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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Managua, March 2003

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

"*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]lo1es,t e c h n

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 implementati ndewTw (Twgw (J. Worum oite first session (UNF0707nited) th0 -12 mi means of achiadoptune 200PlaD 0.0A795 T

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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-

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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]. s a spn of ma 3.2897 ught ogether ed

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

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	0.0	90	0.0
Antigua and Barbuda	**1 175**	**1991**	1 570	1 200	-2.4	900	-2.5
Aruba	**420**	**1986**	420	420			

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

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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: **Household items** Fuel Mangrove Forest Products

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

Year	Firewood	Bark	Timber

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

Product	1987	1988	1989	1990	1991
Fuelwood ($m^3 \times 10^3$)	19.3	19.5	17.5	17.2	23.8
"Cujes" for tobacco drying	0.4				

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]

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.

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).

	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	Technologies required
National	Geographical distribution Extent of	1:500 000 to 1:1 000 000	Satellite imagery Combination with small scale aerial photography
Management planning	Mangrove Road f	1:50 000 to 1:100 000	Stereo analysis combination (limi field and aer sur
	Mangro Forest s		Stereoscopy and photogram Combination gro

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

beginning. *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,		**v** Creates a large amount of logging slash and debris

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:

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 Tj -16.525 365.259.7550 0 TD 0 Tc 0.1875 Tw ( ) Tj -3		

		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 i c h h a c n e

F. Marketing and trade

82. The market and trade for wood and non

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.

- *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
	Knowledg

(b) Establish business conditions attractive to technology-oriented investment, including

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 ofe the responsibility 53.7e88circumstances. In priate approach is to t

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

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

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.

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 Co ast of Ecuador

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

REGIONAL PROJECTS			
REGION	**TITLE**	**DURATION**	**MAIN OBJECTIVES**
Africa			

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.

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	he FRI in the silviculture and forest
	units paying rigid attention to the
	s nning, organization and evaluation gramme ed in establishing a forestry training
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	cluded in this project.
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	management aspects.
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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	NatTechni0 Tc27

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		

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

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 estableo2mmnt areas

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

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 Gree19-9 TD DevelopmTD 0 4c e f 53i ET 79. ( ) Tj 0.75

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,			

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 λnstituti93es and partners

(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

ANNEX 2

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

CONTINENT/COUNTRY	SITENAME	COORDINATES	AREA

			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		

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NORTH AMERICA				
MEXICO				

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	12			

	Timber (m^3/year)
	30,000
	25,430
	18,800
	12,000
	9,000
	7,400
	1,900
	1,597

ANNEX 4

Geographical Information Systems (GIS)

A.

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

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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.

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 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.		

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, A1.75 re f 0.0563 Tc 0.9938 Tw13rvrle						

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	f2Tthorities,a87.75 TD -0.079 Tc

					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					

			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			

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

				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 m

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

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

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).

: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

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.
ambia	SGF/95/GMB	Preparatory Assistance for designation of co669Tj ET		

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 disturbancc -0.erine compur

ɔnduras

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

Gathering basic information for the

ınama SGF/98/PAN/3

enezuela	SGF/95/VEN/2	Status of Jaibas (*Callinectes spp)* population in the Cuare Wildlife Refuge, Edo Flacon, Venezuela

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

9 Tf ( ) Tj 0 -10.5 TD /F2 9 Tf 0s Undj 2lop0 -10Bank Tw (n14 -10.5 TD 0 Tc (Acronyms) Tj 14 -10nagement and conservatioconservronC

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.

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No other association of woody plants and grasses takes root or develops into aan

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 o

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 T60m mangrlriate to0.

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.

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[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.

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[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 res ri9S

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[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-We

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,d andn9z8ns,d andn9z8ns,d aCenol ind cning e ofetem, (la TD 0.2527 Tc 0 g

[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 Coloi3nw (155)7 Tc 0 tero, L. & Tc 0 terheast Msia: What 42: Tw (6nriques 8p Tw ( ) T What 42ste406 Tc (256.) Tj 15 0 TD 0 Tc 0.1875 T
[160] Franks, T. & R. Falconer. 1999. Developing procedures for the su tinable use of mangrove systems. AgriculturterWater ManL. & Tc 0: 59 -64.
[161] ECOSOC. E/CN.17/IPF/1996/5.
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International Forestry Research, Bogor, Indonesia, 303. Pp.
[163] Chipeta, M.
International Forestry Research, Bogor, Indonesia, 303. Pp.
[164] ECOSOC. E/CN.17/IPF/1996/5
[165] United Nations Division for Su tinable Development/Depar t& Tcof Economic and Social Affairs. 1999. International assi tnce
[166] United Nations Environ& TcProgramme.
[167] Adapted from International Society for Mangrove Ecosystems. 2002. Background paper for the International Mangrove Workshop, 19-

[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).