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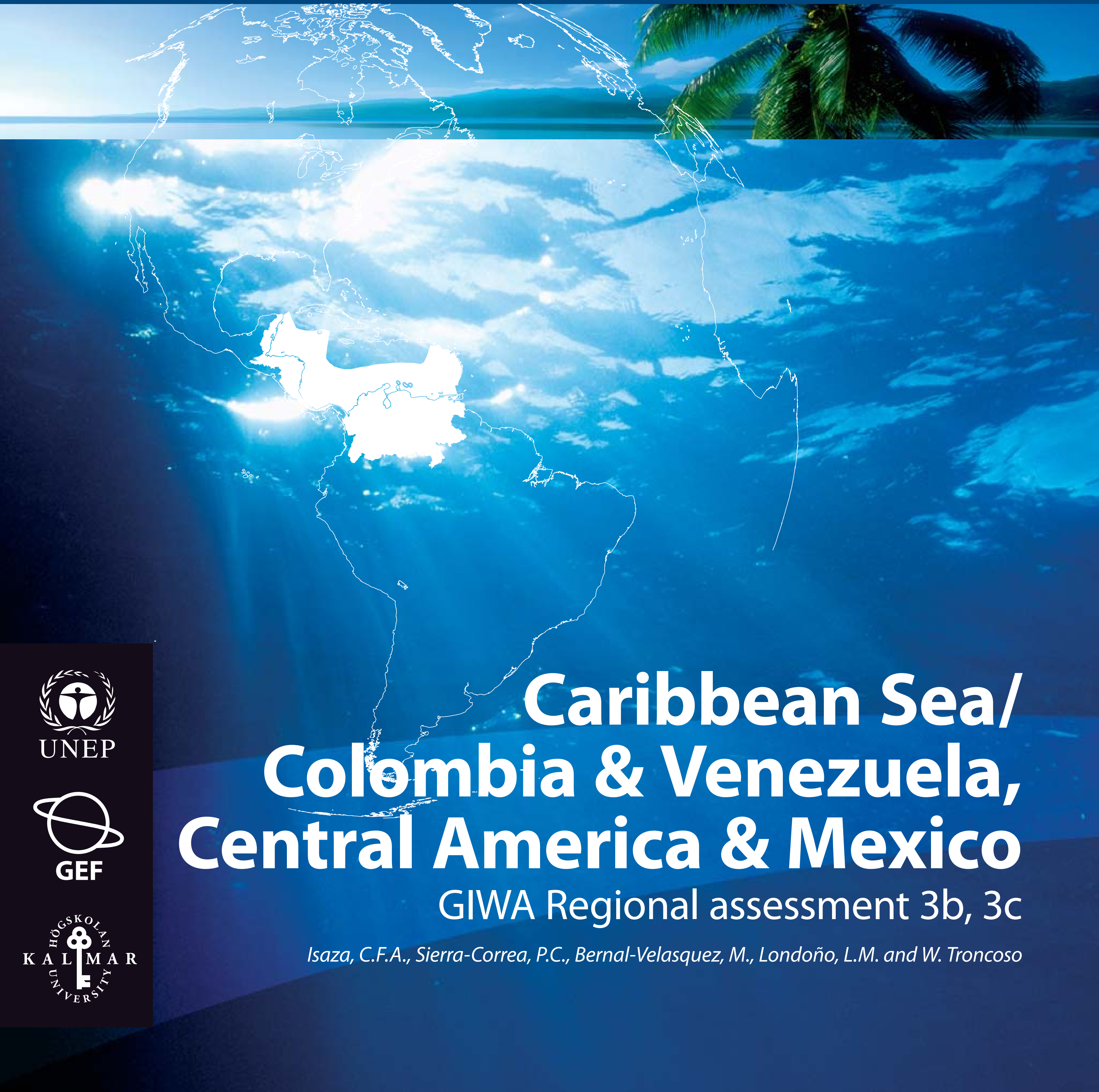

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Caribbean Sea/ Colombia & Venezuela, Central America & Mexico

GIWA Regional assessment 3b, 3c

Isaza, C.F.A., Sierra-Correa, P.C., Bernal-Velasquez, M., Londoño, L.M. and W. Troncoso

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Global International Waters Assessment

Regional assessment 3b, 3c
Caribbean Sea/Colombia & Venezuela, Caribbean Sea/Central America & Mexico

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Executive summary

Regional Definition

The GIWA Caribbean Sea region is part of the Wider Caribbean and includes all or parts of 28 island and mainland states – Antigua & Barbuda, Anguilla, Aruba, Belize, Bonaire, Barbados, British Virgin Islands, Cayman Islands, Costa Rica, Curaçao, Colombia, Dominica, Grenada, Guatemala, Guadeloupe, Honduras, Martinique, Mexico (Quintana Roo state), Montserrat, Nicaragua, Panama, Saint Vincent & the Grenadines, Saint Kitts & Nevis, Saint Lucia, Trinidad & Tobago, Turks & Caicos, United States Virgin Islands and Venezuela. For the GIWA assessment, the region was divided into three sub-systems: the Small Islands (3a); Colombia & Venezuela (3b); and Central America & Mexico (3c). This report presents the results of the assessment of sub-systems 3b and 3c.

The Caribbean Sea is a semi-enclosed ocean basin bounded by the Lesser Antilles to the east and southeast, the Greater Antilles (Cuba, Hispaniola and Puerto Rico) to the north, and by Central America & Mexico to the west and southwest. Water flows from the Atlantic Ocean into the Caribbean Sea mostly through the Grenada, Saint Vincent, and Saint Lucia passages in the southeast, continuing westward as the Caribbean Current – the main surface water circulation in the Caribbean Sea – then out into the Gulf of Mexico via the Yucatan Channel between Mexico and Cuba.

The principal river discharge to the Caribbean Sea is from the Magdalena River, which drains an extensive basin between the Eastern and Central Cordilleras. While the Magdalena River Basin is entirely within Colombia, its river outflow affects a wide sweep of southern Caribbean coastal waters. The Orinoco River, a major river whose basin is shared between Colombia and Venezuela, was also included in this assessment. Although it discharges mainly to the Atlantic Ocean from a delta at the very margin of the Caribbean Sea region, its outflow has a significant impact on southern Caribbean coastal waters because of the prevailing ocean currents. The rivers discharging to the Caribbean Sea from the Central America & Mexico sub-system are small by comparison, though some of them, such as the San Juan River at the borders of Nicaragua and Costa Rica, are transboundary systems.

The Colombia & Venezuela (3b) and Central America & Mexico (3c) sub-systems are characterized by a wide variety of terrestrial and marine ecosystems with rich biodiversity. In the Colombia & Venezuela sub-system, most of the marine ecosystems of the tropical Western Atlantic are represented, including coral reefs, seagrass beds and mangroves. The Central America & Mexico sub-system has the second largest coral barrier reef in the world, extending along Belize's coast, as well as coastal wetlands subject to regional conservation initiatives. Its terrestrial biodiversity represents the confluence of flora and fauna from two biogeographical regions, the Nearctic of North America and the Neotropical of South and Central America, including the Caribbean.

Of the two sub-systems assessed, Colombia & Venezuela has the higher population (60.4 million), with 62% of this in Colombia. The urban population index is the highest in the Caribbean Sea region, with 75% and 87% living in urban areas in Colombia and Venezuela respectively. The inhabitants of Colombia are classified as having medium-low incomes and those of Venezuela, medium-high incomes. The total population of the Central America & Mexico sub-system is about 9.9 million inhabitants, of which 53% are from Honduras, 17% from Guatemala, 14% from Nicaragua, 5% from Quintana Roo (Mexico), 4% from Costa Rica, 4% from Panama and 1% from Belize. Except for Costa Rica, the infant mortality rates of the countries of the Central America & Mexico sub-system are higher than the rest of the region with an average rate of 33 per 1000 live births. The sub-system had an average *per capita* income of approximately 2 600 USD (current value) in 2001.

The regional environmental legislative regime comprises different international conventions that are related to marine and coastal resources management. The United Nations Environment Programme (UNEP) has played a leading role in the establishment of a number of conventions, action plans and protocols including the Caribbean Action Plan and the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region – the Cartagena Convention – and its protocols.

Assessment and Causal chain analysis of the Colombia & Venezuela sub-system (3b)

In the Colombia & Venezuela sub-system, freshwater shortage has *slight* impacts, although the pollution of existing supplies is having *severe* impacts. The environmental impacts of pollution are considered to be *moderate*, with oil spills and suspended solids assessed as the severest issues. Pollution is adversely affecting the health of the sub-system's population and has increased the costs of water treatment. The environmental impacts of habitat and community modification are *severe* and the economic impacts are *moderate*, particularly as they affect the fishing industry. The unsustainable exploitation of fish and other living resources has *moderate* environmental impacts, with the severest issues being overexploitation, destructive fishing practices and the impact on genetic and biological diversity, particularly in Colombia. The reduction in catches has impacted the fishing industry and affected health due to a reduction in food security. Global changes have caused changes in the hydrological cycle and ocean circulation resulting in *moderate* impacts. The climate change induced socio-economic impacts were assessed as *severe*. In future the impacts of freshwater shortage, pollution and the unsustainable exploitation of fish and other living resources are expected to diminish in severity due to the implementation of measures aimed at mitigating these concerns. However, the impacts of habitat modification and global change are expected to increase in severity.

In the Colombia & Venezuela sub-system, habitat and community modification was identified as the priority concern. The Causal chain analysis focused on the Magdalena River Basin because of its concentration of human activities which are resulting in severe ecosystem degradation. The immediate causes of habitat modification are the large quantities of sediment and chemicals in the river's discharge; attributed mainly to the mining and agricultural sectors. Agro-chemicals used in crop production are used inappropriately and enter aquatic systems via runoff or leaching into groundwater. Mining activities have degraded forest, soil and water resources; commonly, the practices employed are non-compliant with environmental guidelines and highly destructive, and have adversely affected the environmental quality of aquatic habitats. Petroleum activities in the upstream areas of the basin are altering habitats by consuming large quantities of water and releasing pollutants, discharged by petroleum-water separating stations, as well as occasional spills and leakages from oil pipelines. Organic material in domestic and industrial wastewater degrades water quality and consequently the health of aquatic ecosystems.

The root causes of habitat and community modification in the Magdalena River Basin included:

- **Demographic:** Approximately 80% of the population of Colombia and the majority of its economic activities are concentrated in the Magdalena River Basin which is, therefore, subjected to a concentration of pollution.
- **Governance:** In general, there is an absence of an integrated development strategy and planning is sectorial. The planning process incorporates neither environmental impact assessments nor mitigation measures. The monitoring capacity of the institutions responsible for environmental management in the basin is inadequate as there is a lack of professional expertise and financial resources.
- **Economic:** Poverty has forced the inhabitants of the region to employ unsustainable practices to exploit natural resources for their short-term survival, using shorter crop-rotation cycles, clearing forests for agriculture and pastures, and overgrazing livestock. Farmers were encouraged to apply agro-chemicals in order to increase productivity. The high price for illegal crops encourages further deforestation to create more cultivated areas. There are insufficient financial and technological resources to develop adequate treatment systems or to use cleaner technologies.
- **Knowledge:** There are a lack of studies evaluating the efficiency and environmental impacts of current practices. There is a dearth of environmental information about the Magdalena River Basin and the Colombian Caribbean coast.

Assessment and Causal chain analysis of the Central America & Mexico sub-system (3c)

The assessment of the Central America & Mexico sub-system showed that freshwater shortage has *moderate* impacts, with the modification of stream flow and the pollution of existing supplies assessed as the most severe issues. The environmental impacts of pollution are *severe*, and chemical pollution was identified as having the greatest impact. Most economic sectors are severely impacted by the pollution concern. The environmental and economic impacts of habitat modification are *severe*, while the health impacts are *slight*. The unsustainable exploitation of fish and other living resources has a *moderate* environmental impact, due mainly to overexploitation and the use of destructive fishing practices. The principal global change issues were changes in the hydrological cycle and ocean circulation, and sea-level rise, which inflict *slight* to *moderate* impacts. The socio-economic impacts are *moderate* to *severe*, taking into account the consequences of natural phenomena such as El Niño. In future, habitat modification may become less severe, but the severity of the other concerns is likely to increase.

The immediate causes of habitat and community modification in the Central America & Mexico sub-system were identified as deforestation and increased erosion. Inappropriate agricultural practices have increased erosion and reduced the productivity of soils. The expansion of agriculture has required the deforestation of large areas of land, resulting in habitat loss and fragmentation. Some habitat modification, for example, from illegal clearance and slash and burn agriculture, can be controlled through more stringent regulations and by strengthening the institutions responsible for environmental management.

The root causes of habitat and community modification in the Central America & Mexico sub-system included:

- **Demographic:** With population growth, the demand for land escalates and environmental degradation intensifies as urban and agricultural areas expand. Land tenancy conflicts have been provoked mainly in zones of collective land use. The institutions responsible for land tenure have insufficient capacity to resolve these conflicts.
- **Governance:** There is a lack of regional policies which promote the development of river basin, coastal and marine planning and management. Surface water management plans at national or regional levels are inadequate. A lack of democratic participation mechanisms has hindered cooperation between governments and the community in the conservation of habitats. Economic and political interests often take precedence over social and environmental improvements. The institutions responsible for environmental management have insufficient financial and technical resources. Commercial fish stocks have declined due to illegal fishing, the weak enforcement of fisheries regulations and the lack of transboundary fisheries management.
- **Legal:** Regulations on the use of pesticides and fertilizers are very weak or non-existent. The main deficiency in water law concerns coastal and marine regulations.

- **Knowledge:** Decision-making processes are hampered by limited information on environmental and economic characteristics (including aquatic ecosystem values), and environmental degradation trends, of river basins and aquifers. There are insufficient research initiatives regarding sustainable technologies and few environmental education programmes.

Policy options

Feasible policy options were identified that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment.

Recommended policy options for the Colombia & Venezuela sub-system (3b):

- Integrated River Basin and Coastal Area Management (policy option 1)
- Strengthen the scientific capacity of the sub-system (policy option 2)

Recommended policy options for the Central America and Mexico sub-system (3c):

- Institutional strengthening (policy option 3)
- Promote sustainable production (policy option 4)

Abbreviations and acronyms

BOD	Biochemical Oxygen Demand
CATHALAC	Centro del Agua del Trópico Humedo para America Latina y el Caribe (Water Center for the Humid Tropics of Latin America and the Caribbean; Panama)
CCA	Causal Chain Analysis
CIA	Central Intelligence Agency
CIRA/UNAN	Centro de investigación para los recursos acuáticos, Universidad nacional autónoma de Nicaragua
CONPES	The National Council of Economic and Social Policy
DDT	Dichlorodiphenyltrichloroethane
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscilation
GDP	Gross Domestic Product
GEF	Global Envionment Facility
GIWA	Global International Waters Assessment
GNI	Gross National Income
HCB	Hexachlorobenzene
IMO	International Maritime Organization
INEGI	Instituto Nacional de Estadística Geografía e Informática
IPCC	Intergovernmental Panel on Climate Change
IUCN	The World Conservation Union
LME	Large Marine Ecosystem
NOAA	National Oceanic & Atmospheric Administration
PCA	Panama Canal Authority
PNUD	Programa de las Naciones Unidas para el Desarrollo (UNDP)
POA	Policy Option Analysis
RAMSAR	The Ramsar Convention on Wetlands
SIMAC	Sistema de Monitoreo de Arrecifes Coralinos de Colombia
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
USD	US Dollar
WWF	World Wildlife Fund

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Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA Assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Caribbean Sea region

GIWA Caribbean Sea region is part of the Wider Caribbean and includes all or parts of 28 island and mainland states, Antigua & Barbuda, Anguilla, Aruba, Belize, Bonaire, Barbados, British Virgin Islands, Cayman Islands, Costa Rica, Curaçao, Colombia, Dominica, Grenada, Guatemala, Guad-

Figure 1 Boundaries of the Caribbean Sea region.

eloupe, Honduras, Martinique, Mexico (Quintana Roo state), Montserrat, Nicaragua, Panama, Saint Vincent & the Grenadines, Saint Kitts & Nevis, Saint Lucia, Trinidad & Tobago, Turks & Caicos, United States Virgin Islands and Venezuela (Figure 1). The GIWA Caribbean Sea regional borders are based on the limits of the Caribbean Sea Large Marine Ecosystem (LME) with some exceptions. This LME is divided into GIWA Caribbean Sea (Region 3) and Caribbean Islands (Region 4), with the border delineated by the 200–nautical mile Exclusive Economic Zone (EEZ) of the countries in the Caribbean Islands region (Bahamas, Cuba, Dominican Republic, Haiti, Jamaica and Puerto Rico).

The sheer number of countries and their diverse socio-economic and ecological characteristics led to the division of the Caribbean Sea region into three sub-systems: Sub-system 3a, the Small Islands; Sub-system 3b, Colombia & Venezuela; and Sub-system 3c, Central America & Mexico (Quintana Roo state) (Figure 1).

- Sub-system 3a includes Antigua & Barbuda, Anguilla, Aruba, Barbados, Bonaire, British Virgin Islands, Cayman Islands, Curaçao, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines, Trinidad & Tobago, Turks & Caicos, and United States Virgin Islands.
- Sub-system 3b comprises parts of Colombia & Venezuela.
- Sub-system 3c includes Belize, Mexico (Quintana Roo State) and parts of Costa Rica, Guatemala, Honduras, Nicaragua and Panama.

This report assesses the transboundary issues of the sub-systems 3b and 3c.

Physical characteristics

The Caribbean Sea

The Caribbean Sea is a semi-enclosed ocean basin bounded by the Lesser Antilles to the east and southeast, the Greater Antilles (Cuba, Hispaniola, and Puerto Rico) to the north, and by Central America to the west and southwest. It is located within the tropics and covers 1 943 000 km^2. The Wider Caribbean, which includes the Gulf of Mexico, the Caribbean Sea and adjacent parts of the Atlantic Ocean encompasses an area of 2 515 900 km^2 (Bjorn 1997, Sheppard 2000, IUCN 2003).

The Caribbean Sea region was formed during the Jurassic period. With the division of the mega-continent Pangaea 180 million years ago, came the separation of the lands that would become North and South America. As well as the subduction of the Cocos and Nazca plates, the continuous collision of continental plates produced continental and submarine mountain ranges including the rise of Central America, which formed a biogeographical bridge, allowing the migration of floral and faunal species between North and South America – an important factor in the high biodiversity in the region (Windevoxhel 2003).

The Caribbean Sea averages 2 200 m, with the deepest part, known as the Cayman trench, plunging to 7 100 m. The drainage basin of the Wider Caribbean covers 7.5 million km^2 and encompasses eight major river systems, from the Mississippi to the Orinoco (Hinrichsen 1998).

The Caribbean Current transports water northwestwards through the Caribbean Sea and into the Gulf of Mexico, via the Yucatan Channel (Figure 2). The source of the Caribbean Current is the equatorial Atlantic Ocean via the North Equatorial, North Brazil, and Guyana currents.

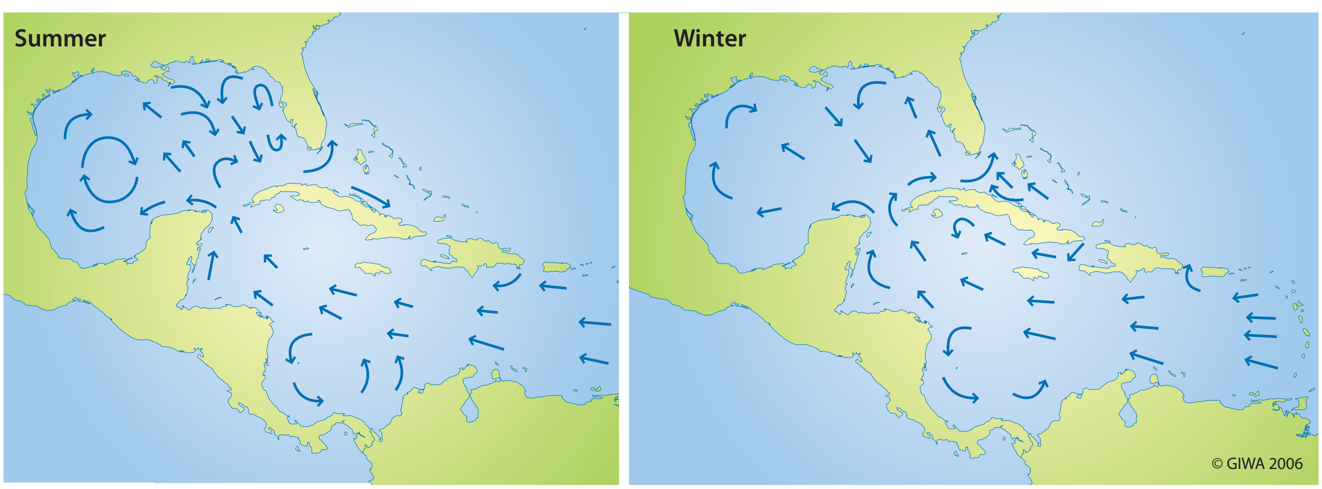


Figure 2 Superficial water circulation of the Caribbean Sea during summer (A) and winter (B).
(Source: NIMA 2000)

Water flows into the Caribbean Sea mostly through the Grenada, Saint Vincent, and Saint Lucia passages in the southeast continuing westward as the Caribbean Current – the main surface circulation in the Caribbean Sea (Wust 1964, Gordon 1967, Roemich 1981, Hernandez-Guerra & Joyce 2000, in Gyory et al. 2004).

The strongest flow in the Caribbean Sea is found in the southern third of the Sea and belongs to the Caribbean Current (Gordon 1967, Kinder 1983, in Gyory et al. 2004). In this area, surface velocities can reach 0.7 m/s along the coasts of Venezuela and the Netherlands Antilles (Fratantoni 2001 in Gyory et al. 2004). There are also strong (0.6 m/s) currents along the Panama and Colombian coasts, but there is little flow over the Central American Rise, since most of the northwestward flow is channelled to the southwest of Jamaica. The flow turns sharply westward as it crosses the Cayman Basin and enters the Gulf of Mexico as a narrow boundary current, called the Yucatan Current, which hugs the Yucatan Peninsula (Fratantoni 2001 in Gyory et al. 2004). This current flows into the Gulf of Mexico through the Yucatan Channel.

The winds in the Caribbean Sea region generate a circulation cell where deep waters upwell along the north coast of South America and surface waters (enriched by upwelling and by discharges from the Orinoco River) are advected northwards into the region, especially during the rainy season. In agreement with Sheppard (2000), satellite images in the visible spectrum clearly show the meridianal spreading of green water in the eastern Caribbean. Tidal currents are the dominant component of the offshore currents superimposed on the mean circulation. Tides throughout the northeast Caribbean Sea exhibit a complex behaviour. Caribbean waters are well stratified, with water at different depths moving in different directions. The structure and composition of the Caribbean's surface water follows a well-defined seasonal pattern (Sheppard 2000). An estimate of sediment discharge into the Wider Caribbean region is presented in Table 1.

Table 1 Estimations of sediment discharge into the Caribbean Sea.

Region/River	Sediments charge (10^6 t/y)
Rivers that flow into the Gulf of Mexico	121
Rivers form Central America and the Antilles	300
Magdalena River	235
Orinoco River	85
Other rivers from Colombia and Venezuela	50

(Source: PAC-PNUMA, 1994)

In the Caribbean Sea region, mangrove, sea-grasses and coral reefs are closely associated; they exist in a dynamic equilibrium influenced by coastal activities. Three main rock types dominate the coastline; limestone, igneous rock and eolianite or beach rock. In addition there are unconsolidated deposits such as beaches, alluvial fans, alluvial plains and dunes (Sheppard 2000).

Colombia & Venezuela (3b)

In the Colombian and Venezuelan Caribbean most of the marine environments and ecosystems of the tropical Western Atlantic are represented. The principal aquatic ecosystems of the sub-system are coral reefs, sea-grass beds, beaches, rock reefs and cliffs, mangrove and coastal lagoons, and estuaries. Coral reefs are scattered over the Colombian continental platform, forming atolls and wide chasms in the San Andres and Providencia archipelago. Along the continental coast, there are small fringing and patch reefs, but around the Rosario and San Bernardo archipelagoes and around Isla Fuerte there are extensive coral reefs (Diaz et al. 2000, Penchaszadeh et al. 2000).

The Colombian coral reefs have a low density of economically valuable marine species. For example, according to a survey in 2000 and 2001, lobsters (*Panulirus* spp.) are sporadic, and crabs (*Mithrax spinosissimus*) and octopuses (*Octopus spp.*) were only observed in limited abundance at Islas del Rosario. Gastropods (*Strombus gigas*) have a wider distribution, but still with a low density. The most abundant and ecologically important species were sea urchins, principally *Echinometra*, but also *Diadema antillarum*. Reef fishes (*Scaridae, Acanthuridae, Haemulidae*) have shown an increasing trend since 1998 (INVEMAR 2002). Mangrove forests are an essential habitat for important commercial and subsistence fish species such as *Mugil incilis*, *Centropomus undecimalis*, *Callinectes sapidus*, *Macrobrachium sp.*, *Polymesoda solida* (INVEMAR 2003a). The mangrove trees are also used for construction, and forests near to the cities at the Magdalena and Orinoco river mouths are particularly vulnerable to deforestation.

The river basins of Colombia & Venezuela (Magdalena, Orinoco and Catatumbo rivers) have a significant influence on the Caribbean Sea (Fandiño 1996, Steer et al. 1997, Penchaszadeh et al. 2000, Sierra-Correa 2001, INVEMAR 2003a).

The definition of the extent of the Colombian coastal zone depends on the characteristics and particularities of the Coastal Environmental Units (Unidades Ambientales Costeras, UAC) and the Integrated Management Units defined in the National Environmental Policy for the Sustainable Development of Oceanic Spaces and Coastal Zones and Islands of Colombia (Política Nacional Ambiental para el Desarrollo Sostenible de los Espacios Oceánicos y las Zonas Costeras e Insulares de Colombia, PNAOCI).

Central America & Mexico (3c)

The Central American States and Mexico's Quintana Roo state are characterized by diverse environmental features, including low-lying terrain, rocks with high permeability (in Mexico), barrier reefs and coastal wetlands (Gobierno de Quintana Roo 2002).

Their biodiversity represents the confluence of flora and fauna from two biogeographical regions, the Nearctic of North America and the Neotropical of South and Central America, including the Caribbean. The Caribbean lowlands support subtropical wet forests and rain forests. In the south, broad-leaved mountain hardwood forests occupy steep and cloud-shrouded slopes.

Sub-system 3c has the second largest coral barrier reef in the world, extending for 250 km along Belize's coast and covering 22 800 km^2 (Kramer et al. 2000). It also contains Chetumal Bay, one of Central America's largest lagoons, Nicaragua Lake, the Natural Park "la Amistad" and the Panama Canal-Gatun Lake. Due to their biological importance, these ecosystems are subject to regional conservation initiatives – the Biological Mesoamerican Corridor and the Mesoamerican Reef. The natural resources of Costa Rica are protected by one of the more ambitious programmes of conservation in Central America: 13.7% (1997) of the total surface of the country are protected as parks or other natural reserves, as opposed to 7.4% in Nicaragua and 9.9% in Honduras.

In the coastal zone, the vegetation consists of different species of Convolvulaceae, Euphorbiaceae, Fabaceae, Cyperaceae, Asteraceae, Poaceae, and Rubiaceae, as well as some herbs including Caryophllaceae and Scrophulariaceae. There are also many bird species such as *Seiurus noveboracensis, S. aurocopillus, S. motacilla, Stelgidopteryx serripenis* found in Sixaola Basin. Lizards, for example, *Ameiba quadrilineata, Norops humilis* and *Gonatodes albogularis,* are also present (Dávila 2000). There are abundant nematodes, including *Neotonchoides* and *Desmodora*, recorded in Chetumal Bay (Herrera 1997).

Table 2 Population in the Caribbean Sea region.

Countries sub-system 3a	Population
Antigua and Barbuda*	68 490
Barbados*	268 200
Dominica*	71 870
Grenada*	100 400
St. Kitts and Nevis*	45 050
St. Lucia*	156 700
St. Vincent and the Grenadines*	115 900
Trinidad and Tobago*	1 300 000
Virgin Islands (U.S.)*	109 300
Anguilla**	11 567
Aruba*	68 724
British Vigin Islands***	21 000
Cayman Islands****	35 527
Guadeloupe****	431 170
Martinica****	418 454
Monserrat****	7 574
Netherland antilles (Bonaire and Curacao)****	212 226
Turks and Caicos****	18 122
Total	**3 460 274**
Countries sub-system 3b	
Belize	247 100
Costa Rica	396 239
Guatemala	1 699 840
Honduras	5 289 250
Mexico	535 624
Nicaragua	1 359 330
Panama	364 145
Total	**9 891 528**
Countries sub-system 3c	
Colombia	37 208 800
Venezuela, RB	23 188 400
Total	**60 397 200**
Total in the Caribbean Sea region	**73 749 002**

Source of information of population 2001: Landscan. 2003. GIWA - regions

** Source of information of population 2001: The World Bank Group - Data and Statistics.2003. http://www.worldbank.org/data/countrydata/countrydata.html Date search: 27-02-04*

*** Source of information of population 2001:Anguilla Goverment 2002. Persons by Broad Age Groups Censuses 1960,1974,1984, 1992 and 2001. http://www.gov.ai/statistics/census/Demography%20&%20Culture%20tables.htm Date search: 03-03-04*

****Source of information of population 2001: Government of British Virgin Islands. 2002. The Development Planning Unit. http://dpu.gov.vg/AboutOurCountry/People.htm Date search 27-02-04*

***** Source of information of population 2001: CIA - The World Factbook. 2001*

Socio-economic characteristics

The Caribbean Sea region

In 2001, the population of the Caribbean Sea region was around 74 million, 82% in Colombia & Venezuela, 13% in Central America & Mexico, and 5% in the Small Islands. The population in these sub-systems shows different trends of growth. While in Colombia & Venezuela and Central America the average annual growth rate is close to 2% (1996-2002), in the Small Islands it is less than 1% (Data for Aruba, Cayman Islands, Guadeloupe, Martinique, Montserrat, Netherlands Antilles and Turks, and Caycos are not included) (table 2; The World Bank Group 2003, CIA 2001, Landscan 2001, and team work estimations). Taking into account the population growth rate for each country in the Caribbean Sea region, it is expected that the number of inhabitants would be close to 89.2 million in 2020 (data for Aruba, Cayman Islands, Guadeloupe, Martinique, Montserrat, Netherlands and Antilles; Turks and Caicos are not included). Figure 3 shows the population density distribution of the Caribbean Sea region.

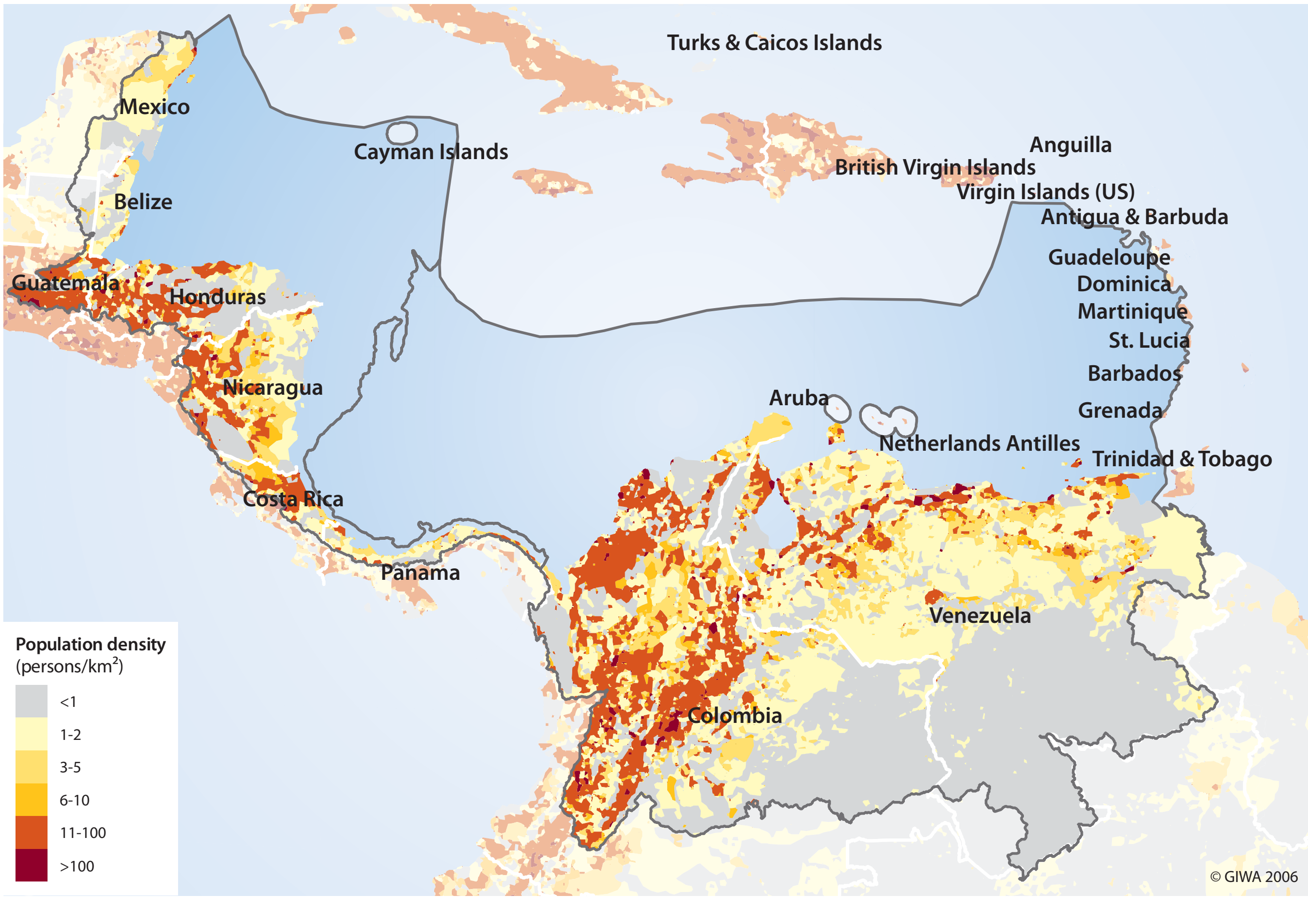


Figure 3 Population density distribution of Caribbean Sea region.
Source: Landscan 2001

Additionally, the population in the Caribbean Sea region swells during the tourist season by the influx of millions of tourists, mostly in beach destinations. Almost all the countries in the region belong to the group of the world's premier tourism destinations, providing an important source of income for their economies.

Colombia & Venezuela (3b)

Of the three sub-systems included in the GIWA Caribbean Sea region, 3b has the highest population with a population of 60.4 million; 62% of these are in Colombia. Between 1996 and 2002 the population of these countries had average annual growth rates of 1.8% (Colombia) and 2% (Venezuela). The population growth rate has begun to decrease. Population densities are low, estimated in 2001 to be 51 and 28 inhabitants per km^2 for Colombia & Venezuela respectively (Figure 3). The urban population index in both countries is the highest in the Caribbean Sea region, with as many as 75% and 87% living in urban areas in Colombia & Venezuela respectively.

The infant mortality rate and the percentage of the population with access to treated water sources are indicators of the sanitary conditions in the region. In the first case, the rate is estimated at 23 and 19 for each 1000 live births in Colombia & Venezuela respectively. In the terms of access to treated water, 91% have access in Colombia and 84% in Venezuela. According to World Bank data (2002), in 2001, annual per capita income (GNI) in Colombia was 890 USD (current value) and in Venezuela 4 760 USD (current value). The inhabitants of Colombia are classified as having medium-low incomes and those of Venezuela, medium-high incomes.

In Colombia & Venezuela, ploughing lands make up 2% and 3%, and lands with permanent crops, 2% and 1%, respectively (For general land cover see Figure 4). The agricultural sector in Colombia has an important export market, principally for coffee, bananas, plantains and flowers; in Venezuela, agriculture has relatively little importance, its major agricultural products including corn, coffee, sugar cane and rice (IICA 2003).

Figure 4 Land cover in the Caribbean Sea region.

In Colombia, the seven most economically important sectors in 2001 were service industries; commerce; agricultural products; financial services; livestock products; and extractive activities for petroleum, natural gas and minerals such as uranium and toro (DANE 2002). Mining activities are the most significant contributor to Venezuela's economy accounting for 22% of GDP in 2000, followed by services (20%) and manufacturing industries (Comunidad Andina 2003).

The size of these economies in terms of GDP for 2001 equates to 82.4 billion USD (current value) for Colombia and 124.9 billion USD (current value) for Venezuela. GDP growth rate between 2001 and 2005, according to estimations by The World Bank (2002), were only 0.7% per year in Venezuela and 2.3% per year for Colombia. The economic structure of the two countries differs, with agriculture contributing a higher proportion of GDP in Colombia, and mining and industry more important in Venezuela. In Colombia, during 2001, the agriculture sector constituted 13% of GDP, industry 30%, manufacturing 16% and the services sector 57%. In Venezuela in 2001, the agriculture sector contributed only 5% to GDP, industry 50.4%, manufacturing 19.8% and services 44.8%. Although these economies are more diversified than those of the countries in sub-system 3a, the Small Islands, they too face the problem of a high dependence on the primary sector for export, particularly petroleum, coffee, fruits, and coal.

The cities that have the highest water consumption are Bogotá, Medellín, Cali, Barranquilla, Pereira, Bucaramanga, Cartagena, Santa Marta, Manizales and Sincelejo.

Central America & Mexico (3c)

The countries of sub-system 3c have a total population of 9.9 million inhabitants, of which 53% are from Honduras, 17% from Guatemala, 14 % from Nicaragua, 5% from Quintana Roo, 4% from Costa Rica, 4% from Panama and 1 % from Belize. The average population growth rate (2.6% per year) is the greatest in the GIWA Caribbean Sea region, with the highest rates in Belize (3.3%), Honduras (3%) and Nicaragua (2.7%). The average population density is 31 inhabitants per km^2, being particularly low in Belize (12 per km^2), Mexico (13 per km^2) and Nicaragua (14 per km^2) (Figure 3). Belize is the smallest country in the sub-system and also has the lowest population density in the whole region, but is currently experiencing high population growth. Approximately 49% of the population lives in urban areas; in Costa Rica, 59%, Nicaragua, 57%, and Panama, 57%. According to INEGI (2003), in the last ten years the population of Quintana Roo, Mexico, has grown by 77%; this population is concentrated in the coastal zone in the north of the State.

Except for Costa Rica, the infant mortality rates of the countries of the sub-system are higher than the rest of the region with an average rate of 33 per 1000 live births. In Costa Rica, the rate is 9 per 1000 live births, while in Guatemala it is 49 and in Nicaragua and Honduras, 36. The average percentage of the population with access to treated water is similar to 3b, estimated at 89%. According to data from The World Bank (2002), per capita income in 2001 was approximately 2 600 USD (current value). There are no available data for Quintana Roo (Mexico) and Nicaragua. Costa Rica and Panama are the richest countries in the region, classified as medium-high income, with 4 040 USD and 3 260 USD per capita income respectively. According to the PNUD (2002), Mexico, Costa Rica, Belize and Panama are ranked in the top 60 countries in terms of human development, whereas Guatemala, Nicaragua and Honduras are in the bottom 100 countries. The ranking is based on indicators (based on official statistics) such as health, life expectancy, technological development and education.

Countries where the agriculture sector contributes most to GDP are Nicaragua (32%), Guatemala (23%) and Honduras (13%). Industry contributes over 20% of GDP in all countries except Panama, where the service sector is dominant (77%). The manufacturing sector is most significant in Costa Rica and Honduras, accounting for 20.8% and 20.3% of GDP respectively. Costa Rica has developed a flourishing sector of eco-tourism.

In 2001, the countries with the largest economies in terms of GDP were Guatemala (20.5 billion USD) and Costa Rica (16.1 billion USD). Belize has the smallest economy (805 million USD), although has the highest per capita income after Costa Rica and Panama. In general, between 1991 and 2001, the countries of 3c experienced good economic growth. Belize, Costa Rica, Guatemala and Nicaragua had an average growth rate higher than 4% during the same period, while the respective growths of Honduras and Panama were 3% and 3.5% respectively.

Legal framework

The regional environmental legislative regime comprises different international conventions that are related to marine and coastal resource management. For the Caribbean region in particular, the United Nations Environment Programme (UNEP) has played a leading role in the establishment of a number of conventions, action plans and protocols. These include:

- The Caribbean Action Plan,
- The Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (the Cartagena Convention), and its protocols.

Other international conventions relating to the Caribbean Sea region include the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCC), the International Convention for the Prevention of Pollution from Ships (MARPOL), the Convention on Wetlands (the Ramsar Convention), and the United Nations Convention on the Law of the Sea (UNCLOS). Figure 5 shows the areas designated as international protected areas in the Caribbean Sea region.

The Caribbean Action Plan

The Caribbean Action Plan emerged as a result of many years of work by governmental and non-governmental representatives of the Caribbean community, assisted primarily by UNEP. The programme objectives embraced by the Caribbean Action Plan, adopted in 1981, include the following (UNEP-CEP 2003):

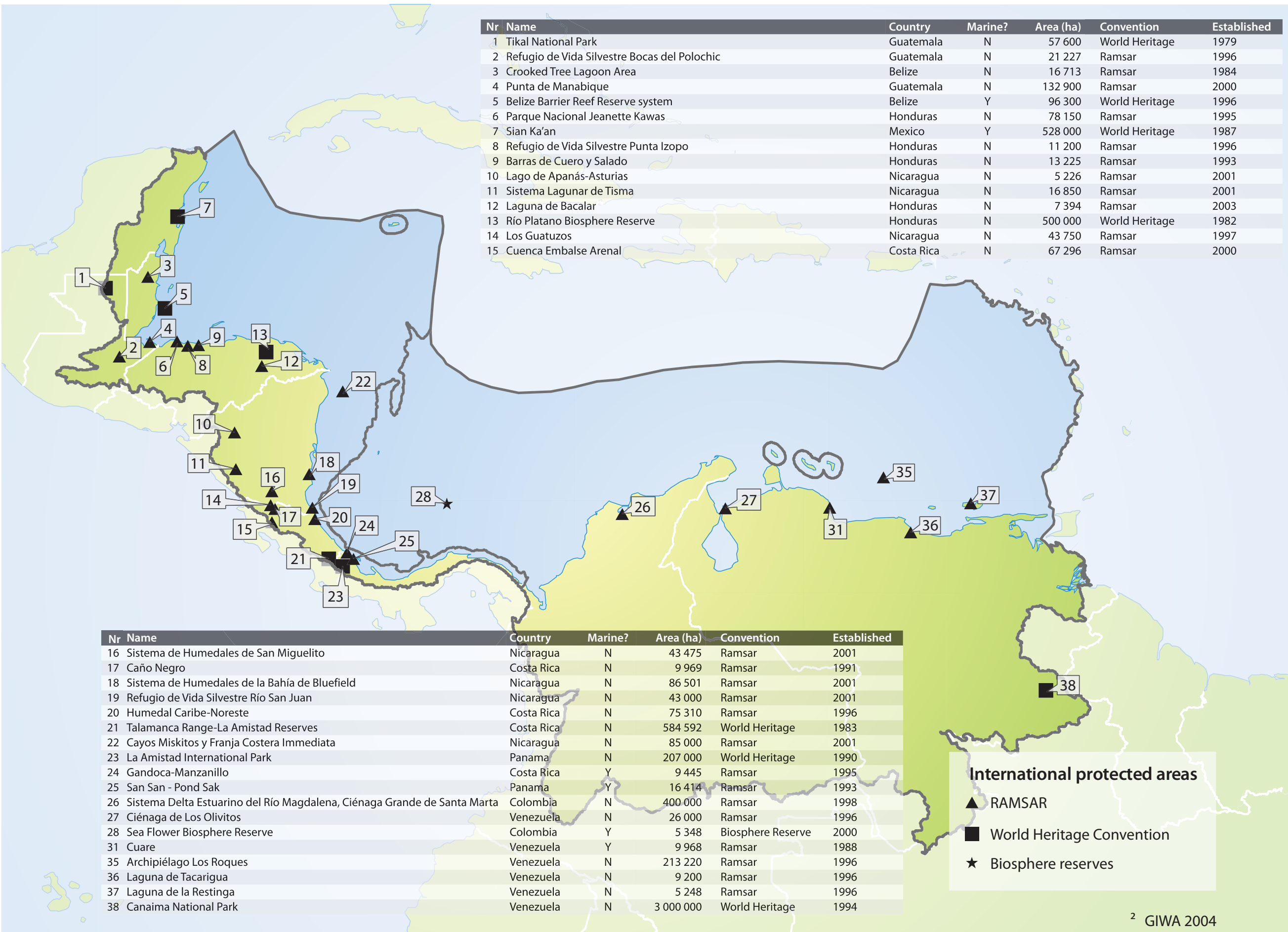
- Assistance to all countries of the region recognising the special situation of the smaller islands;
- Coordination of international assistance activities;
- Strengthening existing national and sub-regional institutions;
- Technical cooperation in the use of the region's human, financial and natural resources.

The Cartagena Convention

The Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention) was adopted in Cartagena, Colombia, in March 1983 and entered into force in October 1986 for the legal implementation of the Action Plan for the Caribbean Environment Programme (UNEP/CEP 1983). The Cartagena Convention has been ratified by 21 United Nations member states in the Wider Caribbean Region and has already carried out 21 Conferences of the Parties (COP). Its area of application comprises the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30° N and within 200 nautical miles of the Atlantic Coasts of the United States.

The legal structure of the Convention is such that it covers the various aspects of marine pollution for which the Contracting Parties must adopt measures. Thus, the Convention requires the adoption of measures aimed at preventing, reducing and controlling pollution of the following areas:

- Pollution from ships;
- Pollution caused by dumping;



Nr	Name	Country	Marine?	Area (ha)	Convention	Established
1	Tikal National Park	Guatemala	N	57 600	World Heritage	1979
2	Refugio de Vida Silvestre Bocas del Polochic	Guatemala	N	21 227	Ramsar	1996
3	Crooked Tree Lagoon Area	Belize	N	16 713	Ramsar	1984
4	Punta de Manabique	Guatemala	N	132 900	Ramsar	2000
5	Belize Barrier Reef Reserve system	Belize	Y	96 300	World Heritage	1996
6	Parque Nacional Jeanette Kawas	Honduras	N	78 150	Ramsar	1995
7	Sian Ka'an	Mexico	Y	528 000	World Heritage	1987
8	Refugio de Vida Silvestre Punta Izopo	Honduras	N	11 200	Ramsar	1996
9	Barras de Cuero y Salado	Honduras	N	13 225	Ramsar	1993
10	Lago de Apanás-Asturias	Nicaragua	N	5 226	Ramsar	2001
11	Sistema Lagunar de Tisma	Nicaragua	N	16 850	Ramsar	2001
12	Laguna de Bacalar	Honduras	N	7 394	Ramsar	2003
13	Río Platano Biosphere Reserve	Honduras	N	500 000	World Heritage	1982
14	Los Guatuzos	Nicaragua	N	43 750	Ramsar	1997
15	Cuenca Embalse Arenal	Costa Rica	N	67 296	Ramsar	2000
16	Sistema de Humedales de San Miguelito	Nicaragua	N	43 475	Ramsar	2001
17	Caño Negro	Costa Rica	N	9 969	Ramsar	1991
18	Sistema de Humedales de la Bahía de Bluefield	Nicaragua	N	86 501	Ramsar	2001
19	Refugio de Vida Silvestre Río San Juan	Nicaragua	N	43 000	Ramsar	2001
20	Humedal Caribe-Noreste	Costa Rica	N	75 310	Ramsar	1996
21	Talamanca Range-La Amistad Reserves	Costa Rica	N	584 592	World Heritage	1983
22	Cayos Miskitos y Franja Costera Immediata	Nicaragua	N	85 000	Ramsar	2001
23	La Amistad International Park	Panama	N	207 000	World Heritage	1990
24	Gandoca-Manzanillo	Costa Rica	Y	9 445	Ramsar	1995
25	San San - Pond Sak	Panama	Y	16 414	Ramsar	1993
26	Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande de Santa Marta	Colombia	N	400 000	Ramsar	1998
27	Ciénaga de Los Olivitos	Venezuela	N	26 000	Ramsar	1996
28	Sea Flower Biosphere Reserve	Colombia	Y	5 348	Biosphere Reserve	2000
31	Cuare	Venezuela	Y	9 968	Ramsar	1988
35	Archipiélago Los Roques	Venezuela	N	213 220	Ramsar	1996
36	Laguna de Tacarigua	Venezuela	N	9 200	Ramsar	1996
37	Laguna de la Restinga	Venezuela	N	5 248	Ramsar	1996
38	Canaima National Park	Venezuela	N	3 000 000	World Heritage	1994

Figure 5 International protected areas.
(Source: UNEP/WCMC 2003)

- Pollution from sea-bed activities;
- Airborne pollution;
- Pollution from land-based sources and activities.

In addition, the countries are required to take appropriate measures to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species and to develop technical and other guidelines for planning and environmental impact assessments of important development projects in order to prevent or reduce harmful impacts (UNEP-CEP 2003).

The Cartagena Convention has been supplemented by three Protocols in respect of Cooperation in Combating Oil Spills, Specially Protected Areas and Wildlife, and Pollution from Land-Based Sources and Activities (Annex III).

The Cartagena Convention is not the only multilateral environmental agreement applicable in the region. However, its regional area of application makes it an important complement to other agreements (UNEP-CEP 2003). Other applicable agreements include the Convention on Biological Diversity, the Convention on Climate Change, MARPOL 73/78, Ramsar, and the Law of the Sea.

The transboundary basins of the Caribbean Sea region

The transboundary basins of the region were defined using the following criteria: (1) rivers that flow through more than one country, with basins shared between countries; (2) basins that affect other countries due to sea currents transporting water discharged by their rivers; and (3) basins affected by other countries in the region. Basins that are shared

Table 3 Transboundary basins in Caribbean Sea region.

Basin	Country/countries
Hondo River (Bahía de Chetumal- Valle de Cotzalco)	Belize, Mexico and Guatemala
Belize River	Belize and Guatemala
Moho River (it flows into Honduras Gulf)	Belize and Guatemala
Temash River (it flows into Honduras Gulf)	Belize and Guatemala
Sarstoon River (it flows into Honduras Gulf)	Belize and Guatemala
San Juan River	Costa Rica and Nicaragua
Sixaola River	Costa Rica and Panamá
Panama canal (Chagras River, Indio River, Burlei Norte River)	Panamá
Magdalena River	Colombia
Orinoco River	Colombia and Venezuela
Catatumbo River	Colombia and Venezuela
Changuinola River	Costa Rica and Panama
Coco River	Honduras and Nicaragua
Motaqua River	Guatemala and Honduras

by two countries, which are part of nature reserves in one country and not in the other, thus causing a transboundary management problem, are also considered. The region's transboundary basins are given in Table 3 and Figure 6.

The basins analysed in this assessment are restricted to those with available information, namely the basins of the Magdalena, Orinoco, Catatumbo, Hondo, Belize, Moho, Temash, Sarstoon, and San Juan rivers, and the Panama Canal. Insufficient information could be found on the Changuinola, Coco and Montaqua basins.

Colombia and Venezuela (3b)

The Magdalena, Orinoco and Catatumbo basins were identified as having transboundary impacts, because they are shared by both countries and/or affect the Caribbean Sea.

Magdalena River

The Magdalena River flows from the eastern and central mountain chains before discharging into the Caribbean Sea (DNP 1995). Water bodies comprise 2.56% of the total catchment area (CORMAGDALENA 2002). The Magdalena and Cauca river systems have the greatest flow and largest extent of any in the Caribbean Sea region. Magdalena is the longest river in the Andes, stretching for 1540 km, and the Cauca, its principal tributary (1015 km). The Magdalena River has more than 500 effluents, not including creeks and small water bodies (CORMAGDALENA & IDEAM 2001). Its source is at the "Macizo Colombiano", a mountain that reaches 3 600 metres above sea level, and it discharges to the sea

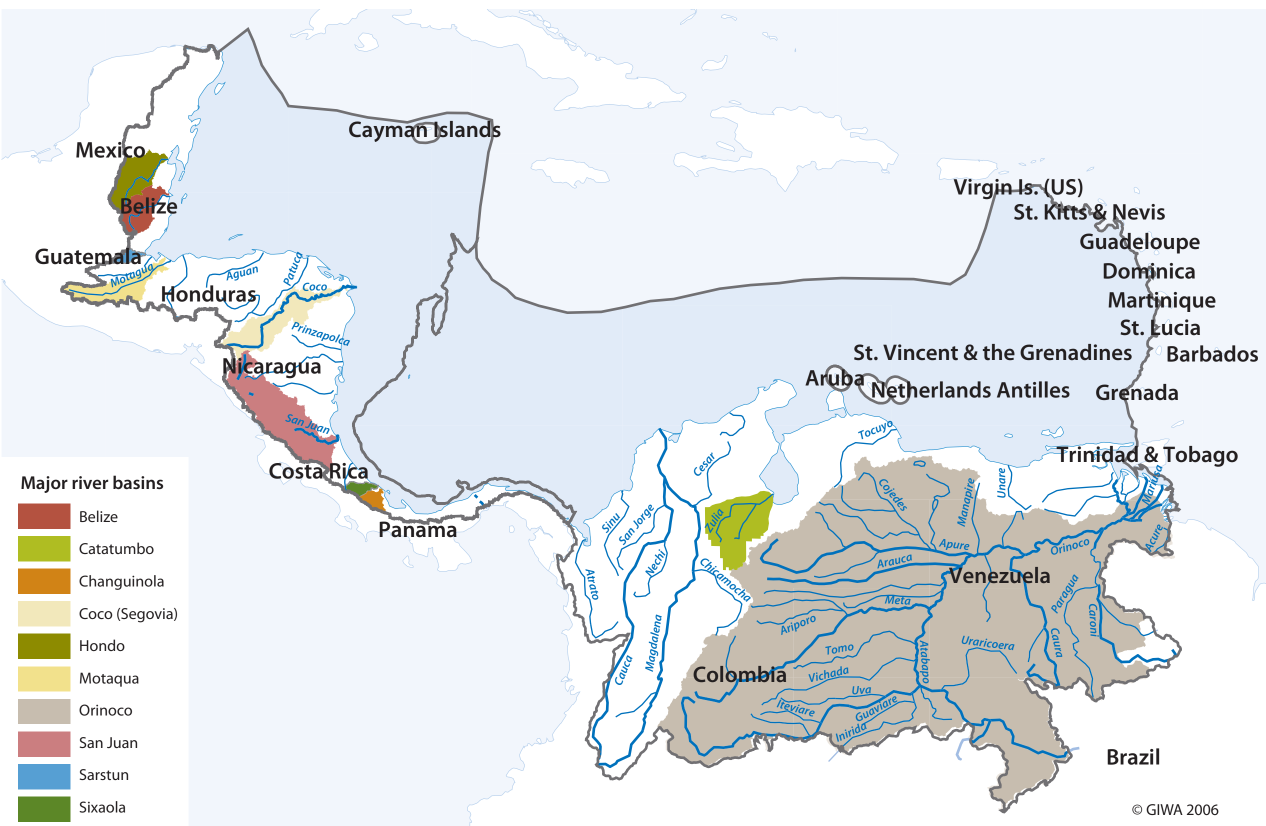


Figure 6 Transboundary river basins of the Caribbean Sea region
(Source: USGS 2001)

through lowland plains and a complex of coastal marshes. The complex is a naturally regulating system, absorbing excess water in the rainy season and releasing it during the dry period (CORMAGDALENA & IDEAM 2001).

Historically, the Magdalena–Cauca River Basin was important for the exploration of the interior of South America and today most of Colombia's economic activities are concentrated in this area (Figure 6). Consequently, the basin has been placed under great ecological, economic, political and social pressures. Approximately 27 million ha of the basin (74% of its area) is affected by agricultural activities, mining operations, human settlements and planted forests. The largest urban settlements in Colombia, including Cali, Medellin, Bogotá, Barranquilla and Cartagena, are all situated within the basin, which is consequently the most densely populated region of the country (CORMAGDALENA 2002).

The economic activities taking place in the Magdalena–Cauca River Basin generate 85% of the country's GDP. It is the location for 90% of the country's industrial production, 75% of agricultural and cattle raising production, 70% of hydroelectric power, 95% of thermoelectric energy, 85% of river transport, 72% of infrastructure for petroleum transport and 80% of forest plantations (CORMAGDALENA 2002).

Orinoco River

The Orinoco River has a catchment area of approximately 1 080 000 km^2 and is mainly considered a white water river. The river measures 2 140 km in length and discharges annually 1.2×10^{12} m^3 of water into the Caribbean Sea (39 000 m^3 per second), constituting the third highest flow in the world (Colmenares 1990, GIPROCOST 2001). Furthermore, the Orinoco River has the world's seventh largest river delta (WWF 1986) (Figure 6). In the south of Venezuela, the Orinoco has many tributaries with vast water resources.

The rainfall patterns in the Orinoco River Basin exhibit a strong seasonal pattern. Precipitation is generally lowest during the initial months of a year, increasing to a maximum around the months of June and July, and decreases rapidly thereafter. Inter-annual variability between 1994 and 1998 was modest, with maximum and minimum deviations from the yearly mean total precipitation of 17% (1997) and 29% (1996), respectively (Corredor and Morell 2001).

The Orinoco River Delta or Amacuro Delta, formed by sediments supplied by the river, extends over an area of 24 553 km^2. Only dense sediment is deposited in the delta, whereas the lighter sediments are suspended in the water column and transported out to sea in what is known as the Orinoco plume (Colmenares 1990, GIPROCOST 2001). The Delta forms an extensive wetland, with a highly dynamic environment controlled by fluvial supply, tides, and wave action. Rich in biological diversity, the Delta is classed as one of eight distinct bio-geographical units within Venezuela, which is one of the world's 17 most biologically rich countries (Bowles et al. 1998 in UNDP 1999), and listed by WWF as a "Global 200" priority ecoregion. Dinerstein et al. (1995 in UNDP 1999) identified three major ecoregions, namely: Orinoco Swamp Forests; Orinoco Flooded Grasslands; and Amazon-Orinoco-Maranháo Mangrove Forests. These categories can be divided further into at least eleven aquatic habitats, including blackwater and whitewater river tributaries, freshwater lakes, seasonal swamps, and various estuarine and marine habitats (UNDP 1999).

The Orinoco Delta lies within Amacuro State, which has a population of 123 000 (0.5% of the national total), including 21 000 Amerindians of Warao ethnicity. The majority reside in a cluster of settlements, with the state capital of Tucupita registering a population of 80 000, leaving the Delta proper with a very low population density. However, with an overall growth rate of 4.1% per year, the population is expected to double within the next two decades. The region has some of the worst social and economic development problems in Venezuela, with 66% of the population living in poverty and 45% of the population living in extreme poverty. Unemployment is 17.3%, higher than the national average, and the UNDP Index of Human Development for the State is 0.62 (the national average is 0.82) (UNDP 1999).

The principal economic activities in the more densely populated western sector of the Orinoco Delta are petroleum and natural gas exploration, extraction activities on a very limited scale, semi-commercial and subsistence agriculture, and employment by the State. The Delta's eastern sector is less populated but supports most of the Warao population (approximately 15 000 persons). Artisanal and subsistence fishing, commercial and subsistence hunting, harvesting of forest products, and semi-commercial agriculture constitute the main land uses. Taro and plantains, both exotic to the region, dominate agricultural production. A growing ecotourism industry is providing a new source of employment (UNDP 1999).

Catatumbo River

The Catatumbo River Basin has an area of 16 200 km^2, 70% of which lies within Colombia and 30% in Venezuela (Wildlife 2003) (Figure 6). In Colombia its principal rivers are the Zulia, Sardinata, Tarra, Táchira, Cucutilla, San Miguel, Presidente, Guarumito and Río de Oro (Colmenare 1990, Meléndez 1999, GIPROCOST 2001).

The Catatumbo moist forests exist as four distinct enclaves within the Catatumbo valley, in both northwestern Venezuela and northeastern Colombia. It is among the richest moist forest in floral diversity in humid tropical areas of Venezuela. These forests flank the lower slopes and lowlands between the Cordillera de Mérida and the Cordillera Oriental of the northern Andes, and occur as several outliers in the vicinity of Lake Maracaibo, at the Caribbean coast (Wildlife 2003).

Some areas in the western and southern part of the region have experienced anthropogenic impacts. Logging, agriculture, and the extension of grazing have impacted the area resulting in secondary vegetation. The only protected area in the region is Catatumbo Bari National Park (IUCN category II), located in the east of Colombia. However, most of the 1 581 km^2 park is located in the Cordillera Oriental mountain forests, and little of the moist forest is protected (Wildlife 2003).

Central America & Mexico (3c)

Hondo River-Bahía de Chetumal- Valle de Cotzalco

The Hondo River is a meandering watercourse that forms the international border between Belize and Mexico (Figure 6) (Microsoft Encarta 2002). It originates in northern Peten (Guatemala), Campeche (Mexico) and the northern Maya Mountains in Belize and debouches into Chetumal Bay. The spatial extent of the Hondo Basin is 13 465 km^2, of which approximately 23% lies within Belize, 22% in Guatemala and 55% in Mexico. The basin is divided into four sub-catchments: Escondido, Hondo River-Mexico, Hondo River-Belize, and Blue Creek.

The basin's relief is very low – more than 70% has a slope less than 5 degrees. The climate is humid and warm with a mean annual temperature of 24-28 °C. The rainy season lasts from June to September and the mean annual rainfall varies between 1000 and 1500 mm. Hondo River has a peak flow of 220 m^3/s during the rainy season and a base flow of 20 m^3/s during the dry season. Waters in the bay are shallow and fisheries resources are limited, with lowland littoral areas consisting of marshland (CONABIO 2003).

Chetumal Bay is a transboundary water body shared between Belize and Mexico (Quintana Roo State) on the southeastern side of the Yucatan Peninsula. It is a hypohaline system, with a surface area of 1 098 km^2 (CONABIO 2003). The bay has a featureless and shallow bathymetry, with depths in the range 1–5 m. Chetumal Bay is an estuarine environment as a result of its interconnectivity with the Hondo River, New River and Fresh water Creek catchments. The shallow bathymetry coupled with very slow water exchange makes the bay vulnerable to impacts from development in the adjacent watershed (CONABIO 2003). The vegetation is composed principally of mangroves (*Rhizophora mangle* and *Conocarpus erectus*) and has a high biodiversity (Herrera Silveira et al. 2002).

The primary water inflow to Chetumal Bay is supplied by Hondo River and through the mouth of the bay to the sea (Herrera Silveira et al 2002). The Hondo River supplies 1 500 million m^3 of freshwater and, through its mosaic of wetlands, lagoons and other water bodies, plays an important role regulating climate and hydrology in the region (CONABIO 2003).

The Mexican portion of Chetumal Bay, located in the south of Quintana Roo, was declared a Manatee sanctuary in 1999 and is designated as an Area for Ecological Conservation – "Bahía de Chetumal - Santuario del Manatí". The total surface of the protected area is 2 813 km^2; 1 013 km^2 terrestrial and 1 800 km^2 marine. A manatee sanctuary has also been created in Belize's portion of Chetumal Bay.

Belize River

The Belize River flows through Guatemala and Belize, and stretches for miles to the west and north of Belmopan (Figure 6). Its broad floodplain is the centre of intensive agricultural development. To the east, the land slopes gently towards the sea and is covered with tropical forest and limestone hills. To the south rise the foothills of the Maya Mountains. The river is flanked by dense forests including vines and epiphytes. The forests are bordered to the east by cohune palm forests and to the west by a belt of pine forest and pine savanna.

There are a number of different protected areas in the basin. One of them is the Community Baboon Sanctuary, located within the lowland broadleaf forests of north-central Belize. It was established to protect one of the few healthy black howler monkey populations in Central America. Despite the existence of protected areas there is evidence that 22% of the basin's vegetation cover has been lost since 1989 (DiFiore 2002, Microsoft Encarta 2002).

Moho River

The Moho River Basin is a transnational watershed, shared between Belize and Guatemala (Figure 6) and occupying an area of approximately 1 188 km^2, of which about 822 km^2 is in Belize. The Moho River has numerous tributaries that drain the uplands of the basin (elevation between 400 and 900 metres) in the vicinity of Little Quartz Ridge. The River flows into the Port Honduras Marine Reserve, home to the endangered West Indian Manatee. The southernmost stretch of the Belize Barrier Reef is the Sapodilla Cays Marine Reserve. Generally the quality of surface water is inadequate for human consumption and supplies during the dry season are insufficient, particularly in Mafredi Creek. Moho River watershed is currently used for forestry, agriculture and rural development. Several attempts have been made to abstract water from Mafredi Creek for crop irrigation.

There are about 20 communities distributed throughout this watershed. The rivers are used domestically as a source of potable water and for laundry and bathing purposes. Most communities rely on hand pumps and cisterns as their principal source of potable water.

Temash River

Temash River Basin has an area of 475 km^2 and is shared between Belize (360 km^2) and Guatemala (115 km^2) (Figure 6). The river system consists of a dense network of streams that drain low-lying sections of the watershed. The elevation in the Belize portion of the watershed is mostly below 100 metres. The watershed is predominantly covered by broad leaf forest, but there is also riparian vegetation with swamps and mangroves. The basin has a low population density, with only six villages, and subsistence farming is mainly practiced, suggesting that water quality and the aquatic ecosystems have been preserved. The streams in this watershed are used primarily for domestic water supply, canoe navigation and fishing.

Sarstoon River

The Sarstoon River forms the southern border between Belize and Guatemala (Figure 6). The watershed covers an area of 2 218 km^2; the majority located in Guatemala (2 024 km^2) while only 194 km^2 is in Belize. The basin is low-lying and most of the land is less than 20 m above mean sea level. The Gracias a Dios and San Pedro Savery ranges on the southwestern border are exceptions with maximum elevations of 219 m and 132 m respectively. The largest river in the watershed is the Sarstoon. The vegetation consists of patches of forest and thicket, and, in more limited distribution, wet savannah, marsh and mangrove swamp. The basin supports the only comfrey palm forests in Belize.

The Government of Belize established The Temash and Sarstoon Delta Wildlife Sanctuary as a protected area in 1992. The Sanctuary covers 166 km^2 situated between the Temash and Sarstoon rivers in the southernmost region of Belize. It is the second largest National Park in Belize (The World Bank 2000) and one of the most remote reserves, providing habitat for a variety of wildlife. The Park contains the oldest and largest area of red mangrove forest in Belize, as well as pristine wetlands, wet forest and an outstanding diversity of bird species, amphibians, fish and reptiles. Huge schools of minnows and shrimp support a thriving population of sea birds. Manatees are common along many of the river mouths, feeding on the rich seagrass beds and calving in the quiet bays and oxbows of the rivers (The World Bank 2000b).

Dolores, Machakilha and Graham creeks contain communities that use surface water predominantly for domestic purposes. Groundwater is not used. Milpa (traditional slash and burn) farming is the primary activity in this watershed. The isolation of the region from major settlements has limited development and preserved its ecosystems.

San Juan River

The San Juan River is the natural frontier between Nicaragua and Costa Rica (Figure 6); its basin extending across southeastern Nicaragua and northeastern Costa Rica to the Caribbean Sea. It flows from Nicaragua Lake for 193 km, forming a large delta south of Mosquito coast in San Juan del Norte Bay. The River also receives runoff from the surrounding chains of mountains, namely the Yolaina, Amerrisque, Volcanic and Central mountains (Microsoft Encarta 2002).

The basin links ecosystems that are particularly valuable for their biodiversity and economic potential. The waters of the Lake Nicaragua and San Juan River watershed flow through at least eight distinct terrestrial ecosystems: (i) dry tropical forest to the east, north, and west of Lake Nicaragua; (ii) cloud forest in the high areas of the Central Volcanic Cordillera of Costa Rica; (iii) moist tropical forest to the south and southwest of Lake Nicaragua and in the eastern foothills; (iv) very moist tropical forest in San Juan Valley and on the coastal plains; (v) gallery forest along river banks; (vi) wetlands to the south of Lake Nicaragua and at the confluences of the Colorado and Tortuguero rivers with the San Juan; (vii) second-growth forest, meadows, and agricultural land in extensive areas of the basin; and (viii) coastal forest and mangrove swamps on the Caribbean coast. The Indio and Maiz river basins are covered by moist and very moist tropical forest (UNEP 2000a).

The main environmental problems in the basin related to international waters are; (i) degradation of the quality of water resources; (ii) physical habitat degradation of coastal and near-shore marine areas, lakes and watercourses; (iii) the introduction of exotic species that disrupt aquatic and land ecosystems; and (iv) excessive and/or inappropriate exploitation of resources due to inadequate management and control measures (UNEP 2000a). The low population density in many parts of the basin has kept it relatively pristine, although there is little information on the potential future impact of human migration trends and the spread of agriculture (UNEP 2000a). The governments of Costa Rica and Nicaragua, with the technical assistance of GEF and UNEP, are already working together on the formulation of a "Strategic Action Plan for the integrated management and sustainable development of the hydrological resources and the San Juan River Basin and its coastal area".

Sixaola River

The Sixaola River Basin is located within the mountain range of Talamanca in the east of Costa Rica (Figure 6). The basin covers area of 27 057 km^2 and reaches elevations of 3820 m above sea level. The fluvial course length is 146 km and its average slope is 1.9%. The vegetation consists of rain-cloud tropical forest around the Paramus at the head of the river basin. According to Herrera (1985), three climate categories characterize the river basin: Humid Climate, Very Humid Climate and Excessively Humid Climate, with variations of temperature during the dry season.

The Sixaola Basin is an area with limited urban development, where the economy is sustained on the production of bananas for export, seasonal cultivated areas, subsistence agriculture and grass. Settlements are dispersed but are found in greater density in the Valley of Talamanca. The main ethnic groups are the Bribris, Cabécares and immigrants from other regions of Panama and Costa Rica.

Panama Canal

The Panama Canal watershed has a surface area of 5 528 km^2 (Figure 6). The Canal is approximately 80 km long, connecting the Atlantic and Pacific oceans. This waterway was cut through one of the narrowest saddles of the Central American isthmus and was officially opened in 1914 (PCA 2003).

The hydrographic basin of the Canal is a water reservoir (ACP 2000). Its resources have the potential to meet the present and future water supply needs of most of the population of Panama and the Panama Canal operations (PCA 2003). The Canal is not only an important water source for ship transport, but also provides 95% of the raw water to be treated for the freshwater supply of Colon, Panama, San Miguelito and in the near future La Chorrera (ACP 2000). Studies are being undertaken to evaluate the potential of the watershed's western region to meet future water demand (PCA 2003).

The Panama Canal watershed has a high biodiversity with approximately 70 species of amphibians, 112 species of reptiles, 546 bird species and over a hundred thousand species of trees (PCA 2003).

Panama offers a unique service for international trading through the canal (ACP 2000), with ships from all parts of the world transiting through the Panama Canal. Some 13 to 14 thousand vessels use the Canal every year. In fact, commercial transportation activities through the Canal represent approximately 5% of world trade (PCA 2003).

The Law 44 of August 1999 established the legal boundaries of the Canal watershed, which includes the Chagres River Basin and part of the provinces of Cocle and Colon that were identified as having a major hydrological potential. Title XIV of the Constitution of the Republic of Panama and the Panama Canal Authority Organic Law have assigned to the Panama Canal Authority (PCA) the responsibility for the administration, maintenance, use and conservation of the water resources of the Panama Canal watershed, due to the importance of water for the operation of the waterway. The law also requires that the PCA administer uses these water resources to ensure the supply of water to adjacent populated areas (PCA 2003).

To coordinate the efforts of government agencies and the Panama Canal Authority for the conservation of the region's natural resources, the Organic Law of the Panama Canal stipulated that an International Commission for the Canal Watershed (CICH) should be established for the main purpose of integrating the efforts, initiatives, and resources for the conservation and management of the watershed and promoting its sustainable development (PCA 2003). The Panama Canal Authority chairs the Commission for the Canal Watershed (CICH) and its other members are the Ministry of Government and Justice, the Ministry of Agricultural Development, the Ministry of Housing, the National Environmental Authority, the Inter-oceanic Region Authority, the NATURA Foundation, and Caritas Arquidiocesana (PCA 2003).

Assessment

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns, i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change, as well as their constituent issues and the priorities identified during this process. The evaluation of the severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 4. Details of the scoping results for each GIWA concern and its associated environmental issues for the region are provided in Annex II.

This report presents the assessment results of the Colombia & Venezuela sub-system (3b) and the Central America & Mexico sub-system (3c) of the GIWA Caribbean Sea region. The assessment is based principally on expert knowledge and professional judgment, and where possible substantiated with scientific papers. However, in certain cases there are no supporting references as the findings are not officially published, are included in grey literature, are part of an ongoing monitoring programme, or there is currently no supporting data available. More studies are needed to support the expert opinion.

It is important to note that in most of the Caribbean Sea region, the impact of human activities on the environment is fairly well studied, but knowledge regarding how the degraded environment affects the social and economic well-being of the region is scarce.

Table 4 GIWA scoring table for the Colombia & Venezuela sub-system and the Central America & Mexico sub-system.

	Colombia-Venezuela sub-system: Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***	Central America & Mexico sub-system: Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1* ↗	2 ↗	1 ↘	1 ↘	1.2	5	2* ↗	3 ↗	2 ↘	3 ↗	2.6	4
Modification of stream flow	1						3					
Pollution of existing supplies	1						2					
Changes in the water table	0						1					
Pollution	2* ↘	2 ↗	2 ↘	2 ↘	1.6	3	3* ↗	3 ↗	3 ↘	2 ↘	2.4	2
Microbiological pollution	1						1					
Eutrophication	1						2					
Chemical	2						3					
Suspended solids	2						3					
Solid wastes	2						2					
Thermal	1						1					
Radionuclides	0						0					
Spills	3						3					
Habitat and community modification	3* ↘	2 ↗	1 ↘	2 ↗	1.9	1	3* ↗	3 ↘	1 ↘	3 ↘	2.2	1
Loss of ecosystems	2						3					
Modification of ecosystems	3						3					
Unsustainable exploitation of fish	2* ↘	2 ↘	1 ↘	2 ↘	1.5	2	3* ↗	1 ↗	0 ↗	3 ↗	2.5	3
Overexploitation	3						3					
Excessive by-catch and discards	1						0					
Destructive fishing practices	2						3					
Decreased viability of stock	1						1					
Impact on biological and genetic diversity	2						1					
Global change	2* ↗	2 ↗	2 ↗	2 ↗	1.7	4	2* ↗	3 ↗	2 ↗	3 ↗	3.0	5
Changes in hydrological cycle	2						2					
Sea level change	1						2					
Increased UV-B radiation	1						0					
Changes in ocean CO_2 source/sink function	1						1					

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

IMPACT 0 No known impacts IMPACT 1 Slight impacts IMPACT 2 Moderate impacts IMPACT 3 Severe impacts

The arrow indicates the likely direction of future changes.

↗ Increased impact
→ No changes
↘ Decreased impact

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

Assessment of the Colombia & Venezuela sub-system

IMPACT Freshwater shortage

The environmental impacts of freshwater shortage are slight, and the socio-economic impacts are considered slight to moderate (Annex II, Scoring tables). There is limited information available on both the Catatumbo and Orinoco river basins; further studies are required to determine their environmental status. The assessment of this concern therefore concentrates on the Magdalena Basin.

Modification of stream flow

The regional team considered the impacts of the modification of stream flow to be slight as there is no evidence of a significant reduction in stream flow in any of the three transboundary basins of sub-system 3b (FAO 1994, Senior et al. 1999).

Stream flow has been modified to a certain extent by higher evaporation and a reduction in rainfall in dry areas such as La Guajira in Colombia. This change in the water balance has resulted in coastal ecosystems experiencing a deficit in water. Consequently, salinisation has increased and mangroves have experienced slow growth rates and some mortality during the dry season (Dirección General de Ecosistemas 2002a). Fisheries resources have been affected in terms of their abundance, and changes in salinity have altered the distribution of marine- and freshwater fish species at Cienaga Grande de Santa Marta and Complejo de Pajarales (see Biological and genetic diversity, 3b) (INVEMAR 2001).

According to CORMAGDALENA (2002), the Canal del Dique marshes in the Magdalena Basin have been affected by dredging and the construction of hydraulic structures. The water surface area and depth of the marshes has decreased as a result of canals diverting water. The change in the water regime, notably in Salamanca Island (Santa Marta) and Tesca and Francés swamps, has impacted the Caribbean mangroves of the Magdalena Basin (CORMAGDALENA 2002).

Pollution of existing supplies

The pollution of existing supplies, principally from oil spills, is considered to have slight impacts. There is some localised river pollution but the assessed transboundary rivers are able to disperse pollutants due to their large volume of stream flow and rapid currents (INDEC 1971, HIMAT 1980, Rincón 1990, ECODES-ECOPETROL 1999). The pollution of freshwater supplies has occurred mainly as a result of the discharge of wastewater and spills from various human activities (CORMAGDALENA & IDEAM 2001, Garay 1990-93-97, Ruiz et al. 1992, Villa 1998). In Magdalena Basin, livestock farming and agricultural practices including the growing of illegal crops are adversely affecting water quality (Villa 1998, Knight 2002, Marquis 2002). In the Orinoco delta, oil spills from defective pipelines have contaminated the local water supply (RAN 2003).

Changes in the water table

The impact of changes in the water table was assessed as having 'no known impacts' as there is no evidence that abstraction of water from aquifers exceeds the natural recharge rates. The present consumption of drinking water is not affecting the water table and effective legislation exists to regulate the use of groundwater in both Colombia & Venezuela.

Economic impacts

The impact of the freshwater shortage concern on the economy of the sub-system is considered moderate. The economic activities in the Magdalena Basin generate approximately 85% of the GDP of Colombia. These activities are highly dependent on water supply; in 2000 the basin's municipalities consumed 1 942 417 m^3, of which 83% was used in urban areas. The industrial sector is the highest consumer of water, using 58% of the total water abstracted in 2000 (CORMAGDALENA 2002). Therefore, any future changes in freshwater availability can significantly affect the economic activities of the region.

Since the mid-1980s, the contamination of the sub-system's freshwater supplies has necessitated the construction of facilities to remove accumulated pollutants originating from the petroleum industry located in Barrancabermeja. These facilities have incurred significant economic costs (CORMAGDALENA 1999).

The pollution of existing supplies was considered to be the most severe environmental issue of the freshwater shortage issues. The economic impacts of freshwater contamination are further assessed under the pollution concern.

Human health impacts

The health impacts of freshwater shortage were assessed as slight. Generally, there is adequate water available for the inhabitants of the sub-system, with 91% in Colombia and 84% in Venezuela having access to treated water. Consequently, there is a low frequency of health impacts from freshwater shortage in the sub-system. Health indicators, such as morbidity, were considered during the analysis. Morbidity from deficiency diseases and stomach diseases is often caused by the consumption of contaminated water; 21.4 people die per 1000 inhabitants from stomach disease in the Magdalena Basin (Mesclier 1999). Isolated cases of cholera associated with water shortages and pollution have occurred in areas of poverty near to the Caribbean coast and Magdalena River (PAHO 1998).

Other social and community issues

There are slight other social and community impacts. The rural population is the most vulnerable, where less than 42% receive water from the aqueduct service. There has been some conflict between water users where either demand has increased or availability decreased.

Conclusions and future outlook

In Colombia & Venezuela, the impacts of freshwater shortage were assessed as slight. There is no evidence of any significant depletion of the region's water resources (CORMAGDALENA & IDEAM 2001). Variations in water availability in the Magdalena and Orinoco basins are consistent with regional climatic fluctuations. During the ENSO (El Niño Southern Oscillation), the water table changes considerably, but this is an external factor (climate change) and is assessed under the global changes concern.

The economic impacts are moderate, where as health impacts and other social and community impacts were assessed as slight. The majority of Colombia's economic activities are located in the Magdalena River Basin and therefore changes in freshwater availability or a deterioration in water quality can adversely affect the country's economy. The assessment identified the pollution of existing supplies as the most severe issue in the basin, with contamination originating from industry, particularly petroleum production. The financial and technological resources necessary to construct treatment systems and employ cleaner technologies are currently lacking (CORMAGDALENA 1999). However, the inhabitants of the sub-system generally have good access to treated water. In certain rural areas the situation is less positive with the inhabitants being more vulnerable to water-related diseases.

In future, freshwater is expected to be used more efficiently and be of a higher quality due to the implementation of new regulations, water use taxes and the development of cleaner production technologies.

IMPACT Pollution

Pollution in the Colombia & Venezuela sub-system was assessed as moderate (Annex II, Scoring tables). Microbiological pollution is impacting the Magdalena Basin, primarily in the dry season when the dispersion capacity of rivers is reduced due to slower flow rates. Poor land management practices have increased the concentration of suspended solids in water bodies, thus obstructing river flow and increasing sedimentation. The sediments contain pesticides and nutrients, causing localized euthrophication and the bioaccumulation of chemicals in aquatic life.

Microbiological pollution

The impacts of microbiological pollution were considered *slight* since there are no major transboundary effects. There is limited evidence of fish contamination and wastewater is likely to be dispersed by river currents.

On the Colombian Caribbean coast, 472 653 m^3/day of untreated sewage are discharged into the sea, produced by 3 073 483 inhabitants from 26 cities. Industry discharges about 6.02 tonnes/day of organic material and about 3.9 tonnes/day of nutrients into Cartagena Bay, in addition to other industrial wastes (INVEMAR 2001). According to Garzón-Ferreira et al. (2000), sewage poses a major threat to most coastal ecosystems. Although there is anecdotal evidence of coral reefs being impacted, no conclusive studies have been performed.

In February 2000, mass fish mortalities were recorded in Barlovento, associated with pathogen bacteria which previously had only been identified in freshwater bodies. It was believed the bacteria were contained in sediments originating from the Orinoco River plume (UNEP 2002). Water quality and sediment studies conducted on the major rivers of eastern Venezuela found that around Matazas the sediments contained high concentrations of organic material. Coliforms were also present at concentrations of 11 000 NMP/100 ml, which far exceed the Venezuelan water standards of 1 000 NMP/100 ml (Senior et al. 1999).

Eutrophication

The impact of this issue is considered *slight* as there is only localised algal growth due to nutrient enrichment, but more studies are needed. However, the recent increase in the use of agro-chemicals, particularly in the production of illegal crops, has increased nitrogen and phosphorus runoff from fields into rivers and coastal areas (Smayda 1990 in GESAMP 2001).

In Lake Maracaibo, Venezuela, there have been reports of localised eutrophication, and in the waters surrounding the cities of Ojeda and Lagunillas, high nutrient concentrations and a surface layer of cyanobacteria have been recorded. Other contaminants, such as petroleum, interact with the nutrients and alter phytoplankton communities, thus reducing the abundance of planktonic algae and the trophic structure of pelagic ecosystems. An anaerobic zone has been created as a result of eutrophication which is maintained by the introduction of high density waters which limit the circulation of deep waters (PNUMA 1999, Rodriguez 2000).

According to Gaspar (1996), nutrient loads and primary productivity remain constant from June to December along the Venezuelan northeast coast despite upwelling only supplying nutrients from January to May. Large rivers, such as the Orinoco, inshore currents and coastal lagoons are believed to enrich the coastal waters with nutrients, resulting in eutrophication between May and November when upwelling is less pronounced. Corredor & Morell (2001) analysed historical data and demonstrated that during the rainy season increased nutrient (Chl-a) concentrations from the Orinoco River plume result in a net increase in phytoplankton carbon biomass.

Most nitrogen in the Orinoco River outflow is in the form of organic compounds. During water quality and sediment studies conducted in eastern Venezuela, concentrations of nitrogen were between 19.87 µmol/l and 35.11 µmol/l. The highest concentrations of nitrites were found at the outflow of a canal from a vanadium enterprise (Senior et al. 1999). Between 1991 and 1996, a climatic anomaly and pronounced nutrient enrichment resulted in a severe phytoplankton bloom followed by sudden oxygen depletion, which led to a reduction of coral reef cover from 43% to less than 5% in Morrocoy National Park, Venezuela (Garzón-Ferreira et al. 2000).

In Cartagena Bay and the Ciénaga de Tesca in Colombia, mass fish mortalities were observed due to the water being deoxygenated. This was attributed to eutrophication caused by the discharge of non-treated wastewater and fertiliser runoff, combined with the stratification of the water column (PNUMA 1999). Branches of Canal del Dique, especially the canals that enter Bahia de Cartagena and Bahía de Barbacoas, are turbid and suffer from eutrophication, and consequently degrade coral reefs at Islas del Rosario (Garzón-Ferreira et al. 2000).

Chemical Pollution

There are *moderate* impacts from chemical pollution in the Colombia & Venezuela sub-system. There is currently a lack of studies regarding the affects of chemical pollution on the aquatic environment, especially given the large presence of industry on the banks of the sub-system's rivers (Ruiz et al. 1992; CORMAGDALENA 2002). Pesticides are used for fishing and agriculture in large quantities within the three transboundary basins of the sub-system. Dioxins and furans are discharged from paper bleaching and incineration plants, mainly in Venezuela. Runoff from mining activities and intensive agriculture along the Urabá Gulf coastline is contaminating the surrounding wetlands (Windevoxhel 2003). In Catatumbo delta, the use of pesticides on behalf of the Colombian authorities to fumigate illegal crops is posing a major environmental problem. During 2002, an estimated 120 km^2 of crops were fumigated (El País 2002).

Chemical pollution has been detected in close proximity to the major cities of Magdalena Basin but there is insufficient data regarding the rest of the basin. Effluents discharged by industry on the Colombian coast are predominantly from Cartagena and Barranquilla, and, to a lesser degree, Puerto Bolivar, Santa Marta, Tolu-Covenas and Turbo. Petrol refineries, distilleries, food processing and packing industries (meat, chicken, shrimps and fish), pulp and paper manufacturers, and chemical industries (organic and inorganic) are the largest polluters. The chicken and fish processing industries of Cartagena discharge 70% of the total BOD_5 released, while petroleum refineries and shipping discharge 80% of all petroleum pollutants in the sub-system (INVEMAR 2001).

The mangroves of the Atlantico Department, Cienaga de Mallorquin (Magdalena Basin), are being degraded by chemical pollution discharged by Barranquilla industries; the accumulation of contaminants in mangrove forests; and the higher sediment loads in the Magdalena River causing increased sedimentation. Wastewater containing chemicals is discharged into the swamps of Balboa and Rincon; impacting the health of the fisheries and mangroves. In Bolivar Department, Cartagena Bay, Cienaga de la Virgen and Cienaga de Tesca, mangrove productivity has been reduced as their growth is stunted by hydrocarbons and other chemical impurities (Direccion de Ecosistemas 2002a).

Marine pollution exists in the principal ports of the sub-system, such as Cartagena, where sea sediments retain heavy metals like copper, cadmium, chromium, lead, zinc and mercury which have accumulated as result of previous activities and discharges. Marine activities, notably dredging in ports, disturb the polluted sediments so that they are suspended in the water column where they are ingested by marine organisms, such as molluscs, and then passed through the food chain.

Suspended Solids

The impacts from suspended solids were considered to be *moderate* as the sediment loads of water bodies have increased due to the expansion of activities such as deforestation, mining and agriculture in the catchment areas. According to Garzón-Ferreira (2000), the increase in sedimentation is the most damaging issue for many coastal areas in the sub-system; in particular, Santa Marta in the Colombian Caribbean and Morrocoy National park in Venezuela. Deforestation, for logging and land clearance for agriculture, is the major cause of sedimentation and nutrient pollution in most of the affected areas.

The Magdalena discharges 235x 10^6 t/a of sediment into the Caribbean Sea (Quintero 1999), the Orinoco 85 x 10^6 t/a, and other rivers in Colombia & Venezuela, 50 x 10^6 t/a. In the Magdalena Basin, between Barbacoas and Bocacerrada, sedimentation is changing the hydrological regime of the area by, for example, obstructing the flow of canals such as the Canal del Dique. Mangroves are, consequently, receiving less water and many have died (Direccion de Ecosistemas 2002a). The coastal zone adjacent to the mouth of the Magdalena River receives sediments from the river that are transported by currents and the tides until they are deposited to form fine mud beaches. The coral reefs located in close proximity to the mouth of the Magdalena are being impacted by sedimentation as a consequence of these additional sediments.

Gomez (1996) calculated that the Orinoco River discharges 2.5 x 10^{12} g C/year of dissolved organic material and large quantities of suspended (80 mg/l) and dissolved solids (34 mg/l) (Blough et al. 1993 in Gomez 1996). A major environmental threat to the Orinoco Basin is that dredged wastes are piled on riverbanks where they inhibit drainage into the rivers. Seasonal changes to the volume of outflow from the Orinoco River influences the concentrations of silicates and dissolved organic substances in the north Venezuelan coastal waters (Gomez 1996). Satellite images have shown that sediments from the Orinoco River can be seen several kilometres offshore.

Solid Wastes

There have been *moderate* impacts from the issue of solid wastes resulting from the inadequacies of collection services for solid wastes in the coastal settlements of the sub-system. The management of waste from the tourism sector is particularly weak. For example, Morrocoy National Park, Venezuela, was temporarily closed in 1990 following the dumping of excessive quantities of solid and liquid wastes when the number of tourists exceeded the carrying capacity of waste management services (Windevoxhel 2003).

Studies in Colombia have recorded significant quantities of debris floating in coastal waters. There is evidence of sea turtle mortality due to the ingestion of plastic bags as they resemble jellyfish. Of 33 dead Leatherbacks found between 1979 and 1988 ten died from ingesting plastic bags, plastic sheets or monofilaments (Direccion de Ecosistemas 2002b, Kemp 2004, Turtle 2004). Coral reefs have also been damaged by the dumping of large debris at sea (RAN 2003).

Oil spills

The impact of oil spills is *severe* as there is widespread and frequent contamination by hazardous spills which degrade aquatic ecosystems and affect fishing and coastal recreational activities in the surrounding area. Previous spills have caused significant mortality of aquatic and avian species with many contaminated carcasses observed on beaches. Additionally, oil is continuously discharged by port and shipping activities. In Cartagena Bay (Colombia), petroleum exploration, extraction, refinement and spills from ships represent 80% of the total petroleum discharged in the region (INVEMAR 2001).

Oil can also be released into the environment because of vandalism to oil pipelines. In the Catatumbo River Basin there are continuous oil spills as a result of pipeline sabotage. In November 2002, 5 000 barrels were spilled after an explosion at the border between Colombia and the Zulia State in Venezuela (Rosillon 2002).

In the Venezuelan portion of the Orinoco Basin, oil drilling leaves oil and other residues that leach into the surrounding mangrove ecosystems. Pollutants from oil exploitation activities in the basin include hydrocarbons; wastewater containing detergents; gases from valves and burners (hydrocarbons, hydrogen sulphide); fire extinguisher agents (halogenated gases, treated water); wastewater from employee camps; chemical products (cement, bentonite, barite, solvents, heavy metals, alkalis); antifoaming agents; radioactive isotopes; battery acid; lubricants (grease); pH salts; biocides; oil; and mineral oil. The longitudinal distribution of aliphatic hydrocarbons, oils and grease in superficial sediments within the Orinoco Basin shows a maximum concentration at Sidor (1.3 mg/g) and Aguas Calientes (0.8 mg/g) (Senior et al. 1999). The likelihood of oil spills from dilapidated pipelines is extremely high and poses a serious threat to the Orinoco delta region. Further, the oil developments alter the basin's drainage patterns and inhibit the flow of freshwater and tidal seawater to the mangrove forests (RAN 2003).

Economic impacts

Pollution has caused *moderate* economic impacts in the Colombia & Venezuela sub-system. The sewage system of the cities of Barranquilla and Cartagena, as with many municipalities in the basin, is completely dependent on the Magdalena River and the Canal del Dique to dispose of its wastewater. The downstream section of the Magdalena River, particularly at its mouth, is highly polluted; greater investment in treatment services is needed. The value of fisheries products has decreased as a result of contamination by hydrocarbons and runoff from the municipalities of Cicuco and Talaiga Nuevo (Gonzalez José pers. comm.).

Magdalena River is a key transport route for the importing and exporting of industrial products. In order to maintain this navigational function, it is necessary to regularly stabilise and dredge the river course due to high sedimentation rates. In 2000 and 2001, an estimated 80 000 million pesos (45.5 million USD) were used for these activities in Barranquilla (Alcaldía Distrital de Barranquilla 1999, República de Colombia 2001). The additional sediments deposited on the beaches adjacent to the mouth of the Magdalena River have detracted from the value of the beaches for tourism, as have solids wastes also discharged by the rivers and deposited on the beaches by coastal currents. The impact of pollution, however, on the economic sectors of the region has not been fully evaluated.

Impacts on human health

The impact of pollution on human health is also *moderate* in the sub-system. Many households in the Magdalena Basin are not connected to the water supply system; relying, instead, on water trucks, rainwater or river water. This primarily affects low income inhabitants. Most of the communities in the lower reaches of the Magdalena River Basin do not have sewage treatment facilities and, consequently, suspended solids and faecal matter detrimentally affect the health of downstream coastal communities which have a high prevalence of gastrointestinal and dermal ailments. Chemical and organic compounds released into the environment by industrial and agricultural activities present a permanent threat to human health (DNP 1995). In the Magdalena Basin, morbidity from digestive diseases was 21.4 per 1000 inhabitants and from skin diseases, 17.6 per 1000 inhabitants (Mesclier 1999).

Other social and community impacts

The social and community impacts of pollution are *moderate*. Rural populations are the most vulnerable to the impacts of pollution due to the inaccessibility of treated water sources. Less than 42% of rural inhabitants are connected to the water supply system and only 17% to a sewage system (CORMAGDALENA 2002).

Conclusions and future outlook of pollution

In the Colombia & Venezuela sub-system, the impacts from pollution are generally *moderate*. The major sources of pollution were identified as oil spills and suspended solids. In the Catatumbo and Magdalena river basins, waste management services are weak resulting in the discharge of untreated or insufficiently treated wastewater and the uncontrolled dumping of solid wastes. Oil pipelines are prone to fracturing, resulting in frequent leaks and spills. Land management practices, such as deforestation, have increased the sediment loads of water bodies. The application of agro-chemicals has increased contamination from agricultural runoff. The Orinoco Basin is polluted by a variety of activities including the production of illegal crops, livestock farming and oil spills. Pollution is impacting human health and increasing the costs of water treatment.

The environmental impacts of pollution are expected to decrease in severity by the year 2020, from *moderate* to *slight*. In future the economic impacts are predicted to remain unchanged while impacts on the health and social wellbeing of the sub-system's population will decrease from *moderate* to *slight* (Annex II, Scoring tables).

Habitat and community modification

The environmental impacts of habitat modification in the Colombia & Venezuela sub-system are *severe* while the socio-economic impacts were classified as *slight* to *moderate* (Annex II, Scoring tables). In the coastal zone, mangroves and coral reef ecosystems have been significantly modified as a result of pollution, poor land use practices and uncontrolled fishing. In the continental portion of the sub-system, especially in Colombia, the government supported development of settlements along the rivers during the 1970s has caused extensive deforestation.

Loss of ecosystems

The loss of ecosystems is assessed as having *slight* impacts. The most severe ecosystem loss was witnessed in the Magdalena River Delta where many mangroves surrounding Barranquilla-Cienaga, Parque Salamanca and the Cienaga Grande de Santa Marta were destroyed. Approximately 95% of the mangroves (280 km^2) were lost due to changes in the hydrological regime including increased salinisation. In 1999, increased salinity levels have resulted in a sharp decline in mollusc populations which were previously a major economic resource in the Delta. For the last 30 years, to the west of Parque Salamanca, there has been mangrove deforestation for charcoal production by settlers of Barranquilla and Sitio Nuevo (INVEMAR 2001). Mangroves have also been cleared due to tourism development in the Magdalena Basin between Cartagena's airport and la Boquilla, as well as in Islas de Baru and Islas del Rosario.

Modification of ecosystems

Habitat modification is considered *severe* as the sub-system's physical, chemical and biological characteristics have been significantly altered to the detriment of its ecosystems. In the middle and lower reaches of the Magdalena River Basin, ecosystems have been modified, particularly wetlands, in terms of vegetation cover, species distribution and biodiversity (Villa 1998, CORMAGDALENA 1999). This has been attributed to the artificial control of the floodplain hydrodynamics, the pervasiveness of pollution, widespread urbanization and the dredging and extraction of sediments. Moreover, alien species were introduced. For example, tilapia (*Oreochromis mossambicus)* were introduced into the Magdalena Basin and Lake Maracaibo (INDEC 1971, MMA-IAVH 1999, Alvarado & Gutierrez 2002).

CORMAGDALENA (2002) noted that 86% of the total mangrove area in the Magdalena Basin has been altered by human activities. Colombia is no longer the country with the fourth largest total mangrove cover in the world (as catalogued in 1956) (CORMAGDALENA 2002). The most extreme impacts in the Magdalena River Delta were concentrated in Cienaga Grande de Santa Marta and Isla de Salamanca, attributed to the blockage of canals that convey freshwater from various rivers; the obstruction of the flux between the marshes and sea due to the construction of roads at Cienaga-Barranquilla and Palermo-Sitio Nuevo; and the construction of flood defences to protect livestock farms. This has resulted in the drying up of floodplains and hypersaline soils of up to 300‰. There are also reports of sedimentation in this area due to deforestation. In the north of the Magdalena River Delta, road construction has modified runoff and caused the salinisation of water and soil, resulting in mangrove mortality. In Barbacoas and Canal del Dique, increased salinity levels and the exploitation of mangrove products has led to the colonisation of glycophyts (Direccion de Ecosistemas 2002a). Further, on the west coast of Golfo de Uraba, the mollusc *Neoteredo reynei* have attacked mangroves such as *Rhizophora mangle* by perforating mangrove branches and causing them to fall (Direccion de Ecosistemas 2002a).

The wetlands on the Caribbean coast of Colombia provide habitat for rare, endangered and commercially or recreationally important wildlife species. They also serve as focal areas for outdoor recreation and provide an important function in enhancing water quality, floodwater storage, storm surge reduction and groundwater recharge (Tiner 1984 in Lyon & McCarthy 1995). However, most of the wetlands are impacted by anthropogenic activities; today, the abundance and diversity of wetland species are under threat. The remaining wetlands are under pressure to be utilised by human activities.

The wetlands of the Magdalena Basin have experienced two main impacts: (i) the total transformation or loss of biological, chemical and physical attributes including the function of ecosystems (e.g. space reclamation, alien species); and (ii) severe transformation which consists of the modification of one of those attributes (e.g. urbanization, control of inundation, pollution) (MMA-IAVH 1999). A wetland assessment of Colombia found that the most severely affected habitats are located in the Magdalena Basin (west, middle, lower), Sinu River, Cauca River, Canal del Dique and Depresión Momposina. The Colombian government has recognised wetlands as a priority for conservation and has recently created a wetland policy (MMA 2002).

Coastal and riparian development over the last few centuries has altered runoff and caused sedimentation which has degraded coral reef ecosystems. During the 17th century, Spanish colonists excavated the Canal del Dique, changing the course of the Magdalena River so that it flows into Cartagena Bay and forms an estuary, thereby eliminating extensive coral communities. Major reef degradation has occurred on the Caribbean coast including remote continental and oceanic reef areas, as well as reefs near urban centres. Figure 7 shows the status of coral reefs in the Caribbean Sea region.

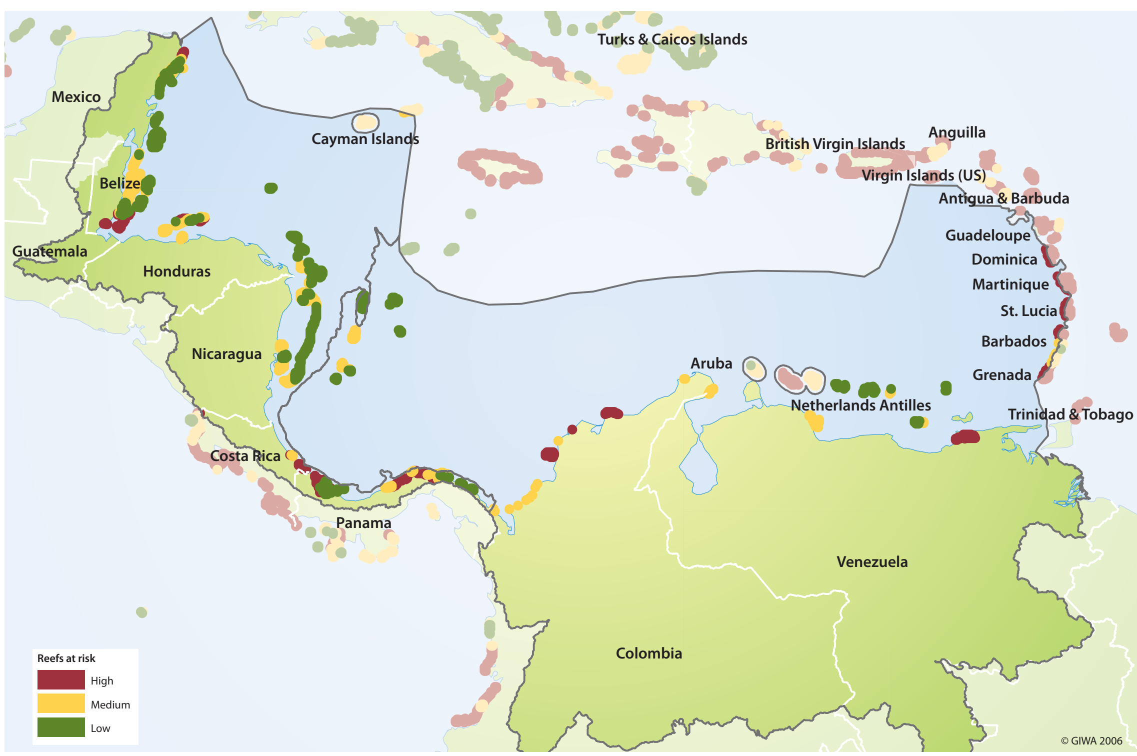


Figure 7 Status of coral reefs in the Caribbean Sea region.
Source: Byant el al. 1998.

Coral reef degradation has been exacerbated by urban and industrial development on the central coast of Venezuela (Puerto Francés-Carenero) where over 80% of associated invertebrate species have disappeared since the mid-1980s. In Morrocoy National Park, coral reefs and associated faunal communities have been destroyed; with coral cover reduced from 43% to less than 5% between 1990 and 1996. This mass mortality was attributed to a climatic anomaly that resulted in a prolific phytoplankton bloom followed by severe oxygen depletion, but also chemical pollution (Garzón-Ferreira et al. 2000). Deep coral communities in Colombia are threatened by the development of new fishing technologies and the expansion of oil and gas exploration (Santodomingo et al. 2004).

In the Orinoco River Delta, oil pollution has changed the pH of the soils and water, causing a severe deterioration in the health of the mangroves. For example, mature trees are prevented from growing sufficient foliage for photosynthesis (RAN 2003).

Economic impacts

The economic impacts of habitat modification are *moderate*; there has been a loss of ecosystem functions and a reduction in environmental services. The environmental problems of the region require large financial investment in order to reverse degradation trends (República de Venezuela 1995). The natural resources of the Orinoco, Magdalena and Catatumbo basins have been exploited in an unsustainable manner. These economic resources will not be available for future generations.

Impacts on human health

The impacts of habitat modification on human health are *slight*. Alterations to the Colombia & Venezuela sub-system's aquatic ecosystems have exacerbated poverty, as food security has been jeopardised. In the Magdalena Basin, the quality of fisheries products has been diminished, due to the bio-accumulation of heavy metals in the tissues of fish until they become toxic to humans. However, mining activities are currently not sufficiently regulated to prevent such contamination. Additionally, overfishing has affected the future abundance and food security of fishing communities (CORMAGDALENA 1999).

Other social and community impacts

The impacts on other social and community issues from habitat modification were assessed as *moderate*, because the lifestyle of the population of the Magdalena Basin has gradually changed as a result of modifications to the sub-system's habitats. The Warao, the indigenous people of the Orinoco Basin, have dwelled in the basin for the past 3 000 years but are now suffering due to the destruction of the habitat on which they depend for their livelihood. The social and community impacts include a loss of territorial rights; the modification and loss of delta ecosystems that provide their means of subsistence; erosion of traditional knowledge and skills; and a loss of cultural values due to the dispersion of indigenous communities.

Conclusions and future outlook of habitat modification

The environmental and economic impacts of habitat modification were both assessed as *moderate*. The fisheries and transport sectors have been the most affected. Significant costs have been incurred, and will continue to be necessary in future, in restoring the degraded habitats. There is limited evidence of impacts to human health but the social and cultural integrity of the Warao indigenous people in the Orinoco Basin has been adversely affected.

By 2020, the habitat modification concern will continue to have *moderate* environmental impacts but if no action is taken the impacts may become *severe*. It is necessary to assess the environmental costs and benefits of economic activities and promote sustainable development in order to limit habitat modification caused by economic development. Overall, it is anticipated that there will be little change in the severity of impacts from habitat modification on the economy of the sub-system.

IMPACT Unsustainable exploitation of fish and other living resources

The environmental impact of the unsustainable exploitation of fish and other living resources in the Colombia & Venezuela sub-system was considered to be *moderate*, while the socio-economic impacts range from *slight* to *severe* (Annex II, Scoring tables).

Overexploitation is the major issue both for marine and freshwater fisheries. Fishing in the river basins is an important economic activity for riparian communities for subsistence and to supply the domestic market. The assessment of this concern is restricted by the lack of reliable fisheries data for the region (UNEP 2000b).

Overexploitation

The overexploitation of the fisheries is having *severe* impacts. The assessment of this issue is based primarily on studies of the Magdalena Basin and the adjacent coastal areas.

Data on the health and abundance of the reef fisheries is extremely scarce for the sub-system. The general consensus is that coral reef fish communities have been changed markedly and populations of important commercial species are severely depleted. These changes are probably caused by reef degradation in combination with overfishing. Recent fish counts by the SIMAC (Sistema de Monitoreo de Arrecifes Coralinos de Colombia) monitoring programme of Caribbean reefs in Colombia showed that some commercial species, such as snappers and groupers, were absent or had population densities less than 1 fish per 60 m^2 (Garzon-Ferreira et al. 2000). Fish stocks of the main commercial species have been depleted throughout the sub-system. These species include *Acanthuridae*, *Balistidae*, *Carangidae*, *Chaetodontenidae*, *Haemulidade*, *Kyphosidae*, *Labridae*, *Ltjanidade*, *Pomacanthidae*, *Pomacentridae*, *Scaridae*, *Serranidae* (Garzón-Ferreira et al. 2000).

The fishing of lobster and gastropods (*Strombus gigas*) along the Colombian Caribbean coast became unsustainable many years ago; their exploitation is now restricted to La Guajira. Lobster exploitation between 1989 and 2000 was approximately 327-356 tonnes per year. The harvesting of *Strombus gigas*, which is listed in CITES Appendix II, between 1994 and 1999 was about 121–129 tonnes per year, while in 2000 it was 74 tonnes (INVEMAR 2001).

The hunting of marine turtles in Colombia in nesting and feeding areas is the principal threat to their conservation. In La Guajira alone, there are more than 2000 individuals caught per year by traditional turtle fishing. The continuous killing of female loggerhead turtles (*Caretta caretta*) and the poaching of their eggs reduced their population by 95% between 1976 and 1987. At present, there are a few nesting reports in Santa Marta, Dibulla and La Guajira. Other species that used to nest on the coast of the Magdalena Basin in departments such as *Buritaca-Don Diego*, were almost exterminated. Since 1973, only two white turtles (*Chelonia mydas*) were registered, two nests of carey turtle (*Eretmochelus imbricata*) and one nest of a canal turtle (*Dermochelys coriacea*) (Direccion de Ecosistemas 2002b).

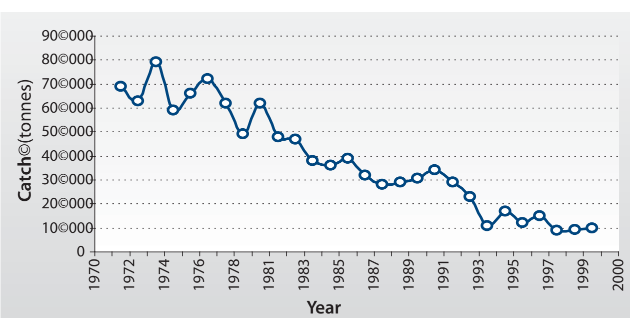


Figure 8 Prochilodus magdalenae ("Bocachico") catches (1970– 2000).
(Source: Rengifo et al., 2002)

Overexploitation is also affecting freshwater ecosystems. For example, landings of *Prochilodus magdalenae* ("*Bocachico*") have significantly decreased in the Magdalena Basin; as shown in figure 8. Wetland wildlife is also overexploited for consumption, their skins and trade in live species.

Excessive by-catch and discards

In general, the impact of excessive by-catch and discards is considered as *slight*. In Colombia there is accidental by-catch of sea turtles by shrimp fisheries, whereas in Venezuela it is regulated.

Destructive fishing practices

The use of destructive fishing practices is having *moderate* impacts as there is evidence of dynamite fishing in all the basins, which is adversely affecting the sustainability of the fisheries (Mojica et al. 2002, Mejia & Acero 2002).

Coral and fish exploitation practices used by subsistence and commercial fisheries are threatening coral reefs in coastal areas. Fishing with dynamite and anchoring on coral reefs in Morrosquillo Gulf, San Andres, Providencia and Islas del Rosario, have caused coral mortality and negatively affected associated species e.g. carey and caguama turtles (Direccion de Ecosistemas 2002b).

Decreased viability of stock through pollution and disease

The impact of decreased viability of stocks though contamination and disease is considered as *slight*. This score considers that there is some evidence of impacts on various species but this has not been substantiated scientifically. For example, the accumulation of pesticides and chemical pollutants on Colombian beaches in the Caribbean produce lixiviates that suffocate nesting sea turtles and kill their embryos (Direccion de Ecosistemas 2002b).

Impact on biological and genetic diversity

The impact on biological and genetic diversity was considered *moderate* because all the basins are impacted by alien species. However, data on the severity of its impacts is scarce. *Oreochromis mossambicus* was introduced into the Magdalena Basin and has changed the structure of the fish community (Alvarado & Gutierrez 2002). At Cienaga Grande de Santa Marta and Complejo de Pajarales in the Colombian Caribbean, fish catch composition changed in 2001 due to changes in wetland conditions. For example *Mojarra* lora changed from representing 67% of the total catch to 1% during the first six months of the year; while eurihaline species increased from 4% to 38% of the total catch. Among the traditional species only Lisa (*Mugil incilis*) and mojarra rayada (*Eugerres* *plumieri*) retained their proportion of total catch but with less abundance (INVEMAR 2001).

Economic impacts

The economic impacts of the unsustainable exploitation of fish and other living resources were assessed as *moderate*. In the Magdalena Basin the impacts of this concern are most pronounced. During the last 22 years, fisheries production in the basin has reduced from 22 000 tonnes per year in 1977 to 7 562 tonnes per year in 1988, with landings decreasing by almost 90% between 1977 and 1995 (INAP 1996). The income of fishers has, consequently, fallen.

Impacts on human health

The impact of this concern on human health is considered to be *slight*. The overexploitation of fisheries resources is threatening the food security of fishers and their families (CORMAGDALENA 1999).

Other social and community impacts

This concern is causing *moderate* social and community impacts. Fishers are among the most vulnerable to food insecurity.

Conclusions and future outlook

The environmental impact of the unsustainable exploitation of fish and other living resources in the Colombia & Venezuela sub-system was assessed as *moderate*. The overexploitation of the fisheries is having *severe* impacts on the ecology of the sub-system. In the Magdalena River Basin, both freshwater and marine commercial fish stocks are significantly depleted. The "*Bocachico*" (*Prochilodus magdalenae*) fish is seriously threatened due to overexploitation (Rengifo et al. 2002) and environmental changes in the Magdalena River Basin (Mojica et al. 2002). The fisheries industry is facing continued economic hardship due to declining catches, which is also jeopardising the food security of fishing communities and preventing fishers from satisfying their basic needs.

By 2020, the situation is expected to improve due to growing public awareness of environmental issues, the fulfilment of environmental regulations and the provision of economic incentives for conservation and sustainable use.

Global change

The environmental impacts of global change were assessed as *moderate* and the socio-economic impacts range from *slight* to *severe* (Annex II, Scoring tables). Changes in the hydrological cycle and sea level rise are having the most influence out the global change issues in the Colombia & Venezuela sub-system. The frequency of hurricanes in the Caribbean Sea has increased, causing longer and more frequent rainy periods.

Changes in hydrological cycle and ocean circulation

The environmental impacts of changes in the hydrological cycle and ocean circulation are *moderate*. This score is based principally on information from Colombia, published in the First National Communication for the Climate Change Convention. According to INVEMAR (2002), the most vulnerable municipalities to climate change are the coastal cities of Cartagena, Barranquilla and Santa Marta, which already experience recurrent and persistent natural hazards, such as tropical storms, heavy rain, hurricanes and storm surges.

Although there has been some data collected on the occurrence of coral bleaching events, the impacts of climate change are insufficiently assessed. All bleaching events coincide with elevated sea surface temperatures, which may be linked with global climate change. On the Caribbean coast of Colombia the most severe bleaching occurred during an ENSO event in 1982/83 when there was severe coral mortality at several localities, but unfortunately this event was poorly documented (Garzón-Ferreira et al. 2000). There is evidence that the ENSO can affect fisheries productivity in the Caribbean coastal waters of Colombia; 6500 tonnes of crustaceans and 1000 tonnes of molluscs were caught in 1991, whereas in 1993 catches of crustaceans were 2000 tonnes and of molluscs 500 tonnes, and in 1997, 2000 tonnes of crustaceans and only 100 tonnes of molluscs were caught (INVEMAR 2001). At Morrocoy National Park in Venezuela, chemical pollution in conjunction with a climatic and oceanographic anomaly resulted in a severe phytoplankton bloom followed by sudden oxygen depletion, which reduced coral reef cover from 43% to less than 5% between 1991 and 1996 (Garzón-Ferreira et al. 2000).

Sea Level Change

The impacts of sea level change are *slight*. It is evident that a rise in sea level will affect coastal ecosystems and modify the biodiversity of terrestrial and marine ecosystems as a result of various impacts, such as flooding, changes in sea depth, soil salinisation and higher erosion rates. Knowledge of marine and coastal ecosystems is deficient and their adaptation capacity and succession features in response to sea level rise are yet to be determined. Sea level rise will be an additional threat for coral reef ecosystems which are already vulnerable (INVEMAR 2002).

Increased UV-b radiation as a result of ozone depletion

Increased UV-b radiation as a result of ozone depletion is considered to have *slight* impacts. There is a dearth of information on this issue and more studies are needed to determine its impacts.

Changes in ocean CO_2 source/sink function

Changes in the ocean CO_2 source/sink function were assessed to have *slight* impacts. Again, there is a lack of information in order to fully assess this issue. Nutrients discharged in river plumes, such as from the Orinoco River, have increased in concentration, thus increasing primary productivity and, therefore, carbon drawdown in the coastal waters of the sub-system (Corredor & Morell 2001).

Economic impacts

The economic impacts of this concern were assessed as *moderate*. A vulnerability analysis of Colombia (INVEMAR 2003b) revealed that 2% of the national population is settled in lowland areas that are at risk of sea level rise and more than 60% of this population is located in the Magdalena Basin. Additionally, the major urban areas of the sub-system are located along the Caribbean coast and are highly exposed to natural hazards such as tropical storms and storm surges which are expected to increase in frequency and severity in response to global climate change. In Venezuela, most economic activities are located along the coast. Coastline retreat has already been observed on the western coast of Lake Maracaibo at a rate of 8 cm per year, partially due to petroleum extraction. This retreat is putting at risk the petroleum industry, the associated investment and the coastal population. Coastal erosion from a rise in sea level of 2 to 10 cm per decade will also threaten economic activities (Hutme & Sheard 1999).

Impacts on human health

The impact on human health from global changes is considered as *moderate*. It is estimated that 2% of the Colombian population living on the coast could be affected by saline intrusion in aquifers due to sea level rise. In 1997, an official Colombian survey estimated that 11.5% of households rely on groundwater resources that are likely to become affected by salinisation.

Higher temperatures are increasing the vulnerability of some Colombian municipalities to dengue fever (IDEAM 2001). In Colombia there are already 60 000 cases of dengue fever and 70 000 cases of malaria every year, with 70% of the population residing in areas at risk of dengue and 80% at risk of malaria (CORMAGDALENA 2002).

IPCC has identified Venezuela as being exposed to extreme phenomena or events. For example, floods are becoming more severe as a result of climate change and are extremely hazardous for coastal and riparian populations (Székely-Taller 2000). Venezuela is considered to have one of the highest prevalence rates of diseases and infections caused by the fungus *Paracoccidiodes brasiliensis*, which is expected to increase as a result of climate change.

Other social or community impacts

The impact of global change on other social and community issues was assessed as *moderate*, taking into account the size of the affected population and their vulnerability due to poverty. About 62% of the inhabitants of the Magdalena Basin do not satisfy their basic needs. The precarious location of many poverty stricken communities on steep slopes or floodplains in Venezuela exacerbates the impact of extreme events which are likely to intensify in future due to global climate change (Székely-Taller 2000).

Conclusions and future outlook

The impact of the global change concern was assessed as *moderate*. The assessment outlined the impact of ENSO events and the possible effects of sea level rise and changes in water tables, but more data is required in order to enhance the accuracy of future predictions. Global climate change may have other effects on natural resources which are yet to be determined.

The economic, health, and social and community impacts were all assessed as *moderate*. This is based on the vulnerability of the population, industries and infrastructure which are concentrated in coastal areas prone to sea-level rise, flooding and storm activity. Climate change is also expected to increase the prevalence of dengue and other illnesses, particularly in communities suffering from poverty.

In future, the situation is not expected to deteriorate as the cities most vulnerable to climate change are developing protection strategies. The cost of defending the sub-system from climate changes will increase significantly but the impacts are likely to be controlled. Saline intrusion could be mitigated through investment in alternative freshwater supplies, as is already being developed in Colombia. However, it expected that inhabitants of the most affected areas will be forced to migrate which may stimulate social unrest in other areas of the sub-system. It is important that precautionary measures are implemented in the short-term in order to respond adequately to the anticipated environmental changes.

Assessment of the Central America & Mexico sub-system

IMPACT Freshwater shortage

The environmental impacts of freshwater shortage in the Central America & Mexico sub-system were assessed overall to be moderate and the socio-economic impacts range from slight to severe (Annex II). In agreement with the report of CATHALAC (1999), there is a lack of information regarding the impact of pollution on freshwater supplies and about the influence of increased water demand for agriculture, tourism and hydroelectric generation on the future availability of water.

Due to the irregular distribution of water resources in Central America, many people do not have ready access to a source of water supply. In fact, at the beginning of the 21st century, 15 million people did not have an adequate water supply (Tribunal Latino Americano del Agua 2003). Despite some country initiatives to improve water management and reduce pollution loads in the sub-system, the pollution of freshwater supplies remains a major problem. Nearly 60% of the freshwater resources in Central America are located in transboundary watersheds - Hondo River, Belize River, Moho River, Temash River, Sarstoon River, Changuinola River, Coco River, Motagua River, San Juan River, Sixaola River and Panama Canal (CATHALAC 1999).

Modification of stream flow

The modification of stream flow is *severe* in the sub-system. The report of CATHALAC (1999), states that scarcity and excess of water are two of the most limiting factors of soil productivity in the sub-system. Approximately 30% of the more fertile soils are facing these problems. More than 50% of the energy produced in Central America is generated by hydropower (UNEP 2000b). Hydroelectric facilities installed in the south of the sub-system are modifying the river flow regime. Even though the south is more affected than the north, the impact of these facilities influences the whole region.

In Guatemala, freshwater is abstracted predominantly from surface supplies (70% in urban areas and 90% in rural areas). Irrigation systems operated by the State use between 3 and 140 million m^3 per year, but there is no available information for private operators. In some areas of the country, there are significant deficiencies in natural and treated water supplies, which invoke conflict between irrigation users (FAO 2000). In Costa Rica, 75% of freshwater resources were catalogued as highly vulnerable in 2001, especially surface and spring waters. According to the GEO 3 report (UNEP 2002), a quarter of the total population will have an insufficient water supply by 2025 due to overabstraction. Most of the rain in Mexico falls during four months of the year and 50% of water runoff comes from the southeast and the coasts of the territory. Water is, therefore, not always available or distributed when and where it is most needed.

Pollution of existing supplies

The pollution of existing supplies is having *moderate* impacts. According to the *Vision on Water, Life and the Environment for the 21st Century* by CATHALAC (1999), water quality is only controlled in less than 5% of rural water supply systems in Central America. As a consequence, 20 million Central Americans consume water of questionable quality. In Panama, only 35% of the rural population has access to treated water (Robles 1992). More than 79% of sewage water in Central America is released into water bodies without any treatment and less than 5% of the drinking water is treated (CCAD 1998 in CATHALAC 1999). It is estimated that the Central American region produces over 19 000 metric tonnes of waste daily, of which only 50% is collected; the rest is dumped haphazardly and contaminates water bodies including rivers, lagoons, bays or coasts. Groundwater, which supplies a large proportion of urban centres, is increasingly contaminated due to the inadequate disposal of domestic and industrial wastewater. Water supplies are also being polluted by nitrates and bacteria originating from septic tanks (CCAD 1998 in CATHALAC 1999).

Despite relatively abundant water resources, Costa Rica is often unable to satisfy demand for potable water in urban centres, partially due to water pollution. The proportion of domestic and industrial wastewater treated in Costa Rica is one of the lowest in Latin America. Additionally, 77% is treated in septic tanks and cesspools which use chemicals which degrade aquifers. Moreover, 80% of the national water supply systems lack permanent disinfection systems. The salinisation of aquifers is commonly associated with tourism developments (Costa Rica 2001).

In Mexico, tourism generates large quantities of wastewater, the management of which has become problematic. It is often discharged directly into lagoons and bays such as Chetumal Bay and Nitchupé Lagoon in Cancun. There is data confirming that temperature, floating solids and phosphorus are at or below permitted levels, but grease, oil, total suspended solids, BOD and faecal coliforms are above. The quality of water for recreational activities is not optimal. In Chetumal Bay, water supply quality has deteriorated due to contamination by heavy metals, organoclorides and faecal coliforms. In a few years, Chetumal Bay is predicted to be highly polluted with grave consequences for human health.

Further, the uncontrolled use of pesticides and fertilizers in Central America has become a major source of pollution. It is transported by surface runoff from agricultural areas, mainly in areas of intensive farming, into freshwater supplies (CATHALAC 1999).

Changes in the water table

Based on evidence that several wells have experienced salinisation as a result of aquifer drawdown, changes in the water table were assessed as *slight*. Groundwater is overexploited to satisfy urban, industrial and irrigation demand. In Mexico, aquifers are also overexploited, despite abundant water availability of about 4 977 m^3 per person, which is high in comparison with countries of Europe. One third of the total water exploitation in Mexico comes from groundwater. In Quintana Roo, the volume of water extracted is twice the recharge rate capacity. There is evidence of changes in the water flow in the phreatic layer at Río Hondo and Chetumal Bay. Water scarcity is a problem for the country, since the tourism sector requires large quantities of water. The Mexican Commission of Freshwater and Sewage estimated that the water supply for Chetumal City will only last for another 50 years. In Costa Rica, approximately 20% of its 650 aquifers are overexploited.

Economic impacts

The impact of freshwater shortage on economic sectors in the Central America & Mexico sub-system is *moderate*. Guatemala and Costa Rica are facing water problems as they are failing to increase water supply in order to meet increasing demand for domestic and production purposes.

Impacts on human health

There have been *moderate* health impacts as a result of freshwater shortages. Rural areas are the most vulnerable as access to medical care is more restricted. Dengue fever and cholera are prevalent in these areas, their frequency directly related to seasonal conditions. Communities have established treatment systems for drinking water, but personnel receive insufficient training in order to operate the systems efficiently. Given that only 35% of the rural population in Panama have access to treated water, the majority of the country's population are exposed to water-related diseases (Robles 1992).

Other social and community impacts

Other social and community impacts of freshwater shortage are considered as *severe*. There is a growing imbalance between water demand and availability in Costa Rica resulting in frequent freshwater shortages. This is provoking conflict between water users (Costa Rica 2001). Freshwater shortages are often the result of supplies being polluted.

Conclusions and future outlook

Overall, the freshwater shortage concern was assessed as having *moderate* impacts in the Central America & Mexico sub-system. The modification of stream flow and the pollution of supplies are the most severe issues. The impact of the concern on the economy and health of the sub-system was regarded as *moderate*, while there are *severe* other social and community impacts. These scores are justified by the disequilibria between water availability and demand, the prevalence of diseases transmitted via untreated water and the provocation of conflicts among water users during periods of water scarcity.

The situation is unlikely to improve in future as population growth and economic development will continue to increase the demand for water. Some countries in the sub-system are developing, or have developed, freshwater management strategies as a national priority.

IMPACT Pollution

Overall, pollution is inflicting *severe* environmental impacts in the Central America & Mexico sub-system, while its socio-economic impacts range from *slight* to *severe* (Annex II, scoring tables). The marine environment has been adversely affected by land-based sources of pollution such as agricultural runoff and solid wastes, causing the deterioration of water quality (UNEP 2002). River basins and coastal areas are closely inter-linked by physical and biological processes, particularly the fluxes of water, sediments and pollution. Coastal and marine zones serve invariably as receptors of riverine pollution, such as suspended sediments, and are affected by changes in the river basin hydrological regime.

Microbiological pollution

The impacts of microbiological pollution in the sub-system are *slight*. In general, there is relatively limited fish mortality or migration caused by microbiological pollution in the sub-system. However, fish mortality attributed to water pollution has been reported in Belize, but this is not supported by scientific documentation. In Mexico, inadequately treated sewage is discharged into Chetumal Bay, resulting in widespread microbiological pollution. Wastewater management and regulations are weak and the coastal population are unawareness of the negative consequences of the pollution.

The San Juan River Basin contains a number of large cities - Masaya, Granada, Boaco, Juigalpa and San Carlos in Nicaragua, and Quesada City in Costa Rica - which discharge their wastewaters into the Basin's water courses. Some of these cities have sewage treatment systems, whereas the rural population lacks basic sanitation services. The problems of wastewater management are exacerbated by the non-planned development of human settlements, which are not covered by basic sanitation services.

Eutrophication

The impacts of eutrophication are *moderate*. There has been a proliferation of algae in the Hondo River-Chetumal Bay Basin and algal growth has increased on the coral reefs of Belize due to the discharge of sewage containing high concentrations of nutrients. Eutrophication is also impacting sea grasses; they now host more epiphytes and their leaves have become shorter and more fragile.

Chetumal Bay contains high concentrations of organic material and marine algae are highly prevalent. Herrera-Silveira et al. (2002) observed the trophic characteristics of different zones in Chetumal Bay in terms of the different nutrients and Cl-*a* at different periods of the year. These results showed that there is a short-term high risk of eutrophication in more than 50% of Chetumal Bay´s surface.

In the San Juan River, studies made by the CIRA/UNAN indicate that the maximum amount of biomass expressed as chlorophyll-*a* was observed in the river's delta (UNEP 2000a). The delta was characterized as having the highest total phosphorus concentrations and above average nitrate concentrations. As a result of runoff containing nitrogen fertilizer, the flora has multiplied causing an ecological imbalance and a high consumption of oxygen with negative consequences for the aquatic ecosystem. Increasing amounts of fertilisers are applied to compensate for the reduction in the natural fertility of soils caused by overcropping (UNEP 2000a).

Chemical pollution

The impact of chemical pollution on the environment is *severe*. There is evidence of high concentrations of organochlorides originating mainly from agro-chemicals used in sugar cane and banana production. High concentrations of pesticides and heavy metals have also been recorded in the basins of the sub-system and unknown quantities of various agro-chemicals are also believed to impact the marine environment. In agreement with the *Vision on Water, Life and the Environment for the 21st Century* (CATHALAC 1999), Central America is the largest user of pesticides per capita in Latin America and, as a result of the current economic model, its use will increase further.

Pesticides and organic waste, principally from coffee production, are the most common source of water pollution in Honduras. In Nicaragua, the pollution of aquifers by non-biodegradable pesticides has been observed, originating primarily from traditional cotton crops. Most urban residual water is not treated in Guatemala; pollution levels are unknown since there is no institution responsible for water quality monitoring (FAO 2000). In San Juan Basin, the use of inappropriate production technologies and the intensive application of agrochemicals on certain crops and areas have impacted the quality of water resources, but this has been barely studied (OAS/UNEP 2002). The release of untreated municipal and industrial residual wastewaters as well as solid wastes is also impacting the ecosystems of the San Juan River Basin. Sugar cane production in the sub-system results in pesticide and fertilizer contamination, many of which are forbidden internationally, such as DDT. These pollutants have gradually entered the aquatic environment via runoff processes and leaching into groundwater.

Studies made by Wesseling & Castillo (1992) show that Panama use the largest quantities of pesticides per inhabitant and per cultivated hectare in Central America. Between 1990 and 1994, the annual average demand for pesticides was approximately 7.8 million kg gross weight. In agreement with Díaz & Lamota (1998), studies in Panama indicate the presence of pesticide residuals in bottom substrates, fishes and crustaceans. Banana plantations at Bocas del Toro and Chiriquí are in close proximity to the habitat of manatees (*Trichechus manatus*) where runoff containing agro-chemicals from the plantations enters the sea. Approximately 22% of the 229 samples taken in different crop areas in Panama have residuals of forbidden pesticides, such as DDT, dieldrin and HCB.

In Chetumal Bay, mass catfish mortalities have been recorded that are attributed to contamination from toxic sediments and residuals transported by Río Hondo which originate from the runoff of agrochemicals and pesticides in the river's catchment area. Concentrations of organochloride pesticides have decreased in Chetumal Bay recently. In 1993, the concentration of organochloride pesticides was about 400 ng/g, increasing to 2 000 ng/g in 1994, but in 1995 it had fallen to 400 ng/g and in 1999 was about 0 ng/g (Magnon 2002, García-Ríos & Gold-Bouchot 2002). In 1996, about 30 000 *Ariopsis assimilis* were recorded as dead; the fish had high levels of heavy metals in their organs and tissues. Studies also revealed heavy metals in the blood and bones of manatees, possibly derived from seagrass consumption.

Suspended solids

The environmental impacts from the issue of suspended solids are *severe*. The sediment loads of water bodies in the Central America & Mexico sub-system have increased due to greater erosion in river basins caused by deforestation, the expansion of agriculture and livestock farming, and the development of settlements. It is estimated that rivers from Central America and the Antilles supply 300 x 10^6 tonnes per year of suspended solids into the Greater Caribbean Region (PAC- PNUMA 1994). Suspended solids have also increased due to natural hazards, such as hurricanes and flooding.

In Costa Rica, aerial surveys in different years have observed suspended solids coming from the middle reaches and headwaters of the San Juan Basin (predominantly from the San Carlos and Sarapiqui rivers), that have intensified sedimentation downstream and occasionally formed sand islands, thus impeding navigation. The suspended solids in this case originate from soil erosion caused by the construction of water infrastructure such as dams, small enterprises and mining development (Costa Rica 1997).

In the San Juan River Basin, shared by Nicaragua and Costa Rica, extensive soil erosion has been caused by agricultural development in inappropriate locations and intensive deforestation, with a national deforestation rate greater than 150 000 ha/year in Nicaragua and 18 500 ha/year in Costa Rica (Allen 2001). In addition to the degradation of soils and decreased agro-productivity, the increased erosion causes greater sedimentation and turbidity in the aquatic environment. Studies made by the CIRA/UNAN indicate that higher turbidity in the San Juan River is preventing the penetration of light, which is inhibiting phytoplankton production (UNEP 2000a). Low primary productivity and the reduced amount of biomass expressed as chlorophyll-*a* were observed in its minimum levels in the River Sarapiquí. In the coastal zone, sedimentation degrades the ecosystems; smothering corals and decreasing the reproduction rate of marine species, many of which are commercially important. Sedimentation is a transboundary problem with accelerated erosive processes within the catchment of the San Juan Basin causing impacts downstream and in the coastal zone (UNEP 2000a).

Solid wastes

The environmental impact of solid waste pollution is considered as *moderate*. Solid wastes are particularly present in tourist areas and along the transit paths of ships. Settlements in the Hondo River Basin often dispose of solid wastes inappropriately. For example, wastes are often dumped in wetlands to reclaim land (CONABIO 2003). Marine floating debris can be derived either from wastes discharged by ships and fishing vessels, solid wastes washed into the sea from coastal settlements and transported by inshore currents, or the discharges of rivers especially during rainy periods when river flows are greatest. Marine solid waste consists of mainly plastic bags, tar balls, fishing nets and boat ropes (PAC-PNUMA 1994). There are no records of solid wastes affecting shrimp aquaculture or fishing.

Thermal pollution

There is a lack of information concerning thermal impacts. Because, however, there are isolated reports of thermal pollution, the issue was assessed as *slight*. For example, sugar cane crops grown close to rivers in Belize cause fish mortality due to oxygen depletion and higher temperatures.

Radionuclides

There are no known impacts of radionuclides in the sub-system. Studies in Panama and Costa Rica found that radionuclide levels were of no concern.

Oil spills

Oil spills in the Central America & Mexico sub-system are having *severe* environmental impacts. The spills occur primarily in the Panama Canal and in the Caribbean Sea. An oil pipeline traverses the transboundary basins from Honduras to Mexico, Belize and Guatemala which could potentially result in oil spills and leakages. Additionally, hydrocarbons from Venezuela are transported by currents to the sub-system. Oil residues are also released by cruise liners when they wash their tanks at sea and are often transported to the sub-system's beaches.

Panama is at a high risk of oil pollution due to its importance as a transport route; approximately 13 000 ships and 70 million tonnes of oil pass through the Panama Canal each year. A significant number of accidental spills occur when transporting and transferring oil in terminals (Guzmán & Jiménez 1992). In Panama, in addition to occasional larger spills, a significant amount of hydrocarbons go directly into the sea during routine operations (Jackson 1989). At the only refinery in Panama there have been two major oil spills. The largest was in 1986 when 8 million litres of raw petroleum was released into Bahía Las Minas (Jackson 1989), affecting 8 km of coast and causing mangrove and coral reef mortality.

Economic impacts

The impact of pollution on the economic sectors of the Central America & Mexico sub-system is *severe*. The tourism, agriculture and fisheries sectors have been particularly affected by pollution, especially in Costa Rica, Nicaragua and Belize. Tourism, one of the most important economic sectors in the sub-system, is impacted by the loss of aesthetic and recreational values, and the health risks caused by pollution. Any reduction in tourists has a direct influence on the economy of the whole region. Studies in Quintana Roo, Mexico, emphasise the importance of eliminating pollution in Chetumal Bay for the success of tourism in the area (Mendoza Gómez et al. 2002, Briceño Millán & Rivas Hernández 2002, Rosado-May et al. 2002).

In Costa Rica, over the last decade there has been a reduction in fisheries production due to the degradation of aquatic ecosystems by pollution and other factors. In the Nicoya Gulf (Costa Rica) catches have declined as a result of the discharge of untreated wastewater, costing the fisheries sector an estimated 183 million USD in 2000. The imminent shortage of potable water in Costa Rica due to the pollution of supplies and increasing demand will necessitate significant investment in treatment facilities (Costa Rica 2001, Costa Rica 2002).

Impacts on human health

The impacts of pollution on human health were considered to be *severe*. Near sugar cane plantations, mutations and a higher rate of miscarriages and sterility in young women have been registered, which has been attributed to the application of illegal agro-chemicals. An assessment of pesticide use in Bocas del Toro, Panama, concluded that the population located around three banana plantations is exposed to 180 899 kg/year of pesticides and 632 171 kg/year of fertilizers. Among the most common illnesses reported in the area are diarrhoea and vomiting. Protective measures are only used by the persons who are directly exposed to pesticides (Gaitán 1998).

In Chetumal Bay, the consumption of contaminated fish is having health implications for the population of Quintana Roo, México, where most of the fish are sold. Bioaccumulation of heavy metals in the tissue of catfish (*Ariopsis assimilis*) has also been reported (García-Rios & Gold-Bouchot 2002). The poor water quality of Chetumal Bay and the adjacent river system is severely affecting human health with frequent cases of eye infection, gastrointestinal and dermatological illnesses. During the cultivation of sugar cane, contact with chemical products has caused new born malformations, mutations and miscarriages. Sewage discharged into the Bay, which contains microbiological pollution, is spreading diseases such as gastroenteritis, typhoid, amoeba, parasites and cysticercoids (Canché 2002).

Other social and community impacts

The impact of pollution on other social and community issues is *moderate*. The environmental quality of the sub-system has decreased as a result of pollution, causing a loss in aesthetic and amenity value. The National Water Laboratory of IICA in Costa Rica (2001) stated that only 58.3% of the national population is supplied with treated water after strict monitoring methods. Among the principal aqueducts, only 19.7% have permanent disinfecting equipment, which represents a risk for the population with low incomes (Costa Rica 2001).

Conclusions and future outlook

In the Central America & Mexico sub-system the overall environmental impacts of pollution were assessed as *severe*. The most important issues are chemical pollution, suspended solids and oil spills. Pollution directly influences the GIWA freshwater shortage concern as many water sources have been contaminated and are unfit for human consumption.

Pollution inflicts *severe* economic and health impacts. The tourism industry has lost income and fisheries production has been reduced in Costa Rica and Chetumal Bay as a result of pollution. Chemical pollution was considered to have the highest relative weight of impact due to the health impacts associated with the use of agrochemicals and the difficulties addressing this form of pollution. The contamination of fisheries products has affected the health of the sub-system's population. Low income groups are the most vulnerable to water-related diseases as they are forced to consume untreated water.

By 2020, it is anticipated that the governments of the region will control and regulate activities which are currently generating pollution so that the situation will improve. For example, it is envisaged that laws governing natural resource planning and protection will be adopted, environmental impact assessments will become statutory and new cleaner technologies will be developed. But this may not be the case for all countries, for example, in Panama water regulations are particularly weak. The main deficiency in water law in sub-system 3c is regarding coastal and marine regulations.

Habitat and community modification

The overall environmental impacts of habitat and community modification in the Central America & Mexico sub-system are *severe* while socio-economic aspects range from *slight* to *severe*.

Loss and modification of habitats and communities

The impacts of the loss and modification of ecosystems are *severe*. There is evidence that marine habitats, especially mangrove swamps, have been modified and destroyed as a consequence of human activities in the coastal zone (UNEP 2000a). Continued population growth is putting increasing pressure on the ecosystems of Central America.

The survival of Sarstoon-Temash's unique wetland and mangrove complex owes a great deal to the careful management practices of the local indigenous people who have throughout history depended on its resources. The area's physical isolation from the national centres of economic and infrastructure development is also a major contributing factor in its preservation. Today, these "natural protections" are being weakened with the national park's exceptionally untouched status now under acute and serious threat (The World Bank 2000b):

- A large logging concession that put great pressure on the forest resources around the park is currently being renegotiated, both in terms of size and location, because of its ecological impacts. However, a number of small concessions are being issued where individuals often willingly/unwillingly violate the Park's protection because it is not yet demarcated, boundaries exist only on paper and monitoring of logging activities is insufficient.
- On the Guatemalan side, all forest vegetation along the border has been replaced by grassland. Villagers around the Park found ample evidence of commercial hunting in the Park (mainly for Iguana).
- Mining of natural resources: A gravel and sand quarry is located in the area. Renewed interest (given current oil market prices) has been expressed in an oil exploration concession, issued in 1998 to an American Company for the whole southern part of the Toledo district. On the list of potential exploration is one site within the Park's boundaries in the Black Creek area (a wetland) and close to Crique Sarco, one of the villages involved.
- A number of small-scale farmers living on National lands as what is called "long term occupants" adjacent to the Park threaten its integrity through agricultural encroachment and overuse of the forest resources.

Coral reefs are affected by climate change which is causing bleaching and mortality, destructive fishing practices, poor land-use practices and unregulated coastal development (Kramer et al. 2000). In Panama, coral reefs are under stress and, on the coast of the Caribbean island of Kuna-Yala, the coral population structure changed during the 1980s as a result of traditional practices of the Kuna community. Coral cover decreased by 79% between 1970 and 2001 while the indigenous population increased by 62%. These practices included the construction of a wall, 20 km long and 16 000 m^3 in volume, and the reclaiming of land from sea using coralline material to increase the surface area of the island by 623 ha. As a consequence, coastal erosion has increased since the protective function of the coral reef has been removed and the sea level has been rising by 2 cm per year (Guzman et al. 2003). According to Jackson et al. (1989), mangroves and coral reefs in Bahía Las Minas were severely affected by the spill of 8 million tonnes of raw petroleum.

In Cancun and Cozumel in Quintana Roo, Mexico, coastal ecosystems and communities are affected by urban expansion and the concentration of economic development along the coast (UNEP 2002). The Hondo River is impacted by deforestation in its watershed, pollution from aquaculture, livestock farming (Sepulveda 1998), the discharge of untreated domestic and industrial wastewater, and agro-chemical runoff from arable land. The wetlands are threatened by road construction, dredging activities, deforestation and intensive agriculture. Soil erosion in the Hondo River Basin is intensified by deforestation and the construction of tracks that allow farmers to access arable lands. Continued agricultural development in the catchment (sugar cane, annual crops, milpa and pasture) increases the potential for agricultural runoff and reduces indigenous vegetation cover.

The aquatic ecosystems of the Hondo River Basin were altered by the introduction of alien species including Tilapia (*Oreochromis mossambicus* and *O. niloticus*) and by the use of poisons and non-selective traps by fishers (CONABIO 2003). The intensive maritime traffic, particularly through the Panama Canal, also introduces alien species that are contained in cargo or attached to ship hulls, which can become invasive. Additionally, there are reports in Costa Rica of illegal hunting and trade in endangered flora and fauna (Costa Rica 2001). Consequently, populations of amphibian species have decreased, including gold toad (*Bufo periglenes*) and clown frog (*Atelopus sp.*). In some cases, the introduction of foreign species threatens indigenous species which have a high cultural value. For example, the guapote has declined since the introduction of the tilapia.

The coral reefs in the Caribbean part of Central America are disturbed with increasing frequency and intensity in recent years. Before 1998, the main disturbances were hurricanes, coral diseases and, more recently, mass coral bleaching (1995 and 1997). During this first well-documented mass bleaching event in Belize, 53% of coral colonies were bleached, although only 10-13% of corals died. These impacts were also observed in Cayos Cochinos, Honduras, where 73% of scleractinian corals and 92% of hydrocorals were bleached and slightly higher mortality was reported. In 1998, there was intense bleaching (>50% colonies) starting in Yucatan in August/September (particularly affecting *Agaricia tenuifolia* colonies) followed by reports from Belize in September (*A. tenuifolia* and *Millepora* spp.) and Honduras in September/October. Surveys indicated that the 1998 bleaching event affected the entire Mesoamerican Barrier Reef region and was possibly more severe than the mass bleaching in 1995, having effects 10 months after the initial bleaching (up to 44% of corals were still bleached). Specific findings included a regional average of 18% coral mortality on shallow reefs; 14% on fore reefs; and up to 75% coral mortality in localized patches and barrier reefs in southern

Belize. The species with the highest mortality were *A. tenuifolia* (>35%), *M. complanata* (28%) and *Montastrea annularis* (25-50%). There was a high incidence of black band disease following the bleaching event on Belize shallow reefs and white plaque in Honduras and Belize. White band disease has devastated *Acropora* populations since the early 1980s including many areas in Belize, where they constitute the primary shallow reef builders. Additionally, the 1983 loss of the grazing sea urchin *Diadema antillarum* has also caused damage to the region (Kramer et al. 2000). The principal anthropogenic threats to coral reef biodiversity affecting the countries of sub-system 3c are given in Table 5.

Table 5 Principal anthropogenic threats to coral reef biodiversity

Theats	Mexico	Belize	Guatemala	Honduras	Nicaragua
Agricultural run-off		✔	✔	✔	✔
Aquaculture development		✔	✔	✔	✔
Coral extraction (curio trade)	✔	✔		✔	✔
Deforestation	✔	✔	✔	✔	✔
Destructive fishing	✔	✔	✔	✔	
Diving activities	✔	✔		✔	
Dredging	✔	✔			
Fish extraction	✔	✔	✔	✔	✔
Garbage pollution	✔		✔		
Heavy metal pollution			✔		
Industrial activities	✔	✔	✔	✔	✔
Maritime activities	✔	✔	✔	✔	✔
Oil pollution		✔	✔	✔	
Over-fishing	✔	✔	✔	✔	✔
Sedimentation/siltation	✔	✔	✔	✔	✔
Sewage pollution	✔	✔		✔	✔
Tourism activities	✔	✔		✔	
Urban development	✔	✔	✔	✔	✔

(Source Kramer et al. 2000)

Natural hazards have an important impact on habitats, including beach loss, erosion and sedimentation. Hurricanes have impacted coral reefs in localized areas of Mexico and Belize with varying degrees of recovery. Results of a large-scale survey assessing the impact of Hurricane Mitch (1998) on the Mesoamerican Barrier Reef system at 151 sites found: (i) the greatest damage was to the Belize barrier (29% of shallow corals and 5% of fore corals damaged); (ii) Guanaja (22%) had more damage than Roatan (13%), Utila (8%), and Cayos Cochinos (5%); and (iii) almost 80% of corals were damaged at NE Globers Reef, the highest in the region. Localized shallow reefs in Belize and Honduras had 50-70% of corals damaged; *Acropora tenuifolia* and *M. complanata* were most affected. There was a major reduction of reef structure on many shallow reefs (Kramer et al. 2000). Habitats in the San Juan Basin have been damaged by at least three hurricanes that caused flooding, soil erosion, changes in river beds, infrastructure damage, human injuries and even death. Other natural phenomena have also degraded the ecosystems, such as desertification caused by the ENSO and seismic activity which can change the riverbeds. For example, the Río Tipitapa connects the Managua and Nicaragua lakes, but following an earthquake in the last century the level of the riverbed rose resulting in the obstruction of the river.

Wetlands in the San Juan River Basin are highly valuable ecosystems that regulate the hydrological cycle and provide nourishment and refuge for hundreds of species of wildlife, including migratory birds. Vast areas of wetland have been drained for agriculture or human settlements. Aerial photos of Caño Negro show that the area of water has diminished over time because of drainage for agriculture and increased sedimentation in the wetlands.

Economic impacts

The impacts of habitat modification on the economic sectors of the Central America & Mexico sub-system are *severe*. The tourism sector has lost income as a result of habitat modification; in Nicoya (Costa Rica), for example, at an estimated cost of 12 million USD per year (Costa Rica 2001). The modification of ecosystems in the Hondo River/Chetumal Bay Basin have impacted the economy of the region by causing a range of problems including environmental migration, increased health costs and reduced productivity of soils. The loss of fisheries habitat has reduced fish catches, thus impacting the fisheries sector. A reduction in the recreational and aesthetic value of the basin's environment has adversely affected the tourism industry. The region's Manatee population has been depleted, with a subsequent loss of natural attractions for tourists. In the San Juan Basin, the loss of ecosystems, particularly coral reefs and mangroves, reduces the natural protection of the coast from erosion processes that affect coastal settlements and infrastructure. As a consequence, the population will be more vulnerable to sea-level rise and extreme weather conditions in the future.

Impacts on human health

Although it is difficult to accurately assess the impact of habitat modification on human health because no direct effects have been documented, the concern was considered to have *slight* impacts. In Chetumal Bay, the limited capacity of the ecosystems to recover from human activities has led to a persistent deterioration in the environmental quality of the area, which has reduced the standards of living for the local population. They now struggle to meet their basic needs and the conditions are suitable for the transmission of diseases through direct contact with water during recreational activities. Furthermore, there has been a reduction in the access of the population to medical services and prevention programmes.

Other social and community impacts

Other social and community impacts are *severe* as indigenous communities are significantly affected by habitat modification. For example, in the Sixaola Basin, a reduction in the productivity of soils due to deforestation and the expansion of banana and plantain plantations has forced indigenous communities to migrate. The Bribis and Cabecares ethnic groups have lost some of their cultural identity as they have lost their lands (Dávila 2000). In Belize, the expansion of large-scale agriculture is expected to result in the migration of additional labourers into the southern region where they will practice agriculture on marginal and highly unstable soils. This, in turn, will push the agricultural frontier further into the interior and encroach on reserves and protected areas, thus leading to more habitat transformation, reductions in biodiversity and increased rates of erosion and sedimentation (The World Bank 2000b).

Conclusions and future outlook

The environmental impact of habitat modification is *severe* as human activities have significantly affected forest, swamp and coral ecosystems. Policy makers have not considered the environmental costs of their development strategies, largely due to a lack of understanding of environmental issues. Regional authorities, however, are now addressing this issue and beginning to restore habitats and reverse degradation trends.

The economic impacts of habitat modification are *severe* as the aesthetic and recreational appeal for tourists has been reduced, which has hindered the expansion of the tourism industry in the sub-system. The impact of this concern on health was considered to be *slight* due to a lack of documented evidence. Finally, the social and community impacts are *severe* due to forced migration and a loss of the cultural identity of indigenous people.

It is expected that, in 2020, the expansion of the tourism industry will have a less significant impact due to the development of eco-tourism. Additionally, sustainable actions and habitat restoration will have government support.

Unsustainable exploitation of fish and other living resources

Overall, the environmental impacts of the unsustainable exploitation of fish and other living resources are *moderate* and the socio-economic impacts range from *slight* to *moderate*. The most severe issues are overexploitation due to the overcapacity of the fishing fleet and the use of destructive fishing practices.

Overexploitation

Overexploitation is *severe* in the sub-system, particularly in the lobster and mollusc fisheries. A large proportion of the total catch supplies the tourist and international market. In Belize and Costa Rica, some fish stocks are exploited above their sustainable level. In a study by Sullivan and Bustamante (1999 in UNEP 2000b), overexploitation was identified in 34 out of the 51 local production systems studied.

Over the last ten years there has been a reduction in catch levels in Costa Rican waters due to the depletion of fish stocks as a result of overexploitation and pollution. Although many sharks are caught as by-catch, they are also deliberately hunted as a result of the decline of traditional coastal fisheries, commercial diversification, the exploitation of offshore fisheries and market demand. The coastal fishery is continuously in decline, including shrimps. Additionally, lobster (*Panulirus argus*) catches, which represented 2% to 4% of the Costa Rican catch, decreased from 271 114 tonnes in 2000 to 38 613 tonnes in 2001 (Costa Rica 2001).

Throughout the Caribbean part of Central America, queen conch (*Strombus gigas*) and spiny lobster (*Panulirus argus*) are overexploited due to their economic, social and cultural value. Additionally, commercial fish stocks have declined due to illegal fishing, the weak enforcement of fisheries regulations, and the lack of transboundary fisheries management. In Mexico, extensive overexploitation in the late 1970s caused conch stocks to collapse, leading to fishery closures in Yucatan (1988) and seasonal closures in Quintana Roo (1991). In Belize, lobster constitutes the largest and most important fishery, but years of overfishing have reduced both lobster and conch populations. The populations are skewed towards smaller lobsters, while many conch are of a legal size but not sexually mature. However, the overall status of lobsters and conch is unknown. Historically, Honduras caught the most lobster in the sub-system but catches have drastically declined as there are no regulations to prevent the overexploitation of the lobster fishery. Large lobsters are rare and populations of conch and lobster are only found in deeper waters. In Nicaragua, little is known about conch stocks; there are no regulations to conserve lobster or conch and illegal fishing by foreign vessels is the greatest threat (Kramer et al. 2000). Landings of the main commercial marine resources in 1998 are given in Table 6.

Table 6 Landings of conch, lobster and fish in Central American countries.

Country	**Conch** (tonnes)	**Lobster** (tonnes)	**Fish** (tonnes)
Belize	252	502	111
Guatemala	-	-	213
Honduras	490 (1996)	306	160
Mexico	3 293	613	93 291
Nicaragua	162	3 729	4 088

(Source: Kramer et al. 2000)

Excessive by-catch and discards

The assessment found that the issue of excessive by-catch and discards has *slight* impacts. However, there is insufficient data to analyze this issue adequately. UNEP (2000b) stated that one of the factors affecting coastal and marine fisheries in the sub-system is accidental by-catch and discharges, including turtles, marine mammals, marine birds and other small species fundamental to the sub-system's ecosystems.

Destructive fishing practices

Destructive fishing methods are inflicting *severe* impacts. Habitats are degraded by the employment of *trasmallo* (fixed fishing nets in shallow waters), illegal nets, trawling, dynamite and poison. There is no data to substantiate this score since most of these practices are illegal and, therefore, difficult to monitor. There is also no documentation about which species are most affected by these practices.

In Mexico, there are reports of fishers using poison and non-selective traps (CONABIO 2003) and queen conch collected using scuba and hook techniques. In Belize, illegal fishing is widely practiced including the use of baited gill nets to harvest lobster, which also damage reefs (Kramer et al. 2000). Today, the shark bull is rarely found in Lake Nicaragua or the San Juan River; this is believed to be attributed to the deterioration of the ecosystem which supports it due to the employment of destructive fishing methods.

Decreased viability of stocks through pollution and disease

The issue of decreased viability of stocks through pollution and disease is considered to have *slight* impacts. There are some reports about different diseases, such as *taura* in aquacultured shrimps in Belize, but there is no evidence of how wild stocks are affected.

Impact on biological and genetic diversity

The impact on biological and genetic diversity was assessed as *slight*. There is evidence that alien species have been introduced, particularly in Belize, but there is no knowledge of how these species are impacting indigenous species.

Economic impacts

The economic impacts of the unsustainable exploitation of the fisheries and other living resources are *slight*. Many communities in the sub-system are highly dependent on the fishing industry and, therefore, have been affected by the decline in catches. Further, due to the reduction in catches, prices have risen, making them less affordable for low income population groups. In Costa Rica, the trend over the last 10 years has been to increasingly exploit the offshore fishery because of decreasing coastal catches (Costa Rica 2001). This situation suggests that the economic impacts of overfishing are masked by the income from newly exploited offshore pelagic fisheries replacing the lost income from the coastal fisheries. This is not a solution for the fishing industry in the long-term.

Impacts on human health

The impact on human health is estimated as *slight*, but there is a lack of data to substantiate this score.

Other social and community impacts

This concern has *moderate* other social and community impacts. The structure of the economy has changed, with a shift of importance from the fisheries sector to the tourism sector. Consequently, the number of people employed in the fisheries sector has decreased. Offshore fishing in Costa Rica is beyond the technical and financial capabilities of artisanal fishers who are forced to rely on the depleted coastal fishing resources (Costa Rica 2001).

Conclusions and future outlook

Overall, the unsustainable exploitation of fish and other living resources was considered to have *moderate* environmental impacts, with the major issues identified as overexploitation and destructive fishing practices. The economic impacts are *slight* due to an expansion in the offshore fisheries compensating for reduced coastal catches. There is a lack of information on the impact on human health. The impacts on other social and community issues are *moderate* as fishers are being forced to change their livelihood strategy in response to the downturn in the coastal fisheries sector.

Commercial fishing resources have been mainly affected by overexploitation, but also by other factors including habitat modification. The fisheries sector will be subject to tighter regulations and stronger enforcement in the near future in order to increase the sustainability of fish stocks. If fisheries management instruments are not fully implemented or enforced, overexploitation will continue and fishers will be forced to exploit other species as the current commercial stocks - both inshore and offshore - become exhausted.

IMPACT Global change

The environmental impacts of global change on the Central America & Mexico sub-system are *moderate* while its socio-economic impacts were assessed as *moderate* to *severe* (Annex II). Changes in the hydrological cycle and sea-level change have caused *moderate* impacts based on the increased frequency of natural hazards, such as flooding, and wetter conditions in the Caribbean and a dryer climate in the Pacific.

Changes in hydrological cycle and ocean circulation

Studies (CRRH 1996 in CATHALAC 1999) on the potential regional affects of climate change suggest that variations in precipitation patterns and an increase in sea level will impact lowland aquifers. Coastal communities of the Caribbean watershed will be the most affected as groundwater is an important source of water. Increased climatic variability will also affect agricultural patterns, especially rain-fed agriculture (CATHALAC 1999).

The sub-system's coastal zone has been impacted by hurricanes throughout history. Hurricane Gilbert (1988) caused severe damage to shallow reefs along the Yucatan Peninsula; Hurricane Haiti (1961) and Greta (1978) were two of the most significant storms to hit the central coast of Belize; and Hurricane Fifi (1974) devastated the coast of Honduras. Then there was Hurricane Mitch, a category 5 hurricane with sustained wind speeds of over 250 km per hour battering the Caribbean coast and parts of Honduras, Nicaragua and Guatemala in late October to early November 1998. The hurricane denuded pine and mangrove forests and reduced coral cover by 15-20% off the coast of the Yucatan Peninsula to Honduras and by as much as 75% in parts of Belize (Kramer et al. 2000).

According to the GIWA regional experts, the coastal zone of Quintana Roo is vulnerable to global changes as a result of urban and tourism developments located in unstable coastal areas that are often prone to subsidence; its location on the path of hydro-meteorological phenomena; and because the removal of beach material has reduced the coastline's natural sea defences. These factors have accelerated erosion processes around Chetumal Bay, stimulated coastal landslides and increased the severity of natural events such as Hurricane Gilberto.

Sea-level change

The impact of sea-level rise in sub-system 3c is *moderate*. In Mexico, there is evidence of coastal erosion and the redistribution of ecosystems associated with sea-level rise, but more scientific studies are needed. According to the regional experts, Chetumal Bay is being significantly eroded in various areas as a result of sea-level rise, and in Costa Rica marine transgression is inundating lowland coastal areas and increasing the area of tidal floodplains.

Increased UV-b radiation as a result of ozone depletion

The impact of UV-B radiation was assessed as *slight*. There is a lack data concerning this issue and studies are needed to determine its potential impacts on coral reefs.

Changes in ocean CO_2 source/sink function

The impact of changes in ocean CO_2 sink/source function was also assessed as *slight*. But, again, there is a severe lack of data regarding this issue and further studies are needed to determine its possible impacts.

Economic impacts

Global changes are having *severe* impacts on the economic sectors of the sub-system, particularly agriculture and tourism which are the most economically important sectors in Central America. In Quintana Roo, 80% of the population resides within the coastal zone, many attracted by employment opportunities provided by the tourism industry. The population living in the coastal zone, including tourists, will face increasing economic, environmental and social risks as a consequence of climate change, e.g. sea-level rise and hurricanes. Significant mitigation costs will be incurred in order to protect the sub-system from climate change induced hazards. Tourist facilities are often particularly vulnerable as they are commonly located in coastal dunes and wetlands that are in the path of storms. For example, in 1989 Hurricane Gilberto severely damaged tourism developments and resulted in a loss of employment.

The increased frequency of extreme events caused by global climate change could severely impact the economy of the sub-system. In 1998, the GDP growth of Honduras decreased from 5.8% to 2.7% due to the impacts of Hurricane Mitch (República de Honduras 2000). Further, NOAA (2000) estimated that 50% of Honduras' agricultural crops were destroyed and at least 70 000 houses and 92 bridges were damaged or destroyed by the hurricane. There was severe damage to the infrastructure of Honduras and entire communities were isolated from assistance. Nicaragua was also affected when a large mudslide inundated ten communities situated at the base of La Casitas Volcano. Guatemala and El Salvador also suffered from flash floods which destroyed thousands of homes, along with bridges and roads.

Evaluations of the vulnerability of Costa Rica's agricultural sector to climate change predict that rice and bean crops will be negatively affected by changes in temperature and CO_2 concentrations but coffee crops will be favoured. The productivity of the latter will be improved as CO_2 will enhance the photosynthesis rate and, therefore, biomass production. Coffee production constitutes the country's primary economic activity, accounting for 20% of GDP. There are, however, uncertainties about the effects of temperature variations on these crops (República de Costa Rica 2000).

In Nicaragua, simulations of the effects of climate change on the production of basic grains showed annual production to be less than baseline growth. Simulations of the effect of climate change on other agricultural products also found that productivity would decline; the basic harvest decreasing by as much as 66% in some areas (República de Guatemala 2001).

Impacts on human health

Health impacts as a result of global change are considered *moderate*. In Guatemala, the First National Communication for the Convention on Climate Change established that serious diarrhoea will have a seasonal behaviour and malaria will decrease in prevalence due to a change in seasonal weather patterns. In general, an increase in temperature and a decrease in rainfall and surface runoff is expected, which will reduce freshwater availability for humans and ecosystems. Consequently, the health of the sub-system's inhabitants will be adversely affected, with an increase in water related diseases such as diarrhoea, and parasitic and dermatological diseases (República de Guatemala 2001). In Quintana Roo, a major problem associated with global climate change is the contamination of groundwater. Following severe storm events an increase in disease is observed, including diarrhoea, cholera, and simple and hemorrhagic dengue, due to the presence of stagnating water.

Other social and community impacts

Global changes were assessed as having *severe* other social and community impacts. Sub-system 3c's population is increasingly vulnerable to extreme weather events which may harm humans and cause forced migration. In Honduras, the houses of 660 000 people were damaged due to Hurricane Mitch; 260 000 people were moved to temporary accommodation and 396 000 had to remain in their homes (República de Honduras 1995). NOAA (2000) estimated that Mitch was responsible for between 9 000 and 12 000 deaths, predominately from rain-induced flooding in portions of Central America, mainly in Honduras and Nicaragua. This makes Mitch one of the deadliest Atlantic tropical cyclones in history, ranking only below the 1780 "Great Hurricane" in the Lesser Antilles, and comparable to the Galveston hurricane of 1900 and Hurricane Fifi of 1974 which primarily affected Honduras. In the case of Quintana Roo, severe weather events have resulted in the relocation of affected populations, stimulating social and economic instability since much of the land left by the relocated population became unproductive, necessitating new housing and sources of employment.

Conclusions and future outlook

The most severe environmental issues of global change were identified as 'changes in the hydrological cycle and ocean circulation', and 'sea-level change' which both have a *moderate* impact. The impact on the regional economy was assessed as *severe* as natural phenomena have affected important economic sectors such as tourism and agriculture. The impact on health was assessed as *moderate*, taking into account the relationship between climate change and water- related diseases. The social and community impacts of extreme events which may be associated with climate change were considered *severe*.

In the future, the situation will become worse as extreme weather events are expected to increase in frequency and intensity. Climate change is already impacting various species, and the ecosystems of the sub-system are sensitive to environmental changes. The current precautionary measures are not far-reaching enough to prepare the region for the increasingly severe impacts of the predicted global changes. Tourism development in coastal areas will continue to destabilise the coastline by, for example, the removal of beach material and mangrove clearance, thus exacerbating the impact of climate change on erosion processes. Global climate change is not a regional problem; the situation must be resolved through international cooperation and action, such as the ratification and implementation of international agreements and treaties.

Priority concerns for further analysis

Priority concerns of the Colombia & Venezuela sub-system

The Colombia & Venezuela sub-system includes the Magdalena, Orinoco and Catatumbo river basins which cover an area stretching from the Andean highlands to the Caribbean Sea. The basins contain a rich diversity of species and ecosystems which are now threatened by habitat loss and fragmentation. Habitat and community modification was correspondingly selected as the GIWA priority concern for sub-system 3b, Colombia & Venezuela. Habitat modification is the consequence of several environmental issues examined under the other GIWA concerns. In particular, pollution and the overexploitation of living resources are resulting in widespread habitat modification. The GIWA concerns were prioritised for the Colombia & Venezuela sub-system (3b) in the following order:

1. Habitat and community modification
2. Unsustainable exploitation of fish and other living resources

3. Pollution
4. Global change
5. Freshwater shortage

The economies of Colombia & Venezuela are highly dependent on the exploitation of their natural resources. The governments of the two countries have tried to address the endemic poverty by promoting the expansion of agriculture into forested areas. The high rates of deforestation are resulting in greater quantities of sediment entering rivers and eventually being discharged into coastal waters. The production of illegal crops has also led to deforestation, and government initiatives to fumigate these crops have resulted in the chemical contamination of the surrounding terrestrial and aquatic ecosystems (Michaels 2001, Knight 2002, Mabogunje 2002). The western and southern areas of the basin are the most affected (Wildlife 2003).

The Caribbean coast of Colombia hosts 71% of the country's total wetlands (MMA 2002) which are highly important for water regulation and in providing habitat for rare, endangered, and commercially or recreationally important wildlife species (Tiner 1984 in Lyon & McCarthy 1995). A range of anthropogenic activities are threatening the wetlands and have reduced the abundance and diversity of wetland species.

Pollution is a major cause of habitat modification in the sub-system. Widespread contamination by spills of hazardous or aesthetically displeasing materials (Garay 1987) has caused the mortality of aquatic and avian species. The spills are often deliberate either by the sabotage of oil pipelines or the discharge of oily residues from port activities and from ship's ballast water (Garay et al. 1988). The flora and fauna has been impoverished in the Orinoco delta region due to frequent oil spills from dilapidated pipelines (RAN 2003).

Coastal and riparian developments alter runoff patterns and release pollutants into the aquatic environment, which has considerably degraded the ecosystems of Colombia. During the 17th century, Spanish colonists excavated the Canal del Dique, diverting the course of the Magdalena River to flow into the Bahía de Cartagena, which converted the bay into an estuary, thereby eliminating extensive coral communities. Coral reefs on the central coast of Venezuela are degraded by urban and industrial development (Puerto Francés-Carenero), resulting in the loss of more than 80% of the associated invertebrate species since the mid-1980s (Garzón-Ferreira et al. 2000). Coral reefs and associated faunal communities also disappeared in Morrocoy National Park (Venezuela) in the 1990s with coral cover reduced from 43% to less than 5%. This mass mortality was related to a severe phytoplankton bloom followed by sudden oxygen depletion, caused by a climatic anomaly and chemical pollution (Garzón-Ferreira et al. 2000).

Priority concerns of the Central America & Mexico sub-system

The habitats of the Central America & Mexico sub-system have been modified by a range of factors including deforestation, surface- and groundwater pollution, industrial dumping, the discharge of untreated or inadequately treated sewage water, the leaching of fertilizers and pesticides, overexploitation of groundwater, increased sedimentation due to deforestation, and more frequent floods. Habitat and community modification was selected as the priority concern for the Central America & Mexico sub-system. The GIWA concerns were prioritised for the Central America & Mexico sub-system (3c) in the following order:
1. Habitat and community modification
2. Pollution
3. Unsustainable exploitation of fish and other living resources
4. Freshwater Shortage
5. Global change

In recent decades, Central America has seen some of the highest deforestation rates in the world. Deforestation is often driven by inequities in land distribution and high population growth rates. In the San Juan River Basin, shared by Costa Rica and Nicaragua, the expansion of agricultural and livestock activities has resulted in the deforestation of practically all the lowland forests in Costa Rica and the modification of indigenous forests up to the boundaries of biological reserves in Nicaragua. Significant areas have been exposed to erosive processes such as high-intensity tropical rains, resulting in a greater loss of soil which is reflected by the increased water turbidity.

The sub-system's mangrove ecosystems have been rapidly disappearing over the last 20 years. In the Caribbean Mexico, for example, up to 65% of mangroves have disappeared (Suman 1994 in UNEP 2000b). Aquatic habitats are modified by chemical pollution discharged by industry. Artificial fertilisers leach into groundwater and runoff from agricultural areas into rivers and coastal areas, thus increasing the nitrogen and phosphorus load of water bodies (Smayda 1990 in GESAMP 2001).

In the Caribbean part of Central America, the coastal zone is under increasing pressure from development activities. The construction of tourism facilities and infrastructure has required the deforestation of mangrove forests and increased erosion which has increased sedimentation on reefs.

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involved a step-by-step process that identified the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis (CCA) recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. The CCA uses a relatively simple and practical analytical model. For further details on the methodology, please refer to the GIWA methodology in Annex IV.

Causal chain analysis of the Magdalena Basin

The GIWA assessment identified Habitat and community modification as the priority concern in the Colombia & Venezuela sub-system. The Magdalena Basin was selected for the Causal chain analysis (CCA) as there is a concentration of human activities located here which are resulting in severe habitat modification. A description of the basin can be found in the regional definition section of this report. The focus of the CCA is to determine the root causes of habitat and community modification in the sub-system, so that the driving forces of the issues can be addressed rather than the more obvious causes. This process traces the cause-effect pathways, from the socio-economic and environmental impacts of the concern identified in the assessment back to the root causes. The root causes can then be targeted by appropriate policy measures in the Policy options analysis (POA) section. For more detailed information on the environmental impacts, the responsible sectors and the immediate causes, please refer to the Assessment chapter.

Figure 9 shows the causal links between the environmental and socio-economic impacts of the habitat and community moficiation concern, the immediate causes, the responsible economic sectors, and the root causes that determine the behaviour of these sectors.

Environmental and socio-economic impacts

The main environmental impacts of habitat and community modification are:

- Loss of biodiversity;
- Impacts on estuarine and coastal ecosystems, particularly the loss of coral reefs and mangroves;
- Changes in community structure; and
- Increased vulnerability of flora and fauna to diseases.

The main socio-economic impacts of habitat and community modification are:

- Loss of income for the tourism and fisheries sectors;
- Loss of aesthetic and recreational value;
- Increased unemployment;
- Economic costs of ecosystem restoration;
- Recurrent morbidity and increased infant mortality rates; and
- Loss of cultural identity for indigenous people.

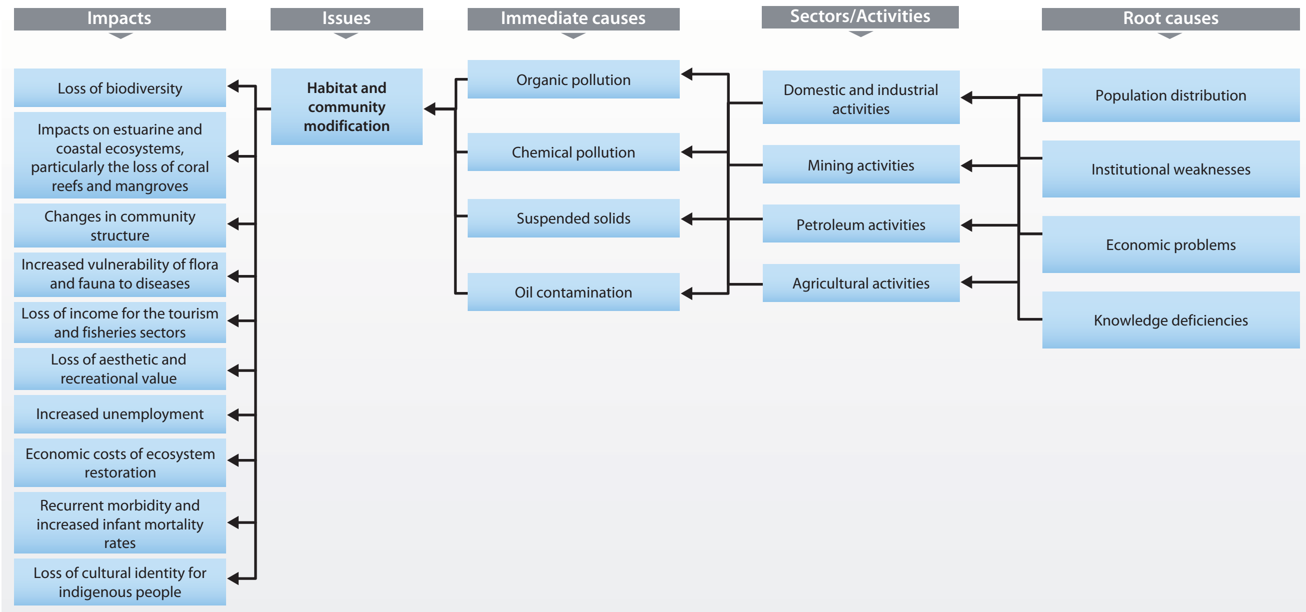


Figure 9 Causal chain diagram illustrating the causal links for habitat and community modification in the Magdalena Basin (sub-system 3b).

Immediate causes/sector activities

Immediate causes associated with domestic and industrial activities: The Río Grande de la Magdalena Basin is the most populated basin in Colombia and has the highest intensity of socio-economic activities. Organic material enters the environment in waste from domestic sources and coffee, food and beverage industries. These wastes modify water quality and consequently the health of aquatic ecosystems (CORMAGDALENA 2002).

Immediate causes associated with mining activities: mining activities have degraded forest, soil and water resources in parts of the Magdalena Basin. Commonly, the practices employed are non-compliant with environmental guidelines and highly destructive (CORMAGDALENA 2002). Mining activities in the Magdalena-Cauca Basin have adversely affected the environmental quality of aquatic habitats. Areas where the rivers have a limited flow rate are particularly vulnerable to chemical pollution and increased sedimentation originating from mining activities. Municipalities at greatest risk are riparian to the following rivers: Vetas, Boque in Santa Rosa del Sur; Serranía de San Lucas; Tarazá in Bajo Cauca; Bagre in the mining region north of Antioquia; and Guavas and Guadalajara in the Ginebra district (CORMAGDALENA 2002).

Immediate causes associated with petroleum activities: Magdalena Basin contains a multitude of petroleum activities including exploration, extraction, refinement and transportation. These activities alter habitats by consuming large quantities of water and releasing pollutants. Petroleum activities are concentrated in the upstream areas of the basin, primarily in the municipalities of Neiva and Aipe in Huila, and in the middle reaches of the basin in Barrancabermeja (Santander), Puerto Nare y Yondó (Antioquia). Large quantities of pollutants are discharged by petroleum-water separating stations, as well as occasional spills and leakages from oil pipelines (CORMAGDALENA 2002).

Immediate causes associated with agricultural activities: agro-chemicals used in crop production are used inappropriately and enter aquatic systems via runoff or leaching into groundwater. Aerial fumigation of rice, cotton and sorghum with excessive doses of pesticides and herbicides is a major source of water, air, soil and food contamination (CORMAGDALENA 2002).

Root causes

Population distribution

Even though the Colombian coast is relatively sparsely populated, approximately 80% of the population of Colombia and the majority of economic activities are concentrated in the Magdalena-Cauca River Basin. The water bodies in the basin are, therefore, subjected to a concentration of pollution which affects coastal biodiversity. Urban development has led to the deterioration of water quality for human use, modified river bank habitats due to construction, changed the drainage patterns and caused a loss of ecosystem functions.

Institutional weaknesses

Lack of integrated management

In general, planning is sectorial with little consideration of the affect on other economic activities or the environment. There is an absence of an integrated development strategy. The planning process does not incorporate environmental impact assessments or mitigation measures. In areas of agricultural development, informal settlements have emerged in ecologically sensitive areas as provisions are generally not made to accommodate migrant workers.

An evaluation of coastal zone management in the sub-system (Steer et al. 1997) concluded that the system of Integrated Coastal Zone Management had not been adequately adopted and the legal framework regulating activities in the coastal zone was particularly weak.

The monitoring capacity of the institutions responsible for environmental management in the basin is inadequate as there is a lack of professional expertise and financial resources. The National Report of the Office Controlling Public Expenses identified a range of institutional weaknesses including a lack of financial mechanisms and control measures, insufficient monitoring, a lack of investment evaluation and inadequate information dissemination to the public.

Armed conflict

Armed conflict in the sub-system has resulted from a combination of social, political and institutional issues in Colombia. The influence of guerrilla armies has allowed the widespread production of illegal crops within their territories. The land is deforested in order to grow these crops causing ecological damage.

Economic problems

Inequity and poverty

In Colombia, industrial production is concentrated in urban areas. Rural populations survive by increasing cultivated areas and livestock farming and by growing illegal crops. After 35 years of precarious agrarian reform in Colombia, agricultural land is owned by relatively few individuals. 12 000 people (0.6% of the population) control 10 million hectares (20% of livestock farming land) and 82.4% of rural properties are small holdings which occupy 15.6% of the national rural territory (ACNUR 2001). According to The World Bank (2004), Colombia has one of the most concentrated land distributions in the world, with a land GINI of 0.86. Land distribution inequality is considered to be a source of poverty in Colombia, in addition to low agricultural productivity due to armed conflict in rural areas. Both issues, inequality and armed conflict, are forcing the poor to overexploit natural resources for their short-term survival, using shorter crop rotation cycles, clearing forests for agriculture and pastures, and overgrazing livestock.

Inappropriate incentives that encourage unsustainable practices

Farmers were encouraged to apply agro-chemicals in order to increase agro-productivity. This increased the prevalence of these substances in the environment. It is now internationally recognised that artificial fertilizers and pesticides contaminate water resources and impact ecology and sanitary conditions (Láñes 2000). In Colombia, sales of herbicides and fungicides increased between 1975 and 1995 from 4 555 to 8 322 tonnes and 4 479 to 7 280 tonnes respectively (MMA & MA 1998). Various incentives were also given for converting forests to arable land and pastures. The high price for illegal crops encourages further deforestation to create more cultivated areas.

Ineffective economic mechanisms for pollution control

Only a limited number of industries have been charged water rates since they were introduced. At present, only 25% of Regional Autonomous Corporations (Corporaciones Autónomas Regionales, CAR) make payable taxes. Industries have therefore no incentive to improve their efficiency or reduce their waste discharges, even if only a minimal investment is required.

At present there are insufficient financial and technological resources to develop adequate treatment systems or to use cleaner technologies during production (CORMAGDALENA 1999). Although the Venezuelan Ministry of Environment and Natural Resources (MARN) has made some effort to implement environmental management, its success has been limited by a lack of financial and human resources. The environmental problems of the region require large financial investment in order to reverse degradation trends. Financial mechanisms are required that encourage industry to restore habitats they have disturbed (República de Venezuela 1995).

Knowledge deficiencies

The technologies currently employed by agriculture, mining, fisheries and other sectors are degrading the environment. There is a lack of studies evaluating the efficiency and environmental impacts of current practices. This has not favoured the adoption of cleaner technologies.

There is a lack of environmental information about the Colombian Caribbean coast where the sub-system's most important deltas are located, including the Magdalena, Canal del Dique, Sinú-Tinajones, Turbo and Atrato. In particular, the influence of upwelling, sediment dynamics and sea-level rise is poorly documented (Correa 2003).

Currently there is a dearth of information on the Magdalena River Basin. There are several deficiencies: (i) there is a lack of baseline information; (ii) data is dispersed between the various regional, national and international institutions; c) the lack of standardized methodologies used to obtain biophysical and socioeconomic data in coastal zones makes it impossible to compare data and information (Steer et al. 1997); d) there is a lack of information for vulnerability evaluation of coastal zones (INVEMAR 2002);

e) limited funding for research, assessment and environmental management; f) insufficient information on the active processes and their interrelations in the coastal zone, deltas, wetlands and river basins; and g) lack of appropriate information for management purposes.

Causal Chain Analysis of the Central America & Mexico sub-system

The priority concern for sub-system 3c is habitat and community modification. The sub-system includes parts of the Central America countries draining into the Caribbean and the State of Quintana Roo in Mexico. Causal chain analysis (CCA) was performed for the whole sub-system. For detailed information on the physical and socio-economic characteristics of the sub-system refer to the regional definition chapter. For more detailed information of the environmental and socio-economic impacts, responsible sectors and immediate causes, please refer to the Assessment chapter.

Figure 10 shows the causal links between the environmental and socio-economic impacts of the habitat and community moficiation concern, the immediate causes, the responsible economic sectors, and the root causes that determine the behaviour of these sectors.

Environmental and socio-economic impacts

Environmental impacts:

- Decreased vegetation cover;
- Loss and modification of biodiversity;
- Erosion and sedimentation.

Socio-economic impacts:

- Limited employment opportunities for the local population;
- Loss of aesthetic and recreational values;
- Increased infant morbidity and mortality rates;
- Conflicts over resources use and land tenancy.

Immediate causes/sectors

Immediate causes associated with agriculture: Runoff from agricultural lands has adversely affected water quality. Pesticides are applied to cultivated areas in order to control weeds, plagues, fungi and other diseases, and fertilizers (rich in N, P and K) to replace lost nutrients and increase the productivity of soils. According to studies made by the OPS and the WHO in Central America, 50 000 hectares of banana plantations use 117 200 tons of polyethylene, polypropylene, fertilizers and nematicides. These chemicals accumulate in soils, runoff into surface water supplies and leach into groundwater. Other solid residues are also generated including *raquis* (225 000 tons) and banana residues (278 000 tons) (Gaitán 1998).

Immediate causes associated with tourism: In the coastal zone of the sub-system, many protected areas are accessible to tourists. There is usu-

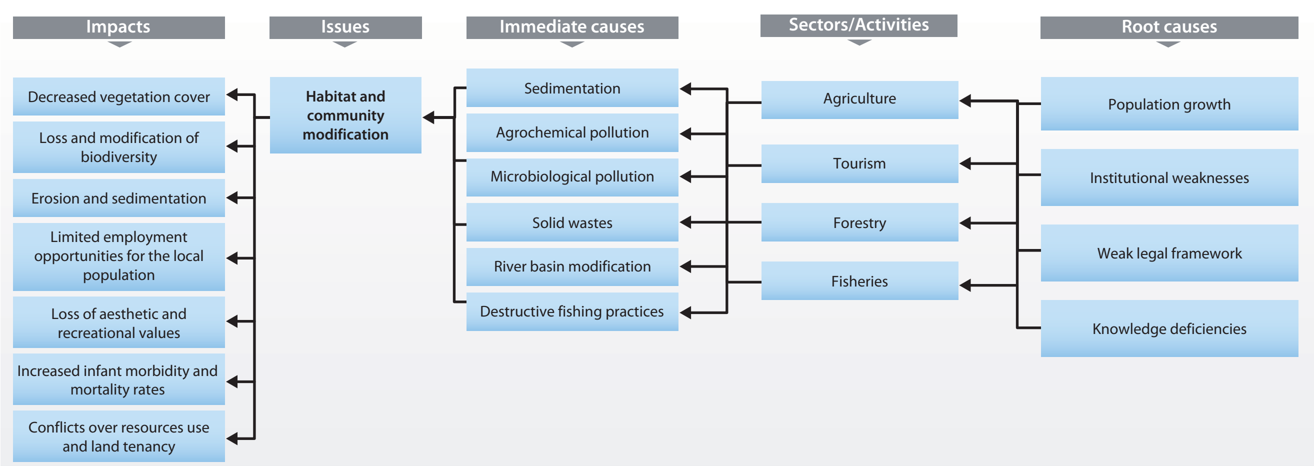


Figure 10 Causal chain diagram illustrating the causal links for habitat and community modification in the Central America & Mexico sub-system (3c).

ally a conflict of interest between conserving the natural resources in these areas and accommodating tourism. Many of the sub-system's natural assets such as the beaches, forests, coral reefs have been degraded as a consequence of tourist activities.

Immediate causes associated with forestry: Forestry is an important economic sector in Central America. Deforestation is resulting in increased erosion and sedimentation in the sub-system.

Immediate causes associated with the fisheries sector: Habitats are degraded by the employment of trasmallo (fixed fishing nets in shallow waters), illegal nets, trawling, dynamite and poison.

Root Causes

Population growth

Costa Rica has experienced one of the highest rates of population growth and deforestation in the world. In the last 50 years, the population has multiplied five-fold and, in the same period, 11 000 km^2 of forest, equivalent to the area of Jamaica, have been deforested (Perez and Protti 1978, Hartshorn 1983, Bonilla 1985). Several studies have shown the correlation between population growth and deforestation (FAO 2000). Population growth and the lack of development planning have led to the establishment of settlements in environmentally sensitive areas.

With population growth, the demand for land escalates and environmental degradation intensifies as urban and agricultural areas expand. Land tenancy conflicts have been provoked mainly in zones of collective land use. The institutions responsible for land tenure (e.g. in Mexico the Secretariat of the Agrarian Reformation, National Agrarian Registry and Commission for the Regulation of Land Tenancy) have insufficient capacity to resolve these conflicts.

Institutional weaknesses

Many of the root causes behind habitat modification in the Central America & Mexico sub-system stem from a lack of institutional capacity. There are no management plans at a national or regional level governing the majority of the sub-system's surface water (CATHALAC 1999). There is a lack of regional policies which promote the development of river basin planning and management. Additionally, the lack of democratic participation mechanisms that allow the involvement of all stakeholders has hindered cooperation between governments and the community in the conservation of habitats. Economic and political interests often take precedence over social and environmental improvements, and during the planning and implementation of development projects little consideration is given to its sustainability or the long-term impacts on the environment. For example, on the Caribbean coasts of some northern areas of the Central America & Mexico sub-system, large hotel complexes are constructed without consideration of the environmental and social costs because central government and industry have the most influence in the decision-making process with limited stakeholder participation.

The institutions responsible for environmental management have insufficient financial and technical resources to adequately monitor and control environmental problems. Developers are able to violate planning regulations as their activities are not monitored. There are insufficient economic and human resources to purchase and operate the necessary equipment for pollution control and monitoring activities. Pollution levels in Guatemala are unknown as there is no institution responsible for water quality monitoring (FAO 2000).

The exploitation of species and other environmental goods and services with high commercial value is insufficiently managed. There is little consideration of the periods of reproduction, the population and sustainability of the species, and of the economic benefits of the species when they are alive. The institutions responsible for managing the coastal fisheries lack the resources to enforce fisheries regulations. In Nicaragua and in Costa Rica, because the marine and coastal zone is poorly monitored, fishing occurs without any controls. Water is used inefficiently, since water users are not charged for the costs of treatment and distribution (CEPAL 1995). In Costa Rica, there is a lack of water conservation or management, particularly in urban areas that consume 80% of the total freshwater abstracted.

Legal framework

Because regulations on the use of pesticides and fertilizers are very weak or non-existent, these materials are applied in excessive quantities which do not improve productivity further but, instead, affect wildlife and contaminate superficial and underground water supplies. The main deficiency in water law in sub-system 3c is regarding coastal and marine regulations.

Knowledge

Decision-making processes are hampered by the limited information availability regarding the environmental and economic characteristics, and environmental degradation trends, of river basins. There are insufficient research initiatives regarding sustainable technologies and very few environmental education programmes. There is no reliable information on the recharge rate and capacity of aquifers (CATHALAC 1999). The benefits that ecosystems in the sub-system provide the population are poorly documented or valuated. In the San Juan River Basin, there is little knowledge of the capacity of fish stocks to recover or the population dynamics.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits, and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

Policy options for the Colombia & Venezuela sub-system

This Policy option analysis will suggest and evaluate policy responses to the main root causes identified in the Causal chain analysis for the Magdalena River Basin.

Definition of problem

Habitat and community modification was selected as the GIWA priority concern for sub-system 3b, Colombia & Venezuela. Habitat modification is the consequence of several environmental issues examined under the other GIWA concerns, in particular, pollution and the overexploitation of living resources. High rates of deforestation are resulting in greater quantities of sediment entering rivers and eventually being discharged into coastal waters where they alter habitats. Aquatic ecosystems have also been degraded by chemical contamination caused by the fumigation of illegal crops and by spills and discharges from petroleum activities. Wetlands and coral reefs have been modified extensively.

Despite considerable efforts to strengthen environment institutions, they still lack sufficient funding and administrative, monitoring and implementation capacity. The sub-system lacks an integrated development strategy and environmental legislation and enforcement is weak. Guerrilla armies hinder environmental protection activities. Poverty drives communities to overexploit natural resources for their short-term survival. Inappropriate incentives and the lack of disincentives encourage farmers to excessively use agro-chemicals. The advantages of adopting cleaner technologies are poorly understood by industry and there is a lack of environmental education programmes.

Political Characteristics

Various institutions and government agencies in the region are involved in addressing and managing water-related environmental issues and problems. In Colombia, a basis for Integrated Coastal Zone Management has been initiated, which is relatively advanced but complex. Environmental policies established to date include the following:

Colombian National Policies

National Environmental Policy for the Sustainable Development of Oceanic Spaces, Coastal Zones and Islands of Colombia (MMA, 2000): The policy facilitates the sustainable development of ocean spaces and the coastal zone, by providing a framework for environmental planning and integrated management, which aims to enhance the quality of life for the inhabitants of Colombia and promote the conservation of marine and coastal resources and ecosystems. The policy aims to develop and execute the concept of "Integrated Coastal Zone Management", based on scientific data and ensuring the participation of entities responsible for coastal and community management, and marine and coastal ecosystem restoration. It also emphasises the need to prevent and control marine pollution from land-based sources.

National Policy for Interior Wetlands (2001): The objectives and actions proposed by this policy aim to promote the rational use, conservation and restoration of wetlands at national, regional and local levels.

National Policy for Biodiversity (1995): The basic principles of the policy are that biodiversity is patrimony of the Nation and has strategic value for the present and future development of Colombia. The benefits derived from biodiversity use should be used equitably in agreement with the community. The National Policy for Biodiversity establishes the general and long-term framework for the national implementation of the Convention for Biological Diversity which was ratified by Colombia and implemented through the Law 165 of 1994.

National Development Plan (2002-2006): The environmental sustainability programme of the Colombian government aims to maintain the natural resource base for the country's future development, to protect environmental goods and services, and to ensure sustainable production trends in order to strengthen the National Environmental System.

The National Policy of Ocean and Coastal Spaces (2002): This policy harmonizes policies of the different marine productive sectors in order to promote economic development in accordance with the sustainable policies of the Ministry of the Environment. It establishes a framework for the governance of maritime activities in terms of institutional, legal, research and technological aspects (INVEMAR 2002).

CONPES Document: Action plan 2002-2004 of the National Environmental Policy for the Sustainable Development of Oceanic Spaces, Coastal Zones and Islands of Colombia

The National Council of Economic and Social Policy (CONPES) approved on May 10th 2002 a document which identified priority actions, institutional actors for its execution, financial resources, and coordination mechanisms required for the consolidation and implementation of environmental planning programmes, sustainable management of productive activities, ecosystem conservation and restoration programmes, and programmes to improve the population's quality of life.

Institutional framework

CONPES is responsible for social and economic decisions. It is directed by the President of the Republic and includes various ministers. The Colombian Ocean Commission (CCO) is an assessment programme which is consulted when developing national policy regarding scientific, technological, economic and environmental matters associated with the coast or ocean.

The Ministry of Environment, Housing and Territorial Planning also have functions related to the marine and coastal environment, water resources and territorial planning. CORMAGDALENA is responsible for maintaining navigation routes, port activity, land planning and conservation, energy generation and distribution, fisheries resources, and other renewable resources. The Regional Autonomous Corporations are the environmental authorities in their geographical jurisdiction, their duties focused at the executive level on natural resource management. The General Maritime Direction (DIMAR) is a maritime authority, with an objective to coordinate and control maritime activities (established by the Decree 2324 of 1984). The National Planning Department has an objective to prepare, implement and evaluate policies, general plans, programmes and projects for the public sector.

Recommended Policy Options

Policy Option 1: Integrated River Basin and Coastal Area Management

Formulate, develop and implement strategies for the mitigation of impacts from the Magdalena-Cauca Basin that are adversely affecting the ocean, coastal zone and islands of the Colombia & Venezuela sub-system.

Justification

River basin management and coastal zone management face different challenges in terms of the environmental characteristics and processes, the types and intensity of human activities, and the institutional context. It is increasingly recognised, however, that, due to the complex environmental and socio-economic inter-linkages between river basins and the coastal zone, it is necessary to manage them together as an integrated planning unit.

This policy option proposes integrating basin, delta and wetland management with management actions initiated through the National Environmental Policy for the Sustainable Development of Oceanic Spaces, Coastal Zones and Islands of Colombia. Because human activities in the Magdalena-Cauca Basin cause considerable impacts on coastal habitats and marine resources, it is necessary to coordinate actions through integrated river basin and coastal area management.

Integrated management and planning is necessary to mitigate the impacts on the coastal zone and ocean originating from sources in the Magdalena River Basin. The introduction and implementation of an integrated management system is essential in adequately managing hydrological resources, restoring and ameliorating environmental services offered by the ecosystems, and in optimizing the use of resources for economic development. It will also improve the efficiency of political interventions and reduce potential conflicts between upstream, downstream and coastal stakeholders. Although the system will be integrated, special attention to the specific physical and socio-economic characteristics of river basins and the coastal zone should be incorporated into the strategy.

Table 7 shows a summary of the analysis of this policy option undertaken by the GIWA regional team.

Actions

At the national level:

- Establish a mechanism for coordinating all relevant decision-making entities;
- Identify and evaluate the impacts of human activities on aquatic ecosystems;
- Provide guidance on the control and monitoring of environmental threats;
- Prevent, reduce and control marine and coastal pollution from land-based sources;
- Formulate and implement precautionary measures to prepare for predicted climate change induced impacts, in particular sea-level rise;
- Promote the economic valuation of ecosystem goods and services;
- Regularly exchange information amongst the countries in the region regarding experiences of environmental management;
- Adopt objectives, policies, common strategies and government mechanisms that recognise the interconnections between river basins and the coastal zone;
- Conduct environmental impact assessments;
- Develop human resources and strengthen institutional capacities;
- Ensure the participation of stakeholders from both the public and private sectors, and from a range of geographical locations in the sub-system.

At the local level:

- Strengthen land-use planning in order to control development in environmentally sensitive coastal areas;
- Identify and valuate natural resources and establish priorities for sustainable development;
- Increase the coverage of wastewater treatment services;
- Protect areas of high ecological value, such as wetlands, deltas and estuaries;

Table 7 Performance of policy options for the Colombia & Venezuela sub-system.

Policy option	Effectiveness		Political viability		Management capacity	
	Option impact	**Obstacles and risks**	**Feasibility**	**Opposition management**	**Existing management capacity**	**Capacity building**
PO 1: Integrated River Basin and Coastal Area Management	Reduce environmental degradation; optimize the use of resources for economic development; improve the efficiency of political interventions; and reduce potential conflicts amongst stakeholders.	Financial and administrative limitations; current lack of integration between sectors; lack of political awareness of benefits of integrated management; information availability; lack of conflict resolution mechanisms; lack of political will; and occupation of large areas of Colombia by Guerrilla armies.	Political opposition if economic interests are affected; there is already a basis of a political framework for river basin, coastal zone and wetland management.	Stakeholder participation; establish conflict resolution mechanisms; increase awareness of benefits of PO through community, institutional and business education programmes.	Among other national systems: National Environmental System (SINA; Decree 632 of 1994); Integrated management of coastal and oceanic areas (PNAOCI, MMA 2000); Plan for river basin planning and management.	Establish mechanisms for inter-institutional coordination and information exchange; evaluate coordination mechanisms; assess the progress of CONPES decisions; develop technical and human resources; and incorporate new policy approaches.
PO 2: Develop scientific capabilities	Accurate, timely and relevant information for effective decision-making; reduce scientific uncertainties; improved inter-institutional data exchange; better implementation of international and regional agreements; and enhanced monitoring of the environment.	Research and technology institutions lack innovation and are reluctant to adopt new methodologies; research is not presented in an understandable manner for policy makers; limited political support and funds for research, and technical and human resources; low priority of research policies; and hindrance of scientific activities by guerrilla armies.	A political framework already exists through which the policy option could be implemented.	Demonstrate economic benefits of PO; periodic meetings of scientists, planners, and investors; and stakeholder participation will improve the acceptability of management decisions that are based on the studies.	National Constitution of Colombia supports research and science (Articles 70, 71 and 209); National System of Science and Technology; National System of Environmental Research; National Environmental System; Regional Commission of Science and Technology; various research institutes and universities.	Develop analytical tools; strengthen the National System of Environmental Research and the National System of Science and Technology; improve information and communication networks; align research with the needs of coastal zone and river basin management; establish inter-institutional coordination mechanisms.

- Formulate strategies to promote sustainable agricultural and forestry practices;
- Protect traditional knowledge when it benefits socio-economic development, environmental protection and guarantees rights and equitable access to coastal resources;
- Rehabilitate degraded ecosystems using traditional or new techniques appropriate to the local conditions.

Policy Option 2: Strengthen the scientific capacity of the sub-system

Strengthen the scientific capacity of the sub-system in order to provide accurate, timely and relevant scientific information for informed decision-making in the management of the coastal zone and river basins.

Justification

To manage the coastal zone and river basins effectively, accurate scientific information is required to allow policymakers to formulate efficient and innovative policies (BID 1998). The Causal chain analysis identified several information deficiencies which are hindering the management of the Magdalena River Basin and its adjacent coastal ecosystems. Changes to the ecosystems need to be monitored in order to assess management actions. It is necessary for scientists and decision-makers to cooperate in order to develop policy strategies based on sound scientific knowledge (GESAMP 1990).

To determine management priorities it is fundamental to know the current status of the sub-system's coastal ecosystems, their economic value, and the intensity of impacts they are experiencing. Decision-makers in Colombia require a systematic, accessible and accurate information tool to initiate sustainable development and social change. The policy option will improve the pertinence and quality of data collected and creates an integrated information system to be shared between institutions and used in the design of plans, policies and programmes in order to improve the success of actions. The enhanced monitoring of the environment will allow such actions to be evaluated in terms of their positive or negative impacts.

Table 7 shows a summary of the analysis of this policy option undertaken by the GIWA regional team.

Actions

At the national level:

- Establish strategic programmes of interdisciplinary research in order to generate knowledge and information to support integrated coastal zone management;
- Strengthen transboundary mechanisms of research, information exchange and resource management;
- Develop methodologies for multi-sectorial assessments;
- Standardise environmental indicators in order to periodically assess the environmental quality of the Magdalena River Basin; socio-economic indicators should be used to monitor human well-being and its relationship with environmental degradation trends (MMA 2000);
- Model the complex interactions of coastal processes so that environmental changes and the affects of human activities can be predicted;
- Develop an information management system for policymakers to utilise in the decision-making process;
- Encourage communication and exchange of knowledge/ideas amongst academic, public and private institutions;
- Disseminate knowledge and scientific information to entities responsible for national and regional coastal management.

At the regional level:

- Undertake studies on the coastal and delta geomorphology, and tectonic activity in the sub-system (INVEMAR 2001);
- Predict the vulnerability of ecosystems and societies to sea-level rise (INVEMAR 2003b);
- Develop an integrated information system to efficiently exchange and process coastal and marine data;
- Research the functional relationships between wetlands, river basins and the coastal zone;
- Orientate research programmes to meet the information needs of integrated river basin and coastal zone management institutions.

Policy options for theCentral America & Mexico sub-system (3c)

Policy Options Analysis

Two policy options were proposed for the San Juan River Basin.

Problem Definition

In the Central America & Mexico sub-system, habitat and community modification was identified as the priority concern. The transboundary ecosystems have been severely degraded as a consequence of the expansion of agriculture, increased pollution loads and inappropriate forestry practices. The analysis of the San Juan River Basin, shared by Costa Rica and Nicaragua, showed that the degradation of ecosystems and the overexploitation of the resources are attributed to a range of sectors and immediate causes including agricultural expansion, changes in land use, and development. The expansion of agricultural and livestock activities in the basin has resulted in the deforestation of practically all the lowland forests in Costa Rica and the modification of indigenous forests in Nicaragua. These deforested areas have been exposed to soil erosion, which has increased water turbidity. In the San Juan Basin, there is a lack of economic alternatives, there has been mass migration from rural areas to cities, and the productivity of agriculture has declined.

The environmental problems were traced back to their root causes. There is a lack of environmental planning and protected areas are inadequately managed. The activities of coastal zone and river basin management programmes are not integrated, and both lack the capacity to effectively regulate activities which are modifying the sub-system's habitats. There is an absence of environmental education programmes and a lack of research programmes that develop sustainable technologies. Many stakeholders are excluded from what is fundamentally a centralised system of decision-making. Coordination between civil society and State institutions is flawed, with information exchange and dissemination ineffective. Further, poverty forces the inhabitants of the sub-system to exploit resources at an unsustainable rate; as their land becomes unproductive they are forced to migrate to more environmentally sensitive areas.

Recommended policy options

Policy Option 3: Institutional strengthening

Design and implement a capacity building programme which aims to strengthen the relevant institutions and develop human resources, and economic and legal instruments for the prevention and reversal of degradation trends in the San Juan River Basin.

Justification

In Nicaragua and Costa Rica there is a lack of institutional and technical capacity to implement environmental management policies. Environmental institutions need to be strengthened in order to implement and evaluate environmental management in the San Juan Basin. There needs to be an institution responsible for the overall coordination of environmental management activities so that decisions can be harmonised. The integrated management of freshwater and coastal resources will enable the protection and restoration of environmental goods and services and optimize the efficiency of resource use. The coordinating institution should be responsible for creating research programmes for sustainable technologies, formulating environmental education strategies and establishing pollution control and monitoring facilities.

Before developing an integrated management system, a strategic plan would clearly define the roles and responsibilities of the institutions within the basin. River basin plans should promote economic development whilst ensuring the sustainable use of natural resources. Education programmes about the effects of increased erosion and sedimentation, and the impacts on ecosystems and societies will improve the acceptability and success of the plans. Stakeholder participation should be a fundamental component of the decision-making process. Economic incentives can encourage producers to adopt sustainable practices that, for example, reduce erosive processes in the San Juan River Basin.

Actions

At a local level:

- Develop land-use plans for the San Juan River Basin and its adjacent coastal zone;
- Design environmental education programmes;

- Evaluate the functions, responsibilities and capacity of governmental institutions;
- Increased regulation of agricultural practices;
- Establish regular communication between the private and public sectors, and scientific community, in order to coordinate decision-making;
- Formulate strategies to combat soil degradation and inappropriate deforestation.

At a regional level:

- Create a monitoring network of environmental and socio-economic indicators, which involves the participation of communities from both riparian countries;
- Conduct a cost/benefit analysis of environmental goods and services to establish conservation priorities;
- Enhance the basin information system as a tool for decision-making;
- Establish guidelines for mining activities located in close proximity to water bodies;
- Design and implement national and regional water policies that define the responsibilities of Costa Rica and Nicaragua regarding the management of the San Juan River Basin;
- Support the implementation of the "Strategic Action Programme (SAP) for the integrated management of water resources and the sustainable development of the San Juan River Basin and its coastal zone";
- Within the framework of the Mesoamerican Biological Corridor, establish action plans to streamline and coordinate the activities of the bilateral commissions and municipalities of both riparian countries;
- Formulate strategies to secure national and international funding for education and technical training and to purchase equipment.

Policy option 4: Promote sustainable production

Promote the sustainable exploitation and production of environmental goods and services in order to alleviate poverty and improve the human well-being of inhabitants in the San Juan River Basin and its adjacent coastal zone.

Justification

The relationship between poverty and environmental degradation is particularly evident in Nicaragua and Costa Rica. The socio-economic situation of the San Juan Basin is characterised by extreme poverty, high population growth rates, inadequate sanitation conditions and a lack of employment opportunities. Economic hardship and soil degradation force inhabitants to migrate to marginal lands, such as mountains slopes, which they convert to agricultural lands. To halt this vicious cycle of land degradation, migration and forest colonisation, sustainable production techniques need to be adopted so the land can sustain future generations. Sustainable production, therefore, can not only provide environmental benefits but can also alleviate poverty by protecting natural resources and providing alternative income sources. This has proved effective in other countries of Latin America (e.g. Colombia and Argentina).

The World Summit on Sustainable Development (WSSD 2002) highlighted poverty eradication as the greatest challenge facing the world

Table 8 Performance of policy options for the Central America & Mexico sub-system.

Policy option	Effectiveness		Political viability		Management capacity	
	Option impact	**Obstacles and risks**	**Feasibility**	**Opposition management**	**Existing management capacity**	**Capacity building**
PO 1: Institutional strengthening	Enable the protection and restoration of environmental goods and services; optimize the efficiency of resource use; a strategic plan would clearly define the roles and responsibilities of the relevant institutions; enhanced quality of life for the basin's inhabitants; participative democracy; and harmonization of policies.	Limited economic resources to fund the proposal; institutional coordination and communication has proved difficult; information availability; lack of stakeholder cooperation; lack of political interest in conservation; political instability prevents the implementation of long-term sustainable policies.	Large-scale farmers and the industrial and mining sectors fear that more environmental regulations decrease the competitiveness of their products.	Stakeholder participation; use conflict resolution mechanisms during the design and implementation of the PO.	Costa Rica has been developing policies and technical capacity to preserve its national resources and has developed a significant ecotourism industry; the future success of which depends on a healthy environment.	Greater institutional coordination; decentralization of decision-making processes; increased stakeholder participation; develop technical knowledge and environmental awareness; provide timely and accurate information; and organise and assess scientific research.
PO 2: Promote sustainable production	Environmental benefits; poverty alleviation by stimulating alternative income sources; sustainable use of natural resources; a participative democracy; harmonization of national and sectorial policies; greater binational integration; and increased public awareness of sustainable development.	Absence of a specific policy for the promotion of sustainable products; a lack of incentives for the adoption of sustainable technologies; limited economic resources; time-consuming and complicated administrative processes; fragmented and weak legislation; and institutional weaknesses.	Industries may be unwilling to adopt sustainable technologies; PO is more feasible in Costa Rica where there are many environmental initiatives; the international market for sustainable products is rapidly growing.	Publicity campaigns about benefits of sustainable production; stakeholder participation; and economic incentives for industries.	Costa Rica has developed a National Forest Development Plan; the Mesoamerican Biological Corridor initiative has built capacity in the institutions of the region; and the UNTACD´s Biocommerce initiative supports such policies.	Increase awareness of the advantages of developing the market in sustainable products; create economic incentives for developing markets in sustainable products; undertake training programmes in using cleaner technologies; and increase stakeholder participation.

and called for specific measures to address this issue. In the WSSD Plan of Implementation, paragraph 13 states that "all countries should promote sustainable consumption and production patterns". Some international initiatives support the trade of goods and services produced in a sustainable manner. Since 1996, the Biotrade Initiative of UNCTAD has promoted the market for biological products produced from sustainable techniques so they have a higher domestic and international market value. Further, the DOHA Declaration, within the framework of the World Trade Organisation, opened negotiations to reduce or eliminate customs duty on environmentally sustainable products from developing countries.

Actions

At a local level:

- Design a national and binational policy for trade in sustainable products;
- Create economic incentives for the adoption of sustainable production technologies;
- Conduct research on locally compatible, sustainable technologies for chemical industries.

At a regional level:

- Modernise the forestry sector so that its products are competitive on the international market;
- Research and design cleaner production technologies;
- Market the basin's sustainable environmental goods and services to the international market.

At a global level:

- Identify international partners to support sustainable production initiatives;
- Remove customs duties for the trade in goods and services produced using sustainable methods;
- In accordance with the Rio + 10 Action Plan, request the transfer of cleaner technologies;
- In accordance with the Rio +10 Action Plan, promote actions which encourage more sustainable consumption and production patterns.

Conclusions and recommendations

Colombia & Venezuela sub-system

Habitat modification was selected as the priority concern of the Colombia & Venezuela sub-system. A range of factors are responsible for the alteration and loss of aquatic ecosystems, many of which were considered under the other major concerns studied by GIWA, particularly pollution. Coastal habitats are being degraded by a multitude of issues such as spills and discharges from oil-related activities and rivers discharging land-based sources of pollution including suspended sediments, urban and industrial wastewater discharges, and agricultural and mining runoff. Coral reefs are severely affected by sedimentation, the sediment originating from river catchments which have been subject to intense deforestation and inappropriate land-use practices. In the 1990s, mass coral mortality was associated with a huge phytoplankton bloom that caused severe oxygen depletion; this was attributed to a climatic anomaly and chemical pollution.

Despite considerable efforts by the governments in recent years, the sub-system is still confronted with the continued degradation of aquatic ecosystems and depletion of their associated resources. Environment institutions remain insufficiently funded and lack administrative, monitoring and implementation capacity. The absence of an integrated development strategy results in uncoordinated actions. Large areas of Colombia are unprotected from development activities as they are controlled by Guerrilla armies. Inappropriate incentives were given to farmers to use agro-chemicals and there is a lack of economic incentives to control pollution. The advantages of adopting cleaner technologies are poorly understood by industry and there is a lack of environmental education programmes. Institutional weakness is a cross-cutting issue affecting socio-economic, technological and scientific development.

Lately, attention has been centred on the urgency to develop integrated water resources management, to adopt preventative rather than reactive measures, to coordinate freshwater, coastal and marine management, and encourage information development and exchange.

Feasible policy options were identified that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. In Colombia, a basis for Integrated Coastal Zone Management has been initiated, which is relatively advanced but complex. However, due to the environmental and socio-economic inter-linkages between river basins and the coastal zone, the GIWA regional experts recommended developing this further by adopting *Integrated River Basin and Coastal Area Management (PO 1)* in the Magdalena-Cauca Basin and its adjacent coastal zone**.** In support of this policy option, there is a need to *Strengthen the scientific capacity of the sub-system (PO 2)* in order to provide accurate, timely and relevant scientific information to decision-makers. In the future, the regional experts anticipate that the impacts of habitat modification in the Colombia & Venezuela sub-system will diminish in severity if appropriate measures are implemented.

Central America & Mexico sub-system

Habitat and community modification was also identified as the priority concern of the Central America & Mexico sub-system. The transboundary ecosystems have been severely degraded as a consequence of agricultural and urban expansion, increased pollution loads and unsustainable forestry practices. As the population of the sub-system continues to increase, the demand for land escalates and environmental degradation intensifies. Poverty forces the inhabitants of the sub-system to exploit resources at an unsustainable rate; as their land becomes unproductive they are forced to migrate to more environmentally sensitive areas.

The management of protected areas faces the challenge of conserving sensitive habitats whilst accommodating the growing numbers of tourists. Many of the sub-system's natural assets such as the beaches and coral reefs have been modified as a consequence of tourist activities. The expansion of agricultural and livestock activities in the San Juan Basin has led to the deforestation of practically all the lowland forests in Costa Rica and the modification of indigenous forests in Nicaragua, resulting in increased erosion and sedimentation in aquatic systems. The excessive use of pesticides and fertilizers in crop production, attributed to weak or non-existent regulations, also degrade aquatic ecosystems when entering water bodies via runoff or leaching.

Many of the root causes behind habitat modification in the Central America & Mexico sub-system stem from a lack of institutional capacity. Coastal zone and river basin management programmes are not integrated, and the sustainability or long-term impacts of development projects are rarely considered. Decision-making processes are hampered by limited information availability and insufficient stakeholder participation.

To address these institutional inadequacies, the GIWA regional team recommend formulating and conducting capacity building programmes in order to strengthen the relevant institutions so that they can better manage the transboundary waters of the San Juan River Basin (*Institutional strengthening, PO 3*). Unsustainable practices are employed in the basin by the forestry, agriculture and fisheries sector, among others. Sustainable production can not only provide environmental benefits but can also alleviate poverty by protecting natural resources and providing alternative income sources (*Promote sustainable production, PO 4*). As a prerequisite, research is needed into locally applicable, sustainable practices and technologies. Mitigation measures, such as those outlined in this report, are needed to be adopted in the short-term in order to halt or revere the ecosystem degradation trends experienced throughout the Central America & Mexico sub-system.

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Annexes

Annex I
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Annex II
Detailed scoring tables Colombia-Venezuela sub-system (3b)

I: Freshwater shortage

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	0.9
2. Pollution of existing supplies	0	70		
3. Changes in the water table	0	10		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	40
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	20
Weight average score for Economic impacts		**2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	30
Weight average score for Health impacts		**1.3**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	30
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Other social and community impacts		**1.3**	

II: Pollution

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
4. Microbiological	1	15	Pollution	1.95
5. Eutrophication	1	5		
6. Chemical	2	15		
7. Suspended solids	2	20		
8. Solid wastes	2	5		
9. Thermal	1	5		
10. Radionuclides	0	5		
11. Spills	3	30		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	50
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	20
Weight average score for Economic impacts		**2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	20
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	20
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Other social and community impacts		**2**	

III: Habitat and community modification

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	40	Habitat and community modification	2.6
13. Modification of ecosystems or ecotones, including community structure and/or species composition	2	60		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	25
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	35
Weight average score for Economic impacts		**2.25**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	20
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	40
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	30
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	30
Weight average score for Other social and community impacts		**1.6**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	40	Unsustainable exploitation of fish	2.2
15. Excessive by-catch and discards	1	10		
16. Destructive fishing practices	2	25		
17. Decreased viability of stock through pollution and disease	1	10		
18. Impact on biological and genetic diversity	2	15		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	50
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	20
Weight average score for Economic impacts		**2.2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	30
Weight average score for Health impacts		**1.3**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	30
Degree of severity	Minimum – Severe 0 1 2 3	1	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	30
Weight average score for Other social and community impacts		**1.6**	

V: Global change

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	50	Global change	1.5
20. Sea level change	1	20		
21. Increased UV-B radiation as a result of ozone depletion	1	10		
22. Changes in ocean CO_2 source/sink function	1	20		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	2	40
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	1	50
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	10
Weight average score for Economic impacts		**1.6**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	2	40
Degree of severity	Minimum – Severe (0 1 2 3)	1	50
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	10
Weight average score for Health impacts		**1.6**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	2	40
Degree of severity	Minimum – Severe (0 1 2 3)	1	50
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	10
Weight average score for Other social and community impacts		**1.6**	

Comparative environmental and socio-economic impacts of each GIWA concern

	Types of impacts									
Concern	Environmental score		Economic score		Human health score		Social and community score		Overall score	Rank
	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)		
Freshwater shortage	0.90	0.90	2.00	2.00	1.30	1.10	1.30	0.80	1	5
Pollution	1.95	1.60	2.00	2.00	2.00	1.10	2.00	1.50	2	3
Habitat and community modification	2.60	2.60	2.25	2.30	1.00	0.50	1.60	2.00	2	1
Unsustainable exploitation of fish and other living resources	2.20	1.60	2.20	2.00	1.30	1.00	1.60	1.40	2	2
Global change	1.50	1.50	1.60	2.00	1.10	1.10	1.60	2.00	2	4

Annex II
Detailed scoring tables Central America & Mexico sub-system (3c)

I: Freshwater shortage

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
1. Modification of stream flow	3	40	Freshwater shortage	1.8
2. Pollution of existing supplies	2	20		
3. Changes in the water table	1	20		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	3	50
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	20
Weight average score for Economic impacts		**2.5**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	1	30
Degree of severity	Minimum – Severe (0 1 2 3)	3	50
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	1	20
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	2	30
Degree of severity	Minimum – Severe (0 1 2 3)	3	60
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	10
Weight average score for Other social and community impacts		**2.6**	

II: Pollution

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
4. Microbiological	1	5	Pollution	2.6
5. Eutrophication	2	10		
6. Chemical	3	30		
7. Suspended solids	3	20		
8. Solid wastes	2	10		
9. Thermal	1	5		
10. Radionuclides	0	0		
11. Spills	3	20		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	3	40
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	3	40
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	20
Weight average score for Economic impacts		**2.8**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	1	20
Degree of severity	Minimum – Severe (0 1 2 3)	3	40
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	40
Weight average score for Health impacts		**2.6**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	2	25
Degree of severity	Minimum – Severe (0 1 2 3)	3	55
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	1	20
Weight average score for Other social and community impacts		**2.35**	

III: Habitat and community modification

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
12. Loss of ecosystems	3	50	Habitat and community modification	3
13. Modification of ecosystems or ecotones, including community structure and/or species composition	3	50		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	3	30
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	3	40
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	30
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	1	34
Degree of severity	Minimum Severe 0 1 2 3	1	33
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	1	33
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	1	20
Degree of severity	Minimum Severe 0 1 2 3	3	40
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	40
Weight average score for Other social and community impacts		**2.6**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	50	Unsustainable exploitation of fish	2.6
15. Excessive by-catch and discards	0	0		
16. Destructive fishing practices	3	30		
17. Decreased viability of stock through pollution and disease	1	10		
18. Impact on biological and genetic diversity	1	10		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	1	40
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	1	50
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	1	10
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	0	0
Degree of severity	Minimum Severe 0 1 2 3	0	0
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	0	0
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	2	20
Degree of severity	Minimum Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	40
Weight average score for Other social and community impacts		**2.4**	

V: Global change

Environmental issues	Score	Weight	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	40	Global change	1.8
20. Sea level change	2	40		
21. Increased UV-B radiation as a result of ozone depletion	0	0		
22. Changes in ocean CO_2 source/sink function	1	20		

Criteria for Economics impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	33
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	34
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	33
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	2	60
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	10
Weight average score for Health impacts		**2.1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	33
Degree of severity	Minimum – Severe 0 1 2 3	3	34
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	33
Weight average score for Other social and community impacts		**3**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)		
Freshwater shortage	1.80	2.50	2.50	3.00	2.00	2.00	2.60	3.00	2.43	4
Pollution	2.60	2.10	2.80	3.00	2.60	2.40	2.35	2.00	2.48	2
Habitat and community modification	3.00	2.80	3.00	2.80	1.00	1.00	2.60	2.00	2.27	1
Unsustainable exploitation of fish and other living resources	2.60	3.00	1.00	2.00	0.00	2.30	2.40	2.60	1.99	3
Global change	1.80	3.00	3.00	3.00	2.10	3.00	3.00	3.00	2.74	5

Annex III
Protocols of the Cartagena Convention

The Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention) was adopted in Cartagena, Colombia, in March 1983 and entered into force in October 1986, for the legal implementation of the Action Plan for the Caribbean Environment Programme (UNEP/CEP 1983). The Cartagena Convention has been supplemented by three Protocols, described below, in respect of Cooperation in Combating Oil Spills, Specially Protected Areas and Wildlife, and Pollution from Land-Based Sources and Activities.

The Protocol Concerning Cooperation in Combating Oil Spills

The Protocol was also adopted in 1983 and entered into force in October 1986. This Protocol applies to oil spill incidents which have resulted in, or which pose a significant threat of, pollution to the marine and coastal environment of the Wider Caribbean Region or which adversely affect the related interests of one or more of the Contracting Parties. The Parties shall, within their capabilities, cooperate in taking all necessary measures, both preventive and remedial, for the protection of the marine and coastal environment of the Wider Caribbean, particularly the coastal areas of the islands of the region, from oil spill incidents. The Parties shall, within their capabilities, establish and maintain, or ensure the establishment and maintenance of the means of responding to oil spill incidents and shall endeavour to reduce the risk thereof. Such means shall include the enactment, as necessary, of relevant legislation, the preparation of contingency plans, the identification and development of the capability to respond to an oil spill incident and the designation of an authority responsible for the implementation of this Protocol.

The Protocol Concerning Specially Protected Areas and Wildlife (SPAW)

The Protocol was adopted in January 1990 and entered into force in June 2000, and there have already been 11 COP. Every Party to this Protocol shall, in accordance with its laws and regulations and the terms of the Protocol, take the necessary measures to protect, preserve and manage in a sustainable way, within areas of the Wider Caribbean region in which it exercises sovereignty, or sovereign rights or jurisdiction: (i) areas that require protection to safeguard their special value; and (ii) threatened or endangered species of flora and fauna. Each Party shall regulate and, where necessary, prohibit activities having adverse effects on these areas and species. Each Party shall endeavour to cooperate in the enforcement of these measures, without prejudice to the sovereignty, or sovereign rights or jurisdiction of other Parties. Each Party, to the extent possible, consistent with each Parties's legal system, shall manage species of fauna and flora with the objective of preventing species from becoming endangered or threatened.

The Protocol Concerning Marine Pollution from Land-Based Sources and Activities (LBS)

The adoption of this Protocol took place in October 1999 in Aruba. Sixteen Member States signed the Final Act to adopt the Protocol, and six (Colombia, Costa Rica, Dominican Republic, France, the Netherlands, and the United States of America) have signed the Protocol itself. The protocol will enter into force after it has been ratified by nine Member States following 2 COP. Each country shall, in accordance with its laws, the provisions of this Protocol, and international law, take appropriate measures to prevent, reduce and control pollution of the Convention area from land-based sources and activities, using for this purpose the best practicable means at its disposal and in accordance with its capabilities. Each country shall develop and implement appropriate plans, programmes and measures. In such plans, programmes and measures, each country shall adopt effective means of preventing, reducing or controlling pollution of the Convention area from land-based sources and activities on its territory, including the use of most appropriate technology and management approaches such as integrated coastal area management. Countries shall, as appropriate, and having due regard to their laws and their individual social, economic and environmental characteristics and the characteristics of a specific area or sub-region, jointly develop sub-regional and regional plans, programmes and measures to prevent, reduce and control pollution of the Convention area from land-based sources and activities.

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Caribbean Sea sub-systems 3b and 3c. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference"*.

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

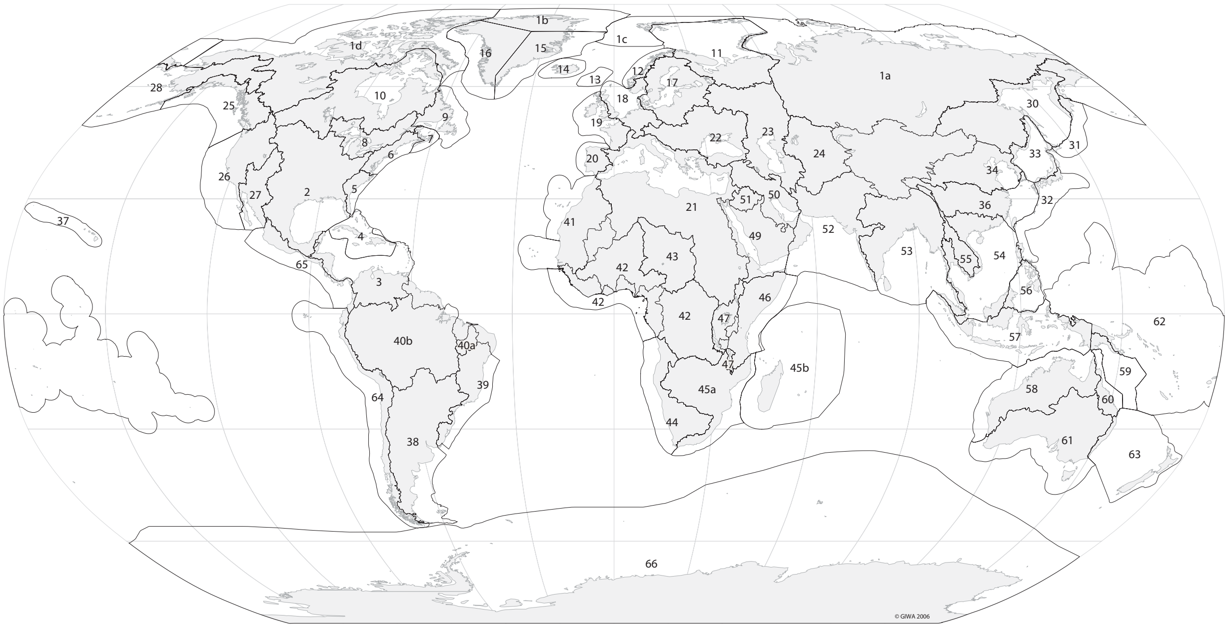
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1a Russian Arctic (4 LMEs)
1b Arctic Greenland (LME)
1c Arctic European/Atlantic
1d Arctic North American
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands (LME)
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal Sea (LME)
21 North Africa and Nile River Basin (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan (LME)
34 Yellow Sea (LME)
36 East China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Northeast Brazil Shelf (2 LMEs)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
49 Red Sea and Gulf of Aden (LME)
50 Euphrates and Tigris River Basin
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal
54 South China Sea (2 LMEs)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Pacific Islands
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific (LME)
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as

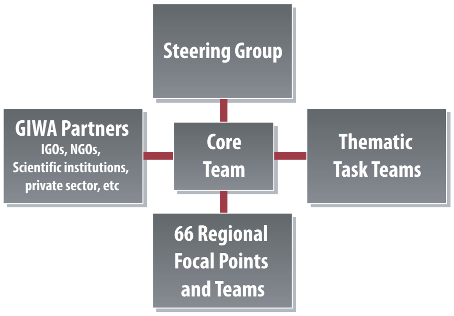


Figure 2 The organisation of the GIWA project.

universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO2 source/sink function	**V Global change**

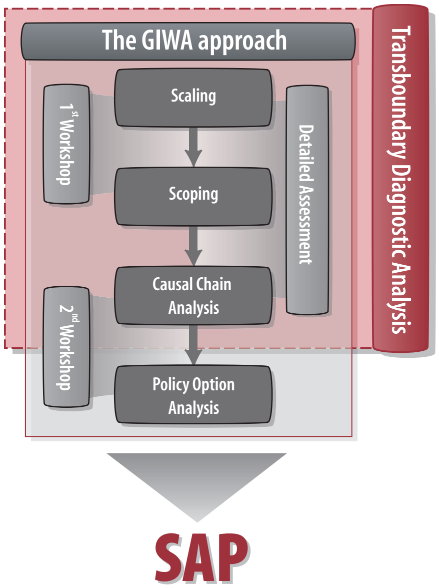

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades*." The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern. In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small (0) 1 2 Very large (3)	2	50
Degree of severity	Minimum (0) 1 2 Severe (3)	2	30
Frequency/Duration	Occasion/Short (0) 1 2 Continuous (3)	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

Global International Waters Assessment

Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the results of the GIWA assessment of the Colombia & Venezuela and Central America & Mexico sub-systems – located in GIWA region 3, the Caribbean Sea. The regional team identified habitat and community modification as the priority concern of both sub-systems. In the Colombia & Venezuela sub-system, coastal habitats are being degraded by a multitude of issues, particularly land-based sources of pollution. The transboundary ecosystems of the Central America & Mexico sub-system have been severely degraded as a consequence of agricultural and urban expansion, increased pollution loads and unsustainable forestry practices. The past and present status and future prospects of these issues are discussed, and they are traced back to their root causes. Feasible policy options are proposed that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment.

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