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 involves a step-by-step process that identifies 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 also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

The United Nations Commission for Latin America and the Caribbean (ECLAC) produced the report "Small Island Developing States Programme of Action for Sustainable Development: Opportunities and Constraints" (Ismael 1998) which identifies some of the particular vulnerabilities of Caribbean Small Islands Developing States (SIDS) such as:

- Economies are largely undiversified, highly open and excessively dependent on trade and export of very few goods;
- Islands are highly dependent on preferential access to export markets;
- Countries are highly vulnerable to fluctuations in commodity prices (e.g. oil);
- The islands are highly vulnerable to natural disasters, such as hurricanes, which can wipe out the entire productive capacity of a country in a few hours;
- National and regional communications systems and policies are weak;
- Small island size equates with limited human resources and consequent limited capacity. As a result, public administration is costly and basic infrastructure is weak with low technology.

For the Causal chain analysis (CCA) of the Caribbean Sea/Small Islands sub-system, it is necessary to mention that the whole sub-system is studied, rather than a specific case study, as was undertaken for sub-system 3b Caribbean Sea/Colombia and Venezuela and 3c Caribbean Sea/Central America and Mexico. 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 by policy makers rather than the more visible causes. This process traces the cause-effect pathways, associated with the habitat and community modification concern from the socio-economic and environment impacts identified in the assessment back to the root causes. The root causes can then be targeted by appropriate policy measures.

Due to the geographical location of the Small Islands sub-system, the islands aquatic systems are vulnerable to a multitude of impacts of local and transboundary origin. A number of regional initiatives and conventions have been undertaken to address the concern of habitat modification and the pollution that often triggers these environmental changes. These include the following:

- Demonstration of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean (GEF/UNDP/UNEP);
- Reducing Pesticide Run-off to the Caribbean Sea (GEF/UNEP);
- Integrated Freshwater and Coastal Zone Management in Small Island Developing States (GEF/UNEP);
- Cartagena Convention and its protocol (see Regional definition, Legal framework).

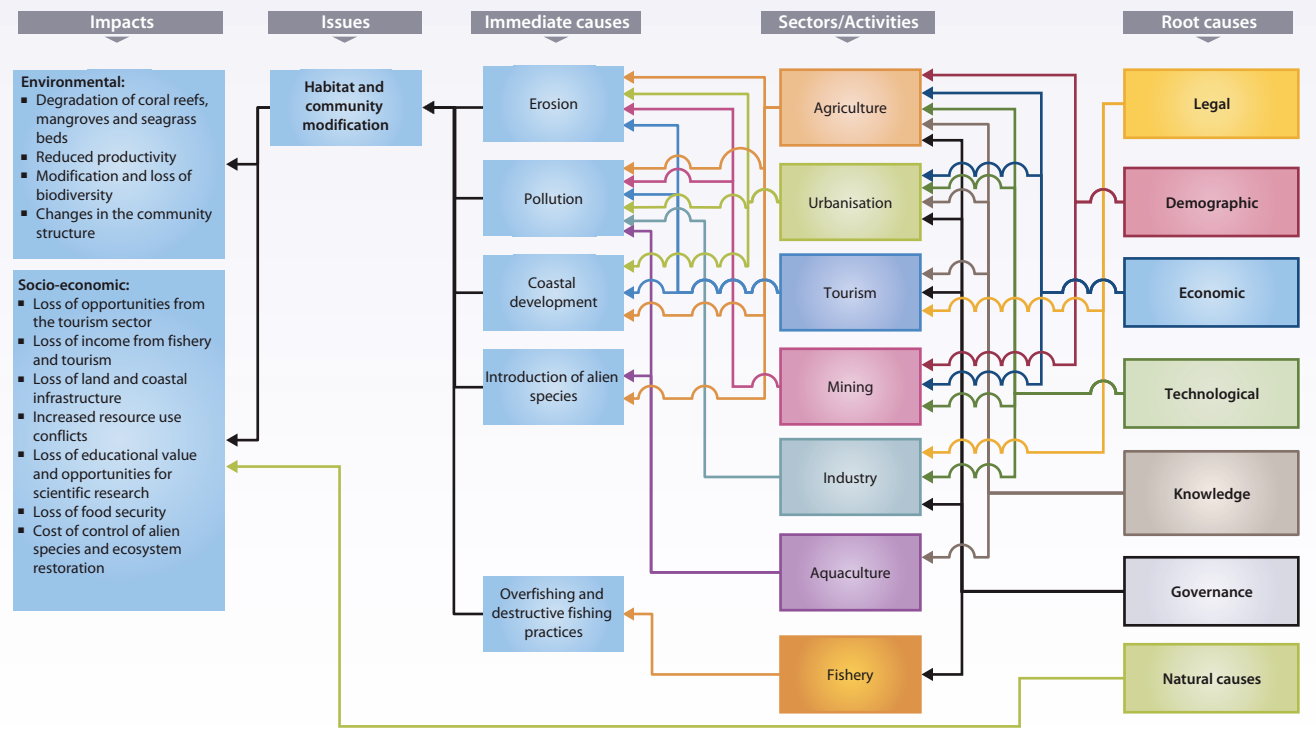

Figure 14 Causal chain diagram illustrating the causal links for habitat and community modification.

A description of the system can be found in the regional definition section, since the casual chain analysis is for the whole sub-system and not case specific.

Environmental and socio-economic impacts

Figure 14 illustrates the main causal links for habitat and community modification in the Small Islands sub-system. This concern in the region has resulted in the following environmental and socio-economic impacts (for further explanation refer to Assessment, Habitat and community modification):

Environmental impacts

Degradation of coral reefs, mangroves and seagrass beds

Coral reefs and other marine ecosystems, as well as fisheries resources, have been degraded and statistics show that around 35% of the Caribbean species are overexploited (FAO 1997c in UNEP 2000b). The degradation of mangroves and seagrass beds has affected important nursery grounds for many reef dwelling fish. There has also been widespread coral mortality. In for example in Saint Lucia, between 1995 and 2001, reefs in the Soufriere area lost on average 47% of coral cover in shallow waters and 48% of the coral cover in deeper waters. On the northwest coast of Saint Lucia, 82% of the reefs are either dead or in poor condition (Department of Fisheries 2003a,b).

Modification and loss of biodiversity

In Antigua & Barbuda for example, loss of nesting habitat was considered to be the greatest threat to the three species of endangered sea turtles (*Eretmochelys imbricata, Chelonia mydas, Dermochelys coriacea*), which are the only marine reptiles to nest on the islands (Office of the Prime Minister 2001).

Changes in the community structure

There has been gradual loss of numerous species of invertebrate animals found within each of the islands' vegetation communities.

Reduced productivity

The concentration of suspended and dissolved solids has increased, resulting in greater turbidity of freshwater bodies and coastal waters. This has modified these ecosystems by increasing turbidity and thus decreasing the amount of light penetrating surface layers and consequently reducing the productivity of freshwater and marine photosynthetic plants and corals.

Socio-economic impacts

Loss of opportunities from the tourism sector

The successful promotion of tourism is strongly correlated with the quality, ambience and aesthetic value of the environment. The degradation of the islands habitats will ultimately reduce the marketability of the islands. Tourism revenues are often directly impacted by habitat modification, particularly coral reefs, because of the loss of amenity value for activities, such as fishing, snorkelling, diving etc. Any damage to the ecosystems of the islands will impact on their entire economies due to the importance of the tourism sector, which is the primary source of foreign investment and income.

Loss of income from fishery and tourism

There has been a loss of economic benefits previously provided by the ecosystems. Degradation of the coral reef, mangrove and seagrass beds has reduced the productivity of the fisheries and subsequently the foreign currency received from this industry.

Loss of food security (fishing)

The ecosystems provide nutritional benefits and economic activities and the modification has reduced the capacity of the local populations to meet their basic human needs.

Cost of control of alien species and ecosystems restoration

There have been increased costs of controlling invasive species and costs of restoring modified ecosystems. There are then subsequent costs of artificially protecting the coastline.

Increased resource use conflicts

The modification has caused a loss in recreational value and affected the cultural integrity of local communities. Conflicts have arisen between tourism and other water-based activities, particularly fishing, due to greater competition for the diminished ecosystem resources.

Loss of land and coastal infrastructure due to lack of physical protection

The loss of physical protection from coral reefs, mangroves and seagrass beds has degraded land and coastal infrastructure.

Immediate causes

The immediate causes of habitat and community modification in the Small Islands sub-system are diverse with complicated interactions and synergies. Below are some of the major causes of the concern.

Erosion through deforestation and land clearance for agriculture

In tropical islands, like Dominica and Saint Lucia, deforestation and the cultivation of steep slopes causes considerable land degradation. For example, in the 1980s, large areas of prime rainforest were cleared in the small islands of the eastern Caribbean to make way for banana plantations. Today, many of these once productive banana fields have been abandoned, and left exposed to erosion processes (Colmore 1999). Private forested land is particularly prone to deforestation as owners are free to clear the land to accommodate farming, land sub-division for housing and other activities. Land degradation has increased the quantities of sediments entering aquatic systems via surface-run-off. This has modified these ecosystems by increasing turbidity and sedimentation.

Pollution

High sediment loads and agro-chemicals, and the discharge of raw or only partially treated sewage are stressing coastal and freshwater ecosystems. Eutrophication as a result of nutrient inputs from agriculture and urban wastes, and a reduction in algal grazers, has degraded many of the reefs in the region, due to a proliferation of algae blocking out sunlight and deoxygenating the water. For example, during the 1980s, many shallow reefs around Grenada & The Grenadines were degraded and became overgrown with algae, presumably resulting from a combination of sewage and agro-chemical pollution, and sedimentation caused by coastal development (Smith et al. 2000). Pollution from heavy metals and pesticides have been found in sediments and animals; only on Martinique and Guadeloupe, 1 500 to 2 000 tonnes of pesticides are imported per year (Smith et al. 2000).

Coastal development

There has been unplanned and uncontrolled development of settlements on the islands, which has destroyed habitats directly through the clearance of land and indirectly through the propagation of pollution, due to the absence of facilities to adequately treat sewage (including grey water), and dispose of solid wastes. Furthermore, these settlements are often constructed at locations vulnerable to events such as landslides, floods, and storm surges, which were previously stabilised and protected by terrestrial flora, coral reefs, seagrass beds, mangroves, beaches, or wetlands. The removal of these coastal habitats for urban development removes natural wave breakers and therefore increases erosion with associated impacts of greater turbidity and sedimentation in freshwater bodies and coastal waters.

Tourism is also affecting the health of coastal ecosystems through the construction of developments in close proximity to the shoreline,

Figure 15 Fishermen carry large fish traps out to their boats on the shore at Vauclin, Martinique.
(Photo: Corbis)

harbour dredging, the destruction of mangroves, anchoring on reefs and seagrass beds, and pollution. The issue of construction in coastal areas is illustrated in Antigua & Barbuda where 39 of the 55 hotels have a beach-front location (GEF/CEHI/CARICOM/UNEP 2001).

Significant areas of wildlife habitat in both terrestrial and marine ecosystems have been eliminated to accommodate development. In recent years, the clearing of natural vegetation and alteration of beaches has facilitated the development of the tourism industry, while divers and boat operators have damaged coral reefs. The US Virgin Island have lost over 50% of the territory's mangrove habitat during the last 70 years due to land clearance and land fill operations to create development sites or provide access to water (DPNR/DEP & USDA/NRCS 1998).

Introduction of alien species

Several fish species have been introduced to the sub-system via aquaculture, which has upset the existing ecological balance of sensitive habitats such as coral reefs. Seagrass beds are known to have been affected by predation from invasive urchins but there is a lack of data concerning the impacts.

Overfishing and destructive fishing practices

Overfishing and the use of destructive fishing methods such as explosives, poisons and inappropriate nets and traps (Figure 15) have negatively affected key ecosystems such as coral reefs, seagrass beds and mangroves. In for example the Cayman Islands, the increasing use of large, small-meshed fish traps has caused localised depletion, and four spawning aggregations of Nassau grouper (*Epinephelus striatus*) are intensively fished with hand-lines, resulting in a decline in the average size and catch-per-unit-effort.

Root causes

It is evident that attempts to protect marine habitats without addressing social, cultural and economic issues are likely to result in the continued unsustainable use of resources and extinction of species. What is therefore needed is an integrated approach to natural resource management and biodiversity conservation, which takes into account the realities of the below mentioned root causes.

Legal

Commendable efforts have been made to protect and preserve the coastal and marine resources of the Caribbean islands through a series of international conventions and subsequent legislative frameworks. However, national legislation inadequately incorporates conservation measures and the administration of the relevant legislation is the responsibility of several governmental agencies with weak institutional provisions for the coordination of environmental initiatives across the various sectors. This compromises the effectiveness of relevant legal and policy instruments. There is also a lack of regulations to provide the necessary guidance for managers and enforcers to implement legislation. Overall, there is an urgent need for appropriate legislation and to build capacity in the relevant institutions in order to better coordinate and enforce relevant initiatives regarding the environment.

Demographic

The majority of the islands populations inhabit the coastline where there are greater economic opportunities and ecosystem services. Population growth has increased the demand for appropriate lands, for agriculture, commercial, residential and tourism purposes. These factors have increased the pressure on coastal ecosystems, and consequently modified habitats through the sprawl of urban areas and the development of economic activities.

Economic

Poverty and unemployment

Endemic poverty and high unemployment is a catalyst for environmental degradation. For their short-term survival the population exploits natural resources at an unsustainable level. There are a lack of opportunities to diversify livelihood strategies when ecosystems services become stressed. The needs and requirements of individuals and communities are not given equal importance at the policy and decision-making level. Furthermore, governments in order to alleviate poverty, formulate development agendas to stimulate economic growth and provide employment, rather than ensuring sustainable development.

Knowledge

Lack of understanding of environmental concepts and absence of public awareness and educational programmes

There is limited understanding from the public to policy makers of the importance in maintaining aquatic ecosystems for the long-term sustainability of their services. There is a lack of realisation of the importance natural systems play in protecting human interests, for example, the filtering of sediments and other pollutants by mangroves that would otherwise diminish water quality in near-shore environments. Communities do not recognise that the resources, upon which their survival depends, are being depleted at an irreversible rate. This can be attributed in part to the absence of public awareness and education programmes to encourage communities to conserve ecosystems, and mechanisms to valuate environmental goods and services. These are necessary to change perceptions and attitudes towards conservation and environmental responsibility.

Insufficient collection and management of data

Insufficient attention is given to the collection and management of relevant data, resulting in a severe lack of information regarding coastal processes (e.g. wave data, current data, shoreline dynamics) to make informed planning and management decisions. Furthermore, Geographic Information Systems (GIS) are not being utilised in coastal zone management. Due to financial difficulties in the region, scientific and technical research does not receive sufficient funding and has not been perceived as a priority by the countries of the Small Islands sub-system. The region has an absence of performance indicators for monitoring and evaluation, with inadequate human resources and weak logistical assistance (e.g. scientific technologies, vehicles). There is an absence of centralised and coordinated regional, and limited national databases.

Technological

Inadequate measures to control pollution

Currently there are inadequate services to treat and dispose sewage. While industrial discharges are currently a relatively minor problem in most of the Small Islands sub-system, the continued discharge of untreated and unregulated effluent will likely pose severe problems to marine habitats in the future if control measures are not put in place. Agricultural run-off and human organic waste products are the more serious priority issues of concern. In many of the islands there is only very limited capacity to handle and treat wastewater, and much of it enters freshwater basins and/or coastal areas directly untreated or only partially treated.

This situation can only be addressed effectively through linking of various sector projects to long-term planning and development strategies. Such programmes must be regularly evaluated through development and effective implementation of monitoring programmes. Fundamentally the issue of agricultural pollution and run-off focuses back on the need to move away from an economy which has traditionally depended on revenues and incomes from high crop returns (often depending on monocultures such as bananas) within limited land space and to look for other forms of associated income (such as certified organic produce) as well as to the need to diversify the economy to make it less vulnerable. It also reflects the need for land

use and water resources management policies that identify the most appropriate uses for limited land resources.

Governance

Inappropriate development strategies

All of the countries in the Small Islands sub-system have a narrow economic base with many of the islands reliant on either export-agriculture or tourism as a source of government revenue and private sector income. In many islands agriculture is the primary sector of the economy and is based on a monoculture, such as sugar and bananas. This has saturated the market, and required greater land to be allocated to these crops as commodity prices have fallen, and increased dependence on agro-chemicals to maintain harvest levels. Inevitably, market forces punish such a single crop-dependency and prices fall, which may lead to a relative collapse in the economy.

In recent years, many of the islands have seen tourism as the main opportunity to replace the lost income from agricultural crops. Again there is a dependency developing on a single principle source of income, which will inevitably prove to be risky and potentially dangerous strategy in the long-term.

Environmentally these trends are also unsustainable. The intensification of agriculture, further clearance of land for expanded planting, and the need for additional water for irrigation translates into the destruction of habitats, changes in the water table and hydrological regime, and increased levels of toxic chemicals and nutrients in watershed and coastal waters. The accumulation of which results in severe degradation of coastal and marine habitats.

The transformation of economies towards greater dependence on tourism has resulted in other pressures. The need for land for development (particularly around coastlines) along with the demand for building materials and increased pressures on infrastructure (energy, waste disposal, food supplies, etc.) inevitably leads to environmental damage and ecosystem stress. Consideration of these environmental concerns is given lower priority than the drive for economic expansion. As a consequence, vitally important and sensitive ecological transition areas (mangroves, wetlands, river deltas and coastal hinterlands) are sacrificed to become development areas while rivers and coastlines are destroyed in the search for building materials.

Development strategies have made unrealistic demands on the limited resources of the countries, including energy provisions, waste recovery and disposal services, transport and water infrastructure, and food requirements. This has ultimately impacted on the environment.

Lack of long-term cross-sectorial development planning

Development planning in the Small Islands sub-system is highly fragmented, focusing exclusively on sector planning with little or no national coordination or long-term perspective. The absence of a coordination mechanism results in the many management strategies of the different governmental departments conflicting rather than cooperating to resolve problems and enable balanced cross-sectorial development. Too often, action to achieve objectives in one policy area hinders progress in another. In addition, the absence of a long-term perspective has resulted in development that is skewed towards certain communities and/or sectors in the economy, resulting in an inequitable distribution of resources and benefits.

Lack of stakeholder participation

Public participation has been lacking in current approaches to planning. This has resulted in the population feeling a sense of indifference to development activities despite it being them that are most affected by the associated impacts.

Figure 16 Queen angelfish (*Holcanthus ciliaris*).
(Photo: D. F. Colvard, The Coral Reef Alliance)

Lack of coordination

Environmental and land use management is fragmented, with ill-defined and often conflicting responsibilities between government agencies and stakeholders. There are no institutional arrangements coordinating environmental initiatives across the various sectors and levels of government. This compromises the effectiveness of relevant policy instruments. Several agencies, both governmental and non-governmental, are responsible for the conservation of natural and cultural resources. This has inhibited the development of a comprehensive framework for the effective conservation and management of these resources. There is presently a trend to enact further environmental legislation, which is overlapping and increases

the complexity of the legislative framework. This creates confusion and legislation is rarely enforced.

Lack of enforcement

One factor contributing to the severity of the problem is that although all of the islands have established some aquatic preserves to protect valuable habitat, the authorities lack the necessary manpower and funding to enforce the regulations (GEF/CEHI/CARICOM/UNEP 2001). Existing zoning, erosion control and fishing regulations are not providing sufficient protection against natural and human stresses. These have caused extensive mortality on reefs on US Virgin Islands around St. John and St. Croix.

The enforcement of legislation is not only constrained by a lack of resources, but also by perceptions and attitudes held by national law enforcement agencies. Environmental offences are given relatively low priority in comparison to other crimes.

Several islands have established marine reserves and protected areas under national legislation but very few have been actively managed. The main objective of creating these reserves was to protect important habitats such as turtle nesting sites and fish nursery and breeding grounds. However, enforcement of the laws governing marine reserves has proven difficult due to their remoteness, a weak enforcement capacity, and as a result of some land-based reserves being privately owned with no legal demarcation of the reserves' boundaries. Although there has been a trend to increase the number of protected areas, there are generally inadequate management and enforcement systems in place to ensure that these areas are serving their intended purpose.

Inadequate human resources

Human and technical resources currently lack capacity to effectively implement environmental policies and projects. National human resource needs should be assessed, as a prerequisite to deciding appropriate training programmes. Irrespective of the nature of policy interventions, it will be critical that capacity building and strengthening of existing human and technical resources be done. The nature of the capacity building should be determined at the national level through comprehensive needs assessments. However, efforts should be made to ensure that training programmes should focus more in-country and in-region to allow maximum exposure to stakeholders. Furthermore, these programmes should be linked to national government's own needs and fit into their long-term personnel planning if they have to be sustainable and effective.

Political commitment and action

Lack of political commitment to implement policies in the Small Islands sub-system is often a reflection of prioritisation at the national level and the need to address apparently more pressing national concerns. The challenge to the success of the selected policy interventions will be to ensure that the linkages between the protection of coastal and marine ecosystem habitats and economic and social priorities are identified, and that holistic, integrated approaches are used in their resolution.

Natural causes

Due to the location of the Small Islands region, the islands are exposed to hurricanes that produce extreme wave and surge conditions that can potentially destroy the coastal habitats. Additionally, sea level rise is causing the inundation of low-lying land and increasing coastal erosion with associated problems of sedimentation in coastal habitats. Periods of severe drought over the past two decades in Antigua and Barbuda are assumed to have impacted bird populations, as have the almost annual hurricanes that have hit the country since 1995 (Office of the Prime Minister 2001).

There was a major coral bleaching event in 1998 when sea surface temperatures exceeded 29°C during September and October (Smith et al. 2000). However, cases of coral mortality were relatively minor, with most corals that were bleached fully recovering. A further threat to the coral reefs arises from massive volcanic eruptions, particularly in Montserrat (for example in 1995 and 1996) where large quantities of ash were deposited on reefs (Smith et al. 2000).

Conclusions

Due the geographical location of the Eastern Caribbean Islands, the Small Islands sub-system is in the convergence area of multiple marine impacts, some of them with local and other with transboundary sources. Small islands of the Caribbean possess fragile, limited and highly vulnerable coastal and marine habitats, which are been affected by transboundary pollution in particular, sedimentation from continental land masses and maritime traffic among another due global change. These aspects must all be addressed through regional and international cooperation, monitoring and enforcement.