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Systematic Review

Management of Mangrove Ecosystems: Republic of Colombia, South America

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Since the mid-nineteenth century, Colombia has developed many ways to use its mangroves both in the Pacific and on the Caribbean coast. On the Pacific coast, mangrove bark is used to obtain tannins, especially from *Rhizophora*. On the Caribbean coast, *Rhizophora, Avicennia* and, *Laguncularia*, *Conocarpus*, are used to process wood in furniture or plywood. In both cases, the appropriate use and development of mangrove resources have not been sustainable. There was also a rudimentary extraction of mangrove wood for purposes that contribute to the livelihood of fishermen and other coastal inhabitants. Mangroves are used for many purposes in the industrial, energy and general economy sectors. Recently, mangroves have begun to be considered as an ecosystem, mainly due to the negative consequences of traditional ways of managing this resource.

Keywords: Mangrove Ecosystems, Colombia, South America.

RESUMEN

Desde mediados del siglo XIX, Colombia ha desarrollado muchas formas de aprovechamiento de sus manglares tanto en el Pacífico como en la costa Caribe. En la costa del Pacífico, la corteza de manglar se usa para obtener taninos, especialmente de *Rhizophora*. En la costa del Caribe, *Rhizophora, Avicennia* y, *Laguncularia* y *Conocarpus*, se utilizan para procesar madera en muebles o madera contrachapada. En ambos casos, el uso apropiado y el desarrollo de los recursos de manglares no han sido sostenibles. También hubo una extracción rudimentaria de madera de manglar para fines que contribuyen al sustento de los pescadores y otros habitantes de las costas. Los manglares se usan para muchos propósitos en los sectores industrial, energético y de economía general. Recientemente, los manglares han comenzado a ser considerados como un ecosistema, principalmente debido a las consecuencias negativas de las formas tradicionales de manejo de este recurso.

1. Brief background to the country

1.1 Regional setting

Colombia is a coastal nation bordered by the Caribbean Sea and the Pacific Ocean. As a result, Colombia is rich in biodiversity and natural resources. The country covers an area of about 2,070,408 km^2; Colombia's border to the

north is the Caribbean Sea (1,600 km); to the east Venezuela (2,219 km) and Brazil (1,645 km); to the south Peru (1,626 km) and Ecuador (586 km); to the west the Pacific Ocean (1,600 km) and to the northwest with Panama (266 km). Colombia possesses two oceanic islands, one in the Caribbean, San Andrés and Providence Archipelago (12º and 16º N - 82º and 78º W) and another in the Pacific, Malpelo Island (3º 58'N - 81º 35'W). The system of mountain ranges and rivers, determines the presence in the country of five main regions: Caribbean, Andean, Pacific, Orinoquian and Amazonian, characterized specifically according to their natural resources, environmental problems and population processes (MMA, 1999b).

In the coastal zone, mangroves are a significant wetland type in Colombia and they fringe many parts of the coastline. Their distribution is associated with the outlet of rivers to the sea, and other coastal formations, e.g. bays, estuaries, coastal lagoons and continental and oceanic islands.

1.2 Size

Colombia covers an area of about 2,021,748 km^2. Out of this total area, 6716.3 km^2 have been protected through a system of national natural parks in the coastal zone. Mangroves dominate in these protected areas, which also feature corals, rocky, sandy and muddy beaches.

1.3 History

Archaeological findings, as well as oral traditions of the Indian, white, black and mulato cultures, demonstrate how mangroves have been exploited as a source of bark, leaves, wood and associated animal life (molluscs, crustaceans, birds, reptiles and mammals). Evidence of the use of mangrove resources comes from semi-nomadic communities in 3000 BC (e.g. archaeological site in Canal del Dique, Bolivar Province). The most ancient ceramic is dated fourth century BD and it was found in the Caribbean coastline mangroves (Reichel-Dolmatoff, 1985; Castaño-Uribe, 1989). Nomad communities are thought to have used mangrove resources from 7,000 BC - 10,000 BC. The nomads located marshes and lagoons rich in molluscs near the coastline (Reichel-Dolmatoff, 1985). As they settled, the consumption of crustaceans and molluscs resulted in the accumulation of enormous amounts of shell material. Today these communities have been named “the inhabitants of the shell-fields”, due to their well-established eating habits (Perdomo-Rojas, 1978; Prahl *et al.,* 1990).

The tradition of using mangrove resources in Colombia can be related to the socio-economic and cultural developments in the rest of the continent (Castaño-Uribe, 1989). The use of mangrove resources has been different on Colombia’s two coastlines, the Pacific and Caribbean. This has been due to cultural adaptation, which is related to the development of settlers and the nomadic and sedentary communities, where they have acted as a basis for further exploitation of the mangrove resources, which has continued to the present day (Castaño-Uribe, 1989). On the Caribbean coast deforestation of mangroves is carried out to build houses and ships, for firewood and charcoal, to protect the banks of channels, support tomato and passion fruit crops and at an industrial level for the production of charcoal and agglomerated boards. The main associated resource extracted is the oyster (Crassostrea rhizophorae) and the copey snail (*Melongena melongena*). On the Pacific coast deforestation of mangrove has been to build houses, for firewood and charcoal, to build enclosures to keep live pianguas or cockles (*Anadara similis* and *A. tuberculosa*) and at the industrial level the bark is exported to extract tannins. The main associated resource used is the cockle.

During the Spanish conquest of Peru, Cristóbal de Molina in 1552 refers to mangrove areas as “the most difficult lands of the kingdom” because of the hardships his soldiers and horses went through. The exploitation of the mangroves on the Pacific coast of Colombia as a source of timber for house construction and ship building led to their local deterioration, exacerbated by the export of wood since the 16th Century, (examples being 6000 logs per year sent to Peru in the 17th Century, and thousands of tons of lumber to Cuba in 1977) (Prahl *et al*., 1990).

During colonial times slave labour from Africa replaced indian labour on both coasts for gold and silver mining, agriculture and household activities. The mixing of three ethnic groups (indians, blacks and whites) resulted in a population that migrated slowly inland from the coastal mangroves where they first settled, to develop new economic activities based on local commerce (West, 1956; Prahl *et al.,* 1990).

From the middle of the 19th Century, Colombia developed many forms of mangrove exploitation on both, the Pacific and the Atlantic coast. On the Pacific coast mangrove bark is used to obtain tannins, especially from *Rhizophora*. On the Caribbean coast, *Rhizophora*, *Avicennia* and *Laguncularia* are used to process wood into furniture or plywood. In both cases the appropriate use and development of mangrove resources has not been sustainable. There was also a rudimentary extraction of mangrove wood for purposes that contribute to the livelihood of the fishermen and other coastal inhabitants (INDERENA, 1991). Mangroves are used for many purposes in the industrial, energy and general economic sectors. Recently mangroves have begun to be looked upon as an ecosystem, mainly because of the negative consequences of the traditional ways of managing this resource.

Table 1. Statistical and other summary information for Colombia

Total Area (km^2)	2,021,748
Land Area (km^2)	1,141,748
Climate	Tropical. Temperature ranges form 0-35^oC. Average rainfall 3,000 mm. The dry period or summer extends from December to April, accompanied by strong winds coming from the north. The period of rains or winter is from May to June and August to November, and is associated with strong rainfall and also irregular and high temperatures. The maximum precipitation occurs in October or November. During July "Veranillo de San Juan" is present, a period characterized by a decrease in rain and the appearance of strong breezes.
Key Environmental Concerns	Air pollution from industrial and vehicular emissions. Water pollution from raw sewage (domestic and industry) and siltation. Deforestation, coastal reclamation, land conversion and armed conflict.
Economic	
GDP (2001 est., million USD)	255,000
GDP Per capita (2001 est., in USD)	6,300
GDP growth rate (2001 est., %)	1.5
GDP Agriculture (2001 est., %)	19
GDP Industry (2001 est., %)	26
GDP Services (2001 est., %)	55
Social	
Population (2002)	44,500,000
% urban (2002)	65.0
% rural (2002)	35.0
Growth rate (2002 est., %)	1.6
Marine and Coastal Resources	
Coastline (km)	3,208 (Caribbean Sea 1,760 and Pacific Ocean 1,448)
Exclusive Economic Zone (to 200 m) (km^2)	880,000 (530,000 Caribbean Sea, 350,000 Pacific Ocean)
Total mangrove area (ha)	379,035
Marine Protected Areas	
Number	11
Area	Caribbean Sea: National Parks Tayrona* (15,000 ha), Sierra Nevada de Santa Marta (383,000 ha), Corales del Rosario y de San Bernardo (17,800 ha), Old Providence and Mc Bean Lagoon (995 ha), Road Park Isla de Salamanca (25,000 ha), Flora and Fauna Sanctuarys Ciénaga Grande de Santa Marta (23,000 ha), Los Flamencos (7,000 ha) and El Corchal Mono Hernández (3,850 ha). Pacific Ocean: National Parks Sanquianga (80,000 ha), Ensenada de Utría (54,300 ha) and Isla Gorgona (61,685 ha).
Marine wild fish catch (2001, tonnes)	100,000 valued at USD 130 million
Aquaculture (2001, tonnes)	10,300 valued at USD 65 million
Change/10 years (tonnes, %)	
1990 wild fish catch	3,000 (+ 3333.3%)
1990 aquaculture	6,000 (+ 171.7%)
Per capita food supply (2002 from fish and seafood, kg)	6.4

Table 1. Continue

Shrimp aquaculture (2002, tonnes)	15,103 (Caribbean 2,711 ha and Pacific 897 ha)
International treaties	
Convention on Biodiversity	Ratified 28 Nov 1994 (as Law 165)
Convention on Wetlands	Ratified in 1997 (as Law 357)
UN Convention on Climate Change	Ratified 23 Mar 1995 (as Law 164)
Kyoto Protocol on Climate Change	Ratified 30 Nov 2001 (as Law 629)
Protection of World Cultural & Heritage Sites	Ratified in 1998 (as Law 397)
International Trade in Endangered Species	Ratified 31 Aug 1981 (as Law 017)
UN Convention on the Law of the Seas	Not Ratified

** Biosphere Reserve (UNESCO-MAB)*

Source: Statistics Department of Fisheries and Aquaculture Institute of Colombia (http://www.inpa.gov.co); *Special Administrative Unit of the System of National Parks* (http://www.parquesnacionales.gov.co); *Ministry of the Environmental, Housing and Territorial Development* (http://www.minambiente.gov.co); *CIA World Factbook* (http://www.cia.gov/cia/publications/factbook/geos/co.html)

1.4 Population

Colombia is a multi-ethnic and multi-cultural society that includes Indian, black, white, and mulato peoples. The history of the consolidation of a "culture national y del populate" and use of the territory and natural resources in Colombia can be divided into five periods, distinguished by qualitative changes in their constituent elements: (1) Prehispanic population phase; (2) Colonization phase (from the colonial period until the beginning of the 20th Century); (3) Regional consolidation phase (during the first half of the 20th Century); (4) Industrialization and urbanization phase (second half of the 20th Century); and (5) Globalisation phase (beginning in the 1980s and continuing into the 21st Century).

This long history, and costs of development involved, explain the difficult economic, environmental, cultural and social conditions that the country now faces. The community despite the decrease in poverty index by 55% still has very low levels of income and expenditure capacity. Regarding the environment, there has been a progressive deterioration and reduction of ecosystems and natural resources, but there is growing awareness in the community of the importance of the environment in relation to sustainable development of Colombia.

1.5 Mangrove resources and biodiversity

The mangroves of Colombia are found in saline water and humid areas along both the Caribbean and Pacific coastlines. In general the Colombian mangroves consist of both developed and young growth mangroves with a volume per acre of 43.0 m^3 in the Pacific (17.4 m^3 ha-1) and 40.0 m^3 (16.2 m^3 ha-1) in the Caribbean (INDERENA, 1991; Yanine-Díaz, 1991). The total area of mangroves in Colombia in 1996 was 379,034.9 ha along the two coastlines (292,724.4 ha on the Pacific Ocean and 86,407.5 ha on the Caribbean Sea) i.e. 70-80% of the mangrove is on the Pacific coast and 20-30% mangrove on the Caribbean coast (Sánchez-Páez *et al*., 1997a; 1997b) (Table 2). By area, Colombia is the 10th ranked country for mangroves in the world.

These statistics are from the most recent national evaluation carried out by the Project Mangroves of Colombia MMA/ITTO. In 1995 and 1996 this project was able to use cartography, aerial photography and remotely sensed imagery supported by ground verification to determine the national cover of mangroves. For the Pacific coast there are data from 1969 showing 306,436.6 ha of mangroves and for 1996 the figure is 292,724.4 ha, i.e. a loss of 13,712.2 in 27 years. Of the total area lost by 1996, 27,337.11 ha were due to anthropogenic impacts. Conversely, on the Caribbean coast it was reported that most of the total loss of 21,921.50 ha was due to natural mortality (Zambrano-Escamilla & Rubiano-Rubiano, 1996, 1997; Sánchez-Páez *et al.,* 1997a, 1997b).

Colombian mangroves support a high diversity of true mangrove and associate species. There are eight mangrove species in Colombia (Table 3), five species on the Caribbean coastline, *Avicennia germinans, Conocarpus erecta, Laguncularia racemosa, Pelliciera rhizophorae* and *Rhizophora mangle* and eight species on the Pacific coastline *A. germinans, C. erecta, L. racemosa, Mora oleifera, P. rhizophorae, R. harrisoni, R. mangle* and *R. racemosa*. *Rhizophora* forests are typically located at the seafront. *Avicennia-Laguncularia* forests are the dominant and typical tidal forest type, often found mixed with other species (*Conocarpus* or *Pelliciera*). Dry land mangroves represent the transition into inland forests and are found towards the landward side of the main mangrove zone, or in the interior of island mangroves. These mangroves are only inundated by occasional spring tides and are often the most diverse. Mora forests commonly

Table 2. Extent of mangroves in Colombia, by Department

DEPARTMENT	**AREA (ha)**
Caribbean	
Antioquia	6,084.7
Atlántico	336.9
Bolívar	5,704.9
Chocó	41.6
Córdoba	8,862.2
Guajira	3,131.2
Magdalena	52477.7
San Andrés and Providencia	97.0
Sucre	9,574.3
Sub Total	**86,310.5**
Pacific	
Chocó	64,750.5
Valle del Cauca	41,961.4
Cauca	36,276.8
Nariño	149,735.8
Sub Total	**292,724.4**
Total	**379,034.9**

Source: Zambrano-Escamilla & Rubiano-Rubiano (1996, 1997)

Table 3. Mangrove species present on the coasts of Colombia

Family and Species	**Pacific Ocean** **Vernacular name**	**Caribbean Sea** **Vernacular Name**
Avicenniaceae		
Avicennia germinans (L.)	Black mangrove, salted, blackish, iguanero	Black mangrove, salted, blackish, iguanero, sietecueros, smoke, utta, salted-colorao
Rhizophoraceae		
Rhizophora mangle L.	Red mangrove, pineapple, gentleman	Red mangrove, coloured mangrove, canillon, junna
Rhizophora racemosa G.F.W. Meyer	Mangrove implant, red mangrove	
Combretaceae		
Conocarpus erecta L.	Zaragoza mangrove, jeli, garbancillo, button, trough mangrove	Zaragoza mangrove, zaragoza black, zaragozo
Laguncularia racemosa R. Gaertn	White mangrove, stupid	Yellow mangrove, fool, sweet, guaton, conchudo, more conchudo, botoncillo, maliiwalaa, white mangrove
Theaceae		
Pelliceria rhizophorae Triana & Planchon	Pinuelo mangrove, good fortune	Pinuelo mangrove, pinuelo
Caesalpinaceae		
Mora oleifera (Triana) Ducke	Born mangrove, born	

Source: Alvarez-León (1997)

occur along the banks of tidal rivers with a large freshwater influence and can extend several kilometres inland.

Some plant species are associated with mangrove forests throughout their distribution in the Pacific and the Caribbean coast and have even been considered as true mangrove species by certain authors. Among them the fern *Acrostichum aureum L.* and the Malvaceae *Hibiscus tiliaceus L.* are the most widespread species, occurring throughout most mangroves in the New World. These species frequently form dense belts along the landward edge of mangroves and more elevated sites and around dry and saline areas inside mangroves. However, not withstanding the widespread distribution of these two species, their biology and ecology are very poorly known.

On the Pacific coast the associated flora are very abundant and represent an important component of the local ecology. The most common plants are: *Euterpe cuatrecasana* (Palmaceae), *Hibiscus tiliaceus* (Malvaceae), *Crenea patentinervis* (Litraceae), *Pavonia rhizophorae* (Meliaceae), *Tabebuia palustris* (Bignoniaceae), *Tuberostylis axillaris* and *T. rhizophorae* (Compositae), *Anphitecna latifolia (*Bignoniaceae)*, Muellera moniliformis (Fabaceae), Phryganocydia phellosperma (*Bignoniaceae). The sandy areas are represented by fixed plants such as *Cenchrus pauciflorus* (Poaceae) and *Homolepis aturensis (*Poaceae*)*, as well as the climbers *Canavalia maritima (*Fabaceae)*, Ipomea pes-capre, I. stolonifera (*Convolvulaceae)*, Pectis arenaria* (Asteraceae) and *Stenotaphrum secundatum (Poaceae)* (Prahl *et al.,* 1990).

On the Caribbean coast the most common salt marsh species associated with mangroves are *Batis maritima* (Batidaceae), *Sesuvium portulacastrum* (Aizoaceae), *Typha domingensis*, *Phryganocydia uliginosa*, the Graminae *Sporobolus virginicus*, *Paspalum vaginatum, Dietichlis spicata*, the Cyperaceae (*Cyperus* spp.), and the Apocynaceae liana *Rhabdadenia biflora*. However, not many studies have been conducted on this plant and its effect on its favourite host, the red mangrove (*R. mangle*), remain unknown (Alvarez-León, 1993, 2003b).

The fauna associated with Colombia's mangroves is large and diverse. Prahl *et al*. (1990) and Alvarez-León (1993) group the species that have been studied as follows: (1) organisms that live in direct association with the roots of the *Rhizophora* and *Avicennia* mangroves; (2) organisms that use the leaves, the stems and the branches of the mangroves: e.g. herbivores (use 15-20% of the foliage), insects (tend to defoliate mangrove leaves), crabs and molluscs (feed on young stems) as well as iguanas, deer and monkeys; (3) birds and bats use the mangroves for perching, for building nests, for sleeping and for cleaning themselves. Parrots and anteaters are attracted to them because of the termites and honeybee combs; (4) terrestrial, amphibian and aquatic organisms that use the mangroves for temporary shelter and as feeding habitat.

There are at least 100-150 species of birds, 200-250 species of fish and hundreds of species of terrestrial and marine invertebrate species associated with mangroves in Colombia. The mudflats that occur at the foreshore of mangroves are the habitat for many invertebrates and are used extensively for the culture of the cockle *Anadara* spp. and portunid crabs *Callinectes arcuatus.* Mangrove meiofauna consist predominantly of free-living nematodes, harpacticoid copepods and amphipods. The macrobenthos community depends on the forest type but polychaetes, gastropods and brachyuran crabs are dominant. The aquatic mangrove fauna in the estuaries, creeks and inlets is also diverse (Prahl *et al*., 1990; Alvarez-León, 1993).

The most common mangrove molluscan and crustacean species on the Caribbean coast include the following: (1) bivalves *Brachiodontes citrinus, B. exustus, Isognomon alatus, Crassostrea rhizophorae, Ostrea equestris, Bankia destructa, B. fimbriatula*; (2) gastropods *Littorina antillarum, Murex antillarum, Thais haemastoma, Nassarius albus, Melongena melongena, Melampus cofeus, Neritina virginea*; and (3) crustaceans *Chtalamus angustitergum, Balanus amphitrite, B. eburneus, Paraclimenes americanus, Synalpheus apioceros, S. minus, Stenopus hispidus, Panulirus argus, Petrolistes armatus, Clibanarius cubensis, C. vittatus, Eurypanopeus depressus, Panopeus fierbstii, P. typica, Microphrys bicornutus, Pinnotheres ostreum, Callinectes sapidus, Pachygrapsus gracilis, P. traversus* (Alvarez-León, 1993).

On the Pacific coast the representative fauna are (1) bivalves: *Isognomon janus, Cassostrea columbiensis, Anomia fidenas, Pododesmus foloiatus, Matesia striata, Bankia gauldi*; (2) gastropods: *Nerita scabricosta, Theodoxus luteofasciatus, Littorina fasciata, L. scabra, L. varia, L. zebra, Thais kiosquiformis, Nassarius wilsoni, Elloium stagnalis, Melampus carolinus*; and (3) crustaceans: *Latreutes antiborealis, Eurytium tristuni, Eurypanopeus transversus, Panopeus chilensis, P. purpureus, Callodes gibbosus, Macrocoeloma villosum, Notolopas lamellatus, Pinnotheres angelicus, Glyptograpsus impressus, Sesarma angustum, S. aequatoriale, Sholometopus occidentalis* and *S. rhizopho*rae (Prahl *et al*., 1990).

2. Cross-sectoral issues in mangrove management

The high productivity of mangrove ecosystems and their capacity to sustain the production of fishery and forestry communities has helped Colombia's economic development. Mangroves are rich feeding and nurturing grounds for many commercial fish species. Other economic and ecological benefits of mangroves include shoreline protection and stabilisation, climate change mitigation, sediment and nutrient retention, water purification and habitats for biodiversity. Tourism in mangroves is also becoming increasingly important. However, the value of mangrove forests, in providing various environmental or cultural services, has rarely been considered in decision-making.

Box 1: Mangrove dynamic experiments, Phase II of the MMA / ITTO-funded Project Conservation and Management for Multiple Use and Development of Mangrove Swamps in Colombia

Restoration of Mangrove Areas

On the Caribbean coast the results obtained from two rehabilitation plots showed survival rates for *R. mangle* seedlings of 100% and 81% in nurseries; 87.34% and 95% in plantations; and 67.36% survival for direct seeding of propagules. The development of *R. mangle* seedlings reached rates of 1.60 mm per day. For *A. germinans* a growth of 42.67 cm was obtained. *Rhizophora* reaches 45.78 cm after 270 days. The results obtained from transplanting with seedlings from nurseries, was much better compared to those that were obtained by direct sowing of propagules (Ulloa-Delgado *et al*., 1998a, 1998b; Sánchez-Páez and Ulloa-Delgado, 2000).

On the Pacific coast, restoration was also more successful with vegetable material used from nurseries, than direct seeding methods, with survival rates for *R. mangle* of 94% and of 84%, respectively. This was also the case with the other three species tested. *L. racemosa* hardly reached 3.4% survival with the method of direct sowing. With nursery material the survival of transplanting *A. germinans* was 42% and *P. rhizophorae* 96%. In the analysed plots *A. germinans* survival with direct seeding was 52% after the first month and 44% after a period of three months. With direct sowing, after five months, the seedlings of *R. mangle* obtained an average height of 34 cm and a maximum of 80cm, while in tree nurseries the average height of 38.9 cm and a maximum of 83 cm was recorded (Sánchez-Páez *et al*., 1997b; Guevara-Mancera *et al*., 1998).

Tree Nurseries

For the Caribbean coast temporary community nurseries were established in the Departments of Bolivar, Sucre and Córdoba. These were Pasacaballos, Bolívar, which was 14 m X 14 m for 24,000 seedlings; Leticia, Channel of the Dike, Bolívar 10 m X 5 m for 7000 seedlings; Island of the Rosario, Bolívar 4 m X 4 m for 4000 seedlings; Boca Cerrada, Sucre 10 m X 7 m for 12,000 seedlings; Los Cocos (Road Park Island of Salamanca, Magdalena) 4 m X 4 m, for 7000 seedlings and Caño Lobo, Córdoba 14 m X 12 m for 24,000 seedlings. The seedling production corresponds to a period of 75 days when able to be transplanted. All these nurseries have already had two production cycles with very good results (Rodríguez-Cruz, 1998; Ulloa-Delgado *et al*., 1998a, 1998b). In 1998 during Phase II of MMA / ITTO project, 35 ha. were restored on the alluvial beach in proximities of the Caños Matunilla and Lequerica, and in the Cispatá Bay. In the first six months of 1999 (Phase II) they settled six nurseries, four of them in the Old Delta Estuary of the Magdalena River, one in Necoclí (Antioquia) and another in San Andrés. This work has been carried out with the competent and active participation of the local communities and Corporations (each Department has a local government environmental authority = corporation). The consultants of the project in the Caribbean region will publish more detailed data on this restoration. On the Pacific coast, three previously built nurseries were refurbished by CORPONARIÑO in the surroundings of Tumaco (Nariño) and two were built in the Cauca. These nurseries were 5 m X 5 m and 7 m X 7 m and built with wood and plastic mesh for confinement for a capacity of 150 and 2500 seedlings in polyethylene bags. Their construction was made near the tidelands to facilitate irrigation and transplanting activities (Guevara-Mancera, 1998, Guevara-Mancera *et al*., 1998).

Physical-Chemical Monitoring of the mangrove waters to help with management and restoration

The physical-chemical parameters of the waters of the mangroves on the Caribbean coast of Colombia were monitored at 19 monitoring stations, located within the permanent growth and rehabilitation plots. The results showed that due to water flow deficiencies and overexposure to light rays, resulting from a lack of vegetation cover, some internal or flood waters tended to have elevated temperatures, with extremes of 40ºC in the Pipe Dago and Bay of Cispatá and 41ºC in the Garzal in the Ciénaga de la Caimanera. During the sampling periods at most other stations, internal waters showed more favourable conditions and non-critical levels with average temperatures of 29.8ºC, maximum of 38ºC and minimum of 25ºC. The pH levels observed were normal, oscillating between 6.5 and 8.5. Salt concentrations in the mangrove waters varied from 0 to 88 spu (salinity practical units), according to the characteristics of the location with significant increases evident in the dry season and decreases in the rainy season. Salinity levels tended to be critical for the development of mangroves at several stations (Pino-Rengifo, 1998; Guevara-Mancera *et al*., 1998).

On the Pacific coast there are 16 monitoring stations located in four Departments for monitoring water quality. The interstitial water in the mangrove forests of the Pacific varies for the measured parameters, during low and high tide, according to the station and in accordance with the influence of the sea or rivers. Salinity can vary from 2 to 30 spu reaching average values of 9 and 26.2 spu and the oxygen from 5,3 to 7,7 mg/litre. During high tide the values of the measured parameters are highest. Temperature and pH, have smaller variations between the stations and the three considered tide levels. Surface waters showed the highest difference in average temparature (28.5 – 29.3ºC). In general, temperature and pH variability was much lower, thus the Pacific mangroves have adequate conditions for their development (Guevara-Mancera and Pinto-Nolla, 1998; Guevara-Mancera *et al*., 1998).

2.1 Forestry

Traditionally, mangroves have been harvested for fuelwood (either high quality firewood or converted to charcoal) and for poles for construction. In addition to mangrove wood, mangroves also provide many non-timber products, but these are produced only on a subsistence level not commercially. For example, mangroves provide by-products for tanning and provide resources for local medicines.

Forestry activities in the Colombian mangroves go back to the 50's years, when mangrove forest logging supplied products for low cost homes, including rods, beams, props and poles as well as for electricity posts, fuelwood and charcoal. The success of mangrove forestry has been due largely to clear forest working plans and the continuous economic output provided by them but they have been wasteful and uncoordinated in many respects. For example, on the Caribbean coast mangroves were used to produce charcoal and wood chips for production of composite boards, but the bark was totally wasted, while on the Pacific coast the bark was used to extract tannins but the wood was wasted. Without planning, and with little or no coordination in management, such forest activities have led to overexploitation and great deterioration of the ecosystem. This in turn has impacted on the socio-economic well being of the local communities that depend on the extraction of fishery and forestry products.

Based on a study by experts (Hernández-Camacho *et al*., 1978a, 1978b), INDERENA decided in 1979 to ban permits given to large industrial companies on the Caribbean coast (Canal del Dique and Ciénaga Grande). On the Pacific coast on the other hand, permits were still permitted issued to allow exploitation of the red mangrove (*Rhizophora* spp.) for the production of timber (Departments of Chocó: 3742 m^3, Valle del Cauca: 4714 m^3; Cauca: 2637 m^3), posts for housing (Department of Choco: 1371 m^3) and bark extraction (Department of the Cauca: 380 m^3) (INDERENA, 1991; Alvarez-León, 2003a).

Field and laboratory experiments carried out later showed the positive benefits of this ban on the Caribbean coast. The high cost of industrial exploitation of the mangrove has led recently to its substitution by other wood varieties on the Pacific coast, but mangrove exploitation on a small scale can still continue on the Caribbean coast. So far, the only laws that regulate mangrove extraction have been adapted from the existing forest legislation. These regulations view the ecosystem as a whole and relate biological productivity with socio-economic values (Resolution 1681 of 1978). Increased interest in adequately administrating the mangrove ecosystems has resulted in the INDERENA policy prohibiting exploitation of mangrove forests being extended to the Pacific coast (Hernández-Camacho *et al*., 1980). Regional Corporations (Environmental Authorities) enforce the restrictions of transporting mangrove materials and have started regional bans on the exploitation of mangroves. There have been national and international conferences related to mangrove ecosystems sponsored by UNESCO and FAO. When the importance of mangroves was recognised, a national project was planned sponsored by the International Tropical Timber Organisation (ITTO), which included a diagnosis of the status of Colombia's mangroves (INDERENA, 1991). This diagnosis was used to support a request for funding from ITTO; the project was approved in 1994 and started in September 1995.

Despite the valuable contribution made by the Colombian forestry sector, with well documented production over the last decade (Silva, 1987), involving more than 300 species, studies on the mangrove forests in the country are quite scarce and for some aspects nonexistent. The vulnerability of the mangrove ecosystems, and the constant pressure to which they have been subjected to by anthropogenic actions, has generated several trials for their recovery on the Colombian coasts (Box 1). Due to climatic and environmental conditions studies have been more frequent in the areas of Cartagena and Rosario's Islands. Studies have been conducted on natural propagation by means of propagules of *Rhizophora mangle*, as well as of induced techniques of transplanting wildlings of this species, or air-layering and sowing of seedlings. Pollution studies have included rehabilitation of *A. germinans, L. racemosa* and *R. mangle* forest affected by hydrocarbons and the affects of polyamines on the growth of *R. mangle* seedlings (Alvarez-León, 1997; 2003). On the Pacific coast, studies have been concentrated on natural regeneration of the intervened areas (INDERENA, 1991) or use of propagules and seedlings of *Rhizophora spp*. in community nurseries in Tumaco (Nariño). Recently in the Valley of the Cauca, studies have been undertaken on seedlings of four mangrove species (*A. germinans, Conocarpus erecta, Pelliciera rhizophorae, Rhizophora spp.*) to compare their performance in relation to soil type, hydrodynamic factors and salinity (Alvarez-León, 1997, 2003a).

2.2 Fisheries

In Colombia fishery resources have been exploited heavily to meet the demands of national consumers and the increasing demand from international markets. The fisheries resources associated with mangroves include molluscs, crustaceans and fish (Table 4). These resources have been valued traditionally and appreciated for their excellent taste and nutritional value. The fisheries sector in Colombia contributed 0.45% of GDP in 2002, with marine fisheries, large scale commercial off-shore trawling and small-scale coastal fishing, contributing 86% of the total production value. The consumption *per capita* of the fishery products in Colombia was 6.4 kg/year in 2002.

Mangrove ecosystems play an important role in fisheries, for example, in Panama, it has been demonstrated that almost 95% of the yield of shrimps and white fish is to

Table 4. Fisheries resources in Colombia

Common name	Scientific name	Region
Molluscs		
Chipi-chipis	*Anomalocardia brasiliensis*, *Donax* spp.	Caribbean
Oysters	*Crasosstrea rhizophorae* *C. columbiensis, Pictada mazatlanica, Strostrea prismatica*	Caribbean Pacific
Cockles	*Anadara imbricata, A. zebra* *Anadara grandis, A. multicostata, A. similis, A. tuberculosa*	Caribbean Pacific
Snails	*Strombus pugilis* *Strombus peruvianus*	Caribbean Pacific
Copey	*Melongena melongena*	Caribbean
Cambutes	*Vasum muricatum* *V. caestus*	Caribbean Pacific
Scallops	*Amusium laurenti, A. papyraceum, Lyriopecten nodosus, Pecten zig-zag*	Caribbean
Clams	*Chione cancelata, Polymesoda arctata Trachycardium muricatum* *Donax assimilis, Macrocallisa aurantiaca*	Caribbean Pacific
Octopuses	*Octopus briareus* *O. vulgaris*	Caribbean Caribbean and Pacific
Squids	*Loliguncula brevis* *Lloligo gahi, Loliguncula panamensis, Loliopsis diomedeae*	Caribbean Pacific
Crustaceans		
Shrimps	*Farfantopenaeus brasiliensis, F. notialis, Litopenaeus schmitti* *F. brevirostris, F. californiensis, Litopenaeus occidentalisi, L. stylirostris, L. vannamei*	Caribbean Pacific
Lobsters	*Panulirus argus, P. laevicauda* *P. gracilis*	Caribbean Pacific
Portunid crabs	*Callinectes boucurti, C. danae, C. sapidus* *C. arcuatus, C. toxotes*	Caribbean Pacific
Crabs	*Cardisoma guanhumi, Ucides cordatus* *Cardisoma crassum, Ucides cordatus*	Caribbean Pacific
Fish		
Tarpon	*Tarpon atlanticus*	Caribbean
Gerrids	*Diapterus rhombeus, Gerres cinereus* *D. peruvianus, G. cinereus, Eugerres* spp.	Caribbean Pacific
Catfishes	*Arius* spp., *Ariopsis bonillae, Cathorops spixii* *Bagre panamensis*, *Galeichthys peruvianus, Sciadeops troschelii*	Caribbean Pacific
Jureles	*Caranx* spp.	Caribbean and Pacific
Corvines	*Cynoscion* spp.	Caribbean and Pacific
Mullets	*Mugil liza* *Mugil cephalus, M. curema*	Caribbean Caribbean and Pacific
Snooks	*Centropomus ensiferus, C. undecinalis* *C. armatus*	Caribbean Pacific
Snappers	*Lutjanus* spp.	Caribbean and Pacific

Table 4. Continue

Groupers	*Epinephelus* spp., *Mycteroperca* spp.	Caribbean and Pacific
Roncos	*Haemulon* spp.	Caribbean and Pacific
Tunas	*Euthynnus lineatus, Katsuwonus pelamis*, *Thunnus* spp.	Caribbean and Pacific
Sierras	*Scomberomorus brasiliensis, S. regalis* *S. sierra*	Caribbean Pacific
Sharks	*Carcharhinus* spp., *Rhizoprionodon* spp. *Sphyrna* spp.	Caribbean and Pacific Pacific
Sawfish	*Pistis* spp.	Caribbean and Pacific

Source: Moreno-Bejarano & Álvarez-León, 2003, 2006; Álvarez-León & De Ayala-Monedero (2009).

some degree dependent on the protection and feeding capacity that is offered by the mangrove swamps and other related coastal areas that harbour them (marshes, estuaries, deltas, swamps, lagoons, tidelands) (Alvarez-León, 1984).

In the Colombian Caribbean, artisanal fishing is carried out especially in the coastal lagoons and estuaries of the big rivers (Magdalena, Sinú and Atrato) where coastal mangrove swamps are abundant. The fishermen use traditional methods to harvest molluscs (by hand or with spades), crustaceans (cast-nets and nasas, made of wood and vegetable fibres in a labyrinth configuration with bait inside or cages) and fish (gill-nets, cast-nets, long line, encircling). On the Pacific coast similar methods are used, while other fishing techniques reflect the local tidal conditions, or characteristics of particular species. Highly destructive fishing methods, including the use of dynamite, nets with very small mesh that catch larval and juvenile stages and the cutting of red mangrove roots to harvest oysters, still occur on the Caribbean coast.

In Colombia the main products derived from mangrove areas continue to be edible species that have been used traditionally for local consumption, including oysters (*Crassostrea rhizophorae*), blue crabs (*Cardisoma guanhumi*), estuarine fish (*Tarpon atlanticus, Mugil incilis, M. liza, Centropomus undecimalis, C. ensiferus*) in the Caribbean and, molluscs (*Anadara similis, A. tuberculata)*, crustaceans (*Callinectes arcuatus*) and fish (*Arius* spp., *Sciadeops troschellii, Lutjanus guttatus, Diapterus peruvianus, Mugil cephalus, M. curema*) in the Pacific.

Through the Ministry of External Relations, agreements have been made with the neighbouring countries of Ecuador and Panama to help their traditional communities trade in fish and molluscan species associated with mangroves. Meetings are carried out on an annual or biannual basis to discuss sanitation, migration, trade of agricultural and fishery products and impacts of contamination by crude oil. Help has been coordinated to alleviate the impact of oil contaminations on fishermen's livelihoods including payment of compensations due to destruction of resources, in particular cockles, shrimps and crabs directly associated with mangroves.

2.3 Aquaculture

There has been a gradual reduction in the natural self-sufficiency of Colombia's coastal ecosystems, due to the modification of mangroves for the express development of coastal infrastructure and the destruction of large quantities of forest at the heads of rivers. This has resulted in a need to maintain aquatic production levels to fulfil the growing national demand (oysters, cockles, snails, blue crabs, portunid crabs, tarpon, catfishes, flat fish, mullets, gerrids, red tilapias) and international demand (microalgae, artemia and shrimp). Therefore the aquaculture sector has been promoted strongly in Colombia.

Coastal aquaculture takes place in mangrove waterways, on mangrove-associated mudflats, and in ponds constructed in mangroves areas. The use of mangrove waterways includes floating cage culture for rearing red tilapia (*Oreochromis* spp.), tarpon (*Tarpon atlanticus*), snappers, snooks and mullets (*Mugil incilis* and *M. liza*) on the Caribbean coast (Mercado-Silgado and Alvarez-León, 2003); and snappers (*Lutjanus* spp.), catfish (*Arius* spp.) and mullets in the estuaries of the Pacific coast (Valverde-Pretelt & Alvarez-León, 2002). Oysters (*Crassostrea rhizophorae*) are cultured on mud flat areas of the Caribbean coast by setting collectors and taking care of the grouped oysters or putting individuals in baskets, while cockles (*Anadara* spp.) are grown on the mud flats of the Pacific coast (Alvarez-León, 1982, 2000).

Molluscs and crustaceans are cultured at an artisanal level, fish are cultured at a semi-intensive and experimental level, whilst farmed shrimp (*Litopenaeus vannamei* and P. *L. stylirostris*) are cultured at an intensive level and exported to Europe, United States and Japan. On the Caribbean coast, wild animal products from valuable species associated with the mangrove are also farmed. They include pets like iguanas (*Iguana iguana*) and boas snail (*Boa constrictor*), skins and meats of crocodiles and

caimans (*Caiman crocodilus, Crocodylus acutus*), stifles, manatees and chiguiros (*Hidrochaeris hidrochaeris*) that are in high international demand (Alvarez-León, 1982, 1984).

Shrimp (*Penaeus vannamei* and *P. stilyrostris*) have been farmed intensively in Colombia since 1984 when the total export achieved was 5 tonnes (value USD 55,000). By the end of the 90's years shrimp exports had soared to 4,500 tonnes from a cultured area of 2,400 ha. supported by 15 shrimp hatcheries (Boyd, 1999). In the initial stages of shrimp culture during the mid 70's years, shrimp postlarvae were captured (*Farfantopenaeus brasiliensis, F. notialis* and *Litopenaeus schmitti* in the Caribbean, *L. stylirostris and L. vannamei* in the Pacific) from the wild, causing great impact on other species of crustaceans and fish. This impact decreased progressively as shrimp hatcheries developed to satisfy the demand for shrimp seed.

In a relatively short time shrimp farming has become widespread in most of the mangroves throughout Colombia, but particularly in south Cartagena Bay, and Cispatá Bay in the Caribbean and, Ensenada of Tumaco in the Pacific. Attempts at expanding the shrimp industry along the Caribbean coast are being promoted by the Ministry of Foreign Trade. Recently an agreement was signed between State bodies and private companies for the establishment of a further 9000 ha of shrimp ponds in the Department of Guajira and 8000 ha in the estuaries of the lower basin of the Sinu River (WRM, 2002).

Shrimp aquaculture can achieve high economic returns, but there are also high risks involved. Feed, seed, maintenance and infrastructure costs are high. Moreover, intensive farming of shrimp (*Litopenaeus vannamei* and *L. stilyrostris*) has had negative ecological impacts (MMA, 2002). For these reasons, there are now large areas of abandoned shrimp ponds in the Pacific mangroves of Colombia. The profitability and productivity of the ponds falls quickly due to acidification of the exposed soil. Gradually the abandoned ponds are recolonised with different swampland species or the mangrove fern (*Acrostichum aureum*). Overall, shrimp aquaculture has had severe impacts on the dynamics of coastal wetlands, e.g. by restricting migration of wild aquatic species, increasing eutrophication and contamination, and restricting access and habitat to artisanal fishermen. However, a positive outcome from the abandoned shrimp farms is that fishermen in the Tumaco area (Nariño) have been able to construct simple ponds in the areas recolonised by *Acrostichum*, in which they harvest natural shrimp by trapping and holding using natural tidal water exchange. The shrimp produced are sold to the local industrial packers.

On the Colombian coast, red tilapias (*Oreochromis* spp.) and oysters (*Crassostrea rhizophorae*) have been cultured in the drainage channels of shrimp farms in order to diversify the production and to take advantage of the high nutrient levels in the drainage water. On the Pacific coast, red tilapias have also proved highly versatile and adaptable in aquaculture. Initially tilapias were cultivated in cages, but many fish escaped into natural waters where they have competed strongly with native species. In some years red tilapias now provide the highest yield in the fisheries of Ciénaga Grande Santa Marta, the biggest coastal lagoon in the Colombia, covering 480,000 ha.

2.4 Other sectors

Agriculture

Large areas of mangrove in Colombia have been reclaimed and converted to oil palm and coconut plantations. However, the high salt, water and pyrite content of mangrove soils limits the number of crops that can be grown. Soils have to be leached and drained and measures taken to limit the oxidation of pyrites to sulphuric acid. On the Pacific coast, hundreds of hectares of mangrove were cleared; bunded and tilled for growing rice, but this was a failure because of the acid sulphate conditions.

Other less well-known agricultural uses of mangroves in Colombia include the feeding of *Avicennia* leaves to goats by the indigenous communities on the Guajira peninsular.

Salt pans

Since prehispanic times local communities on the Caribbean coast have used the salt peter areas adjacent to the mangroves in Manaure in Guajira and Galerazamba in Atlantico. Today the natives of the Community of Wayuú, produce salt in specially prepared ponds and transport the raw product to Cartagena (Bolivar) where it is refined for human consumption. In 2002, 335,738 tonnes of sea salt was produced from the Colombian coast, but this industry does not affect the mangroves except close to the buffer areas.

Residential and Industrial development

Considerable residential, industrial and mixed development projects, including holiday resorts, have been constructed on former mangrove areas. Examples include the development and extension of ports and the development of urban areas along the Caribbean coast at Turbo, Barranquilla, Coveñas, Santa Marta and Cartagena (Caribbean coast), and on the Pacific coast at Buenaventura and Tumaco, which are all situated on reclaimed mangroves. In the town of Tumaco there are still many buildings constructed on wood stilts to avoid the effects of tides when the area was still in transition from a mangrove swamp.

2.5 Coastal protection

Mangroves on the west coast of Colombia are highly sheltered and therefore well protected from major storms and coastal erosion. However, removal of mangroves from

areas susceptible to erosion will aggravate the problem. The number of sites that are seriously affected by coastal erosion has increased on the Caribbean coast. Experimental nurseries to improve the cultivation of mangrove seedlings for transplanting (*Rhizophora mangle, Avicennia germinans, Pelliciera rhizophorae, Laguncularia racemosa, Conocarpus erecta, Mora oleifera*) would be highly beneficial as an activity to support mangrove rehabilitation for coastal protection.

It has been proposed to enforce and extend buffer zones wherever necessary, ensuring additional compulsory protection of eroding coastlines. The Law that designated Natural Reserves included the existence of buffer zones around the reserves. However, in the law, there was no mention about what the size of these buffer areas should be, and freedom was given at local level to define them, according to the conditions of each reserve. So far, no buffer areas have been implemented and enforced at either the national or local level where mangroves are included. Moreover, many factors have delayed the establishment of Natural Reserves including the settlements of black communities, territories of indigenous people (security areas), roads, oil pipes and the electric network among others.

2.6 Tourism and recreation

Colombia attracts a significant number of visitors (international, regional and national) to its coastal resources (beaches and coral reefs) and tourist facilities (hotels and resorts). Many mangrove areas have been reclaimed for the development of tourist infrastructure. Some of the remaining mangrove sites are now gaining importance and value to the local economy as areas for ecotourism.

Examples of the use of mangrove areas in the Caribbean for ecotourism are the Road Park Island of Salamanca (Magdalena), where there is a visitor's centre and an elevated walkway through the mangrove forest comprising of four characteristic species (*Avicennia, Conocarpus, Laguncularia, Rhizophora*). In La Boquilla (Bolívar), fishermen offer walks and boat trips among the red mangrove of the area, including the 'tunnels of love' (channels with a closed mangrove canopy where romantic couples can be quietly pushed by boat). In the Cispatá Bay (Córdoba), fishermen offer trips in the mangroves of the area, which feature attractive native and migratory birds and experimental cultivation of oysters. In both La Boquilla and Cispatá, the tours offered can include a typical lunch of local shellfish and fish.

On the Island of Barú (Bolívar) on the Caribbean coast there is an annual Fair and Handicraft Competition. This is called "The Culture of the Mangrove: The Mysteries of the Green Wall" and lasts for one month from mid-December and mid-January. It includes a gastronomic festival, folklore and story-telling, competitions and local games (Baruleras Olympiads).

Overall, tourism on the Caribbean coast has caused major impacts on the mangroves, due to drainage of wetland areas, infrastructure development and recreational activities (Alviz-Martínez, 1997).

2.7 Biodiversity conservation

The coastal regions of Colombia include Natural National Parks, Sanctuaries for Flora and Fauna, Via Park, Biosphere Reserves (UNESCO/MAB), and RAMSAR sites, in which mangroves are an important ecosystem (Table 1). The Natural National Park Sierra Nevada of Santa Marta was designated a Biosphere Reserve in 1979, the Seaflower and Ciénaga Grande of Santa Marta Biosphere Reserves were designated in 2000. In 1998 the Delta Estuarine System of the River Magdalena, Ciénaga Grande of Santa Marta (400,000 ha) was designated a RAMSAR site. This site is a coastal estuarine system with 20 lagoons of varying salinity, with several rivers running through the area and extensive zones of mangroves. The site is important for its mangrove ecosystem, which is the largest on the Caribbean coast of Colombia. It also serves as habitat and winter breeding ground for several bird species, has at least two endemic bird species, and is also a spawning ground for many fish species.

Due to their status, reserve areas have been more intensively studied to provide knowledge on the diversity of their fauna and flora, this also includes mangrove areas. Currently, investigations are being promoted in these reserve areas to supplement the species inventories and provide information to assist the sustainable management of this diversity.

2.8 Research and education

Scientific research supported by the Government is geared mainly to generating more information on the habitat and ecosystem for effective conservation programmes and management practices for the country. The findings are also useful to impart conservation messages to people. Even though there is a bibliography regarding the Colombian mangrove swamps (Alvarez-León, 1997), more information is needed on Pacific species taxonomy, productivity on both coastlines (Pacific and Caribbean), ecological damage due to human activities, and potential ecological-economic benefits from improved management.

The productivity (ton/ha/year) obtained in representative forests allows evaluation of their potential like the possibility of exporting this energy to neighbouring ecosystems. In the Caribbean productivity varies from 5,93 – 68.72 (ton/ha/year) and in the Pacific from 7.50 – 14.08 (ton/ha/year) (Alvarez-León, 2000) (Table 5).

Table 5. Productivity of the Colombian mangroves by coastal area

COASTAL AREA	LOCALITY	PRODUCTIVITY (ton/ha/year)
Caribbean	Cga. Gde. de Santa Marta	28.84-68.72
	Cga. de Cocoliso	4.07-23.26
	Bahía de Cartagena	7.27-11.04
	Isla de Providencia	6.20-16.79
	Isla de San Andrés	5.93-14.84
Pacific	PNN de Utría	10.31
	Punta Soldado	12.95
	Estero Veneno	11.35
	Estero Limones	7.50
	Guapi	13.46-14.08
	PNN de Sanquianga	12.11
	Pasacaballos	12.12
	Bocagrande	10.84
	Ensenada de Tumaco	9.97
	Hojas Blancas	6.48-10.04
	Bocana Río Rosario	14.03
	Cabo Manglares	10.84

Source: Alvarez-León (2000)

Mangrove research has been favoured by the National Plan for Sea Science and Technology of 1977-2005, which has encouraged international events, and groups of scientists to investigate and publish in scientific reviews (Alvarez-León, 1997). Colombia does not possess a research centre specialized to study the genetics of mangroves, but in Valle University in Cali (Valle) a pioneering study has been carried out on the genetic status of the black mangrove (*Avicennia germinans*) and the piñuelo mangrove (*Pelliciera rhizophorae*), as reported by Cerón-Souza *et al*. (2002) and Castillo *et al*. (2002).

In the country the curricular programs in Biology and Marine Biology and Ecology include several hours' theory and fieldwork on swamp ecosystems. At least four universities have subjects that are related to marine biology and mangroves. The importance is also reflected in the National Seminar of Sciences and Technologies of the Sea, this national biannual event takes place in different cities, in which a working panel is included to highlight the investigations carried out in the Colombian swamps.

National projects, such as MMA/ITTO, have up to 15 investigators (marine biologists, biologists, forest engineers, anthropologists, publicists), and have carried out about 250 workshops each with 20-25 people (family heads and young people). The Regional Corporations (Environmental Authorities) continue the work in the National Plan by carrying out workshops that specially bring up to date and guide on the recovery and use of mangroves.

From social research and conservation projects, Colombia has produced one booklet (Yanine-Díaz and Otavo-Rodríguez, 1993), one video (Caribbean and Pacific coast), two posters (regional level from Rosario and San Bernardo Islands and Ciénaga Grande de Santa Marta, Caribbean) and five leaflets (one general, two from the Pacific coast and two from the Caribbean coast). The video "Las voces del manglar" is produced by Valderrama-Barco (1997) from the project "Conservation and Handling for the Multiple Use and the Development of the Mangroves of Colombia, MMA/ITTO". People that inhabit the swamps are mainly black and indigenous communities, only in very few places are there colonist communities, peasants and natives. The multiethnic population was kept in mind for the publication of these materials. Manuscripts and some pictures were given to selected members of the communities to suggest specific changes, to make the final products (videos, notes and folding) more useful. Unfortunately the number of people involved in these national efforts has not been quantified, and especially those who benefited, for example the local people (family heads, youths and children).

3. Overview of the existing legislation

3.1 Regulatory frameworks

Colombia pays attention to conservation of the environment and to sustainable natural resources

management. At the international level, Colombia is signatory to a number of international agreements and conventions related to mangrove biodiversity conservation and sustainable development. These include the Convention on Biological Diversity (CBD), the RAMSAR Convention on Wetlands, CITES Convention on International Trade of Endangered Species, among others (Table 1). Colombia has also adopted the ITTO 1994 Guidelines for the Sustainable Management of Natural Tropical Forests, which includes mangroves.

The National Committee on Biodiversity oversees the implementation of the national biodiversity policy and matters touching on biodiversity governance with the outside world. Its membership comprises the relevant Ministries and Departments, some of the Institutes and several biodiversity experts.

There is a "National Program for the Sustainable Use, Management and Conservation of Mangrove Ecosystems", this was based on a technical proposal from a MMA/ITTO Project "Strategic Limits for the Conservation and Sustainable Use of the Swamps in Colombia" (Sánchez-Páez *et al*., 2000) and other information such as the documents "Basic Techniques for the Conservation and Sustainable Use of the Interior Wetlands" (Naranjo *et al*., 1999; MMA, 2002b), "Limits of the National Politics of Integrated Classification of the Coastal Areas" (MMA, 1998a, 2001), the Program for the Implementation of the Strategic Plan of the Restoration and the Establishment of Forests in Colombia - Green Plan 1999-2002" (MMA, 1999a, MADR *et al*., 2000), the "National Politics of Biodiversity" (MMA, 1998b; IIBAvH, 2000), and the "National Plan in Bioprospection Continetal and Marine"(Melgarejo et al., 2002). There was also consultation between the Government (Ministry of the Environment, Housing and Territorial Development) and the local communities, corporations, universities and research institutes. This national program for the integrated management of the mangrove ecosystems is based on the strategy suggested by the Convention on Biological Diversity (MMA, 2002a).

Colombia's Vision 2025

The National Program on Sustainable Use, Management and Conservation of Mangrove Ecosystems to 2025, is intended to provide planning and integrated management capacity for mangrove ecosystems, and to guide their sustainable use, management and conservation. This programme allows for the needs of the forest sector and for sustainable development in the country based on scientific and traditional knowledge for the benefit of the Colombian society, and especially the communities that inhabit or live near mangroves (MMA, 2002).

Within the Program there are also various specific action plans for mangroves: (1) zoning of mangrove areas, (2) planning for conservation and sustainable use, (3) mangrove protected areas, (4) mangrove research, (5) community participation and education for conservation and training, (6) restoration and rehabilitation of destroyed or degraded mangrove areas, (8) bring up to date the application norms to do with mangroves, (9) mangrove information system, (10) international invigoration, (11) pursuit of national actions (MMA, 2002).

3.2 Laws and legal status

Colombia has its own legislation, which addresses biodiversity conservation and management of mangroves. Colombia possesses a national regulation contained in five Resolutions (1602/1995; 020/1996; 257/1997; 924/1997; 233/1999; 271/2002), Agreements (CD-018/1995 and CD-024/1997, Valle) and Departmental Resolutions in the Pacific (R-037/1998, Nariño) that forbid mangrove use in their territories; likewise a norm exists that declares the mangroves of San Andrés' Archipelago and Providence a national reservation (Law 47/1993) and natural reservations covering several other mangrove areas or associated forest ecosystems (Agreement 099/1992, Antioquia; Ordinance 012/1993, San Andrés; Agreement 023 Bis/1996, Bolivar; Resolution 763/2002, Bolivar-Sucre). The norms directly related to Colombian mangroves are provided in Table 6.

Colombia has specific regulations to protect the environment beginning from the National Sanitary Code or Law 9 of 1979 and the Ordinance 1541 of 1978. At national level there are decrees covering atmospheric emissions (Decree 02 / 82; Decree 948 / 1995); liquid effluents (Resolution 1594 / 1984); solid wastes (Decree 605 / 1996); garbage (Decree 1543 / 1984), brashes (Resolution 541 / 1994) and dangerous waste (Resolution 2309 / 1986; Law 430 / 1998). In addition to the legal framework, there are voluntary measures in place e.g. Program of Clean Production (Industrial Area of Mamonal, Cartagena, Bolívar; Industrial Area of Barranquilla, Atlántico), and an Environmental Guide for Shrimp Farms (MMA *et al*., 2002). Penalties for violating the environmental regulations are specified by Ordinance 901 / 1997 and the Resolution 273 / 1997.

3.3 Zoning plans

There are various specific action plans that include: (1) zoning of the mangrove areas; (2) planning for conservation and sustainable use; (3) protected areas; (4) investigation; (5) civic participation in education, conservation and training; (6) restoration and reestablishment of altered areas and degraded mangroves; (8) bring up to date the application of norms for mangroves, (9) an information system for mangroves, (10) international promotion; (11) pursuit of national actions (MMA, 2002).

Box 2: Zonation of mangroves in Colombia

Zone of Preservation (ZP)

Defined for their importance, given the high value and meaning of the resources, especially components of swamps that vary in different situations for the execution of objectives. These objectives can be either guaranteeing a balance inside the ecosystem, or maintaining the vital importance for the function that they carry out: coastal protection, fishing productivity, erosion control, special habitat for fauna, maintaining special ecological processes, genetic diversity, the establishment of reservations for scientific investigation, education and preservation of species and communities. Considering the above-mentioned objectives these areas won't support use of vegetation resources but can contemplate possibly with restrictions fishing or collection of other resources and hydrobiology. Elements considered integrally: (1) structural indexes high and/or (2) intervention on the resources, and/or (3) conflicts of the use of the forest floor, and/or (4) productivity half and/or high.

Zone of Production (ZPr)

Areas for their structure and composition, as well as for their density and quantity of resources and for their high resilience power. It allows developing programs for the sustainable use of the resources, in such a way that can be constituted in a model of sustainable development with application of appropriate technologies, subject to management plans, previous detailed studies and to monitoring and permanent control. These areas can be subject, according to the case, for the use of several vegetable species, or animals, zoobreeding, aquaculture and ecotourist travel, provided the forest stays in a sustainable way. Change in the use of the floor should not be allowed where it is forestry and the use should guarantee they don't deteriorate. Elements considered integrally: (1) indexes structural high and/or (2) Productivity half and/or high.

Zone of Multiple Use (ZMU)

Area also denominated of Integrated management that contemplates integral characteristics for preservation, production and recovery for their aptitude, but that to determine specific uses it is necessary to study it with more detail to define specific subunit's. This area supports the use through the concept of sustainable use, the same as the preservation and the restoration, that is to say its integral management. Elements considered integrally: (1) high structural indexes (2) activities of subsistence. (3) productivity half high and/or (4) fragile ecosystems - coastal protection - protection of fish.

Zone of Special Multiple Use (ZSMU)

Characterized by the multiplicity of traditional activities, or of subsistence ones, and those originating in the development of industrial productive activities. Elements considered integrally: (1) high conflicts of use of the forest floor; (2) subsistence activities for primary necessities; (3) High intervention levels on the resources; (4) high structural indexes of the forest floor.

Zone of Recovery (ZR)

It is characterized by having a significant impact, or a level of deterioration that still allows reversible the destructive processes, or in those that a conflict is presented between the current use and the advisable potential according to the environmental offer and that it is viable to reconcile with the participation of the community for the recovery action. These areas should be totally closed from use and avoid activities that will be detrimental to recovery. Elements considered integrally: (1) indexes structural forest floor (2) high intervention levels on the resources (3) changes of use potential of the floor (4) low productivity (decrease of the economic activities).

Source: Sánchez-Páez & Alvarez-León (1998, 2002)

Table 6. Legislation in Colombia directly related to mangroves

Legislation	Description
Resolution 1602 (December 21 1995) of the Ministry of the Environment. By means of which measures are dictated to guarantee the sustainability of mangroves in Colombia.	Consists of eight articles in which precisions are included on: 1º definitions, 2º prohibitions, 3º persistent forest use, 4º studies and zoning proposals, 5º control and surveillance, 6º pursuit and evaluation, 7º sanctions and 8º validity.
Resolution 020 (January 9 1996) of the Ministry of the Environment. By means of which clears up the Resolution December of 1995, 1602 and other dispositions are dictated.	Consists of six articles in which precisions are included on: 1º addition of three paragraphs to the article 2º of the Resolution 1602 of 1995; 2º modifications to the article 3º of the Resolution 1602 of 1995; 3º full validity for the prohibited ones established or that they establish the Corporations; 4º in everything the rest continues effective the Resolution 1602 of 1995; transitory, obligation of presenting Plan of Environmental Handling, and 5º validity.
Resolution 257 (March 26 1997) of the Ministry of the Environment. By means of which minimum controls settle down to contribute to guarantee the basic conditions of sustainable management of the mangrove ecosystem and their surrounding areas.	Consists of 11 articles in which precisions are included on: 1º establishment of the monitoring system, 2º minimum parameters to monitor, 3º diversity and abundance of the biotic component and indicators of sanitary interest according to the Ordinance 1594 of 1984, 4º summary and analysis of the cartography, air pictures and satellite images, 5º design of the sampling models, selection of stations and analysis of the information (maximum term of 18 months); approval on the part of the previous Ministry of Environment (MMA) approval of the Institute of Marine and Coastal Investigations (INVEMAR), 6º responsibility of the Corporations to carry out the control and the monitoring, 7º the registrations of the gathered information will be a correspondent to the ME and the INVEMAR that will conform together with the IDEAM and they will manage the corresponding database, 8º the INVEMAR will be the one in charge of alerting on the environmental anomalies detected in the data and of suggesting the correctives, 9º the Corporations will maintain informed to the inhabitants of the swamp areas on the results of the monitoring and the restoration activities and they will celebrate an annual forum on mangroves with the convocation of the MMA and the INVEMAR, in the Area of Santa Marta's Big marsh, 10º the MMA will support to the Corporations for the prevention, control and handling of different situations related with the good state of the swamps and their influence areas, and 11º validity.
Resolution 924 (October 16 1997) of the Ministry of the Environment. By means of which reference terms settle down for studies on the current state and proposals of zoning of the mangrove areas in Colombia.	Consists of four articles in which precisions are included on: 1º the Corporations in whose jurisdiction is mangroves will present to ME the studies on the current state and the proposals of zoning of the mangrove areas in its jurisdiction (maximum term of 18 months), according to the reference terms included in the Resolution, 2º the annexes are guides to keep in mind, when developing the reference terms fixed in the Resolution, 3º the official communication to the Corporations is in charge of the artificial office of the MMA, and 4º publication and popularisation. The three annexes that make an integral part of the Resolution, are: 1º Methodological Manual for Forest Studies, 2º Methodological Manual for Social and Economic Studies 3º Methodological Manual of Some Elements of Help for the Writing of the Diagnosis, Determination of Units of Handling and the Strategic Planning.

Table 6. Continue

Resolution 233 (March 29 1999) of the Ministry of the Environment. By means of which modifies the Resolution 924 of October 16 1997 and the term is continued foreseen in article 4º of the Resolution 1602 of December 21 1995.	Consists of seven articles in which precisions are included on: 1º partial modification to the Resolution 924 of 1997 as for the term of presentation of the regional diagnoses, 2º modification to the numeral one 2º of the Resolution 924 of 1997 and complementation of the regional diagnoses with the information obtained by the Project Mangroves of Colombia (MMA/ITTO) of the Diagnosis and Preliminary Zoning of the Mangroves of the Caribbean and Pacific, 3º extension of one year at the end of the article 4º of the Resolution 1602 of 1995, counted starting from expiration (April of 1999), 4º official communication to the Corporations, 5º the other parts of the Resolution 924 of 1997 don't modify, 6º appeal resource and 7º popularisation.
Resolution 271 (July 31 2002) of the Ministry of the Environment. For which pronouncement is emitted on the studies and zoning proposals in areas of mangroves presented by the Regional Autonomous Corporations and of Sustainable Development and other determinations are adopted.	Articles 1º and 2º approved the characterization, diagnosis and zoning of the mangroves of the Department of Sucre by CARSUCRE and the Department of San Andres' Archipelago, Providence and Santa Catalina San Andres' Archipelago, Providence and Santa Catalina by CORALINA (with exceptions according to that contemplated in Resolutions 924 of 1997, 233 of 1999 and 694 of 2000). Article 3º and 5º did not approve the study on the characterization, diagnosis and zoning of mangroves in the Department of Magdalena by CORPAMAG, or the study on the characterization, diagnosis and zoning of the mangroves of the Department of Atlántico by CRA. Article 7º, 8º and 9º approved the characterization, diagnosis and zoning of the mangroves of the Department of Córdoba, by CVS, CVC and CARDIQUE. Article 10º requires CARSUCRE, CVS, CVC and CARDIQUE, to elaborate the Management Plans for the entirety of the Areas determined in the Study of Zoning of their jurisdiction or in an independent way for each one of the same ones, approved by the present Resolution, keeping in mind the rules or established guidelines for them. Article 11º The Regional Autonomous Corporations will elaborate the Management Plans for the Areas of Production or of Sustainable Use, in their group, or for each one of them, for that which will keep in mind the rules or guidelines given for the respective Areas approved by the Ministry of the Environment, considering the parameters and orientations, elaborated by this Ministry.

Source: Alvarez-León and Alvarez-Puerto (2016)

3.4 Other actions

Mangrove Reforestation

Since 1998, the mangroves of Colombia Project has actively promoted restoration of degraded mangrove areas, by carrying out restoration activities (see Box 1) with community participation in 13 regional CAR's (Regional Autonom Corporations) and CDS's (Sustainable Development Corporations). (Guevara-Mancera, 1998; Rodríguez-Cruz, 1998; Ulloa-Delgado *et al*., 1998b; Sánchez-Páez *et al*., 2000; Sánchez-Páez & Ulloa-Delgado, 2000). Rehabilitation of degraded mangrove shrimp ponds on the Pacific coast has been limited to natural recovery of red mangrove (*Rhizophora* spp.) and colonisation by the rancocha fern (*Acrostichum aureum*) after the ponds were abandoned.

4. Institutional responsibilities for mangroves

The Ministry of Environment, Housing and Development Territories is responsible for mangroves in Colombia through its Technical Direction of Ecosystems. The Forestry Administration is responsible for the respective Forestry Departments. The forestry service of the ministry, co-ordinates and assists in forestry activities of the various CAR's and CDS's in the Departments of Colombia. Under the Colombian Constitution, Government Departments have jurisdiction over most land matters and land ownership is vested in the Departments. The legislation and executive authority rests with the individual Departments.

All mangroves forest reserves are protected under the administration of the individual Special Administrative Units of the System of Natural National Parks at State level. However, various Regional Corporations and Departments

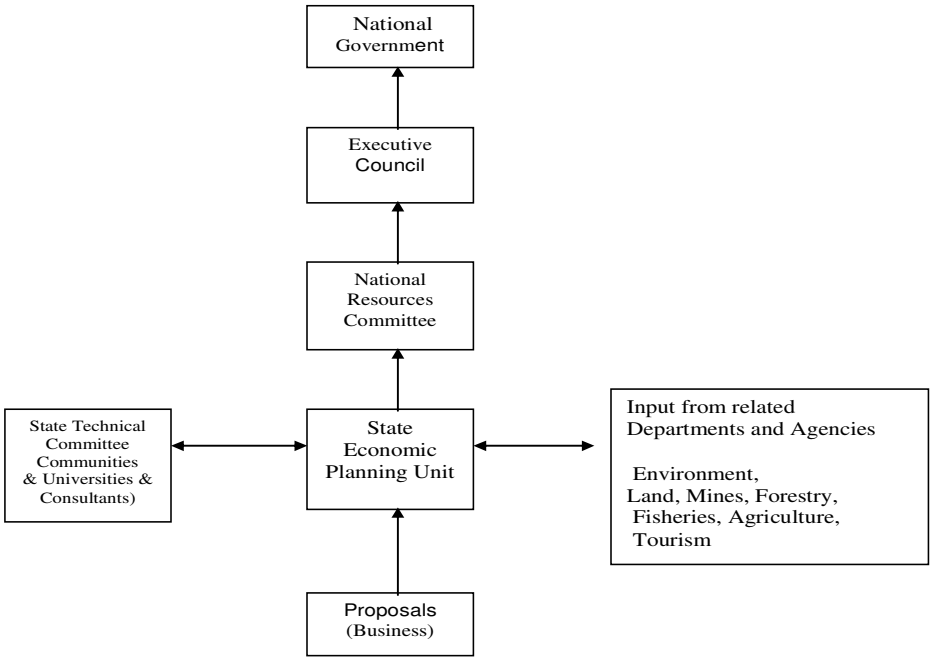

Figure 1. The State Economic Planning Unit.

are involved in management of the coastal resources overall. These government agencies and other statutory bodies have jurisdictions that are relevant to the management of mangrove ecosystems and their resources and/or whose actions directly or indirectly influence, or are influenced, by mangroves.

Other institutions in Colombia that are involved in mangrove conservation activities include Governmental Organisations (GO's), universities and Non-Governmental Organisations (NGO's).

5. Implementation

The procedure for the implementation of development proposals in Colombia is shown in Figure 1. The State Economic Planning Unit discusses business proposals with inputs from universities, consultancy companies and related government departments and agencies. These are then passed through to the Executive Council before final approval by the State Government.

Between September 1995 and July 2000 on the Colombian coast the Project "Conservation and Management for Multiple Use and Development of Mangrove Swamps in Colombia" (PD 171/91) Phases I and II was implemented. This was approved and financed by the Ministry for the Environment (MMA) and the International Tropical Timber Organization (ITTO), in close collaboration with the National Corporation of Investigation and Forest Development (CONIF), the Colombian Reforestation Association (ACOFORE), Regional Autonomous Corporations (CAR's) and Sustainable Development Corporations (CDS's).

During Phase I of the project, a diagnosis of the current status of the mangrove resources, a preliminary zoning of the mangrove forests, mapping and a preliminary description of the socio-economics of the mangrove forest communities was carried out in the 14 coastal Departments of the two coasts (Sánchez-Páez *et al.,* 1997a, 1997b). During Phase II of the project, mangrove dynamics, there were five major areas, growth dynamics and natural regeneration, ecosystem rehabilitation, establishment of temporary nurseries, monitoring of water in the mangrove areas and development of alternative pilot production projects in the 14 coastal Departments of the two coasts (Sánchez-Páez *et al.,* 2000).

Recently, between September 2001 and July 2003, another project was implemented on the Caribbean coast "Management Sustainable of Mangroves for Local Communities of the Caribbean coasts of Colombia" Project (PD 60/01) Phases I and II. This project is supported and financed by the Ministry of Environment (MMA) and the International Tropical Timber Organization (ITTO), in close collaboration with the National Corporation of Investigation and Forest Development (CONIF), Regional Autonom Corporations (CAR's) and Sustainable Development Corporations (CDS's).

6. Co-operation, feedback mechanisms and monitoring

Management of the environment in Colombia is the joint responsibility of the State and local Department level Governments. The State Government has jurisdiction over commerce, trade and industry and is responsible for environmental protection and pollution prevention. The Government also has control over land, water, agriculture, forestry and local governments, and thus retain jurisdiction to protect manage and utilise natural resources. At the same time, both the State and Department levels may exercise concurrent jurisdictions over issues such as the protection of wildlife and national parks, land rehabilitation, fishing and fisheries and agriculture. The distinct division of Constitutional responsibility to the State governments has far reaching implications for the management and use of natural resources and biological diversity, this underpins all efforts to achieve comprehensive and effective management of the environment.

6.1 Co-management and other initiatives

The Mangroves of Colombia Project PD 171/91 Rev. 2 (F) MMA/ITTO in their Phase II (Stages I and II) between 1998 and 1999, is the major, and possibly the only, effort to manage the mangrove ecosystems of Colombia in a multidisciplinary manner. The information collected by the project was disseminated at all levels and was found to be very useful for natural resource administration agencies and for the communities living in mangrove forests or neighbouring areas.

In Colombia there exists (1) a Council of Economic and Social Aspects CONPES that includes all the Ministries and the National Department of Plannig, (2) an association that contains to the Regional Autonomous Corporations and of denominated Sustainable Development ASOCARS and (3) an Environmental National System SINA that gathers the Ministries, Institutes of Investigation and Corporations, of which is Technical Secretary the Ministry of the environment. Political decisions by these three institutions have an important impact on mangroves in the country.

Starting from the approval on the part of the SINA that National Committee of Mangroves is in charge of the Ministry of the Environment, the same as the National Secretary of the Conventions of CITES, CBD and RAMSAR, this Committee has been strengthened and enriched by technical discussions and of national politics, as well as for the treatment of interdisciplinary character of the topics. It has allowed it the unification of condutive approaches to facilitate the operation of the National Program and their so much harmonic development at national level and as international.

6.2 Role of other major stakeholders

6.2.1 Governmental Departments and Agencies

- *Ministry of Environment (MMA)* steers development at state level by co-ordinating and referring views on project proposals to the state Executive Council for decision. (The Ministry of the Environment name and functions have been modified since the Decree 217 (February 17th 2003), the new denomination is Ministry of the Environment, Housing and Territorial Development (MEHDT)).
- *National Institute of Fisheries and Aquaculture (NIFA)* is responsible for sustainable management of fisheries resources, increasing productivity of both capture and culture fisheries. As coastal shrimp farming and fish cage cultures are usually in mangroves the DOF is interested in mangrove management policy and the possible protection of key coastal areas as mangrove nursery sites for fish and shrimp stocks. (The name and functions of this institute have been modified since the Decree 217 (February 17th 2003), the new denomination is Colombian Institute of Rural Development (CIRD)).
- *Technical Direction of Sustainable Development (TDSD)* is responsible for overseeing environmental impact assessments (EIA's) as part of the screening process for development project proposals. The need for EIA's is stipulated by the different laws and regulations. These include conversion of forestland to other uses, resort and recreational development, as well as industrial and infrastructure projects. EIAs are required for aquaculture, agriculture, housing or industrial development projects that involve conversion of mangrove swamps.
- *Technical Direction of Ecosystems (TDE)* has overall responsibility for land allocation and for all state lands and can override other departments' decisions. TDE coordinates the application of land for development by distributing proposals to the other selected departments and then forwarding their comments, together with its own to the State National Resource Committee.
- *Special Administrative Unit of the System of Parks National Natural (SAUSPNN)* conserves and manages wildlife sanctuaries and protects wildlife species in protected areas.
- *National Mangrove Committee (NMC)* is an ad hoc committee set up under the aegis of UNESCO. The NMC produced a set of guidelines on use of the mangrove ecosystem for brackish water aquaculture, and binational and multinational projects.

6.2.2 Local coastal communities

Fishermen and local coastal communities are dependent on the management of mangroves to sustain their livelihoods. Under the MMA / ITTO funded project "Conservation and Management for Multiple Use and

Development of Mangrove Swamps in Colombia" four pilot production projects were developed in the Caribbean for mangrove production harvesting. After being trained in mangrove nursery and rehabilitation activities, local communities submitted proposals for the restoration of mangrove areas and these proposals were technically and financially supported by the project resulting in 40 ha. of *Rhizophora mangle* being planted on degraded lands and alluvial flats in the Canal de Dique, near Cartagena. Similarly, three projects were developed in the Pacific coast, one focused on farming the fish *Mugil curema*, another implemented by the Charcoal and Fuelwood Producers Association of Tumaco involved farming and non-industrialised harvesting of shrimp, and the third involved establishment of food crops by the local communities to provide an alternative for those previously involved in forest logging. The experiences of the pilot production projects are helping to encourage a diversification of activities in mangrove ecosystems which benefits the local communities and gives alternatives to mangrove utilisation.

On the Caribbean coast, the Association of Independent Mangroves of San Antero, a community in Bay Cispatá, operates a concession for the use of the mangrove forests but does so in collaboration with the Regional Autonomous Corporation of the Valley of the Sinú, in order to ensure protection, recovery, restoration and surveillance of the mangroves that its members use.

The Association of Producers for Community Development of the Ciénaga Grande del Bajo Sinu (ASPROCIG) are very concerned over the expansion of the shrimp industry in the estuaries of the lower basin of the Sinu river and are considering various actions to oppose it and have been in contact with FUNDECOL, a community based organisation in Ecuador which is used to dealing with these situations. The communities have developed an important paper, because once they understood the importance of sustainably managing the mangrove ecosystems, they have totally collaborated with all possibilities. The collaboration has included the increased conscience of the community on the advantages of the mangrove ecosystem, the reopening of communication channels through the saltpeter's, propagule sowing and the consulting other communities, people and institutions in the rehabilitation plans.

6.2.3 Private sector interests

The restaurateurs, shops, hotels, tour operators and tourists have an indirect vested interest in biodiversity management of the Caribbean and Pacific mangroves areas of Colombia, as their income is solely dependent on the ecological integrity of the site.

6.2.4 NGO's

The NGO's aim to document Colombia's natural heritage and disseminate this information. NGO's also work to promote sustainable use of wetland resources. Projects have been conducted to date in Colombia including biodiversity surveys, wetland inventory, assessment and monitoring, training programmes, education and public awareness activities and community development work. Several NGO's collaborate in different educational aspects with the departmental governments for the major conservation from the swamp ecosystems to regional level.

Wetlands International-Colombia Office was formed in 2000 and maintains an overview of the wetland situation throughout the country. The Colombia Programme was also instrumental in the country's accession to the RAMSAR Convention in 1994, hence the designation of Ciénaga Grande de Santa Marta as the first RAMSAR site for Colombia. Technical, Project and Information Services are also provided to both commercial and non-commercial organizations to facilitate wetland conservation activities, and to ensure the implementation of environmentally sound activities in wetland areas.

6.2.5 International agencies and research institutions

International sponsor (UNESCO, OEA, FAO, PNUMA, CPPS, CIFCA, ALICMAR, GTZ, DAA, COI, IOCARIBE, ITTO) has been channelled through COLCIENCIAS (Colombian Institute for the Development of Science and Technology "Francisco José de Caldas").

International Tropical Timber Organization (ITTO). Some individual associated scientific staff have considerable expertise in species identification, ecology and sustainable use of mangroves. ITTO promotes sustainable management and optimal utilization of forest resources through technology, research, development and application. IITO previously played a very active role in the field of mangrove forestry research with many programmes, but these activities have now reduced.

7. Achievements, constraints and recommendations

Achievements

The Colombian mangrove forests have legislation to protect and to sustainably manage their resources. There has also been recent reforestation of degraded and altered areas. The recent evaluation studies and the specific legislation that it has been promulgated, have allowed to create the necessary conscience so that the mangrove ecosystem is kept in mind in the actions of planning and sustainable development of the Municipalities and coastal Departments of Colombia. The National Program for the

Sustainable Use, Management and Conservation of Mangrove Ecosystems has been involved in the recent instruments of municipal, departmental and regional organization (Plans of Territorial Classification) and the local communities, they are using the participation mechanisms foreseen in the National Constitution of 1991, regarding the looking of the infrastructure works that impact the mangrove and swamp areas in some form.

Other activities like the formulation and execution of alternative projects of the use of the resources associated to the mangrove have contributed to diminish the pressure on the mangrove ecosystems, providing rich food in proteins (aquaculture, organic agriculture, mangrove nurseries), work (manpower to reasonable price) and enough economic revenues for the local communities.

Constraints

For Colombian mangrove forests to sustain biodiversity and productivity, there needs to be a strong economic reason for their survival. Mangrove forests on state land are potentially at risk from other development objectives, but even reserve forest is not entirely protected from development threats.

RECOMMENDATIONS

The Colombian Government has a genuine interest in maintaining the natural environment and scientific patrimony and as such society should be allowed to continue to do so. The Ministry of the Environment, Housing and Development Territorial is acting as the responsible agency in looking after the mangrove ecosystem that is closely related to the fishing industry, shrimp culture and oyster culture. Regional Department Governments should seriously consider conserving all remaining mangrove areas in the state for the long-term sustainability of the mangrove ecosystem.

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http://www.dane.gov.co
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Special Administrative Unit of the System of Natural National Parks
http://www.parquesnacionales.gov.co
Ministry of the Environmental, Housing and Territorial Development
http://www.medioambiente.gov.co

Glossary

ACOFORE	Colombian Association of Reforesting
ALICMAR	Latin American Association of Aquaculture
CAR's	Regional Autonomous Corporations
CARDIQUE	Regional Autonomous Corporation of the Channel of the Dique
CARSUCRE	Regional Autonomous Corporation of the Sucre
CBD	Convention on Biological Diversity
COI	Commission Oceanography Intergovernmental
CDS's	Sustainable Development Corporations
CONIF	National Corporation of Investigation and Forest Development
COLCIENCIAS	Colombian Institute for the Development of Science and Technology "Francisco José de Caldas"
CORALINA	Corporation for the Sustainable Development of San Andres' Archipelago, Providence and Santa Catalina
CORPAMAG	Regional Autonomous Corporation of Magdalena
CITES	Convention on International Trade of Endangered Species
CPPS	Permanent Commission of the South Pacific
CRA	Regional Autonomous Corporation of the Atlantic
CVC	Regional Autonomous Corporation of Valley of the Cauca
CVS	Regional Autonomous Corporation of the Valleys of the Sinú and San Jorge
DNP	National Department of Planing
FAO	Food and Agricultural Organization
GTZ	Deutsche Geselischaft fur Technische Zusammearbeit
IGAC	Geographic Institute "Agustín Codazzi"
IIBAvH	Institute of Biological Investigations "Alexander von Humboldt"
INDERENA	National Institute of the Renewable Natural Resources and the Environmental
INPA	Fisheries and Aquaculture Institute of Colombia
INVEMAR	Institute of Marine and Coastal Investigations "José Benito Vives D'Andreis"
IOCARIBE	Association of the COI for the Caribbean
ISME	International Society for Mangrove Ecosystems
ITTO	International Tropical Timber Organization
MMA	Ministry of Environment
OEA	American States Organization
PNUMA	Program of the United Nations for the Environment
RAMSAR	Convention on Wetlands
UASPNN	Special Administrative Unit of the System of Natural National Parks
UNESCO	Union Nations Educational, Scientific and Cultural Organization