systems in the seven countries. Land-based sources play a major role in both inland and coastal pollution. Ship-based sources contribute relatively small amounts, but may have severe impacts when large volumes are released such as during major oil spills. Atmospheric inputs may seem innocuous at the present time because of a very poor database and because their impacts are harder to establish given the nature of atmospheric chemistry and the larger scales needed to carry out appropriate studies of air sheds. It must be pointed out however, that atmospheric pollutants are most potent in being transported across national boundaries. This was made evident during the extensive forest fires that occurred in Indonesia that caused smoke to shroud Malaysia and western Philippines. On a global scale, the ashfall debris injected into the stratosphere by Mt. Pinatubo's eruption caused major weather anomalies worldwide.

The density of pollution data differs from nation to nation. (See Appendix 1 for the detailed data compilation of waste production by country). Taken as a regional data set, major gaps exist and there is great need to monitor the major pollutant sources and the rates at which they release pollutants. Monitoring data is often non-existent or in some cases of such poor quality that they are better ignored than used for management decisions. Monitoring the amount of effluent dumped and its effects are essential before remediative efforts are made. Given that pollutants enter water bodies from point and diffuse sources, and interact with the substrate, suspended and dissolved load, it is difficult to attribute any impact to a pollutant or a source with unequivocal certainty. It cannot be repeated enough how important monitoring data are. They provide information on the current state of the environment, the natural variability or noise in the system, the input from anthropogenic sources and the result of mitigative effforts. The impacts are influenced by the nature of the pollutants, not in isolation of other substances and particles in the water but in their interaction with these. Hence, the management of pollution requires a holistic view of the natural and anthropogenic sources and their impacts. Appropriate mitigation can only be achieved by reducing loads across all man-made sources, and by addressing the social and economic drivers which influence these.

Table 3.48 Ranked sources of pollution among participating countries in the South China Sea[1]

Source	Rank & Data base	Contribution to pollution of national aquatic environments (L = Low, M = Moderate, H = High)						
		Ca	Ch	Indo	Mal	Phil	Tha	Viet
• Domestic waste	1-Fair	H	H	H	M	H	H	H
• Agricultural waste	2-Poor	M	H	H	M	H	H	H
• Industrial waste	2-Poor	M	H	H	H	H	H	H
• Sediments	3-Poor	M	H	H	M	H	H	H
• Solid waste	4-Fair	H	H	H	M	H	H	H
• Hydrocarbons	5-Poor	L	M	H	M	M	M	M
• Ship-based sources	6-Poor	M	M	M	M	M	M	M
• Atmospheric	7-Poor	M	M	M	M	M	M	M

[1]Ranking of pollution sources was done during the Second Meeting of National Coordinators (June 1998).

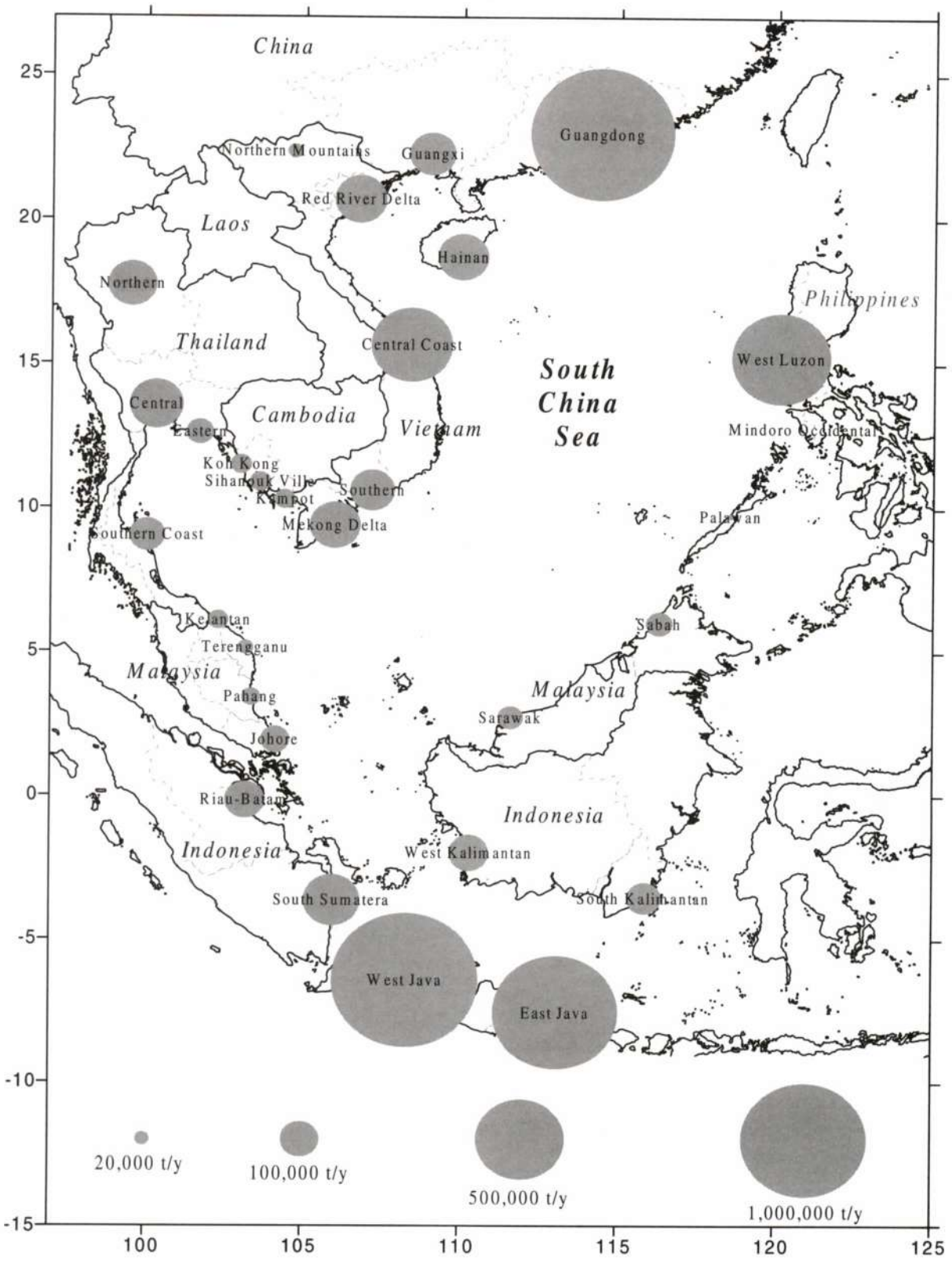

Figure 5. Biochemical oxygen demand loading from domestic sources in each sub-division in the South China Sea.

3.3.2 Domestic wastewater

The data given by the national reports were not amenable to comparisons across countries, but the raw data they provided on a subnational level was crucial in generating the regional picture for watersheds that interact with the South China Sea basin. (See Appendix 1.) To make the data comparable, subnational population growth rates were used to estimate 1996 populations at the South China Sea country level. The BOD generated by each South China Sea country was approximated using WHO daily per capita generation of 0.05 kg. Koe and Aziz, (1995) provided estimates of daily BOD removal for four countries.

About 6 million tons of BOD are generated each year by the coastal population of the 7 participating countries of the South China Sea alone (Table 3.49). Of these, only 11% is removed by sewage treatment in four countries. Assuming the same population growth rates prevail up to 2005, the generated BOD will increase to 6.6 million tonnes. If the amount removed by sewage treatment is not significantly increased from the insignificant level of 11%, the coastal waters of the Sunda Shelf from the Indo-China Peninsula to Malaysia and Indonesia, across to the western Philippine shelf, will become eutrophic.

One of the signs of a reduced assimilative capacity are the frequent incidence of toxic and non-toxic algal blooms in the region. While science still has to determine the mechanisms behind the dynamics of blooms, which occur both in polluted and pristine areas, the role of nutrients in enhancing primary production has been known since Leibig's times in the 1890's. Various species exist along a gradient of nutrient concentrations, so that some prefer low levels while others require high nutrient concentrations. The monospecific dominance that occurs during blooms may be because of optimal nutrient regimes and the concurrent hatching of cysts that may have been seeded in previous blooms and biologically disturbed sufficiently to excyst. The horizontal transport of cyst material may be possible but perhaps occur only at localized scales because of its relatively heavy density. Events like the warm phase of the El Nino-Southern Oscillation may influence the development and spread of toxic algal blooms (MacLean, 1989).

Because human populations congregate in cities, it will be most strategic to prioritize the establishment of sewage treatments in the emerging megacities of the littoral states. In the seven countries, there are 93 cities with populations over 100,000 (Table 2.2). To date, at least 30% of the population live in these crowded areas, so that waters receiving domestic waste from these cities are themselves pollution hot spots.

Table 3.49 Generation of BOD by participating South China Sea countries

Country[1]	South China Sea Population[2] (% National) (x 10^3 persons	Population in cities (x 10^3 persons) (% of South China Sea population)	Pop growth rate (%)[3]	BOD generated (10^3 ton/yr)[4]	BOD removed by sewage treament[5] (10^3 ton/yr)
Cambodia	1,985 (18%)	1,775 (89%)	2.7	36.2	No treatment
China	59,694 (5%)	21,031 (35%)	1.6	1,089.4	<10%
Indonesia	105,217 (50%)	>50,161 (48%)	2.9	1,920.2	364
Malaysia	10,336 (51%)	1,527 (15%)	3.3	188.6	53
Philippines	23,633 (31%)	6,342 (27%)	2.1	431.3	149
Thailand	37,142 (62%)	0	1.4	677.8	89
Viet Nam	75,124 (100%)	2,144 (3%)	1.6	1,371.0	No treatment
Total	313,131 (19%)	>82,980 (>27%)	1.4	5,714.5	655 (11%)
2005	359,837			6,567.0	722 (1995 level of treatment)

[1]Only populations of subdivisions interacting with the South China Sea were included, and were recalculated to 1996 using growth rates in third column.
[2]Total population for all South China Sea subdivisions in a country was obtained.
[3]Average population growth rate for all South China Sea subdivisions in a country was obtained using a weighted mean method.
[4] Estimated BOD production using 0.05 kg/person/day (*Economopoulous* 1993).
[5] Koe and Aziz, 1995.

3.3.3 Agricultural waste

Table 3.50 Use of fertilizers and pesticides in South China Sea countries (TDA national reports)

South China Sea subregions	Rice fields (10^3 ha)	Aquaculture areas (10^3 ha)	Fertilizer use (ton/yr)	Pesticide use (ton/yr)
Cambodia	1,835	No data	>40,000	No data
China	3,425	2,476	3,636,685	>89,000
Indonesia	4,966	243	>5,600,000	28,706
Malaysia	No data	7	No data	No data
Philippines	1,236	20	181,084	No data
Thailand	8,613	No data	No data	No data
Viet Nam	1,500	No data	110,250	No data
Total			**>9,600,000**	**>>118,000**

Waste generated by agriculture and aquaculture and which enters water bodies in a diffuse mode, makes up the second most important group of pollutants in the seven countries (Second National Coordinator's Meeting) and in the region (Koe and Aziz, 1995). These include fertilizers and pesticides (fungicides, herbicides and insecticides) which are applied to enhance plant growth and production by eliminating their competitors, predators and parasites. China uses the most amount of fertilizer at 1000 kg/ha/yr and Cambodia, the least at 22 kg/ha/yr. Fertilizers when leached to aquatic environments contribute to nutrient loading in addition to that contributed by domestic sources. To evolve environmentally friendly farm practices that minimize the use of fertilisers and biocides, and to enhance soil retention of fertilisers should be the aim of efficient farmers.

Data on pesticide use is .scarce, and detecting its presence in aquatic environments requires expensive methods that most government laboratories in the region cannot afford. However, it is important to determine their concentrations in waters next to intensive farming areas as they can decimate biodiversity and productivity in aquatic systems. China reports more than 89,000 tons used in its South China Sea areas in 1995. Indonesia used about 29,000 tons annually during the period 1992-1996 (Table 3.50).

The ill effects of pesticides have been established. As antibiotics, their continued use lead to resistance among target organisms making their population growth less controllable. The more insiduous effects of pesticides are on non-target organisms that are critical to ecosystem function as well as directly to man. They also have a host of adverse effects on man including carcinogenic properties. Integrated pest control programs have been implemented in a number of countries, and the use of pesticides should be reduced to minimum levels.

In the past, the sale of pesticides was not only motivated by the desire to enhance crop production by eliminating undesirable organisms in the culture system. Their use was promoted by chemical manufacturers and the International Monetary Fund through a program called the "Green Revolution" of the sixties (Agenda 21-Indonesia, 1997). Consequently, government provided subsidies to buy pesticides. Worse, the pesticides made available in the region were those that were banned in the countries where they were manufactured because of their broad spectrum effects, e.g. DDT and chlordane. Today, there is no reason or incentive to duplicate this mistake region-wide.

3.3.4 Industrial waste

Table 3.51 Industrial waste discharges from coastal and non-coastal installations

South China Sea regions-Country	BOD (t/y)	N (t/y)	P (t/y)	Heavy Metals (t/y)	Suspended solids (t/y)
Cambodia	No data	No data	No data	No data	No data
China	10,345	370	17	25.4	17,304
Indonesia	25,992	No data	No data	No data	No data
Malaysia	426.4	>1,000	No data	No data	1,369
Philippines	>49,000	No data	No data	No data	No data
Thailand	>340,000	>400	No data	No data	No data
Viet Nam	>>4,500	Data given as wastewater volume		96,560	>13,000
Total	**>430,000**	>1,800	**No basis**		

Considering the incomplete data base, industries release a minimum of about 430,000 tons of BOD into aquatic systems interacting with the South China Sea (Table 3.51). Eighty percent of the reported value comes from Thailand, of which 50% is conveyed by the river systems of Chao Phraya, Ta Chin, Mae Klong, and Bang Pakong.

Data provided on heavy metals are incomplete. Viet Nam whose major rivers are all transboundary, reports an annual load of at least 96,560 tons/year, 96 times more than Japan disposed of in 1988 (Table 3.52). Around 80% of this load come from the Dong Nai-Saigon River. In contrast, China reports the release of only 25 t/y. Metal specific data should bear out whether limits have already been exceeded. Viet Nam indicates in its national report that in the Northern Economic Zone, the amounts of Pb, Zn, and Cu are 7-10 times the allowable limits.

Table 3.52 Estimated disposal of toxic substances (10^6 t) (Source: State of the Environment in Asia and the Pacific, Economic and Social Commission for the Asia-Pacific, 1995 as cited in Agenda 21-Indonesia, 1997)

Country, Year disposed	Estimated production of hazardous waste (10^6 t/yr)[1]	Toxic to humans	Toxic to aquatic organisms	Toxic levels of heavy metals
Japan, 1988	0.82	13,715	15,877	1,034
China, 1987	50	3,226	4,098	155
Indonesia, 1986	5	195	247	7
Malaysia, 1987	0.4	181	217	9
Philippines, 1987	0.08-0.15	118	143	7
Thailand, 1986	0.88	137	167	6

[1]Hernandez, (1993).

Aside from pesticides and heavy metals, hazardous and toxic pollutants include paint and color agents, organic solvents, and other byproducts of industrial manufacturing or processing. Hazardous wastes are products having one or more of the following features: explosive, inflammable, reactive, disease-causing, corrosive, and/ or toxic (based on toxicological tests) (Agenda 21-Indonesia, 1997). Hernandez, (1993) estimated production rates of hazardous waste for a number of South China Sea countries (Table 3.52). The data in this table are estimates derived from various sources, with some as current as 1993 and others pertaining to the late 80s. As the same definition of hazardous waste has not been used in all cases, the information is not comparable between countries and should be used only as a crude estimate. There is a need to monitor the production and disposal of hazardous waste and strategically to control these wastes at the source end by advocating the use of cleaner technologies.

3.3.5 Sediments

In aquatic systems, total suspended solids include sediments brought about by erosion of soil material as a result of mining, agriculture, forest clearance, coastal development including land reclamation, and natural processes. Sediments are a major pollutant in coastal waters they have immediate observable impacts including the smothering of coral reefs, and burial of macrophytes like seagrasses and seaweeds. However, very little quantitative data is available in terms of actual sediment load that

has entered aquatic systems in the region, and little was obtained from the national reports. Rates of shoaling can be used as indicators of sediment deposition, but, these represent net accumulation of both man-induced and naturally-caused particle movements.

Table 3.53 Land clearance in selected countries (Agenda 21-Indonesia, 1997)

Country	Land area (10^3 km^2)	Forest area (% of land)			Clearance rate with reforestation (km^2/y)	Annual roundwood production (10^3 m^3)	Annual average reforestation (km^2)
Year	*1989*	*1981*	*1986*	*1989*		*1985-87*	*1980's*
US	9,167	31.0	28.9	28.3	13,189	485,760	17,750
Germany	244	30.0	30.0	29.5	No clearance	31,583	620
Australia	7,618	13.9	13.9	13.5	3,189	19,907	620
UK	242	No data	9.0	5.7	2,181	5,082	400
France	550	No data	26.6	26.6	No clearance	39,890	510
Malaysia	329	66.0	60.0	57.8	3,122	32,000	250
Indonesia	1,812	75.0	72.5	60.0	32,335	158,075	1,640
Philippines	298	31.0	24.5	21.5	2,516	35,822	630
Thailand	511	47.0	35.0	28.0	11,826	36,900	310

Data from Table 3.53 can be used as a proxy for tree felling in determining the extent of sedimentation as a function of land clearance. Indonesia topped the list at a clearance rate of over 32,000 km^2 of forest/yr to produce 158 million m^3 of roundwood. Thailand came second in the region with a rate of almost 12,000 km^2/y from 1981 to 1989 to produce 37 million m^3 of round wood. If the slopes of the cleared area are given, an index of erosion can be made, to estimate the amount of sediments that can be moved. Given the data above, sediment loads from cleared land in Indonesia would have contributed the most sediment, followed by Thailand, Malaysia and the Philippines.

A similar exercise can be done for the mining sector and for land reclamation projects. Both activities produce a large amount of sediment that is transported by rivers in the case of mining, or dumped directly in to coastal waters as filling. The Baguio Mining district, during its peak operations in the 1980's, produced at least 11 million tons of tailings/year that were conveyed by two river systems draining into the Lingayen Gulf (Maaliw, 1990).

Dredging of silted navigation channels can also indicate the massive amounts of sediments brought to aquatic environments. In the Mahakam River Delta, around 2 million m^3 of sediments were dredged to maintain navigation channels, which presumably were silted by erosion caused by massive logging in the interior of Kalimantan (Hinrichsen, 1998).

The responses of flora to reduced light intensities in turbid coastal waters are variable. Under natural processes of erosion, silt load is trapped by mangrove roots in estuarine waters, and then bound by the rhizomes of seagrasses, as they approach the coral reefs. During massive sediment loads, these natural sediment filters break down. For filter feeders like coral polyps, suffocation leads to death as particle removal

through tentacular movement is greatly restrained under high silt load. For seagrasses and seaweeds, a reduction in light regimes leads to their demise, and reduced productivities of those plants which can normally deal with relatively higher concentrations of silt and high nutrient regimes of coastal waters. Thus, there is a loss both of biodiversity and productivity of benthic macroflora. In the case of phytoplankton, the massive silt load may not necessarily lead to reduced photosynthesis because cells are suspended in the water column, and shading may be episodic as they are mixed in all directions. The high amount of nutrients associated sometimes with high sediment loads sustains high production. Thus, algal blooms very often are initiated in coastal areas, specifically in embayments.

Reduction of anthropogenic activities which exacerbate erosion, and less disposal of sediments into coastal waters, including reclamation, should be carried out. With population growth and industrialization, there is increasing pressure to provide clear land for housing and infrastructure development in support of industries, and food production. These are clearly political decisions but must be made with minimal negative consequences to the natural resource base on land and in the sea.

3.3.6 Solid wastes

Solid wastes are generated by domestic and industrial activities. There are no reported values in the TDA national reports coming from industries. Table 3.54 compares estimates of reported solid wastes generated by domestic activities and those estimated using a value of 0.6 kg/person/day (Economopoulous 1993). The discrepancies could be in the conversion factor used, as well as in the population estimates. Koe and Aziz, (1995) estimated daily per capita generation of solid waste to range from 0.4 kg in Indonesia to 2.00 in Singapore, the amount increasing with affluence. Using the percent disposal at authorized sites in 1989, the amount disposed in non-authorised locations including rivers and coastal waters would be at least 68% of domestic solid waste production for the entire region. When solid wastes reach aquatic systems, they smother predators, and reduce the aesthetic value of beach and underwater sceneries for coastal tourism.

Although the composition of solid waste from domestic sources is mostly organics (putrescible) and paper, their decomposition rates are slow, and others are not biodegradable such are plastics, metals and glass (Table 3.55). Proper solid waste disposal is a major problem in highly populated areas such as in cities. Landfills when not properly maintained can produce toxic leachates which can seep into groundwater, or aggregate hazardous materials that can impair public safety. In Metro Manila, some landfills have become methanogenic (hence the name Smoky Mountain for a landfill located in a suburb of Metro Manila in Navotas) causing severe respiratory illnesses among residents in surrounding areas.

Table 3.54 Solid waste from domestic sources (based on TDA national reports)

Country	Population of South China Sea subregions X 10^3 (% of national)	Estimated solid waste (10^3 t/y) (at 0.6 kg/person/day)	Reported values of solid waste from domestic sources (10^3 t/y)	Percent disposal at authorized disposal sites (1989)[1]
Cambodia	1,985 (18%)	435	560	No data
China	59,694 (5%)	13,073	No data	No data
Indonesia	105,217 (50%)	23,042	22,899	60%
Malaysia	10,336 (51%)	2,264	1,924	65%
Philippines	23,633 (31%)	5,176	1,330	70%
Thailand	37,142 (62%)	6,134	482	40%
Viet Nam	75,124 (100%)	16,452	No data	No data
Total	**313,131 (19%)**	**66,576**		
2005	359,837	78,804		

[1]data from Koe and Aziz, 1995.

Table 3.55 Components of solid waste (Koe and Aziz, 1995)

Country	Solid waste compositon (%) in some South China Sea countries					
	Paper	Glass	Metals	Plastics	Organics	Others
Brunei	26	6	11	13	41	3
Indonesia	2	1	4	3	87	3
Malaysia	25	3	6	8	56	2
Philippines	10	2	3	9	70	6
Singapore	28	4	5	12	44	7
Thailand	19	6	4	10	55	6

3.3.7 Oil and other hydrocarbons from land and sea-based sources

Table 3.56 Extent of oil pollution in the TDA participating countries (data from national TDA reports. For Indo, Phil. & Thai. assume 1L oil weighs 1kg)

Country	Sources		
	Domestic sources (t/y)	Industrial Sources (t/y)	Ship-based/ Platform operations (t/y)
Cambodia	No data	No data	No data
China	No data	187.00	>300
Indonesia	No data	No data	32.8
Malaysia	No data	0.52	No data
Philippines	No data	No data	0.86
Thailand	No data	No data	> .01
Viet Nam	2,132	No data	>4,280

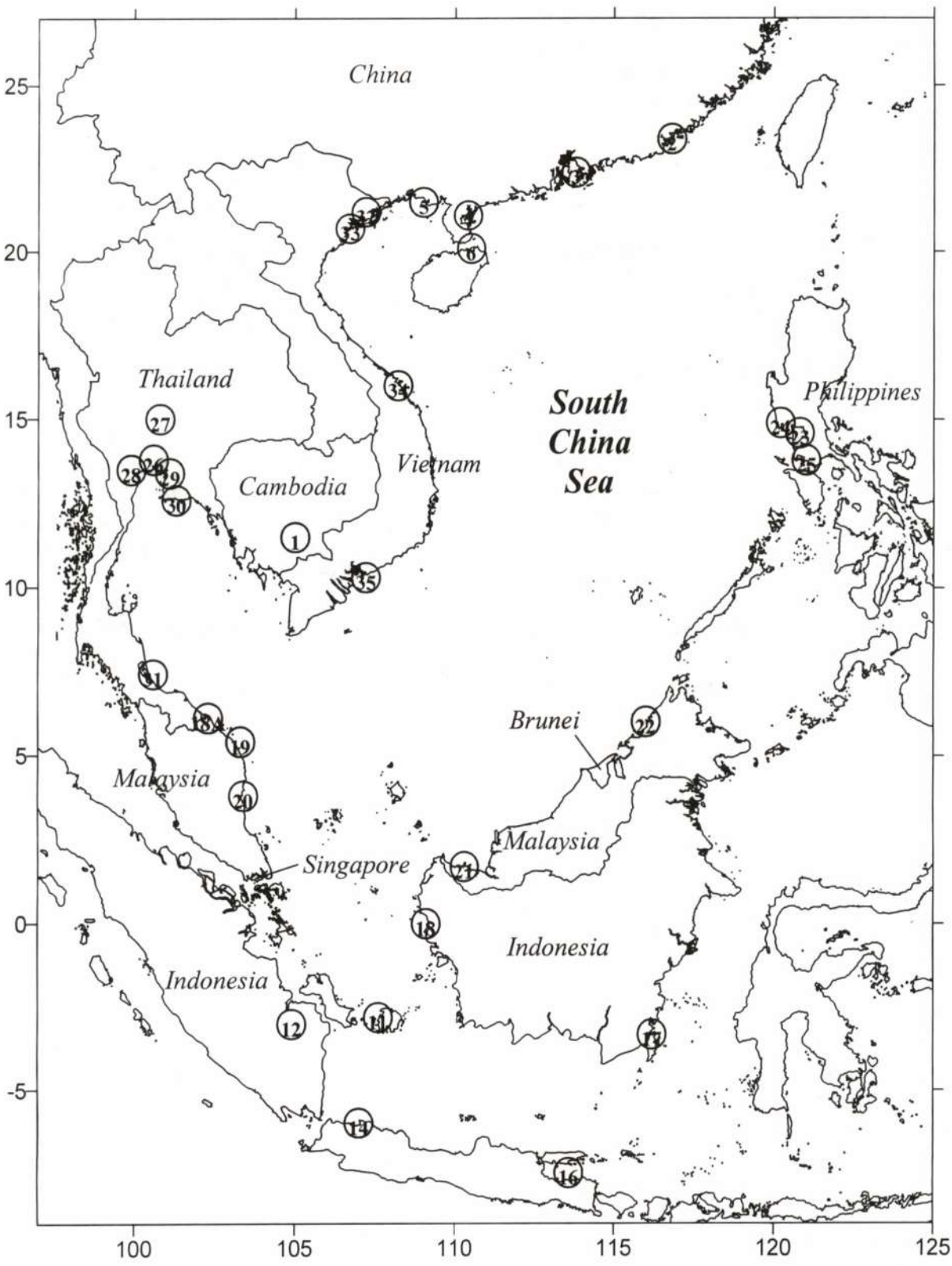

Figure 6. Pollution "Hot Spots" in the South China Sea. Numbers correspond to location listed in Table 2.3.

The data in Table 3.56 is not sufficient to establish the relative importance of each of the major sources of oil and other hydrocarbons in the aquatic environment. For lack of regionally based data, the following estimates (GESAMP, 1993) for the global ocean may hold true for the South China Sea (Table 3.57).

Table 3.57 Relative contribution of different sources to oil pollution

Sources	Inputs (t/y) (% contribution)
1. Municipal and industrial sources	1,175,000 (50%)
2. Marine transportation	564,000 (24%)
3. Atmosphere	305,500 (13%)
4. Natural sources	258,500 (11%)
5. Offshore production	47,000 (2%)

The relative contribution of various sources of oil will vary depending on factors including population density, extent of shipping, mineral exploration, and the degree of industrialization of littoral countries. In the South China Sea, all factors are intensifying so that absolute oil inputs will increase from at least three sources (Table 3.57). The average annual growth rate for oil demand in five of the seven TDA participating countries is projected to be 5% for the period 1993 to 2005.

Table 3.58 Oil demand by selected countries (10^3 barrels/day) (*GEF/UNDP*/IMO 1997)

Country	1993	2000	2005	Average annual growth for, 1993-2005 (%)
China	2,743	4,031	5,001	5.1
Indonesia	756	1,170	1,556	6.2
Malaysia	290	414	522	5.0
Thailand	517	839	1,096	6.5
Philippines	253	367	466	5.2
Japan	4,822	5,086	5,188	0.6
South Korea	1,552	2,217	2,740	4.8
Asia-Pacific	14,197	18,469	21,630	3.6

GESAMP (1993) summarizes the salient effects of oil on a number of marine organisms. Birds coated with oil during major spills have high mortality rates, but their long-term impacts on populations across generations are difficult to establish. High concentrations of oil in critical areas, including spawning and recruitment grounds, have an impact on the viability of populations including reducing the number of potentially reproducing adults. Mangroves are very susceptible to stress by oil because of the clogging of their aerial roots or pneumatophores. As a consequence, they suffer from partial or full defoliation, and may take as long as 20 years to recover. For corals, species accommodate oil contamination along a gradient of tolerance and the associated biota of coral reefs is impacted adversely, especially the young life stages of crustaceans and echinoderms. The water-soluble fractions of oil are the most lethal components. Tainting of food species has yet to be established. It is evident that oil interferes with lipid metabolism but the components of oil residuals and the substances that bind on organisms are unknown, much less their potential impacts on man.

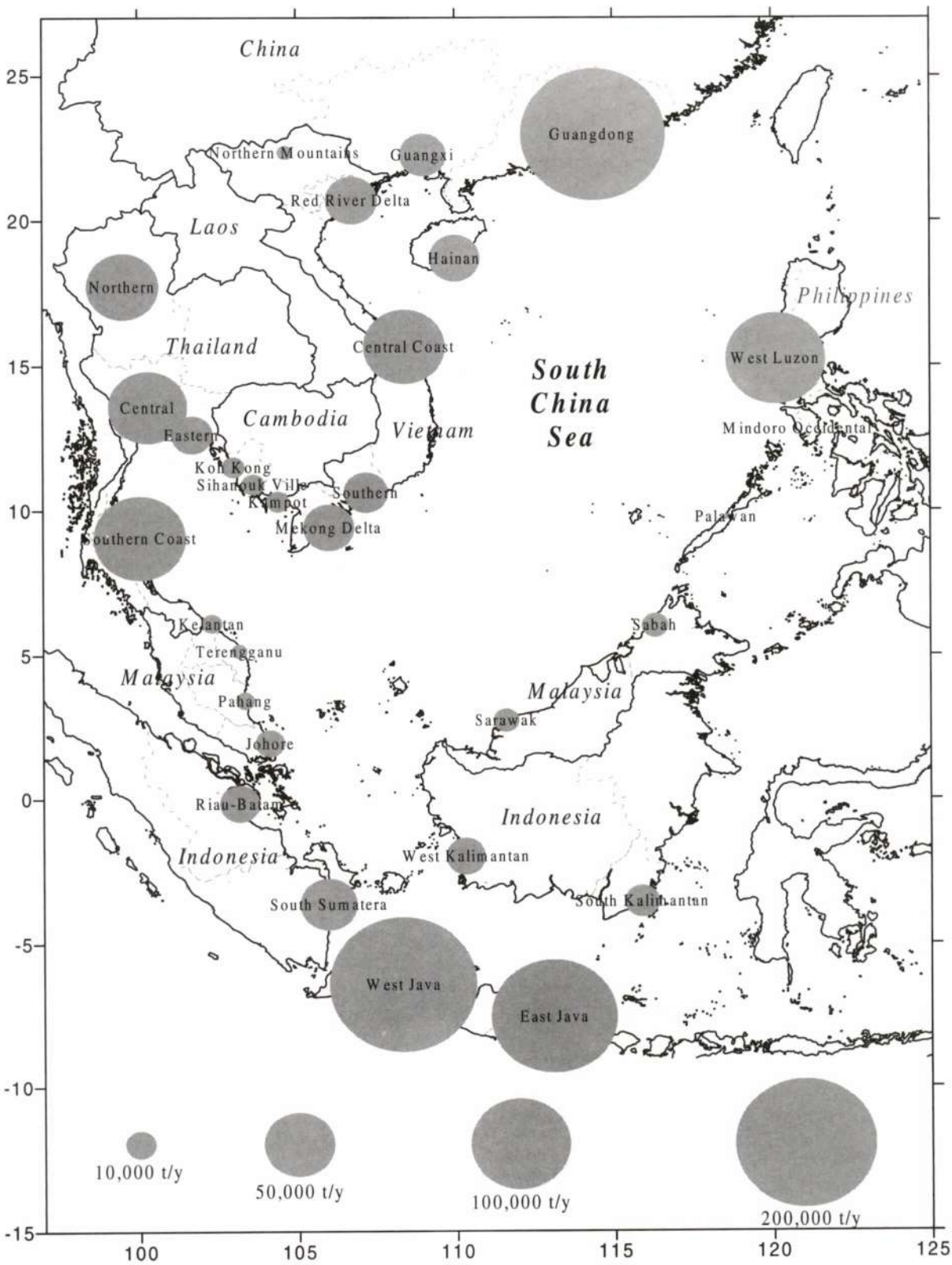

Figure 7. Total nitrogen loading in sub-divisions in the South China Sea.

3.3.8 Atmospheric sources

Emissions from power generation, industries and transportation contribute greatly to airborne pollution. By far, the most significant contributor is the power sector (Agenda 21-Indonesia, 1997). Fuel used for power generation includes fuel and diesel oil, coal and natural gas. Oil and coal are the most common fuels used in South China Sea countries (Table 3.58). The most pollutive of all fuels is coal in increasing intensity as its quality decreases. Most countries opt to use low-grade coal to produce cheaper energy, but the environmental impacts and effects on human health are most severe. The use of cleaner, albeit more expensive, fuel is in fact cheaper than lower quality fuel with its associated costs for the appropriate treatment of noxious emissions and human illnesses, even in the short term (Agenda 21 – Indonesia, 1997).

In urban areas, transportation is responsible for the release of most air pollutants. The number of vehicles will most likely increase to meet the transportation demands of a growing population. Considering only South China Sea-related subregions, Thailand has the most number of vehicles, followed by Indonesia, Malaysia and the Philippines. China and Viet Nam, with their increasing involvement in free trade, will spur the growth of the transport industry. In Jakarta, transportation accounts for 100% of lead, 42% of suspended particulate matter, 89% of hydrocarbons, 64% of nitrous oxides and 100% of carbon monoxide (Agenda 21-Indonesia, 1997). The profile may not be very different for other cities in South China Sea countries.

Sulphorus and nitrous oxides have profound impacts on human respiratory systems. When hydrated by precipitation, these ions form acid rain, a phenomenon that has considerably altered aquatic and terrestial systems in the Northern Hemisphere. The long-range transport of atmospheric pollutants is of transboundary and global concern. Indonesian subregions interacting with the South China Sea are rained on with 1.2 million tons/yr of sulphate. In Thailand and over a smaller area in its central and eastern sections, about 350,000 tons of sulphate goes back to the watershed annually (Table 3.59). Air shed-scale studies are needed to elucidate the transboundary dynamics and transport of acid precipitation in the South China Sea region during normal and anomalous climatological conditions.

Table 3.59 Atmospheric pollution in TDA participating countries. (Data from National TDA Reports)

Country	Oil consumption (10^3 t/y)	Coal consumption (10^3 t/y)	Number of vehicles (10^3 units)	Forest fires (affected area, ha)	Volcanic eruptions (in the last 50 years)
Cambodia	1,089	No data	No data	No data	No data
China-South China Sea	13,094	62,641	2,260	No data	No data
Indonesia-South China Sea Indonesia - Nat	No data 33,580	No data No data	8,951 14,886	No data 263,992 ha in 1997	7 eruptions
Malaysia-South China Sea	No data	No data	2,725	No data	No data

Continued Table 3.59

Country	Oil consumption (10^3 t/y)	Coal consumption (10^3 t/y)	Number of vehicles (10^3 units)	Forest fires (affected area, ha)	Volcanic eruptions (in the last 50 years)
Philippines-South China Sea	10.25 X 10^6 barrels	118.05 X 10^6 barrels	2,062	2,851 ha in 1997	2 eruptions
Thailand-South China Sea	No data	No data	11,050	No data	
Viet Nam	No data	No data	No data		

Table 3.60 Composition of precipitation in Indonesia and Thailand (Data from National TDA Reports)

Indonesia-South China Sea	Rainfall (mm)	Area (km^2)	SO_4 (t/y)	H^+ (moles/yr)	NH_4
Riau-Batam	1,719	94,561	185,729	307,022	172,493
Bangka-Belitung and South Sumatra	1,868	103,688	132,322	313,350	141,605
West Java	858	46,890	155,195	139,489	6,486
East Java	941	47,921	251,294	165,861	25,096
S. Kalimantan	1,644	37,660	196,096	313,823	41,256
W. Kalimantan	2,550	146,760	278,103	437,593	91,303
Subtotal			**1,198,739**	**1,677,138**	**478,239**
Thailand-South China Sea					
Central	1,304	64,044	67,802	42,919	4,927
Eastern	2,142	36,502	286,681	146,781	21,740
Subtotal			**354,483**	**189,700**	**26,667**

3.3.9 River systems

Table 3.61 shows fluxes from rivers in the seven TDA participating countries. Fluxes, obtained by multiplying average concentrations with annual discharge rates, indicate the amount of material conveyed by river systems to the sea, as a combination of load from all sources (agricultural, domestic and industrial). Concentrations at discharge points, are a net result after uptake by organisms, adsorption to particles, and chemical speciation have proceeded, among others. They indicate in what concentrations pollutants finally enter the coastal waters of the South China Sea. Excluding the archipelagic countries where either appropriate data is wanting or wrongly estimated, rough estimates of the total for the five continental countries are indicated. Rivers in Cambodia, China, Malaysia, Thailand and Viet Nam deliver at least 636, 840 tons of nitrogen to coastal waters overlying the Sunda Shelf. Of these, China contributes at least 55%, since they only reported inorganic N. Viet Nam (NO_3-N) and Thailand (DIN), contributed 21 and 20%, resp.

Table 3.61 Pollutant fluxes from rivers of TDA participating countries to the South China Sea

Country/River	Catchment Area (km^2)	Annual discharge (km^3)	BOD (t/y)	Total N (IN) (t/y)	Total P (IP) (t/y)	TSS (t/y)	Oil (t/y)
Cambodia							
Tonle Sap Lake-River System	69,355	36.45	6,022	1,084	303	13,250	No data
Coastal rivers	13,406	21.79	No data	No data	No data	No data	No data
Mekong River, Cambodia section	72,060	128.38	4964	894	255	10,950	No data
China							
Guangdong: Han, Rong, Pearl, Moyang, Jian	488,802	422.20	566,385	(340,050)	(3,768)	58,531,000	9,698
Quangxi: Nanliu, Qing, Maoling	14,051	24.90	57,668	(8,602)	(507)	No data	823
Hainan: Nandu, Changhua, Wanquanhe	15,865	31.0	' 140	No data	No data	No data	368
Indonesia							
Rivers in Jakarta and West Java	14,241	30.7	7,778,716	1,015,013	No data	22,368,391	1,549,979
Malaysia				**Ammonia-N**			
54 rivers	231,000	No data	>81,500	>20,100	No data	>75,000	1
Philippines							
No data	No data	No data	No data	No data	No data	No data	No data
Thailand				**DIN**			
Central, Eastern, Southern rivers	320,553	144.2	299,224	130,044	7,137	12,587	No data
Viet Nam				**NO_3-N**	**PO_4**		
	1,316,701	942.0		135,374	46,232		
			Cu	**Pb**	**Cd**	**Zn**	**Hg**
Thai Binh	28,230	46.26	3,942.2	154.3	163.9	3,352.0	16.5
Red	298,050	200.00	2,817.0	730.0	118.0	2,015.0	11.0
Dong Nai-Sai Gon	47,280	50.50	No data	102.2	No data	77,015.0	25.6
Mekong	830,780	573.10	1,825	190	128.0	1,278.0	<13.0
			BOD	Total N	Total P	Total TSS	Total Oil
>Total South China Sea for continental countries			**1,000,000**	**637,000**	**58,000**	**58,600,000**	

In general, river systems in the TDA participating countries, with the exception of Cambodia and Malaysia are moderate to heavily polluted using standard water quality parameters (Table 3.62). This is especially evident in rivers running through thickly populated areas such as in cities of China, Indonesia, Philippines, Thailand and Viet Nam. The mouths of these rivers are pollution hot spots, and mitigation at the source end from both point and diffuse sources will have to be dealt with.

Table 3.62 Status of river systems in TDA participating countries

Country	Status of River Systems
Cambodia	**Mekong River (Cambodia segment)**: OK
	Tonle Sap Lake-River system: moderate eutrophication during dry season
China	**Pearl River:** discharges 87% of the total COD coming from Guangdong Province; a pollution hot spot
Indonesia	Majority of the rivers on the island of Java empyting into the South China Sea are moderate to heavily polluted.
Malaysia	None of the rivers empyting to the South China Sea are classified as being heavily polluted from agro-based and manufacturing-based industry.
Philippines	**Pasig River**: Biologically dead **Rivers draining into Lingayen Gulf:** moderately polluted, but may have heavy metal contamination from the Baguio mining district.
Thailand	The final 100 km of the Lower Chao Phraya, Petchburi, Bangpakong, Rayong river systems emptying into thre Gulf of Thailand are pollution "hot spots". They convey 50% of total pollution to the Gulf.
Viet Nam	Six river systems (Ky Cung-Bang Gang, Red, Ma, Ca, Dong Nai, Mekong) are transboundary; Red, Dong Nai-Sai Gon, Mekong and Thai Binh Rivers have exceeded allowable limits for heavy metals like Hg and As.

3.3.10 Pollution hot spots, high-risk and sensitive areas

The TDA national reports identified 35 pollution hotspots (Table 3.63 and figure 6) and 26 sensitive and high-risk areas (Table 3.64) in sub-regions interacting with the South China Sea. Pollution loads on aquatic environments are influenced by population distribution and growth, industrial and agricultural development inland as far as catchments extend. The hot spots represent priority areas for monitoring and mitigation since they are places where pollutant load is most concentrated and will have the most impact on natural systems and public health. High risk and sensitive areas indicate locations which need the most protection from continued pollutant loading considering their limited assimilative capacities, their high biodiversity and the key ecological support function they provide. Previous sections on habitat modification have noted that virtually all coastal habitats (mangroves, corals and seagrasses) as well as natural wetlands in the region are sensitive areas and are at high risk. From a regional perspective, the locations of all the identified key areas relative to one another considering circulation regimes and prospective development, are necessary information in inferring the transboundary features of issues related to pollution.

Table 3.63 Pollution hot spots in TDA participating countries (National Reports)

Location	Demography/ Contributing cities or subregions	Pollution load
Cambodia		
1. Phnom Penh City	1,100,000 (1997)	BOD: 20,075 t/y TSS: 44,165 t/y COD: 34,130 t/y Total N: 3,285 t/y Total P: 1,000 t/y
China		
2. Han River	Shantou	COD: 37,102 t/y Oil: 384 t/y IN: 4,296 t/y IP: 697 t/y
3. Pearl Estuary	Hong Kong, Shenzhen, Dongguan, Guangzhou, Zhuhai, Macau	COD, nutrients, SS
4. Zhanjiang Bay	Zhanjiang	COD: 11,691 t/y N: 840 t/y Oil: 190 t/y
5. Behai coastal waters	Behai City	COD, nutrients, SS
6. Haikou coastal waters	Haikou	COD, nutrients, SS
Indonesia		
7. Dumai River	Riau –Batam	BOD: 17.7 – 48 mg/l
8. Pulau Nipah	Riau-Batam	
9. Siburik River	Bangka-Belitum and S. Sumatera	NO_3: 1.38 – 2.14
10. Lahat River	Same	BOD: 3 – 35 mg/l
11. Tanjung Pandan	Same	Cd: 0.005 – 0.017 mg/l
12. Palembang Harbour	Same	BOD: 4 –78 mg mg /l
13. Japat River	Jakarta	BOD: 13.5 – 15.0 mg/l
14. Jakarta Bay	Jakarta	Hg: 0.132 – 0.200 ug/l
15. Kali Mas River	West Java	BOD: 15.6 – 47.0 mg/l
16. Strait of Madura	West Java	BOD: 48 – 91 mg/l Phenol: 0.05 – 1 mg/l
17. Pulau Laut	S. Kalimantan	NO_2-N: 0.03 mg/l
18. Pontianak Harbour	W. Kalimantan	BOD: 135 – 150 mg/l
Malaysia		
19. Kota Bharu	257,792 (population); 0% access to sewerage	BOD generated: 4,705 t/y
20. Kuala Terengganu	268,294; 8.6% access	BOD generated: 4,477 t/y
21. Kuantan	238,738; 24% access	BOD generated: 3,230 t/y
22. Kuching	497,000; no data	BOD generated: 9,070 t/y
23. Kota Kinabalu	271,000; no data	BOD generated: 4,946 t/y

Continued Table 3.63

Location	Demography/ Contributing cities or subregions	Pollution load
Philippines		
24. Manila Bay	Metropolitan Manila and CALABARZON industrial estate	BOD: 4.8 mg/l Coliform: 2.5 x 10^5 ppm
25. Subic Bay	Zambales specifically Subic Port and industrial estate	BOD: 160-234 mg/l Coliform: 1,888 MPN/100 ml
26. Batangas Bay	Batangas City, oil refineries and depots	BOD: 8,838 t/yr from livestock Oil: 1,233 m^3 spilled from 1986-1993
Thailand		
27. Lower Chao Phraya River		Water Quality Index Level 5
28. Pasak River		Same
29. Petchburi River		Same
30. Bangpakong River		Same
31. Rayong River		Same
32. Songkhla Lagoon		Same
Viet Nam		
33. Ha Long Bay	Open pit coal mining, oil depots, port operations	4 x 10^6 t of coal mine sludge/y
34. Hai Phong Port	Population of 564,200; 9,891 industrial firms, 3.5 x 10^6 ton port.	BOD: 3,235 t/y COD: 4,331 t/y Coliform: 1,500 MPN/ 100 ml
35. Da Nang Port	Population of 667,200; 767 industrial firms, 3 oil ports	COD: 3,236 t/y TN: 6,601 t/y TP: 62.4 t/y TSS: 194,316 t/y Coliform: 5-270 x 10^3 MPN/100 ml
36. Vung Tau- Ganh Rai	154,505 population; 2,622,000 tourists/y (1995)	Ganh Rai Bay BOD: 4-11 mg/l SS: 150-260 mg/l TN: 0.2 - 0.5 mg/l TP: 0.02 – 0.05 mg/l Oil: 0.15 – 0.25 mg/l Zn: 0.02 – 0.04 mg/l

Table 3.64 Areas at high risk (HR) and sensitive (S) to pollution in the TDA participating countries (national reports)

Location	Pressures/ Sensitive resources	Pollution risks
Cambodia		
1. Sihanouk Ville – HR	55,440 population; 20 factories; port capacity of 1.2×10^6 tons	BOD: 1,011 t/y COD: 1,720 t/y TSS: 2,226 t/y
2. Tonle Sap Lake – S	Urban centers of Kompong Chnang, Pursat, Battambang, Siem Reap, Kompong Thom	Biodiversity and productivity of the largest permanent freshwater lake in Southeast Asia: part of the transboundary Mekong River Basin
China		
3. Daya Bay, Huizhou City – HR		Pollution from Daya Bay; oil spills from oil terminal
4. Shuidong Port, Maoming City – HR		Oil spills from oil terminal
5. Coastal waters of Sanya City – HR		Pollution from rivers, Sanya City population, coastal industries
6. Yangpu Bay - HR		Industrial pollution
7. Green Turtle Preserve, Huidong Port - S	Green turtle	Near river mouths; with high social and natural value
8. Aquatic Resource Preserve, Daya Bay – S	Aquatic resources	Same
9. Futian Natural Preserve – Deep Bay – S	Aquatic resources	Same
10. Haikang Preserve at Leizhou Bay – S	White butterfly shellfish	Same
11. Dugong Preseve, Tieshan Port Bay – S	Dugong	Same
12. Shankou Mangrove Preserve, Tieshan Port Bay – S	Mangroves	Same
13. Behai Beach - S	Natural landscape	Same
14. Mangrove Reserve, Beilun River mouth – S	Mangroves	Same
15. Mangrove Reserve, Dongzai Port – S	Mangroves	Same
16. Haikou City Beach - S	Natural landscape	Same
Indonesia		
17. Degraded areas in Java, Sumatera, W. Kalimantan	No data given	No data given
Malaysia – No locations given		

Continued Table 3.64

Location	Pressures/ Sensitive resources	Pollution risks
Philippines		
18. Masinloc Bay – HR		Red tide occurences
19. Bacuit Bay, Palawan – S, HR		Offshore oil and gas development
20.Oceanic shoals – S	Marine protected areas for marine turtles and sea birds	Shipping and oil spills
21. Apo Reef, Mindoro Strait – S	Marine protected areas for coral reefs	Shipping and oil spills
Thailand		
22. Head of Upper Gulf – HR		Receives polluted water from 4 rivers; Limited exchange between near and offshore waters; Bangkok Bar Channel isa navigational hazard
23. Ban Don Bay – S	Shellfish culture, coral reefs and seagrass communities; spawning grounds of Indo-Pacific mackerel	Loading from Tapipum Duong river
24. Rayong – S, HR	Coral reefs and seagrasses	Petrochemical industries; oil spills
25. Songkhla Lagoon – HR		Contaminated brackish waters with high BOD and coliform bacteria
Viet Nam		
26. Red River Delta – HR, S	Mangroves, shrimp and fish grounds, shore birds	Red River: Cu: 5.7 – 19.2 ug/l Hg: 0.02 – 0.25 ug/l As: 6.5 – 20.4 ug/l Zn: 22.8 – 53.3 ug/l
27. Mekong Delta – HR, S	Mangroves, shrimps and fish grounds	

3.3.11 Transboundary issues associated with pollution

Transboundary transport of pollutants occurs through international rivers, following circulation along the shared Sunda Shelf, and through the atmosphere. Economic activities like coastal tourism and the trade of waste are anthropogenic agents of pollution transport across national boundaries. The quality of this information is generally poor (Table 3.65).

Table 3.65 Transboundary issues associated with pollution in TDA participating countries

Transboundary Issue – Quality of Information	Ca	Ch	In	Ma	Ph	Th	Vi
1. Pollution of transboundary rivers							
• Mekong River – Poor to Fair	✓	✓				✓	✓
• Red River – Fair (Viet Nam)		✓					✓
• Sai Gon-Dong Nai–Fair (Viet Nam)	✓						✓
2. Transport of polluted coastal waters along the Sunda Shelf–Poor	✓	✓		✓		✓	✓
3. Haze from forest fires – Poor			✓	✓	✓		
4. Acid precipitation – Poor		✓				✓	✓
5. Transport of waste for trade and recyling – Poor	No data	✓	✓	✓	✓	✓	No data
6. Coastal tourism – Fair	✓	✓	✓	✓	✓	✓	✓

Pollution of international rivers. Six countries, four of which are TDA participants, share the Mekong River. China, specifically the Yunnan Province, sits at the source of the Mekong, while Thailand, Cambodia and Viet Nam are mid- and downstream of the river flow before it empties to the South China Sea through the Mekong River Delta. Two pollutants have transboundary impacts on the river basin. These are organochlorines and sediments. The data base for the presence of organochlorines is limited but is listed by the Mekong River Commission (1997), because of the rapidly expanding use of persistent organic pollutants (POPs) in the agricultural sector. All MRB countries contribute to sediment load. In Cambodia, the merging point of the Tonle Sap River with the Mekong has high TSS loads. The same is true for where the Bassac River joins the Mekong in Viet Nam. Poor land use management in the Yunnan highlands with an average slope of 32.3%, has caused significant erosion in 29% of the basin of the Lancang River (Mekong River) within China (Tables 3.66 and 3.67).

Table 3.66 Sharing of Mekong River Basin water resources (Mekong River Commission, 1997)

Resource	Yunnan, Chi	Mya	Lao	Tha	Cam	Vie	MRB
Catchment area (km^2)	147,000	24,000	202,000	184,000	155,000	65,000	777,000
Catchment area as % of nation/province	38%	4%	97%	36%	86%	20%	--
Catchment area of % of total MRB	22%	3%	25%	23%	19%	8%	100%
Annual flow (10^6 m^3)	76,500						475,000
Average flow (m^3 /s) from area	2,410	300	5,270	2,560	2,860	1,660	15,060
Average flow as % of total MRB	16	2	35	18	18	11	100

Table 3.67 Water quality assessment of the Mekong River Basin (Mekong River Commission, 1997, National reports)

Factor	Severity	Spatial scale	Occurrence/ Remarks
Eutrophication	Moderate-severe	local	Development areas High N conc: Chiang Saen, Ban Kok, Yasothon, Ubon, My Tho High P conc: Vientiane, Ban Kok, Luang Prabang, My Tho
Organic pollution	Severe-moderate	local	Development areas
Salinity	Very severe	local	Korat Plateau (evaporite rock salt) Salt water intrusion in Delta
Toxic metals	moderate	local	Limited data Severe in mining areas of western Cambodia; Severe in Viet Nam
Microbial pollution	moderate	local	Development areas
Acidification	severe	local	Delta
Organochlorines	moderate	regional	Limited data
Sediment yields	Moderate-severe	regional	Higher upstream and in wet season

Six of the 10 major river systems in Viet Nam are transboundary in extent (Table 3.68). Of these, four are severely polluted with BOD, nutrients, sediments and toxic heavy metals. Because they are shared water resources, pollution management will have to be pursued by user countries, with due consideration that impacts are felt downstream. All resource users should equitably and effectively control pollution and prevent further degradation.

Table 3.68 Transboundary river systems in Viet Nam (ESCAP, 1995, Viet Nam National Report)

River system	Catchment area (km^2)	River flow volume (km^3/y)		Status
		From outside (% of total)	Total	
Red-Thai Binh	168,700	44.12 (19)	137.00	Severe heavy metal pollution
Bang – Ky Kung	12,880	1.70 (32)	8.92	No data
Ma-Chu	28,400	4.34 (22)	20.10	No data
Ca	272,000	4.74 (20)	24.20	No data
Dong Nai	42,665	1.41 (5)	30.60	Severe heavy metal pollution
Mekong	795,000	500.00 (96)	520.60	Severe heavy metal pollution

Transport along the Sunda Shelf. China, Viet Nam, Cambodia, Thailand, Malaysia, and to a small extent Indonesia, share the Sunda Shelf. Few studies show the possibility of long-shore transport of pollutants across national boundaries. The Viet Namese report indicates that transport of pollutants from its northern pollution hot spots (Red-Thai Binh river mouths, Ha Long City, Hai Phong Port) can influence Hai Nan coastal waters and those along the coast of Quang Chau. Hot spots located south (Sai Gon-Dong Nai River, Mekong River, Vung Tao) can impact the waters of Cambodia, Thailand and Malaysia. Furthermore, oil spills in the Gulf of Tonkin, and along the South Viet Nam shelf can reach China to the north, or Cambodia, Thailand and Malaysia to the south, depending on the prevailing monsoon. (Viet Nam TDA National Report)

Jacinto *et al.*, (1997) discussed the use of nutrients as tracers of water masses in explaining both the horizontal and vertical nutrient profiles across a cruise track between the Philippines and Viet Nam. Nutrient concentrations were higher in stations nearer the Viet Nam shelf (average values of 2 μM for nitrate, 0.35 μM for nitrite, 1.8 μM for ammonia, and 0.70 μM for phosphate in the top 50 m), and within higher temperature and lower salinity regimes compared to adjacent stations. These could indicate runoff water, with the boundary current flowing south along Viet Nam interacting with waters from rivers flowing out of Viet Nam and Thailand.

Long-range atmospheric transport. Forest and grass fires occurred in Indonesia and the Philippines in 1998 at the height of the warm phase of the ENSO. In both countries, forest fires resulted from land clearing for estate plantations, transmigration and animal ranching; spontaneous combustion of coal seams, and those caused by lightning and volcanic eruptions (Agenda 21-Indonesia, 1997). The extent of the fires was significant enough to cause smoke to spread over Palawan, western Philippines, Peninsular Malaysia and Singapore.

Transport of other pollutants along air sheds may not be as visible as haze or smoke pollution, but may be more insidious. The long-range transport of sulfur and nitrous oxides through air masses, leads to transboundary acid precipitation. A report by Canadian Environmental Collaborative (1993) states that acid precipitation occurs in southern China (Sichuan and Hunan Provinces) during the summer months, and affects northern Viet Nam and Laos. During winter, with prevailing winds coming from the southwest, pollutants from Thailand and the rest of the Indo-China Peninsula could be contributing to acid precipitation in coastal southern China. The data are sparse, and when available can yield conflicting models of wind transport. Thus, large scale studies on atmospheric chemistry are a priority concern in the region.

Illegal Waste trade. Waste is transported from source developed countries for dumping (at sea) or for disposal and/or recycling in developing countries. Very little information exists because of the usually illegal nature of waste transport, especially noxious wastes. Media highlights transport of nuclear fuels or wastes, but other equally dangerous waste substances seem to be part of the regular trade traffic. Agenda 21-Indonesia (1997) documents the export of plastic garbage from the US during the months of February-March, 1992 to recipient countries in Asia for recycling (Table 3.68), 73% of which went to China. In certain instances, the cargo was declared as raw materials. Signatories to the Basel Convention, which attempts to regulate the trade and disposal of toxic and hazardous wastes, should be able to address this particular issue, but only if there is strong political will to counter economic exigencies driving the waste trade. Large quantities of noxious but unidentified waste was transported from Taiwan of China to Sihanoukville in Cambodia in 1999 but

international pressure forced Taiwan of China to remove it. (Bangkok Post 16/2/99, 11/4/99, 17/6/99)

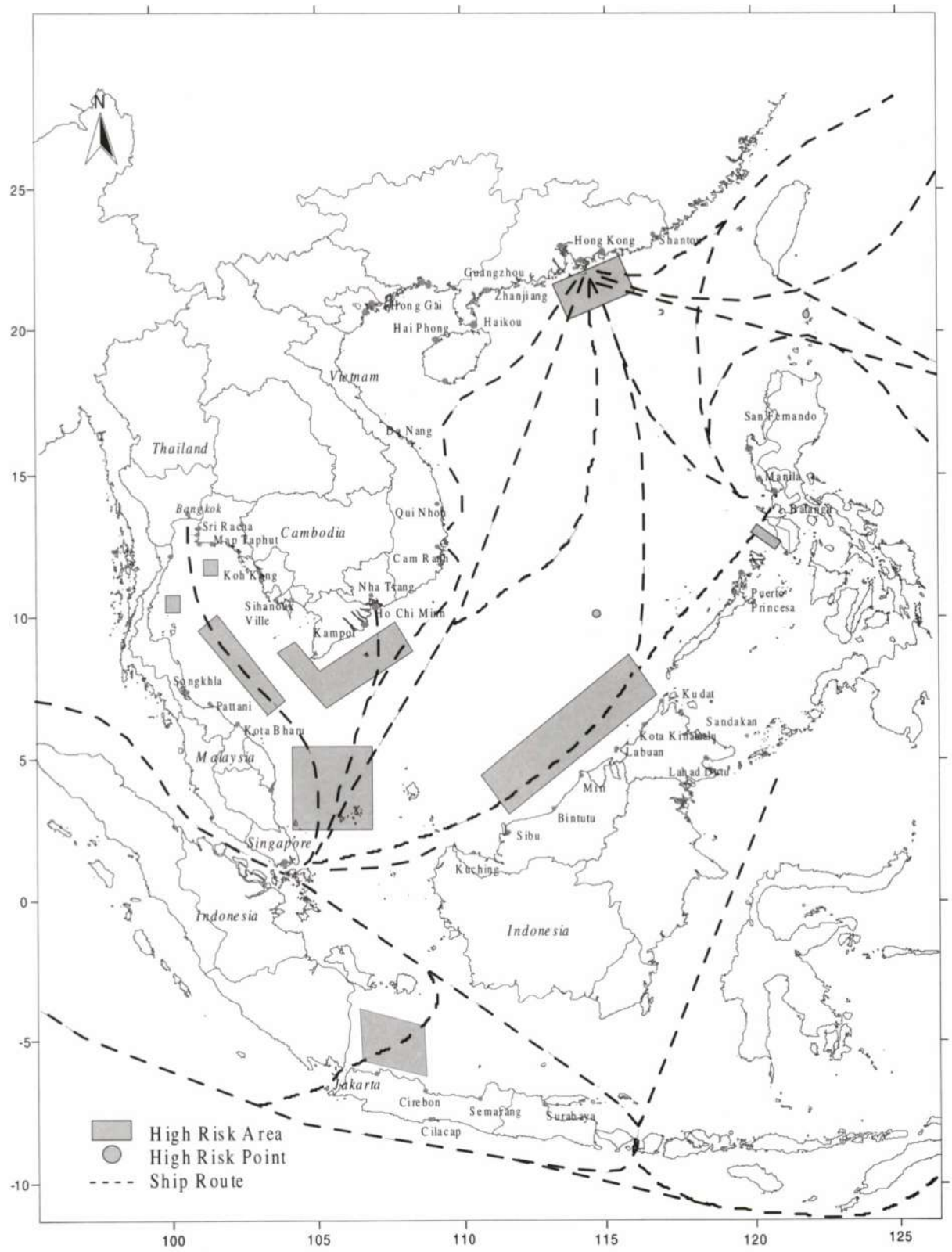

Figure 8. High risk areas for oil pollution in the South China Sea.

Table 3.69 Transboundary transport of waste for recycling from USA (February 1 – March 31, 1992) (Agenda 21-Indonesia, 1997)

Receiving Country	Shipments	Total kg x 10^3
China	598	17,410
Indonesia	50	2,251
Japan	5	51
Korea	8	110
Malaysia	7	255
Philippines	58	2,448
Thailand	6	124
Total (including other countries)	**749**	**23,740**

Coastal tourism. (See section on transboundary issues associated with habitat degradation). Tourism, along the coastal areas of the South China Sea, is dependent on clean beaches and coral reefs. Tourism has contributed significantly to coastal pollution and the degradation of corals, mangroves, beaches and seagrasses. The infrastructure development needed to support coastal tourism and the waste generated by facilities which crowd prime beach areas are traditionally taken as necessary evils that countries must accept in generating tourism-based revenues. As the industry increases (see Table 3.19) these issues must be considered and remediative and environmentally sound management brought into general practise. Tourism cannot be taken on its own, rather the environmental and socio-economic effects on a local and regional basis should be taken into consideration.

Table 3.70 Status of wetlands and associated biodiversity summarized from Scott (1989)
(Note: Strictly, coastal wetlands including saline lagoons and mangrove areas were not included below)

Country: Cambodia

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Mekong River: Associated freshwater swamp forests but widely deforested for firewood and agricultural land	486 km river; 2 M ha of floodplain which includes 1.6 M ha of the Mekong Delta	Supports one of the world's largest inland fisheries (75,000 to 80,000 t for the area from Kratie to Vietnamese border in the 1970s)	➢ proposed irrigation, hydroelectric power projects, flood control structures ➢ deforestation and demand for agricultural land; Cambodian portion of Mekong Delta has 1 M ha under cultivation, almost 90% of which is for rice ➢ domestic wastes and agricultural runoff	➢ principal tree species in swamp forest are *Barringtonia acutangula, Hydrocarpus anthelmintica, Terminalia chabula, Homalium brevidans, and Amelia asiatica* ➢ dry season fish fauna: 54% Cyprinidae or carps; 19% catfish; 8% murrels; & 19% (featherbacks, herring, climbing perch and gouramis, others) ➢ endemic fish include migratory catfish *Pangasianodon gigas* ➢ 3 species of dolphins: Irrawaddy dolphin *Orcaella brevirostirs*, Chinese white dolphin *Sotalla chinensis*, Black finless porpoise *Neophocaena phocanoides* ➢ wetland mammals: smooth-coated otter *Lutra perspicillata*, fishing cat *Felis viverrina*	None

Cambodia (con't)

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Great Lake and Tonle Sap River: ➢ Great Lake, largest permanent freshwater lake in SE Asia ➢ Great Lake connected to the Mekong via the Tonle Sap River ➢ Lake surrounded by freshwater swamp forest, 20-30 km wide, and which in turn are surrounded by a belt of rice paddies up to 25 km wide	➢ Lake area in dry season cover approx. 300,000 ha; in wet season, 1.1 to 1.3 M ha ➢ 1960 estimate of swamp forest was 681,400 ha; 1986 estimate is 564,000 ha	➢ Great lake regulates Mekong floods ➢ fisheries exploitation mostly carried out by straining fish during recession of floodwaters; lake commercial fish productivity estimated to be 40-50 kg/ha/yr or a total of 36,000 t/yr; ➢ total annual fishery estimated to be 139,000 t in 1939-51; 101,700 t in 1956-61; between 50,000 to 80,000 t in early 1970s; and 63,000 t in 1984 ➢ rice cultivation in the paddies	➢ clearance of swamp forest for agriculture, firewood and fishponds ➢ siltation resulting from deforestation	➢ swamp forest as in those around the Mekong River ➢ 38 commercially important fish species ➢ several breeding colonies of large waterbirds including endangered species such as the milky stork *Mycteria cinerea,* giant ibis *Thaumatibis gigantea,* white-shouldered ibis *Pseudibis davisoni,* and the eastern sarus crane *Grus antigone sharpii* ➢ mammals include Eld's deer *Cervus eldi* and Banteng *Bos javanicus*	Angkor Wat National Park of 10,717 ha established in 1925 includes 2,000 ha of swamp forest

Cambodia (con't):

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Stung Sen: ➢ with large areas of seasonally flooded marshes and grasslands along riverbanks; ➢ clearance of original dipterocarp forests led to formation of savanna grasslands with patches of mixed deciduous and dry dipterocarp forest	About 120 km of the Sen River; area of wetlands unknown	➢ sparsely populated ➢ hunting of mammals	➢ civil war with soldiers hunting for game meat	➢ tree species include *Shorea obtusa, Dipterocarpus obtusifolius, D. tuberculatus, Pentarme siamensis;* ➢ waterfowl as in the Great Lake-Tonle Sap system ➢ Siamese crocodile *Crocodylus siamensis* ➢ Grasslands supported herds of Kouprey, Banteng, Gaur, eld's deer, asian elephant and wild water buffalo, tiger and leopard	None
Stung Kaoh Pao and Stung Kep Estuaries: A complex of tidal channels and creeks, low islands, mangrove swamps, tidal mudflats and coastal lagoons of the Kaoh Pao and Kep rivers	Approx. 30,000 ha including 16,000 ha of mangrove forests	No information	No information	➢ Flora mostly mangrove forest; evergreen and deciduous forests of the Cardamome Range ➢ Fauna not known	None

Country: China

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Lufeng Marshes, Guangdong Province: estuarine system with fresh to brackish lagoons, marshes, mangrove swamps and intertidal mudflats	Approx. 2,000 ha	No information	No information	➢ Mangrove forest with about 20 species ➢ Important wintering and staging area for migratory shorebirds	None
Futien Nature Reserve, Guangdong Province: mangrove swamps, intertidal sand flats and mudflats along Hau Hoi Wan and the Shenzhen River; contiguous with the Mai Po Marshes in Hong Kong	About 304 ha including 228 ha of mangroves	➢ Fish and shrimp ponds along Hau Hoi Wan (Deep Bay) ➢ Mudflats support an important oyster fishery	Pollution from agricultural and domestic waste and from industrial development upstream of the Shenzhen River	➢ Seagrass *Halophila* on the mudflats ➢ Mangroves include *Kandelia candel, Aegiceras corniculatum, Avicennia marina, Excoecaria agallocha, Acanthus ilicifolius, Bruguiera gymnorhiza, Sonneratia acida, Rhiziphora stylosa, Derris trifoliata;* mangrove fern *Acrostichum aureum* ➢ 18 species of lamellibranchs, 10 gastropod sp.; 7 crustacean species ➢ Bennett's water snake *Enhydrus bennetti* ➢ Bird species include resident herons and egrets like *Ardeola bacchus, Egretta garzetta, Ardea cinerea;* wintering waterfowl such as *Tachybaptus ruficollis, Phalacrocorax carbo;* ducks including *Tadorna tadorna, Anas crecca, A. poecilorhyncha, Aythya fluigula, Fulica atra;* migratory shorebirds mainly *Charadrius alexandrinus, Calidris alpina* and gulls Larus ridibundus	The whole area is within the Futien-Nei Lingding Provincial Nature Reserve (858 ha) established in 1984: ➢ Sand extraction, wood cutting and hunting are prohibited ➢ Existing fish and shrimp ponds in use but no new construction is allowed ➢ *Acacia confusa* trees planted to shelter the mangrove fringe

China (con't.)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Xi Jiang (Pearl River Delta), Guangdong Province: includes interconnecting river channels, low islands, riverine marshes, intertidal mudflats	475,000 ha	➢ One of China's most important fishing areas ➢ Delta is heavily used for aquaculture and agriculture	➢ Mangrove conversion to fish ponds ➢ Infrastructure for drainage, and reclamation ➢ Pollution from agricultural, industrial and domestic waste ➢ Hunting of shorebirds for food and export	➢ Few mangrove patches remain ➢ Important wintering area for Anatidae, and for migratory shorebirds; nesting species include *Nycticorax nycticorax, Ardeola bacchus, Bubulcus ibis, and Egretta garzetta*	A tiny nature reserve, the Bird Paradise Nature Reserve, was established to protect a breeding colony of *Nycticorax nycticorax*
Beijin Gang, Guangdong Province: brackish marshes, mangrove swamps and intertidal mudflats	1,500 ha	No information	No information	➢ Mangrove forest ➢ Migratory shorebirds	None
Dongzaigang Nature Reserve, Hainan: Small shallow bay with intertidal mudflats and mangrove swamps	5,240 ha	➢ Fiheries ➢ Agriculture	➢ Densely populated ➢ Overfishing	➢ Mangrove forest with *Bruguiera gymnorhiza, B. sexangula, Rhizophora stylosa, Ceriops tagal, Lumnitzera racemosa, Heritiera littoralis, Excoecaria gallocha, Aegiceras corniculatum* ➢ Rich fish fauna ➢ Feeding habitat for waterfowl including *Anas poecilorhyncha, Ardeola bacchus, Egretta garzetta, e. intermedia, E. alba*	Protected area as a National Mangrove Protection Area: ➢ Woodcutting and hunting prohibited ➢ Mangrove restoration programme

China (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Qinglan Gang and Wenchang, Hainan: Consist of brackish marshes, extensive mangrove swamps, intertidal mudflats, sandy beaches and coral reefs	5,733 ha	Fisheries	➢ Densely populated ➢ Overfishing	➢ 25 mangrove species ➢ breeding area for Ardeidae; wintering and staging area for migratory shorebirds	3,733 ha is protected as the Qinglan Gang Mangrove Nature Reserve: ➢ no felling allowed ➢ reforestation program
Yanpu Gang, Hainan: Brackish marshes, mangrove swamps, tidal mudflats, sandy beaches and coral reefs	1,200 ha	Fisheries	➢ Domestic sewage from dense population ➢ Inland agriculture	➢ Mangrove forest ➢ Wintering and staging area for migratory shorebirds	None
Tiehshan Gang and Anpu Gang, border of Guangxi and Guang-dong Provinces: Small estuaries and shallow bays with intertidal mudflats, mangrove forests, sandy beaches	35,000 ha	Fisheries	➢ Domestic sewage from dense population ➢ Inland agriculture	➢ Large tracts of mangrove forests ➢ Wintering and staging area for migratory shorebirds	None
Qingzhou Wan, Guangxi Province: Large shallow bay receiving Qinliang River, several small bays and estuaries, small offshore islands, extensive intertidal mudflats and patches of mangrove forests	36,000 ha of coastal flats and mangroves ; 8,385 ha of islands	Fisheries	No information	➢ Flora: mangrove and seagrass beds ➢ *Dugong dugon*	None

China (con't):

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Wetlands in the Dayao Shan Nature Reserve, Guangxi Province: small freshwater lake and marshes, and a fast-flowing river and associated marshes	Nature reserve: 14,500 ha; Wetland area unknown	No information	No information	➢ No information on flora ➢ Breeding area for *Shinisaurus crocodilurus*	Wetlands protected in the Dayao Shan Nature Reserve (14,500 ha) since 1982.
Dawangling Marshes, Guangxi Province: estensive riverine marshes and large area of rice paddies on marshy plain	19,200 ha	No information	No information	➢ Riverine marshes and rice paddies ➢ Wintering area for migratory waterfowl	Potected in a Nature Reserve establishes in 1980.
Chengbi He Reservoir, Guangxi Province: large water storage reservoir and associated marshes on a tributary of the Yong Jiang River; several small islands	16,200 ha	No information	No information	➢ No information on flora ➢ Wintering area for migratory waterfowl	Protected in a Nature Reserve established in 1980

Country: Indonesia

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Ogan-Komering Lebaks, South Sumatra: Freshwater swamps and marshes along the Ogan and Komering Rivers	200,000 ha	No information	Reclamation for agriculture resulting in deforestation	➢ No information on flora ➢ Rich in waterbirds including the endangered white-winged wood duck *Cairina scutulata*	None
Padang-Sugihan Wildlife Reserve, South Sumatra: Peat swamp forest, sampy grassland, rivering swamp forest and drier *Melaleuca* forest, all of which are periodically flooded; east and west borders of the reserve are the Sugihan and Padang Rivers, resp, and which are very acidic and heavily stained with tannins, among others	75,000 ha	Conservation education	➢ Illegal logging in the swamp forest ➢ Poaching of the Sambar deer and monitor lizards ➢ Clearance for settlement	➢ Dominant vegetation are those in the peat swamp forest; with abundant ferns and orchids ➢ Many species of waterfowl including the endangered white-winged wood duck *Cairina scutulata,* the rare Storm's stork *Ciconia stormi;* 11 species of kingfisher; raptorial birds include *Haliastur indus, Haliaeetus lecogaster, Ichthyophaga nana and I. Ichthyaetus,* and fish owl *Ketupa ketupo* Mammalian fauna: *Panthera tigris sumatrae, felis bengalensis, F. viverrina, elephas maximus sumatranus, Helarctos malayanus, Lutra sumatrana, Aonyx cinerea, Paguma larvata, Cynogale bennettii, Hylobates agilis, Macaca nemestrima, M. fascicularis, Presbitys cristatus, Tragulus napu, T. javanicus, Sus scrofa, S. barbatus, Cervus unicolor*	Declared as a Wildlife Reserve (75,000 ha)

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Pulau Betet, South Sumatra: Large island with mangrove forests, intertidal mudflats and peat swamp forests	About 10,000 ha	Important as nursery ground for fish and shellfish	➢ Illegal logging ➢ Collection of eggs of waterbirds for food	➢ Mangrove forest dominated by Rhizophora and Bruguiera ➢ Important area for resident and migratory waterfowl; at least 30 species ➢ Estuarine crocodile *Crocodylus porosus*	None
Banyuasin Musi River Delta, South Sumatra: Large delta system of the Banyuasin and Musi rivers with extensive mangrove systems, intertidal mudflats	150,000 to 200,000 ha	➢ Fisheries especially shrimps and prawns, and cockles ➢ Timber	➢ Reclamation ➢ Logging ➢ Disturbance of breeding colonies of waterbirds ➢ Hunting ➢ Forest fires	➢ Over 30 species of mangrove; freshwater swamp forests, peat swamp forests, and grassy marshes ➢ 18 species of large waterbirds and 20 species of migratory shorebirds; 3 species of birds of prey ➢ 10 mammal species ➢ *Crocodyllus porosus,* turtle *Chitra indica, Pelochelys bibronii*	None
Sungai Lalan, South Sumatra: Extensive mangrove swamps and intertidal mudflats	586,417 ha including 80,000 of swamp forest	Fisheries	➢ Logging ➢ Forest clearance for transmigration schemes ➢ Crocodile hunting ➢ Pollution and disturbance from boat traffic	➢ Mangrove, freshwater swamp and peat swamp forest species ➢ At least 12 fish species; unknown number of waterfowl species; about 5 mammal species; 5 reptile species	None

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Berbak Game Reserve, Sumatra: One of the largest swamp forest reserves, both peat and freshwater types.	175,000 ha	➢ Unique Kubu tribe of hunter-gatherers ➢ Peat swamp is an important natural water storage during dry season	➢ Drainage of the peat swamp by drainage canals ➢ Illegal logging ➢ Disturbance of the roosts of migratory shorebirds ➢ Capture of freshwater turtles ➢ Forest fires	➢ 150 species of trees ➢ at least 34 species of freshwater fishes and brackishwater water fishes ➢ at least 24 species of shorebirds ➢ about 21 mammal species ➢ at least 16 reptile species	Protected as a game reserve since 1935
Kerumutan Baru, Riau Province: large reserve with extensive peat swamp forests and a small area of dry-land forest; with about 5 rivers crossing through it.	120,000 ha	No information	➢ agricultural encroachment ➢ Illegal hunting ➢ Logging	➢ Peat swamp forest with wet lowland forest ➢ At least 7 mammal species ➢ Unknown number of waterfowl species	Protected as a Nature Reserve (Cagar Alam)
Danau Bawah and Pulau Besar, Riau Province: Peat swamp forests with two freshwater lakes and an island in one of the lakes.	23,750 ha	➢ High aesthetic values ➢ Rich genetic resources	➢ Land clearance for transmigration ➢ Logging ➢ Oil exploration ➢ Road construction	➢ Extensive *Shorea* and *Gonstylus bancanus* swamp forests ➢ Rich in wildlife	Protected as a nature reserve since 1979
Siak Kecil, Riau Province: System of small freshwater lakes in a large area of peat swamp and freshwater swamp forests	c. 100,000 ha	No information	➢ Logging ➢ Oil exploitation	➢ 30 species of peat swamp trees ➢ unknown no. of waterfowl species ➢ important habitat for rare and endangered mammals ➢ breeding area for false gharial *Tomistoma schlegelii*	None

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Bakau Selat Dumai, Riau Province: large area of rich and undisturbed mangrove forest and peat swamp forest.	60,000 ha	Fisheries	➢ Settlements ➢ Logging	➢ Mangrove and peat swamp tree species ➢ Rich in waterbirds and wildlife; no species inventory	None
Ijen Merapi Ungup, East Java: A small crater lake with many sulphur fumerols, 50 ha in area; most with climax forest.	Nature reserve is 2,560 ha	Area of geological and botanical interest	➢ Manmade fires ➢ Sulphur mining ➢ Intense agriculture	➢ With lowland and montane forests; grasslands ➢ Rich fauna but information is little	Nature reserve established in 1920
Pleihari Tanah Laut, South Kalimantan: low-lying coastal area with 40% grassland and shrub land and 50% swamp	35,000 ha	➢ Fisheries ➢ Water supply	➢ Wood cutting ➢ Hunting of deer ➢ Shifting cultivation ➢ Grazing of domestic livestock	➢ Mangrove forests, grasslands and swamp forest, heath forest ➢ Waterfowl and migratory shorebirds ➢ Mammals ➢ Marine turtles, estuarine crocodile and monitor lizard	Protected as a Wildlife Reserve since 1974
Danau Bankau and other swamps in Barito Basin, South Kalimantan: Alluvial plain of the lower Barito Basin; complex system of levees and back-swamps, deep water swamps; peat swampts; two open water lakes Danau Bankau and Danau Panggang	480,000 ha	➢ Deep water swamps for natural flood control ➢ Fisheries	➢ Reclamation ➢ Fishing ➢ Reed cutting ➢ Bird trapping ➢ Forest clearance	➢ Most important freshwater swamp in Kalimantan ➢ Very important area for waterbirds (at least 27 species)	None
Kelompok Hutan Kahayan, Central Kalimantan: large area of swamp forest (peat, freshwater, mangrove)	150,000 ha	➢ Marine fisheries	➢ Timber cutting ➢ Forest clearance for agriculture	➢ Mangrove forest, freshwater and peat swamp forests ➢ No information on fauna	None

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Tanjung Putting National Park, Central Kalimantan: vast low lying area of mangrove, peat and freshwater swamp forests and kerangas forest	Area of wetlands unknown; 296,800 ha out of official area of 300,040 ha has been mapped	Important genetic resource	➢ Illegal cutting ➢ Illegal hunting and fishing ➢ Poaching of waterfowl eggs	➢ Mangrove, peat and freshwater swamp species, kerangas forest ➢ Very rich fauna	Protected as a Biosphere Reserve in January 1977 and a National Park in October 1982
Tanjung Penghujan, Central Kalimantan: swampy coastal area bordered by a fringe of mangrove forest and backed by freshwater swamp forest	40,000 ha	High potential for outdoor creation	Tree felling for wood	➢ Mangroves and freshwater swamp forest ➢ Rich wildlife, but little information; proboscis monkey *Nasalis larvatus* present	None
Muara Kendawangan, West Kalimantan: complete seral succession of lowland habitats from coastal sand bars, mudflats and mangrove forest through swamp forest to dry lowland forest	c. 150,000 ha: 75,000 ha of freshwater swamps; 65,000 ha of peat swamps; 10,000 ha of mangroves	No information	None known; uninhabited	➢ Mangrove, freshwater and peat swamp forests ➢ Rich in wildlife including mammals and birds	None; proposal for establishing a Nature Reserve approved but not implemented

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Gunung Palung and surrounding swamps, West Kalimantan: relatively undisturbed hill and lowland forest including mangroves, freshwater swamp forest, peat swamp forest and wet lowland forest on alluvium.	c. 130,000 ha: 7,000 ha mangrove forest; 20,000 ha of freshwater swamp forest; 30,000 ha peat swamps; 5,000 ha wet lowland forest; 62,000 ha moist lowlar dipterocarp forest; 1,000 ha montane forest; 5,000 wet hill forest	➢ High potential for outdoor recreation ➢ conservation education	➢ Logging ➢ Shifting cultivation	➢ Mangroves, freshwater and peat swamp forests, wet lowland forests ➢ 192 species of birds ➢ mammals: 2 insectivore sp; 4 chiropteran sp, 7 primate sp, 7 rodent sp, 2 carnivore sp, 5 ungulate sp. ➢ 3 reptile sp	A Na ture Monument 30,000 ha in area was estabished in 1930's; upgraded to Nature Reserve and renotified in 1981; proposal to extend to a total area of 100,000 ha made
Hutan Sambas, West Kalimantan: lowland forest including mangrove forest, 100 ha of beach forest; peat swamps and moist lowland dipterocarp forest	120,000 ha: 43,000 ha of mangrove forest; 100 beach forest; rest are peat swamps and moist lowland dipterocarp forest	➢ potential for an international reserve linking up with Samunsam Reserve in Sarawak	➢ Uncontrolled logging ➢ Hunting ➢ Poaching of sea turtle eggs ➢ Shifting agriculture	➢ Mangrove forest, peat swamp forest, freshwater swamp forest, moist lowland dipterocarp forest ➢ Rich in wildlife; large and important sea turtle nesting beaches	None

Country: Malaysia

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Southeast Pahang Swamp Forests, Pahang: swamp forest consisting of peat swamps, freshwater swamps	325,000 ha including at least 90,000 of peat swamp forests	➢ Flood mitigation ➢ Water reservoir ➢ Timber source ➢ Gene pool for commercially important plant species	➢ Reclamation for agriculture and development ➢ logging	➢ largest contiguous area of peat swamp forest ➢ most lowland forest animals occur ➢ birds include 4 sp of hornbills, 5 sp of kingfishers ➢ pythons and freshwater turtles	80,000 ha of swamp forest are Forest Reserves
Sedili Kecil Swamp Forest, eastern Johor: seasonally flooded freshwater swamp forest	c. 5,000 ha	➢ Considerable timber value ➢ Flood mitigation ➢ Scientific interest	➢ Logging ➢ Aquaculture development	➢ Freshwater swamp forest ➢ No information on fauna	Most of the area falls within the Chandangan Forest Reserve
Klias Peninsula, Sabah: Continuous flat area of peat swamp, freshwater alluvium, and mangroves	90,000 ha: 60,700 ha of peat swamp; freshwater alluvium of 14,500 ha; coastal transitional swamp (28,500 ha); mangrove (14,500 ha)	➢ Fisheries including finfish and prawns ➢ Commercially valuable timber	Logging	➢ Coastal mangrove forest, nipa swamp, freshwater and peat swamp forest, grassland ➢ Supports highest known concentration of migratory ducks	Five forest reserves were established with a total area of 31,053 ha; In 1980, 30,900 ha of national park were degazetted
Tempasuk Plain, Sabah: freshwater wetland	Over 13,000 ha including 12,200 ha in Kota Belud Bird Sanctuary	➢ Rice-growing and livestock production ➢ High potential for tourism and scientific research	➢ Large-scale drainage of the swamp for agriculture ➢ Conversion of grazing land to aquaculture ponds ➢ Illegal hunting ➢ Shifting cultivation	➢ Outstanding variety of wetland habitats ➢ Waterfowl: 14 sp of herons and egrets; 7 sp of ducks, 8 sp of rails and crakes; 30 sp of shorebirds, 8 sp of terns	12,200 ha protected as Kota Belud Bird Sanctuary

Malaysia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
The Lower Reaches of the Baram River System, Sarawak: a major river with large catchment area; large areas of peat swamp forest; most highly developed peat swamps	300,000 ha	➢ Fisheries ➢ Flood control thorugh the domed peat swamps	➢ Infrastructure for flood control ➢ Hunting of wildlife ➢ logging	➢ most highly developed peat swamp ➢ 43 sp of fishes ➢ rare reptiles	Entire area is included in State Forest Reserves
Loagan Bunut, Sarawak: seasonal freshwater lake, Loagan Bunut (Sarawak's largest freshwater lake) and surrounding areas of seasonally flooded forest	19,000 ha	➢ Fisheries ➢ Potential for rotational forestry, provided rotation period were not less than 70 years	➢ Logging ➢ Intensive fishing ➢ Disturbance because of road access	➢ No information on flora ➢ At least 10 sp of fish ➢ Breeding colonies of *Phalacrocorax carbo* and *Anhinga melanogaster*	Forests are protected in the Lower Baram Forest Reserve and Marudi Forest Reserve
Third Division Swamp Forest, Sarawak: a vast tract of peat swamp forest, much of which is production forest that is largely exploited	340,000 ha	➢ Domed peat swamps are natural flood mitigation structures ➢ Valuable timber source	➢ Overexploitation of the peat swamp forest ➢ Forest conversion for alternative uses	➢ Peat swamp forest of various types; mangrove forest ➢ No information on fauna	All within Protected Forests and Forest Reserves
Matu-Daro and Sibu Swamp Forest, Sarawak: a large block of peat swamp forest with coastal mangroves and nipa	267,000 ha	Mangroves support important commercial inshore and offshore fishery	➢ Tree felling for woodchips ➢ Reclamation for agriculture	➢ Mangrove forest, nipa swamp, peat swamp forest ➢ Important for migratory shorebirds	Most of the area is within Protected Forests

Malaysia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Maludam Swamp Forest, Sarawak: a peninsula of flat peat swamp forest between the Saribas, Layar and Lupar Rivers	c. 125,000 ha	➢ Source of timber ➢ Peat swamp important in flood mitigation ➢ Freshwater fishery	Non-sustainable logging	➢ Virgin peat swamp forest ➢ Important for migratory shorebirds ➢ Important for the red, black and white form of the banded langur *Presbytis melalophos cruciger*	About 26,500 ha of forest are included in the Triso Protected Forest and 16,800 ha in the Maludam Forest Reserve
Sadong Swamp Forest, Sarawak: large expanse of flat low-lying peat swamp forest drained by the Batang Sadong and the Sungei Simunjan	17,200 ha	➢ Valuable source of timber ➢ Peat swamps for flood control	Overexploitation of forest resources	➢ Peat swamp forest and mixed dipterocarp forest ➢ Occurrence of orang-utans *Pongo pygmaeus,* endangered flat headed cat *Felis planiceps* and the earless monitor lizard *Lanthanotus borneensis*	The whole site is within the Sadong Forest Reserve
Samunsam Wildlife Sanctuary, Sarawak: entire water catchment area of the Samunsam River from the mangrove and nipa swamps of the lower reaches through kerangas and mized dipterocarp forest	20,902 ha	➢ Mangroves support important fisheries ➢ Valuable source of timber and charcoal	➢ Clearance of kerangas for agriculture ➢ Timber exploitation ➢ Infrastructure for power and transportation	➢ 6 types of mangrove forests ➢ empran forests, mixed dipterocarp lowland rainforest and kerangas forest ➢ 24 sp of freshwater species; 240 species of birds of which 50 species are waterfowl sp. ➢ 70 sp of mammals, including 4 rare species ➢ 35 sp of reptiles ➢ 20 sp of amphibians	6,092 ha protected as Samunsam Wildlife Sanctuary in 1979.

Country: Philippines

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Buguey wetlands, Cagayan, northern Luzon: a complex of coastal lagoons, freshwater marshes, brackish and saline marshes, mangrove swamps and intertidal mudflats; located east of the mouth of Cagayan River.	c. 14,400 ha (about 80% of Buguey municipality)	➢ Fisheries ➢ Rice production	➢ Conversion to shrimp and fish ponds ➢ Hunting of waterfowl ➢ Pesticide pollution from agriculture	➢ nipa swamp, mangrove species and *Ipomoea reptans* ➢ important staging and wintering area for migratory waterfowl	None
Pangasinan wetlands, Central Luzon: large area of fish ponds and rice paddies with adjacent intertidal mudflats; over 10 rivers and creeks, all branches of the Agno River, run through the wetland and drain into Lingayen Gulf; lies at the edge of the alluvial plains of Central Luzon	c. 3,000 ha	➢ Fisheries ➢ Rice production ➢	Mangrove loss in favor of aquaculture	➢ remnants of mangrove ➢ 20 species of shorebirds	Mangrove revegetation project was launched in 1987.
Candaba swamp, Central Luzon: a complex of freshwater ponds, swamps and marshes with seasonally flooded grassland, arable land and palm savanna on a vast alluvial flood plain	32,000 ha	➢ Agriculture ➢ Fisheries production ➢ Flood control ➢ Source of irrigation water ➢ Local spot for bird watchers and naturalists	➢ Conversion into fishponds ➢ Drainage to increase agricultural area ➢ Illegal hunting of waterfowl	➢ Patches of nipa and mangrove swamps ➢ 60 species of birds which feed and roost in the swamp area	None

Philippines (Con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Laguna de Bay, Luzon: Largest lake in the Philippnes with a shoreline of aboutr 220 km; drains through the Napindan Channel into the Marikina River which joins the Pasig River and out into Manila Bay; highly eutrophic; fed by 21 small rivers and streams, with the total inflow allowing for flushing the lake once a year	Watershed area is 382,000 ha excluding the area of the lake	➢ Fisheries ➢ Source of potable freshwater	➢ Freshwater aquaculture leading to high organic loading and deteriorating water quality ➢ Conflict between aquaculture and capture fisheries ➢ Industrial, agricultural and domestic pollution ➢ Extensive reclamation for industrial, residential and recreational estates ➢ Deforestation	➢ *Eichhornia crassipes,* marsh vegetation ➢ 23 native fish species belonging to 16 families ➢ wide variety of waterfowl	➢ Haribon Foundation launched a "Save the Lake Movement" ➢ No protected areas have been established
Taal Lake, Luzon: a large caldera lake with an island; lake is fresh and oligotrophic; fed by a number of streams rising on the Tagaytay Ridge and drains into Pansipit River which flows out to Balayan Bay.	23,424 ha	➢ Recreation ➢ Fisheries	➢ Urban encroachment ➢ Siltation ➢ Introduction of exotic fish species ➢ Volcanic activity	➢ Lake flora ➢ Rich crustacean, molluscan and fish fauna and a number of which are is endemic	➢ Volcanic island is a National Park established in 1967 ➢ Lake itself is not protected
Lake Manguao, Palawan: A very deep freshwater lake fed by several small rivers and local run-off	643 ha	No information	No information	➢ No information on flora ➢ *Crocodylus porosus* is believed to occur in the lake	The whole of Palawan Island has been declared a wildlife preserve

Country: Thailand

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Yom River Floodplain, northern Thailand: extensive alluvial basin; intensively cultivated; scattered are many small permanent swamps	c. 50,000 ha	➢ Major recreational area ➢ Fish farming	➢ Illegal hunting of waterbirds ➢ Intensive agriculture ➢ Flood control works	➢ Natural grassland, mixed deciduous or dry dipterocarp woodland ➢ Duck migration area	➢ Nong Nam Kao Non-Hunting Area (57.3 ha) established
Beung Si Fai, northern Thailand: a permanent, freshwater lake, its associated marshes and adjacent rice paddies; fed by overspill from the River Nan during the late rainy season	810 ha	➢ Recreation and tourism ➢ Lake a major social amenity	None known	➢ Small areas of *Arundo donax* and *Cyperus spp.* ➢ Wintering waterfowl	Fishing is not allowed in 24 ha of the lake
Beung Boraphet, northern Thailand: a large freshwater lake along the east bank of the Mae Nam Nan; surrounded by rice paddies; formed in 1930 by the damming of a freshwater swamp in order to develop the fishery	13,000 ha	➢ Fisheries ➢ Source of irrigation water ➢ Tourism	➢ Harvest of emergent vegetation including *Phragmites* ➢ Illegal trapping of waterfowl ➢ Agricultural pollution including pesticides	➢ Dense mats of floating vegetation ➢ Important site for wintering ducks in Thailand	About 45,000 ha including the lake and surrounding paddy declared as a Non-Hunting Area in 1975.
Southern Central Plains, central Thailand: huge area of intensively cultivaled land with numerous small lakes and marshes; plains received water from four major rivers: the Bang Pakong, Chao Phraya, Tachin and lower reaches of the Mae Klong.	1,900,000 ha	➢ Agriculture ➢ Aquaculture of *Macrobrachium* ➢ Waterways for communication and transport	➢ Conversion of marginal areas to agriculture ➢ Reclamation for settlement	➢ Mats of low grasses, floating aquatic vegetation ➢ Important breeding area for waterfowl and roost for wintering birds	➢ About 360 ha of non-hunting areas ➢ Some receive *de facto* protection, such as those near temples or they are within private land

Thailand (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Khao Sam Roi Yot NationalPark, southern Thailand: an area of coastal marshes, paddies; includes the largest freshwater marsh in Thailand (6,000 ha)	13,000 ha	➢ Freshwater and brackishwater fisheries ➢ Tourism	➢ Aquaculture ➢ Encroachment by agriculture ➢ Illegal hunting of wildlife ➢ Tourism	➢ Dominant freshwater marsh flora is *Phragmites australis;* mangroves, mixed deciduous forest ➢ 237 sp of birds	Most of the area protected as a National park
Tapi River and Nong Tung Tong Non-Hunting Area, southern Thailand: a complex of swamps and grasslands along the Tapi River; principal inflow from the catchment of the Tapi River	6,450 ha	➢ Fisheries ➢ Cattle grazing ➢ Source of irrigation water	➢ Gradual intensification of agriculture ➢ Man-made burning of grasslands ➢ Illegal hunting	➢ emergent aquatic plants; lowland evergreen scrub forest	An area of 2,960 ha declared as the Nong Tung Tong Non-Hunting Area in 1975
Thale Noi Non-Hunting Area, southern Thailand: a roughly circular lake surrounded by open swamp vegetation, sedge beds and rice paddies, and an extensive *Melaleuca* swamp forest	*Melaleuca* forest covers 4.220 ha; grasslands and sedge beds, 10,870 ha; lake area is 30,000 ha	➢ Fisheries ➢ Harves of aquatic plants ➢ Capture and sale of snakes ➢ Tourism	➢ Contnued clearance of *Melaleuca* for charcoal ➢ Illegal hunting of wildlife, and their eggs ➢ Domestic and agricultural waste	➢ Floating and emergent plants; marsh vegetation; *Melaleuca* woodland ➢ 186 sp of birds ➢ otter *Lutrra sp* and terrapin *Balangur baska* occur	A non-hunting area; *Melaleuca* forest is a National Reserve Forest where cutting is forbidden
Lake Songkhla, southern Thailand: a huge shallow coastal lagoon of fresh to brackish water which opens to the sea by a narrow channel; fed by 1000 streams and drains 8,000 km^2 of catchment	104,000 ha	➢ capture and culture fisheries ➢ Recreational and educational values	➢ Industrialization and development ➢ Illegal hunting ➢ Burning or cutting of emergent vegetation ➢ Pumping of irrigation water causing salinity intrusion	➢ 40 sp of edible fish ➢ 29 sp of aquatic plants ➢ 48 species of land plants ➢ 140 sp of birds ➢ river terrapins and otters	Thale Sap Non-Hunting Area covers 31,500 ha
Pa Phru, southern Thailand: a large depression supporting 9,700 ha of primary peat swamp forest near 14,600 ha of *Melaleuca* woodland and scrub; and 9,800 of degraded grasslands	c. 34,600 ha	➢ Harvest of forest products ➢ Research and educational use ➢ Culturally ethnic population	➢ Drainage to minimize flooding ➢ Unsustainable development projects ➢ Cutting and burning to free up land for agriculture	➢ Over 50 plant species reported as new to thailand; 66 tree species in 29 families ➢ 16 sp of fish lowland forest birds, mammals and reptiles	16,000 ha as Non-Hunting Area; remaining forest as National Reserve Forest

Country: Viet Nam

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Ba Be Lake, Cao Bang Province: freshwater lake in a limestone mountain area, connected to the Nang River by a channel	450 ha	➢ Regulates water supply ➢ Tourism	Illegal hunting	➢ Tropical rain forest, mountain lake vegetation ➢ 17 native sp of fish ➢ 100 sp of birds ➢ 30 sp of mammals	Declared a National Park in 1985
Thac Ba Reservoir, Hoang Lien Son Province: large water storage reservoir	23,400 ha	➢ Water for irrigation and power generation ➢ Fisheries	Siltation	➢ Reed beds, marsh grasses and low shrubs ➢ Migration route of waterfowl	➢ Restrictions on cultivation along the steep slopes ➢ Reafforestation
Chu Lake, Vin Phu Province: small natural freshwater lake fed by the Van and Thoi streams	300 ha	Small fisheries	No information	➢ Aquatic plants and marsh grasses, shrubs ➢ Waterfowl migration	No information
Chinh Cong, Vin Phu Province: small, natural freshwater lake in the Red River Basin fed by Ca and Ky streams	400 ha	➢ Agriculture ➢ Irrigation ➢ Aquaculture	➢ Drainage for agriculture ➢ Overexploitation	➢ Aquatic plants ➢ Important wintering area for migratory waterfowl	None
Nui Coc Reservoir, Bac Thai Province: water storage reservoir constructed in 1977 on the Cong River, a tributary of the Red River	2,580 ha	➢ Fisheries ➢ Irrigation ➢ Outdoor recreation	➢ Forest clearance for wood, construction and agriculture ➢ Heavy grazing by livestock	➢ Aquatic vegetation, shrub and secondary forest ➢ 10 native fish sp ➢ 40 sp of birds ➢ 15 sp of mammals	➢ Protected Area as of 1985 ➢ Reafforestation program around reservoir
Vac Swamp, Vin Phu Province: a freshwater swamp fed by the Ca Lo and Cau Bon Rivers in the Red River Basin	250 ha	➢ Small fisheries ➢ Irrigation ➢ Resort area	No information	➢ Aquatic plants, marsh grasses ➢ No information on fauna	A reserve covering the swamp has been established

Viet Nam (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Song Da Reservoir, ha Son Binh Province: a large water storage reservoir constructed in 1985 on the Da River for power generation, irrigation, aquaculture and water regulation	72,800 ha	➢ Power generation ➢ Irrigation ➢ Major fisheries ➢ Tourism	Cultivation on steep slopes of the catchment area	Too young and of little value to wildlife	➢ Water catchment area is protected ➢ Reafforestion around the reservoir
Ho Tay, Hanoi: natural freshwater lake on the south bank of the Red River	413 ha	➢ Fisheries ➢ Recreation	➢ Pollution ➢ Reclamation for urban development	➢ Aquatic plants, marsh vegetation ➢ Staging and wintering area for migratory birds	Restrict waste water inflow into the lake
Cam Son Reservoir, ha Bac Province: a water storage reservoir made in 1960 by a dam on Hoa River, a tributary of the Thuong River	2,620 ha	➢ Power generation ➢ Fisheries	Use of poisons and explosives to catch fish	➢ Sanctuary for native stream fishes ➢ Migratory waterfowl	Reafforestion in the water catchment area
Ke Go Reservoir, Nghe Tinh Province: water storage reservoir on the Ba Mo River	2,500 ha	➢ Irrigation ➢ Fisheries ➢ Hydropower	Cultivation of cassava and other crops causing siltation	Migratory waterfowl	➢ Restrictions on cultivation ➢ Reafforestation
Bau Xen Lake, Binh Tri Thien Province: a small freshwater lake 4 km from the sea	200 ha	➢ Irrigation ➢ Fisheries ➢ Water supply ➢ Recreation	No information	Migratory waterfowl	None
Bien Ho Lake, Lai-Kontum Province: natural freshwater lake on a high plateau formed by 3-4 volcanic craters	600 ha	➢ Small fisheries ➢ Potable water source ➢ Irrigation	➢ Siltation ➢ Oil pollution from motor boats	➢ Rich fish fauna ➢ Variety of waterfowl	➢ Measures taken to maintain water quality ➢ Replanting of bare hillsides

Viet Nam (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Lak Lake, Dak Lak Province: a natural freshwater lake in the swamp region of the Dak Lak High Plateau	500 ha	➢ Small fisheries ➢ Irrigation	Siltation because of shore cultivation	➢ Reed beds, swamp vegetation ➢ waterfowl	None
Nam Cat Tien, Dong Nai Province: small permanent freshwater lake and a large area of seasonal lakes and marshes	2,500 ha	Potential for scientific research, conservation education and tourism	➢ Excessive hunting ➢ Manmade fires ➢ Population growth and consequent exploitation	➢ Grassland, swamp forest, humid evergreen forest, semi-evergreen and deciduous forest; 62 sp of orchids ➢ Resident and migratory waterfowl ➢ Mammals and reptiles	Wetland and surrounding forests are protected in the Nam Cat tien Forest Reserve (36,500 ha) established in 1978.
Bien Lac, Thuan Hai Province: a group of natural freshwater lakes and associated marshlands, surrounded by seasonally flooded grassland and forest	2,000 ha during wet season	Fisheries	Overexploitation of living resources	No information on flora and fauna	Protected Area covers Bien Lac and surrounding forests, total area of 10,025 ha
Dong Thap Muoi: large area of seasonally flooded alluvial plains on the north bank of the Mekong	300,000 ha	➢ Contains the largest area of floating rice in the Mekong Delta ➢ Fisheries ➢ Natural flood basin	➢ Settlement ➢ Agriculture ➢ Overexploitation of wildlife	➢ Swamp and grassland vegetation; wild rice ➢ Resident and migratory waterfowl ➢ Mammals and reptiles	Tram Chim Sarus Crane Reserve established in 1986 (9,000 ha)
Minh Hai *Melaleuca* Forest, Minh Hai Province: large area of seasonally flooded *Melaleuca* swamp forest	163,000 ha	➢ Timber products ➢ Fisheries ➢ Potential for nature tourism	➢ Manmade fires ➢ Overexploitation of living resources	➢ 40 sp of aquatic plants ➢ 23 sp of mammals ➢ 91 bird sp ➢ 36 reptile sp ➢ 11 sp of amphibians	Vo Doi Protected Forest of 3,945 ha in the U Minh ha forest was established in 1985

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