### Assessment

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 5.

#### Freshwater shortage

Of the more than 300 drainage basins in the region, the major systems include the Sandakan and tributaries of Sabah; the Kayan, Ketai, Berau, Sesayan and Sembakung rivers of East Kalimantan; the Mindanao River and its tributaries; the Agusan River and its tributaries; and the Libuganon and Sindangang rivers of Mindanao. Numerous smaller rivers and streams flow from the mountainous interiors of most of the islands in the region. Many of these rivers have been extensively modified, primarily through loss of riparian vegetation, major clearing of catchments, with resulting loss of soils as sedimentation into rivers and streams (also see Suspended solids, and Loss and modification of ecosystems or ecotones).

#### Water withdrawal

In the Philippines in 1995, the total water withdrawal was estimated at 55.4 km³ on the basis of the water rights issued by the National Water Resources Board (NW_RB), of which 88% is for agricultural purposes, 8% for domestic and 4% for industry (Table 6). Other sectors using water (non-consumptive use of water) included hydropower (89 km³), fisheries (498 million m³) and recreation (93 million m³) (FAO AQUASTAT 2003).
Production of wastewater in the national capital region and nearby provinces is estimated at 74 million m³, while the volume of treated wastewater reached 10 million m³ in 1994 at the Ayala and Dagat-Dagatan pond. Disposal of wastewater is expected to increase as new sewer lines are being built every year (FAO AQUASTAT 2003).

In Indonesia in 1990, total water withdrawals were 74.3 m³ (Table 6). As the nation has started to implement development programmes in order to meet the sharply increasing needs for irrigation, safe drinking water, industrial water, energy, etc., the demand on water resources has increased rapidly. It is estimated that between 1990 and 2020, the demand will increase by about 220%. More than 50% of all irrigation water is consumed in Java (in the neighbouring GIWA region Indonesian Seas) (FAO AQUASTAT 2003).

In Malaysia, the total water withdrawal was 12.7 km³ (Table 6). About 32% of the water produced is lost in the distribution system due to several factors such as pipe leakage, under-metering, and other unaccounted water losses. The total water demand increased from 8.7 km³ in 1980 to 12.7 km³ in 1995. Irrigation currently accounts for about 9.7 km³ or about 76% of the total water consumption. However, irrigation demand is expected to taper off as no further expansion in irrigated rice cultivation is envisaged (FAO AQUASTAT 2003).

### Dams

In the Philippines, the total dam capacity in 1995 was 4 753 million m³ (Table 7) (FAO AQUASTAT 2003). Three of the large dams are managed by the National Power Corporation (NPC) (Angat, Ambuklao and Palangui IV for a total capacity of 1.5 km³), the two largest dams being managed by the NIA (Magat River Integrated Irrigation System (MRIIS), and Upper Pampanga River Integrated Irrigation System (UPRIIS) for a total capacity of 3.2 km³). The remaining large dam (La Mesa) is managed by the Metropolitan Waterworks and Sewerage System, which is also responsible for the management of a small dam (Ipo). The NPC is also in charge of three small dams (Agus II, IV and V for a total capacity of 27.7 million m³) while all other small dams have been created with various objectives within the framework of the small water impounding management (SWIM) projects, which are implemented by several agencies. A survey of surface water storage potential has identified sites for 438 major dams and 423 smaller dams (FAO AQUASTAT 2003).

In Indonesia and Malaysia, most major dams are situated outside the regional boundaries. In Indonesia in 1995, there were 82 dams, with large dam capacity of 15.83 km³ (Table 7) (FAO AQUASTAT 2003). Malaysia has a total of 56 dams, of which 32 are more than 15 m high. The gross theoretical hydropower potential of the Malaysian Peninsula is 123 000 GWh/year, and that of Sabah and Sarawak together is 107 000 GWh/year. In 1995, the total hydropower generation was about 5 800 GWh, or 30% of all power production in Malaysia (FAO AQUASTAT 2003).

### Groundwater

In Indonesia, groundwater resources are estimated at 455 km³/year, of which 80% (145 km³/year) would constitute the base flow of the river systems (FAO AQUASTAT 2003). The total internal water resources would therefore amount to 479 km³/year. There are four major groundwater reservoirs (Cagayan, 10 000 km²; Central Luzon, 9 000 km²; Agusan, 8 500 km²; Cotobato, 6 000 km²) which, when combined with smaller reservoirs, aggregate to an area of about 50 000 km². Private wells are extensively used in rural areas for domestic purposes. Municipal waterworks wells are drilled by the Local Water Utilities Administration for domestic purposes and deep wells have been drilled by the National Irrigation Administration (NIA) for irrigation purposes (FAO AQUASTAT 2003).

In the Philippines, the total groundwater resources are estimated at 180 km³/year, of which 80% (145 km³/year) would constitute the base flow of the river systems (FAO AQUASTAT 2003). The total internal water resources would therefore amount to 479 km³/year. There are four major groundwater reservoirs (Cagayan, 10 000 km²; Central Luzon, 9 000 km²; Agusan, 8 500 km²; Cotobato, 6 000 km²) which, when combined with smaller reservoirs, aggregate to an area of about 50 000 km². Private wells are extensively used in rural areas for domestic purposes. Municipal waterworks wells are drilled by the Local Water Utilities Administration for domestic purposes and deep wells have been drilled by the National Irrigation Administration (NIA) for irrigation purposes (FAO AQUASTAT 2003).

In Malaysia, the total surface run-off is 566 km³, and about 64 km³ (7% of the total annual rainfall) contribute to groundwater recharge. However, about 80% of the groundwater flow returns to the rivers and is therefore

### Table 6

<table>
<thead>
<tr>
<th>Country</th>
<th>Total water withdrawal (km³)</th>
<th>Water withdrawal by sector (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agriculture</td>
<td>Domestic</td>
</tr>
<tr>
<td>Indonesia</td>
<td>74.34</td>
<td>93</td>
</tr>
<tr>
<td>Malaysia</td>
<td>12.73</td>
<td>76</td>
</tr>
<tr>
<td>Philippines</td>
<td>55.42</td>
<td>88</td>
</tr>
</tbody>
</table>

(Source: FAO AQUASTAT 2003)

### Table 7

<table>
<thead>
<tr>
<th>Country</th>
<th>Dam capacity (km³)</th>
<th>Dams</th>
<th>Hydropower potential (GW/h)</th>
<th>Total installed power capacity (MW)</th>
<th>Electricity generated by hydropower (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>15.8</td>
<td>82</td>
<td>3 388</td>
<td>2 061</td>
<td>16.3</td>
</tr>
<tr>
<td>Malaysia</td>
<td>ND</td>
<td>56</td>
<td>5 800</td>
<td>ND</td>
<td>30</td>
</tr>
<tr>
<td>Philippines</td>
<td>4.75</td>
<td>60</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Note: ND = No Data.

(Source: FAO AQUASTAT 2003)
not considered an additional resource. The total internal water resources of Malaysia are estimated at 580 km³/year (FAO AQUASTAT 2003). As surface water is readily available throughout the year, it is abstracted mainly for irrigation and domestic uses. Groundwater resources are limited to some pockets of the coastal region and is generally exploited by rural people to supplement their piped water supply. Surface water represents 97% of the total water use, while groundwater represents 3%. About 60-65% of groundwater utilisation is for domestic and/or municipal purposes, 5% for irrigation and 30-35% for industry.

**Environmental impacts**

**Modification of stream flow**

Modification of stream flow is having moderate environmental impact in the region as a whole at present, but with severe local effects in some areas of the Philippines (Mindanao and the Visayan Islands) and northeast Borneo. Major dam construction has altered river flows in many Philippines rivers (see above). Here also, significant loss of riparian vegetation has occurred through effects of logging and other destructive land use practices. This has been most severe in the small islands of the Sulu Sea and Visayas, and also significant on the larger scales of Mindanao, Negros, Cebu, East Kalimantan and Sabah. On Negros, the 50% of original forest that remained in the 1930s has been reduced to approximately 4% today. Overall, there has been greater than 80% loss of original land cover in most of the Philippines area of the region, with some 40-60% loss in the Malaysian (Sabah) areas of Borneo (Burke et al. 2002). By contrast, much of the original forest remains in Indonesian East Kalimantan and North Sulawesi.

**Pollution of existing supplies**

Pollution of existing supplies has caused moderate environmental impact, but with highly localised severe damage. There have been reports of fish kills from various chemical inputs, notably from a nematocide in banana pesticides used in Compostela Valley province, Mindanao. There have also been increases in nutrient loads to lakes from aquaculture activities, with likely increases in other inputs.

**Changes in the water table**

Changes in the water table have also caused moderate environmental impact in the region as a whole, with severe impact in small islands of the Sulu Sea, Visayan Islands, Mindanao and Cebu. Wells have been deepened over hundreds of square kilometres in these areas of the Philippines. On Cebu, deforested since the 1880s, saline intrusion has occurred up to 11 km from the coast, and there is little or no potable water available from traditional coastal sources. By contrast, on Palawan, where logging was halted in 1992 and 40% of the monsoon forests remain, there has been relatively little salt intrusion.

**Socio-economic impacts**

Socio-economic impacts range from slight (health and other social and community) to moderate (economic) at present. Most of the major socio-economic impacts are concentrated in the Philippines areas of the Sulu Sea, Visayan Islands and Mindanao and in Indonesian East Kalimantan. For large numbers of people in the region, there is no secure access to potable drinking water from wells or piped supply. According Lins (pers. comm.) speaking at the 10th Annual Philippine Water Conference and Exhibition on Water Resource Management (Philwater) September 2001, many Filipinos, especially the poor, lack safe, potable drinking water to meet even their basic survival needs. About one third of the Philippines population of 81 million people devise their own ways of obtaining water because they have no access to formal sources such as deep wells or reticulated water. Half of the poor and rural households consume less than 30 litres per person per day, barely meeting normal requirements. Many poor people are required to buy water, with the daily consumption levels averaging just 15 litres per day, dangerously close to the survival minimum. Of the 25 million Filipinos whose water supply is self-provided, many are getting water from sources contaminated by human, agricultural and industrial wastes, particularly in Mindanao where the need for safe and adequate water remains is often not met. Some of the surface water does not meet WHO drinking water criteria because of human inputs, particularly in Mindanao. The Philippines population affected by water-related diseases in 1989 was 782 000 and include gastro-enteritis, schistosomiasis and hepatitis (FAO AQUASTAT 2003).

Even in some areas with reticulated water, there are interruptions to supply. Despite its moderate score for the region as a whole, freshwater shortage is already a food-security concern, and is the focus of national and international interventions. Expanded programmes targeting both rural and urban water supplies, with the goal of delivering a reliable potable supply, will be necessary to achieve significant alleviation. In parts of the region (e.g. Mindanao), civil unrest caused by separatist movements is likely to contribute to difficulties in effectively implementing remedial interventions. In Indonesia in 1990, just 35% of the urban population and 33% of the rural population were supplied with water (FAO AQUASTAT 2003).

Additional economic impacts accrue from costs in supplying water for irrigation. In the Philippines, under the National Irrigation System (NIS) schemes, the average cost of irrigation development is estimated at 3 800 to 7 600 USD/ha for new schemes, while the cost for the rehabilitation of existing schemes varies from 1 000 to 1 600 USD/ha (FAO AQUASTAT 2003). Although the cost of the system is borne entirely by the Department of Agriculture (NIA), often poor farmers have to pay
fees to cover operations and maintenance expenditure. There are also about 6,200 communal schemes. In Mindanao, these schemes are generally large, many of them being implemented by the government settlement programmes and then transferred to farmer groups. The association bears 10% of the direct cost of construction, and pays back the balance within 50 years at a 10% interest rate. Private schemes (about 152,100 ha in 1992) are generally supplied through pumping. They find their origin in publicly assisted river lift and groundwater development projects. In 1980, public involvement in this sector ceased because of the high cost of energy needed to operate these systems. Most of the schemes have been abandoned or are now inoperable. For example, of the 379 public tube-wells constructed in 1971, only 22 were still in operation in 1990. Pump schemes located along rivers have also been developed by private owners serving up to about 20 ha. Although this can be successful when supporting high value crops, many are no longer used, largely due to the high cost of operations and maintenance, particularly for rice paddies (FAO AQUASTAT 2003).

On all NIS schemes, the fees collected by the NIA should cover the costs for operation, maintenance and even the investment cost within a reasonable period of time to an extent consistent with government policy. However, in practice, capital cost recovery is confined to the communal sector and the fees collected covered only 80% of operations and maintenance expenditure in 1989. The fees can be paid either in rice or in cash. For crops other than rice, the fees are calculated on the basis of 60% of the rate given for rice fees. In Indonesia, the main objective of irrigation development is to expand the cultivation of rice, the staple food. The major crops cultivated under controlled irrigation are rice and palawija (dry season crops, e.g., corn, soybean). In 1992, the average cost of developing a surface irrigation scheme was 3,645 USD/ha while the average operations and maintenance cost of a surface irrigation system was 8.4 USD/ha/year.

There is also growing water competition among the users; water supply, hydropower, environment, fishing and watershed management are competing with irrigation for water. In the Philippines, the National Water Review Board (NRWB) was established in order to coordinate the use of water for different purposes, but its action is hampered, in part, by a lack of reliable data on present water resources and water use. Erosion and siltation of the canals have resulted in high costs for the operation and maintenance of irrigation schemes, and many are thus in need of frequent rehabilitation. The conversion of agricultural lands for industrial or residential use has significantly reduced the area that can actually be used for irrigated agriculture. The high cost of energy hampers the development of pump irrigation systems. The present pump systems are no longer economically viable if devoted solely to rice irrigation.

Thus, socio-economic impacts from freshwater shortage in the Sulu-Celebes (Sulawesi) region include:

- Loss/interruptions to human drinking water supplies particularly in rural areas of the Philippines;
- Increased costs of irrigation and alternative water supplies, with one-third of the Philippines population having no secure access to potable water;
- Reduction in future use options;
- Human health impacts from lack of regular supply of potable water, as noted above;
- Future costs of improving supply, both reticulated and through deepening wells and pumping;
- Potential damage to infrastructure;
- Increased potential for upstream/downstream conflicts, or conflicts among urban and squatter groups. The water authorities presently do not have adequate capacity for effective enforcement, and much of the infrastructure dates from colonial times.

**Conclusions and future outlook**

Freshwater shortage has caused moderate environmental impact at present and is expected to deteriorate markedly, becoming severe by 2020. Impacts to health and other social and community aspects are expected to deteriorate from slight to moderate by 2020 although the economic situation is expected to improve slightly over the next 20 years, remaining at a moderate level of impact.

Major forcing factors on freshwater shortage include widespread increases in human populations, with a doubling expected by 2035, compounding problems of poor water supply and contamination. Despite the best efforts of government (as outlined in Box 2) and NGOs, a continuing lack of effective regulation and little environmental control is expected to contribute to the further deterioration in socio-economic aspects of freshwater shortage. For example, in both Indonesia and the Philippines, with the sharply increasing needs for irrigation, safe drinking water, industrial water, energy, etc., the demand on water resources has increased rapidly. In 1990, just 35% of Indonesia’s urban population and 33% of the rural population is supplied with water, and it is estimated that between 1990 and 2020, the demand will increase by about 220%. Notably, the actual rate of deterioration will depend largely on the success of the planned interventions (see Annexes III and IV).
### Trends in water resource management in the Sulu-Celebes (Suluwesi) region.

<table>
<thead>
<tr>
<th>Philippines</th>
<th>Indonesia</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td>The majority of the population depends on agriculture for its livelihood and irrigation is considered a crucial element in agricultural production. With the potential irrigable area of 3.1 million ha, irrigation development is only at the halfway stage. Self-sufficiency in food has been set as a target by the Government. Agricultural development through irrigation, therefore, still remains a priority on the Government’s agenda. The Irrigation Crisis Act (Republic Act No. 6978) signed into law in January 1991, mandated the NIA to develop the remaining 1.5 million ha of irrigable lands within 10 years through the construction of irrigation projects including other related project components. Irrigation, soil and water management have been set as a priority on the agenda of the Department of Agriculture. The Medium Term Philippine Development Plan (1994-1998) also envisages rapid irrigation development. However, there are numerous economic and environmental problems, as described above. In addressing these challenges, the NIA, together with the Department of Environment and Natural Resources, is expected to:</td>
<td>The Ministry of Public Works through its Directorate General of Water Resources Development (DGWDR) has identified four main missions in water resources sector programming as part of Repelita VI (1994-1999). They are:</td>
<td>Agriculture will remain the main user of water in the future. However, its importance will decline from the present 76% to about 70% of total water consumption by 2026. In the irrigation sector, future efforts will focus on demand management through improved water management rather than on supply management. Future trends in rice cultivation will focus on group farming as practised in the Trans Perak Area Integrated Agriculture Development Scheme. In the long-term, sustainable rice cultivation will depend on the establishment of effective farmers’ organisations. More business-oriented rice farming is seen as a way to reduce government subsidies to small farmers. Owing to the high cost of rice production, the National Agriculture Policy (1992-2010) aims to gradually reduce the country’s self-sufficiency in rice from the current 80% to 65%.</td>
</tr>
<tr>
<td>- Fully enforce existing laws on environmental protection and conservation, in order to reduce erosion.</td>
<td>- Maintenance of self-sufficiency in rice production to achieve long-term food security. Although Indonesia achieved self-sufficiency in rice production in 1984, demographic growth, land use changes, variations in rainfall, climatic changes, drought, flooding, drainage problems in low-lying areas and urbanisation have resulted in rice shortages requiring the importation of rice and the building up of costly rice buffer stocks. The DGWDR directs its programming towards activities that support the continued increase in rice production to maintain self-sufficiency.</td>
<td></td>
</tr>
<tr>
<td>- Establish institutional arrangements with the NPC, the NEA and the electric cooperatives to reduce power rates for pumps as a government subsidy to small farmers.</td>
<td>- Provision of water to meet increasing water supply demands. Rapid industrialisation, increasing urbanisation and the need to supply the nation’s population with safe drinking water have necessitated the development and maintenance of adequate water sources and supplies of proper quality water in many regions of the country. Often, the water is required at locations far away from good quality water sources, so large capital investments for conveyance infrastructures are needed. The water sources are continuously subjected to water quality degradation due to urban, industrial and upper watershed pollution. The DGWDR directs its programming to develop sources of good quality water and supply to demand centres in order to meet the needs for water.</td>
<td></td>
</tr>
<tr>
<td>- Work with the Department of Agrarian Reform, under the Comprehensive Agrarian Reform Law, to approve the transformation of agricultural lands for non-agricultural uses.</td>
<td>- Flood alleviation and river management. Many of Indonesia’s agricultural and urban areas are located in the lowlands. The majority of rivers flood frequently due to the high intensity rainfall in the watersheds and influx of sediment, particularly in lowland areas. In addition, the river morphology and carrying capacities are continuously changing due to sediment problems, large variations in flow, and human encroachment. In order to protect investment and economic activity as well as to ensure the availability of surface water resources close to demand centres, the DGWDR direct its programming to continuously improve flood protection and drainage, through both structural and non-structural measures, and to manage water bodies such as ponds, lakes and reservoirs.</td>
<td></td>
</tr>
</tbody>
</table>

#### Pollution

Industrial forms of water pollution are focused in the major urban centres, include Davao City and Zamboanga City (Mindanao), Cebu City (Cebu), Puerto Princesa (Palawan), Batangas City and Lucena (Luzon), Bacolod and Daumagete City (Negros), Iloilo (Panay), Tarakan (East Kalimantan), Manado (North Sulawesi) and Sandakan (Sabah, Malaysia). Here also, sewage treatment is superficial at best, with raw and/or primary treated sewage discharged directly into water courses. Agricultural pollution is also widespread, through leaching of fertilisers and pesticides into water courses, massive loss of soils following land clearing and forestry and increasing aquaculture activities.

Total emissions of organic water pollution have remained relatively steady in the Philippines from 1980 (estimated at 182 000 kg per day) to 1993 (181 700 kg per day) with an average input per worker of 0.19 kg per day sector’s share of organic water pollution was mostly contributed by food (53% of the total) (World Bank 2003b). In Indonesia by contrast, there has been a rapid increase in emissions, from some 214 000 kg per day in 1980 to more than 537 000 kg per day in 1993. Here food is the major industrial contributor (59%). Similarly in Malaysia, emissions of organic water pollution have increased, from 77 200 kg per day in 1980 to 136 100 kg per day in 1993, again with food being the major industrial contributor (32%) (World Bank 2003b).
Environmental impacts

Microbiological

Despite its slight environmental impact overall, microbiological pollution is a locally significant problem in the major urban centres, notably Davao and Zamboanga cities (Mindanao) from inadequate sewage disposal and treatment. There are also elevated levels of faecal coliform contamination and in the Visayan Islands there has been a slight increase in incidence of bacterial-related gastro-entric disorders in fisheries product consumers (affecting hundreds of people), but no fisheries closures or advisories. Blooms of toxic dinoflagellates have caused paralytic shellfish poisoning in parts of the region (Maclean 1989).

There is only rudimentary sewage treatment for much of the region, where most sewage is treated by settlement and most primary treatment consists of screening, particularly in the urban areas (e.g. Davao City, Mindanao). For example, the production of wastewater in the Manila region and nearby provinces (part of GIWA region 54 South China Sea) is estimated at 74 million m³ in 1994, while the volume of treated wastewater reached just 10 million m³ at the Ayala and Dagat-Dagatan pond (FAO AQUASTAT 2003). Disposal of wastewater is expected to increase as new sewer lines are being built every year. In Indonesia, municipal and industrial wastewater is discharged virtually untreated into the waterways causing rapid deterioration in the quality of river water. In Malaysia, although much legislation touches on water resources either directly or indirectly, most of the existing laws are considered outdated. For example, the Water Act of 1920 is inadequate for dealing with the current complex issues related to water abstraction, pollution and river basin management (FAO AQUASTAT 2003).

Eutrophication

The present level of environmental impact from eutrophication in the region as a whole is moderate. Impacts are most significant in enclosed bays, harbours and lagoons with limited water circulation, and particularly where sewage or industrial discharges are present, notably in areas of southern Luzon and the Visayan Islands. As noted in the assessment of the impacts of microbiological pollution, blooms of toxic dinoflagellates have caused paralytic shellfish poisoning in parts of the region (Maclean 1989).

Chemical

Chemical pollution is causing only slight environmental impact in the region as a whole, in part related to the lack of major industrial centres in the region (all national capitals and most major industrial areas are outside the regional boundaries), and to the physical oceanography of the Sulu-Sulawesi (Celebes) Sea. Nonetheless, this is a locally significant problem in worst affected areas such as Batangas Bay (heavy metals), urban areas of Mindanao, the Visayas Islands and other industrial, urban (e.g. all larger cities and towns) and major agricultural areas.

Some water contamination also occurs from manufacturing, metal fabrication, ship repair and agricultural and food processing industries (oil milling, sugar refining, and meat and fish processing) and from mining, with contaminant loads concentrated near the discharges. Pargal et al. (In prep) noted that in the case of Indonesia, the textiles, leather tanning, food products and pulp and paper industries are more BOD-intensive than other manufacturing sectors. Pulp and paper is significantly more intensive in organic water pollution (BOD) than food products, although textiles and leather tanning are also relatively BOD-intensive; metal and machinery industries are the least BOD-intensive. Pulp and paper and miscellaneous manufacturing are most intensive in total suspended solids (TSS), while the machinery industry is least intensive.

Philippine coastal waters off Luzon, Negros, Cebu, Samar, Balabac and the Calamian group have suffered from chemical pollution due to mining activities. Releases of chemical and to a lesser extent microbiological pollution from shipping in harbours are also common and widespread, as regulations and controls relating to ship-derived pollution are rarely enforced. Pesticide use is widespread, particularly in plantation agriculture (e.g. nematocides in banana farms). For example, chlorinated residues from pesticides used on rice paddies, such as Aldrin, Dieldrin, Lindane and Endrin, are found in the water column and sediments in Manila Bay and Segara Anakan, with levels exceeding allowable limits set by national agencies (Ludwig 1985, Gunnerson & Cuellar 1988). As noted above, fish kills have occurred from various chemical inputs, notably from a nematocide in banana pesticides used in Compostela Valley province, Mindanao. Nonetheless, there are no indications that pollution from agricultural run-off is a significant problem at the scale of the region at present.

Suspected solids

Environmental impacts from suspended solids are severe, especially in the coastal waters of the Philippines, the result of extensive deforestation (e.g. Chia & Kirkman 2000, Hodgson & Dixon 1988, 1992, Burke et al. 2002). This is compounded by high rates of erosion and siltation rates that are among the highest on Earth. For example, in the Philippines, it is estimated that approximately 1 billion m³ of sediment is lost to coastal waters annually (Burke et al. 2002), carrying high loads of particle-bound nutrients. Additional transboundary impacts result from sediment-laden waters flowing seasonally into the region around the northern coast of Sabah and to the south of Palawan from the
South China Sea (Bate 1999). At present, effects of the nutrients are uncertain and are partly dependent on rates of mineralisation and retention of the dissolved nutrients. There is little evidence of visible effects on the abundance and distributions of biota, of increased frequency of hypoxic conditions, reduced levels of dissolved oxygen, or fish or zoobenthos mortality other than in some enclosed bays (e.g. in southern Luzon and Visayas) and in the immediate vicinity of river mouths. Blooms of toxic dinoflagellates have caused paralytic shellfish poisoning (Maclean 1989). The extent and level of threat posed by sedimentation to coral reefs of the region ranges from low to high (Figure 6). High threat sites include much of the northern coast of Mindanao, several smaller areas of northern Sulawesi and northern Borneo (Sabah, Malaysia) and much of southern Luzon (Burke et al. 2002).

**Solid wastes**

Solid wastes have caused moderate environmental impact in the region. However, there has been severe impact locally, particularly around the larger cities, towns and villages, including Davao City and Zamboanga City (Mindanao), Cebu City (Cebu), Puerto Princesa (Palawan), Batangas City and Lucena (Luzon), Bacolod and Daumagete City (Negros), Iloilo (Panay), Tarakan (East Kalimantan), Manado (North Sulawesi) and Sandakan (Sabah, Malaysia). Here, waste management is generally poor or non-existent. There is widespread litter on beaches giving rise to public concerns regarding recreational use. There are high frequencies of benthic litter recovery and interference with trawling activities, and there are also frequent reports of entanglement/suffocation of species by litter.

**Thermal**

Thermal pollution has only negligible and at most slight impact, being notable only in the immediate vicinity (less than 1 km2) of the few power plants where ocean discharge of cooling waters occurs.

**Radionuclide**

There is no known environmental impact of radionuclide pollution at present. There are no nuclear power plants in the region, although there may be some episodic minor discharge from nuclear-powered ships navigating through the area.

**Spills**

Spills have caused only slight environmental impact at present, despite the southeastern Celebes Sea forming part of the major ULCC oil tanker route between the Indian and Pacific Oceans. International trade is expected to triple by 2020, and much of this trade will be transported by sea. Increased tanker traffic using the ULCC route has the potential for spills to occur that could damage oceanic and coastal habitats; mangroves and coral reefs. Major oil production is being carried out in northwest Palawan, Erb West and Samarang off west Sabah, and the potential for oil spills to affect adversely marine and coastal ecosystems in the region is high. Overall, Southeast Asia produces about 3.5% of the world's crude oil and 2.5% of its natural gas (Valencia 1989), and oil spills in neighbouring regions could also potentially affect the ecosystems of the Sulu-Celebes Sea, especially if occurring during monsoon season. Caution and good management practices must be exercised in current and future exploration initiatives, including the Shell Company’s multi-billion dollar Malampaya Gas Project (in Palawan province, Philippines), which was scheduled to begin operation in 2002-2003 (Werner & Allen 2000). The Philippines and Malaysia have ratified the UN Convention on the Law of the Sea (UNCLOS) and the International Convention on Prevention of Marine Pollution from ships (MARPOL). These nations have taken some steps towards developing oil spill contingency planning, yet little spill control equipment is in place and emergency procedures are not well established.
Socio-economic impacts
The three indicators of socio-economic impacts of pollution have moderate impacts at present. Most impacts are related to poverty and are concentrated in the major urban centres, the Visayas Islands, Mindanao, East Kalimantan and Sabah. The GIWA experts conclude that there have also been significant health issues in these areas, including cases of mercury poisoning, although the total number of cases is unknown. The key socio-economic impacts include:

- Increased risks to human health;
- Increased costs of human health protection;
- Loss of water supplies (e.g. potable water, see Freshwater shortage);
- Increased costs of water treatment (see Freshwater shortage and Regional definition, Socio-economic characteristics);
- Costs of preventive medicine (mostly future cost);
- Costs of medical treatment (e.g. blooms of toxic dinoflagellates have caused paralytic shellfish poisoning in parts of the region) (Maclean 1989);
- Costs of clean-up;
- Loss in fisheries (see Unsustainable exploitation of fish and other living resources);
- Change in fisheries value (see Unsustainable exploitation of fish and other living resources);
- Costs of reduced fish marketability due to aesthetic perceptions (see Unsustainable exploitation of fish and other living resources);
- Reduction in options of other uses of freshwater (see Freshwater shortage);
- Damage to equipment (e.g. particle impacts);
- Avoidance of amenities and products due to perceptions of effects of contamination;
- Costs of preventative measures;
- Costs of contingency measures.

A typical local scale case study in socio-economic impact is provided by recent and future proposed port reclamation in North Sulawesi, close to the city of Manado and the regionally significant Bunaken National Park (Box 3).

Conclusions and future outlook
For the GIWA concern of Pollution as a whole, present level of environmental impact is moderate. However, environmental impact of suspended solids is already severe, primarily resulting from deforestation over the past century and a half (Burke et al. 2002). Over the next years, environmental impacts from pollution in streams and rivers, the intertidal zone, and waters deeper than 200 m are likely to deteriorate markedly. Overall impact in 2020 is expected to be severe, primarily because of the predicted major increase in population (doubling by 2035) without sufficient major improvements in infrastructure to compensate.

The three nations are adopting industrial water pollution control standards similar to those in developed countries. However, formal regulation in the region has been greatly hampered by the absence of clear and legally binding regulations; limited institutional capacity; lack of appropriate equipment and trained personnel; and inadequate information on emissions (Hettige et al. 1996). Indonesia began formal regulation in 1992 (Pargal et al. in prep.), with establishment of maximum allowable volumes and concentrations (in kg/tonnes of output) for emissions of BOD and other water pollutants from 14 broadly-defined industry sectors (e.g. textiles, wood pulping). Although self-reported BOD emissions are now mandated by law, reporting was extremely sparse until recently. Until 1995, the only consistent programme of monitoring and pressure for compliance was a voluntary arrangement instituted in 1989. This PROKASIH or ‘Clean Rivers,’ programme, covers about 5% of Indonesian manufacturing facilities in 11 river basins on the islands of Java, Sumatra (in the neighbouring GIWA region Indonesian Seas) and Kalimantan. While it has succeeded in eliciting significant pollution reductions from some of Indonesia’s largest polluters, PROKASIH represents only the first stage of regulation.

Yet, despite weak or non-existent formal regulation, there are many clean industrial plants in these countries. However, there are also many plants that are among the world’s most serious polluters (Hettige et al. 1996). The analysis of Hettige et al. (1996) demonstrated that pollution intensity was negatively associated with scale, productive efficiency,
and the use of new process technology. It was strongly and positively associated with public ownership, but foreign ownership had no significant effect once other plant characteristics were taken into account. Among external sources of pressure, community action, or informal regulation, emerged as a clear source of interplant differences. The results suggested that local income and education are powerful predictors of the effectiveness of informal regulation. They also showed that existing formal regulation had measurably beneficial effects, even when it was quite weakly developed. Abatement is generally subject to significant scale economies; within-country variations in labour and energy prices have little impact on pollution intensity; and community incomes have a powerful negative association with pollution intensity (Pargal et al. in prep.). Although the plant and firm characteristics are important in Indonesia (and other Asian developing economies), community income is particularly important, since this suggests a powerful role for informal regulation whether or not formal regulation is in place.

Indonesia’s Environmental Impact Management Agency (BAPEDAL) has recently initiated PROPER-PROKASIH. This programme gives participating industrial and other manufacturing plants colour-coded grades indicating their compliance with pollution regulations. PROPER-PROKASIH is in its second year and preliminary results suggest it has had a positive impact on polluter behaviour as well as BAPEDAL’s capacity for regulation. In the Philippines, the Department of Environment and Natural Resources (DENR) is introducing a public disclosure programme called EcoWatch, modelled on Indonesia’s PROPER programme. Despite these and other pollution mitigation initiatives, future deterioration is expected in all three indicators, such that the socio-economic prognosis for 2020 is for severe impacts to economy, health and other social and community aspects from water pollution issues, despite regulatory and other interventions.

Addressing water security alone is a major challenge (as noted in Freshwater shortage above), and little progress is being made in addressing the other major forms of water pollution at present. For example, river and coastal aquaculture projects are growing rapidly, with little regulation or enforcement. In Indonesia, up to 1 million ha of land, mostly mangrove forests, were allocated by the government for the shrimp hatchery industry during the 1980s and 1990s. By 2001, about 70% of the shrimp farms had been abandoned, because the operators found them unsustainable due to the high concentrations of chemicals and the destruction of the mangrove habitat.

### Habitat and community modification

The region is located in the Indo-West Pacific centre of diversity and supports mega-diversity, located near the junction of three major biogeographic zones (Roberts et al. 2002, Cheung et al. 2002). The warm clear waters of the Sulu-Celebes Sea, its currents and upwellings, its active underwater volcanoes, its seamounts, trenches, corals and inter-island passages, constitute an exceptionally rich marine life hot spot. The region supports a significant proportion of the total coral reef area of the Philippines, with some 20 000 km² of coral reefs, and forms part of the ‘coral triangle’ of highest coral diversity with Indonesia and New Guinea (with more than 500 reef-building species) (Burke et al. 2002).

The Sulu-Celebes Large Marine Ecosystem support around 400 species of algae, 5 species of sea turtles, 22 species of marine mammals and over 450 types of coral (LME 2003). More than 2 500 species of fish occur in the region, many of which are exploited using a large variety of different gears and methods. The fishery is comprised predominantly of pelagic species, mostly tuna (Thunnus spp.), skipjack (Katsuwonus sp.), scads and sharks, representing some 80% and 60% of total production of North Sulawesi and East Kalimantan respectively. Five species of sea turtles (Green, Chelonia mydas; Hawksbill, Eretmochelys imbricata; Olive ridley, Lepidochelys olivacea; Loggerhead, Caretta caretta; and Leatherback, Dermochelys coriacea) and 22 species of marine mammal have been recorded (Jacinto et al. 2000). Dugongs (Dugong dugon) are still present in Palawan and Semporna provinces (Philippines), and to the south of the region in areas of Sulawesi and Flores (GIWA region 57 Indonesian Seas), although these were once common in suitable seagrass habitat throughout the entire region.

### Environmental impacts

**Loss of ecosystems or ecotones**

There is already severe loss of ecosystems in the region, with permanent destruction having reduced the surface area of marshes, swamps, riparian belts and forest catchments by more than 30% between the 1850s and the 1970s. As noted above, significant loss of riparian vegetation has occurred through effects of logging and other destructive land use practices. This has been most severe in the small islands of the Sulu Sea and Visayas, and also significant at larger scales on Mindanao, Negros, Cebu, East Kalimantan and Sabah. On Negros, the 50% of original forest that remained in the 1930s has been reduced to approximately 4% today. Overall, there has been greater than 80% loss of original land cover in most of the Philippine area of the region, with some 40-60% loss in the Malaysian (Sabah) areas of Borneo (Figure 7) (Burke et al. 2002). By contrast, much of the original forest cover remains
in Indonesian East Kalimantan (Borneo) and North Sulawesi. There is also extensive evidence of human-induced fragmentation of coastal and marine habitats from siltation, development and destructive fishing practices. It is estimated that 60-80% or possibly more of the mangrove resources in the Philippines has been lost (Atmadja & Man 1994). Development of most ports has resulted in foreshore reclamation and channel dredging, while muro-ami, (Hopley & Suharsono 2000, Pilcher & Cabanban 2000), blasting (Cabanban 1998) and poison fishing (Pratt 1996) has damaged or destroyed more than 70% of coral reefs throughout the region. Muro-ami involves setting a net over a coral reef into which a group of 10-30 swimmers drive the fishes. The swimmers are equipped with weighted (usually rocks) lines that are bounced up and down on the reef in an effort to drive out the fishes (Werner & Allen 2000). Seagrass beds, muddy and sand-gravel bottoms and fringing coral reefs are also impacted by trawling.

Modification of ecosystems or ecotones
There is also severe modification of habitats, with changes to riverine habitats (fast flowing stony bottomed streams and slow flowing sandy/muddy floodplain rivers) and their natural species compliment from introductions (e.g. Tilapia and African catfish). In Indonesia, at least 60 of the 1 400 freshwater fish species are threatened with extinction. In the Philippines, at least 26 of the 230 freshwater species are similarly threatened, whereas in Malaysia some 14 species of a total of 449 freshwater fish species are threatened (WRI 2003).

Overfishing has caused changes in population structures and/or functional group composition (e.g. coral reef fishes) and major changes in ecosystem services (e.g. reef fisheries, mangrove resources). For example, about 70% of coral reefs have been degraded in terms of destructive and overfishing and the important fisheries ‘nursery ground’ roles of large sections of mangroves and seagrass beds have been seriously depleted (Figure 8).

The major causes of loss and modification of the freshwater, coastal and marine habitats include:

- Siltation, conversion for aquaculture, agriculture, industrial development affecting marshes, swamps, rice paddies and riparian belts, notably in northern Mindanao, eastern Palawan, Visayas Islands, southern Luzon and Sabah (Figure 9);
- Deforestation, siltation, damming and waste disposal affecting rice paddies and rivers (most of the Philippines area of the region);
Silica mining and solid wastes affecting sandy foreshores (southern Luzon, Mindanao and Sabah);
Aquaculture conversion and timber collecting affecting mangroves (many areas);
Sediment run-off - siltation and dredging affecting seagrass beds and coral reefs (many areas of the Philippines, notably northern Mindanao and parts of eastern Palawan) (Figure 6);
Destructive fishing affecting coral reefs (much of the region, and notably at the World Heritage Tubbataha);
Trawling affecting soft-bottom habitats (much of the region, notably Sabah);
Mid-water trawling, drift netting and other forms of pelagic fisheries, oil and gas exploration and pipelines affecting oceanic habitats (Sulu Sea).

**Socio-economic impacts**

Socio-economic impacts of habitat and community modification are already moderate (health) to severe (economic and other social and community impacts). The GIWA experts conclude that there are serious economic and health issues in subsistence fishing communities with the highest birth rates, from reductions in animal protein. Additional economic impacts have occurred from loss of mangrove habitats, notably near Zamboanga (Mindanao), and strip mining.

Major economic costs are accruing from loss and modification of coral reef habitats, which are of immense economic value. In Southeast Asia generally, reefs are estimated to be worth some 2.400 million USD per year, based on their value in food security, employment, tourism, pharmaceutical research and shoreline protection (Burke et al. 2002).

The reefs of Indonesia and the Philippines provide annual economic benefits of 1.6 billion and 1.1 billion USD per year in 2002, however, over the next 20 years, human impacts, notably overfishing, destructive fishing and sedimentation could cost Indonesia and the Philippines some 2.6 billion USD and 2.5 billion USD respectively (Burke et al. 2002). As noted above in the Pollution section, up to 1 million ha of land in Indonesia, mostly mangrove forests, were allocated by the government for the shrimp hatchery industry. By 2001, about 70% of the shrimp farms had been abandoned because the operators found them unsustainable due to the high concentrations of chemicals and the destruction of the mangrove habitat. Local NGOs claim that the donor agencies (including the World Bank) should be held accountable for environmental destruction caused by shrimp farming and that the government should establish clear criteria for sustainable shrimp farming and ways to rehabilitate damaged mangroves. In other parts of the region, similar habitat modification and destruction has occurred, and this has also led to human conflict.

Progress in managing human use of habitats is not expected to be sufficient to fully mitigate the damaging effects of population growth, causing:

- Reduced capacity to meet basic human needs (e.g. fisheries) for local populations;
- Changes in employment opportunities for local populations and associated changes in social structures (e.g. through loss of future employment opportunities related to degradation of habitats);
- Loss of existing income and foreign exchange from fisheries, tourism (see Box 4);
- Loss of opportunity for investment income and foreign exchange;
- Human conflicts, national and international, particularly related to fisheries exploitation;
- Increased risks to capital investment;
- Costs of controlling invasive species;
- Costs of restoration of modified ecosystems;
- Inter-generational inequity, particularly in relation to loss of ecosystem services from coastal and marine habitats of coral reefs, seagrass beds and mangrove forests.
According to Burke et al. (2002), destructive fishing practices are the single largest threat to Indonesia’s and the region’s reefs. While the benefits to an individual fisherman may be high in the short-term, the costs as a whole are staggering. The WRI report estimates that the cost from fish bombing alone over the next 20 years will be at least $790 million USD. That sum is more than 10% of the debts recently rescheduled with Indonesia’s international lenders.

Cyanide use can be nearly as destructive, but its focus is often the international market. Prized reef fish like grouper and Napoleon wrasse (Cheilinus undulatus) are chased into corals, where the diver uses cyanide-filled squirt bottles to stun the fish for capture and sale on the live reef fish market, often shipping their specimens aboard large cargo ships to discerning diners in Hong Kong, Singapore, and Taiwan, where the fish are picked out of aquariums just prior to cooking. The cyanide does more than stun the fish, though. Coral is killed as well, particularly since the divers often have to tear apart the coral structure with crowbars to pull the fish out.

Burke et al. (2002) puts the cost to Indonesia from cyanide use at $46 million USD annually. By comparison, the report estimates the annual economic benefit to Indonesia from its reefs - which not only include valuable fish but also protect shorelines from erosion and facilitate the growth of coastal mangroves and seagrass beds - at $1.6 billion USD.

Notably, local businessmen involved in the live reef fish trade, upset at the heightened enforcement in some MPAs (e.g. Bunaken National Park), began lobbying to have effective MPA Director’s reassigned, but in the case of Bunaken National Park, a concerted media campaign has stemmed those efforts for the time being. While surveillance and enforcement may be stemming destructive fishing in the few MPAs like Bunaken, the situation around Indonesia is far less promising. In areas like West Nusa Tenggara in the GWA region, Indonesian Seas, marine police have been the subject of death threats, and fish bombs have been thrown at police boats that dare to approach illegal fishermen. Moreover, the scale of Indonesia’s territory, including over 9,500 km of coastline, makes uniform enforcement and protection all but impossible. For example, the WRI ‘Reefs at Risk in Southeast Asia’ report (Burke et al. 2002) estimates that up to 50% of Indonesia’s 51,000 km² of reef have already been degraded, with 85% threatened by human activities, which includes coastal development, overfishing, and marine-based pollution. Exact figures are difficult to gauge, however, because of the paucity of long-term monitoring and data. Efforts to improve existing data are continuing, particularly in areas like Bunaken, but conservationists worry that the damage being done outside national parks is far worse than that which occurs within view of park officials and police.

At present, most habitats are only poorly represented in protected areas and, of those, most are poorly managed. For example, approximately 4% of Philippine reefs are listed as being protected, although most of these are being degraded at increasing rates from destructive fishing, sedimentation and pollution, and a lack of enforcement (Cheung et al. 2002, Spalding et al. 2001). Coastal development also poses a serious threat to coastal habitats (mangroves, seagrass beds and fringing coral reefs). The ‘Reefs at Risk’ analysis for Southeast Asia (Burke et al. 2002) identified areas of North Mindanao, Cebu, the Visayas Islands, Palawan and North Sulawesi as high threat (Figure 9).

International NGOs including WWF, The Nature Conservancy and Conservation International, among others, are presently working towards assessment and management of critical biodiversity sites in the region. A key strategy in slowing the rate of deterioration is the successful implementation of marine protected areas, many of which are already gazetted but lack adequate management. Improvements in management capacity are occurring, at both local scale (e.g. Apo Island and Danjugan Island, Philippines; Bunaken National Park, Indonesia; Turtle Island, Malaysia) and the larger scale of the coastal and marine areas of the region as a whole (e.g. WWF Sulu-Sulawesi Marine Ecoregion programme). The entire coastal and sea area between Malaysian Sabah, Indonesian East Kalimantan and Philippines is recognised as a special management area named Sulu-Sulawesi Marine Ecoregion (SSME) by WWF, ranked as one of their top four global priority sites (number one in Asia-Pacific) (Trono and Miclat pers. comm.) for coastal and marine management. Objectives of the WWF programme are to conserve the outstanding biodiversity of the area through improved implementation of ecologically sustainable forms of development that allow traditional communities to practice customary fishing rights, while also providing for commercial fisheries and seabed management. There are a total of 16 gazetted protected seascapes measuring at least 10,000 ha within the Philippine territory of the WWF SSME. A 17th MPA was proposed as a network of small protected areas in the Visayas. At present, levels of funding for these initiatives are not assured, which adds an additional degree of uncertainty in assessing the likely situation in the region in the future.

Conclusions and future outlook

For the GWA concern of Habitat and community modification as a whole, present level of environmental impact is already severe, and future levels of environmental impact are expected to remain severe, with continuing deterioration over the next 20 years, because population growth and related exploitation of habitats and target species will more than counter ameliorative interventions (see Causal chain and Policy option analyses).
In total, some 100 marine protected areas have already been gazetted in the region, including:

- Pulau Sangalaki and Pulau Semama (East Kalimantan);
- Bunaken National Park (North Sulawesi);
- Benkoka Peninsula, Elopura, Gum Gum, Kuala Segama and Kuala Maraup, Pulau Penyu (Turtle Island), Sibyte, Pulau Berhala, Pulau Batik, Lahad Datu, Selangan Island, Tanjong Nagas, Semporna, Trusan Kinabatangan and others in Sabah;

At the larger spatial scale, the Tubbataha Reefs of the Sulu Sea is the only World Heritage site conserving coral reef habitats in the region, despite the conservation of representative habitats and communities through development of protected areas being a global priority (e.g. International Coral Reef Initiative ‘Call to Action’ and ‘Renewed Call to Action’). As noted above, the Tubbataha Reef National Marine Park comprises some 33 200 ha, inside the Palawan Man and Biosphere Reserve (1 150 000 ha). The Tubbataha Marine Park includes the North and South Atolls and is a unique example of atolls with high diversity and density of tropical marine biota. The site is recognised as the most biologically diverse coral reef system in the Philippines, and of great importance for maintenance and replenishment of harvested species and density of tropical marine biota. The site is recognised as the most biologically diverse coral reef system in the Philippines, and of great importance for maintenance and replenishment of harvested species in the greater Sulu Sea. In Indonesia, the reef areas around Bunaken and Manado in North Sulawesi are of exceptional conservation value.

Bunaken National Park (BNP), founded in 1991, is one of the most strategically important marine protected areas in the world, located near the centre of the world’s highest marine biodiversity region (‘coral triangle’ of New Guinea, Indonesia, and Philippines, the central Indo-West Pacific) (Box 5). The BNP covers some 90 000 ha of coral reefs, mangrove forests and seagrass beds surrounding five islands and the northern coastal area of Sulawesi, and supports a population of some 30 000 people. Bunaken National Park has become one of Indonesia’s most well known marine ecotourism destinations (Erdmann & Merrill 2003).

Integrity of the natural ecosystem of the Bunaken National Park, and indeed parks throughout the region generally, is threatened by human activities that are both marine and land-based, such as resource overexploitation, destructive fishing practices and unsustainable tourism. Coupled with, and contributing to, these threats is the lack of awareness among villagers, and the lack of human resources for management within the Park and the region generally. The low capacity among Park personnel in the marine sector is demonstrated by the fact that in the late 1990s the majority of recruits had forestry background with no marine related training. These and other shortcomings continue to hinder adequate management, although recent advances are beginning to address some of these issues (also see Policy options and Annex IX). For example, living coral cover (a simple and widely used index of reef condition) was recovering following impacts from destructive fishing and to a lesser extent coral bleaching in the 1990s (Box 6).

At the smaller spatial scale, the region has many community-based MPAs, particularly in the Philippines. These have had mixed success in relation to management effectiveness, particularly in...
Box 6  Increase in coral cover in the Bunaken National Park.

A recent re-survey in 2001 of reefs around Bunaken Island in Bunaken National Park, North Sulawesi, has shown an average increase of 6.36% live hard coral cover in the past 8 months (with an overall average live hard coral cover of 47.5%). Such a rapid increase in hard coral cover is extremely encouraging and provides strong evidence that recent management initiatives assisted by NRM and its partners (the Bunaken National Park Office, the Bunaken Management Advisory Board, the North Sulawesi Watersports Association, WWF Wallacea and others) are having an immediate and very positive effect upon the reefs within the park. Besides the excellent physical conditions for coral growth in Bunaken (deep, clean water, frequent nutrient upwellings and strong currents), specific management initiatives that have likely contributed to the rapid recovery include a ban on anchoring by all tourism boats, a participatory zonation revision that includes very specific rules on activities that are allowed within individual zones, and a 24 hour community joint patrol system that enforces the zonation system and has virtually eliminated destructive fishing practices like cyanide fishing around Bunaken Island.

Increases in live hard coral cover were different among the various zones; the tourism use zones showed an average increase of 5.9% to reach 49.4% average live cover, while the community use zones showed the highest average increase of 7.7% to reach 45.2% average live hard coral cover. The core conservation zone (where no tourism or fishing activities are allowed) showed an average increase of 6.3% to reach 46.3% average live hard coral cover. Anecdotal evidence from repeat divers suggests that fish populations are also staging a comeback.

(Source: NRM Headline News 2001)

The Sulu-Celebes Seas Large Marine Ecosystem is considered an ecosystem with low productivity (<150 gC/m²/year), based on SeaWiFS global primary productivity estimates. A major marine export industry is supplied by the coastal trawling for prawns, while different artisanal fishing techniques are used locally to catch fish which is the primary food resource in the region. The offshore waters are mainly unexploited while a majority of the fishing occurs in coastal areas (LME 2003). In Indonesia as well as in the Philippines most of the landings are from small-scale artisanal fisheries. Many fishing techniques are highly destructive; for example dynamite and cyanide is used when fishing on the reefs of the Philippines. Few countries in the region have implemented fisheries management plans and the exploitation of the resources of the reef is steadily increasing from the escalating number of illegal fishermen. There is indications that the total catches from the Sulu-Celebes LME have increased rapidly from about 30 000 tonnes in the 1950s to approximately 500 000 tonnes by 1975. The total catch of today is fluctuating around 800 000 tonnes annually (Figure 11). The catch of molluscs, crustaceans, sharks/rays and other finfishes, however, have shown relatively modest increase, remaining relatively stable or declining since the 1950s (LME 2003).

More than 2 500 species of fish occur in the region, many of which are exploited using a large variety of different gears and methods. For the Indonesian areas, government statistics indicate that North Sulawesi and East Kalimantan provide some 11% of the total national marine fishery landings (Kahn & Fouzi 2001). The fishery is comprised predominantly of pelagic species, mostly tuna (Thunnus spp.), skipjack

Figure 11  Catches of various fish resources in the Sulu-Celebes (Sulawesi) region.

(Source: University of British Columbia Fisheries Centre 2003)
scads and sharks, representing some 80% and 60% of total production of North Sulawesi and East Kalimantan respectively.

**Environmental impacts**

**Overexploitation**

Overexploitation is having severe environmental impact with many demersal reef fish, holothurian, mollusc and crustacean stocks heavily overfished. About 70% of Philippine coral reefs are heavily overfished, producing less than 5 tonnes/km²/year, with clear indications of ‘trophic overfishing’, in comparison with the remaining 30% of reefs which produce in the order of 15-20 tonnes/km²/year (Licuanan & Gomez 2000). There is also overexploitation of sharks, tuna, bill-fish and other pelagic species. Sharks are also caught as by-catch of the trawl fisheries and the tuna long-line fishery. Benthic invertebrate fisheries, particularly sedentary species of holothurian sea-cucumbers (mostly *Holothuria* spp. (also known as ‘trepang’ or ‘beche-de-mer’), trochus (*Trochidae*), green snails (*Turbo marmoratus*) and clams (*Tridacna* spp.), are overfished, mostly around the major coastal population centres. Crayfish (*Panulirus* spp.) are also overexploited in oceanic waters, sandy reef lagoons and flats and mangrove areas.

Large-scale commercial operations have targeted beche-de-mer and shark, and poison fishing for demersal reef fish to supply the live fish food trade in Hong Kong and China have burgeoned in the 1990s, with prices increasing but catch per unit effort (CPUE) declining sharply (Cesar et al. 2000). There has also been a significant increase in effort in the pelagic fisheries, with more than 500 boats working from Indonesian waters.

Surveys of the Calamianes Islands (northernmost section of Palawan province) found only one octopus from 38 sites surveyed over 16 days (Werner & Allen 2000). There were also very low numbers of spider shells (*Lambis* spp.), conchs (*Strombidae*) and abalone shells (*Haliotus* spp.), which indicates extraordinarily high fishing pressure. There were only a few commercially exploited seashells found and severe depletion of market-sized fishes, including a notable lack of large piscivorous species such as groupers, barracudas, jacks and sharks. Crayfish appear to have been fished to the brink of local extinction.

At present, neither the status nor the future viability of the fisheries are well understood, and for many fisheries, their status may be summarised as being illegal, unreported and unregulated (IUU). There have been increases in biomass of Skipjack tuna (Figure 12) of the order of 400 000 tonnes according to the Philippines Department of Agriculture Bureau, but this is in part related to reduction in biomass of Bluefin and Yellowfin tuna (Figure 13) stocks that previously occupied the niche in western and central Pacific, and possibly to ENSO effects also. Clearly, there are serious discrepancies in the different data available, with a total catch of some 500 000 tonnes for all marine products (as cited in the paragraph above) on the one hand, yet some 400 000 tonnes for Skipjack tuna alone. Notably, the Philippines Department of Agriculture Bureau statistics suggests that yields of some species have continued to increase, but that catch per unit effort has declined steadily, suggestive of ‘Ecosystem Overfishing’. A similar situation exists for some Indonesian Government statistics, particularly in relation to Maximum Sustainable Yields (MSY), in part related to different assessment criteria and areas.

As noted by Kahn and Fauzi (2001): “Overall, the state of (environmental and socio-economic) assessment of Sulu-Sulawesi Sea…fisheries resources is not very accurate and there is a great amount of uncertainty. Based on the limited data available it can be concluded that some of the fisheries have already reached or surpassed their limits. For others, the total lack of information indicates that further expansion would be inappropriate…. It is estimated that 90% of the fishery effort in Indonesia is carried out by artisanal and subsistence fishermen whose catches go unrecorded by official government statistics and it is partly for this reason that government estimates of annual catches…are considered to be gross under-estimates”.

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*Figure 12* Skipjack tuna (*Katsuwonus pelamis*). (Photo: B. Tenge, Regulatory Fish Encyclopedia)

*Figure 13* Yellowfin tuna (*Thunnus albacares*). (Photo: B. Tenge, Regulatory Fish Encyclopedia)
Excessive by-catch or discard
There is little or no by-catch or discards in the region, as virtually all of the much-diminished catch, including turtles, sharks and even whales, is kept and eaten by local fishermen. Two exceptions to this are the by-catch produced by distant-waters fleets and through use of blast fishing and poisons. Discards from the foreign fleets include shark carcasses without fins; sharks are a major feature of by-catch in fisheries targeting tuna, swordfish, shrimp and squid; and carcasses are discarded after the removal of their fins (FAO 1998). There is also significant by-catch of rare and endangered species of turtles and marine mammals, such that the environmental impact of the issue is severe. Massive destruction of marine mammals, sea turtles and fish has been reported from trap nets placed in a pelagic migratory channel at Tangkoko Nature Reserve in the Manado area, North Sulawesi, Indonesia. Between March 1996 and February 1997, it is estimated that catches included some 1,424 Manta rays, 18 Whale sharks, 312 other sharks, 4 Minke whales, 326 dolphins, 577 Pilot whales, 789 Marlins, 84 turtles and 9 dugongs (Rossiter 2002). The illegal fishing is believed to be operated by a joint Taiwanese/Indonesian venture, and has caused outrage among local people.

Destructive fishing practices
Destructive fishing is also having a severe impact in the region (Pilcher & Cabanban 2000). There is widespread habitat destruction of coral reefs from blast and poison fishing and damage to soft-bottom communities from trawling is extensive in the region; with widespread use of explosives (reef bombing), notably in the Tubbataha reefs south of Palawan, and use of cyanide for fishing (Figure 14). Increases in reef bombing have been attributed to increasing competition among fishers and corresponding declines in catches. Many reefs in the region have also been targeted for the lucrative live fish food trade in Hong Kong and mainland China (with prime live reef fish worth 100 USD/kg). Fish were collected initially using potassium cyanide or sodium cyanide and more recently also using poisons derived locally from plants (e.g. Johannes & Riepen 1995). Poison fishing has also been used in collection of ornamental reef fishes for the international aquarium trade (Johannes & Riepen 1995).

Decreased viability of stocks
Decreased viability of stocks through contamination and disease has caused only slight environmental impact. However, there are some developing problems arising from the increased occurrence of ‘red tides’, diseases in pilchards and diseases spreading from aquaculture farms in the Philippines. Tilapia culturing is being conducted in approximately 10% of the lakes in the Philippines, although there has been a marked decline in aquaculture production in some lakes.

Impact on biological and genetic diversity
The present environmental impact on biological and genetic diversity is also severe because there have been extinctions of native species and local stocks as a result of introductions of Tilapia and African catfish and a clear decrease in heterozygosity in cultured fish stocks. The introduced fishes are eating and displacing endemic fishes in Lake Buhi and other areas, with corresponding changes in community structure and diversity.

Socio-economic impacts
Socio-economic impacts related to unsustainable exploitation of fish are already severe, particularly in the smaller islands and internal waters. In the Philippines, the fishing sector has the highest birth rate and population increase (more than 4%) and highest levels of poverty. In many areas, children within fisher families are malnourished as most fish are exported and fish consumption has declined from approximately 36 to 24 kg per person/year, with concomitant decline in local rice production in recent times. There are few alternative options, particularly on the small islands, and the levels of poverty are such that many children are ‘trapped’ into becoming fishermen. There is currently
decreased catch per unit effort with most fishers having to spend longer hours to obtain the same catch (Cesar et al. 2000).

Commercial fishing boomed between 1970 and 1980 in the Philippines, with about 400 fishing units in Calamianes, which declined rapidly to only 10 units (Ingles 2000) due primarily to decreasing low returns from fishing. In the artisanal sector, the demand for seafood has led to an increase in small-scale commercial fisheries. In the Calamianes Islands, the growth in the number of fishers is much higher than that of the agricultural or other sectors (Ingles 2000). In Manila Bay (in GIWA region 57 Indonesian Seas), there are 246 fishers per km of coastline (Armada 1994). The socio-economic costs of destructive blast and poison fishing in Indonesia have been documented by WRI (2003) which estimates the cost to Indonesia from cyanide use at 46 million USD annually. By comparison it is estimated that the annual economic benefit to Indonesia from its reefs are 1.6 billion USD.

There are important gaps in socio-economic data, particularly in relation to commercial connections among population centres and peripheries in terms of resource extraction, traditional village engagement with the marine environment and the extent to which police and military are involved in resource extraction, both legally and illegally (Kahn & Fauzi 2001). Severe socio-economic impacts are also posed by foreign fleets that continue to threaten the region, both within and outside MPAs. For example, local fisherman in Bunaken National Park increasingly report conflicts with foreign tuna fisherman, and are now actively vandalising foreign fishing gears when they encounter them (such as long line radio buoys, fish aggregating devices etc.). The Bunaken fisherman face a double socio-economic impact, with Filipino boats actively poaching the waters just northwest of the park, while Taiwanese, Korean and Hong Kong boats (with official licenses) work the seas to the north and east of the park. The latter have greatly increased in number since the spread of violence in Ambon, when a number of foreign fleets...
relocated from Maluku to Bitung as their home port. Unfortunately, as these bigger and more technologically advanced foreign fleets decimate North Sulawesi’s stocks, the Bunaken fishermen must travel further and further to catch fish (often 3-5 hours travel outwards by wooden speedboat from the island), and now increasingly resort to spear fishing and gillnetting on Bunaken’s heavily touristed reefs in order to catch fish to feed their families. Tourism and fishing, once compatible, are now increasingly at odds due largely to the activities of foreign fishing fleets.

Thus the key socio-economic impacts of unsustainable exploitation of living resources in the region include:

- Reduced subsistence food supply through reduced CPUE to small-scale local village fishermen throughout the Philippines and Indonesia;
- Reduced economic returns to small-scale local village fishermen throughout the Philippines and Indonesia;
- Loss of employment/livelihood among local village fishermen throughout the Philippines and Indonesia;
- Conflict between user groups for shared resources (e.g. among local village subsistence fishermen in Philippines and outsiders, notably foreign vessels and those involved in the live reef fish export trade);
- Loss of food sources (e.g. sources of protein) for human and animal consumption, throughout many parts of the Philippines;
- Reduced earnings in one area by destruction of juveniles and brood stock in other areas (migrating populations and/or life history stages);
- Loss of protected species (e.g. widespread local extinction of dugong from much of their traditional feeding grounds in Philippines);
- Increased risks of disease in commercially valuable stocks, including introduced diseases through increases in aquaculture;
- Inter-generational equity issues (access to resources) among poor local fisher families;
- Potential for human health impacts.

**Conclusions and future outlook**

For the GIWA concern of Unsustainable exploitation of fish as a whole, the present level of environmental impact is severe. Because of the increasing coastal population, greater commercialisation, decline in resources, lack of effective regulation and poor or non-existent enforcement, there is expected to be significant deterioration in all five issues by 2020, and environmental impact is expected to remain severe. Most coastal coral reef areas of the Philippines, particularly those fringing the northern Sulu Sea and those separating the Sulu and Celebes Seas, are at high level of threat from overfishing (Figure 8). Evidence over the past several decades from the region and elsewhere has changed the once widespread belief that reef and other fisheries were virtually inexhaustible. As Jackson et al. (2001) point out: “Overfishing is not a recent phenomenon. Ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change. Historical abundances of large consumer species were fantastically large in comparison with recent observations. Paleoeological, archaeological, and historical data show that time lags of decades to centuries occurred between the onset of overfishing and consequent changes in ecological communities, because unfished species of similar trophic level assumed the ecological roles of overfished species until they too were overfished or died of epidemic diseases related to overcrowding”.

Many of the fringing coral reefs have been chronically overfished over the past several centuries, with major loss of production and serious adverse ‘cascading’ effects to other components of the ecosystems (Ormond et al. 1990, Hughes 1994, Jackson 1997, Carlton 1998, Jackson et al. 2001). In addition to the reduction in population sizes (e.g. major declines in Bluefin and Yellowfin tuna populations) and local extinctions, overfishing has led to:

- Decreased Catch per Unit Effort (CPUE);
- Smaller size fishes and reduced catch sold at markets;
- High by-catch of rare and endangered species;
- Decrease in commercially exploited seashells (e.g. spider shells);
- Degraded habitats through use of destructive fishing methods.

As noted above, about 70% of Philippine reefs are heavily overfished, producing less than 5 tonnes/km²/year, with clear indications of trophic overfishing, in comparison with the remaining 30% of reefs which produce of the order of 15-20 tonnes/km²/year (Licuanan & Gomez 2000). Some 64% of coral reefs are at medium or higher risk from overfishing, with 20% at high risk. Similarly, high levels of threat exist for destructive fishing, particularly around Palawan, other Philippine islands and northeast Sabah (Burke et al. 2002).

Data from reefs of the Philippines indicate that carnivorous families of reef fish will not fully recover their pre-fished levels of biomass for 20-40 years after effective protection has been implemented, when 20-25 kg of catch may be taken from 1 000 m² of reef area annually (equivalent to 20-25 tonnes per km²) (Alcala pers. comm.). It is estimated that a 50% reduction in fishing effort will be needed to restore many fisheries to sustainable levels, particularly in the municipal coastal fisheries which, at present, are 90% artisanal and 10% commercial
It is also predicted that there will be a 10-30% deficit in wild-caught fish production by 2010, to be supplemented by aquaculture.

All socio-economic indicators are also expected to deteriorate by 2020, with severe environmental, economic, social and community impacts associated with overexploitation of fish. This prediction may be ameliorated to some degree by improved enforcement of regulations (e.g. Philippines Fisheries Code) and through successful interventions by government and NGOs (see Policy options and Annexes III, IV). There is also strong potential for well-planned mariculture of some ornamental and food species, with the need for development of appropriate policy and legislation.

The management of fish stocks in the Indonesian parts of the region is overseen by the Directorate General of Fisheries under the Ministry of Fisheries and Marine Affairs (Kahn & Fauzi 2001) (see Annexes III-V), and is in accordance with national policies and objectives:
- To raise income and standard of living of small-scale fishermen and fish farmers;
- To increase productivity of fishing effort and to boost national fish production;
- To increase fish consumption;
- To increase export of fisheries products;
- To have better control of the utilisation and management of fishery resources.

In North Sulawesi, cooperation and coordination for managing marine resources were established through a dialogue forum, primarily to avoid conflict among user groups (Kahn & Fauzi 2001). In order to address overfishing and biologically critical areas, management is directed towards limiting entry and to development of non-marine activities (e.g. mariculture and brackish water ponds). Some regulations have been implemented including:
- Selective fishing gears;
- Establishment of fishing zones;
- Extension services for the utilisation of mangrove forest;
- Enforcement of regulations controlling illegal fishing;
- Establishment of no-take zones in MPAs (e.g. Bunaken National Park).

Despite these management measures, the region’s fisheries stocks remain in urgent need of careful stewardship if their sustainable future utilisation is to be assured. This will primarily require a high degree of local intervention and community-based support, effective enforcement of fisheries regulations, and also reliable stock assessment and monitoring. These need to be founded in an improved understanding of the population biology of the target species and issues of ecological scale and connectivity in relation to replenishment. In particular, there is a lack of reliable data on:
- Catch volumes and CPUE;
- Traditional knowledge (e.g. locations of spawning aggregation sites of major commercial species), for development of protection measures;
- Natural changes in diversity, distribution and abundance of major commercial species, in relation to seasonality effects, predator-prey relationships and recruitment fluctuations (Kahn & Fauzi 2001).

Global change

At present, annual rainfall is greater than 1 000 mm in most parts of the region and annual minimum temperatures are less than 20°C other than in the highlands. Rainfall is highest on the upland areas, notably of central and northern Borneo, central Palawan, and central and eastern Mindanao, with more than 3 000 mm of rain annually. Some parts of the lowlands, coastal areas and other areas in rain shadows (less than 1 000 mm per year) may experience severe water shortages. The northern and central parts of the region are affected by revolving tropical storms (typhoons), bringing intense rains and destructive winds and swells to coastal areas. Passing from the Pacific into the South China Sea through the Philippines Archipelago, typhoons can deliver in excess of 1 000 mm of rain in less than one week, causing extensive flooding and loss of life in worst affected areas.

The region receives an influx of surface oceanic water from the North Equatorial Current, flowing into the area from the northeast through corridors in the Visayas and northern Mindanao, with sub-surface flow in the opposite direction. Additionally, waters from the South China Sea may flow seasonally into the Sulu Sea around the northern coast of Sabah, transporting sediment-laden waters from northwestern Sabah (Bate 1999). Surface waters of Sulu-Celebes (Sulawesi) Sea flow south out of the region through the Makassar Strait and also between Sulawesi and Morotai-Halmahera, contributing to the Indonesian through-flow.

The GiWA Task team identified the need to include an additional issue with major implications for coral reefs in the region: Changes in sea surface temperature. Criteria used for scoring this issue are appended in Annex VI. At the time of the assessment in 2001, there were no known environmental impacts associated with increased UV-B radiation and changes in ocean CO2 source/sink function in the region.
Environmental impacts

Changes in hydrological cycle and ocean circulation

Changes in hydrological cycle and ocean circulation has had slight environmental impact, as expressed through changes in the local/regional water balance in recent decades, and increased variability of current regimes (including those caused by changes in ENSO events). There is oceanographic evidence for changes in internal waves in the Sulu Sea.

Sea level change

Sea level change has also had slight environmental impact, with limited evidence of recent and unprecedented flooding of Turtle Island and Tubbataha World Heritage Park.

Changes in sea surface temperature

Considering the abundance and importance of coral reefs to the region, an additional issue: Changes in sea surface temperature (also see Annex VII), was added to the assessment because of the major implications this factor has for these ecosystems.

Changes in sea surface temperature has had slight impact already, with changes in the structure of coral reef communities from elevated Sea Surface Temperatures (SSTs) during various coral reef bleaching events since 1983, notably during mid-1998 around Santa Cruz Island, Mindanao and Balayan Bay in the Philippines. Sea surface temperatures between May and August 1998 were up to 2°C above average (29-30°C) in areas of the Sulu-Celebes Sea and adjacent South China Sea (Figure 16), causing extensive bleaching in worst affected reefs. In Tubbataha National Park, mean live coral cover decreased by approx. 96% after bleaching in 1998, and has remained stable through 1999 to 2001 (Chou et al. 2002). There was good recovery of most other bleached areas and, on average, the bleaching events appear to have been less severe than those from some other countries (Wilkinson 2002), with the caveat that some of the data are anecdotal.

Socio-economic impacts

The socio-economic impacts associated with Global change are slight at present, although there have already been some economic and health effects. These have been caused by freshwater shortage and flooding, the former clearly linked with the ENSO. For example, major floods in Malaysia occurred in 1967, 1971, 1973 and 1983. Some 29 000 km² are considered as flood-prone areas, affecting about 2.7 million people. The average annual economic damage caused by floods was estimated at 40 million USD in 1980 (FAO AQUASTAT 2003). Other socio-economic problems include overextraction of freshwaters and salinisation of wells; and with linkages to habitat loss (clearing and forest fires). These key socio-economic indicators are adversely affected to greater or lesser degree, particularly into the future:

- Freshwater availability which is a food security issue, with some 20 million Filipinos having little or no access to secure potable water supply;
- Increased costs of human health care, particularly related to lack of water;
- Changes in productivity of agriculture, fisheries and forestry, particularly in relation to loss of terrestrial habitats through continued clearing and drought-induced forest fires, and coastal and marine habitats through land reclamation and destructive fishing;
- Changes in resources distribution and political jurisdiction;
- Response costs for extreme events, with potential increase in frequency and intensity of typhoons and droughts in different parts of the region (Figure 17);
- Loss of income and employment related to all of the above;
- Loss of income and foreign exchange from fisheries, as destructive and overfishing deplete resources (e.g. some 70% of Philippines coral reefs are already overfished) (see Unsustainable exploitation of fish and other living resources);
- Loss of opportunity for investments (both domestic and foreign).
Conclusions and future outlook

The GIWA concern of Global change has had only slight overall environmental impact at present. There is increasing per capita release of carbon dioxide and the increasing populations in both the Philippines and Indonesia will exacerbate local production of greenhouse gases over the next 20 years. However, there is considerable uncertainty in climate model predictions of changes in temperature and sea level. Additional uncertainty is caused by the region’s complex geological dynamics, and also by the capacity for an unknown degree of acclimation and adaptation of species and ecosystems (e.g. see Done 1999 for coral reefs, and also Pilcher & Cabanban 2000). The climate change effects are and will be obscured by the continued effects of habitat destruction and overfishing. Given these uncertainties, environmental impacts of global change are expected to remain slight until 2020. There are, however, likely to be global change effects on freshwater shortage and oceanography (through predicted changes in frequency and intensity of ENSO), and on coral reef ecosystems through predicted changes in ocean chemistry (CO₂ source-sink function) and SST. Corresponding socio-economic aspects are expected to deteriorate over the next 20 years, with moderate levels of economic impact and slight health and other social and community impacts by 2020. The socio-economic impacts are likely to be similar those listed above.

Priority concerns

Future scenarios for the region suggest a human population increase of between 2-3% per year to approximately 50 million by 2020, with increasing urbanisation and increasing reliance on extractive industries. International trade is expected to triple by 2020 (Chua pers. comm.), with major expansion of international shipping through the ULCC route. There are likely to be significant increases in both artisanal and industrial fishing, mining and various forms of plantation agriculture and forestry, and limits on other sectors from freshwater shortage and other concerns.

There are trends of increasingly large-scale forestry, by both national and international commercial operators, increasing industrial fisheries and commercial agriculture. Large areas of the ‘loggable (harvestable) forests’ have already been logged and other areas have been assigned for logging, contributing to severe soil erosion. Large-scale sediment mobilisation from unregulated forestry and agriculture has already impacted on water quality of streams and rivers and ultimately on estuarine and coastal habitats (e.g. fringing reefs) and processes in much of the region. In the Philippines, of the order of 1 billion m³ of sediment is lost to coastal waters annually, carrying high loads of particle-bound nutrients (e.g. see Burke et al. 2002). This is of particular...
concern given that the timber industry has traditionally suffered from mismanagement and corruption, although there have been some recent improvements. Nonetheless, implementation of 'best-practice' forestry management, such as the retention of buffer zones along watercourses, is rarely enforced and violations are common. One exception is Palawan (Philippines), where logging was halted through effective implementation of legislation in the early 1990s (Annex V), providing a major reduction in sediment loss from the catchments and much needed protection for the fringing coral reefs and other coastal and marine habitats (Hodgson & Dixon 1992).

There is already significant offshore oil and mineral exploration, with potential for substantial expansion in coming decades. Exploitation of commercial pelagic fisheries for tuna and billfish is expected to increase by 2020. The industrial fishing fleets are expected to expand across the various ownership types, including private companies, joint corporations and state-owned enterprises, with currently more than 1 000 large foreign vessels operating in the Indonesian EEZ (Kahn & Fauzi 2001). There are also plans to expand aquaculture and mariculture operations substantially. In Indonesia, up to 1 million ha of land, mostly mangrove forests, were allocated by the government for the shrimp hatchery industry in the 1980s to 1990s. The World Bank was one of the major donors to the programme. By 2001, more than 70% of the shrimp farms had been abandoned, because the operators found them unsustainable due to the high concentrations of chemicals and the destruction of the mangrove habitat. Future protection of the remaining coastal habitats and adjacent coral reef areas will be important if these key habitats at the global centre of biodiversity are to be sustained.

Total pressures on international water resources are likely to increase moderately, causing significant deterioration in both the environment and socio-economic structures, despite improved regulation. The worst affected coastal areas in the Philippines face moderate to severe environmental impacts causing severe socio-economic hardship by 2020. There is a lack of capacity for effective policing or enforcement of regulations or for developing measures for alleviation of existing water-related problems, primarily because of low finance and a relatively small taxation base. For example, the Sulu-Celebes (Sulawesi) Sea is a tempting target for illegal fishing activities, including commercial fishers from throughout Southeast Asia and foreign fleets, many of which do not carry legal permits. Unfortunately, accurate data on the extent, number of vessels and their mode of operations are rare, although it is thought that such illegal activities have significant environmental and socio-economic impacts (Kahn & Fauzi 2001).

There are already serious health issues arising from episodic freshwater shortage in the Philippines. The rate of deterioration can be minimised by on-going and future planned interventions, including those at multi-lateral, national, provincial and local government levels and through the concerted efforts of several international NGOs. Nonetheless, continuing international assistance will be required in the short-term for major improvement in water-related issues and concerns.

There was an unambiguous overall prioritisation of the five GiWA concerns, when assigning equal weight to environmental, economic, human health and social and community impacts. The GiWA concerns are prioritised as follows:

1. Unsustainable exploitation of fish and other living resources
2. Habitat and community modification
3. Pollution
4. Freshwater shortage
5. Global change

Unsustainable exploitation of fish and other living resources has the highest priority, with severe present levels of environmental, economic, health and other social and community concerns. Habitat loss and community modification is an equal priority from an environmental, economic and other social and community impacts perspective, but of slightly less priority in terms of health impacts. Pollution is the third priority, with moderate levels of environmental and socio-economic impact. Freshwater shortage is the fourth priority, with moderate levels of environmental and economic impact, but only slight health and other social and community impacts at present. Global change is the fifth priority, with only slight present environmental and socio-economic impacts.

It is clear that the international waters environment and socio-economy of much of the region is already under severe impact, requiring continued concerted international intervention for any chance of amelioration in the short to medium-term. There is expected to be moderate to severe deterioration in most concerns, with consequent difficulties in prioritising those of most importance. With equal weighting applied to the four indicators, Unsustainable exploitation of fish and other living resources, Habitat loss and community modification and Pollution all scored the maximum value, and are all expected to have severe environmental and socio-economic impacts by 2020. Freshwater shortage is expected to have moderate environmental and socio-economic impact and Global change slight to moderate impact.
Habitat loss and community modification received highest priority ranking for the future, followed closely by Unsustainable exploitation of fish and other living resources and then Pollution. Freshwater shortage, the fourth priority, is expected to be under moderate environmental threat by 2020, with the possibility of an improving economic situation but deteriorating health and other social and community concerns. This concern is already being addressed at international and national levels (e.g. PhilWater Conference 2001), which may contribute to its amelioration by 2020.

Future impacts from Global change were sufficiently uncertain for it to be ranked as the least of the GiWA concerns for 2020, although potentially strong linkages with Freshwater shortage and Habitat loss and community modification were identified, complicating the prioritisation analysis. Global change effects on Freshwater shortage are likely to be manifested through changes in the frequency and intensity of ENSO events, typhoons and droughts. ENSO caused water shortages in some parts of the region and flooding in others during the 1990s, and future predicted increases in ENSO are likely to have major environmental and socio-economic impact, particularly given that the human population is expected to double by 2035. Global change effects on habitats are predicted to be manifested through both freshwater shortages and flooding, particularly in lowland stream, river, marshland and riparian communities. Potentially severe global change effects are also expected for coral reef habitats, through the synergistic effects of changes in ocean alkalinity affecting reef calcification processes (Kleypas et al. 1999), and through elevated SSTs causing widespread reef bleaching and death (Hoegh-Guldberg 1999). There are also expected to be severe consequences from complex linkages between habitat loss and fisheries, and pollution and fisheries. The fishing industry also interacts directly with other resource industries, including forestry, farming, mining and tourism, and these industries may also threaten the productivity of fishing grounds (Kahn & Fauzi 2001).