MANGROVE FOREST CONVERTED TO DESERT BY FARMERS IN ORDER TO PRODUCE CHARCOAL.
(PHOTO: M. EDWARDS/STILL PICTURES)

HABITAT AND COMMUNITY MODIFICATION

The GIWA assessment illustrated that the world's freshwater and marine habitats have been extensively modified by human activities. This has resulted in a loss of global biodiversity and led to the proliferation of invasive species in the coastal and freshwater systems evaluated by GIWA. Habitat modification is often the consequence of one or more of the other GIWA concerns and issues, such as pollution, invasive species, the modification of stream flow, and overfishing. The modification of stream flow following the construction of dams and other water infrastructure, particularly to supply water to irrigated agriculture, is the major cause of habitat modification in freshwater systems. In marine systems, however, the fisheries have the greatest impact on habitats and their biodiversity. The majority of regional teams predicted that habitats will deteriorate in the future due to increasing pressure from human activities. Recent mass coral bleaching events are the single most dramatic example of global climate change affecting an ecosystem on a global scale.

GIWA assessed the severity of the environmental and socio-economic impacts of this concern by evaluating two principal issues: loss of aquatic ecosystems and modification of aquatic ecosystems, including community structure and/or species composition. This chapter discusses the status of these two issues for each of five major aquatic habitats that are highlighted in the GIWA regional reports: rivers, lakes, coral reefs, mangroves and seagrasses. Although direct habitat modification is often local in extent, transboundary impacts are not uncommon (Box 21). The overall results of the GIWA assessment for habitat and community modification are summarised in the matrix in the back of this report.

BOX 21. TRANSBOUNDARY HABITAT AND COMMUNITY MODIFICATION

Habitat modifications can have impacts on an international scale in all major aquatic ecosystems. The fragmentation of transboundary river basins by dams and other structures may cause considerable changes to ecosystem functions and services in downstream countries. In lakes and semi-enclosed seas, where water exchange is limited, land-based and upstream sources of pollution and eutrophication may alter pelagic and benthic habitats of more than one country. Wetland habitats and communities are drastically modified as a result of upstream water abstraction, changes in the flooding regime and pollution.

The degradation of coastal marine habitats often reduces the extent of important nursery and spawning grounds for migratory fish. Changes to habitats that host unique communities with high endemic species diversity will result in a loss of global diversity.

Global situation and trends

- Habitat modification was the top priority issue in over one-fifth of the GIWA regions and sub-systems.
- The alteration of the world's freshwater and marine habitats has reduced global biodiversity, changed the structure of aquatic communities and led to the proliferation of invasive species on every continent and in all marine waters assessed by GIWA. Almost three-quarters of the GIWA regions/sub-systems assessed the overall impacts of habitat modification to be severe or moderate (Figure 27).
- Coral reefs have been seriously degraded by destructive fishing practices and coastal land reclamation, particularly in Southeast Asia. They are extremely vulnerable to global climate change.
- Mangrove forests are severely threatened worldwide as a result of the increased demand for timber, construction in coastal areas and aquaculture.
- Freshwater habitats, particularly wetlands, are severely modified by land-use changes, such as drainage, river levees and deforestation.

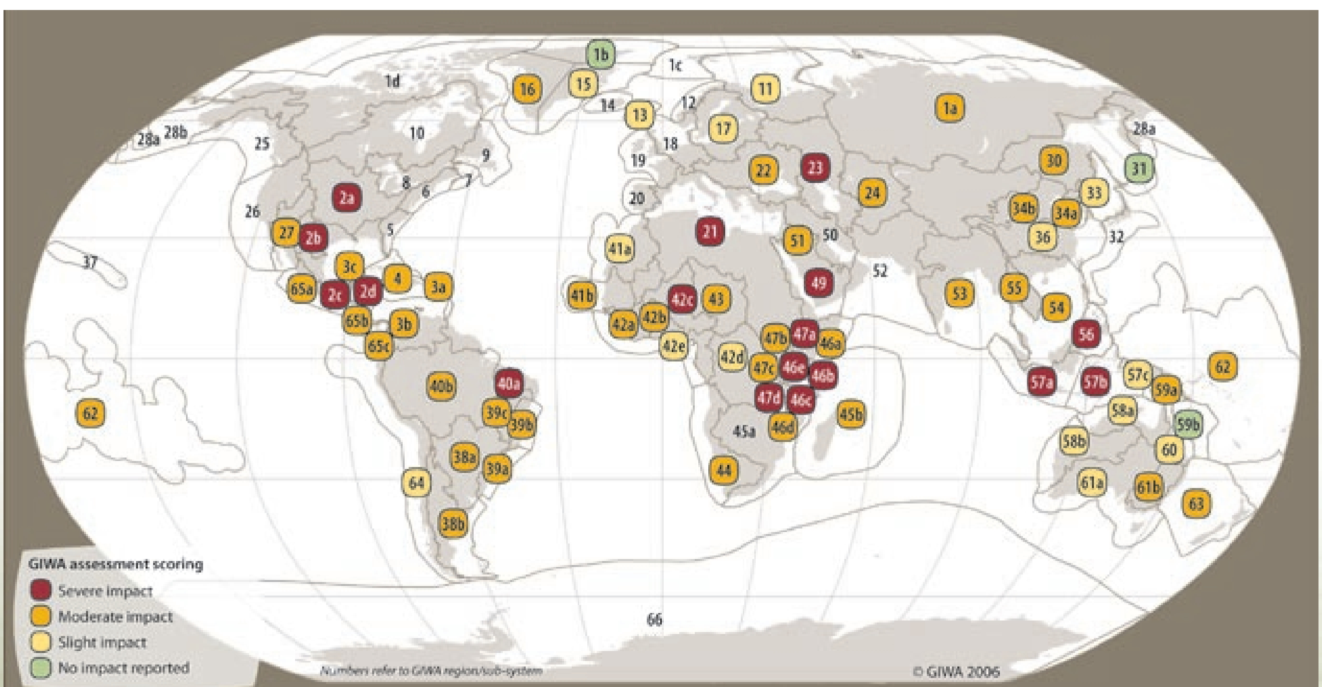


FIGURE 27. OVERALL ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS OF HABITAT AND COMMUNITY MODIFICATION

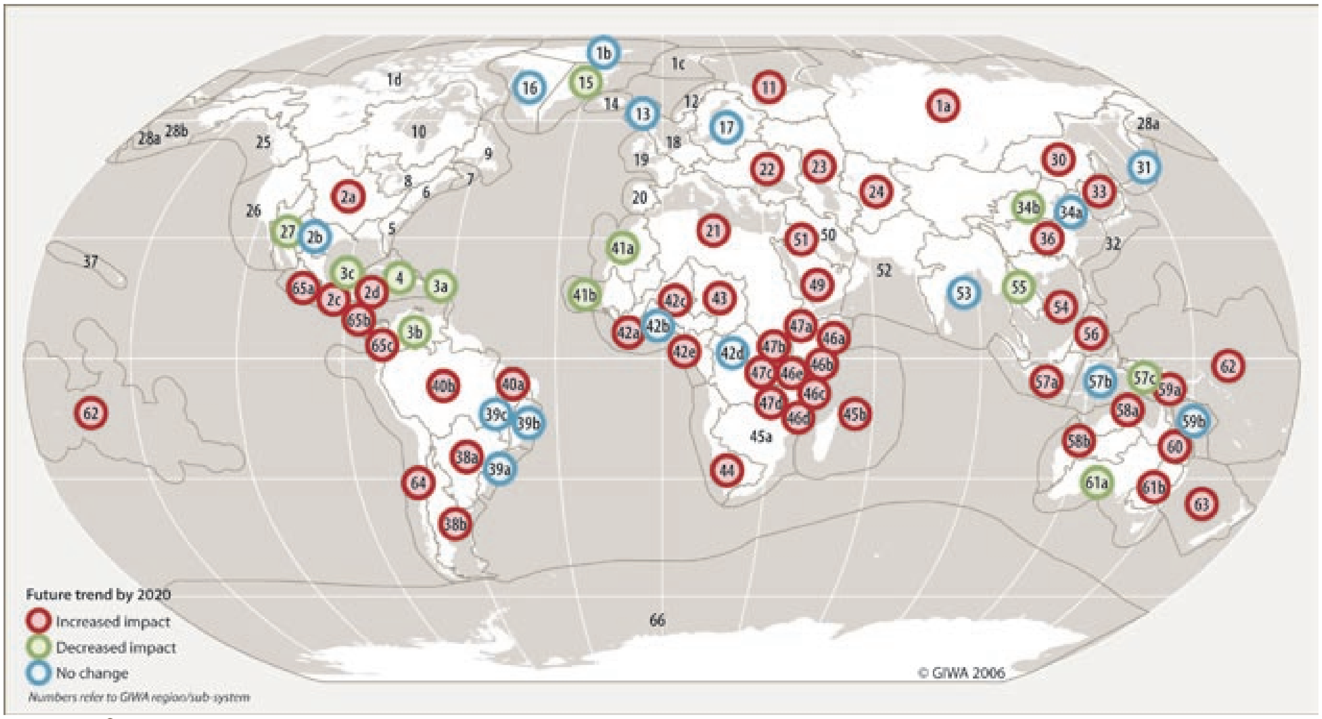


FIGURE 28. FUTURE ENVIRONMENTAL TRENDS OF HABITAT AND COMMUNITY MODIFICATION

- Regional experts forecasted that in the majority of GIWA regions, habitats will deteriorate in the future. Only a few regions are showing signs of improvement, including a cluster in the Caribbean (Figure 28).

ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

Freshwater habitats

Freshwater habitats provide invaluable services to mankind, but growing demand for freshwater resources and services by burgeoning human populations is placing an unsustainable burden on these habitats. The modification and loss of biodiversity and/or ecosystems, and the propagation of invasive species were identified by the GIWA regional teams as the most frequent transboundary environmental impacts of freshwater habitat modification. Wetlands were recognised as severely modified ecosystems, the biodiversity of which has been impoverished by human activities. The most common socio-economic impacts are reduced fisheries revenue, loss of employment and increased costs arising from mitigation and treatment measures (Table 11, Box 22).

Rivers

There are two principal anthropogenic factors which alter the habitats of rivers: (i) inputs of pollutants, sediments and nutrients; and (ii) changes to the flow regime. The former is discussed in the chapter on pollution.

The construction of dams and other structures that control or divert the flow of water in rivers has yielded considerable economic and social benefits throughout the world, including the generation of hydropower, the provision of water for drinking and irrigation, and the mitigation of floods. However, these structures cause massive aquatic habitat and community modification in the world's river basins (Table 11 and 13). Anthropogenic activities have depreciated the value of many habitats for human well-being, including a decreased capacity to meet basic human needs, such as food and fuel.

Impacts of dams arise from either changes in the hydrological regime or the physical barriers imposed by dams (see also the chapter on freshwater shortage). Alterations to flow regimes invariably cause changes to habitats and community structures. The Colorado River Delta, for example, which once covered 780 000 ha and supported between 200 and 400 species of plant, bird and fish, has declined to less than 60 000 ha. This has been attributed primarily to the construction of the Hoover and Glen Canyon dams, and the

TABLE 11. SEVERE IMPACTS ON FRESHWATER HABITATS AND COMMUNITIES IDENTIFIED IN GIWA REGIONS

Freshwater habitats		Environmental impacts						Socio-economic impacts				
GIWA region	Freshwater habitat affected	Modification and loss of biodiversity and/or ecosystems	Changed erosion and/or sedimentation patterns	Establishment of invasive species	Loss and decline in the population of endemic fish species	Reduced fish stocks	Algal blooms	Reduced fisheries revenue and employment	Reduced revenues from tourism, higher employment and a loss of recreational values	Mitigation and treatment costs*	Loss of traditional livelihood and values	Reduced capacity to meet basic human needs (e.g. clean water)
2a Mississippi River (Gulf of Mexico)	Riparian wetlands	✓				✓		✓	✓			
2b Rio Bravo (Gulf of Mexico)	Riparian vegetation, rivers		✓	✓		✓		✓		✓		
27 Colorado River (Gulf of California)	Wetlands, riparian forests	✓		✓				✓	✓	✓	✓	
34a Yellow Sea (Yellow Sea)	Marshlands, lakes, rivers	✓		✓				✓	✓		✓	
34b Bohai Sea (Yellow Sea)	Wetlands, rivers, lakes	✓			✓			✓				
38a La Plata River Basin (Patagonian Shelf)	Rivers, riparian habitats	✓	✓				✓		✓	✓		✓
40a Paranaiba River Basin (Northeast Brazil Shelf)	Rivers, lakes	✓	✓								✓	
42c Niger Basin (Guinea Current)	Rivers, ponds, wetlands	✓	✓					✓		✓		
41b Canary Current South	Wetlands, lakes	✓		✓				✓	✓	✓	✓	
44 Orange-Vaal River Basin (Benguela Current)	Wetlands, riparian vegetation, rivers	✓		✓						✓	✓	
47b Lake Victoria (East African Rift Valley Lakes)	Wetlands, riparian vegetation, open waters	✓		✓				✓		✓		
51 Jordan	Rivers, wetlands, Dead Sea	✓			✓			✓		✓		
61b Muray Darling Basin (Great Australian Bight)	River, riparian vegetation, wetlands		✓	✓	✓					✓	✓	✓

BOX 22. TRANSBOUNDARY SOCIO-ECONOMIC IMPACTS OF HABITAT DEGRADATION: CASE OF THE YELLOW SEA CATCHMENT AREA

The GIWA assessment of the Yellow Sea region illustrates the complexity of marine and freshwater habitat modification, and the resulting socio-economic impacts. Over 30% of the freshwater wetlands, lakes, rivers and lagoons have disappeared in the last 30 years. Alien species, such as the marine cordgrass (*Spartina* sp.), have replaced endemic species, and new diseases have been introduced into both the freshwater and marine environment. The loss of wetlands in the Huai River Basin has decreased fish catches and adversely affected cultural heritage sites. The degradation of ecosystems has reduced employment in tourism and aquaculture in the basin, and overall employment has fallen by 10% over the past decade. Throughout the Yellow Sea region, the production of aquatic life used in Chinese medicine, such as seahorses, seadragons and scallops, has decreased by 40% over the same period.

(SOURCE: YELLOW SEA/34)

overuse of water by agriculture and urban areas in Arizona, California and northwestern Mexico (Gulf of California/27). In the Volta River Basin (Guinea Current/42b) more than 650 dams have impounded the Sudano-Sahelian portion of the Basin, resulting in the loss of wetlands, including marshes and floodplains.

The modification of flow regimes, in conjunction with deforestation along river banks and poor agricultural practices in surrounding catchments, has affected sediment transport, erosion rates and nutrient loads in many rivers throughout the world. In the Mekong River, this has reduced fish abundance and spawning areas, which has been a contributing factor in forcing Cambodia to shift from exporting to importing fish to meet local demand.

The construction of dams has converted many water habitats from flowing to static environments which in several GIWA regions, for example the Amazon/40b and the Patago-

FIGURE 29. ATATURK DAM ON THE EUPHRATES RIVER PROVIDES POWER TO TURKEY. (PHOTO: CORBIS)

nian Shelf/38, has caused a decline in fish species that inhabit fast-flowing, rocky-bottom habitats. Dredging for navigation has significantly modified the benthic habitats of rivers in many regions, including the Brazil Current/39. Common vegetation types, such as riparian marshes, have been displaced by aggressive invasive species, such as Water hyacinth (*Eichhornia crassipes*) and Hydrilla (*Hydrilla verticulata).*

In the Caspian Sea/23 region, international conflicts have arisen from dam-induced habitat modification affecting the commercial fish stocks of the entire region but only the countries that constructed the dams benefiting from the electricity and water for irrigation.

While habitat degradation is currently more severe in developing countries, some of the most extensive habitat modification has previously occurred in developed countries. The midwestern US states have drained the equivalent of 14.1 million ha of wetlands in the Mississippi River Basin (Gulf of Mexico/2a) over the past 200 years.

Lake habitats

Lakes are critical reservoirs that store surface water for a multitude of essential human uses and services, including consumption, agriculture and recreation. According to the GIWA regional reports, the most significant factors affecting lake habitats are: (i) dams reducing downstream flows; (ii) river diversions for irrigation and, to a lesser extent, domestic and industrial water supply; (iii) drainage basin land-use changes; (iv) the introduction of invasive species; (v) overfishing; and (vi) salinisation. Decreases in lake areas have been reported in many GIWA regions, including the Aral Sea/24, Caspian Sea/23, East African Rift Valley Lakes/47, Jordan/51 and Lake Chad/43.

The most spectacular example of lacustrine habitat modification is the retreat of the Aral Sea/24, which resulted from the diversion of water from the Amu Darya and Syr Darya rivers for irrigation. The surface area of the Aral Sea has been reduced by 50% since the 1950s and the water level has dropped 20 metres. Moreover, the increased salinity of the sea has transformed it into a biological desert and caused the total collapse of the once productive fishery. The health of the region's population has deteriorated and employment opportunities for the former shoreline communities have declined. A similar fate is currently befalling the Dead Sea (see Box 3 in the freshwater shortage chapter).

In many transboundary lakes, a reduced influx of water and increasing eutrophication have changed the community structure from open-water systems to marshy habitats, consequently altering fish assemblages. Lake Chad/43 is one of the world's most dramatic examples of rapidly shrinking open-water areas being replaced by marshy wetlands. An effect of this change is that the most important commercial fish, which were previously open-water species, have been replaced by catfish (*Clarias* sp.) and other wetland species. In addition, invasive plants now blanket half the surface of Lake Chad.

Lakes are the recipients of sediments originating from the surrounding drainage basins, which have increased in volume as a consequence of land-use changes. For example, overgrazing and deforestation has intensified sedimentation in Lake Malawi, Lake Tanganyika and Lake Turkana. Nutrients contained in these sediments have contributed to eutrophication, particularly in Lake Victoria, where anoxic conditions have reduced fish abundance and diversity, especially among endemic cichlid populations. Endemic fish populations were additionally impacted by the introduction of Nile Perch (East African Rift Valley Lakes/47).

In many international lakes, the impacts of habitat modification, particularly on fish communities, have been exacerbated by overexploitation. A combination of overfishing and the construction of the Turkwell Dam, which lowered lake levels, led to the collapse of the Tilapia (*Oreochromis* spp.) fisheries in the majority of Lake Turkana (East African Rift Valley Lakes/47a). The loss of income from the fisheries sector had a severe impact as there are virtually no other local employment opportunities.

Marine habitats

The continued health of coastal ecosystems is essential for human well-being, as well as for other ecosystem services, including shoreline protection, water quality and biodiversity reservoirs. Unregulated access to coastal ecosystems is putting these resources at risk (Table 12). The most common transboundary environmental impacts are modification and/or loss of biodiversity, and increased sedimentation or erosion. The most frequent socio-economic impacts are experienced by the fisheries and tourism sectors.

Coastal lagoons and estuaries, tidal mudflats, and sandy and rocky shores are particularly affected by pollution, such as oil spills, solid waste and eutrophication. The follow-

TABLE 12. SEVERE IMPACTS ON MARINE HABITATS AND COMMUNITIES IDENTIFIED IN GIWA REGIONS

Marine habitats		Environmental impacts						Socio-economic impacts					
GIWA region	Marine habitats affected	Modification and/or loss of biodiversity	Changes in populations and community structures	Introduction of invasive species	Loss and fragmentation of coastal habitats	Reduced productivity	Increased sedimentation or erosion	Reduced fisheries revenue and employment	Reduced tourism revenue and employment; loss of recreation values	Reduced revenue from ecosystem services	Mitigation and treatment costs (e.g. control of invasive species, coastline restoration)	Loss of traditional livelihoods	Increased user conflicts
3a Small Islands (Caribbean Sea)	Coral reefs, mangroves, seagrass beds, sandy shores	✓	✓			✓		✓	✓				✓
34a Yellow Sea (Yellow Sea)	Salt marshes, estuaries	✓	✓	✓			✓	✓				✓	
34b Bohai Sea (Yellow Sea)	Salt marshes, estuaries	✓						✓					
39a South/Southeast Atlantic Basins (Brazil Current)	Salt marshes, mangroves, coral reefs, estuaries	✓					✓	✓			✓		
39b East Atlantic Basins (Brazil Current)	Salt marshes, mangroves, coral reefs	✓		✓			✓	✓	✓		✓		
40a Northeast Brazil Shelf	Mangroves, estuaries, coral reefs	✓					✓	✓	✓		✓		
41 Canary Current	Mangroves				✓		✓	✓	✓			✓	
42c Comoe Basin (Guinea Current)	Mangroves, estuaries, lagoons	✓			✓	✓	✓	✓	✓	✓		✓	
44 Benguela Current	Estuaries, sandy foreshores	✓		✓			✓	✓	✓			✓	
53 Bay of Bengal	Mangroves, coral reefs	✓	✓			✓	✓	✓	✓	✓	✓		
54 South China Sea	Mangroves, coral reefs, wetlands, seagrass areas		✓		✓			✓	✓	✓			✓
56 Sulu-Celebes Sea	Seagrass beds, muddy and sand-gravel bottoms, coral reefs		✓					✓	✓	✓			
57a Sunda (Indonesian Seas)	Mangroves, seagrass beds, muddy and sand-gravel bottoms, coral reefs		✓							✓			
57b Wallacea (Indonesian Seas)	Mangroves, coral reefs		✓							✓			

ing section, however, will concentrate on coral reefs, mangroves and seagrass beds where human impacts are manifold.

Coral reefs

The condition of coral reefs varies regionally depending on the level of human pressure placed on them. Coral reefs in more sparsely populated regions of the world, such as the Coral Sea/59, Great Barrier Reef/60 and Pacific Islands/62, are generally in good condition. However, in densely populated regions and in locations where reefs are easily accessible, coral reef ecosystems are degraded by overfishing and destructive fishing methods, sedimentation, inappropriate coastal development and tourism. The reefs of Indonesia provide annual economic benefits of 1.6 billion USD, based on their value for food security, employment, tourism, pharmaceutical research and production, and shoreline protection. However, over the next 20 years, anthropogenic degradation of reefs could cost Indonesia around 2.6 billion USD (Indonesian Seas/57).

Burgeoning coastal populations with few alternative sources of food or income have led to the widespread overexploitation and degradation of coral reef ecosystems in many developing regions. In the Pacific Islands/62 region, the breakdown of traditional community controls on fishing has led to overfishing near populated areas. Here, as well as in most other tropical shallow water systems, overexploitation has greatly affected fish populations and changed the community dynamics of the reefs. Reefs and their dependent species are also altered by the use of dynamite and narrow meshed nets.

Coastal development is a major source of coral reef degradation. In the Indonesian Seas/57 region, development and expansion of ports has destroyed reefs and associated islands. In addition, the construction of hotels along the foreshore adjacent to coral reefs increases the number of people in coastal areas resulting in the accumulation of solid waste, eutrophication from the discharge of untreated effluents and physical damage from anchoring and other tourist activities (Caribbean Sea/3, Caribbean Islands/4) (Box 23).

The addition of nutrients within untreated or inadequately treated effluents from coastal cities has caused dramatic changes to many coral reefs worldwide. Reefs near urban centres in Brazil exhibit 77% macroalgal cover, compared with 41% in less populated areas (Northeast Brazil Shelf/40a). Poor agricultural practices and deforestation have also decreased the extent of coral reefs, especially near river mouths where sediments, pesticides and fertilizers smother the corals and impede their growth.

Up until 1998, the global agenda to conserve coral reefs had concentrated on preventing direct anthropogenic impacts. However, during the last decade, mass coral bleaching events provide tangible evidence of the effect of climate change on aquatic habitats, emerging as potentially the greatest threat to coral reefs (Box 24).

BOX 23. TOURISM AND HABITAT MODIFICATION: CASE OF THE CARIBBEAN

Tourism is a vital industry for the economies of many Caribbean nations, accounting for one-quarter of GDP and one in every five jobs. The Wider Caribbean region attracts 57% of international scuba diving tours; generating nearly 900 million USD in 2005. The cruise industry also represents a significant proportion of tourism, with 14.5 million cruise passengers received by the Caribbean Islands/4 region in 2000. Employment has subsequently shifted from fishing to tourism.

Since the success of the tourism industry is dependent on the beauty and services of coastal ecosystems, it is vulnerable to environmental degradation. Reef dive tourism is inadequately managed in the Caribbean Islands/4, as in many parts of the world, causing significant anchor and diver damage in intensely visited locations. In the Central America/Mexico sub-system (Carribean Sea/3c), hotel construction is of particular concern due to the resultant habitat fragmentation. Land-based sources and ship-borne pollution, including waste discharged by cruise liners and tourist facilities, enters coastal waters, further reducing the environmental quality of the Caribbean.

DIVING BOAT, DIVI FLAMINGO, ANTILLES. (PHOTO: J. OLIVER, REEFBASE)

Habitat modification reduces income opportunities in the tourism sector as fishing, snorkelling and diving become less appealing to tourists. The costs can be considerable; 12 million USD of tourism revenue are lost annually in the Nicoya Gulf of Costa Rica.

(SOURCE: SMALL ISLANDS (CARIBBEAN SEA/3A), CENTRAL AMERICA/MEXICO (CARIBBEAN SEA/3C), CARIBBEAN ISLANDS/4)

BOX 24. CORAL BLEACHING AND THE INFLUENCE OF EL NIÑO AND GLOBAL CLIMATE CHANGE

Bleaching in corals is a stress response caused by the loss of the symbiotic dinoflagellates that reside within coral tissue. Although many factors can cause bleaching in certain localities, only abnormal increases in sea temperature over a period of months can cause coral bleaching on a regional and even global scale. In the 1997/1998 El Niño event, bleaching caused coral mortality, effectively destroying around 50% of the world's shallow water coral reefs. The Indian Ocean was particularly affected but extensive bleaching was also reported in the South China Sea, Sulu-Celebes Seas, the Pacific Islands and throughout the Caribbean. Prior to coral bleaching in the 1990s, the phenomenon was thought to be local in extent. Since then, six mass bleaching events have occurred, always coinciding with an El Niño event. At present, mass bleaching of corals only occurs if an El Niño of sufficient strength prevails for long enough to cause significant increases in sea temperature. However, if global sea temperatures continue to rise as predicted and approach the thermal tolerance limit of corals, El Niños of smaller magnitude would be capable of causing mass bleaching. The increasing frequency and severity of mass coral bleaching events are considered the most significant threat caused by global climate change to an ecosystem on a global scale.

BLEACHED CORALS IN THE GREAT BARRIER REEF, KEPPEL ISLANDS.
(PHOTO: G. LOTTON, REEFBASE)

Mangroves

Mangroves are highly productive forest habitats found along sheltered tropical coastlines. They are essential sources of wood for firewood and construction, as well as invaluable nursery areas for juvenile fish and crustaceans. They also provide coastal protection and filtration functions.

The area of the world's coastline occupied by mangroves is rapidly declining. More than a dozen GIWA regions reported that unsustainable timber harvesting has degraded mangrove ecosystems. In Africa's Volta River Delta, the degradation of mangrove habitats has changed the species composition of 70% of the fish communities since 1969, and has led to the collapse of the shrimp and Jack mackerel fishery and a downturn in the freshwater clam industry (Volta Basin (Guinea Current/42b)). The economic costs can be substantial. For example, in the Indian Ocean Islands/45b, direct monetary costs from loss of mangrove habitats are 600 USD per ha, or 204 million USD per year. Similarly, in many regions, rice paddies, and sugar cane and palm plantations have replaced large areas of mangrove forest.

FIGURE 30. COASTAL DEVELOPMENT NEAR A MANGROVE ESTUARY, SINGAPORE.
(PHOTO: J. OLIVER, REEFBASE)

The growth of coastal towns and cities has destroyed many mangrove forests (Figure 30). In the Guinea Current/42 region, the expansion of Accra in Ghana has cleared 55% of the mangroves and significant areas of marshland in the surrounding area. The expansion of population centres also requires infrastructure development, such as roads, ports and waste disposal sites. In the Philippines, 60-80% of the mangrove forests have been cleared for port developments. The reclamation of land for infrastructure development is often most visible in densely populated islands and atolls, where both space and natural resources are limited. This is demonstrated in the Pacific Islands/62, where more than 50% of the region's mangroves have been removed or severely degraded. In the Brazil Current/39 region and Caribbean/3&4, the construction of tourist hotels and associated facilities, such as marinas, golf courses and airports, has resulted in the destruction of mangrove habitats.

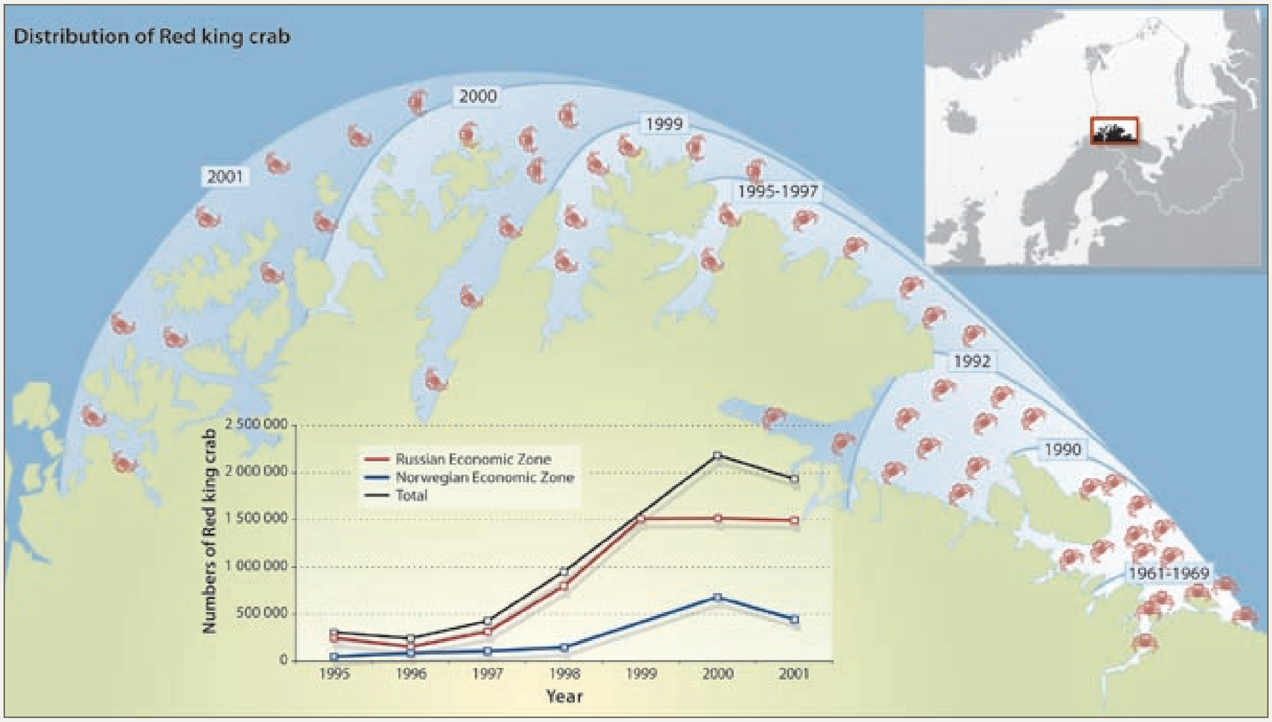
BOX 25. TRANBOUNDARY IMPACTS OF INVASIVE SPECIES

In addition to the increase in global maritime traffic and aquaculture, invasive species, which can be intentionally or accidentally introduced, are now widely acknowledged as a critical transboundary problem in both freshwater and marine habitats. Invasive species have caused environmental impacts in almost half of the GIWA regions. A number of initiatives aimed at limiting the introduction and extent of invasive species have been developed, including the GEF/IMO/UNDP Global Ballast Water Management Programme (GLOBALLAST) and regional activities, such as the GEF-supported UNDP Caspian Environment Programme.

In freshwater systems, the widespread introduction of Tilapia (*Oreochromis* spp.), Carp (*Cyprinus carpio*), Nile perch (*Lates niloticus*) and Water hyacinth (*Eichhorizia crassipes*) has significantly impacted riverine and lake habitats, and has led to the extinction of endemic species in several GIWA regions, including the Gulf of California/27, Benguela Current/44, East African Rift Valley Lakes/47b,c, South China Sea/54 and Indonesian Seas/57a,b. The accidental introduction of the Asian mussel (*Limnoperna fortunei)* into the La Plata River costs nearly 1 million USD every day that the Itaipú Dam has to shutdown power in order to remove the mussels (Patagonian Shelf/38a).

In marine habitats, there are a greater number of introduced species but many remain undetected. The GIWA regional teams that highlighted marine invasive species as a concern include the Barents Sea/11, Baltic Sea/17, Black Sea/22, Caspian Sea/23, Brazil Current/39, Yellow Sea/34, and Benguela Current/44. The impact of invasive species on the ecology of the Black Sea is discussed in Box 19 in the chapter on overfishing and other threats to aquatic living resources.

The Red king crab (*Paralithodes camtschaticus*) of the Pacific was deliberately introduced by Russian scientists into the Barents Sea/11. Since its introduction, the population of Red king crab has increased and spread westwards into Norwegian waters where it has significantly altered benthic communities. In 2002, commercial fishing of the Red king crab began in Norway, which has increased employment in the fish processing sector but at the cost of jobs in factories processing traditional fish catches. Several other invasive species in the Barents Sea have caused economic losses. In Russia, the introduction of the Humpback salmon (*Oncorhynchus gorbuscha*), which is less prized than the Atlantic salmon (*Salmo salar*) for sport and commercial fisheries, has reduced the economic and recreational value of many rivers. Parasites and pathogens caused at least 500 million USD of damage to the Norwegian farmed and wild salmon fishery between 1985 and 2000.



INCREASED EXTENT OF RED KING CRAB IN THE BARENTS SEA.
(SOURCE: MATISHOV & DENISOV 2000)

Aquaculture is probably the greatest single factor behind mangrove deforestation, particularly in South America and Southeast Asia (see Box 18). In the Philippines, prawn aquaculture occupies an area of 500 000 ha and has reduced intact mangrove forests by 50%. In the 1990s, governments of the Indonesian Seas/57 region allocated up to 1 million ha of land, mostly mangrove forests, to the shrimp industry. However, about 70% of the shrimp farms were abandoned by 2001 because they had become unproductive as a result of aquaculture pollution and the creation of acid sulfate soils. Mangrove conversion throughout Southeast Asia has led to conflict between local inhabitants and migrants. The introduction of aquaculture in Brazil has created similar conflicts between prawn farmers and artisanal fishermen. Brazilian prawn farmers buy or appropriate land, which is usually public, and close its access to fishermen, many of whom have fished these areas for many years (Brazil Current/39).

Seagrasses

Seagrass communities are highly productive habitats commonly found in shallow coastal and estuarine waters in many regions of the world. In addition to providing valuable nursery areas for juvenile fish and crustaceans, seagrass beds are important filters and stabilisers of sediments, particularly in regions prone to storms, such as the Pacific Islands/62 and the Caribbean region/3 & 4. These services provide considerable economic benefits; in the South China Sea/54 region the value of seagrass beds and coastal swamps is estimated to be 190 million USD annually.

Seagrass beds are primarily degraded as a result of increasing concentrations of nutrients and particulate matter in coastal waters. Physical disturbance resulting from the increasing use of the coastal zone for transportation, reclamation and fishing also causes extensive damage.

In the Caribbean, land reclamation, and coastal and port construction associated with tourism have caused considerable degradation to seagrass communities and reduced water clarity as a result of dredging and landfill activities. The increase in coastal activity, particularly tourism, recreation and urban development, has resulted in significant impacts on seagrass communities due to increased sedimentation and nutrient loads emanating from sewage discharges, and from physical damage caused by boating, anchoring and other activities. Eutrophication, stimulated by elevated nutrient loads, has increased the turbidity of coastal waters, which subsequently harms seagrass communities and reduces biodiversity. In Southeast Asia, trawling in coastal waters also damages seagrass beds (Indonesian Seas/57, Sulu-Celebes Seas/56).

Box 25 discusses the transboundary impacts of invasive species in marine and freshwater habitats.

ROOT CAUSES

Habitat and community modification was targeted for causal chain analysis in 16 GIWA regions/sub-systems (Table 13 and 14). The most common immediate causes identified by the GIWA regional teams were: (i) pollution; (ii) invasive species; (iii) modification of stream flow; and (iv) overfishing. The principal sectors causing environmental impacts were agriculture and the fisheries. Many of the GIWA causal chain analyses discussed the extent to which the three other GIWA concerns drive habitat modification. The following section examines the root causes of habitat degradation.

Population and economic growth

Demographic change, such as population growth, was identified as one of the main root causes in almost every GIWA regional report that focused on habitat modification in the causal chain analysis. Increasing populations exacerbate the transboundary impacts and causes of habitat modification. In the East China Sea/36 region, for example, thousands of hectares of shoals have been reclaimed in the Yangtze (Changjiang) estuary for the expansion of agriculture and urban areas in order to accommodate an increasing population.

In the neighbouring South China Sea/54, as in many other regions, most of the transboundary habitat impacts and their immediate causes are exacerbated by population growth and migration, as well as economic and industrial growth. These impacts threaten the coastal and marine habitats on which the population depends.

Increased pressure on ecosystems and the consequent modification of habitats are not only a matter of population growth. Economic growth and increasing demand for products are also root causes of habitat modification. The economies of many countries in Southeast Asia, especially China, are growing rapidly. In the Yellow Sea/34 region, as in other parts of Asia, higher living standards have increased demand for cultured fish, which has encouraged aquaculture devel-

TABLE 13. IMMEDIATE CAUSES OF HABITAT AND COMMUNITY MODIFICATION

	Targeted issues																
	Modification and loss of ecosystems																
	Immediate causes								Main sectors involved								
GIWA region	Modification of stream flow	Land use practices	Coastal erosion	Sedimentation	Pollution	Introduction of invasive species	Overexploitation of fish	Increased urban development/expansion	Agriculture	Domestic	Forestry	Fisheries	Maritime traffic	Coastal development	Mining	Industry	Energy
2a Mississippi River (Gulf of Mexico)	✓	✓	✓						✓	✓							
3a Small Islands (Caribbean Sea)			✓	✓	✓	✓	✓		✓			✓	✓	✓			
3b Magdalena Basin (Caribbean Sea)					✓				✓						✓		
3c Central America/Mexico (Caribbean Sea)					✓				✓		✓						
11 Barents Sea						✓						✓					
23 Caspian Sea	✓				✓	✓	✓		✓	✓		✓				✓	✓
34 Yellow Sea	✓				✓	✓			✓	✓		✓				✓	✓
36 East China Sea			✓	✓	✓			✓	✓	✓				✓		✓	
38b Buenos Aires Coastal Ecosystem (Patagonian Shelf)	✓				✓	✓	✓	✓		✓		✓			✓	✓	
40a Paranaiba River Basin (Northeast Brazil Shelf)	✓			✓		✓			✓		✓				✓		
40b Amazon	✓				✓				✓		✓				✓		✓
42c Niger River Basin (Guinea Current)	✓				✓				✓								
54 South China Sea		✓			✓		✓	✓		✓	✓	✓			✓	✓	
56 Sulu-Celebes Sea					✓		✓		✓		✓	✓		✓		✓	

NOTE: THE TABLE PRESENTS A SELECTION OF GIWA REGIONS WHERE THE REGIONAL TEAM HAS CONDUCTED A CAUSAL CHAIN ANALYSIS ON THE GIWA CONCERN HABITAT AND COMMUNITY MODIFICATION.

opment. Fish and seafood consumption has become more fashionable among health-conscious consumers in developed countries, further fuelling aquaculture expansion. Aquaculture has increased pollution, introduced invasive species and converted vast areas of wetland and mangrove forest.

Market failures

Market prices are often not representative of the true value of goods and services provided by ecosystems. While the short-term gains from blast fishing may be impressive, consumer prices do not incorporate the cost of the long-term damage to coral reefs. If fish prices accounted for environmental and social costs, the use of destructive practices would be discouraged.

In the Caspian Sea/23 region, high unemployment rates have led to increased small-scale farming along the coast. The new farms, which are located on infertile soils, are dependent on environmentally harmful pesticides that are both readily available and cheap. The prices of pesticides do not account for the negative externalities from the run-off of these pollutants into the Caspian river basins and adjacent coastal waters. Consequently, farmers have little economic incentive to switch to modern and less damaging substitutes.

Policy failures

In the Niger Basin (Guinea Current/42c) there is little understanding of the complex human-environment interactions, which provides an inadequate basis for sound policy-making. In the Buenos Aires coastal ecosystem (Patagonian Shelf/38b), statistics for fisheries and other ecosystem-based activities are lacking. Furthermore, the datasets of the Argentinean provincial and national governments, as well as the Uruguayan jurisdictions, are incompatible. Scientific experts in the Caspian Sea/23 region lack the financial and/or technical resources to conduct a thorough assessment of living resources. Governments and the fishing industry of the region also pressurise scientists into adjusting scientific recommendations. Political expediency may help the governments of the Caspian Sea/23 region to reach agreements, but they are not founded on sound information nor enforced, which has resulted in a legacy of policy failures. Given the weak information base and lack of coordination between executive and

TABLE 14. POTENTIAL POLICY INSTRUMENTS RELATED TO HABITAT AND COMMUNITY MODIFICATION

Contributing sector	Underlying root causes	Potential policy instruments	
		Short-term	Long-term
Modification and loss of ecosystems			
Agriculture	▪ Lack of monitoring and enforcement capacity ▪ Lack of public awareness ▪ Weak long-term cross-sectoral planning ▪ Fragmented land use management	▪ Improved land use management ▪ Promotion of appropriate technologies ▪ Market-based fees and charges ▪ Education ▪ Capacity building ▪ Stakeholder dialogue	▪ Implement land use planning and management systems ▪ Increase enforcement ▪ Low-impact rain-fed agriculture ▪ Encourage the production of appropriate crop varieties
Energy production	▪ Weak regulations ▪ Inadequate institutional capacity	▪ Improve regulations on dam construction ▪ Environmentally friendly farming	▪ Construct fish migration paths ▪ Stakeholder dialogue
Industry	▪ Inadequate implementation of new technology and infrastructure ▪ Lack of habitat protection ▪ Low enforcement capacity	▪ Promotion of appropriate technologies ▪ Improved stakeholder participation ▪ Strengthen local control	▪ Improved natural resource management ▪ Pollution taxes and fines ▪ Integrated, multilateral conservation
Fisheries	▪ Insufficient enforcement capacity ▪ Lack of research for making sound policies ▪ Inadequate implementation of appropriate fishing gear	▪ Capacity building ▪ Improved regulation and enforcement ▪ Expanded community education programmes ▪ Follow recommendations of scientific organisations	▪ Improved management of protected areas ▪ Adoption of regulations at international level ▪ Partnerships
Urban development	▪ Urbanisation ▪ Inadequate knowledge of sewage treatment ▪ Inadequate financial capacity to promote compliance ▪ Poverty	▪ Strengthen institutions ▪ Increase knowledge	▪ Improve legal framework ▪ Clear and transparent decision-making
Coastal development	▪ Lack of enforcement ▪ Rapid population growth ▪ Poverty ▪ Institutional weakness	▪ Promotion of alternative energy technologies to replace wood fuels ▪ Improved the governance framework ▪ Capacity building in policy formulation	▪ Improved control of population growth ▪ Coastal management planning

scientific organisations, it is not surprising that Argentina and Uruguay (Patagonian Shelf/38) disagree on crucial aspects of administering shared coastal resources and postpone difficult management decisions.

Even when information is available to make sustainable policy decisions, organisations responsible for formulating policies may not include environmental considerations or broad stakeholder involvement in the decision-making process. Political structures in some Southeast Asian countries are still dominated by hierarchy and patronage, with democratic decision-making yet to be common practice. This governance model has resulted in bureaucratic inaction, the misallocation of financial resources and a mistrust of government officials. Consequently, it is difficult to obtain local support for many governmental management policies and even for collecting accurate statistics.

POLICY RELEVANT CONCLUSIONS

Both freshwater and coastal marine ecosystems are confronted and continually degraded by a wide range of powerful stressors. In freshwater ecosystems, increasing human populations will continue to demand additional freshwater for drinking, irrigation, hydropower and waste disposal. The introduction of invasive species will also exert greater influences on freshwater ecosystems in the future. The adoption of integrated management and increased public awareness of the plight of freshwater ecosystems will only partially reduce the rate of habitat degradation.

The pressures exerted by widespread poverty and population growth are also placing a burden on coastal and marine ecosystems and the resources they provide. Overfishing, coastal development, sedimentation, pollution and the expansion of aquaculture are some of the factors that will continue to degrade transboundary coastal ecosystems.

While appropriate legislation is in place in many countries, a lack of capacity to implement or enforce such legislation, particularly in many GEF-eligible regions, will allow negative habitat and community modification to continue in both types of aquatic system.

GIWA regional teams selected specific policy options that address habitat modification and promote an ecosystem-based approach (Table 14). Their suggested interventions are divided into four groups: (i) building a knowledge base; (ii) integrating ecosystem issues into policies; (iii) supporting marine protected areas; and (iv) strengthening institutional capacity. Most successful interventions use multiple instruments to address different root causes and take into account regional environmental and socio-economic particularities.

Knowledge base and assessments

Policy makers require information to evaluate the trade-offs between policies and to set priorities. Despite having made major progress, we are yet to understand important aspects of the interaction between habitats, their organisms and human actions. Furthermore, economic valuation of the goods and services provided by ecosystems is still struggling to gain acceptance as a regular policy tool in most parts of the world. Given the complexity of transboundary issues, these assessments require cooperation between scientists from a range of disciplines. By evaluating impacts and trade-offs, assessments like GIWA can improve the compatibility of different sectoral, national and regional policies.

Policy integration

The management of aquatic habitats and resources, as well as addressing the multitude of causes behind the problems they face, has proven difficult. This has led to the development of an ecosystem-based approach to the management of freshwater and marine transboundary waters. One ecosystem-based approach that is becoming widely accepted is Integrated Coastal Zone Management (ICZM). It is analogous to the integrated water resource management approach discussed in the chapter on freshwater shortage. Many GIWA regional teams throughout the tropics recommend pursuing, or are already implementing, ICZM.

Actions to preserve habitats have traditionally segregated ecosystems from economic activities by establishing protected areas, bans and zoning. However, some of the richest aquatic habitats are located in areas where human activities take place (e.g. fishing in coastal waters). Consequently, policy measures that aim for sustainability have become essential elements of natural resources management strategies. One particularly important aspect of policy integration is to ensure sectoral government agencies, such as ministries of forestry, energy and roads, incorporate environmental and social concerns in their decision-making. Most GIWA regional teams recommended a wider use of economic incentives, such as those included in Table 15. They also stressed the importance of enforcing existing regulations.

TABLE 15. POTENTIAL ECONOMIC INCENTIVES TO ADDRESS TRANSBOUNDARY HABITAT AND COMMUNITY MODIFICATION

Instruments	Incentives	Disincentives	Examples of GIWA regions
Property rights	▪ Ownership, management, access and use rights over biodiversity ▪ Joint, collaborative and co-management of biodiversity ▪ Leases, concessions, licenses, permits and franchises for the management, use, harvesting and prospecting of biological resources	▪ Exclusion from land and biodiversity ▪ Enforcement and penalties for unsustainable or illegal biodiversity use	38b South Atlantic Drainage System (Patagonian Shelf) 11 Barents Sea 34 Yellow Sea 36 East China Sea 42c Niger Basin (Guinea Current)
Market and charge systems	▪ Improvement of existing biodiversity markets and prices, and development of new biodiversity markets and charges, including tourist levies, entrance fees, user fees, prospecting fees and royalties ▪ Tradable quotas, permits, rights and licenses ▪ Develop alternative biodiversity markets and products ▪ Eco-labelling and accreditation of sustainable biodiversity products	▪ Ban on biodiversity impacting products or markets ▪ Biodiversity impacting product quotas or limits	38b South Atlantic Drainage System (Patagonian Shelf) 42c Niger Basin (Guinea Current)
Fiscal instruments	▪ Subsidies for biodiversity conserving activities, technologies and products ▪ Tax relief or differential taxes on land uses, technologies and products ▪ Credits and offsets for biodiversity conserving activities	▪ Taxes or surcharges for products which impact biodiversity ▪ Differential land use, technology and product taxes	23 Caspian Sea
Livelihood support	▪ Improving efficiency, scope and sustainability of biodiversity utilisation	▪ Rural development and livelihood diversification and improvement	56 Sulu-Celebes Sea 54 South China Sea 42c Niger Basin (Guinea Current)

(SOURCE: GIWA AND IUCN 2000)

coral reef, australia

(photo: eyeqnet)

Marine Protected areas

Even when economic incentives are used to promote conservation, some valuable but fragile habitats may be degraded if economic activities are not restricted. Marine Protected Areas (MPAs) can play a major role in conserving marine ecosystems and maintaining their associated value for human well-being. MPAs can range from small, highly protected reserves prohibiting all resource extraction, to large reserves zoned for multiple uses and sustainable development.

Unfortunately, many existing MPAs are only “paper parks” that fail to meet their objectives. On the other hand, there are highly successful MPAs, including: the Apo Island Marine Sanctuary and the Danjugan Island Marine Reserve in the Philippines; the Kiunga Marine Reserve in Kenya; the Chumbe Island Marine Park in Tanzania; and the Great Barrier Reef Marine Park in Australia.

Capacity strengthening

Designing and implementing sustainable use and conservation policies requires the integration of academic disciplines and cooperation among specialists and policy-makers. Institutions responsible for managing habitats frequently lack essential skills necessary for ecological and economic assessments, management, financial reporting and control, monitoring and enforcement.

A lack of financial resources is a constraint for the conservation of aquatic habitats in many regions. Effective actions necessary for the management of protected areas and the enforcement of exclusive economic zones can only be implemented if financial resources are provided.

Social instruments, many based on stakeholder participation, were also frequently recommended by GIWA regional teams. Participation goes beyond consultation; it should empower people to make the decisions and manage the resources on which their livelihoods depend.