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The Global International Waters Assessment *i*

The GIWA methodology *vii*

Executive summary

This GIWA report presents the results of Scaling, Scoping, Causal chain and Policy options analyses conducted for the GIWA region 54 South China Sea region in 2001-2002. The South China Sea region contains nine nations; China, Vietnam, Cambodia, Thailand, Malaysia, Singapore, Indonesia, Brunei and the Philippines. This Large Marine Ecosystem and its catchments are bounded to the west by the Mekong River (GIWA region 55), north by East China Sea (GIWA region 36), east by the Sulu-Celebes (Sulawesi) Sea (GIWA region 56) and Small Island States (GIWA region 62), and south and southeast by Indonesian Seas (GIWA region 57). The assessment determined that the most severe environmental issues facing the South China Sea include:

- Suspended solids resulting from deforestation and agriculture in hundreds of watersheds;
- Habitat loss and modification, through massive deforestation and associated siltation, conversion to agriculture and other land uses (freshwater, coastal and estuarine habitats) and destructive fishing practices (coastal, estuarine and marine habitats);
- Overexploitation and destructive fishing practices.

Priority environmental and socio-economic concerns are Unsustainable exploitation of fish and Habitat loss and modification. Pollution and Freshwater shortage are of secondary environmental and socio-economic concern, with Global change presently of tertiary importance.

The present human population of the region is approximately 350 million, and future scenarios suggest an overall human population increase of approximately 2% per year. There is expected to be increasing urbanisation and reliance on extractive industries (mining, plantation agriculture, forestry and industrial fishing), although there will be considerable variation in sectoral changes among the nations. There is already widespread overexploitation and use of inappropriate technologies, raising serious concerns as to even the medium-term sustainability of the production systems.

At the time of the assessment, many of the relevant laws and regulations were not well accepted and there was little effective implementation. This was compounded by insufficient capacity for effective alleviation, which was, in part, related to currency depreciation, shifts in government spending and difficulties in establishing strong multilateral support for large-scale interventions.

Total pressures are likely to increase moderately to 2020, being driven by the continued population growth. This is expected to cause significant deterioration in environmental and most socio-economic aspects of international waters in the South China Sea region. The rate of deterioration will be contingent upon the success of improved regulation and ongoing and future planned interventions. Priority concerns for the future are the same as those for the present, Unsustainable exploitation of fish and Habitat and community modification.

The Causal chain and Policy options analyses focused on the linkages between habitat loss and unsustainable exploitation, particularly the environmental and socio-economic impacts, causes and policy options of overfishing and destructive fishing practices. Environmental and socio-economic impacts are as follows:

- Loss and fragmentation of mangrove forests from development, including massive conversion for aquaculture;
- Loss and fragmentation of coral reefs from coastal development, sedimentation and destructive fishing;
- Loss and fragmentation of seagrass areas;
- Reclamation of wetlands for urbanisation, industry and agriculture;
- Conflicts among villagers and outside fishers;
- Injuries to fishers;
- Changes to market prices.

The following immediate causes are identified in the analysis:

- Urbanisation and industrial development;
- Expansion of mining activities with coastal run-off;
- Deforestation of old growth forests for settlement and agriculture;
- Expansion of fisheries, including the use of destructive methods, and development of aquaculture.

The identified root causes behind habitat modification and overfishing in the South China Sea are:

- Economic:
  - Economic growth;
  - Overcapitalisation;
  - Foreign aid;
  - Market demand;
  - Export pressures for forest products - building materials;
  - Export pressures for fisheries products, aquarium trade and alien species.
- Political:
  - Military influence.
- Demographic:
  - Overpopulation, particularly among poor coastal communities;
  - Urban migration;
  - Poverty and limited access to alternative livelihoods.
- Knowledge:
  - Perpetuation of environmentally damaging traditional practices;
  - Lack of awareness of environmental change.
- Governance:
  - Lack of political will;
  - Poor governance;
  - Inadequate regulation;
  - Multilateral/inter-sectoral disputes.

The policy option analysis was greatly complicated by the complex interaction of national and regional jurisdictions and the different socio-cultural and religious beliefs, including widely differing views on family planning. There are also many transboundary issues that remain unresolved due to the aftermath of regional conflicts, colonial heritage and international political affiliations. In this regard, the implementation of improved policy can only succeed with the following support structure in place:

- Consolidation of national laws and multilateral agreements to encompass all sectors;
- Improved coordination in management across sectors and levels of governance (local/provincial/national/multilateral);
- Ongoing and expanded community education programmes;
- Improved options for the generation of alternative income/ecologically sustainable livelihoods for the burgeoning poor coastal populations, particularly among the fisheries sector;
- National and international surveillance strategies, with participation from all levels of government, IGOs, NGOs, and local communities;
- Much-improved enforcement supported by stronger legal penalties;
- Improved transparency in governance and policing, with stronger anti-corruption legislation and enforcement.

This framework is crucial in bridging the gaps between policy formulation, development of legislation and enforcement of regulations. Five recommendations and eleven strategic actions relevant to implementing immediate interventions are proposed.

Policy recommendations include the development or expansion of:

- Bio-physical (biodiversity) and socio-economic research focused on improving management effectiveness and efficiency;
- Functional, integrated networks of marine protected areas founded on the above research and with strong co-management focus;
- Sustainable livelihoods;
- Information, education and communication networks;
- Institution and capacity-building, including establishment of inter-governmental mechanisms.

Key strategic actions include:

- Prioritisation of key data and information required for developing and refining policy, legislation and interventions;
- Building or expansion of partnerships at local, provincial, national and multilateral levels, in governments, IGOs, NGOs, and the private sector, in research and development and implementation;
- Ensuring equitability and ecological and economic sustainability in future resource exploitation, including protection of intellectual property and traditional knowledge;
- Gathering responsible fisheries authorities together with expertise from national and international academic and research institutions to adequately assess the state of fisheries in territorial waters;
- Developing regional agreements on providing MPAs within territorial waters to help ease the pressure on sites that are heavily overfished;
- Developing national coastal management plans to underpin these regional MPA agreements (even if MPAs will remain elusive for contested areas);

- Promoting a united call to establish a regional database and monitoring that allows for periodic assessments of key coastal ecosystems;
- Banning further conversion of wetlands, estuaries and mangroves into man-made facilities;
- Establishing protocols to assist national environment ministries to determine carrying capacities of estuaries for extensive and intensive aquaculture facilities (e.g. through SEAFDEC);
- Providing concrete mechanisms to engage IRRI and FAO to provide organic farming protocols for adoption by small-scale farmers and multi-national food companies to address impacts caused by nutrient loading from agriculture;
- Identifying low-cost sanitation technologies, to address domestic sewage inputs, that can be maintained and established in both rural and urban settings (e.g. through the Water Group of the World and Asian Development Banks).

Initial steps towards implementing some of these policy recommendations and strategic actions are already under way, with a World Bank/GEF International Waters project currently being implemented in the region. A 'critical mass' of expertise and a framework for change are developing, involving science, policy, private sector and government, but there is a need to better integrate water-related sectors in policy planning and legislation. In particular, the key linkages among food security, poverty, natural resources, environment pressures, market forces and governance need to be addressed.

Development and population policies in some countries require urgent review if growth over the next several decades is to be managed effectively and the present rapid rate of increase of impacts is to be curbed. There is misallocation of significant amounts of local and international funds, and better allocation and use of government funds and continuing international assistance are urgently required to redress these spiraling impacts. The rapidly changing global situation will cause changes in funding priorities, requiring more efficient allocation of funds to work towards improving future scenarios. Given that the region, with its neighbours Sulu-Celebes (Sulawesi) Sea and Indonesian Seas, lies at the global centre of biodiversity, these findings are of critical international significance.

Abbreviations and acronyms

ADB	Asian Development Bank
ANWRA	ASEAN Network of Water Resources Agencies
ASCMS	ASEAN Subcommittee on Marine Science
ASEAN	Association of Southeast Asian Nations
ASOEN	ASEAN Senior Officials on Environment
BRS	Bureau of Research and Standards
BSWM	Bureau of Soils and Water Management
BOD	Biochemical Oxygen Demand
CBD	Conservation on Biological Diversity
CCA	Causal Chain Analysis
CITES	Convention on International Trade in Endangered Species
COBSEA	Coordinating Body on the Seas of East Asia
COMAR	Project on Research and Training on Integrated Management of Coastal Systems
COMEMIS	Coastal Marine Environment Management Information System
CPUE	Catch Per Unit Effort
DGWRD	Directorate General of Water Resources Development
DID	Department of Irrigation and Drainage
DOE	Department of Environment
DPWH	Department of Public Works and Highways
EEZ	Exclusive Economic Zone
EGAT	Electricity Generating Authority of Thailand
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FMB	Forest Management Bureau
GEF	Global Environment Facility
GCRMN	Global Coral Reef Monitoring Network
ICLARM	International Centre for Living Aquatic Resources Management
IUCN	World Conservation Union
IUU	Illegal, Unreported and Unregulated
LME	Large Marine Ecosystem
LWUA	Local Water Utilities Administration
MARD	Ministry of Agriculture and Rural Development
MARPOL	International Convention on Prevention of Marine Pollution
MOH	Ministry of Health
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
MWR	Ministry of Water Resources
NWRB	National Water Resources Board
MWSS	Metropolitan Waterworks and Sewerage System
NEA	National Electrification Administration
NIS	National Irrigation System
NPC	National Power Corporation
NIA	National Irrigation Administration
NWRC	National Water Resources Committee
OECD	Organisation for Economic Co-operation and Development
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PMO	Project Management Office
PWD	Public Works Department
RID	Royal Irrigation Department
SEAPOL	Southeast Asian Programme in Ocean Law, Policy and Management
Sida	Swedish International Development Cooperation
SPAE	ASEAN Strategic Plan of Action on the Environment
SST	Sea Surface Temperature
SWIM	Small Water Impounding Management
ROAP	Regional Office for Asia and the Pacific
TDA	Transboundary Diagnostic Analysis
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

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Regional definition

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

Boundaries of the region

The GIWA region 54 South China Sea is bounded on its eastern extent by the Sulu-Sulawesi Sea (GIWA region 56) and Pacific Islands (GIWA region 62), southern and southeastern extent by the Indonesian Seas (GIWA region 57), northern extent by East China Sea (GIWA region 36) and part of its western extent by the Mekong River (GIWA region 55). The region is formed of the marine, coastal and hinterland river catchments of nine nations: China, Vietnam, Cambodia, Thailand, Malaysia, Singapore, Indonesia, Brunei and the Philippines. Laos and Myanmar are also part of the region but have no impacts on the water balance and are therefore not further discussed. Figure 1 shows the boundaries of the region.

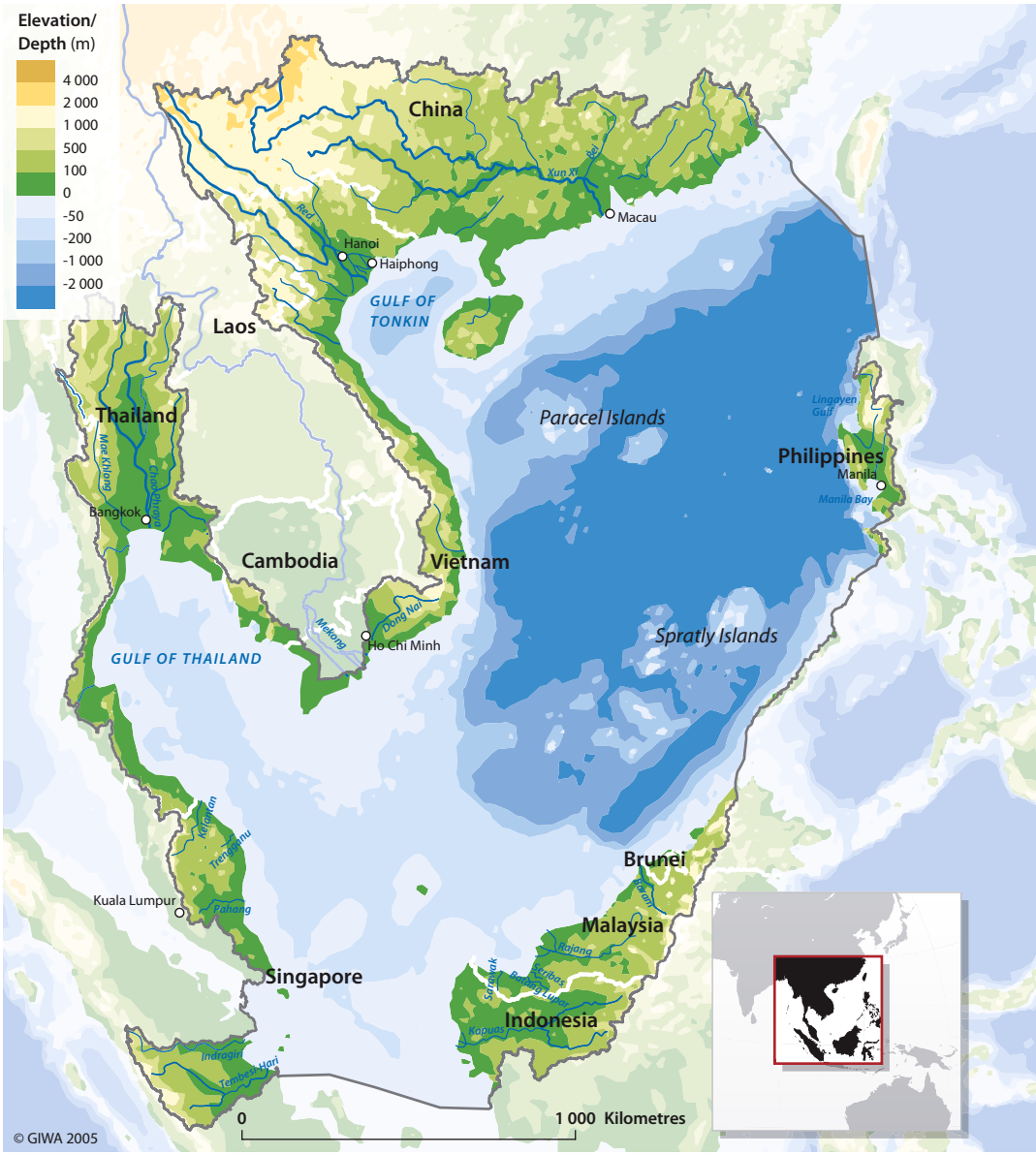

Figure 1 Boundaries of the South China Sea region.

A review of the regional boundaries indicated that a minor revision of the original boundaries was required. The original GIWA boundaries were generally compatible with oceanographic conditions, and also with catchment and river drainage in the region. A slight modification of the land boundary on Borneo was required to include the catchment of the Baram River, while Taiwan is included in the adjacent East China Sea region. The modified boundaries match reasonably with those adopted by UNEP's Transboundary Diagnostic Analysis (TDA) (Talaue-McManus 2000), with the exclusion from the present analysis of the Indonesian Island of Java and part of South Kalimantan (both of which have been included in the GIWA region 57 Indonesian Seas). Within the South China Sea Large Marine Ecosystem (LME), species genetic diversity and oceanographic considerations suggest three ecoregions:

- The northern area (Chinese catchments and coastal waters to the north of Vietnam);
- The southwestern area (Vietnam, Cambodia, Thailand, Malaysia, Singapore, Sumatra catchments and coastal waters);
- The southeastern area (Borneo, Western Philippines and Spratly Islands).

The delineation of precise boundaries of the ecoregions vary within the region, in relation to the specific life histories and dispersal patterns of different groups of organisms, and in this assessment, the region has been considered as a single international waters system.

Physical characteristics

Most of the region, extending east to the island of Borneo, lies on the Asian continental shelf and is physically stable. The coastal area includes low-lying areas composed of sandy beaches and dune systems, mud flats, swamps and marshes, seagrass beds and mangroves and lake systems, to gravel/rocky coasts. Fringing coral reefs are developed in areas away from major rivers or areas of terrestrial run-off. Inland from the coast, large coastal plains have developed, particularly around the major river systems, with the hinterland being predominantly mountainous. Much of the land area was originally covered by tropical forest, however, substantial deforestation has taken place during recent centuries and continuing logging is further reducing the original forest cover. Fertile lowlands and hill areas have been extensively developed for rice production, as paddy fields and upland terraces. Lowland areas and river flood-plains also support mixed agriculture.

Climate

Most of the region lies within the tropical and equatorial zones (from near the Equator to ~22° N). In much of the region there are two seasons, the dry season and the wet season, as the climate is governed by the regime of the northeast and southwest monsoons. The northeast monsoon blows from October to March in much of the region, and is responsible for the heavy rains that frequently cause widespread floods (e.g. in Borneo). The southwest monsoon occurs between May and September, and is a drier period. The period between these two monsoons is often marked by heavy rainfall. The temperature usually ranges from 21° to 33°C, but at higher altitudes the climate is cooler. The average temperature throughout the year in many areas is very stable (26°C). Annual minimum temperatures are usually greater than 10°C other than in the highlands and inland areas of Vietnam and China, where cooler winter temperatures can prevail.

Rainfall in the region is highest on the upland and some coastal areas. These areas receive more than 3 000 mm of rain annually. Some parts of the lowlands, coastal areas and other areas in rain-shadows receive far less rain (<1 000 mm/year), and may experience severe water shortages. However, annual rainfall is usually in excess of 1 000 mm in most areas. Regional variations in temperature and rainfall are mainly due to relief. Humidity is usually between 60 and 80%, due to the high evaporation rate (FAO AQUASTAT 2003).

The northern and central parts of the region are affected by tropical storms (typhoons) during the southwest monsoon months, bringing intense rains and destructive winds 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 is particularly sensitive to ENSO (El Niño Southern Oscillation) fluctuations, notably the major events of the 1990s, which caused significant changes in rainfall patterns (e.g. in Indonesia and Malaysia), and also contributed to major forest fires, which, in turn, had regional climate and environmental effects (e.g. smoke haze and associated air pollution in Indonesia, Singapore and Malaysia).

Rivers of the region

There are approximately 125 major rivers in the South China Sea region, draining 2.5 million km^2. The major basins include:

- Kampar, Indragiri and Tembesi-Hari rivers (Sumatra);
- Pahang, Trengganu and Kelantan rivers (Peninsular Malaysia);
- Batang Lupar, Sarawak and Seribas rivers (South Sarawak);
- Kapuas River (West Kalimantan);
- Rajang and Baram rivers (Sarawak);

- Mae Klong and Chao Phraya rivers (Thailand);
- Mekong, Red and Dong Nai rivers (Vietnam);
- Xun Xi and Bei rivers (Pearl River estuary - China).

There are numerous smaller rivers and streams flowing from the mountainous interior of parts of the region. The Mekong River also flows into the South China Sea, and in the context of GIWA, provides major transboundary considerations. However, this river basin is assessed separately in GIWA regional assessment 55, Mekong River.

Water resources

For more information on irrigation, drainage development and water withdrawal in the region, see Annex VIII.

China

Overall, the average annual river run-off generated in China is 2 711 km^3 of which 1 724.3 km^3 discharge into the sea and 719 km^3 flow into neighbouring countries (FAO AQUASTAT 2003). Although China has several transboundary rivers that flow into neighbouring countries, those that influence the South China Sea region are the Yuanjiang, Lixianjiang, Panlongjiang, which become the Red River when they reach Vietnam. The average annual groundwater resources for the whole of China are estimated at 829 km^3. In addition, China has about 2 300 lakes (excluding seasonal ones) with a total storage capacity of 710 km^3 and, at the end of 1995, China also had the capacity to store 480 km^3 of water in 84 800 artificial reservoirs. The majority of this water (~349 km^3) is stored within a few (~ 400) large reservoirs (FAO AQUASTAT 2003).

Vietnam

Vietnam has 16 river basins larger than 2 000 km^2, nine of which have a catchment area that exceeds 10 000 km^2 (Bang-Ky Cung, Red River/ Thai Binh, Ma, Ca, Thu Bon, Ba, Dong Nai and the Mekong Delta (part of GIWA region 55 Mekong River)). Other basins are either small in area (the Tien Yen and Muc) or have several small rivers grouped together such as the Giang/Huong, Tra Khuc and Cai-Luy. The nine major basins occupy 80% of Vietnam's area and 70% of its water resources (FAO AQUASTAT 2003). The largest basins in Vietnam are the Mekong and Red River/Thai Binh basins, covering half of the country's territory. Six major rivers cross international boundaries: Bang-Ky Cung and Red Rivers which are shared with China; Ma and Ca River which cross from Laos; and Dong Nai and Mekong Rivers which cross the Cambodian border.

Vietnam has abundant surface water resources in terms of total run-off. The Red and Mekong Rivers carry 75%, while each of the other basins carries 1-3% of the water resources (FAO AQUASTAT 2003). The mean annual run-off is approximately 880 km^3 per year, of which only about 40% originates from within the country. The remaining 60% of the total flow in Vietnam originates outside the country. For example, over 90% of the Mekong River Basin lies outside Vietnam. Half of the Red River Basin, about 40% of the Ma and Ca basins and 15% of the Dong Nai Basin area lie outside the country. The contribution of Cambodia (Mekong and Dong Nai rivers), China (Red River) and Laos (Ca and Ma rivers) to total run-off is estimated at 471.5 km^3/year, 44.1 km^3/year and 9.1 km^3/year respectively (FAO AQUASTAT 2003).

The distribution of water resources in Vietnam during the year is highly variable due to unevenly distributed monsoon rainfalls. High variations combined with limited storage and flood control infrastructure result in devastating floods in the wet season and extreme low flows in the dry season. About 70-75% of the annual run-off is generated in three to four months.

There are two natural lakes in Vietnam; Lake Ho-Tay with a surface area of 4.13 km^2 and a volume of 8 million m^3; and Lake Ba Be with a surface area of 4.5 km^2 and a volume of 90 million m^3 (FAO AQUASTAT 2003). There are approximately 3 500 small and 650 large and medium reservoirs in the country. These reservoirs are multipurpose; hydropower, flood control, navigation, irrigation and fisheries. Hydropower generates 70% of the electricity in Vietnam.

The groundwater recharge in Vietnam is estimated at 48 km^3/year (FAO AQUASTAT 2003). Over 50% of these resources are in the central part, about 40% in the north and 10% in the south. A large amount of water is stored in unconsolidated alluvial sand and gravel geological formations found in plains and valleys. A substantial part of these resources (estimated at 35 km^3/year) returns to the rivers as base flow. The exploitable reserves (the volumes of flows of satisfactory quality which can be extracted economically given the present technology) are estimated at about 6-7 km^3/year, and total renewable water resources are estimated at 891 km^3/year.

Thailand

Thailand has seven major river basins with a total surface water availability of 199 km^3/year. Aquifer recharge from rainfall is estimated at 42 km^3/year (about 5-6% of the total precipitation), of which approximately 73% is estimated to return to the river system. The total renewable water resources are estimated at approximately 410 km^3/year. The Mekong River, which forms the northern and eastern border with the Laos and was assessed separately as GIWA region 55, is Thailand's only transboundary river that influences the South China Sea significantly.

The total dam capacity in the country is estimated at 85 km^3, which is about 43% of the annual run-off. However, a lot of dams have been overdesigned compared with the annual recharge obtainable (FAO AQUASTAT 2003). There are four categories of dams in Thailand:

- Large dams with a hydropower component are built by the Electricity Generating Authority of Thailand (EGAT), the Royal Irrigation Department (RID) or the Department of Energy Development and Promotion and managed by the EGAT. Hydropower generation is important in Thailand as its 21 hydropower plants account for 18% of installed capacity and 5% of energy production. However, all these dams are multipurpose dams, and the irrigation component receives priority over the other components.
- Large dams with no hydropower component, and therefore mainly destined for irrigation, are operated by the RID. Their total capacity was estimated at 31.4 km^3 in 1995.
- Small dams, which cost about 200 000 USD, are developed by the Office of Accelerated Rural Development under the Ministry of Interior, mainly for irrigation, livestock and domestic purposes.
- Small dams of around 100 000 m^3 each, developed by the Land Development Department of the Ministry of Agriculture and Co-operatives. They cost about 120 000 USD each and are used for agricultural and domestic purposes. Their total capacity is estimated at 0.1 km^3. Each year, about 200 such dams are constructed or rehabilitated.

Philippines

In the Philippines, rivers are an important means of transportation and a valuable source of water for irrigation for the fields and farms through which they pass. The main river basins in the Philippines part of the region are the Cagayan River Basin in north Luzon (25 470 km^2), the Pampanga River Basin (9 760 km^2) near Manila in Luzon island, and the Agno River Basin (5 950 km^2) in Luzon Island. The country's annual average run-off is estimated at 444 km^3 and, in nine years out of ten, the annual run-off exceeds 257 km^3. The total internal water resources amount to 479 km^3/year (FAO AQUASTAT 2003).

The Philippines National Water Resources Council has divided the country into 12 water resources regions in order to have manageable units for comprehensive planning of water resources. Major considerations taken into account in this regionalisation were the hydrological boundaries defined by physiographic features and homogeneity in climate of the different parts of the country. However, in fact, these water resources regions generally correspond to the existing political regions in the country. Minor deviations dictated by hydrography have affected only northern Luzon and northern Mindanao.

The total dam capacity in 1995 was 4 753 million m^3, consisting of about 54 small dams (for a total capacity of 80 million m^3) and six large dams. The two largest dams, Magat and Pantabangan which have a total capacity of 3 196 million m^3, are managed by the National Irrigation Administration (NIA). The National Power Corporation (NPC) manages three other large dams, Angat, Ambuklao and Palangui IV which have a total capacity of 1 426 million m^3, while the Metropolitan Waterworks and Sewerage System manages the sixth large dam, La Mesa, which holds 51 million m^3. Most small dams in the Philippines have been created with various objectives within the framework of the small water impounding management (SWIM) projects, which are implemented by several agencies.

There are four major groundwater reservoirs in the country; Cagayan 10 000 km^2, Central Luzon 9 000 km^2, Agusan 8 500 km^2 and Cotobato 6 000 km^2. 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 NIA for irrigation purposes. The groundwater resources are estimated at 180 km^3/year, of which 80% (145 km^3/year) constitute the base flow of the river systems (FAO AQUASTAT 2003).

Malaysia

The Malaysian Peninsula is drained by a dense network of rivers and streams, the longest being the Pahang River which follows a course of 434 km before reaching the South China Sea, draining a catchment area of 29 000 km^2. Other major rivers that also drain into the South China Sea are the Kelantan, Terengganu, Dungun, Endau and Sedili rivers. Major river basins in the east of Malaysia tend to be larger than those on the Malaysian Peninsula. Malaysia's longest river is the Rajang River (563 km) in Sarawak. Major floods have occurred in 1967, 1971, 1973 and 1983 and some 29 000 km^2 of the country are considered flood-prone, affecting about 2.7 million people (FAO AQUASTAT 2003). In 1980, the average annual economic damage caused by floods was estimated at 40 million USD. Malaysia has two large dams located in the region. In 1995, the total hydropower generation in Malaysia was about 5 800 GWh, or 30% of all power production in Malaysia (FAO AQUASTAT 2003).

Indonesia

Indonesia has over 5 590 rivers, although the vast majority are in GIWA region 57 Indonesian Seas and are not considered within this assessment. Although water resources are abundant, the seasonal and spatial variation in the rainfall pattern and lack of adequate storage create competition and conflicts among users. The annual renewable water resources are estimated to be about 2 800 km^3

(FAO AQUASTAT 2003). Most of the lakes in Indonesia are of volcanic origin. Lake Toba is the largest volcanic lake in the world with an average surface area of 1 100 km^2 and an average volume of 1 260 km^3. In 1995, the large dam capacity was 15.8 km^3. In 1991, the total installed power capacity was 2 061 MW and hydropower accounted for 16.3% of the electricity generated. Indonesia's groundwater resources are estimated at 455 km^3/year, although about 90% returns as base flow to the rivers. Therefore, the groundwater potential in Indonesia is limited and can meet only part of the urban and rural needs for water supply, while providing irrigation water for very limited areas.

Cambodia

Cambodia has an unique hydrological system. The Mekong River and Lake Tonle Sap are connected by the Tonle Sap River which twice a year reverses its direction of flow. Approximately 85% of Cambodia's territory (156 000 km^2) is included in the Mekong River Basin, the remaining 15% draining directly towards the Gulf of Thailand. The internal renewable surface water resources are 116 km^3. The capacity of the existing dams is very low and has not been estimated. Only one small dam (Ochum, in the northeastern province of Ratanakiri) is used as a hydropower station with an installed capacity of 1 MW (FAO AQUASTAT 2003). The Kirirom power plant, which was installed in 1968 in Kompong Speu province with a capacity of 10 MW, has not been in operation since 1970 due to war damage. A number of dams with high storage capacity are planned for the near future. Groundwater resources are estimated at 17.6 km^3, of which about 74% is drained by rivers and thus cannot be considered as additional water resources. The quality of groundwater is generally satisfactory, although high iron concentrations and increased salinity levels have been encountered in some provinces such as Svay Rieng, Prey Veng and Takeo.

Brunei

There are four main river basins in Brunei; Temburong, Belait, Tutong and Brunei. The Temburong, the smallest of the rivers, drains a catchment area of about 430 km^2. The Belait River has the largest catchment, with an area of 2 700 km^2. The lower catchment comprises an extensive area of peat swamp forest. The river narrows at the town of Kuala Belait and a sandbar restricts the discharge of water to the South China Sea. Some areas in the upper catchment have been cleared for agriculture. The Tutong River Basin, which is about 1 300 km^2, has a complex estuary system formed between two sand spits. Subject to fairly high tidal influence, its lower catchment is mainly floodplain. The upper catchment is jungle with patches of agriculture. The Brunei River flows into Brunei Bay. The upper reaches of the River are a major freshwater source particularly for the western part of the country.

Brunei has two dams with a total storage capacity of 45 million m^3 (FAO AQUASTAT 2003). At present, no hydropower dams have been constructed, although one suitable site has been located within the National Forest Reserve of Temburong. Limited reserves of groundwater have been identified in the Sungai Liang and Seria areas of the Belait district and in the Berakas area of the Brunei-Muara district. The estimated safe yield is 17.3 million m^3/year (FAO AQUASTAT 2003).

Marine characteristics

Large Marine Ecosystems

The South China Sea is recognised as a Large Marine Ecosystem (LME) with specific characteristics of oceanography, biogeography and ecology (see also Annex VII). Much of the southern half of the South China Sea lies on the Sunda Shelf and its coastal waters are shallow (<200 m deep) and influenced by both marine and river/terrestrial inputs. Further north, the South China Sea Basin and Palawan Trough are much deeper (>1 000 m) and are bounded by the shallower continental margins and shelves of China, Vietnam, Cambodia, Thailand, Malaysia, Indonesia and the Philippines. The major gulfs and bays are the Gulf of Thailand, Gulf of Tonkin, Lingayen Gulf and Manila Bay.

The South China Sea is considered a semi-enclosed sea by the UN Convention on the Law of the Sea (UNCLOS): "A gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States" (Article 122 UNCLOS 1982).

Oceanography

Major oceanographic currents include those generated by the seasonal monsoons:

- West flowing current around West Kalimantan;
- North flowing current between West Kalimantan and the Malaysia Peninsula bifurcating into the Gulf of Thailand and South China Sea and flowing north to the east of Vietnam with a gyre developed to the east of central Vietnam, and northeast from east of Hainan towards Taiwan;
- Upwelling areas of northwestern Philippines and off Vietnam.

Waters from the South China Sea may also flow seasonally into the Sulu Sea and Java Sea, contributing to the Indonesian through-flow (Bate 1999). Local current patterns form complex eddies and counter-currents.

Coastal and marine habitats and biodiversity

The South China Sea region lies within the global centre of biodiversity for marine species, with for example more than 2 500 species of marine

fishes and 500 species of reef-building corals present (Figure 2) (Chou 1997, Veron 2000). The region also supports some of the world's most diverse mangrove forests and seagrass beds. River mouths and estuaries, and much of the protected coastlines, were originally fringed by mangrove forests and seagrass beds. However, extensive cutting for timber, conversion for aquaculture, other forms of coastal development and sedimentation have caused major fragmentation and reduction in the area of these habitats (Talaue-McManus 2000). Only one-third of the original mangrove forests remain, while seagrass beds have been reduced or degraded by 20-50% through increased sediments, nutrients and destructive fishing.

The coast under the immediate influence of the major river systems is mostly devoid of fringing coral reefs, although small fringing and patch reefs are present in some places. Fringing reefs are well developed away from the major river estuaries, particularly in the Philippines and the central-southern areas of the region. All major reef types: fringing, patch, platforms (including barrier) and atolls occur, with a total estimated reef area of the order of 10 000 km^2 (based on aggregation and de-aggregation of national statistics) (Spalding et al. 2001). Offshore, a number of large platform reefs and atolls exist, most notably the Spratly Islands, Tung-Sha (Dongsha Qundao) Reefs and Paracel Islands. These reefs are enormously diverse, play key roles in maintenance and replenishment of regional biodiversity, and may be particularly important in replenishment of harvested species (McManus 1994, Talaue-McManus pers. comm.).

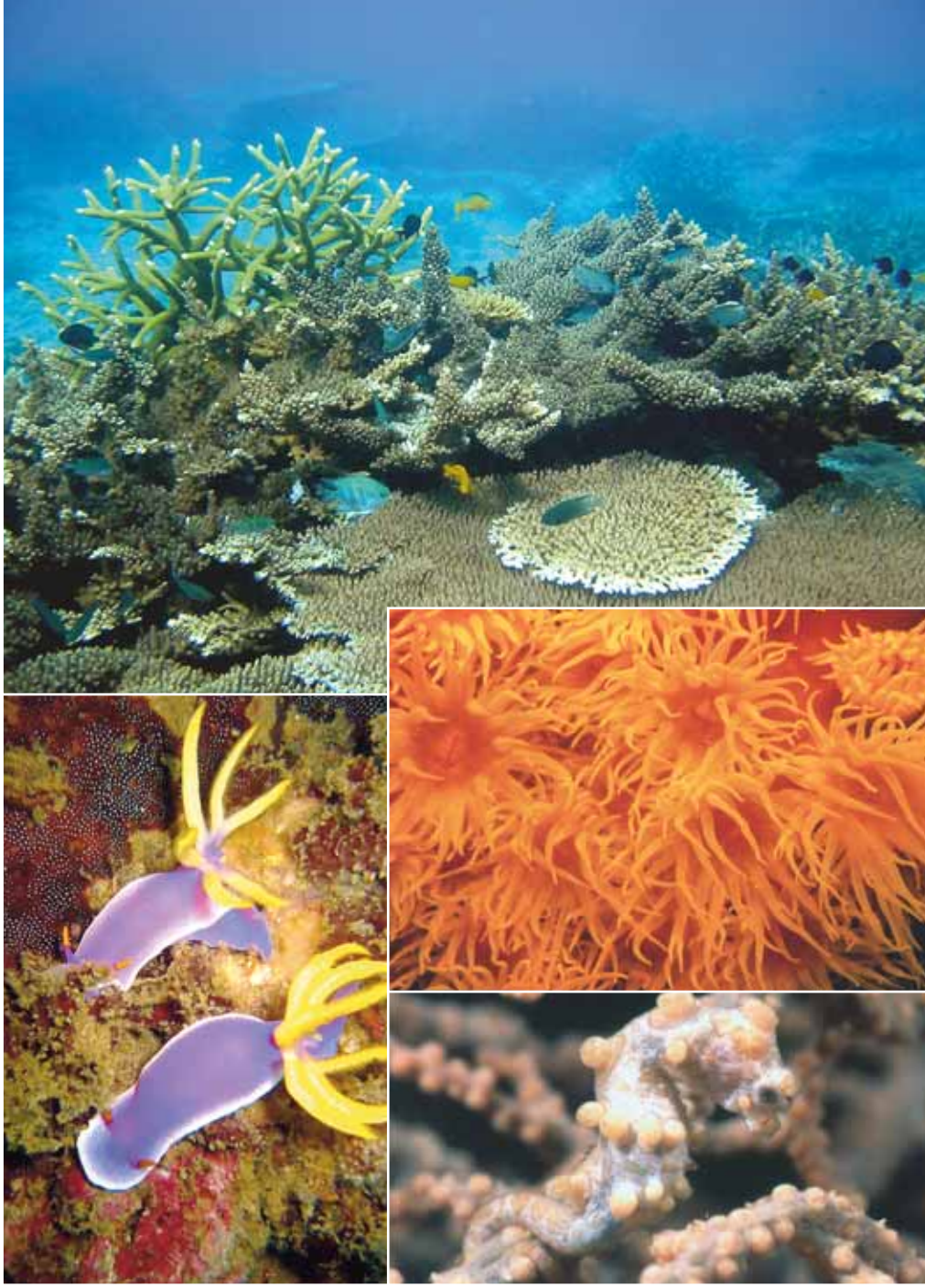

Figure 2 Marine life: Upper: Branching Acropora and damselfishes. Lower left: Nudibranch (*Chromodoris bulloscki*). Centre: Orange cup coral (*Tubastraea coccinea*). Lower right: Yellow pygmy seahorse (*Hippocampus denise*).
(Photo: B. Huzaimi ReefBase, W. Greiner ICRIN, C. Stearns ICRIN)

The territorial jurisdictions of the different reef complexes and individual reefs are disputed among several nations, notably China, Philippines, Vietnam, Malaysia and Brunei, with episodic armed clashes among navy and fishermen from the different countries.

Six species of marine turtles, all considered either endangered or vulnerable by the World Conservation Union (IUCN) occur, as does the dugong (*Dugong dugon*) and many other species of marine mammal also included on IUCN's Red List of Threatened Animals. Many of these exhibit transboundary migratory behaviour, making them particularly vulnerable to threats and providing major challenges for conservation management.

International waters

The South China Sea is one of the world's most contentious areas in relation to international waters, with significant territorial disputes among neighbouring countries, particularly relating to access to fisheries and minerals. In the sense of this assessment, international

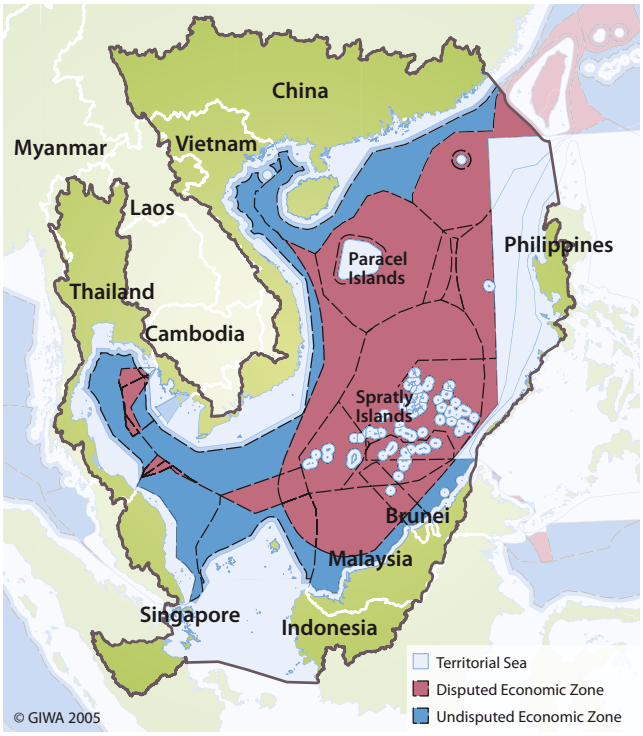

Figure 3 Exclusive economic zones and territorial seas of the South China Sea region.
(Source: GMBD 2003)

waters include all coastal and marine waters, major ports and river systems, as these are all potential sources or recipients of transboundary impacts. These impacts arise primarily from shipping, fisheries (with both legal and illegal foreign fishing effort), migratory species (e.g. larval dispersal and movement of pelagic fishes, turtles and marine mammals), pollution and riverine discharges, and the passive transport of waters and organisms in ocean currents.

The South China Sea is also an area of great multilateral importance, being one of the world's busiest sea-lanes, and a source of potential conflict. There have been significant territorial disputes among nations over sovereignty of the Spratly Islands and other offshore resources (Christy 1980, Catley & Keliat 1997, Castro 1998, Naess 1999) (Figure 3). As pointed out by Naess (1999): "The South China Sea is the maritime heart of a region binding southern China to Southeast Asia. The sea is of great importance economically, politically and environmentally to surrounding nations: China and Taiwan, the Philippines, Vietnam, Brunei Darussalam, Malaysia, Indonesia, Cambodia, Singapore and Thailand. The sea is known to most policy-analysts as an area where China and Taiwan stand against their Southeast Asian neighbours in an unresolved sovereignty conflict over the Spratly Islands. The increased tensions in the South China Sea stem from the provision in the 1982 United Nations Convention on the Law of the Sea III (UNCLOS) that all littoral states can demand an Exclusive Economic Zone (EEZ) of 200 nautical miles measured from the coastline. This provision has caused a number of disputes over maritime delimitation... In the area around the Spratlys, six of seven states, depending on whether Taiwan is considered a state, have made overlapping claims to ocean space. And, since the sea also includes four island groups - the Paracels, Pratas, the Macclesfield Bank and Scarborough Reef - the territorial disputes have become extremely complex. Some of the states have even used arms to prevent other nations from occupying islands or reefs".

Thus, the South China Sea provides a crucial test case for the resolution of international waters disputes, being highly resource-rich, of global importance to biodiversity, and surrounded by emerging nations with burgeoning coastal populations.

The Malacca and Singapore Straits carry approximately one-quarter of the world's commerce and half of the world's oil. Indonesia, Malaysia and Singapore have begun tri-lateral coordinated patrols to bolster maritime security, partly in response to International Maritime Organization initiatives to catalyse international cooperation on the security of vital shipping lanes. A regional consensus has been made on the basis of three principles: (i) the primary role of the littoral states; (ii) the important role of other stakeholders; (iii) and the need for consultation and to proceed in accordance with international law (Hean pers. comm.).

Socio-economic characteristics

Population

The region's human population is represented by a diverse mix of ethnic groups of nine nations, some forming ancestral tribal groups (e.g. in China, Thailand, Vietnam, Malaysia and Indonesia), others of more recent arrival (e.g. Indian traders). Within the broad ethnic groups, there are substantial cultural differences and various forms of religious belief, principally Christianity, Islam and Buddhism. The Philippines is mostly Christian. Indonesia, Malaysia and Brunei are mostly Islamic. Thailand and Cambodia are mostly Buddhist, while Vietnam and China have diverse mixes of Buddhism, Taoism, Christianity and other religions. There is a broad acceptance of different religious viewpoints in most parts of the region, although racial, cultural and religious tensions have been building in some areas in recent times, concomitant with the economic difficulties of the late 1990s.

Table 1 Population characterstics in the South China Sea region.

Country	Population			Population growth (%)	Population density (inhab./km²)		
	Total (million)	GIWA region (million)	Rural (%)		Average	Highest	Lowest
Brunei	0.36	0.36	42	1.4	52	ND	ND
Cambodia	13.4	1	79	1.6	57	4	236
China	1 290	200	70	0.7	129	670[a]	10
Indonesia	214	10	63	1.3	105	800	77
Malaysia	24.8	12	46	1.9	63	ND	ND
Philippines	81.5	30	45	1.9	231	348[b]	47
Thailand	62.0	40	80	0.7	114	ND	ND
Vietnam	81.3	60	79	1.1	227	1 085	115

Note: ND = No Data, [a]Shanghai 2 042 inhab./km², [b]Metropolitan Manila 13 000 inhab./km².
(Source: World Bank 2004, FAO AQUASTAT 2003)

The total population in the region in estimated at 350 million (Table 1). The urban population is distributed in some 100 cities with local populations of more than 100 000. Outside the cities, the population is distributed in thousands of villages spread along the coast, across the lowlands and into the highlands. The larger urban centres in the region include Manila (>10 million, Philippines), Hong Kong/ Macao (~10 million, China), Hanoi, Haiphong and Ho Chi Minh cities (>10 million in total, Vietnam), Bangkok (>5 million, Thailand), Kuala Lumpur (>5 million, Malaysia), Singapore (>2 million), and Brunei (<1 million). Outside the cities, coastal population densities are highest in Vietnam (Gulf of Tonkin >500 persons km²), and China and Philippines (470 persons/km²) (Figure 4).

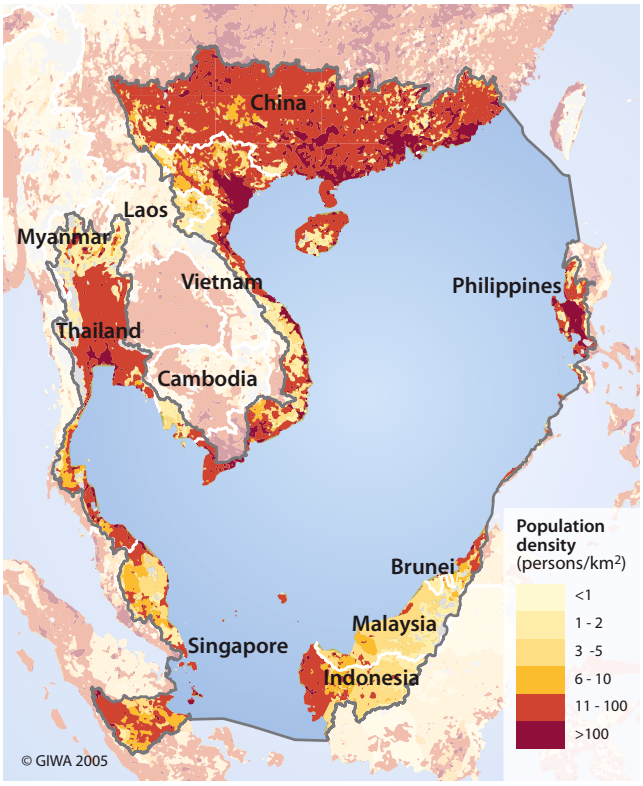

Figure 4 Population density in the South China Sea region.
(Source: ORNL 2003)

For the larger South China Sea LME, some 270 million people (5% of the world's population) are present in coastal areas, and this population is expected to double in the next three decades (LME 2004). Populations are increasing between 1-5% annually (see Table 1), with an overall average increase of ~2.2% per year (Talaue-McManus 2000). Population growth is highest in coastal areas of Cambodia, Indonesia and Malaysia. Parts of the region (e.g. Malaysian Sabah) are experiencing substantial immigration, of the order of 4% annually, mainly from Indonesia and the Philippines (WWF 2001).

Economic activities

The region spans the full gamut of economic activities, from subsistence agriculture and artisanal fisheries to light and heavy manufacturing and high technology industries, being composed of several of the 'Asian Tiger' economies. The Southeast Asian region, along with East Asia, is particularly dynamic with the most rapidly expanding economies of any part of the world, especially during the last three decades (Wilkinson et al. In press).

The region is referred to as 'emerging' as opposed to 'developing' (Fryer 1979), as it is progressively adjusting to the market economies of the North. The region is extremely heterogeneous and includes some of the poorest countries of the world (Cambodia, Laos, Myanmar, Vietnam) alongside extremely wealthy countries like Singapore and Brunei. Recent GDP growth (1996-2000) has been very low in Thailand (0.6%), but high in Cambodia (6.3%) and Vietnam (7.0%) as these economies recover from the economic 'meltdown' of the mid-1990s (Table 2).

Table 2 Economic data in the South China Sea region.

Country	GNP per capita (USD)	GDP growth 2001 (%)	GDP growth 1996-2000 (%)	Tertiary gross enrolment ratio (%)
Brunei	18 000	1.5	2.83	12
Cambodia	260	6.3	6.32	3
Indonesia	570	3.3	3.52	14
Malaysia	3 380	0.4	3.06	28
Philippines	1 040	3.2	3.64	31
Singapore	24 740	-2.0	6.66	45
Thailand	2 000	1.8	0.60	35
Vietnam	390	6.0	6.98	11

(Source: Rosen 2002, Asian Development Bank 2003, Fukuda-Parr 2003, World Bank 2004)

The region can be considered as an entity because of its cultural, social and political affinities, and its specific 'East Asian Model' of development through the Association of Southeast Asian Nations (ASEAN), which was established in 1967. Similar structural components of agriculture, international trade and tourism provide the major economic benefits for the ASEAN countries. Most of the ASEAN countries are part of the 70 countries that develop active relationships with the Organisation for Economic Co-operation and Development (OECD) through its Centre for Cooperation with non-members. They participate at OECD meetings such as Forums for Asian Insolvency Reform or Roundtables for Corporate Governance.

The sectoral composition and contribution to GDP varies widely among the nations in the region. In terms of industrialisation, Singapore, Malaysia, Brunei and Indonesia are ranked ahead of China, Thailand, Philippines, Vietnam and Cambodia (Talaue-McManus 2000), although much of Indonesia's industrial output is in Java, outside the GIWA regional boundaries for South China Sea (see GIWA region 57 Indonesian Seas). Output and consumption varies among nations in relation to degree of industrialisation. For example, Cambodia has a high reliance on agriculture (45% of GDP), less on industry (20% of GDP), whereas in Indonesia 57% of GDP is derived from the industry sector (mostly concentrated in Java). Overall, the annual rate of increase in output is of the order of 5%.

In terms of per capita GNI (Gross National Income, formerly GNP), the city-states of Brunei and Singapore are highest, followed by Malaysia, Thailand, Philippines, Indonesia, Vietnam and Cambodia (Talaue-McManus 2000). In general, there has been increasing output from agriculture, fisheries/aquaculture (net exporters) (Figure 5), plantations, forestry, mining, manufacturing.

Subsistence farming and fishing are the major activities for a large number of people outside of the main urban and industrial centres.

Figure 5 Recently established prawn aquaculture ponds north of Merang, Malaysia.
(Photo: J. Oliver, ReefBase)

Figure 6 Original forest in the South China Sea region.
(Source: UNEP/WCMC 2004)

The major export earners include commercial exploitation of natural resources, particularly fisheries, aquaculture, mariculture, oil palm and other forms of plantation agriculture and mining. Since the 1980s, there have been major increases in aquaculture (notably *Tilapia* in lakes and inland waters) and mariculture (shrimps) in coastal ponds, and also in supplying the live fish trade to Hong Kong, China and Japan. At present, mariculture is largely dependent on wild stocks, although hatcheries are being developed. Forestry is also a major industry although large areas of the loggable forests have already been exploited or are now protected (e.g. Palawan, Philippines) (Figure 6). Secondary industries including resource processing and manufacturing and tertiary industries including electronics are of growing importance.

Service industries, including tourism, have also expanded. However, the Asian financial crisis of the late 1990s and more recent events (international terrorism, SARS) since 2001 have caused a recent decline in international tourism. Overall, the effects of globalisation on the region are not well understood.

Agriculture

In China, the share of agriculture in GNI declined from 28.4% in 1978 to 21.2% in 1993 (FAO AQUASTAT 2003). In Vietnam, agriculture, including forestry and fisheries, is the largest sector in the economy accounting for 34% of GDP and employing 69% of the labour force. The agriculture sector grew at an annual rate of 4.2% between 1991 and 1995. In the Philippines, agriculture is the prime mover of the country's economy and was at the time of the assessment the least import-dependent activity. In Thailand in 1991, the agriculture sector accounted for 11.5% of GDP and agricultural exports represented 23% of total export earnings. In Indonesia, agricultural crop production and livestock contribute approximately 18% of GDP and provides employment for 49% of the population. In Malaysia, the contribution of agriculture to GDP declined from 18.7% in 1990 to 13.6% in 1995. In Cambodia, approximately 73% of the active population is currently engaged in agriculture, and agriculture accounted for 45% of GDP in 1994. In Brunei and Singapore, agriculture accounts for less than 3% of GDP and the countries import >80% of food. Agricultural characteristics in the region are presented in Table 3.

Table 3 Agriculture characteristics in the South China Sea region.

Country	Contributor to GDP (%)	Employment (%)	Change share in GNI (%)	
Brunei	3	ND	ND	ND
China	20	71	28.4 (1978)	21.2 (1993)
Cambodia	45	73	ND	ND
Indonesia	18	49	ND	ND
Malaysia	13.6	ND	ND	ND
Philippines	30	41.5	17 (1988)	17 (1990)
Thailand	11.5	55	ND	ND
Vietnam	34	69	ND	ND

Note: ND = No Data.
(Source: FAO AQUASTAT 2003)

Fisheries

Fisheries in the South China Sea are of great local, national and international importance, being a major contributor to both food and income. In total, the South China Sea produces around 5 million tonnes of catch each year, some 10% of the total global catch (LME 2004). Five of the littoral nations are among the top eight shrimp producers globally, mostly through aquaculture with large-scale consequences to habitats and water quality. Domestic fisheries consumption is highest in the Philippines, with increased production required in Cambodia, Indonesia and Vietnam to meet increasing domestic demand. Reef fisheries provide essential sustenance for artisanal fishermen and their families throughout the region, and also play an important role in supplying commercial quantities of high value products for export to expanding international, national, and local markets. Live reef fish export operations to Hong Kong and the Chinese mainland have burgeoned since the 1980s (Johannes & Reipen 1995), with removal of large numbers of demersal coral reef fishes, mostly through poison fishing, initially using cyanide but more recently also using locally-produced and inexpensive vegetable poisons.

There are clear indications of overfishing, with two-thirds of the major fish species and several major fishing grounds already fully or overexploited (LME 2004). On reefs throughout the region, there is widespread use of destructive fishing methods such as blasting and poisons. Benthic trawling also occurs in close proximity to reefs, with adverse direct effects on reef community structure. Trawl fishermen now target virtually all the catch, and so by-catch and discards are no longer an issue. Collecting of ornamental reef fishes and other organisms for the global aquarium market is also widespread and is expanding. It has already caused serious damage to reefs in some areas through use of destructive techniques of poison fishing and/or coral breakage. All these fisheries issues are covered in detail in the Assessment section below.

Mining and shipping

The region is a globally important source of minerals, with considerable reserves of oil and gas, which continue to cause international tensions. Vietnam and China have unresolved overlapping claims that have delayed exploration of undeveloped oil and gas reserves off Vietnam's coast. Similarly, China has disputed Indonesia's sovereignty of the Natura Islands. The South China Sea is the second busiest international sea-lane, carrying more than half the world's super tanker traffic. As an example, more than 80% of Japan's oil import comes through the South China Sea (Naess 1999).

Shipping, navigation and transportation all depend on stable international relations, and states with a will and capacity to repress piracy (Naess 1999). As the littoral states of the South China Sea are dependent on the sea to export and import goods, and for fishing, tourism, and other uses, there is a critical need for regional cooperation on these issues. Concerns in Malaysia, Singapore and Indonesia for the environmental security in the highly congested Malacca Strait need to be addressed. As one of the world's key throughfares for shipping, it is important for both the regional and outside powers to uphold peace, safety and stability, so as not to disturb the economies dependent on the sea lanes passing through[1].

Legal framework

The South China Sea countries exhibit a wide variety of socio-political systems, from constitutional democracies (Malaysia, Philippines, Indonesia, Singapore), and social-democratic republics (China and Vietnam) to Sultanates (Brunei). The various national constitutions provide the legal basis for development of legislature relevant to use and management of water resources. Seven nations are involved in the governance of the South China Sea LME; Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Vietnam. The region, in experiencing a phase of rapid economic development and population growth, have not accounted for the environmental consequences such as the degradation of its resources and water quality. Until now, narrow state interests and power politics have characterised the interaction between countries, and the influence of environmental groups has remained inconsequential. Rapid economic growth has also sharpened conflicts between the various sectors within governments. This was especially true of China in the past decade. Governments of the South China Sea region are now coming to see that the marine environment in the region is under threat. Environmental ministries are now in place, and environmental laws and regulations are being formulated (LME 2004).

The nations are signatory to various international conventions and have enacted national laws and regulations that are relevant to water-related issues in the region (Annex IV). For example, most nations have ratified the following conventions:

- Conservation on Biological Diversity (CBD);
- Convention on International Trade in Endangered Species (CITES);
- Ramsar Wetlands convention;
- United Nations Framework Convention on Climate Change (UNFCCC);
- United Nations Convention on the Law of the Sea (UNCLOS);
- International Convention on Prevention of Marine Pollution from ships (MARPOL);
- World Heritage Convention.

Most nations, having now ratified UNCLOS, recognise sovereign rights to the 12 nautical mile limit and have also declared 200 nautical mile Exclusive Economic Zone. The Philippines and Indonesia unilaterally use the 'Archipelagic Doctrine' to define their territorial waters.

National government sectors concerned with use of natural resources have proposed policies or legislation relevant to obligations under the various international conventions. However, it is apparent that despite the ratifications, there have been delays in achieving effective implementation and the resolution of related problems. This has been attributed to the lack of action by the various governments in addressing their obligations under the conventions. A recently developed 'Environmental Strategy for the Seas of East Asia' provides many pertinent recommendations and solutions to these problems (Chua pers. comm.).

A recent collaborative project between littoral countries of the region and UNEP, with initial funding from the Global Environment Facility, produced a comprehensive Transboundary Diagnostic Analysis (TDA), a study of issues and problems, and their societal root causes (Talaue-

[1]Detailed maps of oil and gas fields, shipping lanes and crude oil flows in the South China Sea have recently been declassified and can be obtained from http://cat.middlebury.edu/southchinasea.

McManus 2000). This was formulated by UNEP and senior marine scientists of the region in the period 1996 to 1998. This TDA was later used as a basis for the development of a Strategic Action Programme for the South China Sea. In the preparation of these documents, scientists and governmental agencies from seven littoral states; Thailand, Malaysia, Cambodia, Indonesia, Vietnam, China and the Philippines, have been involved in making country-specific studies that were used as a basis for the transboundary analysis, as well as for the Strategic Action Programme (UNEP 1994, 1997, 1999) (Box 1).

There have been major increases in regional capacity for biodiversity assessment, conservation measures and the establishment and management of protected areas, science and policy over the past several decades. For example, a critical mass of regional expertise now resides in inter-government and government agencies, academic institutions and NGOs. Nevertheless, considerable challenges still remain in engendering and coordinating government support among nations and across the different levels; national, state-provincial and local (see Policy options section later, Box 2 and Wilkinson et al. in press).

Box 1 Transboundary environmental issues in the South China Sea region.

Important transboundary environmental problems of the South China Sea region have been identified by the UNEP in cooperation with the national committees. The Transboundary Diagnostic Analysis (TDA) identifies the priorities among water-related problems and concerns, their socio-economic root causes, the sectoral implications of actions needed to mitigate them and the extent to which the problems are transboundary in either origin and effect. The actions proposed in the framework of the Strategic Action Programme are wide ranging in both context and proposed areas for action. Successful implementation of the Programme will depend upon coordination of actions by diverse organisations, agencies, non-governmental organisations, private sectors, and stakeholder groups at both the national and regional levels. Recognising the mandate of the United Nations Environment Programme to coordinate environmental action across the United Nations System, the widest possible range of appropriate partners at national and regional levels will be encouraged and assisted to participate in the execution of the Programme. It is the intention of the participating countries that all actions be undertaken in a spirit of collaboration and partnership, to enhance the synergy between on-going initiatives at national and regional levels, and eliminate duplicative and conflicting actions.

(Source: UNEP 1994, 1997, 1999)

Box 2 Projects in the South China Sea region.

The United Nations Environment Programme has unveiled a regional plan to try to reverse the degradation of the South China Sea by starting nine pilot projects for sustainable development at priority transboundary sites in the region. UNEP's Strategic Action Plan for the South China Sea has been endorsed by all ASEAN members as well as by the People's Republic of China. This is the first time the seven countries have agreed to collaborate around the marine biology of the region. The Chinese government has asked for help from UNDP to implement integrated coastal management through the establishment of demonstration zones. This project was initiated in 1997, with an investment of 1.1 million USD from UNDP, and 2.2 million USD from China.

Several of the countries have contending claims to large areas of the South China Sea, leading to political tensions among them. The claims are about the status of the Paracel Islands and the Spratly Islands, which are said to contain minerals, oil and gas resources. In 2001, these Asian nations agreed to set aside their quarrels in order to save the South China Sea, and signed a joint agreement to the UNEP project. They will cooperate on a 32 million USD plan to protect the marine environment. The Global Environment Facility (GEF) is contributing 16 million USD to this plan. As knowledge of environmental hazard is spread through the region, the impetus for conflict resolution will grow. GEF funding will secure a comprehensive package of marine environmental research and projects that will build human and institutional capacity. Through their concern for the environment the countries of the South China Sea can be brought closer together as they discover their common heritage and the importance of the Sea as a source of protein for the growing coastal populations.

(Source: LME 2004)

Assessment

Table 4 Scoring table for the South China Sea region.

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

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

The arrow indicates the likely direction of future changes.

↗ Increased impact
→ No changes
↘ Decreased impact

South China Sea	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	2* →	2 ↗	1 →	1 ↗	1.8	4
Modification of stream flow	2					
Pollution of existing supplies	1					
Changes in the water table	2					
Pollution	2* →	2 ↗	2 ↘	2 →	2.0	3
Microbiological pollution	2					
Eutrophication	1					
Chemical	2					
Suspended solids	3					
Solid waste	2					
Thermal	1					
Radionuclide	0					
Spills	2					
Habitat and community modification	3* →	3 →	1 →	3 →	2.5	2
Loss of ecosystems	3					
Modification of ecosystems	3					
Unsustainable exploitation of fish	3* ↗	3 ↗	2 ↗	3 ↗	2.8	1
Overexploitation	3					
Excessive by-catch and discards	3					
Destructive fishing practices	3					
Decreased viability of stock	0					
Impact on biological and genetic diversity	2					
Global change	1* →	1 ↗	1 →	1 →	1.1	5
Changes in hydrological cycle	1					
Sea level change	0					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	0					
Changes in sea surface temperature	1					

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

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

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

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 4.

The results presented herein are supported wherever possible by published data. However, for some of the issues and concerns raised in this analysis, some publications are of a confidential nature, either in government or 'commercial in confidence' and thus were unavailable for inclusion in this report. Geo-political issues and sensitivities are of particular significance, notably in relation to foreign fishing, mineral extraction and related territorial/sovereignty disputes. The Transboundary Diagnostic Analysis for the South China Sea prepared for UNEP provides much useful data in support of the present analysis (Talaue-McManus 2000).

IMPACT Freshwater shortage

The large range of climates in the region generates a variety of hydrological regimes. The South China Sea is host to some of the most humid climates (with annual precipitation above 10 000 mm in places) giving rise to major rivers, while in other parts it has a very arid climate, with closed hydrologic systems (FAO 1999). As a result, the region shows a very uneven distribution of its water resources and of its water use conditions. In the humid areas, water management concerns have mostly been dominated by considerations related to flood control. In

the arid areas, where water is scarce, hydrological studies have been oriented much more towards water resources assessment.

The hydrology of the region is dominated by the typical monsoon climate, which induces large inter-seasonal variations of river flows. In this situation, average annual values of river flows are poor indicators of the water resources available for use. In the absence of flow regulation, most of the water flows during a short season when it is usually less needed. A fair estimate of water resources available to a country for use should include figures of dry season low flow. However, such information is available only for a very limited number of countries. In view of the hydrological regime of the rivers in the region, run-off in Southeast Asia and the islands is not significantly affected by withdrawals, while the difference between natural and actual flow may be much more important in the arid regions (mostly China).

In terms of shared water resources, the region is characterised on the one hand by a series of insular, archipelagic countries among which no exchange is possible, and on the other hand by a littoral zone in which shared river basins play a critical role and make the computation of water resources relatively complex. In several cases, large inconsistencies were noted when comparing the flow at the border recorded by neighbouring countries. Indeed, compilation of information on water resources shows large methodological discrepancies between countries.

Agriculture is a major feature of the socio-economies of most South China Sea nations, and thus irrigation, drainage and water withdrawal are of significant relevance to the issues of freshwater shortage and pollution, as outlined for each nation in Annex VIII.

Environmental impacts

Modification of stream flow

Modification of stream flow, including that caused by water withdrawal, has moderate environmental impact in the region, with severe impacts in some areas. In Vietnam, the seasonal discharge of rivers has been altered, mostly as a consequence of loss of hinterland forests and riparian vegetation. In Thailand and Malaysia, stream flow has been affected by loss of riparian vegetation and dam construction, with significant saline intrusion in some areas. In Borneo, significant loss of riparian vegetation has occurred through effects of logging. In the Philippines, there has been saltwater intrusion to large freshwater lake systems and loss of riparian vegetation.

In Thailand, the capital city Bangkok faces problems of both over- and under-supply of water. Flooding occurs frequently in the wet season due to low average ground level, high tides and inadequate drainage (FAO 1999). The Metropolitan Waterworks Authority is unable to supply water to meet all domestic and industrial demand. As a result, in the outskirts of Bangkok, private and industrial abstraction of groundwater exceeds the safe yield of the aquifer. This accelerates the rate of land subsidence (5-10 cm/year), which in turn aggravates the problem of flooding. Indeed, subsidence has caused some parts of the drainage systems to be below the normal water level and has rendered them ineffective. The minimal discharge to maintain a water level of 1.7 m for navigation (this means 300 m^3/s released in the navigation channel from Nakhon Sawan to the Chao Phraya Dam, and 80 m^3/s downstream of the dam) cannot be maintained due to large amounts of water diverted from the rivers for dry season irrigation in the northern and central regions. This reduced the volume of inland waterway transport five-fold between 1978 and 1990. The volumes of water released by the Bhumipol and Sirikit dams are increasingly important to prevent saltwater intrusion, even if they do not meet the navigation demand (FAO 1999).

Pollution of existing supplies

Pollution of existing supplies has caused slight environmental impact across the region as a whole, but with moderate to severe localised impacts. Fish kills from various chemical inputs have been reported, and rivers close to urban centres in all countries (e.g. Bangkok, Thailand; Haiphong, Hanoi and Ho Chi Minh City, Vietnam; Manila, Philippines; Hong Kong, China) are usually polluted. There have also been significant increases in nutrient loads in many rivers and lakes from aquaculture activities, with likely increases in other inputs. In large parts of the region (e.g. Indonesia, Thailand, Cambodia, Vietnam), municipal and industrial wastewater is often discharged virtually untreated into the waterways causing rapid deterioration in the quality of river water (FAO 1999). In Thailand for example, approximately 833 million m^3 of wastewater were produced in 1992. In 1995, only 35 million m^3 of wastewater were treated (FAO AQUASTAT 2003). Numerous wastewater treatment projects are being developed in the Bangkok metropolitan area. There is little to no re-use of treated wastewater in Thailand, or indeed throughout most of the region. In Vietnam, no treatment facilities have been available in manufacturing plants, factories and sewer systems before wastes are discharged into water bodies. In Hanoi, 300 000 m^3/day of wastewater are discharged into the rivers (FAO AQUASTAT 2003).

Virtually all urban streams in the region are highly polluted. Failure to provide adequate sanitation services not only translates to vulnerabilities to contagious and infectious diseases but also increases likelihood of sewage dumping-induced eutrophication in estuarine areas. More detail on sanitation data for individual countries is available from the

web sites of WHO's Joint Monitoring Programme for Water Supply and Sanitation, and World Resources Institute's EarthTrends Environmental Information Portal[2].

Changes in the water table

Changes in water tables have exerted moderate environmental impacts in the region, with severe impact in some areas, notably coastal Thailand (see also Annex VIII). Wells have been deepened over hundreds of square kilometres, with major aquifer draw-down, saline intrusion, and there is little to no potable water available from some of the traditional coastal sources. In Cambodia, the quality of groundwater is generally satisfactory, although high iron concentrations and increased salinity levels have been encountered in some provinces (Svay Rieng, Prey Veng and Takeo). In Indonesia, overexploitation of groundwater has led to critical problems in some areas. For example, in Jakarta, excessive groundwater abstraction (32.6 million m^3 in 1993) has caused saline groundwater to reach about 10 km inland from the coastline and led to land subsidence at a rate of 2-34 cm/year (FAO AQUASTAT 2003).

Socio-economic impacts

Overall socio-economic impacts ranged from slight (Health and Other social and community) to moderate (Economic). Economic impacts included insufficient water supply and irrigation, causing loss of agricultural and tourism uses and lowered productivity.

Economic impacts

There are numerous economic problems associated with freshwater shortage. These include growing water competition among users for potable water supply, industrial water supply, hydropower, environment, fishing, and watershed management, all competing with irrigation (FAO AQUASTAT 2003).

Erosion and siltation of canals have resulted in high costs for the operation and maintenance of irrigation schemes, and many are in need of frequent rehabilitation. The conversion of agricultural lands to industrial or residential use has significantly reduced the area equipped for irrigation that can actually be used for irrigated agriculture. Finally, the high cost of energy hampers the development of pump irrigation systems (see Annex VIII for detail). In most countries, fees collected from farmers to cover costs of irrigation and water supply do not meet the actual operational cost. Governments generally do not seek full cost recovery because the farming community is considered a low income group. For example, in Malaysia, fees cover only 10-12% of the actual operational cost (FAO AQUASTAT 2003). Further, about 32% of the water produced is lost in the distribution system due to pipe leakage, under-metering, and other unaccounted water losses. In many areas of the Philippines and elsewhere, there is insufficient water supply and irrigation, loss of agricultural and tourism uses, and low productivity.

Table 5 Water-borne diseases in some countries of the region.

Country	Number of inhabitants affected	
	Total	% of population
Cambodia	500 000	4.9
Philippines	782 000	1.1
Thailand	1 040 000	1.8

(Source: FAO 1999)

Health impacts

Although considered as slight overall, health impacts are moderate to severe in some areas, with two of the most common water-related diseases, malaria and schistosomiasis, linked to the development of irrigation (Table 5) (FAO 1999). Malaria is already a serious problem throughout most countries in the region. In Cambodia alone, estimates of about 500 000 cases of malaria per year are common, and between 5 000 to 10 000 people die annually. Schistosomiasis was reported in the Kratie area of Cambodia in 1993, while dengue haemorrhagic fever has recently become an important cause of child morbidity in Cambodia. In 1990, about 7 000 cases resulting in 340 deaths were recorded. In 2003-2004 in Indonesia, dengue fever has killed hundreds of people and incapacitated thousands of others for long periods. In the Philippines in 1989, 782 200 people were affected by water-related diseases, including gastroenteritis, schistosomiasis and hepatitis. In Thailand, the main water-borne diseases are acute diarrhoea (affecting 1.48% of the population), dysentery (0.14%), malaria (0.12%) and enteric fever (0.03%) (FAO AQUASTAT 2003).

Drinking water across some parts of the region is of acceptable quality because of pollution management, although in many other areas surface water does not meet WHO drinking water criteria, because of the agricultural, industrial and human inputs. For example, many Filipinos, especially the poor, lack safe potable drinking water to meet even their basic survival needs. About one third of the population of Philippines, some 25 million people, devise their own ways of obtaining water because they have no access to formal sources such as deep wells or piped/reticulated water (FAO AQUASTAT 2003). 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 contaminated sources.

Thus, for millions of people in the region, and indeed the larger area of Southeast Asia as a whole, there is little to no access to wells or piped

[2] *www.wssinfo.org and www.earthtrends.wri.org*

supplies. Even in some areas with reticulated water, there are frequent interruptions to supply. Precise and comprehensive data on access to water supply are not available, and there are major differences in data quoted by different agencies (e.g. FAO and World Bank). FAO (1999) estimated that in Indonesia in 1990, just 35% of the urban population and 33% of the rural population had access to safe water supply. In Cambodia, some 1.75 million people (just 19% of the population) had access to clean drinking water in 1992, representing approximately 40% of the urban population and 15% of the rural population. At that time, only 7 000 of the 30 000 wells needed had been constructed by international organisations.

Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection (Table 6). Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 litres per person per day from a source within 1 km of the dwelling (WHO/UNICEF 2000). These estimates show significant disparities with FAO estimates (e.g. Indonesia), in part because of different criteria.

Table 6 Access to improved water sources in the region.

Country	Access to improved water sources (%)		
	Average	Rural	Urban
Cambodia	75	66	94
China	78	69	90
Indonesia	78	69	90
Malaysia	100	94	100
Philippines	86	79	91
Singapore	100	-	-
Thailand	84	81	95
Vietnam	77	72	95

(Source: UNDP 2001)

Precise and comprehensive data on the provision of environmental sanitation are not available for the region. In Cambodia, access to sanitation is limited to an estimated 1.24 million people (just 13% of the population), representing approximately 53% of the urban population (mostly in Phnom Penh) and 6% of the rural population (FAO 1999). A 1995 survey assessed the quality of water supply, wastewater and sanitation in the main towns of Cambodia. Most of the systems combined sewage and drainage water, and have not been maintained over the past two decades. As a result, they are now in poor condition and not functioning properly. Drainage water often mixes with drinking water with obvious health implications; floods are frequent during the rainy season as the sewers clog rapidly. According to FAO (1999), providing a safe water supply to 65% of the rural population in Cambodia during the period 1996-2000 would have required a capital investment of nearly 31 million USD.

Many local programmes are underway to address river pollution, as for example in Ho Chi Minh City, Vietnam, where polluted waterways are being cleaned as part of the World Bank-funded 'Urban Upgrading Project', including drainage, sewage systems and infrastructure. The once beautiful and clean waterways have been turned unintentionally into a dumping site. The project will work in 109 slums in Ho Chi Minh City, focusing on drainage and sewage networks, costing some 298 million USD over the period 2004-2112, and should benefit some 1.55 million residents). The project is based on the principle that active participation by communities in critical stages of preparation, design and implementation is a pre-requisite to effectively respond to the needs of these areas. This should ensure that numerous low-income communities will have clean water, better sanitation and sewage systems, and reduced flooding, pollution and water-borne diseases (Nhan pers. comm.).

Other social and community impacts

There are significant transboundary implications on the socio-economy of freshwater shortage, particularly in relation to the international nature of many of the river systems, and related potential for upstream/downstream conflicts. An example is Singapore which relies on the State of Johor in Malaysia for most of its water supply. This has been the focus of significant recent disputation between these two neighbouring nations. Singapore's water supply from Malaysia is based on agreements made in 1961 and 1962. Malaysia has, for several years, wanted a major review of the price, which it regards as too low. However, the two agreements provided for price revisions after 25 years, in 1986 and 1987. Singapore's stand is that since the 25-year period passed without review, Malaysia now has no legal basis to raise the price. Malaysia and Singapore continue to hold top-level meetings attempting to resolve this long-standing dispute.

In summary, major socio-economic impacts are spread widely across the region, and include:

- Loss/interruptions to human drinking water supplies (e.g. rural areas of Philippines);
- Increased potential for upstream/downstream conflicts (e.g. Malaysia, Singapore), or conflicts among urban and squatter groups (e.g. China). The water authorities in much of the region presently

do not have adequate capacity for effective enforcement, and much of the infrastructure dates from colonial times;
- Increased costs of alternative water supplies (see Annex VIII);
- Reduction in future use options;
- Human health impacts (e.g. dengue fever, malaria);
- Increased damage to water-related equipment, increased costs of deepening wells and pumping and damage to infrastructure (see Annex VIII).

Conclusions and future outlook

Despite its moderate impact for the region as a whole at present, freshwater shortage is a 'food-security' concern in some areas, and is the focus of national and international interventions (e.g. Philwater International Conference and Exhibition on Water Resources Management). Expanded programmes targeting both rural and urban water supplies, with the goal of delivering a reliable potable supply are beginning to be implemented, with the goal of achieving significant alleviation (see Annex VIII).

The overall environmental situation in regard to freshwater shortage in the South China Sea is expected to deteriorate slightly, remaining moderate by 2020. Socio-economic impacts are all expected to deteriorate, with health effects remaining as slight, other social and community impacts becoming moderate and economic impacts becoming severe. Although major improvements are expected in some locations (e.g. Singapore), many poorer areas in South China Sea do not have the resources or infrastructure to act, compounded by poverty and inadequate sources of water supply. In Indonesia for example, as the nation has started to implement development programmes to meet the sharply increasing needs for irrigation, safe drinking water, industrial water, energy, and other uses, the demand on water resources has increased rapidly. It is estimated that between 1990 and 2020, the demand will increase by about 220% (FAO 1999).

Thus major forcing factors include widespread increases in human populations, with a doubling expected by 2033, and industrialisation, with the compounding problem of increasing contamination. Although either directly or indirectly in all nations in the region, much legislation touches on water resources (Annexes IV and V), most of the existing laws are outdated. For example, in Malaysia, the Water Act of 1920 is inadequate for dealing with the current complex issues related to water abstraction, pollution and river basin management.

Water scarcity is a major issue in China and the Philippines, and increased competition for water between sectors already affects agriculture in China, Malaysia and Thailand. The trend is towards an intensification of the problem due mainly to the rapid growth of the domestic and industrial sectors in these countries. Major inter-basin transfer programmes are being developed in China and Thailand. Water scarcity and the interdependency between water use sectors are pushing countries to develop integrated water resources management programmes, as in Malaysia, Vietnam and Thailand. Water quality is also a growing concern in several countries where industrial development is important, including Malaysia and the Philippines. There is increased importance of water conservation and protection in the national programmes of Indonesia and the Philippines, while in Thailand, the transfer of populations from high density to low density areas has encountered serious socio-economic problems.

Despite the best efforts of governments, IGOs and NGOs, and improvement in regulation and environmental control, the expanding population pressures are expected to cause further deterioration in environmental and socio-economic aspects of freshwater shortage. The rate of deterioration will depend to some extent on the success of the planned interventions. In Thailand for example, in order to solve the problem of competition between sectors, there are plans to establish a water rights market where all parties would be able to trade water rights (FAO 1999). This would stabilise water demand but would have important negative consequences on agriculture. Throughout the region generally, water resources development lacks a comprehensive planning and coordination of all the actions carried out in the sector by the different agencies, although in Thailand, this has been improved since establishment of the Ministry of Natural Resources and Environment of Thailand on October 3, 2002 where water is under responsibility of the Department of Water Resources and Department of Ground Water Resources. There is now a tendency to include the Department of Irrigation to form the Ministry of Water Resources in the near future. Also, Thailand is implementing the water grid project to effectively supply water by pipeline system throughout the country.

Although the Mekong River is considered as part of GIWA region 55 Mekong River, the 1995 agreement established by the four lower Mekong riparian countries provides a useful model for the larger region and new opportunities for regional collaboration in developing the Mekong Basin resources (water and related ecological resources). Some examples of promising collaboration are related to flood control in the Mekong Delta with Cambodia, and the possible importation of hydropower from upper riparian states. Importantly however, there are as yet no similar arrangements for other transboundary rivers.

Pollution

The health of the South China Sea Large Marine Ecosystem is in serious decline due mainly to coastal development. Around 270 million people live in the coastal areas of the South China Sea Large Marine Ecosystem, and this population is expected to double in the next three decades (LME 2004). The area's rapid economic development and population growth are the cause of significant ecological damage in coastal and marine areas. The primary environmental threats by humans in the South China Sea are the destruction of mangrove forests, sewage pollution, exploitative fishing practices and overfishing, coral reef degradation, and damage to seagrasses and wetlands. Sewage pollution affects biodiversity and fisheries, and has health impacts on the downstream population. Pollution, overexploitation and destructive fishing practices are threatening 80% of the coral reefs in the region. Other pollution problems are increased river sedimentation and nutrients, plus destructive fishing practices, are being felt in the region's other major habitat, seagrass communities, of which 20 to 50% were found to be degraded. Many fish nursery areas and breeding grounds are being degraded (LME 2004). Figure 7 shows urban development along Pasig River, Manila.

Figure 7 Development along Pasig River, Manila, Philippines.
(Photo: J. Oliver, ReefBase)

Industrial forms of water pollution are concentrated in the major urban centres. In much of the region, sewage treatment is superficial at best, with raw and/or primary treated sewage discharged directly into water courses (see Freshwater shortage). Agricultural pollution is also widespread, through leaching of fertilisers and pesticides into watercourses, massive loss of soils following land clearing and forestry and increasing aquaculture activities. Pollution from shipping and ports is also significant, as the South China Sea contains some of the world's busiest international sea-lanes, with two of the busiest ports in the world, Singapore and Hong Kong (Coulter 1996).

The environmental impacts and threats from pollution in the South China Sea have been well documented in many reports (e.g. Gomez 1988, Johnston 1988, Chua & Pauly 1989, Soegiarto 1989, Piyakarnchana & Johnston 1990, Chua 1991, Chua & Scura 1991, Chua & Garces 1992, Coulter 1996, Low et al. 1996, Chua & Ross 1998, Johnston 1998, UNEP 1999). The degraded water quality of Ha Long Bay (Hai Phong province, Vietnam) is a typical example. Pollution of the Bay and man-made changes to the environment have threaten coral reefs, marine life and the livelihood of fishermen and hoteliers. In 10 years, 900 million tonnes of sediments polluted by the nearby coal mining, have been transported by the rivers into the Bay. Adding to this, close to 9 million m^3 industrial wastewater contaminated by lead and petrol is discharged into the Bay every year (South China Morning Post in Naess 1999). The coral reefs suffer from the dynamite fishing by the Cat Ba Island fishermen, and untreated wastewater from Haiphong, Vietnam's third-largest city with two million inhabitants, pollutes the Bay. It is also estimated that hundreds of visitor boats spill about 2 tonnes of oil each day. Similar levels of pollution occur at many locations in the South China Sea, although many are not as well documented as the latter World Heritage site.

Thermal pollution has only slight environmental impact in the region, being notable only in the immediate vicinity of the few power plants where ocean or riverine discharge of cooling waters occurs. Radionuclide pollution has no known environmental impact of at present; there are no nuclear power plants in the region, although there may be some episodic discharge from nuclear-powered ships navigating through the area.

Environmental impacts

Microbiological

Microbiological pollution has caused moderate environmental impact in the region. Many areas have high levels of faecal coliform bacteria (e.g. Manila Bay) from inadequate sewage disposal and treatment, with, at best, rudimentary sewage treatment for much of the region. The production of wastewater in the region of the Philippines national

capital and nearby provinces is estimated at 74 million m^3, while the volume of treated wastewater reached just 10 million m^3 in 1994 at the Ayala and Dagat-Dagatan pond (FAO AQUASTAT 2003). Sewage is mostly treated by settlement and primary treatment consists of screening, particularly in the urban areas. 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.

Eutrophication

Eutrophication in the region as a whole has had slight impact, although with moderate impact in some estuarine and coastal areas of the Philippines and Thailand. Nevertheless, it is important to note that eutrophication may be more extensive than has so far been scientifically documented because of generally high nutrient loading from agricultural as well as domestic sewage sources (Talaue-McManus pers. comm.). Hotspots certainly occur in the vicinity of coastal cities, and estuarine areas in non-urban settings where sewage or industrial discharges are directly dumped because of the lack of sewer connections to centralised sewage treatment facilities. This is commonplace in Indonesia, Vietnam and the Philippines, all of which have high total population and population densities. Impacts are most significant in enclosed bays, harbours and lagoons with limited water circulation (e.g. Manila Bay). Use of fertilisers, particularly in plantation agriculture, contributes to eutrophication through leaching into watercourses, although by world standards use is low.

At present, scientific data are scarce to non-existent and the effects of the nutrients are uncertain, depending partly on rates of mineralisation and retention of the dissolved nutrients. There is little evidence of visible effects on the abundance and distributions of biota, or fish or zoobenthos mortality other than in some enclosed bays and in the immediate vicinity of river mouths. There are no indications that eutrophication from agricultural run-off is a significant problem at the scale of the region as a whole, although occurrences of hypoxia have been reported in areas crowded with fish pens and cages especially during extended periods of reduced trade winds and reduced water turbulence, such as during the 1997-1998 ENSO event (Talaue-McManus pers. comm.). Examples of blooms of toxic dinoflagellates that have caused paralytic shellfish poisoning have been reported in some parts of the region. Initial estimates of global nutrient loading can be found in Smith et al. (2003), and the environmental dataset is available from the Land-Ocean Interactions in the Coastal Zone (LOICZ) web site[3].

Chemical

Chemical pollution has had moderate environmental impact, with use of pesticides in agriculture being a significant problem in areas of Vietnam, Philippines, Thailand and Malaysia. Use of chemical defoliants by the United States military during the Vietnam War has caused long-term pollution of some catchments and sediments. Mostly localised water contamination also occurs from industry (manufacturing, metal fabrication, ship repair and agricultural and food processing industries such as oil milling, sugar refining and meat and fish processing) and from mining, with contaminant loads concentrated near the discharges. Releases of chemical and other forms of pollution from shipping in harbours also commonly occurs, as regulations and controls relating to ship-derived pollution are rarely enforced. Much industrial waste, a result of economic activity along the coast, also goes straight into the ocean without treatment.

Overall emissions of organic water pollutants, measured by biochemical oxygen demand (BOD), vary widely among nations (Table 7). In the Philippines, emissions appear to have remained relatively steady from 1980 to 1993 with an average input per worker of 0.19 kg/day (World Bank 1999). The industrial sector's share of organic water pollution was mostly contributed by food. In Indonesia by contrast, there appears to have been a rapid increase in emissions, during the same period. Here food is the major industrial contributor. Similarly in Malaysia, emissions of organic water pollution have increased, again with food being the major industrial contributor (Table 7). Pargal et al. (1997) note that in the case of Indonesia, the industrial sectors of textiles, leather tanning, food products, and pulp and paper are more BOD-intensive than other manufacturing sectors. Pulp and paper is significantly more intensive in organic water pollution than food products, although textiles and leather tanning are also relatively BOD-intensive; metals and machinery are least BOD-intensive. Pulp and paper and miscellaneous manufacturing are most intensive in total suspended solids (TSS), while

Table 7 Emissions of organic water pollutants in the South China Sea region.

Country	**BOD load** (kg/day)		**Food industry contribution** (%)
	1980	1993	
Cambodia	ND	12 078	ND
China	ND	6 500 000	ND
Indonesia	214 010	537 000	59
Malaysia	77 215	136 055	32
Philippines	182 052	181 714	53
Singapore	ND	33 331	ND
Thailand	ND	355 800	ND

Note: ND = No Data.

(Source: World Bank 1999)

[3] *www.loicz.org*

Machinery is least intensive. In the other South China Sea nations, total BOD emissions range across several orders of magnitude.

Suspended solids

Suspended solids have had severe environmental impact in coastal waters throughout most of the region. This has resulted from land use practices causing extensive deforestation in many watersheds, logging and mining, and urban development, compounded by high rates of erosion and siltation. Erosion is a major problem throughout the region (Naess 1999). Logging and 'slash and burn' agriculture create millions of tonnes of sediments that are transported through the rivers to coastal areas and river deltas. Sediments smother coral reef, mangrove and coastal ecosystems, and consequently destroy the productive breeding grounds for fish. There have been major changes in turbidity and levels of suspended sediments in Malaysia, Vietnam, Philippines, Indonesia (Sumatra and Kalimantan) and Thailand. These impacts, with extensive dredging and land reclamation, have caused major changes in biodiversity of affected benthic communities.

In the Philippines, of the order of 1 billion m^3 of sediment is discharged into coastal waters annually, carrying high loads of particle-bound nutrients. 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 to this is Palawan (Philippines), where logging was halted through effective implementation of legislation in the early 1990s, 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). As noted above, in Vietnam's Halong Bay, 900 million tonnes of polluted earth has been carried into the sea by rivers that traverse nearby coal-mining zones (South China Morning Post in Naess 1999). Underwater 'hills of mud' up to 30 m high have been created.

Solid wastes

Solid wastes have caused moderate environmental impact in the region but with severe impact locally, particularly around towns and villages where waste management is poor or non-existent. There is widespread litter on beaches giving rise to public concerns regarding recreational use, and impacting the tourism industry (e.g. many areas of Thailand, Vietnam, Philippines, Malaysia, Indonesia). There are high frequencies of benthic litter recovery and interference with trawling activities (e.g. Manila Bay and some other near-shore areas where half the trawls may be filled with solid wastes). Most cities, towns and villages are situated on the banks of rivers, and cannot manage their waste. The rivers are therefore used as deposits for solid waste (Naess 1999).

Spills

Spills have had moderate environmental impact at present. The South China Sea forms part of the major oil tanker routes between the Indian and Pacific Oceans (Figure 8), with episodic discharges from shipping (tankers, fishing boats, bulk carriers, ferries etc.), and occasional spills from oil exploration and production.

Figure 8 Major shipping lanes in the South China Sea region.
(Source: US Pacific Command 2005)

Ship ballast discharges and 'ballast-washing' also regularly occur, impacting on all littoral countries to varying degrees. Etkin (1997) reported that over 800 million litres of oil had spilled into East Asian seas, including South China Sea, since 1965. International trade is expected to triple by 2020, and much of this trade will be transported by sea (Chua pers. comm.). Most of the countries in the region have ratified the UN Convention on the Law of the Sea (UNCLOS) and the International Convention on Prevention of Marine Pollution from ships (MARPOL), and have taken some steps towards developing oil spill contingency plans. Yet little spill control equipment is in place and implementation of emergency procedures is not well developed.

Socio-economic impacts

Socio-economic impacts of pollution in the South China Sea are all moderate. Most impacts are related to poverty and are concentrated in

the major urban centres. There have been losses in fisheries (e.g. off the Malaysian Sarawak coast), economic losses to aquaculture facilities and shellfish industry through regular advisories of high levels of toxicity (e.g. Philippines, Vietnam, Indonesia, Thailand). There have also been losses in wildlife and recreational value in parts of the Philippines, and conflicts of land use in Philippines, Thailand and Malaysia. Health issues include harmful algal blooms and cases of mercury poisoning. There have also been costs associated with clean-ups and coastal restoration. There is a lack of data in the region to support these statements, however, the key impacts include:

- Increased risks to human health;
- Increased costs of human health protection;
- Loss of water supplies (e.g. potable water);
- Increased costs of water treatment;
- Costs of preventive medicine;
- Costs of medical treatment;
- Costs of clean-up;
- Loss in fisheries;
- Change in fisheries value;
- Costs of reduced fish marketability due to aesthetic perceptions;
- Reduction in options of other uses of freshwater;
- Potential for international conflicts;
- 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.

Conclusions and future outlook

For the Pollution concern as a whole, the present level of environmental impact is moderate. However, environmental impact of suspended solids is already severe, primarily resulting from deforestation over the past 150 years. To 2020, environmental impacts from pollution are likely to deteriorate, but remaining as moderate, primarily because of the predicted increases in forestry and agriculture, and a major increase in population overriding the improvements in infrastructure. Regulations and laws governing the sources of pollution have not been sufficiently developed or followed up by local and national governments as economic growth and industrial development are more highly valued than protection and management of the marine environment.

Although most of the countries have signed and ratified relevant conventions and treaties, many are unable to implement regulations effectively. There is seldom one ministry or department that coordinates the implementation and enforcement of anti-pollution laws. Further, policy makers generally view pollution mitigation or control projects as irrecoverable and unproductive investments (Naess 1999). Consequently, these have a very low rating when government funds are allocated to various sectors. The general lack of expertise and experience in implementing and conducting integrated and sustainable management of marine related pollution problems are a serious obstacle to their effectiveness. Data management and methodologies also vary from country to country, making it difficult to compare and synthesise data (Low et al. 1996, Naess 1999).

However, in some areas of most nations, efforts are now beginning to be made to clean up local pollution sources and impact sites, and implementation of regulations is improving. An early example was the establishment in February 1981 of the Memorandum of Understanding between Indonesia, Malaysia, Singapore and Japan of the Malacca Strait Council, when a Revolving Fund was set up to combat oil pollution from vessels in the Straits of Malacca and Singapore.

Nevertheless, the overall socio-economic prognosis for the future is for deterioration causing severe impact to the economies. By contrast, there is expected to be an improvement in health issues (becoming slight), and both improvement and deterioration in other social and community aspects (remaining moderate), mostly because of an increase in projects for pollution mitigation and control (e.g. sewage treatment). There are expected to be marked differences in the magnitude and success of such interventions among the different South China Sea nations, and both the direction of change and the rates of deterioration and/or improvement will depend on the success of ongoing and planned interventions. In the latter regard, an important recent initiative is the GEF funded UNDP/GEF/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas. The project focuses on four activities:

- Demonstration sites;
- Promotion of ratification of international conventions;
- Development of sustainable financing mechanisms;
- Capacity building.

This regional programme has been successful in bringing national and local governments, industry, donor agencies, NGOs and organisations in the international community together in environmental management projects in three selected sites. Ten countries are members of the programme, established in 1994. Detailed recommendations and strategies for implementing effective pollution management strategies in the region are contained in reports by Chua (1991), Chua & Pauly (1989), Chua & Scura (1991), Chua & Garces (1992) and Chua & Ross (1998) among many others.

Habitat and community modification

The South China Sea region lies within the global centre of biodiversity for marine species. The region supports some of the world's most diverse seagrass beds and mangrove forests, as well as more than 2 500 species of marine fishes and 500 species of reef-building corals (Chou 1997, Veron 2000). Extensive cutting for timber, conversion for aquaculture (Figure 9), other forms of coastal development and sedimentation have caused major fragmentation and reduction in the area of these habitats (Talaue-McManus 2000). Only one-third of the original mangrove forests remain, while seagrass beds have been reduced or degraded by 20-50% through increased sediments, nutrients and destructive fishing. Key aspects of the ecosystems, habitats and biodiversity of the South China Sea are further discussed in the Regional definition.

Environmental impacts

Loss of ecosystems or ecotones

Loss of ecosystems has already caused severe environmental impacts, with permanent destruction having reduced the surface area of mangroves, seagrasse beds, coral reefs, and riparian vegetation by more than 30% in the past several decades, from siltation, development and destructive fishing practices. Development of ports has resulted in foreshore reclamation and channel dredging, while muro-ami, blasting and poison fishing has damaged or destroyed large areas of coral reef. Seagrass beds, muddy and sand-gravel bottoms and fringing coral reefs are also impacted by trawling and siltation. For marshes, swamps, riparian belts, fast flowing stony bottomed streams and slow flowing sandy/muddy floodplain rivers the combined effects of human impacts, including agricultural expansion and, in the case of Vietnam, widespread military use of defoliants, have caused extensive habitat loss and fragmentation in many parts of the region.

Figure 9 Newly excavated aquaculture ponds north of Merang, Malaysia.
(Photo: J. Oliver, ReefBase)

Figure 10 Coastal development near a mangrove estuary, Singapore.
(Photo: J. Oliver, ReefBase)

The original area of mangroves in the South China Sea has decreased by 70% during the last 70 years. With a continuation of the current trend all mangroves will have been lost by the year 2030 (UNEP 1999), with millions of hectares of land, mostly mangrove forests, having already been converted for shrimp hatcheries and mariculture. In Singapore, more than 95% of mangroves and 60% of coral reefs have been lost (Figure 10). In Thailand, there has been major loss of mangroves and marshlands through changing land use patterns, loss of coral reefs through siltation, pollution and destructive fishing exacerbated by the lack of protection, and loss of seagrasses through coastal construction. In Malaysia, loss of mangroves is continuing through coastal development. In Indonesia, of the estimated 39 million ha of coastal and inland swamps, some 7.5 million ha have been identified as potentially convertible to arable land (FAO 1999). In Vietnam, by contrast, the loss of mangroves is being addressed through a major rehabilitation project at Can Gio (43 000 ha). Despite the continuing destruction, significant areas supporting good quality coastal and marine habitats still remain (e.g. Spratly and Paracel Islands; western Palawan, Philippines; and Con Dao Islands, Vietnam), both within and outside MPAs.

Modification of habitats or ecotones

Modification of habitats is also severe, with changes in species compliment/community structure (e.g. coral reefs), 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, the important fisheries 'nursery-ground' roles of large sections of mangroves and seagrass beds have been seriously depleted, while about 80% of coral reefs have been degraded or are under severe threat from destructive and overfishing, siltation, pollution and development (Bryant et al. 1998, Burke et al. 2002). Freshwater habitats have also been impacted from introductions for example Tilapia and African catfish. There have been local extinctions in some areas for example loss of mud crabs in Rayong, loss of turtles and dugongs in many parts of Philippines and Vietnam through habitat loss and exploitation, and loss of freshwater fishes.

Socio-economic impacts

Coastal ecosystems

Loss of riparian and coastal vegetation, including mangroves and seagrasses, has had enormous socio-economic implications.

Mangroves of the South China Sea cover 4 million ha of the coastal areas, representing 28% of the world's mangrove forest and have enormous economic (and environmental) value (UNEP 2004). Products and ecological services provided by these systems are estimated to be worth about 16 billion USD per year (Low et al.1996, Naess 1999, UNEP 1999). Further, the estimated value of seagrass and coastal swamp areas in the South China Sea region is 191 billion USD per year (UNEP 1999). As noted above, the original area of mangroves has decreased by 70% during the last 70 years. With a continuation of the current trend all mangroves will have been lost by the year 2030 (UNEP 1999). Subsequently, many 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 and implement clear criteria for sustainable shrimp farming and ways to rehabilitate damaged mangroves.

Marine ecosystems

Major economic costs are accruing from loss and modification of coral reef habitats, which are also of immense economic value. The reefs provide nursery and breeding grounds for 12% of the world's total fish catch; contributing some 30% of East Malaysia's total catch and 25% in the Philippines (Gomez 1988, Brookfield & Byron 1993, Low et al. 1996). In Southeast Asia, reefs are estimated to be worth more than 2.4 billion 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 provide annual economic benefits of 1.6 billion USD per year in 2002, however over the next 20 years, human impacts, notably overfishing, destructive fishing and sedimentation could cost Indonesia some 2.6 billion USD (Burke et al. 2002). Figure 11 shows the reefs at risk in the South China Sea region.

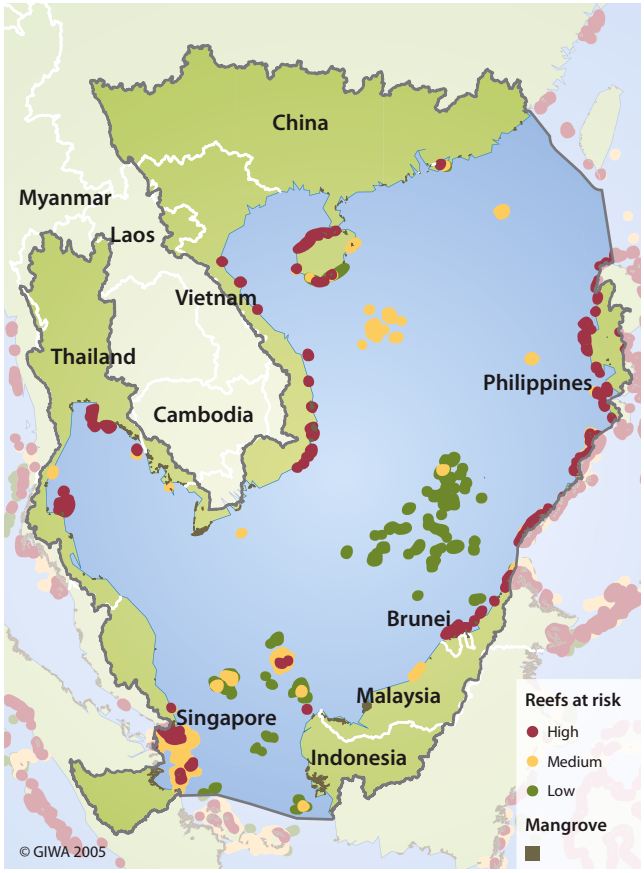

Figure 11 Reefs at risk in the South China Sea region.
(Source: Bryant et al. 1998)

Fishing

In the case of destructive fishing, the bombs, usually constructed from bottles stuffed with explosive potassium nitrate, detonate underwater, killing or stunning fish so that they are easy to net. There is considerable collateral damage to reef communities, with localised death and injury to all incident species, and coral mortality rates of 50 to 80% (Hopley & Suharsono 2000). For the fisherman, the short-term gains from bombing may be impressive, with a 1-2 USD investment returning up to 15-40 USD in profit on the local market. Moreover, given the ease with which fish bombs are assembled (potassium nitrate is a common component of fertiliser), fishermen seldom want to make the switch to more sustainable, but time-consuming, technology like spears and hooks. As a result, in many coastal areas, bombed reef fish often dominate local markets. But the practice has a devastating effect on coral reefs, which may take more than 50 years to recover.

Cyanide use can be nearly as destructive as blast fishing, but its focus is often the international market, rather than local supply. Prized reef fish like grouper (Serranidae) and Napoleon wrasse (*Chelinus 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. These fish are usually shipped 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, as coral is killed as well, particularly since the divers often have to tear apart the coral structure with crowbars to pull the fish out.

Tourism

Although often considered a relatively benign 'non-extractive' industry, additional socio-economic impacts can accrue from tourism, usually at

two stages in the development of the industry (Hopley & Suharsono 2000). The early construction phase may employ damaging techniques of land clearing and quarrying of the coastline and fringing reefs for resort construction. After the resort is occupied, damage may result from sewage disposal, anchor damage at dive sites (mooring facilities are not normally installed) and breakage of corals by inexperienced divers and snorkelers (particularly where operators are not trained to give environmental advice to the tourists). Tourism may also create conflict with the local communities (e.g. Djohani 1995).

Thus present socio-economic impacts of habitat and community modification range from slight (Health) to severe (Economic and Other social and community impacts), primarily because of:

- Reduced capacity to meet basic human needs (food, fuel) for local populations (many areas of South China Sea);
- Changes in employment opportunities for local populations and associated changes in social structures (e.g. Thailand, Vietnam, Philippines);
- Loss or reduction of existing income and foreign exchange from fisheries, tourism, and other uses (many areas, but also attributable to factors additional to habitat loss);
- Human conflicts, national and international (e.g. territorial disputes over exploitation of Spratly Islands reefs);
- Injury and death to fishermen using destructive fishing methods (e.g. blast fishing in many areas);
- Loss of future opportunity for investment income and foreign exchange, and increased risks to capital investment (e.g. failure of coastal aquaculture projects in many parts of the region);
- Costs of controlling invasive species (e.g. *Tilapia*);
- Costs of restoration of modified ecosystems (e.g. coral reef and mangrove forest restoration programmes are already being undertaken);
- Inter-generational inequity.

There are particularly serious economic issues in fishing communities, where local fishermen are unable to catch sufficient fish for sustenance.

Figure 12 Cora reefs: Left: Lemon damsel (*Pomacentrus mollucensis*) and mixed coral species, Pulau Perhentian, Malaysia. Right: Crown of thorns starfish, north of Pulau Gut off Pulau Tioman, Malaysia.
(Photo: B. Huzaimi, ReefBase)

There are also economic conflicts between investors and local users, and also from loss of mangrove habitats, loss of charcoal production and costs of rehabilitation, and failures in aquaculture. There are also health (loss of traditional medicines, pharmaceuticals, potential increases in mosquito-borne diseases), educational and scientific issues arising from habitat loss. Other social and community impacts include relocation of villages and conflicts among different user groups (e.g. among shallow and deep water fisheries). Progress in managing human use of habitats is not expected to be sufficient to fully mitigate the damaging effects of population growth.

Conclusions and future outlook

As with the neighbouring regions of Sulu-Sulawesi Sea and Indonesian Seas, 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;
- Deforestation, siltation, damming and waste disposal affecting rice paddies and rivers;
- Silica mining and solid wastes affecting sandy foreshores;
- Aquaculture conversion and timber collecting affecting mangroves;
- Sediment run-off, siltation and dredging affecting seagrass beds and coral reefs;
- Destructive fishing affecting coral reefs;
- Trawling affecting soft-bottom habitats;
- Mid-water trawling, drift netting and other forms of pelagic fisheries, oil and gas exploration and pipelines affecting oceanic habitats.

For the Habitat and community modification concern as a whole, present level of environmental impact is already severe, although there are some positive steps. These include mangrove rehabilitation programmes, notably in Vietnam, and the protection of forests, watersheds and reefs in some areas (e.g. Palawan, Philippines). UNEP has undertaken the Coastal Marine Environment Management Information System (COMEMIS), to help improve the region's capacity to make sound environmental assessments through GIS. Even some habitat modifications, such as a coastal reclamation project in Singapore, have had positive effects, providing a nesting site for turtles and birds.

At present, most habitats are only poorly represented in protected areas and of those, many are poorly managed. For example, approximately 4% of Philippine coral 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. There are only two international protected areas conserving coral reef habitats in the region (Figure 13). Approximately 125 other marine protected areas have already been gazetted, although there are insufficient resources for management and enforcement of fisheries and other regulations in many MPAs at present, which limit their effectiveness. By contrast, several small community-based management initiatives have proven very successful at protecting coral reefs and facilitating replenishment of reef-based fisheries (e.g. Apo Island in the neighbouring Sulu-Celebes (Sulawesi) Sea region) (Russ 1985, Russ & Alcala 1996a, b).

Future levels of environmental impact are expected to remain as severe, with both some improvement and some deterioration to 2020. Future socio-economic scenarios are also for significant deterioration by 2020, with severe economic and other social and community impacts, and both deterioration and improvement in the health situation, which should remain as slight.

Given that the region lies at the centre of global biodiversity, with adjacent regions of Indonesian Seas and Sulu-Sulawesi Sea, the present situation and future prognosis indicate that more extensive and intensive intervention is required, including (PEMSEA pers. comm.):

- Direct on-the-ground community-based conservation programmes, including further development of protected areas;
- Training programmes to build additional long-term capacity among governments, NGOs, and communities;

Figure 13 International and national protected areas in the South China Sea region.
(Source: UNEP/WCMC 2003)

- Assessment programmes for identification of critical areas for biodiversity (e.g. through government agencies and NGOs such as WWF, IUCN, The Nature Conservancy and Conservation International);
- Multilateral integration to maximise effectiveness of obligations under international conventions and treaties (e.g. the Convention on Biodiversity, UNCLOS, MARPOL, Ramsar Wetland Convention).

Conservation of representative habitats through continued development of protected areas is a regional priority of global importance. Nations bordering the South China Sea already have many legally designated protected areas including coastal and marine habitats, and some multilateral conservation agreements have been established. Of the more than 125 coastal and marine protected areas in the region, many contain coral reefs (Spalding et al. 2001, and see Cheung et al. 2002 for comprehensive lists and tables). There are also two World Heritage sites (Halong Bay, Vietnam and Puerto Princesa Subterranean River National Park, Philippines), although their inscription on the World Heritage Register was primarily for geomorphological and cultural features, rather than habitats. The effectiveness of many MPAs is limited at present by insufficient resources for management and enforcement of regulations, with just 10-20% considered as effectively managed (Box 3) (Cheung et al. 2002).

Recommendations for priority actions in regard to improving MPAs in the region include (Cheung et al. 2002):

- Implement legislative reforms;
- Incorporate planning and management into an Integrated Coastal Management framework;
- Develop/enhance sustainable financing to continue adaptive management including co-management;
- Fill gaps in establishment of representative MPAs in underrepresented biogeographic zones;
- Establish/improve joint research and cooperative management areas.

Many lessons have already been learned from the few successful MPA models, and the future successful development of protected areas will include extensive community and stakeholder consultation, education and regulations offering real protection, with agreement and strong support from the customary resource owners and users. In collaboration with the respective governments, national to local, several international NGOs, including WWF, IUCN and The Nature Conservancy, are presently working towards assessment and management of critical biodiversity sites in the region.

Box 3 Marine Protected Areas in Southeast Asia.

The ASEAN countries have developed several models for the management of MPAs:

- Centralised or top-down whereby they are managed by a single authority, normally the government. This often applies in Indonesia, Malaysia, Thailand and Vietnam.
- Local, bottom-up level, such as the predominantly community-based management projects in Indonesia, Thailand or the Philippines.
- Shared between several stakeholders. This usually involves the community and government, but could also include NGOs, IGOs and universities, thereby constituting collaborative or co-management strategies.

There are numerous case studies of successful management of MPAs in Southeast Asia, with the collaborative and community-based management strategies being especially fruitful, demonstrating that the paradigms for sustainable management of coastal and marine resources in the region have already been developed. However, these examples appear to be the exception, as the statistics illustrate that marine resources are failing to get the adequate attention that they require. Only 7% of the total number of MPAs in the region are effectively managed, while 68% have poor or unknown management. Thus, most MPAs, while they look good on paper, can be regarded as 'paper parks'. They have been declared as MPAs, but they are protected only in theory and not in practice, as there are no management plans and only weak attempts at implementing effective control of national regulations. For many, the management effectiveness rating is 'unknown' (48.6% of the MPAs in the region), which probably indicates that there is no management. Alternatively, this lack of information may be partly explained by the political and security sensitivities in Southeast Asia with some areas inaccessible for research and monitoring. This status is largely due to a lack of field knowledge, experience, and political will from the governments.

(Source: Wilkinson et al. in press)

IMPACT Unsustainable exploitation of fish and other living resources

The South China Sea ranks fourth among the world's 19 fishing zones in terms of total annual marine production. Southeast Asian Seas annually yield approximately 7 million tonnes of fishery resources (McManus 1994). The annual value of this catch exceeds 6.5 billion USD. The ASEAN nations export nearly 1 billion USD worth of fish products annually. More significantly, fisheries contribute approximately 65% of the animal protein consumed in countries such as the Philippines, Malaysia, and Indonesia, with the highest dependencies being found among the poorest coastal people (McManus 1994).

Areas adjacent to the Spratly Islands are particularly productive, such that the annual catch from the reef-studded waters of the Sabah-Palawan area is about 10 000 tonnes, valued at approximately 15 million USD. The local fish stocks in most of these areas are heavily fished. Adult fish are very difficult to find on some reefs in the region (McManus1994). Figure 14 shows catches in the South China Sea LME by country. For more information on the South China Sea LME see Box 4.

As with neighbouring regions, neither status nor future viability of the fish stocks are well understood, and for many fisheries, their status may be summarised as being illegal, unreported and unregulated (IUU). There are significant gaps in data on population dynamics for some

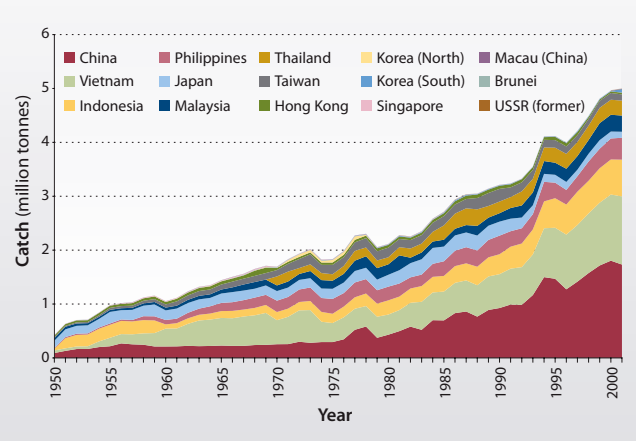

Figure 14 Catches in the South China Sea LME by country.
(Source: LME 2004)

fisheries. Data issues affecting significant areas of the region include (Alban pers. comm.):

- No village statistics, with little or no capacity to collect fisheries statistics at village level;
- No data on reef and other fisheries;
- For artisanal fisherman, a resistance to collect or understand/use data, rather traditional judgements/knowledge prevail;
- Lack of data on fishing grounds, their location, extent, seasonality, productivity;
- Lack of integration, appropriate use of data in management, with urgent need for better coordination;
- Data often not management-related, having been collected for science, not for fisheries management;
- Data reliability issues;
- Field data reporting systems and standardisation varies across fisheries and countries (e.g. log books), with significant effort needed to define what is unique and what is shared, what works and does not;
- Funding difficulties in developing standard data collection and reporting for shared fisheries - relevant to management of the South China Sea as a whole (e.g. PISCES genetic project to define relations among stocks in South China Sea).

Box 4 The South China Sea Large Marine Ecosystem.

The coastal and estuarine areas off of Vietnam, China and Cambodia are very productive. In the past, a substantial fraction of the Vietnamese catch was taken by artisanal, non-mechanised boats. South Vietnam's demersal resources were exploited primarily by Taiwanese vessels. The northwestern coast of the Philippines is a soft-bottom area fished intensively by trawlers. The deep shelf area of South China Sea is predominantly fished by Taiwanese vessels. There are no catch or biomass data for shrimp or crabs, and information on catches of demersal fish is sparse. In deep oceanic waters (200 to 4 000 m), fisheries are limited to large pelagic fishes, mainly tuna. Other species harvested are billfish, swordfish, shark, porpoise, mackerel, flying fish, anglerfish and shrimp. The total fish harvest is approximately 5 million tonnes per year. This is about 13% of the area's total fish production, the rest being eaten by predators. Five of the countries are among the top eight shrimp producers of the world. Fishermen sometimes use small meshed nets and practice destructive fishing methods, such as cyanide and dynamite fishing. While two thirds of the major fish species are overexploited, carefully constructed fishing regimes could result in increased catches. The Vietnam/China area was lightly exploited from the mid-1970s to the mid-1980s. By now much of this potential has probably been realised. The deeper coralline areas and those situated in the central portion of the LME are only slightly exploited, leaving room for an increase in production there. The potential areas for an increase lie in the deeper areas of the LME, but these are areas difficult to fish.

(Source: LME 2004)

Scale of the different fisheries is another major issue, with substantial differences among different fisheries; commercial inshore/offshore/international foreign offshore, in terms of boat numbers, sizes, catch capacity, area sizes fished and gear types. This leads to increasingly complicated management strategies related to multi-species fisheries.

Environmental impacts

Overexploitation

Overexploitation in the South China Sea region has already had severe environmental impacts (Box 5). Many stocks, including demersal reef fish, holothurians, molluscs and crustacean stocks, are considered to be exploited beyond Maximum Sustainable Yield (MSY), partly through overinvestment and with encroachment of large-scale commercial operations, including incursions by foreign vessels using long drift nets into traditional/artisanal fishing areas. There is also overexploitation of sharks, tuna, bill-fish and other pelagic species. Sharks are also caught as

Box 5 Overexploitation in the South China Sea region.

The GIWA regional Task team raised concerns about the GIWA definition of overexploitation: "Overexploitation refers to the capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."

The concepts of Maximum Sustainable Yield (MSY) are outdated , see e.g. Jackson et al. (2001) and Pauly et al. (2002). More appropriate criteria would include proportions of spawning biomass for individual species and a 'whole of ecosystem' approach to multi-species fisheries. In particular, there are significant differences between tropical multi-species and multiple trophic level fisheries versus temperate single-few species and trophic level fisheries, in relation to:

- Multiple gear selection, adaptation, modification in response to fisheries diversity and level of poverty of fishermen (some fisherman cannot afford to diversify into specialised gear);
- Increasing coastal populations, initially target common species (e.g. mullet), but overexploitation leads to diversification to non-target species;
- Fish meal/oil production encourages fishermen to take everything;
- Targeted by-catch e.g. turtles.

Given the above, the four defined categories of overfishing; recruitment, growth, target and malthusian, all occur in the region and have different impacts in the different fisheries/nations, in relation to natural fluctuations in stock population sizes from:

- Recruitment variability, large annual fluctuations in recruitment, cohorts, size/year classes, differences in susceptibility to overfishing among year classes, climate effects on recruitment and distribution;
- Differences in life history characteristics across species, degree of aggregation, spawning sites susceptibility to overfishing.

These natural fluctuations produce significant inter-annual variability in stock sizes that in turn affect productivity and the socio-economics of the different fisheries, be they subsistence or industrial. Subsistence fisheries are largely limited to shallow coastal waters because of lack of equipment and/or knowledge. This can lead to tension with foreign fishermen who have broader options.

(Source: GIWA Task team 2004)

by-catch of the trawl fisheries and the tuna long-line fishery. Additionally, the benthic invertebrate fisheries, particularly for sedentary species of holothurian sea cucumbers (Trepang or Beche-de-mer), trochus, green snails and clams, are overfished, particularly around the major coastal population centres. Spiny lobsters are also targeted in oceanic waters, sandy reef lagoons and flats and mangrove areas.

Poison fishing for demersal reef fish is also widespread having burgeoned in the 1990s to supply the live fish food trade in Hong Kong and China, and also the aquarium trade, with prices increasing but catch per unit effort (CPUE) declining sharply (Cesar et al. 2000). Existing fisheries for endangered species (turtles and dugong) are continuing, and there have been localised species extinctions.

There has also been a significant recent increase in effort in the pelagic fisheries. For example, data from the Philippines Department of Agriculture suggest that yields of some pelagic species have continued to increase, but that catch per unit effort has declined steadily, suggestive of 'ecosystem overfishing'. In Malaysia, Sabah's fishery stocks have declined by 70% since 1995. In Thailand, the Gulf of Thailand provides a classic case-study of a collapsed fishery (Pimoljinda & Boonraksa 1999).

Further, around 70% of coral reefs in the broader region (including Sulu-Sulawesi Sea and Indonesian Seas) are heavily overfished, producing less than 5 tonnes/km^2/year, with clear indications of 'trophic overfishing', in comparison with the remaining 30% of reefs which produce of the order of 15-20 tonnes/km^2/year (DeVantier et al. 2004). 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 m^2 of reef area annually (equivalent to 20-25 tonnes/km^2) (Alcala pers. comm.).

At present, neither status nor future viability of some fisheries are well understood in parts of the region, and their status may be summarised as being illegal, unreported and unregulated.

Excessive by-catch and discards

Environmental impacts of excessive by-catch and discards are also severe, although some of the assessment criteria are largely irrelevant to the situation in the region. Here, there is little to no by-catch or discards, as virtually all of the much-diminished catch - including turtles, sharks and even whales - is kept and eaten, with massive overexploitation of species regarded as by-catch in other regions.

There is however widespread capture, either intentional or accidental, of rare, threatened and endangered species in traditional and commercial fisheries. These are usually kept as part of the catch. Smaller 'trash' fish taken in trawls are used as feed in aquaculture. Further, substantial, though unquantified, levels of by-catch are produced by distant waters fleets, through use of blast fishing and poison methods, and in the milkfish and shrimp fry fisheries, where juveniles of all other species are discarded. There is also considerable targeted and incidental capture of endangered species of turtles and dugong. The Philippines and Malaysia have developed a bi-national agreement for conservation of marine turtles, but this is not observed in remote areas. In many areas there are few biological regulations in fisheries, or enforcement.

Destructive fishing practices

Destructive fishing is also having severe environmental impacts. Massive habitat destruction and fragmentation, and changes in population and community structure are occurring from trawling and mechanised 'push-netting' (with minimal use of by-catch exclusion devices), widespread use of explosives (reef bombing), electric fishing, 'muro-ami' and use of poisons for fishing. Widespread reef bombing has been attributed to increasing competition among fishers and corresponding declines in catches. Many reefs in the region have also been targeted with poison fishing for the live fish food trade in Hong Kong and mainland China, initially using potassium cyanide or sodium cyanide and more recently also using poisons derived locally from plants. Poison fishing has also been used in collection of ornamental reef fishes for the international aquarium trade. Figure 15 shows a fish trap off the coast of Sharp Island, Hong Kong.

Decreased viability of stocks through contamination and disease

Decreased viability of stocks has no known environmental impact at present. However, there are some developing problems arising from

Figure 15 Fish trap off the coast of Sharp Island, Hong Kong.
(Photo: A. Cornish, ReefBase)

the increased occurrence of 'red tides', diseases in pilchards and diseases spreading from aquaculture farms. In areas adjacent to the region, there has been a marked decline in aquaculture production in some lakes, with Tilapia culturing affected in approximately 10% of lakes in the Philippines. In the Java Sea, part of GIWA region 57 Indonesian Seas, major loss of maricultured prawns has occurred, with disease spreading into wild stocks.

Biological and genetic diversity

Biological and genetic diversity has moderate environmental impact in the region, but with severe local impacts. There have been extinctions of native species and local stocks as a result of introductions and a clear decrease in heterozygosity in cultured fish stocks (e.g. Tilapia). The introduced fishes are eating and displacing endemic fishes in the Philippines, Vietnam and other areas, with corresponding changes in community structure and diversity. There is also evidence of reduction in genetic diversity in milkfish stocks in the Philippines due to repeated spawning of cultured offspring, and release of cultured broodstock into the wild.

Socio-economic impacts

Socio-economic impacts related to unsustainable exploitation of fish are severe from economic and other social and community aspects, with moderate health effects. There has been widespread loss of income from fisheries collapse and loss of productivity (e.g. Gulf of Thailand), with concomitant shifts in target species. Fishing 'down the food-chain' is widespread in most, if not all, countries of the South China Sea. There have also been increasing levels of competition for fisheries resources among traditional artisanal fishermen and commercial and foreign fleets.

In the Philippines and elsewhere, the fishing sector has the highest birth rate and highest levels of poverty. In many areas, fisher families' children are malnourished as most fish are sold and fish consumption has declined from approximately 36 kg/person/year to 24 kg/person/year, with consequent high levels of malnutrition (DeVantier et al. 2004). There are few alternative options, and the levels of poverty are such that many children are 'trapped' into fishing. Injuries and deaths from blast fishing and diving are common, with frequent deaths of children during muro-ami fishing. There are also conflicts among different fishing groups, influx of foreign nationals to the fisheries, with conflicts on the fishing grounds. 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 (DeVantier et al. 2004). It is also predicted that there will be a major deficit in wild-caught fish production by 2010, to be supplemented by aquaculture. Figure 16 shows fish pens in Manilia Bay, Philippines.

Figure 16 Fish pens in Manila Bay, Philippines.
(Photo: J. Oliver, ReefBase)

Disputes over sovereignty of the Spratly Islands have resulted in significant levels of multilateral tension in recent years. Some of the states have even used arms to prevent other nations from occupying islands or reefs (Naess 1999). Examples include an incident in 1988 when a Vietnamese attempt to stop the Chinese occupation forces led to the sinking of Vietnamese ships and drowning of more than 70 men. Subsequently, tensions have developed between the Philippines and China.

Given the above, the key socio-economic impacts of unsustainable exploitation of living resources in the South China Sea region include:

- Reduced economic returns and loss of employment/livelihood (e.g. from overexploitation causing fishery collapse in the Gulf of Thailand and elsewhere);
- Conflict between user groups for shared resources (e.g. between local and outside/foreign fishermen, Vietnam and elsewhere);
- Loss of food sources (e.g. sources of protein) for human and animal consumption (e.g. reduction in consumption among poor fisher families in Philippines and elsewhere);
- Reduced earnings in one area by destruction of breeding populations and/or juveniles in other areas (migrating populations, widespread throughout the region);
- Loss of protected species (e.g. turtles, dugongs, whales, which is widespread throughout the region);
- Reduced commercial value resulting from tainting (particularly in areas adjacent to major population centres);

Box 6 Fisheries status and prognosis for South China Sea.

In the South China Sea, the fisheries situation resembles malignant and incongruent problem. Fishing fleets of individual countries are depleting the common resources of the sea, thereby causing long-term costs (loss of future fishing opportunities) to all, and reaping short-term benefits at the cost of others. Although there are unilateral attempts at improving the current situation (e.g. China's fishing ban), regulation of fisheries is dependent on a regional approach to the problem where all littoral (states) have to commit themselves to agree upon a limit to annual catches. The long-term effect of this development might lead to the break down of the ecosystem. Scientists of the region have published widely on the current situation of important ecosystems and of fisheries, they have attended numerous regional conferences, and they participate in government funded projects, but as the political will to pursue environmental policies, based on this knowledge, remains limited, as protection and management of South China Sea ecosystems is left to the individual state. Consequently, no political space is left for non-state actors, such as marine scientists, to influence in practice the development of the marine environment of the region.

(Source: Excerpted from Naess 1999)

- Increased risks of disease in commercially valuable stocks (aquaculture diseases affecting productivity and also infecting wild stocks are all widespread throughout the region);
- Inter-generational equity issues (access to resources);
- Human health impacts (child malnutrition, direct risks to blast fishermen, diving injuries to dive fishermen are all widespread throughout the region).

Conclusions and future outlook

For the GIWA concern of Unsustainable exploitation of living resources, 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 to non-existent enforcement, there is expected to be a significant environmental deterioration. This will be manifested mostly through overexploitation, lack of by-catch and discards, destructive fishing and changes in diversity, and with the potential for decreased viability of stocks, such that the level of environmental impact in 2020 is expected to remain as severe, and get worse than the current situation (Box 6).

Furthermore, all the socio-economic indicators are expected to deteriorate, with severe economic and social and community impacts and moderate health impacts associated with overexploitation of fish by 2020. This prediction may be ameliorated to some degree by improved enforcement of regulations (e.g. Philippines Fisheries Code, Chinese fishing bans in some areas) and through successful interventions by government and NGOs.

Most South China Sea nations recognise that fisheries are resources that are threatened if the current trend continues, but they also need the fishery products to feed their populations and to uphold industries based on fishery production (Naess 1999). East Asia was the fastest growing economic region in the world in the 1980s and 1990s, and also one of the most heavily populated. The governments have to provide food for their people, and seafood is the main source of animal protein for most Asians (two-thirds of the animal protein consumed in Asia comes from fish and crustaceans) (Coulter 1996). Thus, there is constant competition between socio-economic and environmental concerns, where the socio-economic concerns often win as food and economic income are more important to the individual and the government than sustainable use of coastal resources (Naess 1999).

It was the unanimous view of the GIWA Task team that the region's fisheries stocks, as with stocks in neighbouring Sulu-Celebes (Sulawesi) Sea and Indonesian Seas, are 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, and effective enforcement of fisheries regulations. There also needs to be more reliable stock assessment and monitoring, founded in improved understanding of the population biology of the target species and issues of ecological scale and connectivity in relation to replenishment. There is strong potential for well-planned mariculture of some ornamental and food species, with the need for development of appropriate policy and legislation.

Global change

The southern part of the marine region, with adjacent Indonesian Seas and Sulu-Sulawesi Sea, forms part of the "heat engine" of global atmospheric circulation, with complex ocean-atmospheric dynamics. The northern and central parts of the region are affected by typhoons during the southwest monsoon months, bringing destructive winds as well as intense rains in excess of 1 000 mm of rain in less than 1 week (Figure 17). The warm ocean and its links to the atmosphere contribute to the El Niño Southern Oscillation (ENSO) phenomenon. The influence of El Niño, La Niña and the Australian and Asian monsoons contribute to the unique climate conditions in this region, an object of global climatology research. The region also has complex oceanography and current flow (see Regional definition).

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 (SST). 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 sea level change, increased UV-B radiation and changes in ocean CO_2 source/sink function in the region.

Figure 17 Typhoon Imbudo over the South China Sea, 23 July 2003.
(Photo: NASA)

Environmental impacts

Changes in hydrological cycle and ocean circulation

Changes in the local/regional water balance in recent decades and increased variability of current regimes (including those caused by changes in ENSO events) have had slight environmental impacts. There is anecdotal evidence for changes in coastal currents and erosion patterns in Thailand and in oceanographic upwelling patterns following ENSO (e.g. Philippines) and hydrological evidence of changes in rainfall and storm patterns (e.g. Sabah).

Changes in sea surface temperature

Changes in the sea surface temperature has also had a slight impact already, with changes in the structure of coral reef communities from elevated SSTs during various coral reef bleaching events since 1983, notably during mid-1998. There has been good recovery of most bleached areas and, on average, none of the bleaching events appear to have been as severe as those from some other countries, with the caveat that most data are anecdotal (Wilkinson 2000, 2002).

Socio-economic impacts

The socio-economic impacts associated with Global change, as they relate specifically to international waters, are negligible to slight, with a major degree of uncertainty remaining. There have been some economic and health effects associated with drought and linkages to habitat loss (clearing and forest fires) and freshwater shortage, particularly overextraction of freshwaters and salination of wells. Health effects include potential links to dengue and haemorrhagic fever and respiratory illnesses from haze and forest fires, with some displacement of communities due to fires and floods.

The following key socio-economic indicators are likely to be adversely affected to greater or lesser degree:

- Freshwater availability;
- Food security;
- Employment security;
- Changes in productivity of agriculture, fisheries and forestry;
- Changes in resources distribution and political jurisdiction;
- Response costs for extreme events;
- Loss of income and employment;
- Loss of incomes and foreign exchange from fisheries;
- Loss of opportunity for investments (both domestic and foreign);
- Increased costs of human health care.

Conclusions and future outlook

According to Talaue-McManus (2000 and pers. comm.) there is sufficient evidence of major environmental changes resulting from global climate change in the region. While the socio-economic impacts are yet to be evaluated, their signature on SSTs as well as long term changes in air temperatures and on atmospheric chemistry are unequivocal. Nevertheless, assessing the impacts of Global change using the GIWA scoring criteria determined that this concern had only slight overall environmental impacts at the time of the assessment. Environmental impacts are expected to deteriorate, but remain slight by 2020. There are increasing per capita releases of CO_2 and the increasing population will increase local production of greenhouse gases. However, there is considerable uncertainty in climate model predictions of changes in temperature and sea level, and also in the capacity for acclimation and adaptation of species and ecosystems. Corresponding socio-economic aspects are also expected to deteriorate, with moderate levels of economic impact and other social and community impacts and slight health impacts by 2020.

Priority concerns for further analysis

Future scenarios suggest a rapid human population increase, with increasing urbanisation and increasing reliance on industrialisation and extractive industries. This population explosion is driven primarily by socio-cultural and religious attitudes, and influenced by factors as diverse as world trade, tourism, industrialisation, fisheries, and oil exploration and exploitation. The region's rapid economic development and population growth are the cause of significant ecological damage in coastal and marine areas. The primary environmental threats by humans in the South China Sea are the destruction of mangrove forests, sewage pollution, exploitative fishing practices and overfishing, coral reef degradation, and damage to seagrasses and wetlands (LME 2004).

There are likely to be significant increases in industrial fishing and aquaculture (shrimps, seaweeds) in the region. Exploitation of commercial pelagic fisheries for tuna and billfish is expected to increase by 2020. The increasing reliance on motorised fishing craft and major increase in industrial fishing is expected to cause severe overexploitation with decreasing production from coastal and reef fisheries, and concomitant food shortages. Regulating fishing pressure provides a complex management challenge, with important linkages to the application of Marine Protected Areas (MPAs) in stock replenishment. Future protection of coastal and coral reef areas will be important if these key habitats at the global centre of biodiversity are to be sustained.

There are trends of increasingly large-scale forestry, by both national and international commercial operators. Large areas of the 'loggable forests' have already been logged and other areas have been assigned for logging, contributing to severe soil erosion in many areas. 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.

There is potential for expanded offshore oil and mineral exploration, and increased tanker traffic through South China Sea between Japan and the greater Pacific Ocean and the Indian Ocean - west Asia-Europe, with attendant risks of collisions and spills (Etkin 1997, MPP/EAS 1998, Chua pers. comm.).

Expansion of fisheries, mining, various forms of plantation agriculture and forestry, increasing urbanisation and manufacturing will further increase pressures on catchments and rivers, and increasing water shortages are likely to impact on a large proportion of the population. There will be limits on other sectors from freshwater shortage and other concerns. Thus, 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 areas face moderate to severe environmental impacts causing severe socio-economic hardship by 2020. Despite recent improvements in national and regional capacity, there remains insufficient 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. There are already serious health issues arising from episodic freshwater shortage. The rate of deterioration can be minimised by on-going and future planned interventions, including those at multilateral, 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 international waters-related issues.

For the present, six of the 23 environmental GIWA issues are already having severe impacts:

- Suspended solids;
- Loss of ecosystems;
- Modification of ecosystems;
- Overexploitation of fish;
- Excessive by-catch and discards;
- Destructive fishing practices.

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:

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

These findings are consistent with those of the UNEP Transboundary Diagnostic Analysis (TDA), which rated habitats (mangroves, coral reefs, seagrasses and estuaries) and marine and freshwater fisheries as the highest priority concerns, followed closely by pollution (sewage and freshwater contamination) and freshwater concerns (Talaue-McManus 2000). Thus, these two large-scale analyses (TDA and GIWA), using different approaches, have concurred on the key international waters concerns in the region. Both analyses confirm that the international waters environment and socio-economy of much of the South China Sea are already under severe impact, requiring continued concerted national and international intervention for any chance of amelioration in the short to medium-term.

There is expected to be deterioration in the environmental and economic impacts of most GIWA concerns, but with some stabilisation and even improvement in others, notably for health and other social and community aspects. There is also expected to be widening gaps in both implementation and success of interventions among different countries.

With equal weighting applied to the four indicators, there was little overall change in scores or ranking for the future:

1. Unsustainable exploitation of living resources.
2. Habitat loss and community modification remain jointly of primary concern and are expected to have severe environmental and mostly moderate to severe socio-economic impacts.
3. Freshwater shortage ranked third and is expected to have moderate environmental and socio-economic impacts.
4. Pollution is also expected to have moderate environmental and socio-economic impacts and is ranked fourth because there will be an increase in pollution-mitigation projects in the region.
5. Global change, with slight to moderate impact, ranked fifth.

Future impacts from Global change were sufficiently uncertain for it to rank 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 is expected to impact on freshwater shortage and oceanography and on habitat loss. Other two-way linkages with high potential for 'feedback' will occur between freshwater shortage, pollution and habitat loss and between habitat loss and overexploitation of fish. Global change effects on freshwater shortage are likely to be manifested through changes in the frequency and intensity of ENSO events. ENSO during the 1990s caused water shortages in some parts of the region and flooding in others. Future predicted increases in both the frequency and intensity of ENSO events are likely to have major environmental and socio-economic impacts, particularly given that the human population is expected to double by 2033. 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, Wilkinson 2000, 2002). There are also expected to be severe consequences from complex linkages between habitat loss and fisheries, and pollution and fisheries. It is expected that environmental and socio-economic impacts of climate change will increase after 2020.

The following cuasal chain analysis will focuses on the linkages between Habitat and community modification and Unsustainable exploitation of living resources, particularly the environmental and socio-economic impacts and causes of overfishing and destructive fishing practices.

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details on the methodology, please refer to the GIWA methodology chapter.

The Causal chain analysis focuses on the linkages between the two GIWA concerns Habitat and community modification and Unsustainable exploitation of living resources, particularly the environmental and socio-economic impacts and causes of overfishing and destructive fishing practices. The causal chain diagram illustrating the causal links for Habitat and community modification and Unsustainable exploitation of living resources is shown in Figure 18.

The overall setting for the following analysis is summarised by Naess (1999) (see Box 7).

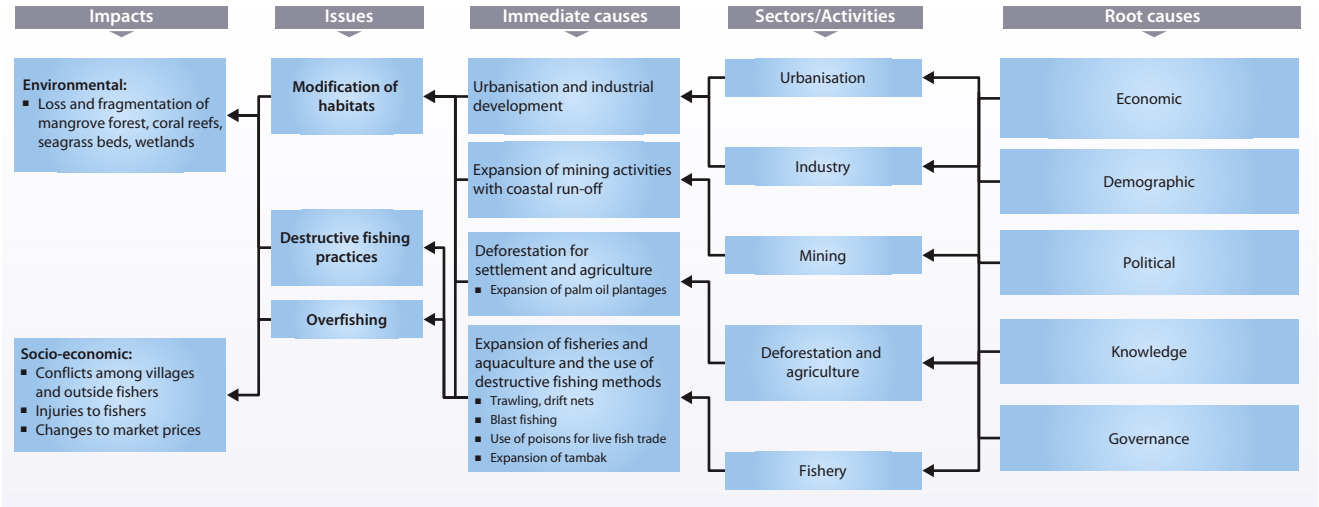

Figure 18 Causal chain diagram illustrating the causal links for Habitat and community modification and Unsustainable exploitation of living resources in the South China Sea region.

Box 7 Transboundary disputes in the South China Sea region.

More than 70% of the population in the South China Sea area live in coastal areas, and their dependency on the sea for resources and a means of transportation is high. Fisheries in the Southeast Asian region represented 23% of the total catch in Asia, and about 10% of the total world catch in 1992. At the same time, high economic growth is overshadowing environmental problems like overfishing, destructive fishing methods, habitat devastation and marine pollution. The environmental security aspect is therefore pertinent. High economic growth, often coupled with depletion of natural resources, intensifies conflicts like the one in the South China Sea. The fact that the area is rich in marine resources, and potentially rich in oil and gas, are some of the reasons why the claimants are aggressive and stubborn in their claims and political rhetoric. The environmental security concept refers to a field of research where the relationship between security issues and environmental issues is in focus. Increasing transboundary environmental problems generated by economic growth and a lack of commitment to protect and manage marine resources need integrated political action between the countries of the region. Fisheries make a good example. Their high economic value and the fact that seafood is the main source of animal protein for a rapidly growing coastal population, have made countries around the South China Sea publicly exhort their fishermen to venture into disputed waters to catch fish. This has resulted in a number of incidents, notably within the disputed Spratly area. Illegal fishing, overfishing, and poaching of rare species are not an exception, but the norm. In this case, the 'ASEAN way' represents an impediment to establishing regional regulatory instruments. While fish stocks are being depleted, and the ASEAN member states recognise the need for conservationist programmes, they continue to implement production-oriented policies and encourage their fishermen to catch more and more living resources.

(Source: Excerpted from Naess 1999)

Environmental and socio-economic impacts

- Loss and fragmentation of mangrove forests from development, including conversion for aquaculture;
- Loss and fragmentation of coral reefs from coastal development, sediment pollution etc. (Figure 19);
- Reclamation of wetlands for urbanisation, industry and agriculture;
- Loss and fragmentation of seagrass areas;
- Conflicts among villagers and outside fishers;
- Injuries to fishers;
- Changes to market prices.

Immediate causes

Urbanisation and industrial development

The countries bordering the South China Sea are undergoing intensive economic development, despite the Asian financial crisis of the late 1990s. The high population growth and population density has made the region a focus for the location of manufacture, and many multinational companies have relocated to the Southeast Asian region seeking to reduce labour costs. Political stability and low infrastructure costs, as well as a favourable climate for investment in a poorly regulated and easily manipulated financial environment assist the growth of industry. This in turn contributes to growing urbanisation, as workers are drawn from the lowly paid rural occupations to the comparatively better paid urban industries. This is especially true of young women who make up much of the industrial working-class.

Poorly regulated development of industry, and the overcrowding that results from intensive resettlement near industrial areas, or within industrial dormitories, has had a detrimental effect on local environments. Wetlands have been reclaimed, many are poorly drained and subject to seasonal flooding, and mangrove forests have been removed in order to gain access to cheap land close to cities and the coast.

Expansion of mining activities with coastal run-off

As with industrial development, the growth of mining has resulted in the alteration of the coastal environment. Coral mining for building and making of cement is common, and the need for sand and gravel has been stimulated by the development of urban and industrial growth. Changes to the flow of rivers have been significant and siltation of river systems is common.

Deforestation for settlement and agriculture

The growth of the population in coastal Southeast Asia and the simultaneous growth of an affluent middle class have stimulated the demand for high quality timber for use as furniture and in building. Old growth rainforest timbers are especially prized, both in the region and abroad. With the rise in rural populations has come the need to expand agricultural areas to provide food for growing populations. The demands of the urban middle-class are also changing with the importation of western packaged foodstuffs and the fashion for American foods. This has means that more land has been given over to the production of varieties of food, not just staples.

Expansion of palm oil plantations

Palm oil plantations have increased in area right throughout the Southeast Asian and Pacific region. Coconut plantations and virgin coastal wetlands are now increasingly being removed and replaced by the more economically profitable oil palms. These are closely planted and the undercover areas are often dark, mosquito-infested and home to feral animals and pests, including snakes and rats. The land also becomes covered in refuse and palm branches and has a tendency to become sour. Plantations are often close to, or in, watercourses and coastal lowlands.

Figure 19 Islands and fringing reefs near Singapore showing a golf course and road development.
(Photo: J. Oliver, ReefBase)

Expansion of fisheries and aquaculture and the use of destructive fishing methods

The growth of coastal populations, the high demand for fish as a source of protein (particularly needed by poor coastal populations) and the demand for high quality large fish for the luxury and tourist markets have all stimulated the rapid expansion of fisheries. There has been recent major expansion in large foreign capital commercial operations and mariculture, notably the development of the live fish trade. The live fish trade, where fish captured from regional waters are transported to large holding cages, sometimes in international waters, before shipping to the luxury market in Hong Kong, Singapore and China, provides improved, but still negligible returns for local fishers. Blast fishing, trawling and other destructive fishing techniques are 'endemic' in the region, including within MPAs, and have caused massive destruction to coral reefs (e.g. Hon Mun MPA, Vietnam) (Vo et al. 2002).

Trawling, drift nets, use of mechanised push nets by commercial operators

The intensive use of large-scale fish nets has been a major component in the overexploitation of fish and destruction of habitats in the South China Sea. Trawlers and drift net commercial operators are often part of foreign fishing fleets that are not based in the region and do not market products in the region. The value-added component of the industry, services, labour, accommodation, fuel and equipment supply, is also sourced away from the region, generally in north Asia. The region therefore suffers the effects of declining resources and environmental quality with few if any economic benefits, either short- or long-term.

- Trawling is a high capital industry, numbers of trawlers are not regulated and activities are not monitored. The result is widespread environmental damage.
- Large drift nets are a major environmental threat. Nets may be several kilometres long and many metres deep and trap virtually all

pelagic animals. When they are abandoned or lost, they drag over the bottom and collect any benthic marine organism regardless of size, protected status or possible economic use and continue to trap animals drawn to the trapped carcasses.

- Push-nets, nets attached to large poles spread from the front of a boat, scour the ocean bed and effectively remove bottom dwelling organisms. The three forms of netting over time can denude large productive marine areas.

Blast fishing by artisanal, small-scale commercial operators

In order to compete in a declining, overexploited market, local artisanal and small-scale commercial fishers are reverting to the use of explosives rather than line fishing (Figure 20). Blast fishing stuns all fish in the immediate radius of the explosive charge and these fish can then be gathered from the surface of the ocean; other organisms are shattered and die on the bottom. Fish caught using this method can be identified at the market by the glassy state of their eyes but are often sold cheaply due to size, type and quantity.

Figure 20 Damaged corals, North of Pulau Gut, Malaysia.
(Photo: B. Huzaimi, ReefBase)

Use of poisons by commercial and small-scale operators for live fish trade

Reef food fishes and ornamental aquarium fishes are frequently caught using cyanide and other poisons. The immediate effects are not noticeable, and as the market depends on a speedy delivery from fisher to market and diner, the final consumer is unaware of the method of catch. The aim of the live fish trade is to provide large fish, preferably species that are red or blue in colour (signs of good luck) quickly and cheaply. The diner however, is charged a considerable mark-up for the supply of fresh, live swimming marine organisms.

Expansion of tambak

Tambaks are small prawn and fish ponds built in mangrove areas, and are a popular means for increasing local fish production. However, the use of tambaks is not controlled and the water in most ponds is only cleaned and aerated by tidal action. The tambaks generally last only one or two seasons unless there is careful management of the water and walls; the ponds are then neglected and the area becomes useless for long periods. Many coastal mangrove forests have been lost to the construction of poor quality tambaks.

Root causes

Economic

Economic growth

Negative aspects of increasing economic growth have placed high pressures on the environment. While the financial and social stability of the Southeast Asian region have been welcomed after decades of stagnation and political crises, the management of the terrestrial and marine environments has been neglected.

Foreign aid

High levels of foreign aid have been expended in the South China Sea region, particularly as support for poverty alleviation programmes and infrastructure development (e.g. following the Vietnam War). Industrialisation is capital intensive, as are programmes to improve agricultural productivity and fishing efficiency. The region remains a focus for international aid. These programmes have both positive and negative aspects: production and employment have been increased; living standards for the general middle classes have improved; education and health facilities are comparatively high; but the overcapitalisation of fisheries has meant that high operational costs have forced fishers to seriously overfish, particularly in the inshore regions.

Market demand

Local and international market demands have been important in driving the exploitation of resources that have resulted in the destruction of habitats and community modification. A key example is the rapidly increasing demand for high quality, expensive fish and seafood, a product of rising living standards and the growth of the affluent middle-class in Southeast and East Asia.

Export pressures for forest products - building materials

Market demand, both local and international, for high quality rainforest timbers, is driving the forestry industry to use clear felling techniques.

Companies, some being Malaysian in origin, are now establishing operations as far away as Papua New Guinea where forests are relatively pristine. Economic pressures are driving this approach and most of the high quality material is exported as manufactured furniture or as sawn timber. The results are loss of ecosystems, reduction of native forests and erosion following the heavy wet season rains. Many of the rainforest areas that have been modified or destroyed are located in fragile environments, frequently mountainous with seasonally high rain, tropical storms and generally shallow soils.

Export pressures for fisheries products, aquarium trade and alien species

Economic growth, increasing prosperity and changing cultures have altered export market demand for diversity of fisheries foodstuffs. This has increased the exploitation of alien species once reserved for festivals or eaten by the richer members of local societies. In coastal communities, especially those marginalised by economic development, negative social attitudes, or lacking access to regional infrastructure, the pressures on marine resources are considerable. Poor communities still rely on catches of small fish, shellfish and animals collected by gleaning and strand gathering.

Increasing market demand in the live reef fish food trade has caused expanded use of large cages, in both national and international waters, as holding pens for live fish. The collection of fish by mother ships for rapid transport to markets in Singapore, Hong Kong and other wealthy centres supports the development of the industry. Many aspects of the fishery are in contravention of local and national regulations, but continue because of inadequate policing, lack of governance, local and regional corruption, and declining infrastructure.

The foreign aquarium trade that relied on the supply of high quality small ornamental reef fish to international markets is also highly profitable. The increasing popularity of live coral aquaria around the world increases the demand for particular, mostly colourful, species. This has contributed to changes in species composition/abundance, ecological structure and function of coral reefs that are closely targeted.

Overcapitalisation, technology 'creep', stock targeting

The commercial fishery in the South China Sea is overcapitalised and depends on rapidly changing technology in order to keeps boats at sea for longer periods as well as specialised computer aids for locating shoals of species highly prized by the market. This has led to excessive stock targeting of particular species of fish, especially those in high demand. Overcapitalisation, subsidies (national/international) to increase fish catch through improvement of gear, with increasing effort, and little or no consideration for long-term sustainability is widespread (e.g. in the Philippines there has been gear improvement but no consideration of habitat or stock sustainability). Competition among different fisheries sectors to continually increase catches usually overrides efforts to sustain fisheries.

Political

Military influence

The region has a high military presence, due to long periods of political instability, and the military in all countries have considerable political influence. China, to the north, exerts considerable influence in all regions of Southeast Asia and has growing economic power. Territorial disputes (e.g. Spratly Islands) with military involvement have contributed to the failure to implement ameliorative policies addressing habitat loss and overexploitation (e.g. establishment of a multilateral MPA network including Spratly Islands).

Demographic

Overpopulation - migration to cities

Rapid population growth and migration of rural populations to the large commercial and industrial cities of the region is a common aspect of social change in the last 20 years. The cities are centres of health, education and employment infrastructure and the rural poor have little opportunity to access a better quality of life in the provinces that have often been neglected by the urban-based bureaucracy and wealthy elite.

Most of the impacts and their immediate causes (poor management of agriculture, forestry, coastal fishing pressure and exploitation of inshore resources) are exacerbated by population growth and migration. Throughout the region, there has been significant settlement on 'marginal' lands in recent decades; coastal wetlands are often the only available land for the landless. It can be expected that this will continue. The recent purges of transmigration settlers by local inhabitants in Indonesia is only one example of the consequences of internal forced migrations.

Poverty - limited access to other forms of livelihood

Poverty, overpopulation and the limited access to other forms of livelihood for the rural subsistence farmers and workers are all factors that continue to impact on the overexploitation of inshore fisheries and other living marine resources. Almost everything from the sea will be eaten or otherwise used, unless it is harmful. Biodiversity, protection of native stocks and environmental management are complex questions

to explain to people who are at subsistence levels reliant largely on their immediate environment for food.

Knowledge

Perpetuation of environmentally damaging traditional practices exacerbated by a lack of awareness of environmental change

At village and local community levels, traditional practices are still highly regarded, with both positive and negative effects. In regional Indonesia, for example, the Adat laws are still powerful and regulate daily life in villages. Awareness of the holistic nature of contemporary environmental management and broader issues such as climate change, overexploitation of marine resources, poor management of terrestrial soils and vegetation, and disposal of garbage and human wastes are still inadequate. Although the people are not ignorant, they need to be reached in ways that do not imply lecturing by government bureaucrats or foreign experts, and local attitudes and opinions must be considered. In many cases, the education resources are not available at a level of instruction suitable for regional communities that often have poor literacy and speak dialects.

Governance

Lack of political will, poor governance, inadequate regulation, multilateral/inter-sectoral disputes

Lack of political will, combined with inadequate legislation is a major driving force behind environmental degradation. Political structures in Southeast Asia are still dominated by hierarchy and patronage and democratic decision-making is not a feature of most policy making, even in countries with reasonably open electoral systems. The political and educated elite have extremely high levels of power in most regional societies.

Widespread, ineffective governance leads to the growth of corruption. This is endemic in many nations of the region. Bureaucratic inaction, lack of financial resources and a general mistrust of government officials at village levels makes it difficult to obtain accurate statistics on issues such as resource exploitation. Regional language differences, lack of education standards and complex notions of quantifying catch in provincial areas are also issues to be overcome in attempting to rectify the problems of overexploitation of marine resources.

Control of commercial fisheries by the operators in circumstances of poor governance and inadequate regulation foster the continuance of poor management practices. There is limited, generally ineffective, fisheries regulation and enforcement in the marine states of the region, as the resources required to maintain surveillance and effect prosecution of offenders is prohibitive.

All forms of natural resource exploitation are subject to considerable manipulation by bureaucratic agencies and entrepreneurial groups with vested interests in expansion of industry and wealth generation. Poor governance, which impacts on inadequate legislation, lack of management expertise and financial resources, and political interference in decision-making, has meant that environmental management programmes have often fallen short of their planned targets.

Efficient environmental management in Southeast Asian nations is still in its infancy. Fisheries management lags behind terrestrial environmental management. The large-scale nature of the commercial fishing industry means that it can manipulate government and bureaucracy and the consequent lack of incentives on the part of both industry and government to change the situation makes it possible for inappropriate practices to continue (Box 8).

In relation to management systems, major improvements are required in relation to:

- Lack of feasibility assessment (or EIA) in developing new fisheries, stock assessments and data for planning and managing fisheries;

Box 8 Committments to multilateral programmes.

Although an Action Plan for the East Asian Seas was agreed upon as early as 1981, this plan has had minor effects on the South China Sea region, because of a lack of commitment by the signatory states to fund and undertake activities in accordance with the initial idea of the plan. Initially, only the five original ASEAN members joined the Coordinating Body on Seas of East Asia (COBSEA). Thus the scope of the East Asian Seas Action Plan was limited. This is not to say that nothing has been done regarding environmental problems, it is rather that the management of common resources depends on the individual state, or a sub-regional group of states. Numerous sub-regional projects have been established without help from the COBSEA, for example the Asian Development Bank's Coastal and Marine Environmental Management in the South China Sea project, involving Cambodia, Vietnam and China; and the Malacca Strait Co-operative Programme, established by Singapore, Malaysia and Indonesia. In addition to these three, a sub-regional programme on the Gulf of Thailand, including Malaysia, Thailand, Cambodia and Vietnam, seems to be on its way with help from the Southeast Asian Programme in Ocean Law, Policy and Management. Although there is a lack of a binding environmental agreement among South China Sea littoral states, ASEAN has achieved a lot in terms of bringing the ASEAN member states together in maritime environmental projects. The ASEAN Subcommittee on Marine Science (ASCMS) and the ASEAN Senior Officials on Environment (ASOEN) have been responsible for cooperative projects with Australia (the ASEAN-Australia Marine Science Programme), Canada (ASEAN-Canadian Marine Pollution Programme), the USA (ASEAN-US AID Coastal Resources Management Programme), Japan, the Republic of Korea, and the European Community. Most of these projects have come about as a result of cooperation among marine scientists, decision-makers and foreign aid agencies.Other projects have been established with help from NGOs, IGOs or international aid agencies. Various UN organisations have sponsored marine scientific research projects like the UN-ESCAP Regional Mineral Resources Development Centre and UNESCO's major Inter-Regional Project on Research and Training on Integrated Management of Coastal Systems (COMAR) in Asia-Pacific. An influential NGO is the International Centre for Living Aquatic Resources Management (ICLARM, now WorldFish Center), which has sponsored a range of activities, from conferences and workshops on waste management and marine pollution management, to the establishment of important databases like FishBase, ReefBase, etc. The Asian Development Bank (ADB), with assistance from the Swedish International Development Cooperation (Sida), has been managing a project since 1993 called Coastal and Marine Environmental Management in the South China Sea. The project aims at improving Vietnamese, South Chinese and Cambodian capabilities in coastal environmental management, and has succeeded in bringing the two ASEAN countries and China together.

(Source: Excerpted from Naess 1999)

- Introduction of management schemes by international 'experts' with no local knowledge;
- Top-down decision making systems;
- Little complementarity/communication across fisheries sectors in most nations (e.g. Thailand where there is some complementarity);
- Insufficient transboundary communication on fisheries statistics, planning and management, although FAO, ICLARM, UNEP-GEF and APEC fisheries advisory group among others, are working towards improving this;
- Insufficient collective vision for sustainability of fisheries e.g. 'Tragedy of the Commons' at local, national and regional levels;
- Permit issues: Some areas are not well defined in terms of necessity for permit (e.g. Spratly Islands, Sulu Sea) and foreign boats overexploit resources. In other areas, foreign boats gain permits to fish then overexploit resources, particularly in some MPAs. This can lead to tensions from local and international competition.
- There is a general lack of data, which contributes to the management difficulties (see Assessment, Overexploitation);
- There is endemic corruption, including the illegal selling of permits/licenses, and production of fake permits (e.g. Taiwanese boats 'registered' in Indonesia).

These all contribute to the lack of management control of exploitation of natural resources and development of capacity in the region.

Conclusions

The key root causes of Habitat and community modification and Overexploitation, and indeed of most other international waters-related issues, were easily identified and almost axiomatic throughout much of the region. However, addressing these root causes will continue to be extremely difficult. The rule of law is being steadily eroded in many areas, with endemic corruption among enforcement agencies and legislature, and there has been insufficient commitment and progress in effective implementation of multilateral treaties and agreements (Box 8). Thus, by 2020, the predicted population increase is expected to cause a moderate increase in impacts and pressures despite improved technical, policy and regulatory changes, surveillance and enforcement of regulations.

Policy options

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

Definition of the problem

The policy analysis for the South China Sea region is, like that for the related region of the Sulu-Celebes (Sulawesi) Sea (GIWA region 56), greatly complicated by the complex interaction of national and regional jurisdictions. There are many transboundary issues that remain unresolved due to the aftermath of regional conflicts, colonial heritage and international political affiliations. Within this unique transboundary milieu, the concept of sustainable development has many interpretations: economic development is a leading feature of national planning is all countries of the region and environmentally sustainable development is often a minor component within government policy.

If the South China Sea is compared with other semi-enclosed seas like the Mediterranean, Baltic, and Caribbean, it is apparent that the South China Sea lacks formalised cooperative instruments that integrate and coordinate efforts by littoral states at managing and protecting the marine life, and regulating marine economic activities (Naess 1999).

The nations of the South China Sea region have not established effective conventions or legal frameworks for common governance of the marine environment. Of the multilateral treaties and conventions already in place, there has been insufficient implementation to date. Fisheries, ecosystems, shipping and pollution are all regularly discussed in meetings among scientists and at various levels of government and inter-governmental meetings (e.g. ASEAN), but the attempts at addressing these important questions multilaterally remain elementary.

The few attempts at bringing the littoral states together in creating regional regimes by UNEP, and also by individual ASEAN member states, appear to run into difficulties as proposals for cooperation are often blocked by one or several states; often because of economic or other selfish state interests. As pointed out by Naess (1999): "The states around the South China Sea have not clarified their claims to maritime zones in accordance with the provisions of UNCLOS … regardless of the political situation. The use or abuse of international law will have important effects on all claimants, and how the LOS is interpreted and implemented in the South China Sea has and will have important implications. Almost everything remains to be done in terms of implementing UNCLOS".

The following Policy options analysis seeks approaches that will address these issues and are suggested to assist government thinking on the search for national and regional solutions.

Construction of the policy options

The initial step in construction of useful policy options is definition of some key present deficiencies and needs, as detailed above and below.

While the Philippines, Malaysia and Indonesia have adequate environmental legislation to overcome many of the issues and concerns affecting their waters in the region, other nations, such as Vietnam, Cambodia and China, have inadequate environmental regulations and operate political systems that do not participate as freely in multilateral environmental coordination. Capacity building is a major issue in the region at all levels.

Thus, at both international and national levels, there is a wide range in the processes and capacity for policy development (and enabling legislation) to address resource management and protection. Furthermore, in all nations of the region, there are inefficiencies related to the transfer and application of international and national legislation at provincial and local levels. The national and provincial laws relevant to different sectors such as fisheries, mining, forestry and environmental protection, are also not fully integrated. Some legislation does not refer specifically to particular sectoral or environmental systems, thereby causing uncertainty in the application of legislative instruments. This has caused confusion over which laws have priority, responsibility for management, and the rights of stakeholders and interest groups. Furthermore, some government departments are hampered by a lack of qualified and experienced staff, and also by funding short-falls and cut-backs. There is widespread lack of awareness and acceptance of most laws, and lack of compliance with regulations. There is also insufficient capacity for enforcement of regulations and quotas (Box 9).

Box 9 Approaches to managing the South China Sea.

In the South China Sea, so far, there has been no integrated, formal approach to management of resources. The lack of a formal agreement means that there is no regulation of fisheries, no regional regulation or cooperation in combating pollution. Overlapping claims to maritime zones make it impossible to decide which state is responsible for environmental protection and management, and there is no sense of any temporary shared responsibility although many speak of joint development or joint management. This sounds very much like a situation that Garrett Hardin (1968) named the 'Tragedy of the Commons'. As the South China Sea is not partitioned according to the UNCLOS in Exclusive Economic Zones (EEZ), where the individual state has the jurisdiction to the resources that exist within the zone, large areas of sea, and especially the living resources in these areas, are left to the ones who manage to catch them. This means that one littoral state has the opportunity to exploit and deplete the living resources that actually belong to all the littoral states in the area. According to Oran Young (1994), there are roughly three ways to regulate this problem. One is to solve the sovereignty question with reference to ideas developed in UNCLOS. Normally, this would lead to a delimitation agreement between all claimants on how to define the limits of EEZs and solve the question of sovereignty to islands. This is not very likely to happen in the near future. A second solution is to establish a joint development zone in the disputed area, share the cost and responsibility for development and divide the benefits of resource exploitation between themselves. This is what China and Taiwan have suggested in principle since 1993, without, however, presenting any concrete proposals. No joint development zone is likely to be established in the near future. China's understanding of joint development also seems to imply that the other participants must negotiate bilaterally with China, not multilaterally. The third option is to create a regime or formalised agreement where all states in the region join forces to set up a joint management regime (fisheries regulation, environmental protection and marine scientific research) while abstaining from drilling oil and gas.

(Source: Excerpted from Naess 1999)

Policy deficiencies and needs

- Insufficient information transfer and linkages among science, policy and management;
- In many cases fisheries legislation adopts a single species approach, rather than managing multi-species, with compounding lack of consideration of trophic level effects;
- Lack of fisheries habitat protection across and within fisheries sectors (gear type, effort, MPAs, no take zones);
- Lack of consideration of threatened/endangered species status and compounding lack of data;
- Lack of clear inter-sectoral demarcation of responsibility (e.g. mangrove management versus fisheries versus aquaculture versus construction);
- Low enforcement capacity;
- Problems in national and local interpretation of international conventions and data (e.g. UNCLOS, CBD, MARPOL, CITES for smuggling stocks of sharks, migratory species, transboundary straddling stocks);
- Maritime limitations in relation to EEZ, continental shelf boundaries and UNCLOS;
- Lack of regional conventions and adherence to obligations/ coordination among nations in international conventions;
- Lack of partnerships and urgent need to implement transboundary approaches in stocks management;
- Lack of policy development to provide alternative livelihoods;
- Lack of policy development for sustainable financing of management;
- Insufficient communication across government departments/ agencies in terms of coordination of fisheries and MPAs etc.;
- Urgent need to address pressures and investment on lower trophic level fisheries because upper levels are already overexploited;
- Urgent need to expand community-based sustainable management approaches more widely;
- Urgent need to develop more equitable distribution of benefits and address the loss of benefits to local stakeholders;
- Urgent need to develop better fisheries security against poaching;
- Urgent need to develop stronger political will for habitat protection and fisheries sustainability;

- Urgent need to increase assertiveness of international funding agencies in terms of implementation of policy;
- Urgent need to develop better conduits for getting research findings into policy and collaboration;
- Urgent need to increase coordination and cooperation across agencies (e.g. use of navy vessels in research, and an enforcement 'green navy')
- Urgent need to develop transboundary, international approaches to policy analysis, an essential factor in determining policy issues and future options (Box 9).

Integrated, multilateral environmental conservation and development is a requirement for the success of any future policy development, as policies must conform to international multilateral conventions, treaties and obligations. Regional government support and cooperative inter-sectoral and jurisdictional agreements are factors in the success of any forward planning. However, regional cooperation concerning the use and overexploitation of the marine resources of the South China Sea region is still limited in scope.

The major policy factors relating to a lack of progress are poor governance, lack of human and fiscal resources, and social issues such as high population growth, poverty and large-scale urban development. Environmental management and education are still generally poor. Scientific understanding, monitoring and surveillance of regional fisheries activities is limited; the enforcement of laws is even more difficult in such a diverse, complex and multi-jurisdictional environment.

Furthermore, the influence of scientific research on the political process in the South China Sea is not straightforward (Naess 1999). Research findings rarely speak for themselves, and whether the decision-makers consider scientific advice to be important or not depends on several conditions. In this process, science can be 'contaminated' by political

Figure 21 Pulau Redang Marine Park Center, Malaysia.
(Photo: J. Oliver, ReefBase)

agendas, if political factions or governments use professionals as a means for promoting their political agendas (Andresen et al. 1994, Naess 1999). Because the claimant states regard the resources of the South China Sea as affecting vital national interests, the trust given to expert advice can be presumed to be extremely limited when such interests are at stake (Naess 1999). Thus overcoming state self-interest is of crucial importance.

At the broadest policy development levels, recommendations for improvement include implementation of an integrated multi-national conservation and development approach for the South China Sea, complemented by an effective strategy to address multilateral and international obligations under the various conventions and treaties. As each of the nations has signed UNCLOS, and all except Cambodia and Thailand have ratified it, the states are obliged to take into consideration the terms of the Law of the Sea regime. In particular, the emphasis should be on states to endeavour to cooperate directly or through a regional organisation to manage the sea together, to coordinate scientific research policies and to coordinate implementation of rights and duties under the convention (Article 123 UNCLOS 1982, Thayer 1999, Naess 1999).

However, at the national level, the multiplicity of agencies dealing with the maritime environment, and an apparent lack of interest at the highest political levels, make efficient and integrative ocean policy development and implementation almost impossible (Naess 1999). This problem has accumulated on the regional level, where no agency exists that can coordinate efforts at improving the maritime environment. The ASEAN institutions and non-ASEAN institutions that operate in the region are not coordinated at the regional level (Papoyo 1996).

As noted above, there is a wide range among South China Sea nations in the adequacy of both policy and enabling legislation to address the key concerns analysed in this assessment. Most nations are already parties to the key international conventions and treaties. What is currently lacking is multilateral coordination and capacity to apply the existing legislation and to review and amend the legislation to improve its functionality, particularly cross-sectorally. It is particularly important to ease tensions arising from sovereignty and jurisdictional disputes over the Spratly and Paracel Island groups, and ocean space adjacent to the littoral states. This approach is compatible with the regime for semi-enclosed seas as set forth in UNCLOS 1982 (Dr. Hasjim Djalal and Prof. Ian Townsend-Gault, quoted by Naess 1999).

In this regard, improved policy can only succeed with the following support structures in place:

Figure 22 School of silverside (*Atherinomorus* sp.) near surface, Cagar Hutang, Redang Island, Malaysia.
(Photo: B. Huzaimi, ReefBase)

- Consolidation of national laws and multilateral agreements to encompass all sectors;
- Improved coordination in management across sectors and levels of governance (local, national and multilateral);
- National and international surveillance strategies, with participation from all levels of government, NGOs and local communities;
- Much-improved enforcement;
- Improved transparency in governance/policing, with stronger anti-corruption legislation and enforcement;
- Ongoing and expanded community education programmes;
- Improved options for the generation of alternative income and ecologically sustainable livelihoods for the burgeoning poor of coastal populations, particularly among the fisheries sectors.

This framework is crucial in bridging the gaps between policy formulation, development of legislation and enforcement of regulations (Box 9). As Talaue-McManus (pers. comm.) notes: "Tracing root causes is important in highlighting the bigger socio-economic and political contexts with which to view environmental problems. However, it becomes counterproductive to orient policy options to only the root causes, as these will not be doable within 10 times the lifetime of any project or initiative. What then becomes crucial is breaking the policy options into doable segments, addressing both immediate and intermediate causes and cognizant that significant changes could be achieved if these were implemented even if the root causes remain."

Identified policy options

Five policy recommendations and eleven strategic actions are proposed as relevant to implementing immediate interventions.

Key policy recommendations

The key policy recommendations include the development and expansion of:

- Institutional and capacity-building, including establishment of inter-governmental mechanisms;
- Information, education and communication networks;
- Functional, integrated network of marine protected areas founded in focused, applied research;
- Alternative, sustainable livelihoods for poor coastal populations;
- Bio-physical (biodiversity) and socio-economic research focused on improving management effectiveness and efficiency.

Key strategic actions

The key strategic actions include:

- Prioritise key data and information required for developing and refining policy, legislation and interventions;
- Build and expand partnerships at local, provincial, national and multilateral levels, in government, NGOs, and the private sector, in Research and Development and implementation;
- Ensure equitability and ecological and economic sustainability in future resource exploitation, including protection of intellectual property and traditional knowledge;
- Gather responsible fisheries authorities together with expertise from national and international academic and research institutions to adequately assess the state of fisheries in territorial waters;
- Develop regional agreements on providing MPAs within territorial waters to help ease the pressure on sites that are heavily overfished;
- Develop national coastal management plans to underpin these regional MPA agreements (even if MPAs will remain elusive for contested areas);
- Promote a united call to establish a regional database and monitoring that allows for periodic assessments of key coastal ecosystems;
- Ban further conversion of wetlands, estuaries and mangroves into man-made facilities;
- Establish protocols to assist national environment ministries to determine carrying capacities of estuaries for extensive and intensive aquaculture facilities (e.g. through SEAFDEC);
- Provide concrete mechanisms to engage IRRI and FAO to provide organic farming protocols for adoption by small-scale farmers and multi-national food companies to address impacts caused by nutrient loading from agriculture;
- Identify low-cost sanitation technologies, to address domestic sewage inputs, that can be maintained and established in both rural and urban settings (e.g. through the Water Group of the World and Asian Development Banks).

One of the major root causes of overfishing is, like in forestry and mining, the ever increasing need for foreign exchange. It is important to monitor whether countries around the South China Sea remain net exporters of fishery products as indicated in the Transboundary Diagnostic Analysis for South China Sea (Talaue-McManus 2000). Globalised trade will seem to exacerbate this pattern. A free and reliable source of trade statistics is available at the US National Marine Fisheries Service web site[4].

Performance of the chosen alternatives

Initial steps towards implementing these policy recommendations and strategic actions are already under way, though a variety of interventions. A pertinent example is the World Bank Global Environment Facility International Waters project administered by UNEP. The goal of the project is conserving the marine environment of the South China Sea from the effects of climate change, coastal development, pollution and overfishing. Initiation of the project followed agreement among seven nations (Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Vietnam). The project is both timely and highly relevant to the present analysis. As noted by Dr. Klaus Toepfer (Executive Director of UNEP): "Without a concerted regional approach to environmental management, it is unlikely that the present rates of habitat degradation will be slowed, resulting in the loss of globally significant biodiversity and the livelihoods of millions of people".

The major cause of environmental degradation is the density and growth of coastal populations, which are expected to double by 2033, with concomitant increases in world trade, industrialisation, fisheries and mineral exploitation.

Funding for the project comes from the GEF (16 million USD), from participating countries (9 million USD) and other donors (7 million USD). The seven nation project is producing a programme of action and framework for regional cooperation in management. Initial implementation is focused on nine pilot projects for sustainable development of marine resources (Kirkman pers. comm.).

[4] *www.st.nmfs.gov*

Klaus Toepfer (UNEP) concluded: "The real success of the project will be in providing a platform for ongoing marine protection programmes, beyond its five year span. Its major goals are to establish the national capacity, the mechanisms and the regional cooperation necessary to protect the marine environments of the seven participating countries".

In the latter regard, the effectiveness, efficiency, equity, political feasibility and implementation capacity of the policy recommendations arising from the present analysis will all be contingent, to greater or lesser degree, on the success of the present intervention and lessons learned. If successful, the present intervention should provide much of the necessary key framework for successful future interventions. However, significant problems and difficulties remain, and the present project is only the beginning of this process.

And, as Talaue-McManus (pers. comm.) cogently argues: "It is imperative to lay out policy initiatives at both the national and regional scales, so that these are formulated more or less in tandem and with substantive harmony, thus creating a synergy that ultimately enhances political will at the national level of governance. ASEAN and ASEAN-based initiatives have tried to foster this spirit and in some ways have had some success. For the most part, however, the politics cannot break away from the tradition of "non-binding agreements that will never impose on any country's sovereignty". The UNEP Regional Seas Programme for the East Asian Seas has failed miserably to achieve any substantive regional agreements in the last 30 years because the COBSEA never grew beyond representing the lack of national political will".

Talaue-McManus (pers. comm.) suggests several key strategies which overlap and support the policy strategies proposed herein:

- Bring the fisheries bodies together with expertise from national and international academic and research institutions to pin down the state of fisheries in territorial waters.
- Develop regional agreements on providing MPAs within territorial waters to help ease the overfished status of sites where this state is established.
- Develop national coastal management plans to underpin these regional MPA agreements (even if MPAs will remain elusive for contested areas).
- Promote a united call to establish a regional database and monitoring that allows for periodic assessments of key coastal ecosystems.

Talaue-McManus also suggests several criteria for key actions:

- Banning more conversion of wetlands, estuaries and mangroves into man-made facilities.
- SEAFDEC should work on establishing protocols to assist national environment ministries to determine carrying capacities of estuaries for extensive and intensive aquaculture facilities.
- In the case of nutrient loading from agriculture, provide concrete mechanisms to engage IRRI and FAO to provide organic farming protocols for adoption by small-scale farmers and multi-national food companies.
- To address domestic sewage inputs, the Water Group of the World and Asian Development Banks should assist in identifying low-cost sanitation technologies that can be maintained and established in both rural and urban settings.

Much remains to be done, at local, provincial, national and multilateral levels. In the latter regard, the multilateral security dialogue in this region has, in the past, functioned as an impediment to regional environmental cooperation, and thus also blocked attempts by non-state actors to influence regional political processes (Naess 1999). Environmental experts try to inform their governments about risks and challenges, but so far the governments of the region have not adequately prioritised management of the marine environment. Recent developments, such as the ASEAN Regional Forum on Regional Cooperation in Maritime Security, may be a step in the right direction, and similar mechanisms are required to address the other threats and impacts described herein. Environmental experts try to inform their governments about risks and challenges, but so far the governments of the region have not adequately prioritised management of the marine environment.

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Annexes

Annex I
List of contributing authors and organisations

The senior authors gratefully acknowledge the invaluable assistance of these people listed below. They participated during the meetings in the region and also provided valuable material during the production of this report. Most importantly was the extensive experience of the region that they were able to provide, particularly advice on policy options that would be applicable in some cultures but not in others. We wish to thank them for their help and sadly note that two of these have since deceased and will be sorely missed: Achmad Abdullah and Suraphol Sudara.

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Annex II
Detailed scoring tables

I: Freshwater shortage

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

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

Note: N/a = Not applied

II: Pollution

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

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

Note: N/a = Not applied

III: Habitat and community modification

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

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

Note: N/a = Not applied

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	N/a	Unsustainable exploitation of fish	3
15. Excessive by-catch and discards	3	N/a		
16. Destructive fishing practices	3	N/a		
17. Decreased viability of stock through pollution and disease	0	N/a		
18. Impact on biological and genetic diversity	2	N/a		

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

Note: N/a = Not applied

V: Global change

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

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

Note: N/a = Not applied

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)	Present (a)	Future (b)		
Freshwater shortage	2	2	2	3	1	1	1	2	1.8	4
Pollution	2	2	2	3	2	1	2	2	2.0	3
Habitat and community modification	3	3	3	3	1	1	3	3	2.5	2
Unsustainable exploitation of fish and other living resources	3	3	3	3	2	2	3	3	2.8	1
Global change	1	1	1	2	1	1	1	1	1.1	5

Annex III
List of important water-related programmes and assessments

Major inter-governmental agreements and actors

UN Economic and Social Commission for Asia and the Pacific, ESCAP

Within the Water Resources Programme under its Environment and Natural Resources Development Division, the UN ESCAP organises seminars and workshops on various issues relating to water resources, including: water resources assessment; integrated water resources development and management; protection of water resources, water quality and aquatic ecosystems; river basin development and management; promotion of infrastructure development and investment for drinking water supply and sanitation; water pricing and promotion of private investment in the water sector; water demand management, water saving and economic use of water; and mitigation of water-related natural disasters, particularly flood loss reduction.

Association of Southeast Asian Nations (ASEAN)

ASEAN was established in 1967 and has 10 member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The ASEAN Declaration states that the aims and purposes of the Association are: to accelerate the economic growth, social progress and cultural development in the region through joint endeavours in the spirit of equality and partnership in order to strengthen the foundation for a prosperous and peaceful community of Southeast Asian nations, and to promote regional peace and stability through abiding respect for justice and the rule of law in the relationship among countries in the region and adherence to the principles of the United Nations Charter. In 1995, the ASEAN Heads of States and Government re-affirmed that "Cooperative peace and shared prosperity shall be the fundamental goals of ASEAN."

- ASEAN work on water conservation (inclusive ANWRA) and seas and marine environment;
- ASEAN Network of Water Resources Agencies (ANWRA);
- the Strategic Plan of Action for the Environment (see below), adopted by the ASEAN Ministers of Environment;
- ASEAN 1997 Jakarta Declaration on Environment and Development.

UNEP Regional Office for Asia and the Pacific (ROAP)

Working closely with the Division of Regional Co-operation and Representation in UNEP's Nairobi-based headquarters, the Regional Office for Asia and the Pacific (ROAP) looks to adopt global environmental policy to regional priorities and needs. It acts as a catalyst, coordinator, facilitater and mobiliser of resources. It puts particular emphasis on building partnerships with regional and sub-regional inter-governmental fora, other UN agencies, national governments, NGOs, the private sector, academic and research institutions, and civil society, and the media.

East Asian Seas Regional Coordinating Unit

Information on the UNEP East Asian Seas Programme can be found on the web site of the Coordinating Unit, which is located with ROAP. The Unit is the coordinating body for the East Asian Seas Action Plan (see below).

Financial institutions

Asian Development Bank (ADB)

The Asian Development Bank, a multilateral development finance institution, was founded in 1966 by 31 member governments to promote the social and economic progress of the Asia-Pacific region. It now has 58 member countries - 42 from within the region and 16 non-regional. ADB gives special attention to the needs of the smaller or less-developed countries, and to regional, subregional, and national projects and programs. Promoting sustainable development and environmental protection is a key strategic development objective of the Bank. To fulfill this objective, the Bank: (i) reviews the environmental impacts of its projects, programs, and policies; (ii) encourages DMC governments and executing agencies to incorporate environmental protection measures in their project design and implementation procedures, and provides technical assistance for this purpose; (iii) promotes projects and programs that will protect, rehabilitate, and enhance the environment and the quality of life; and (iv) trains Bank and DMC staff in, and provides documentation on, environmental aspects of economic development. The Asian Development Fund (ADF) is the concessional lending window of the Bank.

Action programmes, strategies and research

Strategic Action Programme for the South China Sea

The Strategic Action plan is based on the findings of the Transboundary Diagnostic Analysis for the South China Sea (see below). The actions proposed are wide-ranging in both context and areas of action. Targets for environmental quality are proposed with regard to habitats (mangroves, coral reefs, seagrass, estuaries and wetlands), fisheries management, and land-based pollution.

ASEAN Strategic Plan of Action on the Environment

The Strategic Plan of Action on the Environment for 1994-1998 has the following five objectives:

- To respond to specific recommendations of Agenda 21 requiring priority action in ASEAN;
- To introduce policy measures and promote institutional development that encourage the integration of environmental factors in all developmental processes both at the national and regional levels;
- To establish long-term goals on environmental quality and work towards harmonised environmental quality standards for the ASEAN region;
- To harmonise policy directions and enhance operational and technical cooperation on environmental matters, and undertake joint actions to address common environmental problems; and
- To study the implications of AFTA on the environment and take steps to integrate sound trade policies with sound environmental policies.

Despite the impacts of the recent economic crisis on the natural resources and environmental conditions, the ASEAN Environment Ministers at their Fifth Informal Meeting in April 2000 discussed the importance of keeping their commitment to environmental protection and sustainable development. Hence, to move forward towards the future goals and directions that the ASEAN leaders expressed in ASEAN Vision 2020 and the Hanoi Plan of Action (adopted in 1997 and 1998 respectively) the Ministers adopted the ASEAN Strategic Plan of Action on the Environment (SPAE) for 1999-2004. It consists of the key activities to be implemented by ASOEN (ASEAN Senior Officials on the Environment) and its subsidiary bodies over the next five years, including the areas of coastal and marine environment, nature conservation and biodiversity, multilateral environmental agreements, management of land and forest fires and haze, and other environmental activities.

Partnership in Environmental Management for for the Seas of East Asia (PEMSEA)

A GEF project, focusing on "building partnerships within and among governments of the region, as well as across public and private sectors of the economy. The goal is to reduce or remove barriers to effective environmental management, including inadequate or inappropriate policies, disparate institutional and technical capabilities and limited investment in environmental facilities and services". PEMSEA is "based on two management frameworks developed and tested in an earlier GEF Project: Integrated coastal management, addressing land-water interactions and the impacts of human activity in coastal areas; and risk assessment/risk management, applying to subregional sea areas and the impacts of human activities on marine ecosystems." PEMSEA web resources include: Virtual ICM; a Legal Information Database Reference Catalogue; a Directory of Research and Management Institutions in Southeast Asia; and a database of Good Practices. See also the PEMSEA Updates, a free online newsletter.

UNEP Regional Seas Programme

The Regional Seas Programme was initiated in 1974 as a global programme implemented through regional components. The Regional Seas Programme is UNEP's main framework in the field of the coastal and marine environment. It includes 14 regions and three partner seas, involves more than 140 coastal states, and focuses on sustainable development of coastal and marine areas. Each regional action plan is formulated according to the needs and priorities of the region as perceived by the Governments concerned. Regional conventions are in place for several areas. See a map of all regional seas, and go to more information on the Black Sea, Wider Caribbean, Mediterranean, East Asian Seas, South Asian Seas, Eastern Africa, Kuwait Region, North West Pacific, Red Sea And Gulf of Aden, South East Pacific, North East Pacific, South Pacific, Upper South West Atlantic, and West and Central Africa. The UNEP Regional Seas web site also contains information on What's at stake, Major threats, and Actions.

East Asian Seas Action Plan

On the initiative of the five States of the East Asian region - Indonesia, Malaysia, Philippines, Singapore and Thailand - the Governing Council of UNEP in 1977 decided that "steps are urgently needed to formulate and establish a scientific programme involving research, prevention and control of marine pollution and monitoring " for a regional action plan in East Asia. An Action Plan for the Protection and Sustainable Development of the Marine Environment and Coastal Areas of the East Asian Region was adopted in 1981, with a decision making body, the Coordinating Body on the Seas of East Asia (COBSEA). A revised Action Plan and a Long-term Strategy for the COBSEA for the 1994-2000 period were developed in 1994 and Australia, Cambodia, China, Korea and Vietnam joined the Action Plan. A new East Asian Seas Action Plan (Leading the EAS Action Plan to the 21st Century) has been elaborated for the period 2000-2009.

State of the regional environment

Transboundary Diagnostic Analysis for the South China Sea

The TDA for the South China Sea and its associated catchment areas was a process that focused on identifying water-related problems and concerns, their socio-economic root causes, and the sectoral implications of actions needed to mitigate them. The chapter on State of the Environment covers modification of habitats, overexploitation of living aquatic resources, and pollution of aquatic environments.

GEO 2000 State of the Environment: Asia and the Pacific

Global Environment Outlook 2000. GEO is:

- A global environmental assessment process, the GEO Process, that is cross-sectoral and participatory. It incorporates regional views and perceptions, and builds consensus on priority issues and actions through dialogue among policy-makers and scientists at regional and global levels.
- GEO outputs, in printed and electronic formats, including the GEO Report series. This series makes periodic reviews of the state of the world's environment, and provides guidance for decision-making processes such as the formulation of environmental policies, action planning and resource allocation. Other outputs include technical reports, a web site and a publication for young people.

GEF Projects in the region

Projects under implementation

UNDP/GEF - International waters: Building Partnerships for the Environmental Protection and Management of the East Asian Seas

The objective of the project is to assist the riparian countries of the East Asian Seas to collectively protect and manage their heavily stressed coastal and marine environments through inter-governmental and inter-sectoral partnerships. These countries include the Republic of Korea which for the first time is a GEF recipient. Building upon the methodologies, approaches, typologies, networks and lessons learned from the pilot phase, the project would enhance and complement national and international efforts by removing or lowering critical barriers regarding policy, investment, capacity, which are having negative effects on the management of the coastal/marine environment in the region. Together with several water body-based projects in the area, these projects constitute GEF's programmatic approach to these coastal and marine waters with globally significant ecosystems that are experiencing severe degradation.

UNDP/GEF - International waters: Prevention and Management of Marine Pollution in the East Asian Seas

Development of policies and plans to control marine pollution from land-based and sea-based sources, upgrading of national and regional infrastructures and technical skills, and establishment of financing instruments for project sustainability. Project will include selection of demonstration sites, establishment of regional monitoring and information network, and involvement of regional association of marine legal experts to improve capacity to implement relevant conventions.

UNEP/GEF - International waters: Reversing Degradation Trends in the South China Sea

Major outcomes will include an approved Strategic Action Programme that will include: a targeted and costed programme of action and a recommended legal framework for improved regional cooperation in the management of the environment of the South China Sea; a series of national and regional management plans for specific habitats and issues; nine demonstration management activities at priority transboundary sites; a regional management plan for maintenance of transboundary fish stocks; and pilot activities relating to alternative remedial actions to address priority pollutants and adopted water quality objectives and standards. Activities include national level analyses and reviews and management of demonstration activities and regional harmonisation and coordination of national level actions.

World Bank - GEF - Biodiversity: Hon Mun Marine Protected Area Pilot Project, Vietnam

This project will support the conservation of critical marine biodiversity values at Hon Mun Island and its surrounding waters, located off Nha Trang in Khanh Hoa Province, south-central Vietnam. This will be achieved through the development of a zoned, multiple-use marine protected area (MPA) that protects globally important examples of Vietnam's best remaining coral reef, mangrove and seagrass ecosystems. This project will establish Hon Mun as an MPA pilot site, developing methodologies for MPA establishment and management that can be replicated in other areas as part of a national MPA system.

Project concepts in the pipeline

UNEP/GEF - International waters: Formulation of a Transboundary Diagnostic Analysis and Preliminary Framework of a Strategic Action Programme for the South China Sea

The primary objective of this project is to undertake an extensive transboundary diagnostic analysis for the South China Sea and the watershed draining into it. The transboundary diagnostic analysis will form the basis for formulating a framework for a SAP.

UNDP - GEF - Biodiversity/International waters: Biodiversity Management in the Coastal Area of China's South Sea

The project aims at protecting globally significant marine and coastal biodiversity along China's sub-tropical and tropical southeast.

Other actors, initiatives and resources

WorldFish Center (formerly ICLARM)

An international research organisation "devoted to improving the productivity, management and conservation of aquatic resources for the benefit of users and consumers in developing countries".

ICLARM is one of the research centres of CGIAR, Consultative Group on International Agricultural Research. ICLARM, in collaboration with the the Food and Agriculture Organization of the United Nations (FAO) and other partners, and with support from the European Commission, has developed FishBase, a global information system on fishes for research scientists, fisheries managers, zoologists and many more. FishBase contains full information on 23 500 species. ICLARM has also developed similar systems on coral reefs and their resources (ReefBase) and management of fish stocks in Asia (TrawlBase).

International Coral Reef Initiative (ICRI)

An environmental partnership that brings stakeholders together with the objective of sustainable use and conservation of coral reefs for future generations. ICRI is an informal mechanism that allows representatives of over 80 developing countries with coral reefs to sit in equal partnership with major donor countries and development banks, international environmental and development agencies, scientific associations, the private sector and NGOs to decide on the best strategies to conserve the world's coral reef resources.

Coral Health and Monitoring Programme (NOAA)

The mission of the NOAA Coral Health and Monitoring Program is to provide services to help improve and sustain coral reef health throughout the world. Long term goals: Establish an international network of coral reef researchers for the purpose of sharing knowledge and information on coral health and monitoring. Provide near real-time data products derived from satellite images and monitoring stations at coral reef areas. Provide a data repository for historical data collected from coral reef areas. Add to the general fund of coral reef knowledge. See also Global Coral Reef Monitoring Network, GCRMN.

The International Coral Reef Initiative (ICRI) launched the GCRMN in 1996 to improve management and sustainable conservation of coral reefs for people by assessing the status and trends in the reefs and how people use and value the resources. The GCRMN links existing organisations such as Reef Check, CORDIO, CARICOMP, AGRRA and ReefBase to promote ecological and social, cultural and economic monitoring of coral reefs. The GCRMN produces the 'Status of Coral Reefs of the World' reports every 2 years and activities in the South China Sea are coordinated from the WorldFish Center in Penang Malaysia (www.gcrmn.org & www.reefbase.org).

Annex IV
List of institutions that affect water use

Institutional Environment Water Sector

China

The main institutions involved in water resources management are:

- Ministry of Water Resources (MWR), responsible for water resources survey and assessment, rural water planning and development, and management and protection of water resources. The Ministry of Water Resources directly supervises the Water Resources and Hydroelectric Power Construction Corporation, and administers 13 higher education institutions and 7 regional basin commissions.
- Local Water Resources Management Department, responsible for water administration at provincial level. Each province has a Water Resource Bureau responsible for planning, survey, design, construction, operation and management of irrigation, drainage, flood control works, and rural hydroelectricity. Water resources bureaux at the prefecture and county levels are directly responsible for the construction and maintenance of main and secondary canals, associated irrigation and flood control structures, and medium-sized reservoirs. Townships and villages share responsibility for constructing and maintaining branch canals, ancillary works, and small reservoirs.
- Ministry of Geology and Mineral Resources cooperates with the MWR in the management of groundwater resources.
- State Environmental Protection Bureau deals with the protection of water resources.
- Ministry of Agriculture is responsible for state farm water conservation, construction and management.
- Ministry of Construction is responsible for urban water conservancy including groundwater exploitation and protection.

China's water law was enacted in 1988 and establishes principles, general guidelines, and technical standards for water resources management.

Vietnam

The Ministry of Water Resources (MWR) is the main body charged with setting policy, and responsible for the planning, management and allocation of water resources at the central level. The MWR is responsible for constructing headworks and canals for schemes larger than 150 ha, while the provinces are responsible for developing smaller schemes. Several divisions of the MWR are particularly important for agricultural water control. The Institute of Water Resources Planning prepares national plans, policies, objectives and strategies for water resources management and development which are used as guidelines by the provinces. It also prepares prioritised lists of investment projects for consideration by the state planning committees.

The Office of Irrigation and Drainage Management oversees the management of irrigation and drainage structures, develops policy guidance, produces operations and maintenance guidelines and collects data. It operates one national irrigation scheme in Dau Tieng, and interacts with other schemes through provincial or regional Irrigation and Drainage Management Committees and Provincial Peoples Committees.

The Vietnamese Hydraulic Investigation and Design Company is the technical design arm of the MWR. The Construction Management Department, financially autonomous since 1994, develops procurement and construction management policies and guidelines for the water resources sector and monitors the activities of construction enterprises building MWR schemes. Other institutions involved with irrigation planning and management include the Ministry of Science, Technology and Environment, which formulates environmental policies, which may include water related issues. The General Department for Meteorology and Hydrology undertakes surveying and hydrographic data collection and monitoring. The Ministry of Energy manages electricity generation, transmission, and distribution for uses including irrigation pumping.

The World Bank irrigation rehabilitation project, being implemented since 1995, is funding the rehabilitation and completion of seven irrigation schemes comprising a total area of 130 000 ha, at a total investment cost estimated at 40 million USD. The Red Delta water resources sector project provided 75 million USD, financed by the Asian Development Bank, to rehabilitate or upgrade 20-30 small to medium-scale irrigation schemes in the Red Delta. The project was implemented by the MARD and was completed recently.

Thailand

Some 38 ministerial departments under 10 ministries, one independent agency and six national committees are involved in water resources development, with responsibilities for water policy, irrigation, domestic and/or industrial water supply, fisheries, flood alleviation, hydropower generation, navigation or water quality. The National Water Resources Committee (NWRC), under the Office of the Prime Minister, is responsible for setting a policy to develop water resources throughout the country. The National Economic and Social Development Board is responsible for economic planning. The Department of Mineral Resources, under the Ministry of Industry, monitors groundwater resources, while surface

water monitoring is mainly carried out by the Department of Energy Development and Promotion under the Ministry of Science, Technology and Environment, and the RID, which has its own network.

Many departments or agencies are involved in water supply for domestic or industrial purposes. The main one is the Metropolitan (or Provincial, outside Bangkok) Waterworks Authority. Wastewater treatment and water quality are mainly the responsibility of the Ministry of Science, Technology and Environment. Large dams are operated either by the RID or by the EGAT, while small dams have been developed by the Land Development Department or the Office of Accelerated Rural Development (under the Ministry of Interior). The Harbour Department is in charge of protecting inland waterways, and of issuing licenses for navigation. Irrigation is managed by the RID for public schemes, or by the Department of Energy Development and Promotion for the electric pumped schemes. The RID is the supervising agency for private irrigation.

A groundwater act adopted in 1987 defines the responsibilities, rights and duties of each of the various parties involved. In May 1998, a national water resources act was awaiting cabinet approval. This act should establish the NWRC as the coordinating agency for water resources development. Although work began some years ago on a national water resources mater plan for water resources development in the 25 river basins, this work has come to a standstill due to lack of funds.

Philippines

The NWRB coordinates the activities of the different agencies involved in the water sector (irrigation, hydropower, flood control, navigation, pollution, water supply, waste disposal, watershed management, etc.). The others main agencies involved in water resources management are:

(i) In water supply and wastewater:

- Metropolitan Waterworks and Sewerage System (MWSS) of the Department of Public Works and Highways (DPWH), which is responsible for water supply, storage, treatment, research, design, construction and maintenance of water supply and sewage systems in the national capital region and outlying service areas in nearby provinces.
- Local Water Utilities Administration (LWUA) of the Department of Public Works and Highways (DPWH), which is responsible for the development and improvement of water and sewerage systems in areas not covered by the MWSS.

(ii) In water resources monitoring and development:

- Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), which conducts monitoring, data gathering and maintenance of information on rainfall and evaporation.
- Bureau of Research and Standards (BRS) of the DPWH, which is engaged in monitoring and studies of water resources as well as water research and quality standards. The DPWH is also responsible for flood control.
- NPC, which conducts water resources monitoring, research and hydropower generation.

(iii) In irrigation:

- NIA of the Department of Agriculture, which was created in 1974 with the mandate to initiate an 'irrigation age'. Its tasks include the development, operation and maintenance of irrigation systems throughout the country. In particular, it has been responsible for the construction of NIS schemes, and is now responsible for the recovery of irrigation fees.
- Bureau of Soils and Water Management (BSWM) of the Department of Agriculture, which handles, through its Project Management Office (PMO), the construction and maintenance of SWIM projects.

The SWIM projects have been implemented by the Government to mitigate damage brought about by insufficient water supply during the dry season and the frequent floods during the rainy season. The objectives might differ from one project to another, and the following agencies are involved:

- DPWH, for water supply, inland fishing and mini-hydropower;
- NIA, for irrigation;
- Forest Management Bureau (FMB), for watershed management with an incidental purpose of flood control;
- National Electrification Administration (NEA), for mini-hydropower generation.

The 1976 Water Code of the Philippines revised and consolidated the laws governing the ownership, appropriation, utilisation, exploitation, development, conservation and protection of water resources which are subject to government control and regulation through the NWRB.

Malaysia

The responsibility for water resources planning and development is shared by various government agencies. Malaysia has no single water resources authority for an overall coordinated planning and integrated river management approach.

The Department of Irrigation and Drainage (DID), under the Ministry of Agriculture, is responsible for the planning, implementing

and operation of irrigation, drainage and flood control projects throughout the country. The Department of Agriculture (DOA) is responsible for providing advice and extension services to the farmers. In the water supply sector, the Public Works Department (PWD), under the Ministry of Public Works, is responsible for the planning, implementation and operation of urban water supply projects. However, in line with the Government's privatisation policy, many water supply projects have already been taken over by water supply companies or privatised.

The Ministry of Health (MOH) provides untreated but drinkable water to rural communities not served by the local water authorities. The MOH also monitors water quality at water treatment plant intakes as well as the quality of water within the distribution system for compliance with national drinking water standards.

The control of water pollution is the responsibility of the Department of Environment (DOE), which is empowered to enforce compliance with effluent standards for point sources of pollution. The Ministry of Housing and Local Government is responsible for compliance with regulations and standards on sewerage works which have been privatised to a national sewerage company. Although either directly or indirectly much legislation touches on water resources, most of the existing laws are considered outdated. The Water Act of 1920 is inadequate for dealing with the current complex issues related to water abstraction, pollution and river basin management.

Indonesia

The 1945 constitution declared national water and land resources to be controlled by the State and that they should be utilised in an equitable manner for the benefit of the people. The responsibilities for the development and management of water resources and irrigation schemes are specified in laws, presidential instructions and government regulations. The most important are:

- Presidential Instruction No. 1 (1969), on the management of irrigation water and maintenance of irrigation networks;
- Law on water resources development No. 11 (1974);
- Government regulations on:
  - Beneficiaries contribution for maintenance cost of water resources facilities No. 6 (1981),
  - Water management No. 6 (1982),
  - Irrigation, No. 23 (1982),
  - Rivers (1991) and swamps (1991);
  - Decree of the Minister of Mining and Energy concerning underground water resources management (1983).

Numerous institutions are presently involved in water resources management. Their tasks and responsibilities are clearly stated in national legislation:

- The Ministry of Public Works, with its Directorate General of Water Resources Development, is responsible for planning, design, construction, equipment, O&M, and guidance in water resources development.
- The Ministry of Forestry is responsible for catchment area development.
- The Ministry of Environment is responsible for environmental quality development and management.
- The Environmental Impact Management Agency is responsible for environmental impact control.

Cambodia

The public institutions involved in the water sector are:

- General Directorate of Irrigation, Meteorology and Hydrology of the Ministry of Agriculture, Forestry and Fisheries, with:
- Department of Water Management, which is responsible for the O&M of all irrigation infrastructure in Cambodia, including the operation and repair of pumps. The office also undertakes rural water supply, including well drilling;
- Department of Engineering, which is responsible for the design and construction of hydraulic structures;
- Department of Hydrology, which carries out the installation and maintenance of a network of hydrological stations, and collects and processes data;
- Department of Meteorology, which is in charge of meteorological data collection and forecasting;
- Department of Research, Training and Extension;
- The Mekong Secretariat.

An informal 'water resources law task force' has been established through the Irrigation Sector Meeting of the interested parties. As part of this process, an adviser to the Ministry of Agriculture, Forestry and Fisheries (MAFF) has compiled a draft law on the water resources of Cambodia, which was due to be submitted in 1996. Domestic water supply is the responsibility of several institutions: the Department of Hydrology, the Ministry of Public Works and the Ministry of Rural Development.

Annex V
Criteria for scoring environmental impacts

Issue 23: Changes in ocean surface temperature	
This refers to the impact on populations, species, and communities from changes in Sea Surface Temperature as a result of global change.	
Score 0 = No known impact	No measurable or assessed effects of SST increase.
Score 1 = Slight	Slight impact is determined when one or more of the following criteria are met or exceeded: Measured assessed effects of SST are causing a behavioral change in some species without affecting the viability of the population
Score 2 = Moderate	Moderate impact is determined when one or more of the following criteria are met or exceeded: Community structure is measurably altered as a consequence of changes in SST. Populations are declining.
Score 3 = Severe	Severe impact is determined when one or more of the following criteria are met or exceeded: Measured/assessed effects of changed SST are leading to massive loss of communities or a change in biological diversity.

Annex VI
The South China Sea Large Marine Ecosystem

(Excerpted from LME 2004)

Brief description

The South China Sea Large Marine Ecosystem is bounded by the coasts of Vietnam, China, Taiwan, the Philippines, Malaysia, Thailand, Indonesia and Cambodia. It is separated from the Gulf of Thailand, to the West, by a shallow sill (Piyakarnchana 1989, Eiamsa-Ard & Amornchairojkul 1997). The South China Sea contains many biological sub-systems and a variety of habitats. These include mangrove forests, seagrass beds, coral reefs and soft-bottom communities. The 50 m depth contour largely follows the coast, with the widest shelves occurring along the eastern edge of the LME. Much of the South China Sea is below 200 m. Small coralline areas can be found south of Cambodia, between Borneo (Malaysia) and Sumatra (Indonesia), and off Palawan Island (Philippines) in waters deeper than 200 m (Pauly & Christensen 1993).

Productivity

The South China Sea is a biologically diverse marine ecosystem. It is considered a Class II, moderately high productivity (150-300 gC/m^2/year) ecosystem based on SeaWiFS global primary productivity estimates. High productivity levels are found in gulfs, along the coast, and in reef and seagrass areas, common in the Philippines portion of the LME (Pauly & Christensen 1993). Production decreases with depth. For a study of productivity in the Southwestern South China Sea (eastern peninsula of Malaysia and southeastern Sumatra), see FAO (1981). Oceanic waters ranging in depth from 200 to 4 000 m cover nearly one-half of the South China Sea. Pauly and Christensen (1993) have developed a static, stratified model of the South China Sea ecosystem that accounts for consumption, exportation by fishing and migration, predation, and other mortality.

Fish and fisheries

The Pauly and Christensen (1993) fisheries model incorporates data from several regions. The coastal and estuarine areas off of Vietnam, China and Cambodia are very productive. In the past, a substantial fraction of the Vietnamese catch was taken by artisanal, non-mechanised boats. South Vietnam's demersal resources were exploited primarily by Taiwanese vessels. The Northwestern coast of the Philippines is a soft-bottom area fished intensively by trawlers (Silvestre et al. 1989). The deep shelf area of South China Sea is predominantly fished by Taiwanese vessels (Yeh 1981). There are no catch or biomass data for shrimp or crabs, and information on catches of demersal fish is sparse. In deep oceanic waters (200 to 4 000 m), fisheries are limited to large pelagic fishes, mainly tuna (Pauly & Christensen 1993). Other species harvested are billfish, swordfish, shark, porpoise, mackerel, flying fish, anglerfish and shrimp. The total fish harvest is approximately 5 million tonnes per year. This is about 13% of the area's total fish production, the rest being eaten by predators. Five of the countries are among the top 8 shrimp producers of the world. Fishermen sometimes use small-meshed nets and practice destructive fishing methods, such as cyanide and dynamite fishing. While 2/3 of the major fish species are overexploited, carefully constructed fishing regimes could result in increased catches (Pauly & Christensen 1993). The Vietnam/China area was lightly exploited from the mid-1970s to the mid-1980s. By now much of this potential has probably been realised. The deeper coralline areas and those situated in the central portion of the LME are only slightly exploited, leaving room for an increase in production there (Alcala 1981, White 1989). The potential areas for an increase lie in the deeper areas of the LME, but these are areas difficult to fish. The University of British Columbia Fisheries Center has detailed fish statistics for this LME.

Pollution and ecosystem health

The health of the South China Sea Large Marine Ecosystem is in serious decline due mainly to coastal development. Presently, 270 million people (5% of the world's population) live in the coastal areas of the South China Sea LME, and this population is expected to double in the next three decades. This population explosion is driven by world trade, tourism, industrialisation, fisheries, and oil exploration and exploitation. The area's rapid economic development and population growth are the cause of significant ecological damage in coastal and marine areas. The primary environmental threats by humans in the South China Sea are the destruction of mangrove forests, sewage pollution, exploitative fishing practices and overfishing, coral reef degradation, and damage to seagrasses and wetlands. Only a third of the region's mangrove forests remain. 65% of mangrove forests have been lost or converted into shrimp farms, industrial areas or tourist resorts. The mangroves are chopped up for wood chips or firewood. Their disappearance on such a large-scale has led to sediment erosion, water pollution, loss of biodiversity and a critical loss of nursery habitat for young fish. Sewage-laden water causes disease downstream. Sewage pollution affects biodiversity and fisheries. 2/3 of major fish species are overfished. 80% of the coral reefs are at risk from pollution, overexploitation and cyanide and dynamite fishing for reef fish. Other pollution problems are increased river sedimentation and the effects of climate change, which affect the corals. 125 major rivers flow into the South China Sea. The effects of increased sedimentation and nutrients, plus destructive fishing practices, are being felt in the region's other

major habitat, seagrass communities, of which 20 to 50% were found to be degraded. Many fish nursery areas and breeding grounds are being degraded. UNEP has undertaken the COMEMIS project (Coastal Marine Environment Management Information System), to help improve the region's capacity to make sound environmental assessments through GIS.

Socio-economics

The South China Sea LME contributes to the livelihood of millions of people engaged in world trade, tourism, industry, fisheries and oil exploitation. However, the ongoing depletion of the sea's marine resources is likely to adversely affect the region's economy. The South China Sea is the world's second busiest international sea lane.

Governance

Seven nations are involved in the governance of the South China Sea LME. The countries are Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Vietnam. The region, in experiencing a phase of rapid economic development and population growth, did not account for the environmental consequences: the degradation of its resources and water quality. Until now, narrow state interests and power politics have characterised the interaction between countries, and the influence of environmental groups has remained inconsequential. Rapid economic growth has also sharpened conflicts between the various sectors within governments. This was especially true of China in the past decade. Governments of the South China Sea region are now coming to see that the marine environment in the region is under threat. Environmental ministries are now in place, and environmental laws and regulations are being formulated. The Chinese government has asked for help from UNDP to implement integrated coastal management through the establishment of demonstration zones. This project was initiated in 1997, with an investment of 1.1 million USD from UNDP, and 18 million yuan (2.2 million USD) from China. The United Nations Environment Program (UNEP) has unveiled a regional plan to try to reverse the degradation of the South China Sea by starting 9 pilot projects for sustainable development at priority transboundary sites in the region. UNEP's Strategic Action Plan for the South China Sea has been endorsed by all ASEAN members as well as by the People's Republic of China. This is the first time the seven countries have agreed to collaborate around the marine biology of the region. Several of the countries have contending claims to large areas of the South China Sea, leading to political tensions among them. The claims are about the status of the Paracel Islands and the Spratly Islands, which are said to contain minerals, oil and gas resources. In 2001, these Asian nations agreed to set aside their quarrels in order to save the South China Sea, and signed a joint agreement to the UNEP project. They will cooperate on a 32 million USD plan to protect the marine environment. The Global Environment Facility (GEF) is contributing 16 million USD to this plan. As knowledge of environmental hazard is spread through the region, the impetus for conflict resolution will grow. GEF funding will secure a comprehensive package of marine environmental research and projects that will build human and institutional capacity. Through their concern for the environment the countries of the South China Sea can be brought closer together as they discover their common heritage and the importance of the Sea as a source of protein for the growing coastal populations. For a map of the area and information on managing potential conflicts in the South China Sea LME, on the status of conventions, and for a transboundary diagnostic analysis for this LME, go to the University of Oslo web site (http://sum.uio.no/southchinasea/links/recommend.html).

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Annex VII
Irrigation, water withdrawal, and drainage development

(Excerpted from FAO Aquastat 2004)

China

Since the founding of the People's Republic of China in 1949, irrigation and drainage have experienced a period of vigorous development. From 1958 to 1985, about 64 368 million yuan were spent on irrigation and drainage projects. The irrigated area for farmland increased from 16 million ha in 1949 to 51 million ha in 1996. After 1949, in order to promote agricultural production, pump irrigation and drainage were developed rapidly. The total area equipped for irrigation, including farmland, orchards and pastures, was 52 943 200 ha in 1996, representing 55% of the total cultivated area. Surface irrigation is the method practised (mainly for rice, wheat, millet, vegetables, corn and cotton) on about 99% of the total equipped irrigated area. The remaining 1% is under sprinkler and localised irrigation. The total water withdrawal was 525.5 km^3 in 1993, of which 385 km^3 for irrigation, 22.66 km^3 for rural domestic uses and livestock, 25.17 km^3 for urban domestic and public uses, and 92.55 km^3 for industrial water use. The total water demand for 2000 was estimated at 593 km^3, with 7% for domestic and municipal use, 21% for industry, and 72% for irrigation. In 1995, the total amount of wastewater produced was 37.29 km^3, of which 23.33 km^3 was treated. The re-used treated volume was 13.39 km^3. The Ministry of Water Resources estimates the maximum possible area which might be brought under irrigation in the first half of the 21st century at 64 million ha. Nevertheless, as much of the land proposed for irrigation is located in arid and semi-arid zones, a long-term viable strategy has to be formulated as to how to provide additional water resources to irrigate these lands.

Vietnam

Modern irrigation development stagnated until the reunification of the country in 1975. Early post-1975 growth was in small and medium irrigation schemes, while in the period 1985-1990, growth was concentrated in large irrigation and multipurpose schemes. The total irrigated area expanded at a rate of 2.9%/year in the period 1980-1987, while between 1988 and 1994 it was 4.58%/year. The total annual water withdrawal for agriculture, industries and domestic purposes was estimated at 54.3 km^3 in 1990. The total domestic demand in 1990 was estimated at 2.0 km^3/year for both urban and rural consumers. This volume for domestic water use was estimated at 1.3 km^3 in 1980 and is expected to reach 2.9 km^3 by 2000. National industrial demand was 1.5 km^3 in 1980, rising to 5.3 km^3 in 1990. It is expected to reach 16.0 km^3 in 2000. In 1980, agriculture used 35.0 km^3 of water. In 1990, agricultural water withdrawal was estimated at 47.0 km^3, or 86.5% of the total water demand, of which some 6.5 million m^3 were for livestock. The estimated water demand for agricultural purposes for 2000 is 60.5 km^3. Approximately 1.46% of Vietnam's water demand is met by groundwater. The balance comes from surface water sources such as rivers, lakes and reservoirs. Groundwater is mainly used for domestic water supply in urban areas. With rehabilitation of existing infrastructures in the Red and Mekong deltas, there is the potential to expand irrigation to some 700 000 ha. The overall irrigation potential in Vietnam is estimated at 6 million ha. In 1994, the actual irrigation capacity was just 70% of the three million ha of equipped area. Two-thirds of this area were in the two large deltas (37% in the Red Delta, and 27% in the Mekong Delta). In 1994, about 49% of the cultivated area was irrigated. In 1990, there were 5 071 irrigation schemes in operation. The drainage system covers over 1 million ha, mostly in the northern and central parts of the country, particularly the Red Delta.

Thailand

In modern times, canal construction for irrigation started at the beginning of the 20th century. The aim was to maintain water in canals for irrigation and navigation, and to drain paddy fields during periods of flooding. Irrigation has traditionally been supplementary irrigation for the wet season. It is only recently that schemes have been designed for dry season irrigation. The area equipped for wet season irrigation was estimated at 5 003 724 ha in 1995. Thailand develops 120 000 ha of irrigation each year (2% of the equipped area). In 1988, the area actually irrigated was estimated at 91% of the equipped area. All schemes are irrigated by surface irrigation: sprinkler and drip irrigation are at an experimental stage only on fruit trees. The irrigation potential for the wet season can be roughly estimated at 12 million ha, considering both soil and water availability but excluding basin transfers. The total area suitable for irrigation is estimated at 16 million ha. The total water withdrawal in 1990 was estimated at 33.13 km^3, of which 91% was for agricultural purposes. Domestic and industrial water withdrawals are increasing substantially every year.

Philippines

The major irrigation investment periods have been the 1920s, the post-second world war period and the 1970s and early 1980s when public involvement in the irrigation subsector was at its maximum. In this respect, the creation of the National Irrigation Agency (NIA) in 1964 has been decisive. The irrigation potential was estimated at 3.1 million ha in 1990. It corresponds to the area where irrigation facilities can easily be provided by the Department of Agriculture

or the NIA. A World Bank survey has proposed the reassessment of irrigation potential as the figure of 3.1 million ha was obtained without considering new settlement on agricultural lands, water resources availability, water resources development cost, need of flood control and drainage facilities, etc. In 1992, the area of land equipped for full/partial control irrigation was estimated at 1 532 751 ha. Irrigation water is generally supplied by river diversion. The total water withdrawal was estimated on the basis of the water rights issued by the National Water Resources Board (NWRB) to 55 422 million m^3 in 1995, of which 88% is for agricultural purposes, 8% for domestic and 4% for industry. Other water withdrawal (non-consumptive use of water) included hydropower (89 000 million m^3), fisheries (498 million m^3) and recreation (93 million m^3). Production of wastewater in the national capital region and nearby provinces is estimated at 74 million m^3, while the volume of treated wastewater reached 10 million m^3 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.

Malaysia

Since the formation of the Department of Irrigation and Drainage in 1932, irrigated areas for paddy cultivation have progressively increased. By 1960, about 200 000 ha had been developed, the emphasis then being on supplementing rainfall for single crop cultivation. During the 1960s and early 1970s, the introduction of double cropping of rice cultivation required the development of adequate water resources for the second cropping season. During the 1980s, the priority for irrigation took on a new dimension with the need to rationalise rice cultivation and increase its productivity. Malaysia has over 932 irrigation schemes covering an area of 340 633 ha. In addition, there are 21 967 ha which are inundation and control drainage schemes (1994 estimates). The current irrigation efficiency is around 35-45%. In 1994, the total drained area was 940 633 ha. About 600 000 ha were drained for oil palm cultivation, using public funding for smallholders. The issues of salinity, waterlogging and water-borne diseases are not reported as being significant. The annual internal renewable water resources are estimated at 630 km^3. As surface water is readily available throughout the year, it is abstracted mainly for irrigation and domestic uses. The groundwater potential is 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. The total water demand increased from 8.7 km^3 in 1980 to 12.7 km^3 in 1995, and was projected to increase to 15.2 km^3 by 2000. Irrigation currently accounts for about 9.7 km^3 or about 76% of the total water consumption. However, irrigation demand is expected to taper off as no further expansion in irrigated paddy cultivation is envisaged. The potential irrigable area is approximately 413 700 ha.

Indonesia

Modern irrigation systems were introduced in the middle of the 19th century. In 1969, with the launching of the five year development plan (Repelita), the Government started a major program in irrigation development which included:

- Rehabilitation of existing irrigation works;
- Expansion of service areas in existing schemes;
- Construction of new irrigation systems;
- Upgrading of semi-technical irrigation systems to technical level;
- Introduction of special maintenance to upgrade the physical infrastructure;
- Implementation of efficient operation and maintenance procedures for launching sustainable Operation and Maintenance (O&M) programmes;
- A credit programme;
- Among other initiatives.

In the first 25 years of development, spanning five Repelitas (1969-1993), water resources policies were directed to support the development of different sectors with the primary emphasis being on agriculture. The success of this development is demonstrated by the country having achieved food self-sufficiency, particularly in rice, since 1984. Another result of Indonesia's development was the reduction of poverty from 44% of the population (54 million people) in 1969 to 13% (26 million people) in 1993. Indonesia has now embarked on the second 25-year development period (1994-2019), with emphasis on sustainable development and management of water resources. Water resources have now been elevated to a full sector level and policies are directed to promoting a more effective and efficient management of water resources in an integrated manner. Greater emphasis is placed on sustaining self-sufficiency in rice and on the O&M of water resources infrastructure. In addition, the Government is implementing a crash programme in Repelita VI to improve 1 million ha of village irrigation systems and to develop a 600 000 ha rice estate by swamp reclamation in central Kalimantan. In 1990, water withdrawals were 69.24 km^3 for agriculture, 4.73 km^3 for domestic and municipal water supply and 0.38 km^3 for industrial use.

Cambodia

Modern irrigation systems were first developed in the period 1950-1953. Many of the structures built during that period functioned until 1975. Most of these structures, such as the 'colmatage' canals, have become non-functional as a result of the network of irrigation/drainage

systems built during the period 1975-1979. Since then, most attempts to rehabilitate these newer schemes have failed. Irrigation potential has never been estimated in terms of physical area which could be irrigated considering water and land resources. A recent FAO survey indicates that a number of areas appear suitable for groundwater exploitation, though there are still uncertainties about water quantity and quality. The lack of data, particularly on water quality, is a cause for concern as there are reports on iron toxicity from Svay Rieng province, close to the border with Vietnam, as well as increased tidal saline incursion from the Mekong River in May-June. Water withdrawal was estimated at 520 million m^3 in 1987, of which 94% is used for agricultural purposes.

Brunei

Urban water supply is entirely from surface water. The major use of water in industrial processes is for the liquefied natural gas industry which abstracts and treats its own water from the Sungai Belait River. Other industrial uses are on a smaller scale for timber/sawmills, dairy farms, soft-drink manufacture and workshops which account for an estimated 25% of overall water demand. In 1994, the total water withdrawal was estimated at 91.59 million m^3. Initially, groundwater abstraction was undertaken in the 1950s for use by the oil and gas industries. This has been replaced by surface water sources. Groundwater abstraction, which accounts for 0.5% of the total water supply, is currently limited to the local bottled water industry. All irrigation facilities were equipped in 1980. There are only minor irrigation schemes (up to 0.9 ha). Irrigated agriculture represents 1 000 ha, and all irrigation is surface irrigation. The existing infrastructure and facilities are being upgraded in rural areas, but the irrigated area has remained unchanged since 1980. The major irrigated crops are rice, vegetables and fruits. The figures for rice show that the country is able to meet only 3.6% of the total demand of 27 500 tonnes/year. Lack of labour is the main constraint on agricultural development in the country.

Socio-economic costs

In Thailand, early irrigation systems were designed to operate at full capacity only in the wet season. The canal capacities and control regulators are inadequate for the increasing demand for dry season irrigation. Furthermore, irrigation water demand has to compete with demand from other sectors. This becomes a sensitive issue during the dry season. A certain flow of water must be maintained for navigation, to prevent saltwater intrusion, and to supply water for domestic and industrial purposes in the Bangkok area. In the dry season, water resources can no longer meet the increasing water demand from all sectors, and particularly for the irrigation subsector which needs to withdraw more and more water because of the development of dry season irrigation (FAO 1999). This water competition has led to poor agricultural performance in recent dry seasons.

On average, the Government of Thailand spends 45 USD/ha/year for O&M. In the northeast, 10% of the irrigated land is affected by salt (FAO 1999). The salt bearing nature of the soil parent material has been identified as the primary cause for this. Other activities such as irrigation could be classed as secondary causes for accelerating this locally. Many programmes have been launched in order to correctly manage cash crops and paddy on saline soils. Salinisation is now reported to be affecting large areas in the coastal parts of Thailand's central plain.

In China, most irrigation projects constructed in the 1950s and 1960s can no longer be operated effectively. The development of sprinkler irrigation, initiated since the early 1950s, increased until 1980, when large areas were abandoned due to the poor quality of equipment and poor management. This has resulted in a continuous decline in irrigation benefits and has had a direct impact on the stability of agricultural development and on the economy. In principle, all water users must pay water charges. FAO (1999) report that since 1985, the water charge has been calculated on the basis of the cost of the water supply. The water charge for agriculture is usually lower than that for industry. Where shortages occur, a rational water allocation system is practised and dissuasive charges are applied to extra volumes of water. On average, water charges for irrigation varied between 150 and 300 yuan/ha (17.96 and 35.92 USD/ha) in 1995.

In Cambodia by comparison, a recent FAO survey has estimated that the development of 1 ha irrigated by pumping would require an investment cost of 2 800 USD, and 85 USD/year for operation and maintenance (O&M), placing considerable strain on the economy. In Indonesia in 1992, the average cost of developing a surface irrigation scheme was 3 645 USD/ha while the average O&M cost of a surface irrigation system was 8.4 USD/ha/year. In Vietnam, irrigation fees were first established in 1984 in some provinces (e.g. Vinh Long). The fee for irrigation and drainage services represents from four to 8% of the total crop output.

In the Philippines, under the National Irrigation System (NIS) schemes, the average cost of irrigation development is estimated at 3 800-7 600 USD/ha for new schemes, while the cost for the rehabilitation of existing schemes varies from 1 000-1 600 USD/ha. On all National Irrigation System schemes in the Philippines, the fees collected by the National Irrigation Agency 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 O&M expenditure in 1989.

In Malaysia, water supply is undertaken by government agencies and privatised water companies. The coverage for water supply is 99% for urban areas but 77% in the rural areas. Farmers pay nominal irrigation charges which vary from 3-15 USD/ha/year. It is estimated that fees collected from farmers cover only 10-12% of the actual operational cost. The Government does not seek full cost recovery because the farming community is considered a low income group. 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.

Trends in water resources management

China

The whole country is facing increasing water shortages. The policy of low water fees and free water delivery services practised in irrigation and drainage projects in the past has led to a situation where the funds needed for their regular maintenance and rehabilitation have not been available. In order to achieve the goals stipulated by the Government in the 9th Five Year Plan, irrigation should increase by 3.3 million ha and grain production capacity should increase by 40-50 million tonnes in the period 1995-2000. To achieve these objectives, the Government has decided to allocate part of the basic national construction fund for agriculture to the rehabilitation of the irrigation works. In 1985, the Government issued a new rule requiring water charges to be collected according to the cost of water delivery. At present, water charges are on average between a half to two-thirds of the water delivery costs. It is expected that cost recovery will be accelerated in the near future, with regional variations to take account of farmers' ability to pay.

Vietnam

Government plans indicate an accelerated growth rate of 4.5-5% for the agriculture sector. Other targets include:

- Reducing the number of very poor people by 50%;
- Reducing malnutrition among children to less than 30%;
- Providing clean drinking water to all the urban population and 80% of the rural population.

About 40% of the investment needed is projected to come from the Government, 15% from state enterprise and the rest from the private sector. The main items in the public investment program are transport and water supply (33%), and irrigation and agriculture (24%). The Ministry of Agriculture and Rural Development (MARD) has prepared a programme for rural development, which complements and builds on the strategy for the agriculture sector. The major objectives are to raise incomes and living standards in rural areas; diversify the rural economy through increased production of high value crops; and conserve the natural resource base, particularly land and water.

For 2010, the main targets are to:

- Raise GDP per capita in the rural areas to 1 000 USD;
- Irrigate 80% of all cultivated land;
- Increase forested areas;
- Raise food production to 40-45 million tonnes.

Thailand

A lot of sites for dams have been identified in order to supply more water to the Chao Phraya River. However, nearly all the suitable sites for large-scale projects have been already exploited. The remaining undeveloped potential sites are either in heavily populated areas or in national park reserves. The resettlement of population and environmental issues are so sensitive that no decision has been taken concerning such dams, even though detailed design studies have been ready for more than 15 years in some cases. The Kaeng Sua Then and the Nam Choan projects have been a cause of conflict between developers and conservationists. It seems increasingly clear that there will be less scope for the development of such large-scale projects in the future.

There is a great need for water in the central region for both irrigation and urban water supply. Most of the water used in the central region comes from the northern region. This follows a set of rules established when the main needs were in the central region. In the last few years, there has been an increasing demand for water, especially in the irrigation sector, in the northern region. If the observed trend continues, and if all projects are implemented, a point will be reached in the near future where water released from the northern region, after satisfying requirements there, will not be sufficient to meet the irrigation water demand in the central region. To address this problem, the Government has launched many programmes to both reduce demand and increase the resources available. The ongoing national economic and social development stresses the need for a more efficient use of water, and in particular the importance of collecting water fees in irrigated agriculture to avoid wastage. Agricultural water fees should cover only O&M costs, while for the other sectors (domestic and industrial) the fees should also take account of the construction and maintenance costs of water distribution systems. To increase the available resources, inter-basins transfer projects are being studied and implemented. One such project already exists, diverting water from the Mae Klong River to the Chao Phraya central plain. Other projects, such as diversion of water from the Mekong, Mae Kok and Mae Ing rivers to the Yom and Nan rivers, are more politically sensitive. Desalination or re-use of treated wastewater have still not been envisaged.

Philippines

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 National Irrigation Agency to develop the remaining 1.5 million ha of irrigable lands within ten 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 a fast pace in irrigation development.

Malaysia

Agriculture will remain the main user of water in the future. However, its importance was projected to decline from approximately 76% to about 70% of total water consumption by 2000. In the irrigation sector, future efforts will focus on demand management through improved water management rather than on supply management. In the water resources sector, there is a need to review the planning and development of dams. Most of the existing dams were generally designed for one single purpose by various government agencies and privatised utility companies. Future dams will be designed with consideration for multipurpose usage through improved coordination and the optimisation of resources. There is also an urgent need to address the issue of water pollution, which could have a serious economic impact if left unchecked. The Government is studying the feasibility of setting up a national body to manage the rivers as well as the creation of a national water council to improve federal-state government cooperation in water resources management.

Indonesia

The Ministry of Public Works through its Directorate General of Water Resources Development (DGWRD) identified four main missions in water resources sector programming as part of Repelita VI (1994-1999):

- 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 importing of rice and the building up of costly rice buffer stocks. The DGWRD directs its programming towards activities which support the continued increase in rice production to maintain self-sufficiency.
- 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 needs are at locations far away from good quality water sources, so requiring large capital investments for conveyance infrastructures. The water sources are continuously subjected to water quality degradation due to urban, industrial and upper watershed pollution. The DGWRD directs its programming to develop sources of good quality water and supply to demand centres to meet the needs for water supply.
- 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. To protect investment and economic activity as well as to ensure the availability of surface water resources close to demand centres, the DGWRD 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.
- Water resources development, conservation and management. The archipelago nature of the country, variations in rainfall, large fluctuations in river flows and lack of proper storage sites have hindered the nation's ability to meet the increasing water demands. The gradual degradation of upper watersheds, poor groundwater resources, increasing water quality problems in the lower reaches of the rivers, and the inefficient use of water require a greater focus on water resources, conservation and prevention. Thus, to ensure the continued availability of water resources, the DGWRD direct its programming towards steps to improve water resources availability through appropriate conservation and management measures.

The four missions directed by the DGWRD are being implemented through a number of major and support programmes. The water resources sector now has two major subsectors:

- Water resources development, with three major programmes:
  - Water resources development and conservation,
  - Supply and management of water,
  - Management of rivers, lakes and other water resources;

- irrigation with, two major programmes:
  - Development and management of irrigation networks,
  - Development and management of swamp areas.

Cambodia

Under the National Socio-Economic Development Plan, 1996-2000, water supply and wastewater treatment have been set as priorities by the Government. As new irrigation scheme development has a low economic internal rate of return (1-6%), the rehabilitation of existing schemes has been set as a priority by the Government. Priority is given to small-scale schemes, as large-scale schemes have serious operation and maintenance problems. The estimated potential of irrigated agriculture production is high for small-scale irrigation schemes with active community participation and in combination with other agricultural technology packages, especially balanced fertiliser use. Indeed, soil fertility is a major problem in Cambodia and production increase with irrigation alone would remain relatively limited. Priorities include:

- The development of well-designed flood control devices in conjunction with irrigation facilities to enable drainage in times of flooding, and irrigation in the dry season;
- Construction of several dams, mainly for hydropower purposes.

Brunei

The water demand for 2000 was estimated at 105 million m^3, depending on the growth of the population and expected increase in per capita consumption as a result of increased urbanisation. Efforts are being made to diversify the economy away from a heavy dependence on oil and gas towards a more independent agriculture sector. The first of the Government's four major objectives in agriculture is to enhance domestic production of paddy, vegetables, poultry and livestock. The Government is trying to stimulate greater interest in agriculture through the establishment of model farms, and by providing training, advice and support.

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the South China Sea region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

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

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

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

policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

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

The Global Environment Facility (GEF)

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

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

United Nations Environment Programme (UNEP)

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

UNEP work encompasses:

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

University of Kalmar

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

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

International call for action

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

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

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

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

International waters and transboundary issues

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

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

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

The conceptual framework and objectives

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

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

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

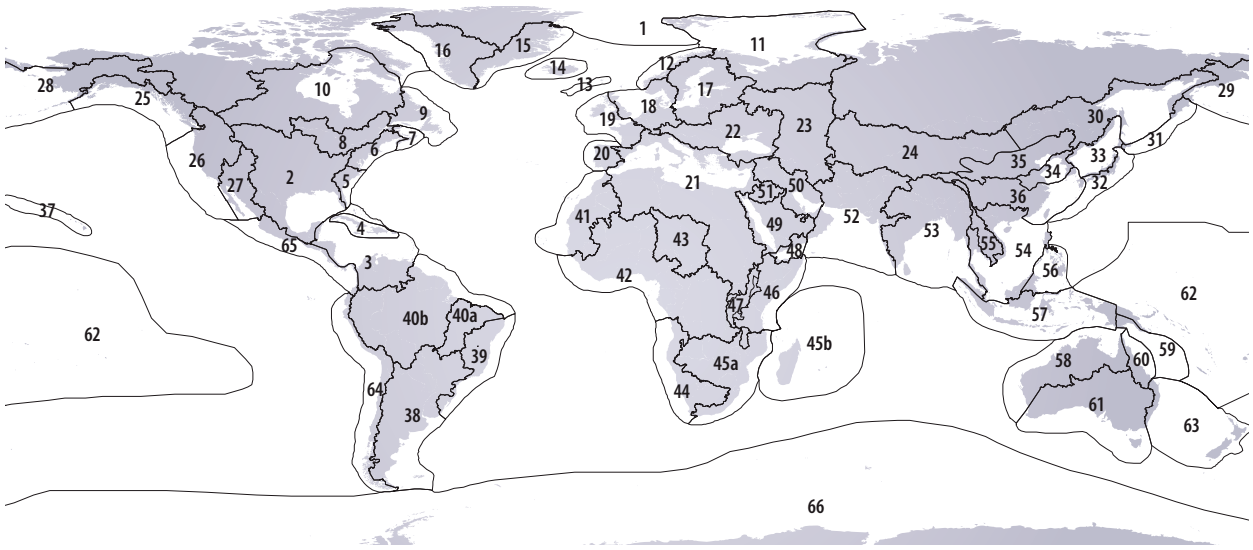
- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater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

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

The organisational structure and implementation of the GIWA

The scale of the assessment

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



1	*Arctic*	12	*Norwegian Sea (LME)*	24	*Aral Sea*	36	*East-China Sea (LME)*	46	*Somali Coastal Current (LME)*	58	*North Australian Shelf (LME)*
2	*Gulf of Mexico (LME)*	13	*Faroe plateau*	25	*Gulf of Alaska (LME)*	37	*Hawaiian Archipelago (LME)*	47	*East African Rift Valley Lakes*	59	*Coral Sea Basin*
3	*Caribbean Sea (LME)*	14	*Iceland Shelf (LME)*	26	*California Current (LME)*	38	*Patagonian Shelf (LME)*	48	*Gulf of Aden*	60	*Great Barrier Reef (LME)*
4	*Caribbean Islands*	15	*East Greenland Shelf (LME)*	27	*Gulf of California (LME)*	39	*Brazil Current (LME)*	49	*Red Sea (LME)*	61	*Great Australian Bight*
5	*Southeast Shelf (LME)*	16	*West Greenland Shelf (LME)*	28	*East Bering Sea (LME)*	40a	*Brazilian Northeast (LME)*	50	*The Gulf*	62	*Small Island States*
6	*Northeast Shelf (LME)*	17	*Baltic Sea (LME)*	29	*West Bering Sea (LME)*	40b	*Amazon*	51	*Jordan*	63	*Tasman Sea*
7	*Scotian Shelf (LME)*	18	*North Sea (LME)*	30	*Sea of Okhotsk (LME)*	41	*Canary Current (LME)*	52	*Arabian Sea (LME)*	64	*Humboldt Current (LME)*
8	*Gulf of St Lawrence*	19	*Celtic-Biscay Shelf (LME)*	31	*Oyashio Current (LME)*	42	*Guinea Current (LME)*	53	*Bay of Bengal S.E.*	65	*Eastern Equatorial Pacific*
9	*Newfoundland Shelf (LME)*	20	*Iberian Coastal (LME)*	32	*Kuroshio Current (LME)*	43	*Lake Chad*	54	*South China Sea (LME)*	66	*Antarctic (LME)*
10	*Baffin Bay, Labrador Sea, Canadian Archipelago*	21	*Mediterranean Sea (LME)*	33	*Sea of Japan/East Sea (LME)*	44	*Benguela Current (LME)*	55	*Mekong River*		
11	*Barents Sea (LME)*	22	*Black Sea (LME)*	34	*Yellow Sea (LME)*	45a	*Agulhas Current (LME)*	56	*Sulu-Celebes Sea (LME)*		
		23	*Caspian Sea*	35	*Bohai Sea*	45b	*Indian Ocean Islands*	57	*Indonesian Seas (LME)*		

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

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

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

Large Marine Ecocsystems (LMEs)

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

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

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

The global network

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

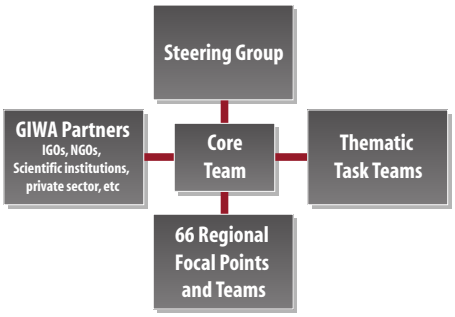


Figure 2 The organisation of the GIWA project.

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

GIWA Regional reports

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

UNEP Water Policy and Strategy

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

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

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

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

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

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

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

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

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The GIWA methodology

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

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

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

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

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

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

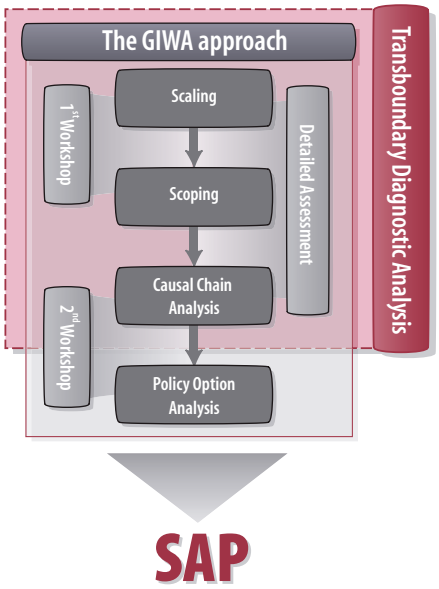

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

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

Scaling – Defining the geographic extent of the region

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

Scoping – Assessing the GIWA concerns

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

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

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

results were distilled and reported as standardised scores according to the following four point scale:

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

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

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

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

Table 2 Example of environmental impact assessment of Freshwater shortage.

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

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

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

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

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

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

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

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

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

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

Causal chain analysis

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

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

Conceptual model

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

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

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

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

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

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

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

Policy option analysis

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

Construct policy options

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

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

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

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

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

Global International Waters Assessment

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

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

Table 5b: Scoring criteria for environmental impacts of Pollution

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

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

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

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

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

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

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

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

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

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

Broad Transboundary Approach

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

Regional Assessment – Global Perspective

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

Global Comparability

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

Integration of Information and Ecosystems

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

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

Priorities, Root Causes and Options for the Future

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

This Report

This report presents the GIWA assessment of the South China Sea region, which lies in the global centre of tropical marine biodiversity and comprises nine nations: China, Vietnam, Cambodia, Thailand, Malaysia, Singapore, Indonesia, Brunei and the Philippines. The region supports a rapidly growing coastal population, and has rapidly deteriorating marine ecosystems with the likely immediate collapse of many of its coral reefs and pelagic fish populations. Habitat modification and overexploitation of living resources were found to cause the most severe transboundary environmental and socio-economic impacts in the region. The past and present status and future prospects of these issues are discussed, and they are traced back to their root causes. Policy options to mitigate these problems are proposed that aim to provide solutions to these fundamental issues, in order to enhance the management of the region's aquatic environment.

UNEP

GEF

HÖGSKOLAN KALMAR UNIVERSITY