation - Rice culture in mangrove swamps FAO-AGO–TCP/GBS/8803	1979	n.a.
Guyana	Rehabilitation of Agriculture Following Heavy Rains and Tidal Waves FAO-FO--TCP/GUY/8953	1990	Les études sur le reboisement et l'érosion égalenet en relation avec les forêts de mangrove, ont éte réaliseé durant la phase de développement de ce projet.
Haiti	Reboisement et lutte contre l'erosion FAO-FO--DP/HAI/72/012	1974 -1977	Studies, also related with mangrove forests, on reforestation and erosion have been done during the development of this project .
Indonesia	Technical assistance to the National Forest Inventory. UTF/INS/066/INS	Jul 1988 - Jun 1996	The development objective was to develop and establish a NFI (National Forest Inventory) and forest resource monitoring capability within the Ministry of Forestry (MOF) through: a) forest resources monitoring, covering o Monitoring of forest cover type, using low resolution RS technology o Monitoring change assessment, involving a statistically designed system of 'hidden' b) forest resources assessment, including: o Forest type mapping, using high resolution RS technology o field sampling for volume and growth, based on Temporary Sample Plots (TSPs) and PSPs c) a geographical information system, comprising a computerized GIS incorporating DIAS d) user involvement through the formation of a user group.
Indonesia	Shrimp Culture Development, Indonesia FAO-FI–INS/85/009	Apr 1987 - Oct 1990	The development objective was to contribute to government priorities in the fisheries sector, which call for increase in shrimp production, in non-oil foreign earnings from shrimp production, and in in comes and employment in the small form sector. The Immediate objective was to develop the BADC (Brackishwater Aquaculture Development Project) and its regional sub-centres into a network capable of providing technical support to the shrimp culture industry and of making the environment conductive to the development and successful operation of small-scale shrimp hatcheries and tambak forms. This project also analysed the relation between mangroves and shrimp farms.
Indonesia	National Parks Development Project. National conservation plan for Indonesia FAO-FO--INS/78/061	Feb 1979 - Sep 1982	1. Prepare a national Master plan for Indonesia to identify priority areas for environmental conservation 2. Establish six national parks; strengthen directorate of nature conservation as a parks management agency; environmental protection 3. Multiple forest use schemes for buffer zones around the protected areas. Proposal for mangrove national park included.
Indonesia	Forestry and Forest Products Development, Indonesia. FAO-FO--INS/78/054	Jan 1979 - Dec 1981	1. Strengthening forestry development planning capacity 2. Identification of opportunities for forest industries development. 3. Assistance in the plantation management, forest inventory, logging techniques, land use planning, manpower planning. Activities included mangrove afforestation.
Indonesia	Indonesia - Development of the aquatic resources of Indonesia FAO-FI–DP/INS/72/064/1	Apr 1973 - 1976	Provide advisory services to the Director-General in appropriate sectors of the fishery development programme. Mangroves studies were included in the objectives of the projects

Kenya	Mangrove Conservation and Management FAO-FO--TCP/KEN/0051 FAO-FO--TCP/KEN/0051(A)	Sep 1990 - Aug 1992	1. Develop of strategy to conserve/develop productivity of mangroves for coastal protection, forest products, fisheries, aquaculture. 2. To prepare a project document for long term project on mangrove management.
Madagascar	Fisheries Development and Management Project for the South West Indian Ocean FAO-FI--RAF/87/008 FAO-FI--WP/44/89	Jan 1988 - Feb 1991	The mayor objective of the project is to assist the countries having seaboards on the Southwest Indian Ocean to attain self-sufficiency in monitoring their fisheries and in planning for their development and management. (regarding mangroves the country studied is only Madagascar). Some information on socio-economic aspects of mangrove ecosystem is also given in the project.
Madagascar	Assistance a l'Administration des Peches et de l'Aquaculture, Madagascar FAO-FI--MAG/85/014	May 1987 - Dec 1991	L'objectif à long term du projet était de contribuer au développment et à l'aménagement de la pêche maritime et continentale à Madagascar. Par là même, le projet visait à créer de nouveaux emplois, à élever le niveau de vie des pêcheurs et des piscicultures, à améliorer la situation nutritionnelle des populations, à accroître les exportations et à améliorer la participatio du secteur à l'effort général de développement du pays. Des in formations générales sur l'écosystème de palétuvier du Madagascar sont également données .
Maldives	Support to Community Tree Planting FAO-FO--TCP/MDV/2251 FAO-FO--TCP/MDV/2251(A)	Jan 1993	To provide: 1. The means by which tree planting by the people could be supported 2. Advice to arrest the loss of natural mangrove forest. Mangrove forests have been studied under ecological and conservation aspects.
Mexico	Programa de investigaciones y fomento pesqueros. FAO-FI--MEX/15	1972 - 1974	n.a.
Mozambique	Support to the Management of Forestry and Wildlands Resources Pre-Programme FAO-FO--MOZ/92/013	Jan 1993 - Dec 1994	1. To contribute to sustainable natural resource management and utilization through improved effective and cost efficient forestry and wildlands related activities 2. To elaborate a programme of investment actions in the forestry sector. The studies on mangrove were especially focused on the determination of the deforestation rate. (The project is a follow up of proj MOZ/86/003 and MOZ/86/029).
Mozambique	Institutional Support to Rehabilitation of Forestry and Wood Processing Industries FAO-FO--MOZ/86/003	Jan 1987 - Dec 1989	1- Rehabilitation of forestry industries to increase production 2- Help implement national reforestation plan 3- Training at all levels 4- Participate in operation of provincial forestry service 5- Technical assistance to organization of Nat For Directorate The mangrove resource of Mozambique were evaluated and assessed.
Mozambique	Inland Fisheries Research and Development Project FAO-FI--GCP/MOZ/006(SWE)	1980 - 1988	The project included activities on the relation between aquaculture and mangrove ecosystem.
Myanmar	Environmentally Sustainable Food Security and Micro Income Opportunities in the Ayeyarwady (Mangrove) Delta FAO-FO--MYA/99/008	Jul 1999 - Sep 2001	1. To enhance the understanding of natural resources with special emphasis on the environmental constraints with a view to design land based food security and income generation initiatives; 2. To enhance scope of income generation opportunities for identified target population for sustainable living; 3. Strengthen capacities of grass root communities to implement environmentally sustainable food security and environmental conservation initiatives and for self-reliance. Among others one of the objectives related with mangroves is the establishment of Mangrove Extension Centers covering different aspects of mangroves.
Myanmar	Environmentally Sustainable Food Security and Micro-Income Opportunities in the Ayeyarwady (Mangrove) Delta, Union of Myanmar FAO-AG--DP/MYA/96/008	Oct 1996	1. To achieve sustainable food security and micro-income generating activities for its population 2. To increase agricultural and allied production for sustainable food security 3. To increase incomes of lower income groups. 4. To increase production and supplies of food by involving small farmers, who predominate project area, requires careful coordination with many other agencies to get a tangible result over time.
Myanmar	Community Development of Ayeyarwady Mangroves FAO-FO--DP/MYA/93/026	Feb 1994 - Feb 1996	To strengthen rural capacity in planning / implementing Mangrove protection and conservation, improved sustainable fisheries and fuelwood supplies. (This proj forms an integral part of the cross-cutting under the multisectoral "Human development initiative" which calls for sustainable beneficial grassroots impacts, in line with UNDP GC decision, along with other two proj. MYA/93/003 and MYA/93/005

Myanmar	Feasibility Study on Mangrove Reforestation FAO-FO--MYA/90/003	Apr 1991 - Dec 1993	Rehabilitation and management of Mangroves. Other aspects of the mangrove ecosystem that have been analysed in the framework of this project are: products and utilization, reforestation techniques, extent, inventory and status.
Pakistan	Forestry Sector Master Plan FAO-FO--PAK/88/018	Aug 1990 - Aug 1992	Prepare a long term plan for the forestry sector setting out a 25-year development and investment strategy and programme for Pakistan. A specific study on mangrove forest has been carried out.
Panama	Forest Industries Development Project in Latin America. FAO-FO--RLA/77/019	Jan 1978 - Jul 1982	1. Study investment possibilities in Latin American countries whose forestry resources would permit in short term the development of industry 2. Assist in priority projects for investment and promote and stimulate the execution of approved projects 3. Strengthen the national technical and planning capabilities on forest industry projects. Mangrove management and harvesting aspects in Panama were studied.
Papua New Guinea	Assistance in Selective Technical Aspects of Forestry FAO-FO--PNG/84/001/A/01/12	1985 - 1986	The long term objectives is to promote scientific management and rational utilization of the forest resources of PNG for the production of sustained benefits over the long term to the economy, in general, and to the rural people, in particular. The Immediate objectives were to reinforce and complement the current research of the Government in the proper management of lowland tropical forest and provide relevant documentation which will assist the Government in implementing its reforestation policy. The project included activities related to demonstrating the economic viability and environmental feasibility of mangrove forest exploitation.
Philippines	Soil and land resources appraisal and training. FAO-AGO–PHI/74/003	Jun 1974 - May 1978	The long-term objective was to assist in attaining substantial increases in agricultural production, through the provision of accurate and comprehensive information on the potentials and most appropriate uses of land, and through strengthening the Government's permanent machinery for land resources appraisal. The immediate objectives were: 1. To assist in implementing the initial phase of nationwide soil and land resource appraisal programme 2. To assist in training government technical personnel responsible for long-term continuation of the programme. Some references to mangrove ecosystem are also given. The Government planned to follow-up the project. Previous UNDP/FAO assistance in related activities was given through the project 'Soil Fertility Survey and Research' (PHI/63/510) which operated between 1963 and 1971.
Senegal	Mise en valeur de la Basse et Moyenne Casamance, Republique du Senegal. Inventaire forestier FAO-FO--DP/SEN/71/522 (first phase) FAO-FO--DP/SEN/78/002 (second phase)	1973 - 1981	Premier Phase: préparation d'un plan de développement des forêts et industries forestières de Basse et Moyenne Casamance et la formation pratique des agents techniques des eaux et forêts sortant de l'Ecole forestière de Ziguinchor. Certains des objectifs immédiats étaient: Inventaire des périmètres forestiers classés et d'autres périmètres forestiers reconnus comme contenant suffisamment de volume ligneux et vide de population de façon à permettre une exploitation rationelle; des sondages deraient également effectués en mangrove; recommandations quant aux technqies possible d'aménagement, notamment d'éclaircies et d'entretien des plantations forestières existantes, en vue d'améliorer leur productivité; recommendations sur le choix de nouvelles essences à introduire et sur les méthodes et techniques appropriéetes; propositions quant aux tyes d'industries forestières à établir soit dans la région, soit dans les zones de consommation. Deuxième phase: Contribuer à freiner le processus de désetification du Sahel
Sierra Leone	Integrated Mangrove Management FAO-FO--TCP/SIL/3451	Oct 1994 - Feb 1995	To formulate a project entitled "The integrated Management and Utilization of the Scarcies River Mangroves" meeting international donor requirement as regards project presentation and content.
Sierra Leone	Community Participatory Forestry for Fuelwood Production in the Western Area FAO-FO--DP/SIL/88/008	Oct 1988 - Sep 1990	1. To upgrade the capacity of the forest division to plan and implement a programme to increase supplies of fuelwood, charcoal, poles to the western area. 2. The establishment of fuelwood plantations. More in the specific case studies on mangroves management were conducted during the project.

Sierra Leone	Alleviation of the Fuelwood Supply Shortage in the Western Area FAO-FO--DP/SIL/84/003	Jun 1985 - Dec 1988	The project wanted to supply strengthening of the forest division in the Western Area through the training of forest division personnel in resource and management and favouring the increase of utilization forest resources improvement in yield. Studies on mangrove and community forestry were conducted.
Sierra Leone	Strengthening of the Division of Land and Water Development FAO-AGL--SIL/80/010	1981 - 1984	At long term the project intended to carry out studies and make recommendation on: 1. development of agriculture research with particular emphasis on self-sufficiency in the staple foods 2. Improvement in the conservation and effective use of land and water resources to ensure sustained agricultural production 3. increased production of cash crops as a foundation for the development of agroindustries. The immediate objectives were to assist the LWDD in carrying out nationwide, land suitability evaluation studies, detailed surveys and studies in specific areas identified as a having development potential and selected by the Government and improving and increasing the advisory capacity of the Division to meet the increasing demands for agricultural planning and development. A specific study on swamp ecosystem has been carried out during the development of this project.
Sierra Leone	Assistance to the West Africa Rice Development Association FAO-AGO–RAF/75/220 (first phase) FAO-AGO–RAF/75/022 (second phase)	Feb 1972 - Dec 1981	1. Provide assistance to WARDA's activities undertaking missions for project identification and appraisal 2. Exchange of information and conducting joint missions with bilateral and multilateral financing institutions 3. Carrying out general and sectorial studies 4. Preparing training manuals and other documents; providing library assistance. The mangrove ecosystem aspect studied in the framework of this project is essentially the pathology one.
Sierra Leone	Sierra Leone: integrated development of the agricultural sector AGS-UNDP/SF SIL/3	Aug 1967 - Mar 1970	Examine and make recommendations on institutional requirements for stimulating the agricultural progress and transition from a subsistence to a market economy. The project highlight the relation between agriculture and mangrove swamp.
Sierra Leone	Land Resources Survey, Sierra Leone FAO-AG–DP/SIL/73/002	1977 - 1981	Among other things a brief description of mangrove ecosystem in general is given in this project.
Sudan	Fuelwood Development for Energy (Phase III) FAO-FO--GCP/SUD/047/NET	Apr 1992 - Mar 1996	1. To support tree planting 2. To strengthen the capability to prepare and implement multiple use management plans for woodlands and forests with community participation 3. To promote wood energy conservation through development and dissemination of means to reduce wastage 3. To develop the FNC capability in multi-level planning. A specific work on mangrove conservation and status has been carried out in the framework of this project. (Extension of GCP/SUD/033/NET which started on 7-9-1983 and ended on 31-3-1992)
United Arab Emirates	The mangroves and related coastal fishery resources in the United Arab Emirates FAO-FO--UAE/78/002	1978 - 1981	Development objectives: 1. To assess and develop mangrove resources of the country and the related coastal fishery resources 2. To formulate a long term forestry/fishery policy to maintain and conserve coastal resources. The immediate objectives were: 1. To make a detailed and accurate evaluation of present extent of mangrove resource and to maintain, develop and expand (if possible) the resource 2. To conduct stock assessment of coastal fishery resources so that appropriate measures for their utilization and development can be adopted 3. Effect a programme of optimum utilization of the coastal fishery resources 4. Identify coastal resources not presently ut ilized or underutilized and recommend measures for their proper utilization.
Venezuela	Forestry development and industrial promotion of less known forest species of Venezuelan Guiana FAO-FO–VEN/72/019	1975 - 1979	Se estudió la fauna del ecosistema manglar, con particular atención a la avifauna, y algunos aspectos del manejo de estas forestas.

Vietnam	Technical Support to Afforestation programme in different areas FAO-FO--VIE/86/027	Nov 1988 - Oct 1991	1. Carry out species selection and plantation trials 2. Identify tree species, potential of sites, elaborate proper technology 3. Provide technology / technical materials for establishment of fuelwood plantations Specific studies on mangrove plantation were conducted in this project.
Vietnam	Forest Management Planning and Implementation FAO-FO--VIE/82/002	Jun 1985 - May 1990	Assist Government in formulating national forest management . Prepare and implement model forest management plans including case studies on mangroves.

Table 22. Projects with mangrove components funded by the World Bank since 1990[169]
(for additional projects see Table 22, below)

1. Viet Nam - Coastal Wetlands Protection and Development Project (Approved: FY'99, IDA Credit: $31.8 million, Mangrove Component: Primary)

Project Objectives:
Re-establish the coastal mangrove wetland ecosystem and protect their aquatic nurturing and coastal protection functions.

Mangroves:
The primary focus of the project is on mangroves which will be effected by direct interventions as follows:
- the expansion of coastal mangrove planting
- the sustainable management and protection of mangrove wetlands
- the revised zoning of mangrove areas
- capacity building of forest institutions
- increases environmental awareness

Indirect interventions include:
- improved livelihood of populations living around mangrove wetlands
- extension and outreach activities directed to farmers
- communal investment fund
- commune action plans

2. Haiti Forest and Parks Protection Technical Assistance Project (Approved FY'96, IBRD Credit: $21.5 million, Mangrove Component: Significant)

Project Objectives:
To establish the institutional, policy and financial foundation for the Government to protect the remnants of Haiti's forest ecosystems and slow the pace of degradation of forest resources.

Mangroves:
The Haiti project is listed as covering 150 km^2 of degraded mangrove forest. As such, mangroves will benefit from the following direct interventions:
- support for the management of forests and national parks
- support for buffer zone development to reduce pressure on protected areas

Indirect interventions include:
- strengthening of Government capacity to mange and protect the natural environment

3. Bangladesh Forest Resources Management Project (Approved: FY'92, IDA Credit: $49.6 million, Mangrove Component: Significant)

Project Objectives:
Following on from the Mangrove Afforestation Project and the Second Forestry Projects, the Forest Resources Management Project aims to establish a forest management system which will improve the productivity of government owned forests and protect the forest environment.

Mangroves:
Mangroves comprise some of the government owned forest in Bangladesh and therefore, will be included in project activities including direct interventions such as:
- the establishment of coastal plantations
- supporting technical education and training including mangrove research
- pilot community forestry projects
- mangrove afforestation

Indirect interventions include:
- improving the Resource Information Management System
- integrating environmental and socio-economic factors into forest management

4. Honduras Sustainable Coastal Tourism Project (Approved: FY'01, IDA Credit: $5 million, Mangrove Component: Minimal)

Project Objectives:
Facilitate the development of sustainable coastal tourism along the North Coast of Honduras by supporting interventions at the local, municipal and national levels.

Mangroves:
Mangroves are addressed from a preservation point of view in recognition of their value to sustainable coastal tourism. Direct interventions which address mangroves include:

- reduction of unauthorized logging

Indirect interventions include:

- increased local capacity for environmental management
- development of the Sustainable Tourism Action Plan

5. Indonesia Integrated Swamps Development Project (Approved: FY'93, IBRD Loan: $65 million, Mangrove Component: Minimal)

Project Objectives:
The project objectives include alleviating poverty by developing the agricultural potential of swamp lands while ensuring sound environmental practices in swap areas.

Mangroves:
Mangroves are present in Indonesian wetlands and therefore will be directly effected by:

- coastal zone management including the establishment of a protected area and buffer zone

Indirect interventions include:

- improved water control infrastructure
- development of agricultural potential and food crop production
- land titling component

6. Brazil Ecological Corridors Project (Approved: FY'02, IBRD Loan: proposed, Mangrove Component: Minimal)

Project Objectives:
Pilot ecological corridors as effective conservation mechanisms through building sustainable economic, social and political frameworks.

Mangroves:
Mangroves are included in the Central Atlantic Rainforest Corridor (CARC) and while their exact extent isn't listed the best approximation is that the interventions that impact the CARC also have the potential to affect mangroves. Direct interventions include:

- development of corridor planning and management plans
- environmental monitoring
- Corridor Patrolling and Vigilance systems
- protection of biodiversity in indigenous areas

Indirect interventions include:

- the preparation of Municipal Management Plans
- corridor marketing
- decentralization of management activities to local levels

7. China Sustainable Forestry Development Project (Approved: FY'02, IBRD Loan: $93.9 million, Mangrove Component: Unknown)

Project Objectives:
Develop a participatory approach to the conservation and sustainable use of forest resources and the associated biodiversity.

Mangroves:
As one of the forest types in the Hainan province mangroves may be included in natural forest management component and the protected areas management component. The degree to which these components include mangroves however, is not explained. The interventions which would affect mangroves, if mangroves fall within the project area of that particular intervention include, direct interventions:

- re-zoning and reclassification of forest areas
- review of current regulations based of optimal yield studies
- economic valuation of forests
- participatory forest management plans and co-management options
- protected areas management

Indirect interventions include:

- plantations to reduce pressures on natural forests

- research and special studies (e.g. study on fuel-wood usage)

8. Papua New Guinea Forestry and Conservation Project (Approved: FY'02, IBRD Loan: $17.36 million, Mangrove Component: Unknown)

Project Objectives:
Increase institutional capacity to conserve and sustainable manage forest resources while ensuring the sustainable livelihoods of populations with customary titles in forest areas.

Mangroves:
Mangroves are mentioned as one of the forest types in Papua New Guinea however it is not evident as to what interventions affect mangroves. General interventions which may or may not cover mangroves include direct interventions:
- conservation through landowner managed conservation areas
- improved systems of monitoring and enforcement in forest areas
- regeneration after logging

Indirect interventions include:
- improved capacity of landowner organizations
- industrial plantations to relieve pressure on natural forests
- improved capacity of the Office of Environment and Conservation

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Table 23. Projects on mangrove forest management funded by organisations other than ITTO and FAO since 1980

REGION/ COUNTRY	TITLE OF PROJECT	YEAR	IMPLEMENTING AGENCIES	FUNDING AGENCIES
ASIA				
Bangladesh	Mangrove afforestation project	1980-	N/A	World Bank
India	Tourism and the environment: case studies on Goa, India, and the Maldives	Report submitted 2001		World Bank
India, Sri Lanka	Assessment of mangrove degradation and resilience in the Indian subcontinent: cases of Godavari estuary and South-West Sri Lanka	1994-1998	VUB (Belgium) and other countries	EC ERB, FWO – Flanders
India	An assessment of the ecological importance of mangroves in the Kakinada area, Andhra Pradesh, India	1994-1998	Mangrove Management Group, Vrije Universiteit Brussel –	EC, FWO – Flanders
Indonesia	The development of sustainable mangrove management project	1992-1997	Japan International Cooperation Agency (JICA)	JICA
Indonesia	Handbook production of mangroves in Indonesia-Bali and Lambok	1997	ISME-JICA	JICA
Malaysia, Thailand, Vietnam	SE-Asia Tropical Coastal Ecosystem Project	1997-2000	Danish/ Thailand, Malaysia and Vietnam Governments	DANCED
Maldives	Tourism and the environment: case studies on Goa, India, and the Maldives	Report submitted 2001	-	JICA
Maldives	Experimental Plantations, Raising Nurseries of Some Mangroves, and Research for Restoration of Mangrove Ecosystems in the Republic of Maldives	2000-	ISME	Japan Fund for Global Environment
Myanmar	Mangrove Forestation Project	1999-2004	Action for Mangrove Reforestation (ACTMANG)	Tokyo Marine
Pakistan	Korangi-Phitti Creek Mangrove Project	1991-1998	IUCN-Pakistan	NORAD
Pakistan	Rehabilitation of mangrove along the Balochistan Coast	1994-1997	IUCN-Pakistan, ISME	Ministry of Post and Telecommunications ,Japan
Pakistan	Rehabilitation of Mangrove Forests in the FOTCO Terminal area of Port Qasim	2001	IUCN-Pakistan	The Fauji Oil Terminal Company (FOTCO)
Pakistan	Mangrove walkway	1996	IUCN-Pakistan	IUCN-Pakistan

REGION/ COUNTRY	TITLE OF PROJECT	YEAR	IMPLEMENTING AGENCIES	FUNDING AGENCIES
Pakistan	Honey bee-keeping in Mangrove		IUCN-Pakistan	NORAD, UNDP
Philippines	First national roads improvement and management project (NRIMP)	2000-2004	Dept. Public Works and Highways	World Bank PO39019
Philippines	Prediction of the Resilience and Recovery of Disturbed Coastal Communities in the Tropics (SE Asia):	1998-2001	MERC (Partners: Spain, Denmark, Netherlands, Portugal, UK and the Philippines)	EU
Philippines	Project on Coastal resources issues	?	GreenCOM. USAID	USAID
Philippines	Mangrove plantation project	1992-	ADB, Philippines, OISCA	ADB, Philippines Government
Thailand	The integrated multidisciplinary survey and research programme of the Ranong mangrove ecosystem	1982-1990	UNDP/UNESCO work with representatives from 15 countries from all regions	UNDP/UNESCO
Vietnam	Coastal Wetlands Protection and Development Project	1999-2006	MARC, Prov. Peoples Committee	World Bank
Vietnam	Evaluation of effects of planted mangrove forests on biodiversity, socio-economy and environmental education in coastal area of Nam Dinh and Thai Binh Provinces	1996-2000	MERC	Danish Red Cross
Vietnam	PREDICT project: Prediction of the Resilience and Recovery of Disturbed Coastal Communities in the Tropics (SE Asia):	1998-2001	MERC (Partners: Spain, Denmark, Netherlands, Portugal, UK and the Philippines)	EU
Vietnam	MacArthur Project: Comparative Research Studies and Training for Sustainable Planning Development in Vietnam Coastal Zone	1996-2000	MERC	MacArthur Foundation, USA
PACIFIC Australia	Western Australia mangrove assessment project 1999-2000	1999-2000	Marine & Freshwater Research Laboratory, and Murdoch University	The Natural Heritage Trust, Australia
Micronesia, Palau	*Rhizophora* in Micronesia	1998 (2 months)	Marine Botany Group, Univ. of Queensland	US Forest Service
LATIN AMERICA Belize	Roads and Municipal Drainage Project	2000-2004	Min. of Works	World Bank
Brazil, Colombia, Venezuela ,Argentina, Uruguay	South American Basins (SAMBAS)	1999-2003	LOICZ	International Council of Scientific Union (ICSN) /NIOZ
Brazil	Trace Metal Biogeochemistry and Diffuse Pollution in Mangrove Ecosystems	1997	ISME	JIFPRO
Caribbean	Caribbean Basins (CARIBAS)	1999-2003	LOICZ	ICSN/NIOZ
Mexico, Honduras, Guatemala, Belize	Conservation and sustainable use of the Mesoamerican Barrier Reef System Project (GEF)	2001-2006	Central American Commission on Environment and Development	
AFRICA Congo	Wildlands Protection and Management Project	1993-2000	Min. of Planning	
Kenya, Tanzania, Mozambique	Anthropogenically induced changes in groundwater outflow and quality, and the functioning of Eastern African nearshore ecosystems	1996-2000	Netherlands Institute of Ecology, RIKZ (The Netherlands), and other countries	
Madagascar	Rural development support project	2001-2007	Ministry of Agriculture	World Bank
Mozambique	Railway and Ports Restructuring project	1999-2004	CFM	World Bank
Senegal	Raising a mangrove nursery for restoration of coastal areas in Senegal	1997	ISME	JIFPRO
Sierra Leone	Initial assessment of environmental problems	Report submitted 1994	-	World Bank
Tanzania	Project on coastal resources issues	?	GreenCOM, USAID	USAID

REGION/ COUNTRY	TITLE OF PROJECT	YEAR	IMPLEMENTING AGENCIES	FUNDING AGENCIES
GLOBAL All regions	Forest mapping and data harmonization	1987-	UNEP-WCMC	UNEP-WCMC
All regions	JICA Group Training course, "Sustainable management of mangrove ecosystems	1995-	ISME	JICA

IX. THE ITTO MANGROVE FOREST ECOSYSTEM WORK PLAN 2002-2006

113. In 2000, the International Tropical Timber (IIT) Council requested the Executive Director of the ITT Organization to develop a work plan to assist member countries in the conservation, rehabilitation and sustainable utilization of mangroves. To this end, two expert meetings were held in 2002 (the International Mangrove Workshop, Colombia, February; and the Expert Panel on the ITTO Mangrove Work plan, Japan, April) which culminated in the draft "Mangrove Forest Ecosystem Work Plan" for 2002-2006 submitted to the 32nd session of the ITT Organization (Indonesia, May 2002). The final work plan, as adopted in May 2002, is compromised of six activity areas dealing with mangrove conservation and sustainable management, awareness, socio-economic aspects, ecosystem functions, cooperation and capacity building, and policies and legislation (see Annex 11).

114. The pivotal role that scientific and technological knowledge can play as the basis for the sound management of mangrove ecosystems needs to be further emphasized in the ITTO work plan. They shall be the cornerstone for designing or modifying national policies and strategies that take account of the economic value of mangrove goods and services and provide for the internalisation of environmental goods. Areas which need to be enhanced and/or added as part of the ITTO mangrove work plan include:

(i) The economic valuation of mangrove products, services and functions (in terms of *inter alia* food security, ecological services, biodiversity, income for local communities, flood buffer areas to protect human populations along the coast, large-scale filters assimilating pollutants);

(ii) Trend analysis for selected areas;

(iii) Inventories, zoning and identification of highly vulnerable and priority mangrove ecosystems;

(iv) Transboundary issues;

(v) Impact on mangrove ecosystems from different threats (e.g., climate change and land-based activities such as aquaculture, tourism development, changes in sediment flows due to hydrological changes, pollution from agriculture and municipal sources);

(vi) Best practices; development/adaptation of guidelines and standards; and

(vii) Innovative technologies for the sustainable use of mangroves (harvesting, processing, reforestation) including, *inter alia*, local restoration, domestication of high value mangrove timber and integration of mangrove plantations with aquaculture.

115. The establishment of an archival system with reports (published and unpublished) on efforts (successful and unsuccessful) on rehabilitation of mangroves which should be available via the Internet and other means is also recommended. ITTO and ISME should take the lead, in cooperation with relevant agencies, programmes, institutions and individuals, in establishing this system and assume responsibility for maintaining it. Cooperative/operational links with relevant ongoing and planned efforts and regional initiatives (e.g., International Coral Reef Initiative) should also be pursued.

116. The main barriers to the sustainable utilization of mangrove ecosystems, as identified by the above-mentioned workshops and meetings, include: lack of awareness and appreciation of the value of

mangroves, *ad hoc* nature of mangrove scientific/technological research, duplication of efforts among regions and thus limited use of lessons learnt, uncertainty of the impact of threats on mangroves at the national/region level and lack of funding. Virtually all of these barriers and constraints are originated from, or at least influenced by, the limited coordination between actors and stakeholders[170].

117. What is thus probably needed is an action-oriented, decentralized global international framework that facilitates effective coordination for implementing a mangrove ecosystem management approach. An approach that takes into account land and coastal/ocean issues in an integrated manner. Such an international framework should rely on the strengths, experiences and institutional arrangements of existing regional cooperative mechanisms which, in turn, will facilitate, *inter alia*, capacity building and institutional strengthening at the local and national level, and the mobilization of resources and expertise at the regional and international level. One of these existing mechanisms could be existing regional agreements/bodies - which already have programmatic and operational linkages with major relevant multilateral environmental agreements - and which include the UNEP regional seas, the UNESCO International Oceanographic Commission regional programmes, the FAO regional commissions, the World Bank-led initiatives, the Ramsar Convention on Wetlands and the IUCN-The World Conservation Union regional programmes. Coordination and implementation of the Global Plan of Action on Mangrove Ecosystems would be facilitated through a Secretariat comprised of the United Nations Forum on Forests, the International Tropical Timber Organization[171], UNEP, UNESCO/IOC[172] and IUCN-The World Conservation Union, which will be advised by the International Society for Mangrove Ecosystems. One of the main functions of this Secretariat would be the mobilization of financial resources from a variety of sources, including the Global Environment Facility, to support projects on various aspects of mangrove conservation and sustainable utilization in developing countries.

X. RECOMMENDATIONS

118. In addition to the various issues identified in the previous sections of this overview, the following main issues/needs should be addressed/considered in order to improve the transfer of environmentally sound forest technologies for the sustainable use of mangrove forests:

- Improvement of the availability, accessibility and sharing of information on environmentally sound technologies relevant to the management of mangrove forests North-South, South-South;
- Conduct technology assessments at the national level (e.g., what is available, what is being used, what could be more appropriate/suitable for local conditions, which technologies are in demand);
- Development and maintenance of inventories of available technologies relevant to the sustainable use of mangrove forests products (e.g., sources of technology, method of application, environmental friendliness and risks, and broad terms under which technology may be acquired);
- Pilot projects focusing on selected technologies could be developed and implemented: attention should be given to intellectual property rights and technologies ready for commercialisation; the accessibility and utility of inventories could be monitored by individual countries through a survey of inventory users; assistance could be provided by international agencies, programmes and donors for adaptive trials to support technology adoption;
- Human and institutional capacity building (e.g., personnel training, development of methodologies and indicators for technology assessment, development and transfer);
- Suitable holistic methodologies for monitoring and evaluating mangrove forests to improve our understanding on sustainability trends;
- Promote and facilitate more active participation of the private sector through, *inter alia*, public-private partnerships;

- ❖ Establishment of a clearing-house mechanism (based on existing networks, institutions and researchers) to, *inter alia*, disseminate information to managers and end-users, promote sharing of expertise and knowledge and to facilitate the establishment of joint ventures and partnerships;

- ❖ Policy issues such as intellectual property rights, biosafety, technology standards, incentive structures, trade and pricing, ecolabelling, certification, institutional support, and environmental accounting. Appropriate policy interventions to improve receiving and delivery capacity are essential for adoption of new technologies.

119. Also, the "Government-designated Expert Meeting on Transfer of Environmentally-sound Technologies for the Sustainable Management of Mangrove Ecosystems in Latin America and the Wider Caribbean" (Managua, Nicaragua, 3-5 March 2003) reached the following agreements and recommendations – which were submitted by the Government of Nicaragua, as part of the final report of this Latin American initiative on mangroves, to the Secretary-General of the United Nations and to the Third Session of the United Nations Forum on Forests (Geneva, 26 May-6 June 2003):

"The meeting agreed on the following priority actions and recommendations to follow up on this Latin American initiative on mangroves, finalize the regional strategies and begin activities identified by the experts for 2003:

(i) ***Invite*** the Government of Nicaragua to present the final report of this meeting to the Third Session of the United Nations Forum on Forests (Geneva, 26 May-6 June 2003) and to participate on the discussions about the regional initiatives to be held at that session;

(ii) ***Invite*** the Government of Nicaragua to present the results of this expert meeting to the next meeting of the ITTO, the regional meeting on watersheds (Arequipa, Perú, June 2003) and other fora;

(iii) ***Send*** the present report and the draft regional strategies on mangroves for the consideration of the Secretariats of the three regional Conventions (Wider Caribbean, Northeast Pacific and Southeast Pacific) and to the countries of the Upper Southwest Atlantic for their consideration and eventual adoption and inclusion into the programmes or workplans of such Conventions and agreements;

(iv) ***Request*** the Member Status of those regional Conventions to internalize institutionally the strategies and to provide the necessary political support for effective implementation of the various activities identified in the regional strategies;

(v) ***Invite*** organizations, agencies and multilateral mechanisms, the private sector, regional development banks and non-governmental organizations to join the efforts of the Governments of the region in implementing the regional strategies through the establishment of partnerships and concrete agreements which contribute to the conservation and sustainable use of mangroves;

(vi) ***Recommend*** to countries' focal points to emphasize during the Third Session of the United Nations Forum on Forests the importance of the mangrove regional initiatives and thus the importance of seeking support to implement them, in particular from the UNFF and the members of the Collaborative Partnership on Forests;

(vii) ***Establish*** Mangrove National Committees as part of the National Committees on Wetlands established within the framework of the Ramsar Convention on Wetlands;

(viii) ***Recommend*** that the Government-designated experts that participated in this meeting act as interim contact points for this regional initiative on mangroves until Governments decide the most appropriate mechanisms to establish Mangrove National Committees;

(ix) ***Recommend*** that the experts that represented in this meetings the international agencies and organizations act as contact points between their organizations, Governments, regional and global Conventions towards implementation of the regional strategies;

(x) ***Recommend*** that the Governments and Secretariats of regional environmental Conventions introduce and support this Latin American initiative on mangroves in the various relevant fora;

(xi) ***Inform*** the Secretariat of the Ramsar Convention on Wetlands about the results of this meeting, highlighting the importance that the meeting gave to using the framework of the Convention as the global legal basis for developing and implementing the present Latin American initiative, as well as the need to follow up on implementation of the several resolutions of the Contracting Parties as a means to implement the mangrove regional strategies;

(xii) ***Inform*** the Conventions and relevant international initiatives (e.g., the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, the Stockholm Convention on Persistent Organic Pollutants, MARPOL, the International Coral Reef Initiative and the Global Programme of Action for the Protection of the Marine Environment on Land-based Activities) on this regional mangrove initiative and the results of the present meeting, especially on the development of regional strategies, inviting them to participate on their implementation;

(xiii) ***Develop*** criteria for the selection of demonstration projects on the sustainable management of mangroves during 2003-2005;

(xiv) ***Establish*** a regional group of Government-designated experts on mangroves in order to facilitate coordination, follow up to the agreements reached at the present meeting and implementation of the strategies;

(xv) ***Recommend*** that the Hemispheric Center of the Ramsar Convention on Wetlands located in Panama be used to support implementation of the regional strategies in topics dealing to education, training and exchange of information;

(xvi) ***Establish*** an informal inter-agency group of representatives of the Ramsar Convention on Wetlands, FAO, ITTO, the World Bank, UNFF and the Secretariats of the Northeast Pacific, Southeast Pacific and Wider Caribbean regional seas, to support the regional Government-designated expert groups in implementing the regional strategies on mangroves;

(xvii) ***Finalize*** the working documents submitted to the meeting and publish them; also, to submit them as inputs (information documents) of Latin America and the Wider Caribbean to the global meeting on transfer of environmentally-sound technologies for sustainable forest management (to be held in early 2004) being organized by the UNFF;

(xviii) ***Establish***, on the basis of existing information clearing-house systems at the regional level, a decentralized system (possibly localized in the headquarters of the Secretariats of the Northeast Pacific, Southeast Pacific and Wider Caribbean, and in the Upper Southwest Atlantic) on mangrove ecosystems and environmentally-sound technologies for the sustainable use, conservation, rehabilitation and sustainable management of these ecosystems;

(xix) ***Suggest*** that in developing mangrove national strategies due account be given to ongoing programmes, such as the one of Colombia and other countries in the region;

(xx) ***Welcome*** the interest expressed by the WWF, the World Conservation Monitoring Center of UNEP and the UNESCO in supporting this Latin American initiative on mangroves and invite them to participate actively in the implementation of the regional strategies; and

(xxi) ***Request*** Latin American governments to send their evaluations on environmentally-sound technologies for the sustainable management of mangroves at national level, to the UNFF, as was agreed as part of the workplan of the regional strategies."

ANNEX 1

Distribution of mangrove forests (www.fao.org)

Africa

- Angola
- Benin
- Cameroon
- Comoros
- Congo
- Côte d'Ivoire
- Dem.Rep. of Congo
- Djibouti
- Egypt
- Equatorial Guinea
- Eritrea
- Gabon
- Gambia
- Ghana
- Guinea
- Guinea-Bissau
- Kenya
- Liberia
- Madagascar
- Mauritania
- Mauritius
- Mayotte
- Mozambique
- Nigeria
- SaoTomé and Principe
- Senegal
- Seychelles
- Sierra Leone
- Somalia
- South Africa
- Sudan
- Tanzania
- Togo

Americas

- Anguilla
- Antigua and Barbuda
- Aruba
- Bahamas
- Barbados
- Belize
- Bermuda
- Brazil
- British Virgin Islands
- Cayman Islands
- Colombia
- Costa Rica
- Cuba
- Dominica
- Dominican Republic
- Ecuador
- El Salvador
- French Guiana
- Grenada
- Guadeloupe
- Guatemala
- Guyana
- Haiti
- Honduras
- Jamaica
- Martinique
- Mexico
- Montserrat
- Netherlands Antilles
- Nicaragua
- Panama
- Peru
- Puerto Rico
- Saint Kitts and Nevis
- Saint Lucia
- Saint Vincent / Grenadines
- Suriname
- Trinidad and Tobago
- Turks and Caicos Islands
- US Virgin Islands
- United States of America
- Venezuela

Asia

- Bahrain
- Bangladesh
- Brunei Darussalam
- Cambodia
- China
- East Timor
- India
- Indonesia
- Iran (Islamic Rep. of)
- Japan
- Malaysia
- Maldives
- Myanmar
- Oman
- Pakistan
- Philippines
- Qatar
- Saudi Arabia
- Singapore
- Sri Lanka
- Thailand
- United Arab Emirates
- Viet Nam
- Yemen

Pacific Islands

- American Samoa
- Australia
- Fiji
- Guam
- Kiribati
- Marshall Islands
- Micronesia (Fed. States of)
- Nauru
- New Caledonia
- New Zealand
- Niue
- Northern Mariana Islands
- Palau
- Papua New Guinea
- Samoa (Western)
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu
- Wallis and Futuna Islands

ANNEX 2

Ramsar sites worldwide containing mangroves (Secretariat of the Ramsar Convention on Wetlands)

CONTINENT/COUNTRY	SITENAME	COORDINATES	AREA	
AFRICA				
BENIN	Basse Vallée du Couffo, Lagune Côtiere, Chenal Aho, Lac Ahémé	06°30'N 002°00'E	47,500	1
BENIN	Basse Vallée de l'Ouémé, Lagune de Porto-Novo, Lac Nokoué	06°39'N 002°32'E	91,600	1
COTE D'IVOIRE	Parc national d'Azagny	05°12'N 004°53'W	19,400	1
DJIBOUTI	Haramous-Loyada	11°35'N 043°09'E	3,000	1
GABON	Wongha-Wonghé	00°45'S 009°25'E	380,000	1
GABON	Petit Loango	02°15'S 009°45'E	480,000	1
GABON	Setté Cama	02°40'S 010°05'E	220,000	1
GHANA	Muni Lagoon	05º22’N 000º40’W	8,670	1
GHANA	Densu delta	05°33'N 000°18'W	4,620	1
GHANA	Sakumo Lagoon	05°40'N 000°10'W	1,340	1
GHANA	Songor Lagoon	05°45'N 000°30'E	28,740	1
GHANA	Anlo-Keta lagoon complex	05°55'N 000°50'E	127,780	1
GAMBIA	Baobolon Wetland Reserve	13°31'N 015°52'W	20,000	1
GUINEA.	Iles Tristao	10°55'N 015°00'W	85,000	1
GUINEA.	Rio Kapatchez	10°25'N 014°33'W	20,000	1
GUINEA.	Rio Pongo	10°08'N 014°08'W	30,000	1
GUINEA.	Konkouré	09°45'N 013°41'W	90,000	1
GUINEA	Ile Blanche	09º26’N 013º46’W	10	1
GUINEA-BISSAU	Lagoa de Cufada	11°43'N 015°02'W	39,098	1
MAURITANIA	Banc d'Arguin	20º50’N 016º45’W	1,200,000	1
MAURITANIA	Parc National du Diawling	16°22'N 016°23'W	15,600	1
MAURITANIA	Chat Tboul	16°33'N 016°24'W	15,500	1
SIERRA LEONE	Sierra Leone River Estuary	08°37'N 013°03'W	295,000	1
SENEGAL	Delta du Saloum	13°37'N 016°42'W	73,000	1
SOUTH AFRICA	Kosi Bay	27°01'S 032°48'E	10,982	1
CONGO, DEMOCRATIC REPUBLIC OF	Parc national des Mangroves	05°45'S 012°45'E	66,000	1

			3,372,840	**26**
ASIA				
BANGLADESH	The Sundarbans	22°03'N 089°25'E	596,000	1
BAHRAIN	Tubli Bay	26°11'N 050°34'E	1,610	1
CHINA	Dongzhaigang	19°59'N 110°35'E	5,400	1
CHINA	Mai Po Marshes and Inner Deep Bay	22°30'N 114°02'E	1,513	1
CHINA	Shankou Mangrove Nature Reserve	21°28'N 109°43'E	4,000	1
CHINA	Zhanjiang Mangrove National Nature Reserve	20°54'N 110°08'E	20,279	1
INDONESIA	Berbak	01°24'S 104°16'E	162,700	1
INDIA	Ashtamudi Wetland	08°57'N 076°35'E	61,400	1
INDIA	Bhitarkanika Mangroves	20°39'N 086°54'E	65,000	1
INDIA	Point Calimere Wildlife and Bird Sanctuary	10°19'N 079°38'E	38,500	1
IRAN, ISLAMIC REPUBLIC OF	Khuran Straits	26°45'N 055°40'E	100,000	1
IRAN, ISLAMIC REPUBLIC OF	Deltas of Rud-e-Shur, Rud-e-Shirin and Rud-e-Minab	27°05'N 056°45'E	45,000	1
IRAN, ISLAMIC REPUBLIC OF	Deltas of Rud-e-Gaz and Rud-e-Hara	26°40'N 057°20'E	15,000	1
IRAN, ISLAMIC REPUBLIC OF	Govater Bay and Hur-e-Bahu	25°10'N 061°30'E	75,000	1
JAPAN	Manko	26°11'N 127°41'E	58	1
CAMBODIA	Koh Kapik and Associated Islets	11°28'N 103°04'E	12,000	1
SRI LANKA	Annaiwilundawa Tanks Sanctuary	07°42'N 079°49'E	1,397	1
PHILIPPINES	Olango Island Wildlife Sanctuary	10°16'N 124°03'E	5,800	1
PAKISTAN	Jiwani Coastal Wetland	25°05'N 061°48'E	4,600	1
PAKISTAN	Miani Hor	25°24'N 066°06'E	55,000	1
THAILAND	Don Hoi Lot	13°21'N 099°59'E	87,500	1
THAILAND	Krabi Estuary	07°58'N 098°55'E	21,299	1
THAILAND	Had Chao Mai Marine National Park - Ta Libong Island Non-Hunting Area - Trang River Estuaries	07°22'N 099°24'E	66,313	1
THAILAND	Kaper Estuary - Laemson Marine National Park - Kraburi Estuary	09°36'N 098°35'E	122,046	1
THAILAND	Mu Koh Ang Thong Marine National Park	09°37'N 099°41'E	10,200	1
THAILAND	Pang Nga Bay Marine National Park	08°17'N 098°36'E	40,000	1
VIET NAM	Xuan Thuy Natural Wetland Reserve	20°10'N 106°20'E	12,000	1
			1,629,615	**27**

NORTH AMERICA				
MEXICO	Humedal de Importancia Especialmente para la Conservación de Aves Acuáticas Reserva Ría Lagartos	21°30'N 088°00'W	60,348	1
MEXICO	Marismas Nacionales	22°08'N 105°32'W	200,000	1
MEXICO	Reserva de la Biosfera Pantanos de Centla	18°18'N 092°27'W	302,706	1
MEXICO	Reserva de la Biosfera La Encrucijada	15°11'N 092°53'W	144,868	1
UNITED STATES OF AMERICA	Everglades	25°00'N 080°55'W	566,143	1
UNITED STATES OF AMERICA	Pelican Island National Wildlife Refuge	27°48'N 080°25'W	1,908	1
			1,275,973	**6**
OCEANIA				
AUSTRALIA	Cobourg Peninsula	11°25'S 132°15'E	220,700	1
AUSTRALIA	Kakadu (Stage I and components of Stage III)	12°40'S 132°45'E	683,000	1
AUSTRALIA	Hunter Estuary Wetlands	32°52'S 151°43'E	2,971	1
AUSTRALIA	Kakadu National Park (Stage II)	12°30'S 132°30'E	692,940	1
AUSTRALIA	Ord River floodplain	15°15'S 128°22'E	141,453	1
AUSTRALIA	Roebuck Bay	18°07'S 122°16'E	55,000	1
AUSTRALIA	Eighty-mile Beach	19°29'S 120°35'E	125,000	1
AUSTRALIA	Moreton Bay	27°20'S 153°10'E	113,314	1
AUSTRALIA	Bowling Green Bay	19°27'S 147°15'E	35,500	1
AUSTRALIA	Shoalwater and Corio Bays	22°40'S 150°17'E	239,100	1
AUSTRALIA	Great Sandy Strait (incl. Great Sandy Strait, Tin Can Bay, and Tin Can Inlet)	25°28'S 152°54'E	93,160	1
AUSTRALIA	Hosmie's Spring	10º28’S 105º41’E	1	1
AUSTRALIA	Towra Point	34º00’S 151º10’E	386	1
AUSTRALIA	Corner Inlet	38º45’S 146º32’E	67,186	1
AUSTRALIA	Port Phillip Bay & Bellarine Peninsula	38º04’S 144º36’E	22,897	1
AUSTRALIA	Western Port Bay	38º22’S 145º17’E	59,297	1
NEW ZEALAND	Firth of Thames	37º13’S 175º23’E	7,800	1
PAPUA NEW GUINEA	Tonda Wildlife Management Area	08°45'S 141°23'E	590,000	1
			3,149,705	**18**

NEOTROPICS				
BRAZIL	Reentrancias Maranhenses	01°41'S 045°04'W	2,680,911	1
BRAZIL	Baixada Maranhense Environmental Protection Area	03°00'S 044°57'W	1,775,036	1
BAHAMAS	Inagua National Park	21°05'N 073°20'W	32,600	1
COLOMBIA	Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande Sta.Marta	10°45'N 074°29'W	400,000	1
COSTA RICA	Palo Verde	10°20'N 085°20'W	24,519	1
COSTA RICA	Caño Negro	10º52'N 084º45'W	9,969	1
COSTA RICA	Tamarindo	10°19'N 085°50'W	500	1
COSTA RICA	Terraba-Sierpe	08°52'N 083°36'W	30,654	1
COSTA RICA	Gandoca-Manzanillo	09°37'N 082°40'W	9,445	1
COSTA RICA	Manglar de Potrero Grande	10°51'N 085°47'W	139	1
CUBA	Ciénaga de Zapata	22°20'N 081°22'W	452,000	1
CUBA	Buenavista	22°27'N 078°49'W	313,500	1
CUBA	Ciénaga de Lanier y Sur de la Isla de la Juventud	21°36'N 082°48'W	126,200	1
CUBA	Gran Humedal del Norte de Ciego de Avila	22°19'N 078°29'W	226,875	1
CUBA	Humedal Delta del Cauto	20°34'N 077°12'W	47,836	1
CUBA	Humedal Río Máximo-Cagüey	21°43'N 077°27'W	22,000	1
ECUADOR	Manglares Churute	02°28'S 079°42'W	35,042	1
ECUADOR	Isla Santay	02°13'S 079°51'W	4,705	1
ECUADOR	Humedales del Sur de Isabela	00°57'S 090°58'W	872	1
FRANCE	Grand Cul-de-Sac Marin de la Guadeloupe	16°20'N 061°35'W	20,000	1
FRANCE	Basse-Mana	05°40'N 053°45'W	59,000	1
FRANCE	Marais De Kaw	04°38'N 052°07'W	137,000	1
GUATEMALA	Manchón-Guamuchal	14°28'N 092°05'W	13,500	1
GUATEMALA	Punta de Manabique	15°50'N 088°28'W	132,900	1
HONDURAS	Barras de Cuero y Salado	15°45'N 087°02'W	13,225	1
HONDURAS	Parque Nacional Jeanette Kawas	15°51'N 087°40'W	78,150	1
HONDURAS	Refugio de Vida Silvestre Punta Izopo	15°44'N 087°21'W	11,200	1
HONDURAS	Sistema de Humedales de la Zona Sur de Honduras	13°20'N 087°25'W	69,711	1
HONDURAS	Laguna de Bacalar	15°08'N 085°10'W	7,394	1
JAMAICA	Black River Lower Morass	18°04'N 077°48'W	5,700	1
NICARAGUA	Cayos Miskitos y Franja Costera Immediata	14°23'N 082°46'W	85,000	1

NICARAGUA	Deltas del Estero Real y Llanos de Apacunca	12°53'N 087°13'W	81,700	1
NICARAGUA	Refugio de Vida Silvestre Río San Juan	10°56'N 083°40'W	43,000	1
NICARAGUA	Sistema de Humedales de la Bahía de Bluefields	11°55'N 083°45'W	86,501	1
NETHERLANDS (Aruba)	Het Spaans Lagoen	12°30'N 070°00'W	70	1
NETHERLANDS (Netherlands Antilles)	Het Lac	12°06'N 068°14'W	700	1
PANAMA	Golfo de Montijo	07°45'N 081°07'W	80,765	1
PANAMA	San San – Pond Sak	09°30'N 082°30'W	16,414	1
PANAMA	Punta Patiño	08°18'N 078°14'W	13,805	1
PERU	Manglares de Tumbes	03°25'S 080°17'W	2,972	1
SURINAME	Coppenamemonding	05°56'N 055°43'W	12,000	1
TRINIDAD & TOBAGO	Nariva Swamp	10°23'N 061°04'W	6,234	1
UNITED KINGDOM (Turks and Caicos Islands)	North, Middle & East Caicos Islands	21°45'N 071°45'W	58,617	1
UNITED KINGDOM (Cayman Islands)	Booby Pond and Rookery	19°40'N 080°04'W	82	1
UNITED KINGDOM (British Virgin Islands)	Western Salt Ponds of Anegada	18°43'N 064°19'W	1,071	1
UNITED KINGDOM (Bermuda)	Hungry Bay Mangrove Swamp	32°16'N 064°45'W	2	1
UNITED KINGDOM (Bermuda)	Lover's Lake Nature Reserve	32°21'N 064°42'W	2	1
UNITED KINGDOM (Bermuda)	Paget Marsh	32°16'N 064°46'W	11	1
UNITED KINGDOM (Bermuda)	Somerset Long Bay Pond	32º17'N 064º51'W	1	1
VENEZUELA	Cuare	10°55'N 068°20'W	9,968	1
VENEZUELA	Archipielago Los Roques	11°50'N 066°45'W	213,220	1
VENEZUELA	Laguna de la Restinga	11°02'N 064°09'W	5,248	1
VENEZUELA	Laguna de Tacarigua	10°12'N 065°56'W	9,200	1
VENEZUELA	Ciénaga de Los Olivitos	10°55'N 071°26'W	26,000	1
			7,493,166	54

ANNEX 3a[173]

Mangrove timber production for selected countries

Country	Year	Timber (m^3/year)	Country	Year	Timber (m^3/year)
Nigeria	1990	4,000,000	El Salvador	1992	30,000
Indonesia	1983	2,779,476	Vietnam	1983	25,430
Philippines	1972	2,684,720	Nicaragua	1983	18,800
Malaysia	1990	2,506,845	Venezuela	1990	12,000
Thailand	1993	193,145	Brazil	1991	9,000
Cuba	1992	110,000	Panama	1988	7,400
Honduras	1992	100,000	Costa Rica	1992	1,900
India	1989	72,000	Fiji	1985	1,597
Colombia	1991	70,000			

ANNEX 3b

Mangrove-based fishery catches

Region/country	Year	Production/value
ASIA		
Malaysia	1981	209,000 ton
Thailand	1982	166,000 ton (shrimp)
Indonesia	1992 1934	939.6 ton (fish) 37,000 ton (molluscs)
AFRICA		
Nigeria	1989	204,977 ton
Senegal/Gambia	1984	24,000 ton
Cameroon	1993	20,000 ton
Madagascar	1991	2,000 ton
Benin	1988	340 ton
LATIN AMERICA		
Brazil	1997 1988	1,162 ton (shrimp) 200-400 ton (finfish)
Venezuela	1983	500 ton
Cuba	1991	15 ton

ANNEX 3c

Cultured shrimp production (tons) from mangrove areas for selected countries in 1994

Countries	Cultured shrimp	Exported to Japan and USA
Thailand	250	78.83
PR of China	100	27.64
Indonesia	100	49.45
Ecuador	70	36.91
India	50	43.77
Vietnam	35	25.32
Taiwan	35	
Philippines	30	
Bangladesh	25	6.05
Other countries	63	

ANNEX 3d

Non-timber mangrove forest products for selected countries

Country	Products	Amount	Year	Value (US$)
Malaysia	*Nipa* sugar *Nipa* alcohol	1786 ton 8,406 litres	1982 1980	2,143,200
Madagascar	Bark for tannin	200,000 ton	1982	
Papua New Guinea	Bark for tannin	20,000 ton	1956	
Panama	Bark for tannin	720 ton	1983	
Cuba	Bark for tannin Honey	121 ton 1700-2700 ton	1991 Every year	
Nicaragua	Bark for tannin	36 ton	1984	85,800
Sri Lanka	Bark for tannin	12 ton	1988	860

ANNEX 4

Geographical Information Systems (GIS)

A. The main components of GIS

GIS have three major components: computer hardware, sets of software, and the human resources and organization that make the system work.

(a) Computer hardware

The hardware components of a GIS include units that are common to any computerized data base management system - a general purpose computer, several disk drive units for storing data and programs, tape drives for back up copies of data, colour graphic display units, and other general purpose computer peripherals. The GIS has, in addition, several specialized hardware components, including: a digitiser or scanner, which is used to convert the geographical information from maps into digital form and send it to the computer; a plotter, which prints out the maps and other graphic outputs of the system; and a visual colour graphics workstation on which spatial data editing and display can be performed by the user.

(b) Software

The main GIS software components are designed to perform the following functions, where data implies both cartographic and/or attribute data: data input (digitising or scanning the lines on the maps and entering the attribute information from a keyboard), data base management, data analysis and processing - interaction with the user (map editing) and data output and presentation (plotting).

- Data input involves the conversion of data from maps, field observations, processed satellite images and aerial photographs into compatible digital form. Many GIS today utilize a manual digitising approach to input maps. This means that someone must sit down with the map at a large, flat, digitising table, and using a small cursor pad, follow the thousands of lines that make up the map, carefully keeping the cursor (cross hairs) on the lines, ensuring that lines are not double digitised or left out, and that intersections are accurately closed and no gaps are left in lines. However, large cartographic data inputs are generally made using automated digitising systems such as scanners. These eliminate the manual work of following the lines and ensure consistent, repeatable results each time a map is scanned. Although scanning is quicker than digitising, only good quality maps can be scanned, and even then the quality of the products is generally not as high. However, as in most areas of computerization, the technology is continually being improved. Furthermore, once a map has been digitised, it can be reproduced and transformed at will (much as a written document can be quickly edited or corrected once it has been entered into a word processor). The quality of input data will affect the quality of GIS products regardless of the sophistication of its hardware and software. In many cases, inventories of natural resources are often not completed or up to date and information in maps may have to be revised before digitising.

- Data base management operations mainly consist of the following functions: structure, query, analysis and reporting of the attribute data linked to the features on the maps.

- Data processing covers two types of operation: firstly, preparing data by removing errors or updating, and secondly, analysing data to provide answers to the questions the user puts to the GIS. Processing can operate on the spatial and non-spatial aspects of the data, or on both. Typical operations include overlaying different thematic maps, computing areas and distances, acquiring statistical information about the attributes, changing the legend, scale and projection of maps, and making three-dimensional perspective view plots using elevation data, as shown in the figure at right.

- Data output and presentation deals with the way the information is displayed to the user. This can either be as a visual display (soft copy) or hard copy drawn by a plotter, or as magnetically recorded or

printed information in digital form. The plotter is to the GIS what a printer is to the standard word processor: it produces a copy of map on paper.

(c) Human resources and organization

When describing a GIS one tends to think in terms of hardware and software as the entire system, which overlooks perhaps the most important component: the people needed to make the whole system function effectively. As with any computer system, the information produced is only as good as the information that is put in. Incorrect or inadequate information fed into the GIS will produce incorrect or inadequate answers, no matter how refined or "user-friendly" the computer technology may be. As in any map-making operation, data collection and data input operations require high standards of design and work, intensive training and frequent monitoring for quality control. In other words, in addition to having the right hardware and software to do the job, effective utilization of a GIS requires adequate staff training as well as planning, organization and supervision in order to maintain the quality of the data and the integrity of the final product.

Another essential element of successful GIS operation is the need for data input and processing to be a joint effort involving the computer specialist and the subject matter specialist (e.g. crop production, forest management, and aquaculture). This ensures that the necessary specialized subject matter expertise is applied in the interpretation and evaluation of data. Specialists in remote sensing and cartography may also be involved.

In many developing countries, resource information collection and processing systems are still relatively undeveloped. This means that application of GIS at the country and sub-country level will, in many cases, need to be accompanied by the improvement of existing information collection systems and the introduction of new ones. This provides an opportunity for international assistance.

B. Applications of GIS technology

An easy way to think of how GIS can be applied is to think in terms of the questions that the user might want answers to. As has been mentioned, one of the first steps when setting up a GIS is to survey the potential users to determine their information needs, and to identify those needs that can best be met by a GIS incorporating various combinations of data retrieval and transformation. The ultimate use of GIS lies in its capability for modelling: constructing models of the real world from digital databases, and using these models to simulate the effect of a specific process over time for a given scenario. Modelling is a powerful tool for analysing trends and identifying factors that affect them, or for displaying the possible consequences of planning decisions or projects that affect resource use and management. At the continental level, for example, terrain maps can be combined with hydrologic maps and climatological data to produce maps of land suitability for various types or intensities of use, or specific crops. Demographic and administrative data can be added to provide projections of future supply-and-demand scenarios by region or country. At the national and local level, possible GIS applications are almost endless. For example, to decide on the best potential sites for growing a certain cash crop, the agricultural planner might use geographic data bases combining soils, topography and rainfall to determine the size and location of biologically suitable areas, and then overlay this with landownership and transport infrastructure, labour availability and distance to market centres. Further, he or she could then change the characteristics of various attributes over time to determine the probable impacts of changing circumstances, such as the effects of a drought, the rise or fall of domestic or world prices, or the development of additional roads.

In summary, what the GIS provides is a means of converting spatial data into digital form that can then be displayed, manipulated, modified and analysed and reproduced quickly in a new format, available for either visual display or hard copy reproduction. Conventional (paper) maps, in contrast, are time-consuming to prepare manually, and the display and analysis of changed data or the comparison of more than one set of map data (soil and vegetation, for example) requires additional manual labour. The digital data can also be easily transmitted from one user to another or from one GIS to another merely on disk, tape or by the Internet. As digital maps come into wider use, the cost of digitising can be shared by many users. In fact, some digitised maps on CD-ROMs cost less than the same maps on paper. As networks and libraries of

databases grow, information exchange should reduce the need for redigitising regional or national maps and other geographic databas es than are in common use.

For additional information see FAO GIS Home Page or contact GIS-Manager@fao.org or the Geographic Information Systems Group Environment and Natural Resources Service (SDRN), FAO Research, Extension and Training Division

ANNEX 5

Valuation approaches of ecosystem services

1. ***Market Prices – Revealed Willingness to Pay***: The values of ecosystems good or services traded in the markets can be measured using market prices and can be estimated by estimating consumer and producer surplus. Other ecosystems services (e.g., clean water) are used as inputs in production, and their value may be measured by their contribution to the profits made from the final good. Some ecosystem or environmental services (e.g., aesthetic views, recreational experiences) may not directly buy and sold in markets. However, the prices people are willing to pay in markets for related goods can be used to estimate their values. This approach includes the following methods:

- Market price: Estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. This method can be used to value changes in the quantity or quality of a good or service and uses standard economic techniques for measuring the economic benefits from marketed goods, based on the quantity people purchase at different prices, and the quantity supplied at different prices.
- Productivity: Also knows as net factor income or derived value method, estimates the economic value of ecosystem product or services that contribute to the production of commercially marketed goods. This method is applied in cases where the products or services of an ecosystem are used, along with other inputs, to produce a marketed good.
- Hedonic pricing: Estimates economic values for ecosystem or environmental services that directly affect market prices. This method is most commonly applied to variations in prices that reflect the value of local environmental attributes.
- Travel cost: Estimates the value of forest recreational benefits. This survey-based method is based on the assumption that consumers value the experience of a particular site at no less than the cost of getting there, including all direct transport costs as well as the opportunity cost of time spent travelling to the site (i.e., foregone earnings)

66. ***Circumstantial Evidence – Imputed Willingness to Pay:*** The value of some ecosystems can also be measured by estimating what people are willing to pay, or the costs of actions they are willing to take, to avoid the adverse effects that would occur if these services were lost, or to replace the lost services. This approach includes the following methods:

- Damage cost avoided, replacement cost, and substitute cost: These related methods estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the costs of replacing ecosystem services, or the cost of providing substitute services. They consider that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. This is based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. Thus, these methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be, made.

3. ***Surveys – Expressed Willingness to Pay: Many*** ecosystem services are not traded in markets, and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for them through their market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario. Alternatively, people can be asked to choose tradeoffs among different alternatives, from which their willingness to pay can be estimated. This approach includes the following methods:

- Contingent valuation: Estimates economic values for all kind of ecosystems and environmental services. This method can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. It is also one of the most controversial of the non-marketed valuation methods. This method involves directly asking

people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called "contingent" valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service

- Contingent choice (choice modelling): Differs from contingent valuation because it does not directly ask people to state their values in monetary terms. Instead, values are inferred from the hypothetical choices or tradeoffs that people make. This method asks the respondent to state a preference between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Because it focuses on tradeoffs among scenarios with different characteristics, this method is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. Also, while this method can be used to estimate monetary values, the results may also be used to simply rank options, without focusing on monetary values.

ANNEX 6

Mangrove rehabilitation projects worldwide[174]

Country	Main mangrove species planted	Aim (s) of planting programme	Area of mangrove planted (km^2)	Area of natural mangrove (km^2)
Australia	*Avicennia marina, Aegiceras corniculatum*	Enhancement of natural regeneration	<1	9695
Bangladesh	*Sonnerata apetala, Avicennia officinalis Heritiera fomes*	Sustained yield of forest products, coastal protection	>1200	5767
Benin	*Rhizophora racemosa R. mangle*	Rehabilitation of degraded areas and introduction in new locations	<0.1	69
PR China	*Kandelia candel*	Coastal protection	<0.1	366
Colombia	*R. mangle*	Rehabilitation of national park	<0.1	3659
Costa Rica	*R. harrisonii, R. mangle*	Timber production	--	370
Cuba	*R. mangle, Avicennia germinans Laguncularia racemosa Conocarpus erectus*	Barriers to erosion, rehabilitation of degraded areas, timber production	>0.5	7848
India	*A. marina, A. officinalis, Sonneratia caseolaris, R. mucronata, R. apiculata*	Rehabilitation of degraded areas	>100	6700
Indonesia	*Bruguiera gymnorrhiza, R. apiculata R. stylosa, R. mucronata*	Rehabilitation of degraded areas, timber production	>400	45,421
Malaysia	*R. mucronata, R. apiculata*	Timber and charcoal production	>50	6424
Myanmar	*A. officinalis, S. apetala, R. mucronata, R. apiculata, K. candel, Ceriops decandra B. gymnorrhiza*	Rehabilitation of degraded areas, timber and firewood production	>20	3444
Pakistan	*A. marina, C. tagal, R. mucronata R. apiculata, A. corniculatum*	Rehabilitation of degraded areas, timber production	>20	1683
Panama	*R. mangle*	Rehabilit ation after an oil spill	<0.2	1814
Philippines	*R. apiculata, R. mucronata, R. stylosa C. tagal, Nypa fruticans*	Rehabilitation of degraded areas	>440	1607
Sierra Leone	*R. racemosa, R. mangle*	Rehabilitation of degraded areas	<0.1	1695
Sri Lanka	*R. apicula ta, R. mucronata*	Protection of lagoons and estuaries	<0.1	80
Thailand	*R. mucronata, R. apiculata*	Timber and charcoal production, rehabilitation	>110	2641
USA	*R. mangle, A. germinans, L. racemosa C. erectus*	Rehabilitation of natural areas	<0.4	1990
Vietnam	*R. mucronata, R. apiculata, R. stylosa K. candel, Avicennia alba, C. decandra, S. caseolaris, N. fruticans*	Rehabilitation of degraded areas, sea dike protection, mixed shrimp farming-mangrove areas	>530	2525
UAE	*A. marina*	Landscaping	<0.1	30

ANNEX 7

Examples of management alternatives for mangrove forests in Pagbilao, the Philippines[175]

Preservation	Subsistence forestry	Commercial forestry	Aqua-silviculture[176]	Semi-intensive aquaculture	Intensive aquaculture	Commercial forestry /intensive aquaculture	Subsistence forestry/intensive aquaculture
Extraction of forest products is not allowed. Poaching should be prevented.	Extraction of forest products is allowed. The dependence of coastal communities on the mangrove forest products (e.g., fuelwood, charcoal, poles/timber for fences and posts) is recognized Management of the forest will be responsibility of the communities. To sustain the benefits derived from the mangroves, a maximum allowable cut (MAC) must me imposed and maintain despite the projected increases in the demand for forest products. This alternative is sustainable under the following conditions: (a) the MAC takes into account system-wide effects of use; (b) since the MAC is less than current estimated demand for forest products, the shortfall can and will be met by increased exports from mountain areas; (c) information of how the allowed cut should bets be taken can me communicated to and implemented by the forest users; and (d) entry into this sector is controlled	Provides for exploitation of the mangroves by commercial forestry where a specified commercial volume can be harvested. High value products are to be harvested, primarily timber, with incidental fuelwood from tree branches. Various techniques need to be applied to encourage regeneration of the forest. Associated conditions to promote sustainability are: (a) the MAC takes into account system-wide effects of use; and (b) information on how the allowed cut should best be taken can be communicated to and implemented by the foresters/	Excluding the buffer zone (see footnote), ca. one third of the mangroves will be converted to fishponds. The forest will be harvested sustainably by the fishpond owners for the own needs but may also supplement incomes. The following three conditions must be met: (a) the buffer zone is sufficient for shore stabilization and flood mitigation; (b) the buffer zone is not exploited; and (c) wastes released by the ponds into the nearby environment do not overload the system's capacity for self-purification and so good water quality is maintained.	The forest is converted to fishponds and their water distribution system, with the only remaining mangroves in the buffer zone. Sustainable conditions as the same as for aqua-silviculture.	The forest is converted to fishponds, but management of the ponds is on a more intensive basis. Sustainable conditions are the same as for aqua-silviculture.	A mixture of alternatives Commercial forestry & Intensive aquaculture.	The same as Commercial forestry/intensive aquaculture, except that the remaining forest, excluding the buffers zones, ix exploited sustainable for subsistence forestry products.

ANNEX 8

Available forest-related certification schemes and initiatives[177]

- International certification schemes:
  - Forest Stewardship Council (FSC)
  - International Standards Organisation (ISO)
  - The Pan-European Certification Process
- Regionally based certification systems
  - African Initiatives
    - African Timber Organisation
    - Ghana
    - Developments in the countries of the Congo Basin
  - North American and Canadian Initiatives
    - American Forest and Paper Association (AFANDPA)
    - Canadian Standards Association (CSA)
    - Other American Initiatives
  - Indonesian Ecolabelling Institute - Lembaga Ekolabel Indonesia (LEI)
  - Malaysia
  - Scandinavian Initiatives
  - Fauna and Flora International - Soundwood Programme
  - The United Kingdom
  - Initiatives in the Pacific Region
  - National Initiatives

ANNEX 9

International assistance for the transfer of environmental sound technologies of potential relevance to mangrove forests[178]

Programme/Source	Recipients	Type of support	Specific areas of support	Selection criteria	Programme goals	Future plans	Contact
Environment Protection Group, Environment Australia	National government agencies, companies, local authorities	Technical (technology need assessment, transfer and adaptation of technologies), financial (aids/grants)	Environmental problems, environmental technologies		Raising environmental technology awareness	Workshops in countries of the region to demonstrate Australian environmental technologies	Director, Environment Technology and Best Practice Section www.environment.gov.au
GEPNET-European Network on Good Environmental Practices, Joanneum Research	National government agencies, local authorities, companies, research and development institutes, universities, financial institutions	Technical support, e.g., transfer of technology, education/training, support for research and development	None	None	To spread environmentally sound practices worldwide		
Caribbean Development Bank	Anguilla, Antigua & Barbuda, Bahamas, Belize, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Trinidad & Tobago, Turks and Caicos Islands: national government agencies, research and development institutes, universities	Financial support, e.g., aid/grants, loans Education and training	Diversification in agriculture and services; solid wastes, coastal zone, disaster mitigation; poverty reduction, protection of vulnerable groups	Related to poverty reduction, environment, human resources and capacity building	Not a formal programme		
Belgian Administration	Africa, Asia, Middle East:	Institutional (e.g., university cooperation,		Evaluation of scientific value of	Capacity building of universities and research		

Development, Ministry of Foreign Affairs	research and development institutes, universities	technology needs assessment, transfer of technology, education/training), support for research and development		projects by focal and thematic selection committees	and development institutes		
International Development Research Center	Latin America, Africa, Middle East: international development organizations, community groups, universities, research and development institutes	Technolo gy innovation (e.g., small, medium and micro enterprises, adaptation of technology, transfer of technology, support for research and development), financial support (aid/grants)	Micro, medium and small enterprises	The appraisal is done according to a standard set of criteria that evaluates a project's scientific and technical merit and its potential development impact	To assist developing countries to design and implement appropriate and effective initiatives to the growth of competitive, environmentally sustainable small, medium and micro-enterprises to generate sustainable employment		
Canadian International Development Agency (CIDA)	All developing countries eligible for Canadian assistance aid: companies, local authorities, national government agencies, universities, research and development institutes	Technical and institutional support (e.g., technology needs assessment, transfer of technology, adaptation of technology, education/training, capacity development), financial support (aid/grants)	Poverty reduction, advancement of women, infrastructure improvement, private sector, environmental sustainability, human rights		To promote environmentally sound sustainable development in developing countries		
Danish Cooperation for Environment and Development (DANCED)	Countries of Southeast Asia (Thailand and Malaysia) and Southern Africa (South Africa, Botswana, Lesotho, Namibia and Swaziland)	Technical and institutional support (e.g., technology needs assessment, transfer of technology, adaptation of technology, education/training, capacity development), financial support (aid/grants)	Forest and wood resources, sustainable use of energy, biological diversity, agriculture, water resources, urban development and industrialization		To contribute to the protection of the global environment by the introduction of preventive measures, by transferring Danish know-how and experiences adjusted to local conditions in the cooperating countries		
Carl Duisberg Gesellschaft E.V. (CDG), Section of Production Management and Technology	Africa (SADC), Asia (ASEAN countries, PR China, India), Latin America (Bolivia, Brazil,	Technical support (e.g., implementation of different training programmes/projects, such as those related to biotechnology and	Focusing on those economic sectors which are trying to contribute to environmentally and socially sustainable economic development	Suitable political and economic conditions, strength of local partner institution (s) and their level of contribution, degree	To provide developing countries with access to environmentally sound technologies, to strengthen dialog between North and South as well as South-		

Transfer	Chile Colombia, Peru): national government agencies, local authorities, companies, research and development institutes, universities	environmental technology), education and training		to which training and dialogue can help to achieve a project's objective	South, to increase activities through more cooperation with other bilateral or multilateral organizations; one focus area in future plans will be Latin America		
TaT Transfer Center Appropriate Technologies, International Cooperation Programme	Asia, especially the Philippines and Indonesia. Africa: companies, research and development institutes, business associations, chambers of commerce and industry	Technical support (e.g., transfer of technology, education/training, business cooperation)	Renewable energies, renewable resources, eco-construction of houses, environmental problems	Financing for technology transfer is available	Matchmakin g for business cooperation between German companies and partners in developing countries in environmental protection technologies		
Ministry of Economic Cooperation and Development, German Appropriate Technology Exchange (GATE)	West Africa, Southeast Asia, Latin America	GATE Technical Inquiry Service, GATE Regional Networking, GATE Small Scale Project Fund: technology needs assessment, transfer of technology, adaptation of technologies, education/training, demand oriented information service on appropriatetechnology	Rural and urban small enterprises including farming; waste and wastewater, energy, organic farmers; poverty alleviation		To test, adopt and disseminate appropriate technology, to strengthen regional information services on appropriate technology, to assist in building up technological competence		
German Ministry of Economic Cooperation and Development, Strengthening Environmental Technological Capability (ETC)	Asia (Thailand, India, Indonesia): national government agencies, local authorities, companies, research and development institutes, universities	Technical support, institutional support (technology needs assessment, transfer of technology, workshops with participation of private companies from industrialized countries), financial support (aid/grants)	Environmental problems		To strengthen environmental technological capability in partner countries, to develop proposals for new forms of information exchange among actors in developing countries and partners from German industry, information events, workshops and contact meetings among		

					States, industry, research and education sectors are organized		
GTZ, Germany	National government agencies, local authorities, companies (only in special cases), research and development institutes, universities, financial institutions, industry chambers and associations	Technical support, institutional support (e.g., transfer of technology, education/training, support for research and development, technology needs assessment, adaptation of technologies), financial support (aid/grants)		As a government organization for technical cooperation, GTZ is involved in several projects that are planned according to individual criteria	Strengthening capabilities of partner countries in managing their own environmental problems, developing institutional structures in developing countries that are efficient and permit resolving environmental problems on their own		
Central American Bank for Economic Integration (CABEI), Central American Environmental Fund (FALIDES)	Central American countries (Costa Rica, Honduras, Guatemala, El Salvador, Nicaragua): national government agencies, local authorities, companies, private development organizations and NGOs	Transfer of technology, education and training, support for research and development, adaptation of technologies, loans	Economic sector (infrastructure), productive sector (tourism, social development, research and development, small and medium size enterprises, promotion of exports), environmental problems (carbon market, energy efficiency, vulnerability), social concerns (reduction of poverty)	To be related with the agreements signed in the Alliance for Sustainable Development and to be congruent with the guidelines for credit policies of CABEI as well as with the national strategies and development plans of the countries	Promotion of the development of new sustainable energy sources, research and development of new agricultural and industrial products, energy efficiency programme		
Food and Agriculture Organization of the United Nations (FAO), Sustainable Research and Training Division	National government agencies, local authorities, universities, research and development institutes	Technical support (e.g., technology needs assessment, research and development, education/training, adaptation of technology, transfer of technology)	Social concerns, environmental problems	High priority by the government	Strengthen the capacity of national systems to access knowledge, integration of agricultural knowledge and technology transfer in national extension and education systems		
Japanese Government, Overseas Economic Cooperation Fund (OECF)	All developing countries: national government agencies	Long-term, low-interest loans	OECF's official development assistance loans primarily support the development of economic and social infrastructure in developing countries; to support sustainable development,	The projects are appraised in light of their technical, economic, financial, institutional and environmental viability	To assist developing countries in achieving sustainable economic and social development		

			OECF considers environmental and social concerns during preparation and implementation of ODA loans projects				
Kuwait Fund for Arab Economic Development	All developing countries: national government agencies	Transfer of technology, adaptation of technologies, training, support for research and development, financial support (aid/grants, loans)	Environmental problems	Priority projects in terms of the country's national program, and in their economic situation	To support technology development		
Asian Development Bank, Advisory Technical Assistance	Asia and Pacific countries: national government agencies	Technical support (advisory technical assistance), financial support (aid/grants)		To build government agencies' capacities to evaluate needs for environmentally sound technologies, to assess the financial and economic viability of the technologies, and to establish self-sustained Technology Centers	Establishing Environmental Management Systems for selected developing countries, establishing a regional fund to promote cleaner production in small and medium enterprises		
Islamic Development Bank	Member countries (53) of the IDB and other Muslim communities in non-member countries: national government agencies, local authorities, companies, research and development institutes, universities	Technical support (e.g., technology needs assessment, transfer of technology, adaptation of technologies) financial support (loans, aid/grants)	Agriculture and food security, poverty alleviation, infrastructures, health, education, medium and small scale industries, human resources development including support to selected pilot projects and regional agencies which are specifically involved with environmental preservation	Endorsement by the government, relevance to socio-economic development, feasibility and sustainability, availability of resources	Applications of viable technologies in the production sectors for improved socio-economic gains such as: developing techniques to introduce new types of plants which can tolerate high salinity and temperatures, and developing human resources that can bring technologies to the developing countries		
Regional Institute of Environmental Technology, Asia-EcoBest	Asia and Europe: local authorities, companies, research and development institutes, universities	Technology needs assessment, education/training, transfer of technology, adaptation of technologies, support for research and development, events,	Advanced environmental management solutions	Provide a forum for dialogue and understanding of Asian environmental threats and opportunities, research environmental			

		financial support (aid/grants)		behaviour, performance and management practices in Asia, promote business-led strategy responses to Asian environmental difficulties, disseminate advanced-country inspired environmental management solutions relevant to the Asian region, instigate development of environmental industrial partnerships for the benefit of the environment			
Swedish International Development Agency (SIDA), Integrated Approach to Energy, PSD	Main Swedish cooperation countries: national government agencies, local authorities, companies, research and development institutes, universities, NGOs	Technical support, institutional support (e.g., technology needs assessment, education/training, transfer of technology, adaptation of technologies, specific areas of support for research and development), financial support (aid/grants, transactions insurance, loans)			Sustainable development		
Swedfund International AB	Developing countries and countries in Central and Eastern Europe	To provide capital and know-how for projects in emerging markets, in partnership with financially sound companies	Provides risk capital and know-how for long-term investments in emerging markets, in partnership with Swedish companies	Swedfund's aim at complementactivities of the private sector by making debt and equity finance available for sound commercial ventures, where sufficient long-term capital is unavailable	Development of competitive companies		

ANNEX 10

Mangrove projects supported by the Ramsar Convention on Wetlands (as of 1 March 2003) (Secretariat of the Ramsar Convnetion)

Wetlands for the Future Fund

Country	Project code	Project name	Status	Comments
Brazil	WFF/97/BRA/5	Possibility of the Mangrove Bioecology Laboratory-BIOMA to become an information and educational mini-center	CLOSED	Support the BIOMA to increase its human resources training activities and expand the services offered to researchers and technical staff dealing with working on mangroves and coastal zones by linking them to the world wide web
Brazil	WFF/99/BRA/3	Dynamics of mangrove ecosystems in Laguna de Canaéia-Iguape, Estate de Sao Paulo-Brazil	CLOSED	Support for elaboration of master's thesis on the dynamics of mangrove ecosystems, including books, computer and fees for participation in mangrove conference.
Brazil	WFF/99/BRA/4	Use of mangrove bark for extracting colorant used in decoration of pottery	CLOSED	The Project consisted of a study on the use of mangrove bark for extracting colorant used in decoration of pottery. Developed brochures for promotion of this traditional craft as well as for the need to conserve the ecosystem that maintains it.
Brazil	WFF/99/BRA/5	Anthropic impacts on mangrove areas at Braganca City, Pará State, Brazil	IN PROGRESS	Support for thesis with the following aims: to identify socioeconomic patterns in the traditional uses of ecosystem resources; to propose necessary mangrove restoration steps damaged by economic activity; to support development of management and conservation programs that minimize negative local impacts.
Brazil	WFF/99/BRA/12	Implementation of the CAMRIS (GIS) System for wetland inventory	CLOSED	A Geographic Information System course took place 7- 17 September 1999 with the support of the Administrative Authority, San Pablo University and the Wetlands for the Future initiative. 20 Participants were trained in the use of the Computer Aided Mapping and Resource Inventory System (CAMRIS). As a result, the participants were taught the basics required to enter data, retrieve data and generate hard copy. The system provides many of the GIS (Geographic Information System) functions required by most resource users quickly and inexpensively.
Brazil	WFF/00-2/BRA/2	Studies on Brazilian Coral Reefs: training and application of remote sensing techniques	ONGOING	Train specialists and protected area managers from different parts of Brazil in using remote sensing and GIS techniques at the Spatial Research National Institute. After the courses a workshop will produce a final map of Brazil's unique northeastern coast coral reefs. These maps will assist coral reef monitoring, conservation decision making, and ultimately a coral reef

				protecting system.
Brazil	WFF/01-2/BRA/3	Support for attending training at IUCN Law Center in Bonn for analysis of Mangrove legislation in the Neotropics	CLOSED	Develop framework for undertaking comparative studies of environmental law related to mangrove ecosystems. Produced paper entitled "Conservation and Wise Use of Mangrove Ecosystems: Legislation in Brazil, Colombia, Costa Rica and Nicaragua"
Brazil	WFF/98/BRA/2	Technical training on management and conservation of wetlands used by intercontinental migratory shorebirds in the coast of Maranhão	CLOSED	The project provided training on techniques for conservation of the different biological communities in the area's wetlands, in particular for the migratory shorebirds that inhabit the north-central coast of Brazil.
Brazil	WFF/99/BRA/9	Guidelines for qualification of teachers of public and private schools from Sepetiba Bay region, with emphasis in the area of Guaratiba Biological and Archaeological Reserve aiming the establishment of environmental education programs	IN PROGRESS	Project will provide environmental education training to schoolteachers and NGOs in the vicinity of the Nature Reserve. This initiative was carried out in the framework of a larger public awareness project focused on highlighting the importante of mangrove conservation.
Caribbean	WFF/01-2/CAR/1	Mangrove Curriculum Transfer	IN PROGRESS	Adaptation and translation of MPAs mangrove education curriculum into Spanish. Introduction of MPA's mangrove education curriculum to at least 50 teachers at a two day workshop in Honduras and at least 50 teachers at a two day workshop in San Andres/Old providence (Colombia). Establish a temporary part-time education co-coordinator at CODDEFFAGOLF (Honduras)
Colombia	WFF/97/COL/1	Diagnostic and ecological assessment of the ancient Sinú river basin, with emphasis on Cispatá Bay and surrounding marshes	CLOSED	The project disseminated the results of the ecological assessment study of the estuary, particularly to the local authorities, in order to assist them with the implementation of training and educational workshops.
Colombia	WFF/98/COL/4	Environmental education for local communities on good and services of the Parque Nacional Natural Isla de Salamanca	CLOSED	Project developed a participative environmental education program directed at stakeholders using the natural resources of the Parque Nacional Natural Isla de Salamanca.

Colombia	WFF/98/COL/10	Development of public awareness materials for Caribbean manatee (Trichechus manatus) conservation program in Bajo Magdalena, Colombia	CLOSED	Project produced public awareness materials, including audiovisuals that will support an environmental education program focused on manatees. The program's aim was to create awareness on the ecological value and the need for preservation of the ecosystem that this animal inhabits.
Costa Rica	WFF/01/CRI/2	Preparation of a Procedure Manual for the Management of mangroves	IN PROGRESS	Project seeks to develop a tool that will facilitate and standardize the procedures to be followed by Protected Areas personnel in response to different requests from users of the resources found in mangrove areas. The future manual/training tool will compile information on the following topics: ecology, legislation, uses, impacts, and administrative mechanisms for management.
Costa Rica	WFF/95-96/CRI/9	Effects of cattle grazing in Palo Verde National Park	PENDING REPORTS	Master's thesis that aimed to quantify the vegetation in Palo Verde, estimating biomass production, and species cover under two cattle grazing rates. Cattle grazing in the wetland has been used as a tool to regulate wetland vegetation and has created habitat for thousands of aquatic birds.
Costa Rica	WFF/97/CRI/6	Water quality of the Irrigation National System (SENARA), its agroindustrial reutilization in Cantón 6º of Cañas Subdistrict and its effect on the wetlands of the lower basin of Tempisque, Costa Rica	PENDING REPORTS	Master's thesis to study the presence of agrochemical in the wetlands of Cañas before and after an agricultural scheme. In addition, the final destination of pesticides applied in the irrigation ditches will be studied and their effect on the Madrigal Lagoon, a nesting site for aquatic birds
Costa Rica	WFF/97/CRI/9	Communication strengthening in Mesoamerica as a tool for improving management and conservation of wetlands and coastal zones within the region	CLOSED	The aim of the project was to improve the quality of the services offered by the Documentation Wetland and Coastal Zone Center, establishment of an user's web in the Mesoamerican region and training for various sectors on wetlands, coastal zones and the use of the database.
Costa Rica	WFF/98/CRI/8	Cattle grazing in the wetlands of the Parque Nacional Palo Verde: a case study on sustainable development	PENDING REPORTS	Master's thesis whose objectives were to determine the level of sustainability of cattle grazing and to compare the benefits of sustainable use vs. traditional use of the wetland.

Costa Rica	WFF/98/CRI/23	Participation of the Bagatzí community in the wetlands of Palo Verde	PENDING REPORTS	Master's thesis whose aim was to find out the level of participation of the Bagatzí community in conservation and management of the Palo Verde wetlands, as well as to help define the necessary conservation and management strategies.
Costa Rica	98X-2	Participation of Ramsar site administrators in management procedures for Parque Nacional Palo Verde	CLOSED	The aim of the project was to support the participation of the Administrative Authorities of Guatemala and Trinidad & Tobago in an orientation course of management for Palo Verde Ramsar site in Costa Rica. The objective was to promote on-site training and to help create a network of site administrators in the Neotropics.
Costa Rica	WFF/99/CRI/2	Wetlands monitoring carried out by the community of Caño Negro (first stage)	PENDING REPORTS	Project will design a yearly monitoring program and network in the community of Caño Negro in order to give technical training to Friends of the Earth staff. It will also seek to foster the wise use of wetland resources by the local community.
Ecuador	WFF/95/ECU/2	Logistic support for field research on a mangrove Ramsar site	CLOSED	Provide increased knowledge on the ecological processes in wetlands to assist in the management of the Reserve, building the capacity of students in research metodologías.
Ecuador	WFF/01/ECU/1	Anthropological, social y Bio-environmental Interaction for the Reserve Cayapas-Mataje	ONGOING	Includes the implementation of programs of control and surveillance, inventories and information of flora and fauna, and providing training to local communities.
Ecuador	WFF/01-2/ECU/2	Conservation of wetlands (mangroves) from the Arenillas Ecological Reserve and its buffer zone.	ONGOING	Project proponed by NGO that seeks to work with Administrative Authority to nominate a recently declared Nature Reserve as a Ramsar site. Includes training of military personnel responsible for managing site, as well of creating public awareness amongst local population on the need to conserve mangrove ecosystems at the site.
Ecuador	WFF/02/ECU/4 - phase 2	Anthropologic Interaction in Cayapas-Mataje - Phase 2 (de WFF/01/ECU/1)	ONGOING	Continuation of WFF/01/ECU/1. Additional funds will be used to purchase another outer board engine, to strengthen monitoring task in site.

Guatemala	WFF/01/GTM/2	Promotion of conservation and wise use of Punta Manabique wetland, Izabal, Guatemala	CLOSED	NGO produced brochures, posters and a promotional section for a national newspaper on the Punta Manabique Ramsar site. Additionally, a series of public awareness and training workshops were carried out with the local community and site managers.
IUCN-ORMA	WFF/00/ORMA/1	Practical training in conservation and management of wetlands through the Coastal Zone and Wetlands Program of IUCN-ORMA	CLOSED	The project established a training program for local young professionals at the IUCN Mesoamerica office. The interns became involved in technical and administrative activities related to conservation and management of wetlands in the Region.
Mexico	WFF/98/MEX/1	Capacity building for the management and conservation of coastal tropical wetlands	CLOSED	Three training courses were carried out with the support of the Merida University. The topics covered by the courses were: the Ecological Basis for Management of Coastal Ecosystems; Ecology and Management of Tropical Estuaries; Analysis and Simulation of Ecosystems: A natural Resources Research and Management Tool. The beneficiaries of the course were the administrative personnel and technicians of institutions involved in conservation, restoration, uses and research in the coastal wetlands like universities, federal and state government personnel and NGO´s.
Mexico	WFF/02/MEX/1	Capacitating and training local communities for the conservation of wetlands in Alvarado, Veracruz	ONGOING	The Laguna de Alvarado is one of the riches and most extensive wetland ecosystems in Veracruz. Currently, the exploitation of forest resources, mostly mangrove, presents the greatest threat to the site. Project will carry out workshops to train and involve active members of the community in conservation of the wetland.
Mexico	WFF/98/MEX/4	Training for the wise use of wetlands and promotion of sustainable fisheries in Reserva de la Biosfera La Encrucijada, Chiapas, México	CLOSED	Aims to provide technical, administrative and legal training to fishermen and Reserve personnel on the management of projects for the development of sustainable fisheries.
Venezuela	WFF/00/VEN/2	Participation of Ramsar site managers in international course on ecology and management of mangroves and coral reefs.	PENDING REPORTS	Ramsar site managers form Venezuela attending at international course will also help create public awareness on Ramsar by making presentation on the Convention and giving out promotion materials.

Venezuela	WFF/02/VEN	Consolidation of the “Young Park Rangers” en Parque nacional Laguna deTacarigua	TO START IN 2003	Project will put into action a volunteer program for children to get involved in conservation and environmental education at Ramsar site.
Workshop	WFF/01/WKS/2	Support to the attendance to the mangrove workshop in Orleans, France	CLOSED	Support for a Brazilian expert to attend and give two presentations on mangroves at the 8th French Congress of Sedimentology (Orleans, France).

nall Grants Fund

:azil	SGF/93/BRA	Study ecologic of mangroves of the west coast Estate of Maranhao.	CLOSED	Conduct an ecological study of the mangrove wetlands on the western coast of the state of Maranhão. This vital area, proposed by the Government for Ramsar designation and one of the most important tropical coastal ecosystems in the world, is under intense pressure from the local population, who depend upon its resources for subsistence. The planned studies and vegetation surveys contributed to better knowledge of the biodiversity of these wetlands and laid some of the groundwork for a management plan for the area. The area was designated as Ramsar site in 2000.
:azil	SGF/97/BRA/1	Management actions at State Marine Park of Parcel de Manuel Luís, Maranhao	CLOSED	The Marine State Park of Parcel de Manuel Luís in the State of Maranhao was created to preserve one of the southernmost Neotropical coral reefs. The allocated SFR 40,000 for management actions at State Marine Park of Parcel de Manuel Luís will help carry out two main objectives: The first, to make a more detailed characterization of the reef, in order to establish norms and rules that will be included in the management plan of this conservation unit, and the second, to begin studies on the relationship between the coral reef area of Parcel de Manuel Luís and the mangrove areas of the Reentrancias Maranhenses Ramsar site in order to extend its boundaries and include the coral reef area.
ıina	SGF/97/CHN	Capacity building and management planning for Dongzhaigang Ramsar site, Hainan	CLOSED	The Dongzhaigang National Nature Reserve in the Hainan province is one of China's six Ramsar sites. The area is probably the best remaining area of mature mangrove forests in China and is of primary importance for wintering and migrating waterbirds. It also provides significant resources for more than 4000 families living around the Bay. The granted will help to build the capacity of the Forestry Bureau of Hainan to develop and achieve conservation and wise use at Dongzhaigang through training, community outreach and local participation; provide urgently needed staff training in management planning and wise use concepts; assist with the development of a 5-year management plan; carry out public awareness campaigns, and update the information of this Ramsar site.
ɔlombia	SGF/99/COL/1	Formulate a management plan for the Cienaga Grande de Santa Marta (Ramsar site)	ONGOING	The wetland of the Cienaga Grande de Santa Marta constitutes one of the most important wetlands in Colombia. In 1998 it was designated as the first Ramsar site in the country. In this context it was necessary to prepare a management plan to promote its wise use and to guarantee the maintenance of the ecological character.

ɔsta Rica	SGF/97/CRI/2	Plan for the protection of the Mata Redonda wetland - Wildlife Refuge, Guanacaste	UNDER EVALUATION	Project aimed to develop a management plan for the protection of the Mata Redonda wetland and its designation as a Ramsar site (Palo Verde). People from local communities keep cattle in the Mata Redonda wetland - as they used to in Palo Verde - which by trampling and eating the vegetation ensure spaces of open water attractive to birds. Fish and invertebrates are abundant, and the site is vital for colonial nesting birds in the region as well as for wintering/migratory species. To ensure efficient protection, the necessary infrastructure and legal actions have to be set up, which require ecological evaluation of the area; analysis of the legal situation of the Refuge and surrounding zones; revision of its legal status with regard to land tenure; preparation of audio-visual materials in collaboration with local communities and authorities, plus the organisation of workshops for public awareness.
ıba	SGF/02/CUB/1	Preparation for participative management of coastal wetlands in northeast Cuba	TO START IN 2003	The specific objectives were to characterize the coastal wetlands, community/institutional capacity building, and preliminary economic valuation. Community workshop and info materials for developing local awareness. Economic valuation study.
ıambia	SGF/95/GMB	Preparatory Assistance for designation of Bao Bolong Wetland and Niumi National Park as Ramsar sites	CLOSED	Project will help to identify, assess, delineate and map the Bao Bolong wetland and the Niumi National Park areas for designation as Ramsar sites. The proposed sites are shared wetlands with Senegal and their designation will lead to collaboration in the management of the sites between the two countries, as called for in Article 5 of the Convention. The wise use concept will be particularly applicable in the two sites since they are very important areas for use by local communities.
hana	SGF/98/GHA/1	Rehabilitation and Community Management of Mangroves and Coastal Wetlands in the Lower Volta Delta (1)	PENDING REPORTS	The Green Earth Organization (GEO) on behalf of eight communities in the Lower Volta Delta area presented this proposal. Due to human intervention such as commercial exploitation of mangrove resources, industries, and dams, the communities have initiated efforts to enhance the growth and survival of the trees in the western segment of the Lower Delta. The aim of the project was to support the rehabilitation and community management of mangroves and coastal wetlands in the Lower Volta Delta (Ramsar site). Degraded coastal wetlands will be restored and managed by planting mangroves, fruit trees and woodlots, and the local communities will be involved in the protection and wise use of these resources for the conservation of biodiversity and provision of alternative sources of income.

uatemala	SGF/94/GTM	Evaluation and delimitation of distribution of vegetation types in the Manchon-Guamuchal wetland	CLOSED	The Manchón-Guamuchal wetland is the last "rather undisturbed" mangrove area on the Pacific coast of Guatemala. The main threat is from wood ext raction, but research was needed on how this affects vegetation and the water regime. Through the project it was intended to identify areas of forest regrowth and investigate modifications in the water system over the past 40 years, permitting a more solidly based management plan.
uinea	SGF/94/GIN	Preservation of Tristao Islands	CLOSED	One of the most important stopping places in Africa for migrating waterbirds, the Tristao Islands are an estuarine complex at the mouth of the river Kogon in northwestern Guinea. This Ramsar site has for some time been under increasing threat by humans, particularly illegal hunting and the disturbance of birds during nesting periods. The SGF grant allowed for improved management of the site, with boundary delimitation, sign-posting, mangrove replanting, and training for managers, as well as the development of a programme of public awareness and community participation.
onduras	SGF/93/HND	Plan emergency for the protection of the wildlife refuge Cuero y Salado	PENDING REPORTS	Honduras requested emergency aid to assist in controlling unauthorized access to the Cuero and Salado Ramsar site by hunters, fishermen, and ranchers of the area. SGF funding helped strengthening enforcement and at the same time began to develop public awareness of the potential benefits of wise use of the site.
onduras	SGF/95/HND/2	Cadastral surveying of Jeannette Kawas National Park	PENDING REPORTS	An emergency proposal was submitted involving the land tenure survey of "Jeannette Kawas National Park". The land "ownership" is mixed, partly belonging to local farmers, partly to the state and with some communal lands. The lack of clear and official tenure (there were no maps or limits established) was actually the cause of the murder of conservationist Jeannette Kawas. The grant helped to have a clear definition of land tenure in the park; determined the land use and location of its inhabitants; and established the limits of the National Park in conjunction with the local communities. This gave the authorities the tools for fighting against invasion of developers and poachers and helped the communities know the types of land use, with their own participation and agreement.

onduras	SGF/96/HND/1	Strengthening management and development of Jeannette Kawas National Park	PENDING REPORTS	PROLANSATE is a coalition of local and central government agencies and environmental and community-based NGOs with long experience in the conservation and wise use of the site formerly known as Punta Sal, renamed Jeannette Kawas National Park. The grant was to strengthen PROLANSATE's capacities in a crucial time for the site and to assist in implementing the Park's management plan.
donesia	SGF/92/IDN	Improvement of Management and Conservation of the Berbak National Park	CLOSED	The former Berbak Wildlife Reserve in Sumatra (Indonesia's only Ramsar Site, 1992), newly elevated to the status of Berbak National Park. The aim of the project was to provide staff training in habitat monitoring, maintenance of facilities and patrol boats, and construction of a field office, a staff mess, and a guesthouse near one of the watch posts, all especially urgent goals with the increase of tourism that its national park designation implies.
an	SGF/99/IRN/2	Integrated management plan for the "Hara Biosphere Reserve"	ON GOING	Development of a management plan for Hara Protected Area, located within the Khouran Straits. This site, the largest mangrove / mudflat ecosystem in the Middle East, is facing the threat of industrial development, and was in need of an integrated management plan to ensure the sustainable use of its resources. Under the project, several activities were expected to be carried out: a study of the ecological and socio-economic importance of the site, identification of threats, development of guidelines for ecotourism and mangrove harvesting, and enhancement of public awareness regarding the values of the wetland and its biodiversity.
an	SGF/99/IRN/2	Integrated management plan for the "Hara Biosphere Reserve"	ONGOING	Grant awarded for the development of a management plan for Hara Protected Area, located within the Khouran Straits. This site, the largest mangrove / mudflat ecosystem in the Middle East, is facing the threat of industrial development, and was in need of an integrated management plan to ensure the sustainable use of its resources. Under the project, several activities were expected to be carried out: a study of the ecological and socio-economic importance of the site, identification of threats, development of guidelines for ecotourism and mangrove harvesting, and enhancement of public awareness regarding the values of the wetland and its biodiversity.

maica	SGF/98/JAM/1	Towards management of the Black River Morass (Ramsar site) - gathering biological, social and economic data (1)	PENDING REPORTS	A grant was approved towards the management of the Black River Morass (Ramsar site) by gathering biological, social and economic data. The need for protection of this area had become critical as threats have increased drastically (pollution from agriculture, aquaculture, industrial activities, and tourism). The objective of the project was to collect, analyze, and map biological, social, and economic data, followed by the development of a management plan, including legal aspects and continuous monitoring.
auritania	SGF/97/MRT	Development of ecotourism in Banc d'Arguin National Parks	PENDING REPORTS	Activities to be carried out included pilot tours with travel agents with experience of collaboration in the field of protected areas; accompanying local communities to help them identify an active participatory role for monitoring, reception of tourists and management of resources; a workshop on ecotourism with all people concerned; training workshops in the villages of the Park whose inhabitants will be leading actors in this project; an investment programme for acquisition of equipment and their use, such as new tents, sightseeing boat, stalls for sale of products, and sewing, handicraft and fishing materials. A competent person will be hired to coordinate the activities that were most urgent, supported by a network of people in each community.
ıama	SGF/97/PAN/1	Monitoring and protection of shrimp species in the Punta Patiño wetland and surrounding areas, Darién Province	CLOSED	The objective of the project was to undertake the monitoring and protection of shrimp populations in the Punta Patiño wetland (Ramsar site) and surrounding areas in the Darién province. This project aimed at obtaining information for the evaluation of the current situation of shrimp fishing in the whole area, in order to ensure conservation and wise management of this marine resource of vital commercial importance. Fishing in the Punta Patiño Nature Reserve and surrounding areas is qualified to be industrial and traditional. Maps were developed showing the distribution of shrimp species in the different phases of their life cycle. Active participation of the local communities was an important objective, aiming at their training on the conservation and wise use of these natural resources and making them aware of their role as impacting and regulating entities of the environment.

ıama	SGF/98/PAN/3	Gathering basic information for the development of a global management plan for the "Golfo de Montijo" Ramsar site.	PENDING REPORTS	At least 14% of the country's mangroves are found in the "Golfo de Montijo". The disorderly development of certain economic activities is seriously affecting the sustainable use of this ecosystem, its ecological functions, and the basic needs of around 10,000 people mostly poor people who depend on its resources for their survival. The grant was aimed at gathering basic information for the development of a global management plan for the "Golfo de Montijo" Ramsar site. Besides the establishment of such a global management plan, the basic information assembled facilitates the sustainable development of the whole area. Moreover, thanks to the economic resources of the area, the Ramsar Administrative Authority in Panama was able to finance the management of the site.
ıriname	SGF/97/SUR/1	Preparation for the development of a rational management system for the North Coronie Wetlands	CLOSED	The aim was to develop a management system for the Coppename -Monding Nature Reserve and the surrounding North Saramacca area.
inidad & Tobago	SGF/96/TTO/1	Development of a management plan for the wise use of the Nariva Swamp	PENDING REPORTS	With the long-term aim of developing a management plan for Nariva Swamp, this project, was a follow-up to the recommendations in the Convention's 1995 application of the Management Guidance Procedure at the site, which called for, among other things, an Environmental Impact Assessment of Sector B of the swamp that would also take into consideration the environmental, social and economic issues related to the entire catchment area. The EIA provided the specific information necessary to designate categories of conservation/use of Nariva that would form the basis for development of the management plan.
inidad & Tobago	SGF/98/TTO/1	Filling in of the irrigation channels (Rehabilitation of the Block B Area of Nariva Swamp)	CLOSED	Nariva Swamp was designated as a Ramsar site in 1992 and listed on the Montreux Record in 1993. Illegal squatting by rice farmers and ad hoc rice farming methods within Block B of the swamp resulted in the construction of 15 irrigation channels. This affected the hydrology of the swamp and there a rapid draining of the marshes at the onset of the dry season. Extreme dryness made the area conducive to fires and more than 3,000 acres of marshlands were destroyed by bush fires. The project was aimed at rehabilitating the 15 irrigation channels.
enezuela	SGF/95/VEN/1	Evaluation of fisheries in the Cuare Wildlife Refuge	PENDING REPORTS	The area, Cuare, a Ramsar site, is of great importance as a nursery for fish and shellfish. The objective of the project was to establish the wise use – in a scientific context – of the mangrove crab by the local communities.

enezuela	SGF/95/VEN/2	Status of Jaibas (*Callinectes spp)* population in the Cuare Wildlife Refuge, Edo Flacon, Venezuela	CLOSED	The project included the study of the populations of fish in the Cuare Ramsar site with commercial value, in order to determine the minimum size of individuals and areas more suitable for exploitation. The results were to benefit both the local communities, which depended on the wise use of this resource, and the fish populations.

ANNEX 11

ITTO MANGROVE WORKPLAN 2002–2006

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FOREWORD

The ITTO Mangrove Workplan has been prepared and published as part of the Organization's policy work and is a concrete example of the importance that ITTO members place on the sustainable management and conservation of these unique forest ecosystems. Prior to the publication of this Workplan, ITTO had funded approximately US$9 million in mangrove-related projects. These projects have laid the framework in many countries for overall mangrove management and conservation plans, as well as contributing to the restoration and rehabilitation of extensive areas of mangroves. ITTO's project work has also contributed to global information collection and dissemination on mangroves, and has fostered several fruitful collaborative initiatives with other organizations active in this field. This Workplan will guide the work of the Organization and its member countries on mangroves over the next five years by providing insights into the kinds of activities that are seen as priorities by the Organization for future project work. ITTO looks forward to working together with its many mangrove partners to implement this Workplan and further contribute to the long-term survival of mangrove ecosystems around the world.

Manoel Sobral Filho
Executive Director, June 2002 International Tropical Timber Organization

ACRONYMS

ADB Asian Development Bank
CIDA Canadian International Development Agency
DANCED Danish Cooperation for Environment and Development
EU European Union
FAO Food and Agriculture Organization of the United Nations
ISME International Society for Mangrove Ecosystems
ITTA International Tropical Timber Agreement
ITTC International Tropical Timber Council
ITTO International Tropical Timber Organization
IUCN International Union for the Conservation of Nature and Natural Resources
IUFRO International Union of Forestry Research Organizations
JICA Japan International Cooperation Agency
UNDP United Nations Development Programme
UNEP United Nations Environment Programme
UNESCO United Nations Education, Scientific and Cultural Organization
USAID United States Agency for International Development

ITTO MANGROVE MISSION STATEMENT

ITTO aims to promote the conservation, rehabilitation and sustainable management of mangroves to benefit the global community, particularly communities living in the mangroves and their surrounding areas, by engaging in activities within the scope of the ITTA. ITTO's work on mangroves will be carried out in collaboration with relevant organizations and be based upon scientific research of the highest standards, as well as traditional knowledge and value systems.

ITTO MANGROVE WORKPLAN
2002–2006

1. Introduction

ITTO is one of the main international organizations concerned with the sustainable management of mangrove forests and their conservation. Over the past decade ITTO has undertaken substantial project work to improve the sustainable management of mangroves, their conservation and rehabilitation in several countries around the world. In November 2000, the International Tropical Timber Council through its Decision 9(XXIX) reiterated and strengthened its support for mangrove forests. ITTO further recognizes the importance of mangroves as explicitly stated in the overall ITTO Action Plan for 2002–2006, which calls on the Organization to, *inter alia*, "promote the conservation, rehabilitation and sustainable utilization of mangroves in collaboration with relevant organizations". The Council's Decision 7 (XXXI) led to an International Mangrove Workshop in early 2002 and, following review by an Expert Panel, to the development of this Workplan. The ITTO Mangrove Workplan will provide guidance for the Organization's future work in this area, for the years 2002–2006. ITTO's work on mangroves is consistent with the Organization's objectives, as laid out in Article 1 of the International Tropical Timber Agreement (ITTA). These objectives fall under three broad categories:

• Effective consultation and cooperation between members on issues related to the international trade and utilization of tropical timber and sustainable management of its resources;
• Promotion, expansion, diversification and strengthening of tropical timber trade and greater market transparency; and
• Encouragement of reforestation and forest management, sustainable utilization and conservation of the tropical forest and its genetic resources.

Mangrove ecosystem goods and services have links with ITTO objectives. When effective consultation and cooperation is promoted between mangrove timber producing and consuming countries, and there is more diversification and transparency in the international trade of mangrove products, there will be fair sharing of income and the tendency for resource over-exploitation will be reduced. Moreover, when producers are encouraged and supported to practice reforestation, rehabilitation, conservation and proper management of the mangrove ecosystem, the result is healthy or restored mangrove forests that mimic natural conditions. Rehabilitated mangrove ecosystems bring back all the benefits of the ecosystem to the local people who depend on it for livelihood, including the provision of products for international trade.

1.1 Importance and Uniqueness of Mangroves

Mangroves constitute a unique tropical ecosystem, occurring most extensively along the protected coastal shores with muddy to sandy bottoms, which is alternately covered and uncovered by tidal fluxes. Mangroves often extend also into the sub-tropical zone of some eastern coasts of continents and major landmasses due to warm marine coastal currents. The development, structure and dynamics of mangrove ecosystems are otherwise regulated by the interplay of marine coastal waters with fresh or brackish waters from land drainage. In general, geography, coastal topography (including geomorphology), and tidal rgime determine the presence or absence and extent of the mangroves. Structure, physical properties and chemical composition, salinity, acidity of the soil and sediments, the nature of the substratum as well as the climate determine the development, growth and productivity of the mangrove ecosystem. Mangroves differ from other forest ecosystems in that they receive large inputs of matter and energy from both land and sea. They also store large quantities of organic carbon. They display a high degree of structural and functional diversity, placing mangroves amongst the most complex ecosystems. Ecologically, mangroves represent a rather sharp transitional gradient between the marine and fresh water environments. Thus, only flora and fauna that have broad physiological tolerance can survive.

No other association of woody plants and grasses takes root or develops into a forest in the intertidal zone anywhere in the world. In spite of the demanding environment, mangrove ecosystems are home to a wide range of plant and animal biological diversity. In terms of animal biodiversity, mangrove ecosystems serve as habitats for many species of birds, mammals, reptiles, fishes, molluscs, and crustaceans, as well as a wide range of hitherto unknown species of micro-organisms. Although the existence of endemic mangrove fauna is rare, some species are highly dependent on mangrove ecosystems.

Mangroves provide many other functions such as coastal stabilization, erosion prevention, biological filtering, and serve as a sink for several pollutants. Mangroves also serve as natural laboratories where scientists can discover new or poorly known ecological or physiological processes, relationships between morpho-types and DNA sequences of the flora and fauna, responses to elevated atmospheric CO2, etc. In addition, mangroves provide many economic benefits. Firewood, charcoal, logs and raw materials for paper and chipboard are useful timber products derived from the mangrove forest. Mangroves provide medicines and fodder, as well as habitats and nursery grounds for many

commercially important aquatic species. Mangroves are also increasingly viewed as ecotourism destinations. While products from mangrove ecosystems do not generally play a large part in international trade, they are very important for local communities. Integrated management plans are necessary to take account of the complexity of goods and services provided by mangroves.

1.2 Problems and Impacts

In recent times, over-exploitation and destruction of mangroves due to human activities have caused heavy damage to these ecosystems worldwide. Mangrove soil is generally marginal for agriculture, yet conversion of mangrove land for agriculture is widespread. In several parts of the world mangroves have been destroyed to create shrimp ponds which cannot sustain their production over time due to acid sulphate soils, viral diseases, etc. Mangrove destruction is also due to a variety of other reasons: the need for fuelwood, oil prospecting and production, conversion to cattle-ranching, the salt industry and coastal development everywhere (harbor, urban and industrial development, airports, power plants and others). International and national demand for mangrove forest resources and land is at present one of the main causes of the destruction of mangroves. Poor policies and legislation (and lack of enforcement) also contribute to mangrove destruction and degradation. This is partly due to the fact that information on mangroves and their importance is often lacking or inaccessible. During the last decade approximately 1 000 km² of mangroves have been destroyed annually. Mangroves are not wastelands and their destruction, for whatever purpose, invariably results in ecological degradation and social impoverishment of local people. The restoration of degraded mangroves can be extremely costly and time-consuming. All abiotic and biotic factors acting on mangrove ecosystems vary between and within countries. Over and above this, anthropogenic factors have induced changes in almost all the mangroves of the world, predominantly in a negative manner. Significant changes of all sorts became increasingly damaging during the second half of the 20th century. The changes have affected the distribution, extent and health of single mangrove species and of the ecosystem as a whole. The coastal zone everywhere in the world is extremely dynamic. It may be described as a chaotic system where an infinitely large number of variables are in constant and relentless interaction. The chaotic nature of coastal zone systems makes the impact of changes hard to anticipate and often dramatic. Mangroves are home to and provide livelihoods for millions of people, but the opinions of local residents regarding their management have seldom been sought. Public awareness regarding mangroves and their conservation is often lacking. There is an urgent need to bring people and nations together to apply the knowledge and wisdom of experience to use the mangrove forest judiciously. By and large, the contemporary attitude is that mangroves are an expendable commodity. It is widely believed that after total felling the forest will regenerate spontaneously. On the contrary, this only happens under very special conditions and usually with human assistance. Many see in mangroves not much more than timber, charcoal and woodchips, despite the many benefits and functions listed in Section 1.1. Indirect benefits offered by mangroves are easily forgotten and set aside when quick profits can be generated by converting mangroves to other uses. The experience of ITTO and others has shown that unregulated mangrove use leads to the abuse and wastage of natural capital wealth and hampers natural regeneration. It is therefore imperative to find ways and means for rational management appropriate to ecological and socio-economic needs and constraints everywhere. Such management, however, can only be fully developed and implemented at the local level with the collaboration of local people, legislators and experienced mangrove professionals, and must incorporate the development of viable alternative livelihoods.

1.3 Current Activities Undertaken in Mangroves

1.3.1 ITTO

ITTO has contributed immensely to the conservation, rehabilitation and management of tropical forests, including mangroves, through governments, individuals and organizations. The Organization has sponsored numerous projects worldwide to contribute to the goal of sustainably managing the world's tropical forests. ITTO's extensive experience in the conservation, rehabilitation and management of mangrove ecosystems is summarised in the report of the ITTO International Mangrove Workshop held in Cartagena, Colombia, in February 2002. Between 1990 and 2001, ITTO financially supported mangrove projects totaling about US$9 million in member countries. The projects include research activities, workshops on conservation and sustainable utilization of mangrove forests, establishment of an international network for the conservation and sustainable utilization of mangrove forest genetic resources, establishment of a mangrove information database, and publication of the world mangrove atlas and the manual for mangrove ecosystem restoration.

1.3.2 Other Organizations

Interest in mangrove ecosystem research and management has risen in recent times among many stakeholders. Many other organizations apart from ITTO carry out research, conservation, rehabilitation and management activities in mangrove ecosystems. Organizations such as ADB, CIDA, DANCED, EU, FAO, ISME, IUCN, IUFRO, JICA, Ramsar Convention, UNDP, UNEP, UNESCO, USAID, Wetlands International as well as numerous national governmental,

non-governmental and educational organizations have sponsored programs on mangrove ecosystem conservation and management. The experiences of many of these organizations in conservation, rehabilitation and management of mangrove ecosystems are summarized in the report of the Cartagena workshop.

The project areas covered by other organizations include, *inter alia*:

• tourism and environment case studies;
• nursery and plantation projects in mangrove areas;
• railway and port restructuring;
• bee-keeping in mangrove forests;
• production of handbooks on mangroves;
• creation of mangrove walkways; and
• establishment of protected areas.

ITTO has undertaken collaborative work on mangroves with several of these organizations, especially ISME, with which it collaborated to produce the World Mangrove Atlas and other important outputs.

1.4 Other Considerations

The complexity of the mangrove forest and the adaptability and vulnerability of mangrove species and of the entire ecosystem are the basic realities to be considered for the construction of an overall mangrove workplan. To acquire knowledge of mangrove bio-ecology and rational utilization and management of the system, a large number of variables should be taken into account. On the basis of past experience it is clear that knowledge acquired for the utilization of mangroves in one area cannot be directly transferred to other areas without prior adaptation to local environmental conditions. Detailed local workplans that consider and include the interests and knowledge of local populations should always be developed on this basis. The value of mangrove forests varies widely from place to place as a function of species composition, local productivity of the system and of particular species, and the needs of the local population for livelihoods and trade. The interaction between international agencies, universities and specialized laboratories must be strengthened as appropriate to facilitate mangrove research and funding. In this context, collaboration and assistance from all stakeholders is essential to ensure the successful implementation of this ITTO Mangrove Workplan.

2. Workplan Objective

The objective of this Workplan is to guide the work of ITTO on mangroves during the period 2002–2006 and to provide guidance to member countries seeking support from the Organization for mangrove management, conservation and rehabilitation through project activities. The Workplan can also serve to guide further collaborative activities between ITTO and others.

3. Activities

The following list of activities, which can be divided into six program areas, is based on recommendations from a panel of mangrove experts. In the formulation of these activities, the panel took account of comments by Council members, the recommendations made by the Cartagena workshop, and the draft Mangrove Workplan considered at the Thirty-first ITTC session. The criteria used to select activities for this Workplan are as follows:

1. ITTO's past history of conducting successful work in the area;
2. Relevance to ITTO's mandate (ITTA Article 1 – Objectives);
3. Relevance to program areas specified in Decision 9(XXIX) as follows:

• increase awareness among members to promote conservation of mangroves
• encourage cooperation among members to intensify ITTO's activities to conserve existing mangroves and rehabilitate degraded mangroves;
• promote the sustainable management and utilization of mangroves;

4. Geographic scope (limited to ITTO membership);
5. Duration of activity;
6. ITTO's comparative advantage;
7. Financial implications for ITTO.

Activities will be carried out by member countries, by ITTO or by both, and whenever possible in collaboration with other relevant organizations. These activities should be submitted and implemented through the ITTO project cycle,

taking into account appropriate levels of financial and human resources to be allocated, and the overall balance between all activities of the Organization.

Area 1: Conservation and sustainable management

• Assess existing, and if applicable develop new, methodologies and guidelines for assessing qualitative and quantitative aspects of mangroves
• Assess existing, and if applicable develop new, criteria and indicators for sustainable management of mangrove ecosystems
• Encourage members and assist them where appropriate to:

- implement sustainable mangrove management and establish protected mangrove areas, including buffer zones surrounding and influencing such areas
- prepare and implement mangrove management plans
- establish bilateral and multilateral arrangements for transboundary conservation and management areas
- rehabilitate degraded mangroves.

Area 2: Mangrove information and awareness

• Maintain, expand and improve access to existing mangrove information databases in collaboration with other organizations [e.g. the Global Mangrove Database and Information System (GLOMIS)]
• Update/revise the World Mangrove Atlas
• Support and participate in an International Year of Mangroves under the United Nations system
• Encourage members and assist them where appropriate to:
- publish and disseminate mangrove information in local languages
- conduct assessments, monitoring, mapping, boundary demarcation, etc., where reliable information on mangrove resources is lacking.

Area 3: Socio-economic aspects

• Encourage members and assist them where appropriate to:

- carry out work to assess the contribution of mangroves to, and impacts of mangrove degradation on, local communities and to generate sustainable socio-economic benefits from mangroves for local communities
- document and promote use of traditional systems of knowledge and management for mangroves
- conduct valuation studies of wood and non-wood goods and services from mangrove areas.

Area 4: Mangrove ecosystem functions and health

• Encourage members and assist them where appropriate to:

- undertake studies and projects to improve understanding of mangrove forest ecosystem structure, growth and function
- undertake systematic research and monitoring activities to be used to assess the health of mangrove species and their habitat including, *inter alia*, the effects of climate change/sea-level rise
- undertake studies of ecological impacts of wood harvesting and other human actions (e.g., hydrological alterations, creating shrimp ponds) on different types of mangrove ecosystems and innovative technologies for reducing the adverse impact of human uses.

Area 5: Cooperation and capacity building

• Provide training and fellowships, through the ITTO Fellowship Program, with the intention of sharing and increasing awareness, understanding and skills relating to mangrove ecosystems
• Encourage members and assist them where appropriate to:

- establish National Mangrove Committees (NATMANCOMs) to coordinate all activities relevant to mangrove ecosystems
- increase mangrove management capacity for extension workers, government officials and local community leaders
- encourage and support cooperative relations between all stakeholders (e.g. national and international bodies, local communities, private sector, environmental NGOs) with responsibility for the conservation and sustainable utilization of mangrove ecosystems through networking, workshops, etc.

Area 6: Policies and legislation

• Encourage members and assist them where appropriate to:

- formulate appropriate laws and policies on mangroves with participation of all stakeholders and ensure their enforcement
- conduct analyses of existing laws/policies and their impacts on mangrove management/conservation.

END NOTES :

[2]For instance, paragraph 19 of the Johannesburg WSSD Plan of Implementation focuses mainly on technology transfer. Sub-paragraphs (a) and (n) are of particular relevance: "(a) t ake further action to mobilize the provision of financial resources, technology transfer, capacity-building and the diffusion of environmentally sound technologies according to the recommendations and conclusions of the Commission on Sustainable Development as contained in sect ion A, paragraph 3, and section D, paragraph 30, of its decision 9/1 on energy for sustainable development" & "(n) Utilize financial instruments and mechanisms, in particular the Global Environment Facility (GEF), within its mandate, to provide financial resources to developing countries, in particular least developed countries and small island developing States, to meet their capacity needs for training, technical know-how and strengthening national institutions in reliable, affordable, economically viable, socially acceptable and environmentally sound energy, including promoting energy efficiency and conservation, renewable energy and advanced energy technologies, including advanced and cleaner fossil fuel technologies."

[3] ECOSOC. E/CN.17/2001/PC/11.

[4] ECOSOC. E/CN.17/IPF/1996/5.

[5] ECOSOC. E/CN.17/IFF/1998/4.

[6] In paragraph 43 (f) of the Plan of Implementation, States and other partners agreed to take action to: "Create and strengthen partnerships and international cooperation to facilitate the provision of increased financial resources, the transfer of environmentally sound technologies, trade, capacity-building, forest law enforcement and governance at all levels, and integrated land and resource management to implement sustainable forest management, including the Intergovernmental Panel on Forests (IPF)/Intergovernmental Forum on Forests (IFF) proposals for action."

[7] ECOSOC resolution E/2000/35.

[8] ECOSOC. 2001. UNFF report of the organizational and first sessions (12 and 16 February and 11-22 June 2001). Official Records, 2001, Supplement No. 22 (E/2001/42/Rev. 1, E/CN.18/2001/3/Rev. 1).

[9] In August 2002, the CPF members were: the secretariat of the Convention on Biological Diversity (CBD), the secretariat of the Convention to Combat Desertification CCD), the Centre for International Forestry Research (CIFOR), the Food and Agriculture Organization of the United Nations (FAO), the secretariat of the Global Environment Facility (GEF), the International Tropical Timber Organization (ITTO), the United Nations Department of Economic and Social Affairs (EN/DESA), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank (WB).

[10] Minutes of the first meeting of the UNFF 3 Bureau. UNFF Secretariat, 9 May 2002.

[11] UNFF. 2002. The IPF and IFF proposals for action: main actors and degree of action. Internal document, August, 63 pp.

[12] Department of Agriculture, Fisheries and Forestry, Australia & Program on Forests (PROFOR) at the World Bank. No date. Implementat ion of the IPF/IFF proposals for action: fostering national-level assessments and action. Summary of the IPF/IFF proposals for action and assessment methodology for in-country support to National Forest Programmes. 25 pp.

[13] Spalding, M.D., F. Blasco & C.D. Field. 1997. World mangrove atlas. International Society for Mangrove Ecosystems, Okinawa, Japan.

[14] Hossain, Md.S. 2001. Biological aspects of the coastal and marine environment in Bangladesh. Ocean & Coastal Management 44: 261-282.

[15] Bacon, P.R. 1997. The role of the Ramsar Convention in mangrove management. Intercoast Network: International Newsletter of Coastal Management (Special Edition 1, pp. 25-26). Coastal Resources Management Project of the University of Rhode Island's Coastal Resources Center and the US Agency for International Development.

[16] Adapted from Aizpuru, M., F. Achard & F. Blasco. 2000. Global assessment of cover change of the mangrove forest using satellite imagery at medium to high resolution. In EEC research project no. 15017-1999-05 FIED ISP FR, Joint Research Center, Ispra. Cited in: Blasco, F. J.L. Carayon & M. Aizpuru. 2001. World mangrove resources. GLOMIS Electronic Journal, Vol. 1, No. 2, 3 pp.

[17] Adapted from Windevoxhel, N.J., J.J. Rodriguez & E.J. Lahman. 1999. Situation of integrated coastal zone management in Central America: experiences of the IUCN wetlands and coastal zone conservation program. Ocean & Coastal Management 42: 257-282.

[18] GESAMP & ACOPS. 2001. Protecting the oceans from land-based activities - Land-based sources and activities affecting the quality and uses of the marine, coastal and freshwater environment. Rep. Stud. GESAMP No. 71, 162 pp.

[19] Lacerda, L.D., W. Machado & M. Moscatelli. 2000. ISME/GLOBIS Electronic Journal, Vol. 1, No. 1.

[20] Global Environmental Outlook 2000. United Nations Environment Programme, 398 pp.

[21] Paez-Osuna, F. 2001. The environmental impact of shrimp aquaculture: causes, effects, and mitigating alternatives. Environmental Management 28 (1): 131-140.

[22] Primavera, J.H. 2000. Development and conservation of Philippine mangroves: institutional issues. In: The values of wetlands: landscape and institutional perspectives. Special Issue. Ecological Economics 35: 91-106.

[23] Lars, H. 2002. Toward improved environmental and social management of Indian shrimp farming. Environmental Management 29 (3): 349-359.

[24] Plathong 1998, *in* Field, C.D. 1998. Rehabilitation of mangrove ecosystems: an overview. Marine Pollution Bulletin 37 (8-12): 383-392.

[25] Ashton, E.C. & D.J. Macintonsh. 2002. Preliminary assessment of the plan diversity and community ecology of the Sematan mangrove forest, Sarawak, Malaysia. Forest Ecology and Management 166: 111-129.

[26] Aizpuru, M., F. Achard & F. Blasco. 2000. Global assessment of cover change of the mangrove forest using satellite imagery at medium to high resolution. In EEC research project no. 15017-1999-05 FIED ISP FR, Joint Research Center, Ispra. Cited in: Blasco, F. J.L. Carayon & M. Aizpuru. 2001. World mangrove resources. GLOMIS Electronic Journal, Vol. 1, No. 2, 3 pp.

[27] In the Bahia of Caraquez and Chone River estuary in Ecuador, 90% of the mangroves forests have been cleared to build shrimp ponds (from 3973 ha in 1969 to only 392 ha in 1995). While the mangroves of this area only represent 0.37% of the country, with its 6,000 shrimp ponds the area produces some 11,000,000 pounds of shrimp annually, i.e., 10% of the country production[27]. Another

problem is posed by overpumping of groundwater for coastal aquaculture which causes land subsidence. For instance, 1010 km2 along Taiwan's southwestern coast (more than 10% of Taiwan's flat land) has been affected by land subsidence, which increases excessive flooding and destroys mangrove forests. Fan, K-Ch. 2002. Mangroves in Taiwan: current status and restoration projects. Bois et Forêts des Tropiques 273 (3): 43-54.

[28] Lacerda, L.D. & R.V. Marins. 2002. ISME/GLOMIS Electronic Journal, Vol. 2, No. 1.

[29] Botero, L. & H. Salzwedel. 1999. Rehabilitation of the Cienaga Grande de Santa Marta, a mangrove-estuarine system in the Caribbean coast of Colombia. Ocean & Coastal Management 42: 243-256.

[30] Kelaher, B.P., A.J. Underwood & M.G. Chapman. 1988. Effect on the semaphore crab *Heloecius cardiformis* in temperate mangrove forests. Journal of Experimental Marine Biology and Ecology 227: 281-300.

[31] Duke, N.C., K.A. Burns, R.P.J. Swannell, O. Dalhaus & R.J. Rupp. 2000. Dispersant used and bioremediation strategy as alternate means of reducing impacts of large oil spills on mangroves: the Gladstone field trials. Marine Pollution Bulletin 21 (7-12): 403-412.

[32] Obura, D.O. 2001. Kenya. Marine Pollution Bulletin 42 (1`2): 1264-1278.

[33] For additional and more detailed information on mangrove distribution, status, uses and specific field/cases studies, see: (i) PNUMA. 2002. Evaluación sobre las Fuentes terrestres y actividades que afectan al medio marino, costero y de aguas dulces asociadas en la región del Pacifico Nordeste. Background document, Primera reunión intergubernamental del Plan de Acción del Convenio de Cooperación para la Protección y el Desarrollo Sostenible de las Zonas Marinas y Costeras del Pacifico Nordeste, Guatemala, 19-22 de febrero de 2002, 130 pp; (ii) Kjerfve, B., L. Drude de Lacerda & El H. S. Diop, eds. 1997. Mangrove ecosystem studies in Latin America and Africa. Published by the United Nations Educational, Scientific and Cultural Organization, 349 pp; (iii) T. Ammour, A. Imbach, D. Suman & N. Windevoxhel, eds. 1999. Manejo productivo de manglares en América Central. Serie Técnica, Reuniones Técnicas no. 71, Centro Agronómico y Tropical de Investigación y Enseñanza, 364 pp.; (iv) Suman, D.O, ed. 1994. El ecosistema de manglar en América Latina y la cuenca del Caribe: su manejo y conservación. 263 pp.; (v) UNEP. 2000. GEO Latin America and the Caribbean. United Nations Environment Programme, 143 pp; (vi) UNESCO. 1998. CARICOMP – Caribbean coral reef, seagrass and mangrove sites. Costal region and small island papers 3, UNESCO, Paris, 347 pp; (vii) CPPS. 2002. Estado del medio ambiente marino y costero del Pacifico Sudeste. Comisión Permanente del Pacifico Sur, Quito, Ecuador, 165 pp.; (viii) UNEP. 1999. Assessment of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the wider Caribbean region. UNEP Regional Seas Reports and Studies No. 172, 121 pp; (ix) UNEP. 1999. Assessment of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the South-East Pacific. UNEP Regional Seas Reports and Studies No. 169, 73 pp.; and (x) UNEP. 2000. Overview on land-based sources and activities affecting the marine, coastal and associated freshwater environment in the Upper Southwest Atlantic. UNEP Regional Seas Reports and Studies No. 170, 57 pp.

[34] D.O. Suman, ed. 1994. El ecosistema de manglar en América Latina y la cuenca del Caribe: su manejo y conservación. Available from: Division of Marine Affaire & Policy, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149, USA, 263 pp.

[35] G. Kelleher, C. Bleakley & S. Wells. 1995. A global representative system of marine protected areas. Vol. IV: South Pacific, Northeast Pacific, Northwest Pacific, Southeast Pacific and Australia/New Zealand. Published by the World Bank, 212 pp + map supplement.

[36] Unless otherwise indicated, this section is based on PNUMA. 2002. Evaluación sobre las Fuentes terrestres y actividades que afectan al medio marino, costero y de aguas dulces asociadas en la región del Pacifico Nordeste. Background document, Primera reunión intergubernamental del Plan de Acción del Convenio de Cooperación para la Protección y el Desarrollo Sostenible de las Zonas Marinas y Costeras del Pacifico Nordeste, Guatemala, 19-22 de febrero de 2002, 130 pp.

[37] Although in this country mangrove formations have been degraded by shrimp production, salt extraction and cutting for fuelwood.

[38] Flores-Verdugo, F.J., F. González-Farias, M. Blanco-Correa & A. Núñez-Pasten. 1997. The Teacapan-Agua-Brava-Marismas Nacionales mangrove ecosystem on the Pacific coast of Mexico. Pp. 35-46, In: : Kjerfve, B., L. Drude de Lacerda & El H. Salif Diop. 1997. Mangrove ecosystems studies in Latin America and Africa. UNESCO, Paris

[39] Unless otherwise indicated, this section is based on) CPPS. 2002. Estado del medio ambiente marino y costero del Pacifico Sudeste. Comision Permanente del Pacifico Sur, Quito, Ecuador, 165 pp.

[40] Unless indicated other wise, this section is based mainly on D.O. Suman, ed. 1994. El ecosistema de manglar en América Latina y la cuenca del Caribe: su manejo y conservación. 263 pp. For additional detailed information, see B. Kjerfve. 1998. Caribbean coral ref., seagrass and mangrove sites. Published by UNESCO, 345 pp

[41] Kjerfve, B. & D.J. Macintosh. 1997. The impact of climatic change on mangrove ecosystems. Pp. 1-7, In: Kjerfve, B., L. Drude de Lacerda & El H. Salif Diop. 1997. Mangrove ecosystems studies in Latin America and Africa. UNESCO, Paris.

[42] FAO 2003. State of the World's Forests 2003. FAO, Rome, Italy.

[43] GESAMP & ACOPS. 2001. Protecting the oceans from land-based activities - Land-based sources and activities affecting the quality and uses of the marine, coastal and freshwater environment. Rep. Stud. GESAMP No. 71, 162 pp.

[44] GESAMP & ACOPS. 2001. Protecting the oceans from land-based activities - Land-based sources and activities affecting the quality and uses of the marine, coastal and freshwater environment. Rep. Stud. GESAMP No. 71, 162 pp.

[45] Hossain, Md.S. 2001. Biological aspects of the coastal and marine environment in Bangladesh. Ocean & Coastal Management 44: 261-282.

[46] Primavera, J.H. 2000. Development and conservation of Philippine mangroves: institutional issues. In: The values of wetlands: landscape and institutional perspectives. Special Issue. Ecological Economics 35: 91-106.

[47] See, for example, Costanza, R., S.C. Farber & J. Maxwell. 1989. Valuation and management of wetland ecosystems. Ecological Economics 1: 335-361; Aylward, M., E.B. Barbier & D. Knowler. 1992. Valuing environmental functions in developing countries. Biodiversity Conservation 1: 34-50; Bennet, E.L. & C.J. Reynolds. 1993. The value of a mangrove area in Sarawak. Biodiversity Conservation 2: 359-375; Barbier, E.B. 1994. Valuing environmental functions: tropical wetlands. Land Ecology 70: 155-173; Farber, S. 1996. Welfare loss of wetlands disintegration: a Louisiana study. Contemporary Ecological Policy 14: 92-106; Janssen, R. & J.E. Padilla. 1996. Valuation and evaluation of management alternatives for the Pagbilao mangrove forest. Vol. 9. Institute for Environmental Studies, Amsterdam, the Netherlands; Bann, C. 1997. An economic analysis of alternative mangrove management strategies in Koh Kong Province, Cambodia. Economy and Environment Program for Southeast Asia, Singapore; Barbier, E.B., M.

Acreman, & D. Knowler. 1997. Economic valuation of wetlands: a guide for policy makers and planners. Ramsar Convention Bureau, Department of Environmental Economics and Management, University of York, Cambridge, UK - Listed by Kaplowitz, M.D. 2001. Assessing mangrove products and services at the local level: the use of focus groups and individual interviews. Landscape and Urban Planning 56: 53-60

[48] Stubbs, B.J. & P. Saenger. 2002. The application of forestry principles to the design, execution and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.

[49] For instance, tens of thousands of people died in October 1999 when a cyclone hits the eastern coast of India, with winds of to 300 km per hour. It brought a tidal surge and torrential rain, causing rivers to break their banks. The flat land near the coast was flooded and slums as a far as 50 km from the coast were destroyed. The tragedy would have been much smaller if the coastline had still been covered with mangrove forests, as they would have dissipated the energy of the waves and greatly reduced the damage and loss of live. GESAMP & ACOPS. 2001. A sea of troubles. Reports and Studies of GESAMP No. 70, 35 pp.

[50] See, for example, Tri, N.H, W.N. Adger & P.M. Kelly. 1998. Natural resource management in mitigating climate impacts: the example of mangrove restoration in Vietnam. Global Environmental Change 8 (1): 49-61.

[51] Summarized in Document ITTC (XXXII)/5 Appendix 4, Background paper for the ITTO International Mangrove Workshop, Cartagena, Colombia, 19-22 February 2002.

[52] Gilbert, A.J. & R. Janssen. 1998. Use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes. Ecological Economics 25: 323-346.

[53] Adapted from Stubbs, B.J. & P. Saenger. 2002. The application of forestry principles to the design, execution and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.

[54] Kautsky, N., P. Rönnbäck, M. Tedengren & M. Troell. 2000. Ecosystem perspectives of disease in shrimp pond farming. Aquaculture 191: 145-161.

[55] Lacerda, L.D., W. Machado & M. Moscatelli. 2000. ISME/GLOBIS Electronic Journal, Vol. 1, No. 1.

[56] Machado, W., M. Moscatelli, L.G. Rezende and L.D. Lacerda. In press. Mercury, zinc, and cooper accumulation in mangrove sediments surrounding a large landfill in southeast Brazil. Environmental Pollution.

[57] Carballo, J.L. 2000. Distribution of *Ecteinascidia turbinata* (Ascidiacea: Perophoridae) in mangroves of the Yucatán Peninsula, México, Revista de Biología Tropical 48 (2-3): 365-369.

[58] International Society for Mangrove Ecosystems. 2002. Background paper for the International Mangrove Workshop, 19-21 February 2002, Cartagena, Colombia. Document ITTC (XXXII)/5 Appendix 4, 26 pp.

[59] Unless otherwise indicated, the information for this region is based on: D.O. Suman, ed. 1994. El ecosistema de manglar en América Latina y la cuenca del Caribe: su manejo y conservación. Available from Division of Marine Affaire & Policy, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rcikenbacker Causeway, Miami, Florida 33149, USA.

[60] FAO. 1994. Mangrove forest management guidelines. FAO Forest Paper 117, 319 pp.

[61] Roth, L.C. 1997. Implications of periodic hurricane disturbance for the sustainable management of Caribbean mangroves. Pp. 18-34 In: Kjerfve, B., L. Drude de Lacerda & El H. Salif Diop. 1997. Mangrove ecosystem studies in Latin America and Africa. UNESCO, Paris.

[62] Kjerfve, B., L. Drude de Lacerda & El H. Salif Diop. 1997. Mangrove ecosystem studies in l,atin America and Africa. UNESCO, Paris, 349 pp.

[63] Ramsar Convention on Wetlands. 2002. Sinopsis regional de la aplicación de la Convención y su plan estratégico 1997-2002: el Neotropico (Ramsar COP8 DOC. 28) & Ramsar. 2002. Perspectiva regional de la aplicación de la Convención y de su plan estratégico 1997-2002: América del Norte (Ramsar COP8 DOC. 29). Valencia, Spain, 18-26 November 2002.

[64] Illueca, J. 1997. The Paseo Pantera agenda for regional conservation. Pp. 241-258 In: Coates, A.G, ed. Central America – A natural and cultural history. Yale University Press, New Haven and London.

[65] G. Foster & S. Olsen. 1992. Las costas de Centro América – Diagnósticos y agenda para la acción. Published by the US Agency for International Development, AID Regional Office for Central America Programs and the Coastal Resources Center, University of Rhode Island, USA, 290 pp + appendixes.

[66] T. Ammour, A. Imbach, D. Suman & N. Windevoxhel, eds. 1999. Manejo productivo de manglares en América Central. Serie Técnica, Reuniones Técnicas no. 71, Centro Agronómico y Tropical de Investigación y Enseñanza, 364 pp.

[67] UNEP. 1995. Global programme of action for the protection of the marine environment from land-based activities. UNEP(OCA)/LBA/IG.2/7, 60 pp.

[68] See, for instance, PNUMA. 2002. Evaluación sobre las Fuentes terrestres y actividades que afectan al medio marino, costero y de aguas dulces asociadas en la región del Pacifico Nordeste. Background document, Primera reunión intergubernamental del Plan de Acción del Convenio de Cooperación para la Protección y el Desarrollo Sostenible de las Zonas Marinas y Costeras del Pacifico Nordeste, Guatemala, 19-22 de febrero de 2002, 130 pp.

[69] UNESCO. 1998. CARICOMP – Caribbean coral reef, seagrass and mangrove sites. Costal region and small island papers 3, UNESCO, Paris, 347 pp.

[70] Unless indicated otherwise, this section on remote sensing is primarily based on information taken from FAO's Sustainable Department web page (www.fao.org). More information can be found there as well as in FAO's Remote Sensing for Decision-Makers Series (Resources/FAO Publications on Remote Sensing), copies of which can be obtained from Environment and Natural Resources Service (SDRN), Sustainable Development Department, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy. Email: Changchui.He@fao.org

[71] Summarized in Table 5.2 (p. 108) of FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[72] Visual interpretation of low resolution satellite imagery should be limited to broad forest and land-use classification, while computer processing of satellite imagery appear to be superior for mangrove cover types classification. Digitally processed Lansat data also provides information on the location of mudflats, sandy areas and newly accreted lands. For details, see FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[73] These images have the limitation that tree species cannot be identified using radar imagery and information required for forest management (e.g., species composition, forest structure, stand description) should be obtained from ground or aerial surveys. Also, all water bodies display the same the same dark tone, and sand bars and mud banks near estuaries need to be above water level to be

recorded in the image. Despite these limitations, radar imagery provides a good impression of the terrain's physiographic conditions and, thus, in low land areas such as mangroves the drainage patter is clearly visible. In many tropical countries, persistent cloud cover during long periods of time prevents the acquisition of cloud free images with photographic or Multi Spectral Scanner sensors. One way to solve this problem is by using synthetic aperture radar. This system has been most successful in mapping coastal forests and mangroves.

[74] A DBMS generally provides a language for analysing data, which allows users to describe to the system what they want to know with little or no attention to the mechanics or methods used by the system. A DBMS must also contain procedures for checking consistency of the data and maintaining their integrity. In addition to DBMS, GIS also has many capabilities similar to automated map making, computer-assisted cartography and computer graphics systems. However, as well as having a powerful capability for processing graphics, GIS must also be able to process non-graphic attributes, such as statistical data, in conjunction with the spatial data to which they are related. For example, if the user modifies the spatial data the GIS will make the necessary modifications in the related statistical database automatically. This link between the two types of data must be present if a system is to be considered a true GIS

[75] Dahgouh-Guebas, Farid. PhD. Thesis. Mangrove vegetation structure dynamics and regeneration.

[76] Field, C.D. 1996.

[77] Dahgouh-Guebas, Farid. PhD. Thesis. Mangrove vegetation structure dynamics and regeneration.

[78] Summarized from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[79] A detailed description of the methods used, and of their limitations, to obtain these types of information for mangrove forests are given in FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[80] The information which can be incorporated on the map include: forest lands (natural and planted), lands used for aquaculture, agricultural lands within mangrove areas, mining and industrial zones, and infrastructure, settlements and urban areas. See, FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[81] Adapted from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[82] Detailed habitat mapping should be undertaken using digital airborne scanners or interpretation of colour aerial photography; the acquisition of the first is more expensive than the latter but is offset against the huge investment in time required to create maps from colour aerial photography. For a detailed discussion on the cost-effectiveness of remote sensing for tropical coastal resources, including mangrove forests, see Mumby, P.J., E.P. Green, A.J. Edwards & C.D. Clark. 1999. Journal of Environmental Management 55 (3): 157-166.

[83] Summarized from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[84] For a detailed description of these techniques, see FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp. Details on the techniques with potential use for mangrove forests, such as sampling design, intensity, unit shape and size, can be found thereby.

[85] Janssen, R., A. Gilbert & J. Padilla. 2000. Use of environmental functions to communicate the values of mangrove ecosystem under different management regimes. Response to a critique. Ecological Economics 35: 141-143.

[86] Nasi, R., S. Wunder & J.J. Campos. 2002. Forest ecosystem services: Can they pay our way out of deforestation? Discussion paper prepared for the Global Environment Facility for the Forestry Roundtable held in conjunction with the second session of the United Nations on Forests, New York, March 2002, 29 pp.

[87] Some commonly used terms dealing with forest management include: *Afforestation*. Establishment of forests plantations on land that, until then, was not classified as forest. Implies a transformation from non-forest to forest. *Reforestation.* Establishment of forest plantations on temporarily unstocked lands that are considered as forests. *Deforestation*. The conversion of forest to another land use or the long-term reduction of the three-canopy cover below the minimum 10% threshold. Deforestation includes areas of forest converted to agriculture, pasture, aquaculture, water reservoirs and urban areas. The term specifically exclude areas where the trees have been removed as a result of harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures. *Forest improvement.* Changes within the forest, which positively affects the structure or function of the stand or site, and thereby increases the capacity to supply products or services. *Plantation.* A forest established by planting or/and seeding in the process of afforestation or reforestation. It consists of introduced species or, in some cases, indigenous species (which meet all the following criteria: one or two species at plantation, even age class, regular spacing). *Replanting*. Establishment of planted trees, either because afforestation or reforestation failed, or the three crop was felled and regenerated It is not an addition to the total plantation area.

[88] FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[89] It comprises thee main components: (a) the method of regeneration chosen suited to local ecologies, site potential and preferred species; (b) the form of the crop produced; and (c) the systematic arrangement of the crops over the whole forest. FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[90] It comprises thee main components: (a) the method of regeneration chosen suited to local ecologies, site potential and preferred species; (b) the form of the crop produced; and (c) the systematic arrangement of the crops over the whole forest. FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[91] Stubbs, B.J. & P. Saenger. 2002. The application of forestry principles to the design, execution and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.

[92] For a review, see Saenger, P. 2002. Mangrove ecology, silviculture and conservation. Kluwer Academic Publishers, Dordrecht, the Netherlands, 361 pp &

[93] In a clear –felling in alternate strip system, natural seed sources are: existing advance growth of seedlings/saplings; seeding from perimeter trees around the felling strip; seeding from standards (mother-trees); water-borne propagules from adjacent stands; and propagules from felled trees

[94] Details of assisted regeneration for Australia and the USA are found in: Saenger, P. 1996. Mangrove restoration in Australia: a case study of Brisbane International Airport. Pp.36-51 In: Field, C. (ed), Restoration of mangrove ecosystems. ISME/ITTO, Okinawa, Japan; and Snedaker, S.C. & P.D. Biber. 1996. Restoration of mangroves in the United States of America: a case study in Florida. Pp. 170-188 In: Field, C. (ed), Restoration of mangrove ecosystems. ISME/ITTO, Okinawa, Japan

[95] Summarized from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp. & Stubbs, B.J. & P. Saenger. 2002. The application of forestry princip les to the design, execution and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.

[96] This section is based on the review by Stubbs, B.J. & P. Saenger. 2002. The application of forestry principles to the design, execut ion and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.

[97] For more detailed information, see Hamilton, L.S & S.C. Snedaker (ed). 1984. Handbook for mangrove area management. Environment and Policy Institute, East-West Centre, Hawaii, USA, 123 pp.

[98] For more detailed information, see Saenger, P. & N.A. Sidiqui. 1993. Land from the sea: the mangrove afforestation program of Bangladesh. Ocean & Coastal Management 20: 23-39; Field, C.D. (ed). 1996. Restoration of mangrove ecosystems. International Society for Mangrove Ecosystems/International Tropical Timber Organization, Okinawa, Japan, 250 pp.; Youssef, T. 1997. Approaches in mangrove planting: some options for Darwin mangroves. Pp. 321-333 In: Hanley, J.R., G. Caswell, D. Megirian & H.K. Larson (eds), Proceedings of the sixth international marine biological workshop – The marine flora and fauna of Darwin Harbour, Northern Territory, Australia. Northern Territory Museum of Arts and Sciences, Darwing, Australia.

[99] See Youssef, T. 1997. Approaches in mangrove planting: some options for Darwin mangroves. Pp. 321-333 In: Hanley, J.R., G. Caswell, D. Megirian & H.K. Larson (eds), Proceedings of the sixth international marine biological workshop – The marine flora and fauna of Darwin Harbour, Northern Territory, Australia. Northern Territory Museum of Arts and Sciences, Darwing, Australia.

[100] For details, see Carlton, J.M. & M.D. Moffler. 1978. Propagation on mangroves by air-layering. Environmental Conservation 5: 147-150.

[101] For additional information, see Basak, U.C., A.B. Das & P. Das. 1995. Metabolic changes during rooting in stem cuttings of five mangrove species. Plant Growth Regulation 17: 141-148; Youssef, T. 1997. Approaches in mangrove planting: some options for Darwin mangroves. Pp. 321-333 In: Hanley, J.R., G. Caswell, D. Megirian & H.K. Larson (eds), Proceedings of the sixth international marine biological workshop – The marine flora and fauna of Darwin Harbour, Northern Territory, Australia. Northern Territory Museum of Arts and Sciences, Darwing, Australia; Eganathan, P., C.S. Rao & A. Anand. 2000. Vegetative propagation of three mangrove tree species by cuttings and air layering. Wetlands Ecology and Management 8: 281-286.

[102] Gonzáles-Calderón, D. & B. Rivas-Echeverri. 1997. Obtaining *Rhizophora mangle* seedlings by stimulation of adventitious roots using air-layering technique. Pp. 98-107, In: Kjernfve, B., L. Drude de Lacerda & El H. Salif Diop. 1997. Mangrove ecosystems studies in Latin America and Africa, UNESCO, Paris.

[103] *Rehabilitation* of an ecosystem is defined as the act of partially, or more rarely, fully replacing structural or functional characteristics of an ecosystem that have been diminished or lost, or the substitution of alternative qualities or characteristics than those originally present with proviso that they have more social, economic or ecological value than existed in the disturbed or degraded state. *Restoration* of an ecosystem is the act of bringing an ecosystem back into, as nearly as possible, its original condition. Restoration is seen as a special case of rehabilitation. This section is mostly based in Field, C.D. 1998. Rehabilitation of mangrove ecosystems: an overview. Marine Pollution Bulletin 37 (8-12): 383-392.

[104] For instance, various projects - with various degrees of success - started in the 1980s and 1990s in Panama, Guatemala and Nicaragua. For more details, see Ammour, T., A. Imbach, D. Suman & N. Windevoxhel. 1999. Manejo productivo de manglares en America Central. Serie Técnica, Reunio nes Técnicas No.7, Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica, 364 pp.

[105] Yap, H.T. 2000. The case for restoration on tropical ecosystems. Ocean & Coastal Management 43: 841-851.

[106] Also, it has been suggested that although wetland regulatory programs are still needed the future of wetland management is more likely to be successful with an emphasis on conservation and restoration programs with mitigation/compensation being only one small part of the entire program. The political will is simply not there to properly fund effective wetland compensatory mitigation programs. See Lewis, R.R. 2000. Ecological based goal setting in mangrove forest and tidal marsh restoration. Ecological Engineering 15 (3-4): 191-198.

[107] Field, C.D. 1998. Rehabilitation of mangrove ecosystems: an overview. Marine Pollution Bulletin 37 (8-12): 383-392.

[108] For instance, since 1996, 120,000 ha of mangroves have been planted in Bangladesh for protecting and stabilizing coastal areas and substantially increasing timber production.

[109] Yap, H.T. 2000. The case for restoration on tropical ecosystems. Ocean & Coastal Management 43: 841-851.

[110] Melville, F. & M. Burchett. 2002. Genetic variation in *Avicennia marina* in three estuaries of Sydney (Australia) and implications for rehabilitation and management. Marine Pollution Bulletin 44: 469-479.

[111] For details, see T. Ammour, A. Imbach, D. Suman & N. Windevoxhel (eds). 1999. Manejo productivo de manglares en América Central. Centro Agronómico de Tropical de Investigaciones y Enseñanza (CATIE), Serie Técnica, Reuniones Técnicas No. 7, 363 pp.

[112] Available at the itto web site (www.itto.or.jp). The ITTC decided to finance a number of actions to promote the uptake of the guidelines by member countries, including the convening of six sub-regional workshops to promote the promulgation of the guidelines and to encourage further regional and country-level initiatives in the area. It also encouraged members to apply the guidelines on a pilot scale and to submit project proposals to ITTO where appropriate

[113] Kunstadter, P., E. C. F. Bird & S. Sabhasri. (eds). 1986. Man in the mangroves - The socio-economic situation of human settlements in mangrove forests Proceedings of a workshop held at Nong Nuch Village, Pattaya, Thailand, 27-31 May 1985, sponsored by the United Nations University and the National Research Council of Thailand.

[114] Kunstadter, P., E. C. F. Bird & S. Sabhasri. (eds). 1986. Man in the mangroves - The socio-economic situation of human settlements in mangrove forests Proceedings of a workshop held at Nong Nuch Village, Pattaya, Thailand, 27-31 May 1985, sponsored by the United Nations University and the National Research Council of Thailand.

[115] The classification presented herein is that of the IUCN-World Conservation Union.

[116] In terms of ecotourism, the most common and successful innovative financial arrangements for marine and coastal protected areas devised by the World Bank, in association with Global Environment Facility grants, include (i) the development of park authority capacity to levy fees and manage revenue associated with park entry fees, park-related tourist taxes, lease and fees to manage park and buffer zone resource extraction; (ii) commercially viable ecotourism partnerships with the private sector, local communities and non-governmental organizations; and (iii) collaboration and co-management with local communities and other stakeholders to contribute in-kind to support park conservation efforts and monitor biodiversity protection. In addition, biodiversity-oriented projects have been

at the forefront of establishing "Green Conservation Trust Funds" that capitalize donor and domestic funds while including provisions for debt for nature swaps. See, Megateli, N.Z.Z. 2001. Innovative sustainable financing for marine and coastal environments subject to land-based stressors: A review of World Bank Group experience.

[117] Technical assistance on biotechnology is provided, for instance, by FAO's Inter-Departmental Working Group on Biotechnology. Of particular significance is the research, training and analytical support provided by the FAO/IAEA Agriculture and Biotechnology Laboratory in Austria. FAO collaborates with other partners in building the capacities of member countries in biotechnology and related issues through technical co-operation and training. Within this context, FAO's work focuses on helping to strengthen national capabilities in biotechnology research and application as an integral element of overall agricultural research, geared towards increasing and sustaining agricultural production, including marginal conditions, natural resources (including biodiversity and genetic conservation), biosafety and risk-analysis (www.fao.org).

[118] FAO. 2001. State of the world forests. 166 pp.

[119] For more information, see Satuwong, I., I. Ninomiya & K. Ogino. 1995. Callus and multiple shoot formation in *Bruguiera gymnorrhiza*. Bulletin Ehime University of Forestry 32: 25-33; Rao, C.S., P. Eganathan, A. Anand, P. Akrishna & T.P. Reddy. 1998. Protocol *in vitro* propagation of *Excoecaria agalocha* L., a medicinally important mangrove species. Plant Cell Reports 17: 861-865; Cousins, J.M. & P. Saenger. In press. Development of a protocol for *in vitro* propagation of the grey mangrove *Avicennia marina*. International Association for Plant Tissue Culture & Biotechnology, Australian Branch, 7th Meeting, Plant issue culture – Its importance in biology, ecology and agriculture/horticulture, January 2002, Armidale, Australia.

[120] Detailed in Ammour, T., A. Imbach, D. Suman & N. Windevoxhel. 1999. Manejo productivo de manglares en América Central. Serie Técnica, Reuniones Técnicas No.7, Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica, 364 pp.

[121] Adapted from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[122] The FAO Forest Harvesting Bulletin (available at www.fao.org) is published regularly to disseminate information on environmentally sound harvesting practices. Seminars, workshops, expert consultations and training events on harvesting are organized and supported to identify issues, disseminate information, promote environmentally sound forest harvesting practices and to develop human resources.

[123] Adapted from FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[124] FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.

[125] UNEP. 2002. Integrated assessment of trade liberalization and trade-related policies – A country study on the forestry sector in Tanzania. 55 pp.

[126] Summarized from the Certification Information System, European Forest Institute (www.efi.fi/cis).

[127] Since Governments (i) have already discussed and agreed at international for a criteria and indicators for the measurement of progress towards sustainable forest management; (ii) have incorporated the principle of sustainability into legislation of most countries; and (iii) have restructured and strengthened national institutions, and have taken other actions to enforce law, improve monitoring and control. See, Tomaselli, I. 2001. The private sector and sustainable forest management – South America perspective. Pp. 56-78 In: Chipeta, M.E. & M. Joshi (eds), The private sector speaks: investing in sustainable forest management. Center for International Forestry Research, Bogor, Indonesia, 303 pp.

[128] For more details, see the Global Ecolabelling Network (www.gen.gr.jp).

[129] ECOSOC. E/CN.17/IPF/1996/5.

[130] Sayer, J.A., J.K. Vanclay & N. Byron. 1997. Technologies for sustainable forest management: challenges for the 21st Century. Center for International Forestry Research, Occasional Paper No. 12, 11 pp.

[131] See, for instance, Primavera, J.H. 2000. Development and conservation of Philippine mangroves: institutional issues. In: The values of wetlands: landscape and institutional perspectives. Ecological Economics 35: 91-106

[132] For instance, the lack of consultation with end users and the private sector of research results and neglect of the subsistence sector have lead to continued unsustainable practices. A stronger collaboration between academia/research institutions, private sector and government is critical for developing, improving and expanding the technical capabilities of developing countries in particular.

[133] ECOSOC. E/CN.17/IPF/1996/5.

[134] As noted previously, the coastal and marine environments are becoming increasingly important in fulfilling socio-economic, development and strategic objectives for developing countries. Given that mangrove forests are considered public goods (i.e., their use is non-exclusive) and thus are converted to other uses - mainly because their functions are grossly undervalued - the identification and valuation of mangrove forests functions and services, and the incorporation of these parameters into policy and the encouragement of appropriate property rights (whether communal or private) are necessary firsts steps in promoting the conservation and sustainable utilization of mangrove forests.

[135] Tri, N.H., W.N. Adger & P.M. Kelly. 1998. Natural resource management in mitigating climate impacts: the example of mangrove restoration in Vietnam. Global Environmental Change 8 (1): 49-61.

[136] The underestimation of the total value of the variety of environmental good and services provided by mangrove forests, and of the impact of human activities on them is probably the main factor contributing to the past and continued world-wide demise of these and other forest ecosystems

[137] Kengen, S. 1997. Forest valuation for decision-making – Lessons of experience and proposals for improvement. FAO, Rome, 134 pp.

[138] Private ownership of coastal land and its use in coastal development (e.g., urbanization, tourism, roads, airports) often leads to problems and even to social conflicts when trying to implement integrated coastal management initiatives. This is compounded when local community concerns (including environmental considerations) are not addressed or considered in coastal development projects since decisions are taken by national instead of local authorities.

[139] Harborne, A.R., D.C. Afzal & M.J. Andrews. 2001. Honduras: Caribbean coast. Marine Pollution Bulletin 42 (12): 1221-1235.

[140] FAO. 1994. Technology assessment and transfer for sustainable agriculture and rural development the Asia-Pacific Region: a research management perspective.

[141] FAO. 1994. Technology assessment and transfer for sustainable agriculture and rural development the Asia-Pacific Region: a research management perspective.

[142] FAO. 1994. Technology assessment and transfer for sustainable agriculture and rural development the Asia-Pacific Region: a research management perspective.
[143] ECOSOC. E/CN.17/2001/PC/11.
[144] See, for example, Harborne, A.R., D.C. Afzal & M.J. Andrews. 2001. Honduras: Caribbean coast. Marine Pollution Bulletin 42 (12): 1221-1235; Sarah et al. 2002. Ambio. An entitlement approach to the challenges of mangrove management in El Salvador; Primavera, J.H. 2000. Development and conservation of Philippine mangroves: institutional issues. In: The values of wetlands: landscape and institutional perspectives. Ecological Economics 35: 91-106; Kaplowitz. 2001. Assessing mangrove products and services at the local level: the use of focus groups and in dividual interviews.
[145] Sayer, J.A., J.K. Vanclay & N. Byron. 1997. Technologies for sustainable forest management: challenges for the 21st Century. Center for International Forestry Research, Occasional Paper No. 12, 11 pp.
[146] FAO. 1994. Technology assessment and transfer for sustainable agriculture and rural development the Asia-Pacific Region: a research management perspective.
[147] Dahgouh-Guebas, Farid. PhD. Thesis. Mangrove vegetation structure dynamics and regeneration.
[148] Field, C.D. 1996.
[149] Dahgouh-Guebas, Farid. PhD. Thesis. Mangrove vegetation structure dynamics and regeneration.
[150] FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.
[151] For instance, European Remote Sensing Satellite (ERS) Synthetic Aperture Radar (SAR) images are suitable for monitoring the seasonal changes of the wetland areas, which are difficult to monitor on land. ERS SAR images can be used to define differences within a wetland system from which can be interpreted areas of changing vegetation; areas of open water; and areas of bare soil. On the other hand, NOAA AVHRR thermal inertia approach has proven to be effective in monitoring wetland systems. It has been found that AVHRR images can give an overall idea of area measurements and boundary locations. If more precision is required or if an area needs to be analysed in depth, for example, the classification of vegetated areas, then SAR images offer a better facility. The choice between SAR and AVHRR depends upon the purpose of the study and the accuracy required. The two formats can work well together as it has been demonstrated in this study, the AVHRR providing a quick, clear, initial interpretation and the SAR providing the detail and accuracy. Travaglia, C. & H. Macintosh. 1996. Wetlands monitoring by ERS Synthetic Aperture Radar (SAR) data in Zambia. From: Wetlands monitoring by ERS-SAR data – a case study: Lake Bangweulu wetland system, Zambia. RSC Series 69, FAO 1997.
[152] Kunstadter, P., E. C. F. Bird & S. Sabhasri. (eds). 1986. Man in the mangroves - The socio-economic situation of human settlements in mangrove forests Proceedings of a workshop held at Nong Nuch Village, Pattaya, Thailand, 27-31 May 1985, sponsored by the United Nations University and the National Research Council of Thailand.
[153] Kunstadter, P., E. C. F. Bird & S. Sabhasri. (eds). 1986. Man in the mangroves - The socio-economic situation of human settlements in mangrove forests Proceedings of a workshop held at Nong Nuch Village, Pattaya, Thailand, 27-31 May 1985, sponsored by the United Nations University and the National Research Council of Thailand.
[154] See Stubbs, B.J. & P. Saenger. 2002. The application of forestry principles to the design, execution and evaluation of mangrove restoration projects. Bois et Forêts des Tropiques 273 (3): 5-21.
[155] Baran, E. & J. Hambrey. 1998. Mangrove conservation and coastal management in Southeast Asia: What impact on fishery resources? Marine Pollution Bulletin 37 (8-12): 431-440.
[156] Botero, L. & H. Salzwedel. 1999. Rehabilitation of the Cienaga Grande de Santa Marta, a mangrove-estuarine system in the Caribbean coast of Colombia. Ocean & Coastal Management 42: 243-256.
[157] Field, C.D. 1998. Rehabilitation of mangrove ecosystems: an overview. Marine Pollution Bulletin 37 (8-12): 383-392.
[158] FAO. 1994. Mangrove forest management guidelines. FAO Forestry Paper 117, 319 pp.
[159] Certification Information System, European Forest Institute (www.efi.fi/cis).
[160] Franks, T. & R. Falconer. 1999. Developing procedures for the sustainable use of mangrove systems. Agricultural Water Management 40: 59-64.
[161] ECOSOC. E/CN.17/IPF/1996/5.
[162] Chipeta, M.E. & M. Joshi, eds. 2001. The private sector speaks: investing in sustainable forest management. Center for International Forestry Research, Bogor, Indonesia, 303. Pp.
[163] Chipeta, M.E. & M. Joshi, eds. 2001. The private sector speaks: investing in sustainable forest management. Center for International Forestry Research, Bogor, Indonesia, 303. Pp.
[164] ECOSOC. E/CN.17/IPF/1996/5
[165] United Nations Division for Sustainable Development/Department of Economic and Social Affairs. 1999. International assistance programmes for transfer of cleaner production technologies. 37 pp.
[166] United Nations Environment Programme.
[167] Adapted from International Society for Mangrove Ecosystems. 2002. Background paper for the International Mangrove Workshop, 19-21 February 2002, Cartagena, Colombia. Document ITTC (XXXII)/5 Appendix 4, 26 pp.
[168] Provided by Mette L?yche Wilkie, Forestry Officer (Forest Management), Forest Resource Division, FAO Forestry Department, Rome, Italy.
[169] Provided by Dr. Marea Hatziolos, Environment Department, the World Bank.
[170] This was evident, for instance, in the very low participation in the International Mangrove Workshop held in Cartagena, Colombia, in February 2002: only 14 of the 59 countries, 6 of the 16 international organizations and 2 of the 6 non-governmental organizations invited actually attended the workshop
[171] The call for the strengthening of ITTO's coordinating, empowering and facilitating roles in the area of mangrove ecology and ecology was stressed by ISME.
[172] Which provides de Secretariat for the Ramsar Convention on Wetlands and the World Heritage Convention.
[173] Adapted from International Society for Mangrove Ecosystems. 2002. Background paper for the International Mangrove Workshop, 19-21 February 2002, Cartagena, Colombia. Document ITTC (XXXII)/5 Appendix 4, 26 pp.
[174] Field, C.D. 1998. Rehabilitation of mangrove ecosystems: an overview. Marine Pollution Bulletin 37 (8-12): 383-392.
[175] Gilbert, A.J. & R. Janssen. 1998. Use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes. Ecological Economics 25: 323-346.

[176] As noted by the authors, a condition for all alternatives incorporating aquiculture is the retention of a mangrove strip (buffer zone) of at least 50 m between ponds and the sea, and at least 20 m between ponds and waterways, to limit damages caused by storms. Exploitation of the buffer zone will not be allowed.

[177] For details and addition, see the Certification Information System, European Forest Institute (www.efi.fi/cis).

[178] Adapted from United Nations Division for Sustainable Development/Department of Economic and Social Affairs. 1999. International assistance programmes for transfer of cleaner production technologies. 37 pp. More details can be obtained from Mr. Tarcisio -Alvarez Riverro (alvarez-rivero@un.org) and/or www.un.org/sustdev/est1.htm).