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 responsible human activities and economic sectors 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 of the methodology, please refer to the GIWA methodology chapter.

Based on the results of the assessment (see priority concerns above), the CCA of the Eastern Equatorial Pacific region was conducted for the priority concerns of each sub-system. The analysis considered the following sub-systems for each priority concern:

- Freshwater shortage in the Central Equatorial Pacific sub-system
- Pollution in the Central Equatorial Pacific and Southwest Mexico sub-systems
- Unsustainable exploitation of fish and other living resources in the Pacific Colombian sub-system

Freshwater shortage

Although the Central Equatorial Pacific sub-system has abundant water resources, they are unevenly distributed, with some countries having a surplus and others having deficient supplies. In 2002, the discharge of

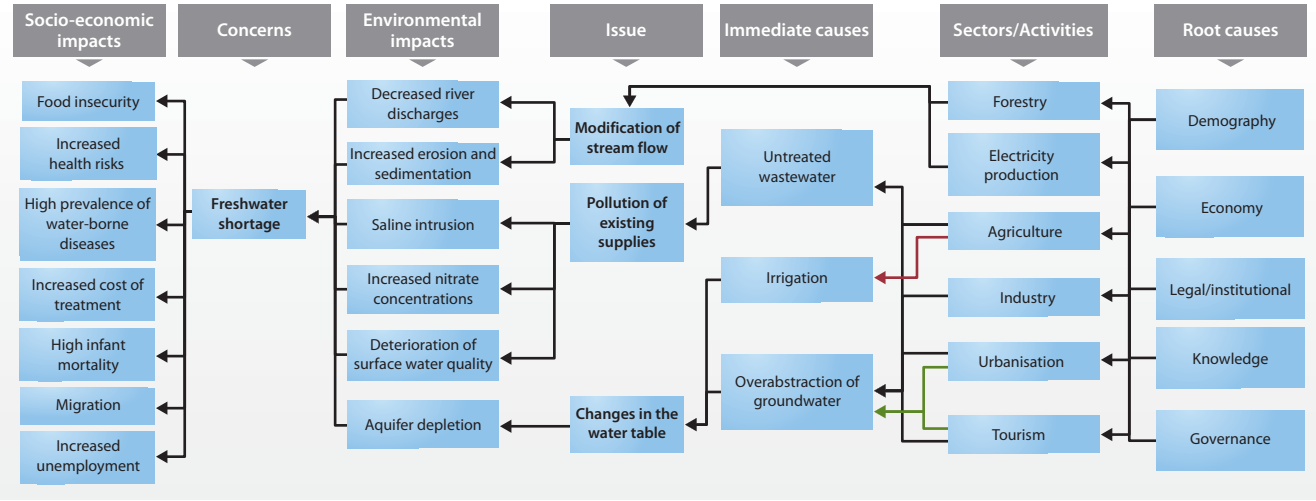

Figure 19 CCA diagram Freshwater shortage in the Central Equatorial Pacific sub-system.

the Lempa River – shared by El Salvador, Guatemala and Honduras – was 42% below the historic average (SNET 2002). Approximately 70% of the total population and 80% of the economic activities are located in areas with a shortage of freshwater. About one-quarter of the population in the sub-system did not have access to safe freshwater in 2000.

During the Causal chain analysis, the issue of pollution of freshwater supply is emphasised because it is the issue best documented in the sub-system. The information regarding the other two issues is somewhat limited, not current and tends to focus on specific localities and rivers.

Figures 19 and 20 show the causal links between the environmental and socio-economic impacts of the freshwater and pollution concerns, the immediate causes, the responsible economic sectors, and the root causes that determine the behaviour of these sectors.

Immediate causes

Climatic variability

Despite all countries of the Central Equatorial Pacific sub-system having abundant water resources and extracting relatively limited quantities, some areas experience water scarcity during the dry season when river flows are considerably reduced. During the El Niño, river flows are notably smaller, exacerbating the effects of a normal dry season.

Land-use changes and practices

Deforestation and inappropriate agricultural practices in the catchments have affected run-off and river flow patterns. These practices have increased sedimentation, reducing the capacity of freshwater bodies including reservoirs, thus increasing the extent and frequency of floods. The reduction in water availability has also been attributed to the loss of fog forests in the upper sections of the basin. The removal of natural forest cover may also be affecting both the recharge rate and water quality of aquifers (Ballesteros 2003).

River diversion and groundwater abstraction

River discharges are affected by dams, which interrupt the natural flow of nutrients to coastal waters. Groundwater is the main source of freshwater in the sub-system and aquifers in most countries are unsustainably exploited. For example, the aquifers that supply Managua (Nicaragua), San José (Costa Rica) and San Salvador (El Salvador) are overexploited (Lezama-López 2003). According to the International Hydrological Programme of UNESCO, groundwater abstraction in 2010 is expected to be nine times the rate in 1950. Illegal connections consume a large proportion of the water available for the cities of the sub-system. Groundwater use will increase as the quality of surface water deteriorates in the future.

Discharge of untreated wastewater

Freshwater supplies are contaminated in several major basins of Central America, including the Lempa River and the Grande de Tárcoles River basin. According to PNUMA (2001), 95% of the municipal wastewater generated in the sub-system enters natural water bodies without appropriate treatment. El Salvador is particularly affected as the main sources of freshwater, the Lempa River and lakes Ilopango and Coatepeque, are highly polluted by wastewater discharges. In the Lempa River, a two-year study found that 95% of samples contained *E. coli* (Levin 2002). Industries, particularly coffee production, also discharge large amounts of wastewater without treatment.

Agricultural run-off

The sub-system has one of the largest rates of pesticide consumption in Latin America (2 kg/person), which contribute to the deterioration of surface and ground water quality. Aquifers in the metropolitan area of Alajuela, Cartago and Guanacaste contain increasing concentrations of nitrates originating from fertilisers and septic tanks (Reynolds & Fraile 2002). Urban and agricultural run-off are responsible for polluting the Managua aquifer that provides freshwater to 1.2 million people.

Root Causes

Demography

The demographic trends of the last four decades have led to increasing demand for freshwater resources for drinking water, agricultural production and industrial processes, among other uses. Urbanisation has intensified and concentrated demand in areas that have limited freshwater availability. The following demographic trends are driving freshwater shortage issues in the sub-system:

- Over the past 30 years, the population of the sub-system has increased by 98%, from 19.3 million to over 37 million. The population density increased over the same period from 39 to 66 inhabitants/km^2. The population of the sub-system will continue to grow rapidly, reaching 40 million within the next decade.
- The population is concentrated in specific areas. In general, the population occupies only a quarter of the sub-system's territory with 70% inhabiting the Pacific slope. The urban area is expected to increase from 596 km^2 to 913 km^2 by 2030 if current urbanisation trends continue.
- Urban populations increased by 29% over the period of 1975-2000. About 75% of the population will live in urban areas by 2030 as a consequence of natural population growth, longer life expectancy and migration from rural areas. Most rural populations are poor and migrate for economic reasons, while others are environmental refugees fleeing from natural disasters (OPS/OMS 2001a). The larger urban population will increase further the pressure on water and

sanitation services. The influx of immigrants into urban areas has created an illegal land market and the establishment of illegal settlements which have no freshwater supply or sanitation services.

The Lempa River basin is the most densely populated and intensively exploited area of the sub-system. Its population was 4.7 million inhabitants in 2001, of which 3.9 million live in the Salvadorian part of the basin. The population is expected to double in the next 25 years (Granados in Llort & Montufar 2003). The majority of economic activity and the two major urban centres (San Salvador and Santa Ana) of El Salvador are located in the Lempa River Basin. These socio-economic characteristics are exerting extreme pressure on the freshwater resources of the basin.

Freshwater supply and sanitation services

The current water distribution systems are obsolete and highly inefficient. The countries of the Central Equatorial Pacific sub-system lack the economic resources needed to adopt water efficient technologies. Water supply and sanitation services are subsidised. As a consequence, insufficient revenues are generated to maintain current and invest in new technologies, and the population has no incentive to save water. Most countries in the sub-system depend on foreign imports rather than developing their own technologies that are culturally compatible and suitable for their local environmental conditions. The Pan-American Health Organization has stated that technical solutions used to solve water supply problems in rural areas are not always appropriate for either the local communities or the environment.

The development of both freshwater supply and sanitation coverage is not keeping pace with population growth. The health of the increasing number of people without access to these basic services is at risk. Some urban areas such as the capitals of most countries in the sub-system (e.g. Panama, San José, San Salvador, Managua and Tegucigalpa) have grown in a disorganised manner. They are characterised by the occupation of fringe urban areas by a rural migrating population or by people displaced from neighbouring countries. In these cities, where public services do not cover even the formal population, urban development will increase pressure on the aquifers that are already depleted.

The average freshwater supply coverage in the sub-system was 78% in 2000, of which 69% was through the network and 9% through easy access (OPS/OMS 2001a), which, in most cases, increases human heath risks. Besides the low level of coverage, several cities in the sub-system have deficiencies in treatment processes, forcing the population to boil water for direct consumption. Only a small proportion of rural communities apply chlorine to water for disinfection. In most countries, water supply is not continuous (between 27% and 98% of the systems), with a supply only available for 6-20 hours/day because of the poor condition of the equipment. This is especially true in rural areas. Almost 40% of water systems have leaks due to the poor maintenance of the network and the use of obsolete technology. In Costa Rica, only 50% of the water abstracted is actually charged to users, with the other half being consumed through illegal connections or wasted as a result of dilapidated pipelines (Ballesteros 2003). Illegal connections increase the costs of operation and maintenance, and create an additional problem in quantifying water losses.

Economic

The assessments by OPS/OMS (2001a) for Latin American and the Caribbean are also valid for this sub-system. Both reports highlighted the differing situations facing the countries, but noted that they share the following economic problems:

- Substantial resources are required to improve the current infrastructure and to improve the level of freshwater supply coverage.
- Service charges do not cover operational and maintenance costs. As a consequence, governments subsidise water supplies.
- Difficulties estimating operational and maintenance costs as a result of distortions introduced by governmental subsides, and inefficient management and technical deficiencies.
- Subsidies do not benefit the population directly but, instead, hide operational and management inefficiencies.
- The lack of realistic tariff rates and jurisdictional uncertainty discourages private investment in sanitation and wastewater treatment.
- The privatisation of public services reduces the possibility of improving the level of wastewater treatment coverage and the introduction of integrated water resources management. In several cases of privatisation, environmental costs are charged to users and the government assume an intermediary role.
- Management lacks an enterprise approach.
- There is a vulnerability to political pressures.
- Current statistics show that a high proportion of the population use *in situ* sanitation solutions, which involve environmental risks. For example, if latrines are located in porous soils, leachates may contaminate aquifers.

Legal/Institutional

Most countries in the sub-system have a weak legal and institutional framework for water management which results in overlapping responsibilities and a duplication of effort. There is a lack of control and surveillance during the implementation of current regulations

(Dourojeanni 2001). Some regulations, particularly those regarding permissible limits for individual substances or groups of substances, have been modernised. Others are obsolete or incomplete (UNEP/GPA 2001) as they do not include provisions for new approaches and administration procedures, such as those necessary for a sustainable development approach. The legislation considers water quantity separately from water quality. They are also managed by different institutions, making it difficult to implement a holistic approach at the institutional level (Escobar 2003). Environmental policies regarding water management are predominantly sectorial and fail to take into account the multiple uses of water.

Most water services in the sub-system are managed by centralised governmental agencies which lack the capacity to maintain and update the distribution networks and equipment, as well as to monitor the quality of the water supplied. Incipient decentralisation processes suffer from inadequate governmental support for the transfer of responsibilities for water management to local governments. Traditionally, local stakeholders were not consulted in the management of water resources. The lack of a multidisciplinary approach leads to inter-institutional conflicts. There is an absence of an integrated policy for population distribution, urban development and the provision of water services. An integrated river basin management approach to shared river basins has not been sufficiently adopted.

Knowledge

Countries in the sub-system lack water monitoring programmes and environmental, social and economic impact assessment processes. There is a dearth of knowledge regarding water quality and the effect of pollutants on ecosystems and their biota. Most of the countries lack the economic and technological resources necessary for strengthening the territorial agencies responsible for undertaking studies on biophysical, hydro-geological, meteorological and other environmental parameters. The monitoring of water quality is inadequate as it only focuses on a few indicators (Ramírez & Espejel 2001). These knowledge deficiencies are impeding the development of a better management framework that incorporates the particularities of the sub-system's environment. The Workshop of Experts on Municipal Liquid Wastes in Latin America, held in September 2001 in Mexico (UNEP/GPA 2001), identified the absence of monitoring and surveillance of water quality as a major obstacle to combating pollution in the region and recommended the standardisation of water quality criteria (Ballesteros 2003).

There is a lack of public awareness of water issues and the associated socio-economic impacts, particularly regarding sanitation. There is no culture of water conservation in the population of the sub-system. This prognosis is evidenced by the use of inappropriate farming practices which result in severe impacts on the water cycle, the lack of treatment for industrial and domestic wastes, and the disregard by the public for their impact on the environment. Other than the consumptive benefits of water, there is little recognition or valuation of the indirect benefits water provides through ecosystem goods and services.

Pollution

Microbiological contamination was considered to be the priority pollution issue in the Central Equatorial Pacific and Southwest Mexico sub-systems. In the Central Equatorial Pacific sub-system, chemical pollution was also considered to be a priority.

Immediate causes

Discharge of untreated municipal wastewater

The failure to appropriately dispose of excrement and the use of latrines and septic wells in porous soils contribute significantly to the load of microbiological pollution. The low levels of wastewater treatment in both sub-systems results in around 95% of wastewater reaching the Pacific Ocean with a high load of organic matter, nutrients and microbial pollutants (PNUMA 2001). Livestock production may also contribute considerable microbiological pollution to the surface waters of the Central Equatorial Pacific sub-system. High concentrations of pathogenic micro-organisms associated with water pollution have been recorded in water bodies and on beaches in the Central Equatorial Pacific and Southwest Mexico sub-system. Many of these beaches are important for the tourism industry; the pollution can discourage visitors and cause health problems for bathers.

Agricultural run-off

Agricultural run-off is the main source of chemical pollution due to the large-scale use of pesticides in agriculture, especially for export production. High concentrations of pesticides have been found in several coastal sites in water, sediments and biota, posing risks for humans and other living organisms.

Industrial and mining run-off

Heavy metals are introduced into water bodies from mining washes and industries. Other chemicals are discharged in small concentrations within wastewater. Heavy metals, such as lead, copper and chromium, have been reported in sediments and surface waters in several countries in the Central Equatorial Pacific sub-system, particularly Panama, Nicaragua and Costa Rica.

Root causes

Population demography and economic development

Today, half of the Central Equatorial Pacific sub-system's population is urban and by 2030 the proportion is expected to increase to three-quarters. The coverage of sanitation services has not expanded sufficiently to cope with the increasing quantities of wastewater produced by the swelling urban population. The growing population and export market requires more food which is leading to the application of more agro-chemicals and, thus, increased chemical pollution.

The tourism boom in Mexico's coastal regions is benefiting the economy but harming coastal ecology. The growing numbers of visitors and associated development are increasing the volume of point and non-point sources of pollution (Rivera-Arriaga & Villalobos 2001) and placing additional pressure on sewer infrastructure and wastewater treatment facilities. The negative environmental impacts of untreated wastewater are particularly apparent in and around the coastal tourist cities of Acapulco, Ensenada, Veracruz, and Xihuatanejo (Ascencio pers. comm.). In cities such as these, largely uncontrolled coastal tourism development has put enormous pressure on the ability of the ecosystems to absorb municipal waste.

Technology

The major cities in the Central Equatorial Pacific have dilapidated wastewater treatment systems (OPS/OMS 2001a). In Guatemala, only 15 municipalities treat wastewater, and only 4 out of 16 plants in the metropolitan zone are functioning (FAO 2004a). Design flaws have frequently led to new systems failing soon after installation.

Industrial processes often involve the use of antiquated technology. Political will to force or encourage industry to adopt cleaner technologies is lacking. Industry managers are also uninformed about new technological alternatives and there is a lack of facilities for the recycling of industrial wastes. Guidelines on agricultural best practice including techniques to reduce the use of agro-chemicals and to improve soil management are not disseminated to farmers.

Mexico's water treatment infrastructure is significantly less advanced than that of other nations in the Organisation for Economic Cooperation and Development (OECD), as well as other countries in Latin America. At least 20% of the existing treatment facilities in Mexico are non-operational and a significant percentage of those in operation are performing below their capacity (OECD 2003). While over 76% of the Mexican population is connected to sewer systems, only 26% is connected to wastewater treatment facilities (OECD 2003); the wastewater is therefore discharged directly into the ocean or inland waterways without treatment.

Economy

Low tariff rates for water and underinvestment in sanitation infrastructure are the principal causes of the lack of basic sanitation services in the Central Equatorial Pacific sub-system. In Panama, water and sanitation services are subsidised resulting in the authorities receiving insufficient revenues to invest in the expansion of sanitation services. As a consequence, investment was limited to maintenance during the 1990s. Privatisation of sanitation services has led to the improvement of waste collection rather than sewage treatment or water supply. In fact, there is no example of wastewater treatment services being privatised. There is a lack of economic incentives to encourage industries to adopt environmentally friendly technologies and practices. In terms of disincentives, polluters are not taxed appropriately for the environmental damage that their activities cause. In the Southwest Mexico sub-system, federal authorities lack the appropriated mechanisms to collect fines from local governments. Such fines could be used for maintenance or for the construction of new wastewater treatment plants.

Legal/Institutional

All countries in the sub-system are failing resolve their pollution problems, in part due to financial problems and in part due to the unwillingness of governments to regulate economic activities for fear of constraining development. There is a lack of common coastal and marine policies with specific environmental objectives that address pollution issues. This has resulted from an inappropriate institutional framework and the application of freshwater criteria to marine environmental legislation. The countries within the sub-system have differing marine policies, except those related to maritime aspects such as traffic and national security. Institutional weaknesses and a lack of coordination among the different governmental sectors hinder the implementation of legislation and environmental management instruments (e.g. environmental impact assessments, management plans and environmental auditing). Industries and agriculture are regulated by a weak and uncoordinated legal framework. In most countries, the institutions responsible for river basin management only focus on water distribution and consumption, have overlapping responsibilities and rarely encourage stakeholder participation in the decision making process. The control and surveillance of pollution is undertaken by a variety of institutions. River basins and the coastal zone are managed autonomously by different institutions (Escobar 2002).

The legal regime and the institutional organisation of several countries in the Central Equatorial Pacific sub-system have been characterised by Jouravlev (2001):

- In Costa Rica, legislation is disarticulate and, in part, obsolete (Ballesteros 2003). In several cases, laws and decrees are conflicting or are not implemented due to a lack of institutional capacity.
- In El Salvador, the diversity of laws related to water resources creates confusion in defining responsibilities. In fact, there are numerous laws but few that have specific regulations needed for implementation. To solve these problems a new Law of Waters is being developed.
- Guatemala does not have a general water law but secondary laws partially regulate issues related to water, its use and conservation.
- In Honduras, until recently, the responsibilities for implementing regulations regarding water management were dispersed between several institutions. However, important advances in water management have been achieved, including the creation of the National Council for Sustainable Development (CONADES) and the Secretary of Natural Resources and Environment (SERNA). The Framework Law of Waters, currently in development, will provide a modern, legal, technical and institutional basis for the integrated management of water resources.
- In Nicaragua, the integrated management of water continues to be fragmentary and lacking in coordination (MARENA in FAO 2002a).
- In Panama, institutions in charge of water management do not have an integrated legal framework. The lack of appropriate technical knowledge and economic constraints impede the implementation of current regulations.

In Southwest Mexico, SEMARNAT, Comision Nacional del Agua (CNA) and other regulatory bodies have achieved increasing success in controlling large volume industrial polluters whose wastes flow into federal waterways. These agencies have direct jurisdiction over facilities affecting federal waters and are able to enforce fines for exceeding pollution targets. They have even shutdown the worst offenders. Despite these improvements, pollution levels are still high due to a lack of direct control over municipal pollution sources. Under the Mexican Constitution, municipalities are responsible for the maintenance of their water systems and are largely autonomous from state and federal authorities (Constitucion Nacional de Mexico 1992). Therefore, attempts to regulate municipal pollution have been largely ineffective as the government has little enforcement power to collect fines from municipalities who exceed federal pollution limits, and no power to directly fine those who pump their waste into these municipally controlled waters.

The Mexican federal government and several international NGOs have invested in the construction of sewers and treatment facilities. However, the strong legal provisions guaranteeing municipal autonomy prohibit federal authorities from funding the ongoing maintenance and upkeep of these investments. This means that in communities with limited economic resources, funding of waste treatment services is often a low priority. These aspects of municipal water control have resulted in the breakdown of many recent environmental initiatives. While many state and municipal governments have turned to outside contractors to run their wastewater treatment operations (called operating agencies), major sanitation-related decisions are often made by municipal officers. These decisions are frequently based on political considerations that have little relevance to the long-term water and sanitation needs of a community.

Many pollution problems impact downstream communities and ecosystems, especially those on the coast. There is insufficient investment in upstream sewage infrastructure which could reduce the impact on the economy and public health of many other communities sharing the same watershed. These problems are exacerbated by the sheer number of municipal governments.

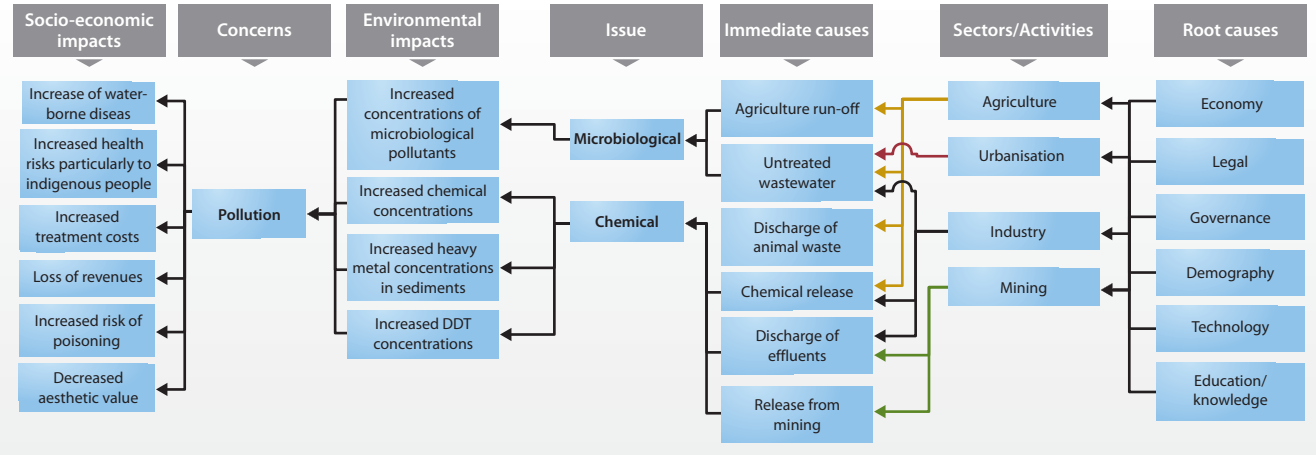

Figure 20 Diagram showing the Causal chain analysis of microbiological and chemical pollution in the Central Equatorial Pacific and Central Mexican sub-systems.

Knowledge

In the Central Equatorial Pacific sub-system, available information is dispersed, sparse and not current, which restricts the understanding of the real situation. Limited research and technological development hinders progress in addressing pollution issues. In the Southwest Mexico sub-system, local municipal governments lack personnel with the necessary technical expertise to create and maintain complex wastewater treatment networks. Additionally, politicians poorly understand wastewater and pollution issues and their effects on public health and local economies. This often leads to political decisions that do not recognise the environmental and social benefits that could be obtained through investments in pollution control.

Unsustainable exploitation of fish and other living resources

The unsustainable exploitation of fish and other living resources was considered to be the priority concern in the Pacific Colombian sub-system. The Causal chain analysis focuses on the issue of overexploitation as it is having the most severe impacts, but also considers destructive fishing practices and excessive by-catch and discards.

Immediate causes

Excessive fishing effort

The current level of fishing effort is unsustainable. According to FAO (2004c), catches of marine fish, crustaceans, molluscs and other marine living resources decreased in Colombia between 1992 and 2000.

Destructive fishing practices

The use of destructive fishing gear has resulted in a decline in recruitment and the degradation of the habitat of some commercial species. Today, shrimp trawling nets and gillnets are considered the main threat to marine turtles in Colombian waters.

Excessive by-catch and discards

Although there have been no studies of the level of by-catch in the Pacific Colombian, based on studies in territories within close proximity of the sub-system, it is believed that large quantities of fish are caught as by-catch in the shrimp trawling industry and the majority are discarded.

Root causes

Technology

On the Colombian Pacific coast, non-selective and destructive fishing gear is employed in the artisanal and industrial fisheries. Such gear is used to increase short-term profits, but at the expense of the long-term sustainability of fish stocks. As the distribution of fish species has changed and stocks of traditionally exploited species have declined, the fishing industry has began to exploit stocks which are further offshore using new technologies.

Economy

Investment in the fisheries sector is aimed at increasing catches of species valuable on the international market; there are few incentives to supply local demand.

Legal/Institutional

There is a lack of harmonisation between national and international fisheries policies. Although Colombia has a legal framework for the

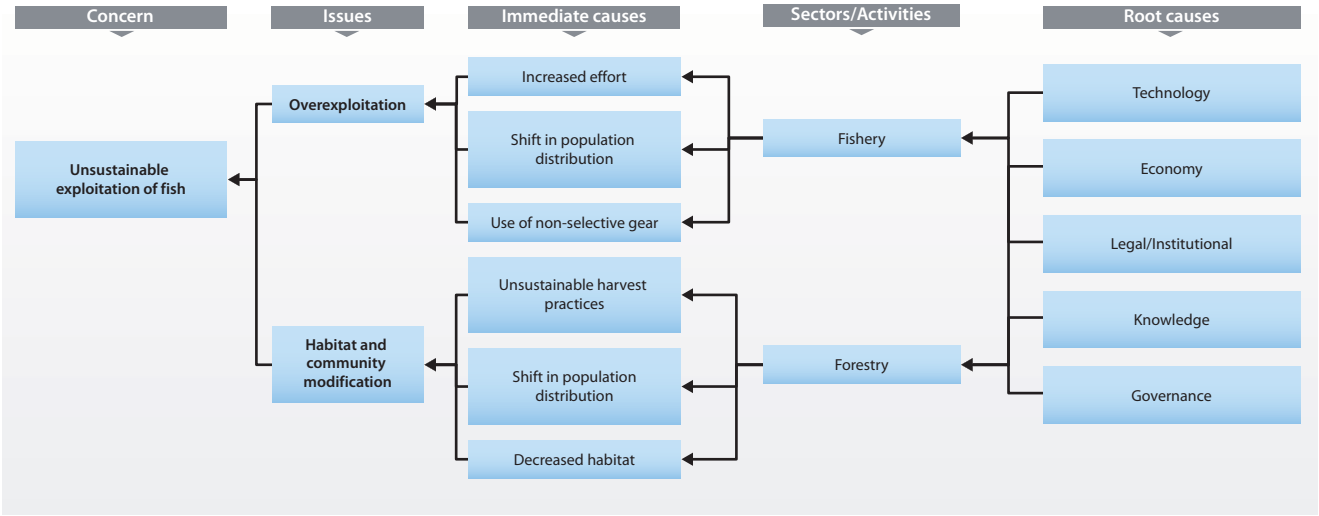

Figure 21 Diagram of the Causal chain analysis of overexploitation in the Pacific Colombia sub-system.

management of natural resources, there is a lack of inter-institutional coordination, resulting in the weak implementation of existing environmental laws. Domestic and foreign fishing fleets are able to avoid legislation due to weak enforcement. Limited stakeholder participation in decision making processes often results in the unsuccessful implementation of fisheries policies.

Knowledge

There is a lack of detailed information about the exploitation and status of fishing resources in Colombia. Although recent data has shown a decreasing trend in the catches of some important species, the long-term effects on fish stocks are unknown. The fisheries are irregularly monitored and there is limited surveillance of aquatic ecosystems (INVEMAR 2003c). The quantity and impact of by-catch and discards produced by the fishing industry in the sub-system, as well as the distribution and influence of introduced species, has not been studied.