Review of Land-based sources of pollution to the coastal and marine environments in the BOBLME Region

Shipbreaking

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Acronyms & terms

AAECP	ASEAN-Australia Economic Cooperation Programme
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of South East Asian Nations
AWGCME	ASEAN Working Group on Coastal and Marine Environment (TH)
BOB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem
BOBP	Bay of Bengal Programme
BOD	Biological oxygen demand (ppm or mg/l)
BOI	Board of Investment (LK)
BPI	Bribe Payer's Index
CBO	Community-based Organisation
CCD	Coast Conservation Department (LK)
CEA	Central Environment Authority (LK)
CEPOM	Committees on Environmental Policy & Management (LK)
CETP	Common effluent treatment plant
CIEDP	Committee on Integrating Environment & Development (LK)
CIESIN	Centre for International Earth Science Information Network, Colombia University
CO_2	Carbon dioxide
COD	Chemical oxygen demand
COMAPS	Coastal Ocean Monitoring & Prediction System (IN)
CPC	Could be CFC Ceylon Fisheries Cooperation (not explained in source) (LK)
CPCB	Central Pollution Control Board (IN)
CPI	Corruption Perceptions Index
CRZ	Coastal Regulation Zone (IN)
CZERMP	Coastal Zone Environment & Resources Management Project (TH)
CZM	Coastal Zone Management
DO	Dissolved oxygen
DOD	Department of Ocean Development (IN)
DOE	Department of Environment
EIA	Environmental Impact Assessment
EMP	Environmental Management (& Monitoring) Plan
ENTRI	Environmental Treaties and Resource Indicators (CIESIN, Colombia University)
EPL	Environment Protection License (LK)
EQA	Environmental Quality Act (MY)
ESI	Environmental Sustainability Index
EU	European Union
EVI	Environmental Vulnerability Index
EVI	Environmental Vulnerability Index
FAO	United Nations Food & Agriculture Organisation
GDP	Gross domestic product
GEF	Global Environment Facility
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GPA	United Nations Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
GTZ	German Development Assistance
IAEA	International Atomic Energy Agency
ICMAM	Integrated Coastal & Marine Areas Management (IN)
ICZM	Integrated Coastal Zone Management
IFC	International Finance Corporation (World Bank Group)
IMO	International maritime Organisation

IOTC	Indian Ocean Tuna Commission
IP	Industrial Park
IRBM	Integrated River Basin Management (MY)
ISO	International Organisation for Standardisation (ISO 3166 codes for countries)
ITI	Industrial Technology Institute (LK)
MENR	Ministry of Environment & Natural Resources (LK)
MFOR	Ministry of Fisheries & Ocean resources (LK)
MoEF	Ministry of Environment & Forests (IN)
MPPA	Marine Pollution & Prevention Authority (LK)
MRCWG	Marine Resources Conservation Working Group (TH)
MST	Ministry of Science & Technology (LK)
NAD	Nanggroe Aceh Darussalam province (Sumatra, ID)
NARA	National Aquatic Resources Research Agency (LK)
NEC	National Environment Commission (TH)
NERIC	National Environment & Resource Information Centre (ASEAN Members)
NO_2	Nitrate
NO_3	Nitrite
NORAD	Norwegian Agency for Development (LK)
NOSCP	National Oil Spill Contingency Plan (LK)
NPK	Nitrogen, Phosphorus & Potassium-based fertilizers
NSF	National Science Foundation (Sri Lanka)
NWSDB	National Water Supply & Drainage Board (LK)
OCPs	Organochlorine pesticides (e.g. BHC, DDT, Endrin, Dieldrin, Methoxychlor, Lindane, Ethyl and Methyl parathion, Telodrin)
OECD	Organisation for Economic Cooperation & Development
OEPP	Office of Environmental Policy & Planning (TH)
PCBs	Polychlorinated Biphenyls (part of the POP group of pollutants)
PCD	Pollution Control Division (TH)
POPs	Persistent organic pollutants
SAARC	South Asian Association for Regional Cooperation (BD, IN, MV, LK of the BOBLME countries)
SAM	Special Area Management (LK)
SAP	Strategic Action Programme (for BOBLME)
SCMSAT	ASEAN Sub-committee on Marine Science & Technology
SD	Sustainable Development
SDA	Southern Development Authority (LK)
SIDA	Swedish International Development Agency
SLPA	Sri Lanka Ports Authority (LK)
SLRDC	Sri Lanka Land Reclamation & Development Corporation
SOE	State of the Environment Report
SOM	Senior Official Meeting (of APEC)
SOPAC	South Pacific Applied Geoscience Commission
TSS	Total suspended solids
UN	United Nations
UNEP	United Nations Environment Programme
UNGPA	United Nations Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
WB	World Bank
WHO	World Health Organisation
WQI	Water Quality Index (MY)
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development (Johannesburg 2002)

ISO Codes for BOBLME Countries

Country	A2	A3
Bangladesh	BD	BGD
India	IN	IND
Indonesia	ID	IDN
Malaysia	MY	MYS
Maldives	MV	MDV
Myanmar	MM	MMR
Sri Lanka	LK	LKA
Thailand	TH	THA

Executive Summary

The Bay of Bengal Large Marine Ecosystem (BOBLME) is one of 64 large marine ecosystems (LMEs) recognised world-wide, some of which have recently become the subject of the development of an ecosystem approach focused on sustainable management of biomass yields. The BOBLME encompasses the Bay of Bengal, Andaman Sea and Straits of Malacca, which are bordered by Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand, and includes approximately ¼ of the world's human population.

The countries of the BOBLME region have agreed to work together to manage their shared living resources through the preparation of a regional Strategic Management Plan (SAP). The motivation behind the SAP has come from the realisation that human activities are causing serious environmental degradation and are threatening the sustainable management and health of the region as a whole. One of the most important threats to the health and productivity of the BOBLME is pollution from land-based sources. This review examines issues of land-based pollution, including its status and changing patterns in the region, and an identification of priority issues that are common to the countries and/or have transboundary significance.

The highest priority issues of land-based sources of pollution in the region are concerned with sewage, agriculture / aquaculture, and industry. Other issues were identified, but some of them are components of these three, or can be considered lower priority because their impacts are likely to be less widespread and not as important to the functioning of the LME. There are also issues of the mobilisation of pollutants through rivers, run-off, floods and cross-border movements of pollutants through international rivers.

It is expected that current problems associated with land-based sources of pollution in the region will continue to deteriorate unless radical measures can be introduced in a short period of time. The main forces operating to worsen the existing problems of pollution include increasing populations sizes, urbanisation, coastal migration, development imperatives and improving lifestyles, shifts in industry, expanding tourism and intensifying methods of agriculture and aquaculture. The root causes of issues associated with land-based sources of pollution in the region include the expansion and increasing density of human populations, poor large-scale awareness, a low economic base for funding actions at all levels, insufficient scientific information and lack of technology. Many of these factors are amplified by inherent characteristics of at least some of the BOBLME countries which have high rainfall, are low-lying, dissected by a large number of rivers and are subject to cyclones and floods. These characteristics ensure that pollutants are mobilised and transported large distances.

There are over a hundred local and national initiatives, programmes and laws, and 37 international treaties in force in the region relating to the management of land-based sources of pollution. Some of these are innovations made by individual BOBLME countries, have had significant successes and could replicated in other parts of the region to address priority issues. These include projects on organic agriculture, sewage recycling in aquaculture, water quality monitoring programmes, common effluent treatment plants and incentive schemes for good practices. The UN Global Programme of Action for the Protection of the Marine Environment from Land-based Activities

(GPA) and Regional Seas Programmes are the most significant regionally focused programmes.

Impediments to addressing issues in the region include knowledge gaps, clashes, loopholes and overlaps in policies and legislation, corruption at several levels, insufficient involvement by local governments, NGOs and communities, poor enforcement, and several significant problems in underlying assumptions. A total of 22 actions targeted at a range of levels is suggested for addressing the most significant problems of land-based pollution to the coastal and marine environments in the region.

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1. Introduction

1.1 Background

The Bay of Bengal Large Marine Ecosystem (BOBLME) Programme has eight member countries, Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand, which are preparing an ecosystem-wide, regional Strategic Action Plan (SAP) for the integrated and coordinated management of their shared marine living resources. The impetus for the preparation of the SAP has been the realisation that certain activities are causing serious local and cumulative environmental degradation that threatens the sustainable management and health of the BOBLME as a whole. Continuation of such activities, together with on-going overexploitation of marine resources, could pose serious problems for the future health and food security of millions of people in coastal communities who depend on these resources for their livelihood (Verlaan 2003).

The main recognised threats to the BOBLME include:

1. Pollution from land-based sources (including wastes from industry, urban development, agriculture, aquaculture, mining and tourism);
2. Pollution from sea-based sources (oil spills, oil exploration and production);
3. Damage to critically important habitats (fish spawning and nursery areas, coral reefs, mangroves and estuaries);
4. Cyanide fishing in the coral reefs of the region for the lucrative live food fish markets; and
5. Unsustainable fishing (unregulated fishing, open access, unauthorized incursions by foreign fleets and the encroachment of nationals into the territorial waters of their neighbours).

These problems are further complicated by poor national resource management, conflicts between artisanal and large-scale fishermen, unaddressed transboundary environmental issues and insufficient knowledge and data on the functioning of the Large Marine Ecosystem (LME) as a whole. The countries of the BOBLME region recognised the need for integrated and coordinated management of their coastal and near-shore living marine resources and supported the development and submission by FAO to the Global Environment Facility (GEF) (International Waters Portfolio) of a proposal for a project to pursue a large marine ecosystem approach to management. In

its first phase, the proposed approach included (a) the establishment of national and regional coordination mechanisms; (b) the synthesis and assessment of existing information on the status of living marine resources and the environment, including transboundary issues; (c) workshops to identify issues, constraints and priorities; and (d) development of a draft project brief leading to the development of a SAP. This review forms part of component (b).

1.2 Purpose of this review

Pollution is a by product of human activities, and now very much a part of global ecosystem processes. It is the accidental or deliberate release of unwanted chemical, biological and physical materials and/or energy into the surrounding environment. These by products can include materials which disrupt normal processes occurring in healthy ecosystems. For example, nutrients can unbalance ecosystems by feeding and encouraging the overgrowth of certain species, such as algae or bacteria. Hormone disrupters are chemicals that in minute doses can affect the growth, maturation and reproduction of organisms. Oil and sediments can smother organisms, and a host of other chemicals can affect metabolic functions (e.g. heavy metals). Where the receiving ecosystems are able to cope (convert, recycle) with the pollution entering them without damage, accumulation or spread, we consider the pollution load within their carrying capacity. Where this is no longer the case, we see the degradation of ecosystems and the goods (e.g. forests, soils, fisheries) and services (e.g. future pollution attenuation, storm protection) they provide. This is true both on the land and in the sea.

Globally around 80% of the pollution load entering the coastal areas and ocean originates from land-based sources. This is hardly a surprising figure since most human activities occur on land and the opportunities for mobilising and transmitting pollution to the sea abound through the global hydrological cycle. Pollution, particularly from land-based sources is an integral part of the five most serious problems thought to be affecting the coastal and marine environments globally: (1) Alteration / destruction of habitats and ecosystems; (2) Effects of sewage on human health; (3) Eutrophication; (4) Decline of fish stocks and other resources; and (5) Changes in sediment flows (GESAMP 2001).

The sources of pollution, relative impacts on the environment, root causes for issues, and impediments to and priorities for corrective actions are likely to differ among

countries, regions and more specifically LMEs around the globe. The purpose of this review of the land-based sources of pollution to the coastal and marine environments was to identify these characteristics as they relate to the unique conditions found in the BOBLME region. Its focus was on the eight participating countries in the programme, with particular emphasis on those coasts that face the Bay of Bengal, Andaman Sea and Straits of Malacca. The purpose of the review was to:

1. Identify and determine the status of forms of land-based pollution and how they might be changing;
2. Identify common and transboundary issues;
3. Analyse root causes of issues;
4. Prioritise the regional severity of issues of pollution;
5. Identify local, national and regional initiatives currently being used to address issues;
6. Examine knowledge gaps, policy distortions and institutional deficiencies that might impede development of solutions;
7. Suggest actions to address any issues;
8. Develop need-based priorities for integrated ecosystem actions consistent with international instruments such as the GPA (United Nations Global Programme of Action for the Protection of the Marine Environment from Land-based Activities);
9. Improving the understanding of transboundary issues and cooperation to solve them; and
10. Suggest the location of proposed activities to maximise demonstration or to address areas where the need is greatest.

2. Overview of land-based sources of pollution

2.1 The language of pollution

The Global Programme of Action for the Protection of the Marine Environment from land-based Activities (GPA) and the Regional Seas Programme recognise nine primary focal categories of land-based sources of pollution (Table 1). The most important 'sources' globally come from domestic sewage, agricultural and industrial waste, solid waste, chemical and hazardous wastes and aquaculture (GPA 2003). In terms of contaminant classes and physical alteration, the priorities after sewage are nutrients, sediment mobilisation, persistent organic pollutants (POPs), heavy metals and physical alteration (GESAMP 2001). These two lists cover the same topics in different ways, suggest different priorities and have resulted in some confusion of how we classify the types of pollution we are trying to manage.

In Table 2, four different classifications of pollution is given, each suggesting a different focus for addressing issues, and 3 of which could be considered 'sources'. Pollution from land-based sources may be discussed in relation to the governmental concept of sector, or by the processes that produce it, or by the pollution mixture generated and released into the environment and which may contain inert as well as active substances. In the National Reports, the BOBLME countries identified issues at all of the 4 levels identified in Table 2, but not all of the more important relationships between them. For example, run-off is often mentioned as a 'source', but is associated with pollution from at least 4 of the sectors, at least one polluting action, 4 of the pollution mixes released into the environment, and at least 5 'active components'. If we need to address run-off, we need to be able to identify the issues that surround it and pinpoint the particular issues that are of highest priority. This does not prevent us from identifying or talking about sewage or POPs as priority issues. It may however lead us to understand that the main reason we are concerned about sewage is because of its nutrient effects (if that is the case), and prevent us from treating them as an independent categories of pollution. The interrelatedness and different ways of looking at the problem of pollution needs to be better understood and integrated into any ecosystem approach to management.

Table 1: Pollution source categories as defined by the UN GPA and Regional Seas Programmes
Included are the lead partner agency for each category. Source: http://www.gpa.unep.org

Pollution Source category	Lead Partner Agency
Sewage	WHO
Persistent Organic Pollutants (POPs)	UNEP
Radioactive Substances	IAEA
Heavy Metals	UNEP
Oils (Hydrocarbons)	IMO
Litter	IMO
Nutrients	FAO
Sediment Mobilisation	FAO
Physical Alteration & Destruction of Habitat	UNEP

Table 2: Alternative ways of categorizing land-based pollution
When people talk about pollution, they usually use terminology from several or all of these interrelated lists. Sources are Sector, Action/Process or Mixture. The shaded cells are just some of the different aspects of the pollution issue associated with run-off.

SECTORS	ACTIVITIES	MIXTURES	ACTIVE COMPONENTS
Agriculture / Aquaculture	Disruption of coastal processes	Municipal waste	Plastics
Domestic	Mining	Sewage	Sediments
Fisheries	Port Development	Medical waste	Radioisotopes
Industry	Habitat destruction	Litter	Heavy metals
Mining	Deforestation	Effluents	Nutrients
Tourism	Urban development	Leachates	POPs
Transport	Run-off	Slag / tailings	Biohazards
	Flooding / tides	Pharmaceuticals	Hydrocarbons
	River flow		
	Leaching	Pesticides	POPs
	Tourism	Fertilizers	Hormone mimics
	Sewerage		
	Agriculture	Oil	Cytotoxic drugs
	Aquaculture		
	Spills		
POLICY	PROCESSES	MIXES	EFFECT
Focus on controlling how sector operates	Focus on the processes producing pollution	Focus on pollutant mixes	Focus on effect of pollutants

Point sources of pollution are those for which a particular point of entry of pollution into the environment can be identified. They can be associated with localised gradients in the concentration of pollutants and can often be traced and found in this way. Point sources are usually found for industrial plants, sewage outfalls, reclamations and other earth works, but can occur in other pollution categories not normally thought of as point sources, such as groundwaters exiting in a lagoon. Point sources of pollution may only account for a fraction of the land-based sources affecting marine environments.

Diffuse sources are harder to identify and result from broad-scale activities that cannot be as readily identified as originating from a single source (GESAMP 2001). These are harvested from large areas within which polluting activities are occurring and are

usually mobilised by water or air. They usually are carried by urban storm water run-off, overflow discharges, and run-off from forests and agriculture / aquaculture (UNEP-CEP 2000).

Both of these forms of pollution are discharged either directly into the sea, or enter through rivers, floods, tides, groundwater or by atmospheric deposition. This means that pollution sources can be located far away from coastal areas and still have an impact, despite an on-going process of attenuation that might be occurring on the way. What is a point source and what is a diffuse source of pollution is also partly a matter of scale. From an ecosystem perspective and in terms of the entire Bay of Bengal, a whole city could be considered a point source of pollution into the LME, while on a decreasing scale, one might focus on a particular river or creek, or at the smallest scale on a particular factory or sewage plant. The results of broad-scale ambient monitoring could be used to identify sources of pollution at different scales and indicate priorities.

Point sources	Diffuse (non-point) sources
Sewage outfall	Sewage (septic tank, latrine)
Industrial outfall	Industrial parks
Aquaculture	Aquaculture
Agriculture (husbandry)	Agriculture (cropping)
Land clearance	Run-off
Mining	Mining
Excavation	Storm surge
Reclamation	Groundwater
	Tide
	Flood
	Atmospheric emission
	Urban areas
	Transport

Overall, a consideration of point and diffuse sources of pollution is not instructive as a classification of its own. The issues arising are about particular pollutants or particular generators or conveyors of land-based pollution. The issue comes up in the BOBLME region mostly in relation to industrial effluents and secondarily for sewage, and as part of the process of identifying strategies for reducing overall releases into the environment. Point or diffuse sources *per se* will not be effective pollution categories to pursue in the region.

2.2 Regional issues of land-based pollution

An ecosystem approach for the restoration of coastal areas by 2010 was adopted by coastal countries at the World Summit on Sustainable Development (WSSD) at Johannesburg in 2002 (Sherman 2003). This and earlier work on large marine

ecosystems has resulted in a lot of attention being focused on understanding the issues and their underlying causes, providing technical assistance, advancing new policies and taking direct actions on the control of pollution and eutrophication in coastal areas.

The BOBLME was included as one of the 39 of 64 LMEs of the world for which case studies were prepared. The case studies (Sherman et al. (eds) 1992, 1998 in Sherman 2003) focused on stressors, mitigation, sustainability and management of the BOBLME in terms of the principal driving forces affecting biomass yields (Sherman 2003). That is, the approach focuses on managing ecosystems for the production of ecosystem goods (e.g. fisheries) but not necessarily on ecosystem services (e.g. metabolism of pollution), except where they influence yields. This approach is slightly oblique to assertions that the overriding objective is to manage the overall performance of a complex system (Costanza 1992 in Sherman 2003). The LME approach lead to a *Modular Assessments Strategy* to provide information for the monitoring, assessment, restoration and management. One of the five resulting modules targets pollution and *ecosystem health* (Sherman 2003). As Sherman (2003) pointed out, a precise definition of 'ecosystem health' continues to elude us, so a series of indicators is being developed of ecosystem resilience and stability for multiple ecosystem states. That is, a healthy and sustainable ecosystem must maintain metabolic activity, internal structure and organization and be resistant to external stress over relevant spatial and temporal scales. Monitoring of key variables over time is central to this approach and relevant to locating and (adaptively) managing land-based sources of pollution and their effects. Some of the most relevant variables are NO_2, NO_3, 'pollution', run-off and Mussel Watch[1].

A worldwide emerging theme in the GEF LME projects is the problem of nitrogen over-enrichment and eutrophication (Sherman 2003), a problem also specifically identified for the Bay of Bengal region. The cause of this problem has been attributed to agriculture (and more recently aquaculture) through conversion of wetlands and the utilization of more chemicals and irrigation. Sewage is a significant contributor in the drainages of large cities, and atmospheric deposition of vehicle and agriculture

[1] NOAA's National Status &Trends Program's Mussel Watch Project monitors a suite of contaminants in the tissue of bivalve molluscs (mussels and oysters) and in sediments in coastal and estuarine waters of the United States. Mussels and oysters serve as useful indicators of temporal trends in environmental quality because they accumulate some contaminants in their tissue at levels many times higher than in the surrounding water and they adjust quickly to changes in contamination. Molluscan tissue samples are monitored annually for about 70 contaminants including 24 polycyclic aromatic hydrocarbons (PAHs); 20 congeners of polychlorinated biphenyls (PCBs); 15 chlorinated pesticides, including chlordane and DDT (and breakdown elements of DDT); butyltins; four major elements; and 12 trace elements. On a less frequent basis, sediments are collected at Mussel Watch sites and analyzed for the same chemicals.

emissions may also play a role. The root causes of declines in ecosystems arise because of the high variability and complexity of ecosystems and deficiencies in the human systems. On the human side the issues are inadequate capacity development (human and infrastructure), legal framework (regional & national), implementation of regulatory tools, planning at all levels, public involvement and financial mechanisms and support.

In the BOBLME pollution from land-based sources is considered a major problem, but the effects of increasing loads of pollutants may be mitigated in part by circulation patterns which link it to the larger Indian Ocean Basin (Martosubroto & Willmann 2003). The quantities, fate and effect of pollutants have not been studied extensively and represents a key topic for research. It appears that many pollutants are deposited as estuarine sediments, while a smaller portion is flushed out to deeper waters. It may be that for now the ecosystem's assimilative capacity on the whole has not been exceeded and that pollution problems are localised in nature and mostly confined to the source country (Martosubroto & Willmann 2003).

There is a transboundary dimension to the question of land-based sources of pollution, with the need to manage the overall ability of the Bay of Bengal to metabolise pollutants and absorb sediments (Table 3). Current knowledge on the extent of interactions between countries and their use of the Bay as a sink of organic and inorganic wastes and sediment runoff from the land is still limited. In the long term all or most of the coastal countries might be directly affected by the intensity of use of the assimilative capacity (or carrying capacity) of the BOB by any one of them. In the short term, the more immediate interactions are between neighbouring countries (Table 3), the interactions among which could be more complex than we now understand.

Table 3: Transboundary environmental issues / resources related to pollution
Extracted from Martosubroto & Willmann 2003, directional arrows have been added here and need to be confirmed.

Environmental resource	Countries
Organic water pollution	All
	Bangladesh←India (?)
	Bangladesh↔Myanmar
	Indonesia↔Malaysia↔Thailand
Inorganic water pollution	India↔Sri Lanka (?)
	(?)
Siltation / sedimentation	All
	Bangladesh↔India (?)
	Bangladesh↔Myanmar
	Indonesia↔Malaysia↔Thailand
	India↔Sri Lanka (?)

The sources of coastal and marine pollution originating from the land vary in importance according to the nature and intensity of development activities, size of the human population and state and type of industry, agriculture and aquaculture in a country (UNEP-CEP 2000). Globally, sewage is seen as the most important issue of land-based pollution to the sea, followed by agricultural run-off and industry (GESAMP 2001, Table 4). If categorised by 'contaminant class' (GESAMP 2001), the top 3 priorities are sewage, nutrients and sediment mobilisation. Interpreting these contaminant class categories, the priorities are largely the same, focusing on sewage (includes human wastes as nutrients, POPs, pharmaceuticals, sediments etc) and agriculture (nutrients, POPs, sediments etc), with the signal for industry contributing in terms of heavy metals, sediments, nutrients and POPs. For East Asian Seas countries (ID, MY, TH) the priorities are similar in terms of GPA sources (Table 4).

In their national reports, the BOBLME countries identified land-based pollution as a major issue for ecosystem management of the Bay of Bengal (Table 5). When broken down into sources (actually a combination of sectors, processes, pollutant mixes and active components) sewage, agriculture and industry are identified as the top 3 priorities, in agreement with global and East Asian Seas findings. BOBLME countries perceive their problems with land-based pollution sources in a similar fashion to the rest of the world.

Below rank 3, the message becomes less clear, less a matter of regional priority, and more a matter of national priority. Solid wastes, sediment mobilisation and aquaculture are probably the next highest priorities in the BOBLME region, but these may be embedded in the top 3 as part of domestic wastes and agriculture. To determine the real priorities in the region, it will be necessary to ask the countries to rank issues again, in terms of a better naming of sources along the lines of the categories shown in Table 2. In any case, it is clear that issues such as shipbreaking apply largely to Bangladesh and India, and tourism is more of an issue in Maldives (not ranked as such in the national report) and Sri Lanka.

Table 4: Global and regional priorities for addressing land-based sources of pollution
The rankings were reported in terms of 'source' (GPA definition) and 'contaminant class' so where these overlap rankings are repeated. The South Asian Seas region is not included because its listed priorities are institutional actions that cannot be directly associated with contaminants or physical alteration (Chia & Kirkman 2000, GESAMP 2001).

		Global (from Regional Seas)	East Asian Seas	GESAMP Interpretation of East Asian Seas
Source (GPA)	Sewage	1	1	1
	Agricultural run-off	2	2	
	Industrial facilities	3	3	
Contaminant Class	Nutrients	2		2
	Sediment mobilisation	3		3
	POPs	4*		5
	Heavy metals	5*		
	Physical alteration	6	4	4

* These were given higher priority by the world's Regional Seas Programmes than GESAMP who would have ranked physical alteration higher.

Table 5: Approximate ranking of land-based sources of pollution in BOBLME countries from National reports
Most of the national reports did not provide a clear ranking of pollution priorities, or contradicted their rankings within the report. The categories here were all mentioned by at least one country (including oil which has no ranking at all). Repeated rankings by a country (e.g. sewage and solid wastes both scored 3 in Malaysia) indicate that the sources were either grouped, or contradictory. The priorities indicated in the 'All' countries column were derived by averaging the rank for a source across countries and dividing by the number of countries giving a rank to that source (combination of rank and signal strength).

	All	BD	IN	ID	MY	MV	MM	LK	TH
Overall priority for land-based pollution	**1**		**1**	**1**			**1**		**1**
Sewage	**1**	1		1	3	1		1	1
Agriculture	**2**	3		2	4	2	1	6	2
Industry	**3**	2		3	2			2	5
Solid wastes (municipal)	**4**	1		4	3			5	
Sediments	**5**				1				
Aquaculture	**6**	5					2	8	4
Heavy metals	**7**				5	3			
POPs	**8**	6				4			
Tourism	**9**							3	
Urbanisation	**10**								3
Sand mining	**11**					5		9	
Harbours	**12**							4	
Ship breaking	**13**	4							
Fisheries	**14**							4	
Hazardous	**15**			5					
Marine tin mining	**16**								6
Power	**17**							7	
Coral mining	**18**							8	
Oil spills	**19**								

2.3 Status of the top priority issues in the BOBLME region

2.3.1 Sewage and other domestic wastes

Sewage: Sewage was identified as the top priority issue globally, in the BOBLME region in national reports and for at least part of the region by the regional Seas Programmes (UNEP-CEP 2000, Chia & Kirkman 2000). This category includes pollution in the form of nutrients, POPs, household chemicals, medical wastes, excreted pharmaceuticals and sediments. It is also one of the aspects of most concern for tourism, and part of the concern for commerce and industry. Sewage arrives in the Bay of Bengal from point and diffuse sources and may be carried by run-off, rivers, floods, tides, groundwater and storm surges. It is also a major concern in relation to urbanisation and population growth which are increasingly leading to the disposal of sewage in concentrations far above the assimilative capacity of the receiving environments, with little scope for natural attenuation across the land and rivers before wastes find their way to the coast. Although sewage treatment is seen as a way to reduce nutrient loads before release to the environment, this depends on the use of high levels of processing (secondary and tertiary) (GESAMP 2001) which can be costly, require large amounts of wetland areas or both.

BOBLME countries have some of the largest populations sizes (India, second only to China) and highest population densities (Maldives, ninth) in the world (Table 6). Sewage collection systems are few and treatment is poor, if done at all. According to WRI (WRI 2003) access to 'improved' sanitation may include connection to a public sewer, septic tank, pour-flush latrine, simple pit latrine or ventilated improved pit latrine, and is not necessarily the same as *sanitary*. Access to improved sanitation varies between 61% and 100% in the region for urban areas, and between 15% and 98% in rural areas (Annexe 1, WRI 2003). However, most of the systems being used in the region would do little to reduce nutrient loads before release into the environment. This argument does not mean, however, that disposal of human wastes to the ocean is necessarily a bad approach, provided that they are separated from industrial wastes, and that they bypass the coastal areas where eutrophication and hypoxia often occur (GESAMP 2001).

Table 6: Summary of national characteristics of BOBLME countries
* EVI Database, ** including rivers, ~WRI 2003

General country indicators	BD	IN	ID	MY	MV	MM	LK	TH
National population (millions)	129	1014	212	22	0.31	46	19	61
*National population density (#/sq km)	992	341	117	68	1036	69	291	119
*Population within 100km coast** (millions)	71	267	203	22	ND	22	19	23
*Population density within 100km coast (#/sq km)	544	155	112	66	ND	34	291	46
~National population growth 1980-2000	1.9%	1.9%	1.7%	2.4%	3.0%	1.5%	1.5%	2.9%
~Rural areas	1.3%	1.6%	0.3%	0.9%	2.7%	1.2%	1.4%	2.1%
~Urban areas	4.6%	3.0%	4.8%	4.0%	3.8%	2.2%	1.5%	4.7%
~GDP per capita 2000 (in 1995 USD)	356	463	986	5,024	1,833	ND	880	2,712
~ by Agriculture	25%	25%	17%	11%	ND	ND	20%	10%
~ by Industry	24%	27%	47%	45%	ND	ND	27%	40%
~ by Services	51%	48%	36%	44%	ND	ND	53%	49%

Solid wastes: Solid wastes are generated through almost every human activity, including households, tourism, commercial enterprise, public facilities, and general urban and coastal development and construction. The types of wastes involved include litter (a GPA category), plastics, paper products, masonry and sediments many of which can be carried by rivers, floods and run-off towards the sea. The worst of these seems to be plastics which often float and take many years to degrade. Social characteristics have an influence on the types of solid wastes found in coastal areas. For example in Indonesia, flip-flops are a major litter category, while in other areas plastic containers and metal cans predominate (GESAMP 2001). There is not much specifically said about solid wastes in the BOBLME national reports, other than the mention of poor collection and disposal services in most of the cities and uncontrolled dumping of municipal wastes. Bangladesh recorded significant problems with solid wastes, ranking it as top equal priority with sewage (Hossain 2003, Table 5).

Medical waste: This includes all the waste generated by hospitals, research facilities and laboratories. It also includes all biological and non-biological materials (ATSOR in Hossain 2003) including infectious and non-infectious solid waste, pharmaceutical products, hazardous waste and low-level radioactive waste, many of which join the sewage waste stream in the region. The pharmaceutical products may include hormone mimics, cytotoxic drugs, mercury and dioxin. Medical waste also contains potentially harmful microorganisms that are able to exist in the environment for as long as 46 weeks (Table 7). Medical waste is a public health risk and a risk to the environment.

Table 7: Survival times in the marine environment of major potential pathogens and indicators of sewage
Source: Ashbolt 1995.

Group	Name	Time of survival
Viruses	*Adenovirus*	50 days
	Astrovirus	unknown
	Calcicivirus	unknown
	Coronavirus	unknown
	Coxsackie A and B	2 days - 46 weeks
	Echovirus	2 days - 46 weeks
	Hepatitis A	> 24 days
	Poliovirus	2 - 130 days
	Reovirus	> 4 days
	Rotovirus	2 - 34 days
Bacteria	*Aeromonas spp.*	indigenous
	Campylobacter jejuni	poor
	Enterotoxigenic	5 hours - 2 days
	Escherichia coli	
	Faecal coliforms	2 hours - 2 days
	Faecal *Streptococci*	2 hours - 12 days
	Mycobacterium marinarum	indigenous
	Salmonella spp.	12 hours - 5 days
	Shigella spp.	< 15 - > 70 days
	Vibrio spp.	indigenous / < 6 days
	Yersinia enterocolitica	days - weeks
Protozoa	*Cryptosporidium parvum*	unknown
	Entamoeba histolytica	unknown
	Giardia intestinalis	unknown
Helminth worms	*Ascaris spp.*	unknown
	Taenia spp.	unknown

Tourism: Tourism in the BOBLME region is evolving in its nature, growing in importance and spreading geographically, becoming an increasingly important source of wealth. In the period 1996-97 to 1998-99, India's tourism increased by 5.2%, Sri Lanka's by 14.4% and Maldives' by 8.6% (SOE South Asia 2001). In Maldives, the absolute number of tourists visiting each year is now greater than the size of the resident population (Table 6). Tourism stresses urban infrastructure and natural resources, including those that are needed to metabolise the often disproportionate amounts of additional pollution created. Tourism can be a major driver for transport development and urbanisation including the construction of roads, hotels, shopping, and entertainment facilities. These issues are part of a feedback loop since the existence of the industry itself is often dependent on the quality of the natural environment it damages.

2.3.2 Agriculture and aquaculture

Nutrients (fertilizers) and pesticides: Agriculture and aquaculture, originally extensive in nature in the BOBLME countries are now becoming more dependent on inputs of artificial (NPK) fertilizers and toxic pesticides (POPs). Although in 1989 the South Asia area was still on average using just over a quarter of the fertilizers per hectare of agricultural land compared with high income countries (GESAMP 2001), rates have

increased such that by 2001, the application rates were comparable (WRI 2003, Annexe 1). The application rates of fertilizers and pesticides varies greatly among the BOBLME countries. The lowest application of fertilisers and pesticides occurs in Myanmar, with 15 kg/ha/yr of fertilisers, and 0.016 kg/ha/yr of pesticides. The highest application rate of fertilizers per hectare of cropland in the region is by Malaysia which uses 200 kg/ha/yr. The highest application rate for pesticides is in Sri Lanka with a staggering value of around 6.3 kg/ha/yr, almost 400 times as much as Myanmar. The effect of using such high levels of these nutrients and pesticides on aquatic environments of the BOBLME region is poorly quantified, but in other parts of the world is associated with eutrophication, hypoxia and shifts in planktonic communities (GESAMP 2001). The inputs to the coastal and marine environments of fertilizers is added to the nutrient loads associated with sewage, so the total amounts of nutrients reaching the Bay of Bengal in organic and inorganic forms must be close to the highest in the world.

2.3.3 Industry

Manufacturing: In the South Asia area, which includes Bangladesh, India, Sri Lanka and Maldives, there has been a region-wide structural shift away from agriculture and towards increased industrialisation, a trend which is expected to increase into the future (SOE South Asia 2001). This represents 5.6% industrial growth, and a quadrupling in the past 30 years. Many of the large industries are centred on the transformation of raw materials into steel, paper and chemicals, though electricity generation, oil refining, and leather tanning are also important. Many chemical manufacturers are shifting to the developing world, mostly to south Asian countries. These industries are resource-intensive and tend to produce a disproportionately large amount of toxic and hazardous wastes. Large industries emit nitrogen, sulphur and CO_2 in the air and lead, arsenic, chromium, and a range of other wastes into soil and water. The extraction of the raw materials (mining) also leads to large-scale surface disturbance and erosion. With industrialisation came urban growth, increased standards of living, smaller family sizes and decreased mortality, and more recently technological changes which have resulted in a shift towards lighter consumer (plastics, communications) and service industries ('restructuralisation'). Small and medium scale industries may now contribute up to 40% of total industrial output and are probably responsible for 50% of the pollution generated. They belong to the 'unorganised' sector and are difficult to regulate. There are regulatory bodies in all of the countries, but there are problems with manpower,

technical and financial resources and corruption. There are also loopholes in the environmental regulations and no country has been able to implement them effectively (SOE South Asia 2001).

2.3.4 Other important pollution sources

Sediments: Although sediment mobilisation occurs with sewage, and urban and port developments, in terms of quantity it is deforestation, together with agriculture and aquaculture that are probably the most important sources. The area of land used for agriculture in the region varies among countries between 3,000 (Maldives) and 169,700,000 (India) hectares (Annexe 1). The approximate total area of agricultural land for the region is 246.7 million hectares, which is about 38% of the total land area. A much larger area of the land in each country has been deforested for a range of reasons. These include agriculture, aquaculture and silviculture (e.g. mangroves), but also urban, industrial and port developments and logging. The amount of original[2] forest cover lost in countries of the BOBLME region varies between 36% in Malaysia, to as high as 92% in Bangladesh (Annexe 1). This amounts to around 408,479,000 hectares of land, or 63% of the land in the region from which original forest cover has been removed. Much of this land is now covered by crops, pastures, urban areas and secondary forests which are known to lose sediments through run-off and floods much more readily than the original forest.

2.3.5 Relatively ignored pollution sources

Episodic events: The BOBLME region is subject to cyclones and floods which periodically mobilise pollutants that would not normally find their way into rivers or which would otherwise remain relatively localised. None of the BOBLME countries raised the possibility that pollutants usually accumulating or stored in sediments, landfills and lakes might find their way to the sea during floods in catastrophic quantities. Bangladesh is subject to some of the worst flooding problems on the planet. There are no estimates of the likely contribution to pollution of the Bay of Bengal caused by periodic events. The importance and relative contribution of floods in the region needs to be assessed, since inputs to the Bay of Bengal may cause ecosystem shock and account for damage that would not occur if inputs were only at a lower level and on a daily basis.

[2] This is in relation to original cover 8,000 years ago, assuming current climatic conditions (see WRI 2001).

Waste trading: Added to the national industrial waste loads is pollution from the international waste trade. In 1986 only 3 countries around the world prohibited waste imports, but today the number has risen to 101. During that transition, South-East Asia became a dumping ground, with a recent shift more towards South Asia (SOE South Asia 2001). All of the BOBLME countries are party to the Basel Convention 1989, except Myanmar (Annexe 3). Despite this, wastes continued to be imported into at least Bangladesh and India at least up until 1993 (Table 8). It is not clear whether this practice is on-going in the region.

Table 8: Some of the known shipments of toxic wastes that entered Bangladesh and India in the 1990's from the developed world
Source: SOE South Asia 2001.

Country	Year	Waste	Amount (tonnes)	Source
Bangladesh	1993	Tin waste	7	Britain
	1993	Plastic waste	16.5	USA
	1993 (Proposal)	Unspecified	12,000 t/day	USA
	1991	Cd, Pb and other wastes	1,000 (secretly mixed with fertilizer, ⅓ of which was applied to farms before stopped)	USA
India	1993	Plastic waste	1,198	USA
	1992	Metal wastes, including Cu, Al, Zn, Sn, residues.	9,915	UK
	1992	Sn & brass waste	34,946	Australia
	1992	Fe, Zn, ash, residue, polystyrene and other plastic wastes	106,518	Canada
	1992	Pb	1,000	Canada
	1992	Plastic waste	7,000	USA
	1989	Metal wastes	484,700 (?)	Germany

2.4 Changing patterns of pollution

At least seven powerful and interrelated driving forces are operating in the Bay of Bengal region to create the pollution problems we see today, and those we can anticipate in the future. Under a business as usual scenario, pollution is expected to rise because corrective policies and technology are being far outpaced by basic growth and development. The principal drivers of pollution are many of the same factors operating throughout the world: (i) population, (ii) urbanisation, (iii) coastal migration, (iv) a strong regional desire to develop, (v) shift in industrial activity, (vi) expanding tourism, and (vii) intensifying agriculture and aquaculture. The first three of these act to increase and focus population density so that more and more areas can be expected to become polluted as their receiving environments become overloaded. This also means that we could expect more secondary pollution. That is, pollution changing in character and mobilising more widely because the original receiving environment has undergone ecosystem change and becomes a pollution source in itself. Eutrophied lakes and some of the rivers in the BOBLME region have become pollution sources in their own right.

The remaining drivers are more concerned with the lifestyle and development choices being made in the region and therefore the impact that each member of the (expanding) population has in terms of pollution. Big consumers create more pollution, and more of *that* is in a form that is toxic or difficult to degrade in the environment.

Population, urbanisation and coastal migration: The total population in the BOBLME countries has increased dramatically over the past 30 years. In 1975 the population of the region was 23% of the world total at 928 million. By 2001 it had expanded to 1.5 billion (India doubled) and accounted for ¼ of the world's population. By the year 2015, it is expected that the population in the region will exceed 1.8 billion and account for almost 26% of the world's population (HDR 2003, Figure 1a). That is, by 2015 the population in the region will have expanded from today's levels by a further 20%, despite a slowing growth rate (Figure1b). Further, the distribution of people is likely to become more uneven across the countries, as there is an increasing trend towards urbanization (Figure 1c) and a migration towards coastal areas.

From a pollution perspective, the aggregation of people in cities, or *urbanisation*, leads to problems of locally over stressing the assimilation capacity of the environment. At low human population densities, usually also associated with lower economic and industrial development, wastes produced can often be assimilated in the immediate environment. For urban areas, pollution effects can be experienced locally as well great distances from their source. The BOBLME region is still primarily rural, but is undergoing rapid urban growth. In 2000, the percentage of the population living in urban areas was 25% in Bangladesh, 28% in India, 24% in Sri Lanka and 26% in Maldives, with an annual urban growth rate of 2.6-5.8% (SOE South Asia 2001). A range of environmental problems results in urban areas of the region, including pollution of the land, rivers, groundwater and sea, and increasing problems with disposal of solid wastes.

Development and environmental controls: In common with most of the rest of the developing world, reducing poverty and increasing standards of living are the driving forces behind a strong urge to develop in the region. In the past, this push to develop has resulted in the environment being sacrificed in return for faster growth, and allowed the rapid establishment of 'dirty industries', toxic waste trading and the conversion of ecosystems in the region (e.g. mangroves to prawn farms, Kaly & Jones 1998). The annual growth in GDP in the region was generally high between 1975 and 2001 for all

countries except Myanmar and Bangladesh, reaching almost 5.4% in Thailand. After 2001, the rate of growth in GDP slowed for Indonesia and Malaysia (Figure 1d) and rose to 5.7% in Myanmar, while the remaining BOBLME countries stayed at around the same levels. During this time, while governments and people focused on financial benefits, hidden losses were being sustained in the environment in terms of loss of resources and pollution.

The character of this drive to develop is now changing and there is increasing evidence that the contribution of the environment to human welfare is slowly being understood. At least 36 international conventions that pertain to pollution have been signed by governments in the region (Annexe 3) and though many are not being fully observed (for a range of reasons) the first steps have been taken. The countries established departments of environment through the 1990's and are now exploring a range of options for building their capacity and making them part of the development process. Some countries have begun systematically monitoring their environment (e.g. India, Malaysia) and most are now exploring ways of managing their pollution and enforcing standards. If governments, the private sector, communities and individuals follow these changes through, from paper into action, we could expect to see a significant lessening in the rates of industrial and agricultural pollution in the region in the future.

Shifts in industry: There are three patterns of change occurring in industry in the BOBLME region that are likely to affect pollution in the future. The first of these refers to a recent shift from heavy and 'dirty' industries such as manufacturing of steel, paper and chemicals, and oil refining to lighter consumables, technology-based and service industries. It is not clear whether this shift will reduce problems of pollution overall since the new materials being manufactured include a range of POPs (in plastics, paints, chemicals) not traditionally part of heavy manufacturing and which can have ecosystem-wide effects in extremely small doses. The second trend in industry is the recent move of big business to relocate their manufacturing and service industries into the region to take advantage of cheaper labour and possibly lower production costs related to environmental and other standards. The final major trend is the proliferation of small and medium scale industries that are hard to regulate, and relatively more polluting than larger enterprises (SOE South Asia 2001). Taken together, these three trends do not paint a bright picture for the region in terms of industry. Unless standards can be enforced and levels of pollution curbed, the negative impacts from this sector are likely to increase in the short to medium term.

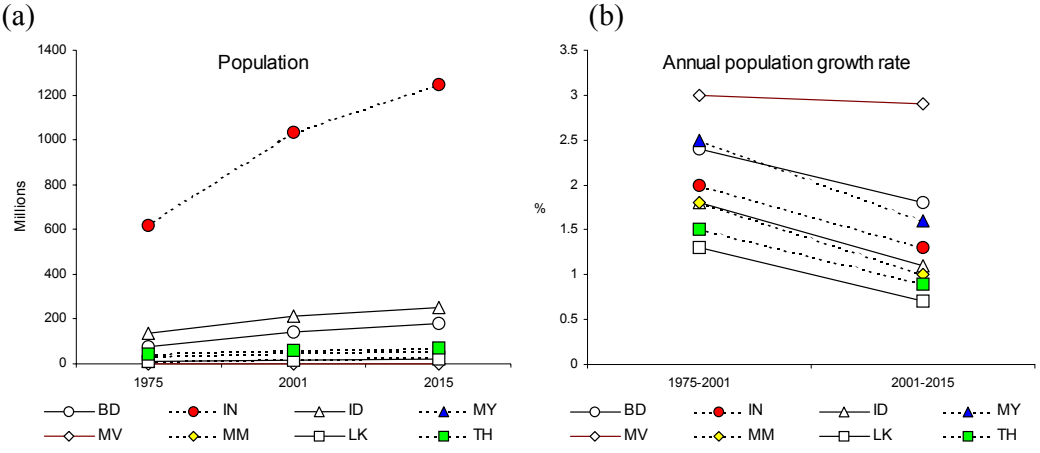
Expanding tourism: Tourism is expanding rapidly in the region under active government policy and incentives designed to attract people from other regions and capture part of the expanding world market. In the 1996-2000 period, the average tourist arrivals per year ranged between 380,000 (Myanmar) and 8.3 million (Thailand) (Annexe 1). There is one estimate that the numbers arriving in the Andaman area of Thailand could now be as high as 20 million per year (Juntarashote 2003). In Maldives, the number of tourists arriving per year is greater in number than the resident population. Tourism adds to population stresses on the environment, including its contribution to sewage, litter, municipal wastes, pharmaceuticals, urban and port developments and industries. With tourism likely to continue to increase, it is likely that it will increasingly compound the pollution problems in the region in the short and medium term.

Intensifying agriculture and aquaculture: Traditional agriculture and aquaculture in the countries of the BOBLME region were extensive in nature, resulting in problems of habitat modification (deforestation) and increased sedimentation, but little in the way of chemical pollution. In the past few decades there has been an increasing trend towards the use of artificial fertilizers and pesticides in an attempt to increase yields. On land this means NPK fertilisers and a range of POPs, and in aquaculture it includes the introduction of antibiotics and a range of other chemicals into the environment. The current application rates of fertilizers and pesticides in agriculture are high, with Malaysia having one of the highest application rates of fertiliser in the world (Annexe 1). The reason for this is clear: high applications of fertilizers do correlate with increased crops yields (FAO in GESAMP 2001), at least in the short term. The drive to develop and feed an expanding population in the region is likely to promote continuing high applications of agricultural chemicals, despite the significant effects on the environment (agriculture as second priority for pollution in the region). It is likely that unless major changes in approaches to agriculture and aquaculture are made, pollution from these sources will increase.

The overall prognosis: Most of the changes in population and development now occurring in the region will lead to increased problems with land-based sources of pollution in the future. The exception to this is progress which is now being made in the areas of public awareness and government policy which will act to green industry and other developments. It is however unlikely that these changes will be able to negate

the overall increases in pollution expected if demographic patterns change as predicted. Even in the face of shifting development priorities, radical changes would be needed in a short period of time. If the experience of more developed countries can be legitimately used as a rough predictor, we can expect that patterns of consumption will increase as growth in GDP occurs (Figure 2). Most of the BOBLME countries currently have relatively low consumption rates (and low GDP), except for Malaysia. Malaysia's Consumption Pressure Index (ESI 2001) is the second highest of 120 countries and is second only to Singapore (Figure 2). In terms of the ecological footprint, or amount of land required to support people and lifestyle in the region, the BOBLME countries are right at or just above carrying capacity (Figure 3). The global trend is that an increase in GDP leads to a country's carrying capacity being exceeded, with Singapore being in the worst position. Of perhaps even more concern for this discussion is that the BOBLME countries could be on a path to even greater levels of consumption and exceed their environmental carrying capacity at far greater levels than the rest of the world (see trend in Figure 2 & Figure 3). The consequences of the countries pursuing a lifestyle similar to that of Singapore, for example, would be devastating.

Figure 1: Trends in population size and growth, urbanization and growth in GDP in the BOBLME region.
Values are from HDR 2003. Note the time periods used for annual growth in GDP per capita are non-independent, with the first period covering 1975-2001 and the second covering 1990-2001.



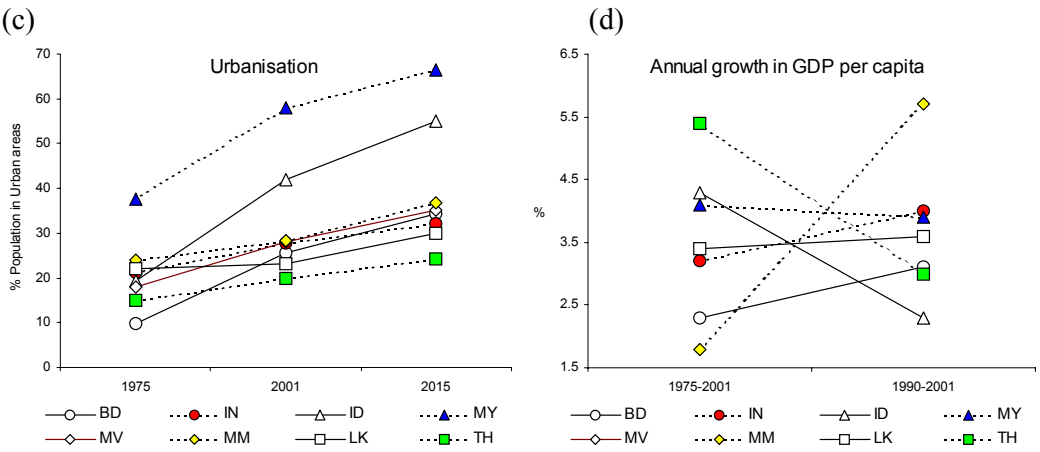


Figure 2: Consumption pressure per capita in relation to GDP per capita
Data are from HDR 2003 and ESI 2001. The Consumption Pressure Index value was calculated using the same methodology used by WWF for the 1998 Living Planet report, but using only grain-equivalent, fish, wood-equivalent and cement consumption per person. For each commodity, a country's per capita average was divided by the global per person average, giving a relative score. The relative scores for all the 4 components were then averaged to give the consumption pressure per person for that country (ESI 2001).

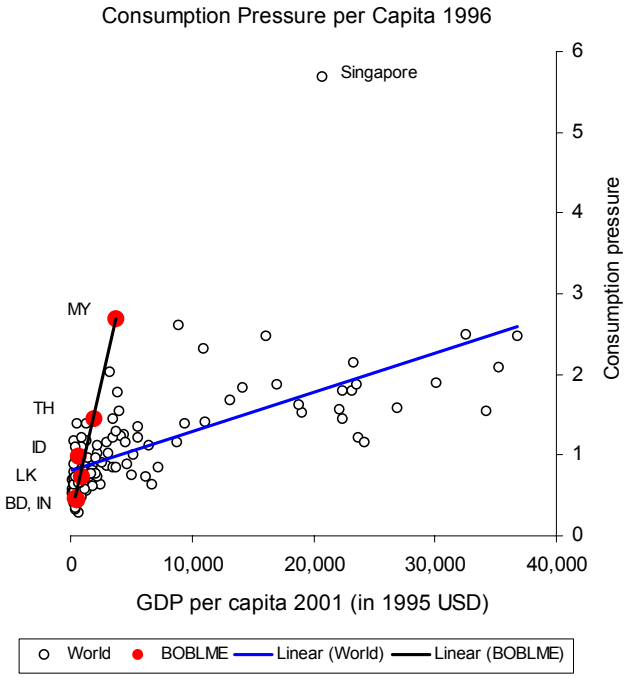
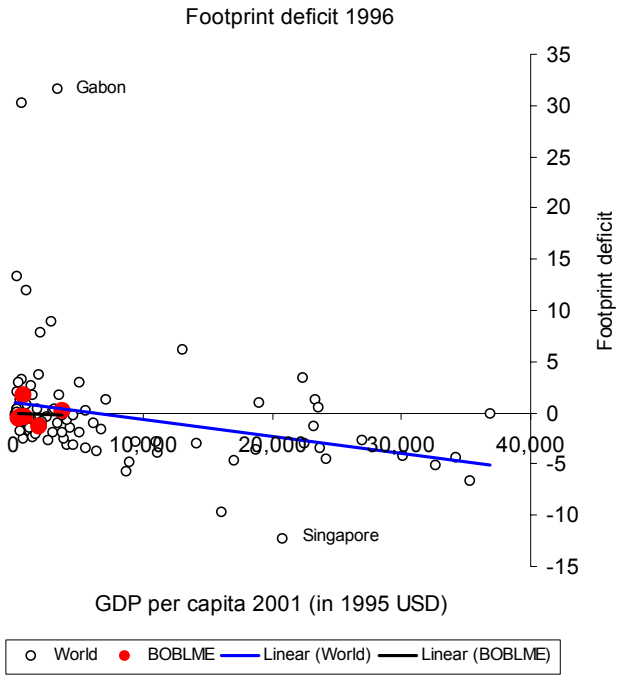


Figure 3: Footprint deficit in relation to GDP per capita
Data are from HDR 2003 and ESI 2001. The ecological footprint is a measure of a country's impact on global environmental resources. A negative number (deficit) indicates that a country requires more land area than it actually has in order to support its economy, and a positive number means that it has a surplus of biologically productive land (ESI 2001).



3. Common and trans-boundary issues relating to land-based sources of pollution in the BOBLME Region

For the purposes of this study, *common* issues pertaining to land-based sources of pollution to the coastal and marine environments are those that are present in two or more of the BOBLME countries, even if the issue or effect does not physically cross any country boundary. *Transboundary* issues are those that two or more countries have in common and that are either likely to require collaborative interventions by the countries involved, or for which a single-country intervention would benefit the region as a whole.

3.1 Common issues

Most of the important issues of land-based sources of pollution identified in the National Reports are present in 2 or more of the BOBLME countries (Table 9). The exceptions are fisheries wastes and power generation which were identified as significant issues only by Sri Lanka; and tin mining identified only by Thailand (Table 5). There were other issues not given a high priority by several of the countries, but which need to be considered further. Sedimentation, although mentioned in almost all National Reports, was considered a priority issue only by Malaysia, and is clearly an issue for all BOBLME countries. Tourism was considered a significant source of pollution by Sri Lanka, but is probably even more of an issue in Maldives. Sri Lanka also identified ports and harbours as important sources of land-based pollution which no other country considered important. Ship breaking was given a ranking of 4 by Bangladesh and is also an issue in India. Urbanisation and hazardous wastes were given some priority by Thailand and Indonesia respectively, but are important issues of regional significance in all countries. It is likely that all of the issues identified as important in the region are common to most countries (except ship breaking and tin mining) and that the apparent differences identified here are a direct result of problems with naming and pooling pollution categories.

Table 9: Identification of common and transboundary issues of land-based pollution in the region

Pollution type	Rank	Common	Transboundary
Sewage	**1**	✓	✓
Agriculture	**2**	✓	✓
Industry	**3**	✓	✓
Solid wastes (municipal)	4	✓	
Sediments	5	✓	✓
Aquaculture	6	✓	
Heavy metals	7	✓	
POPs	8	✓	✓
Tourism	9	✓	
Urbanisation	10	✓	
Sand mining	11	✓	
Harbours	12	✓	
Ship breaking	13	✓	
Fisheries	14		
Hazardous	15	✓	
Marine tin mining	16		
Power	17		
Coral mining	18		
Oil spills	19		

3.2 Transboundary issues

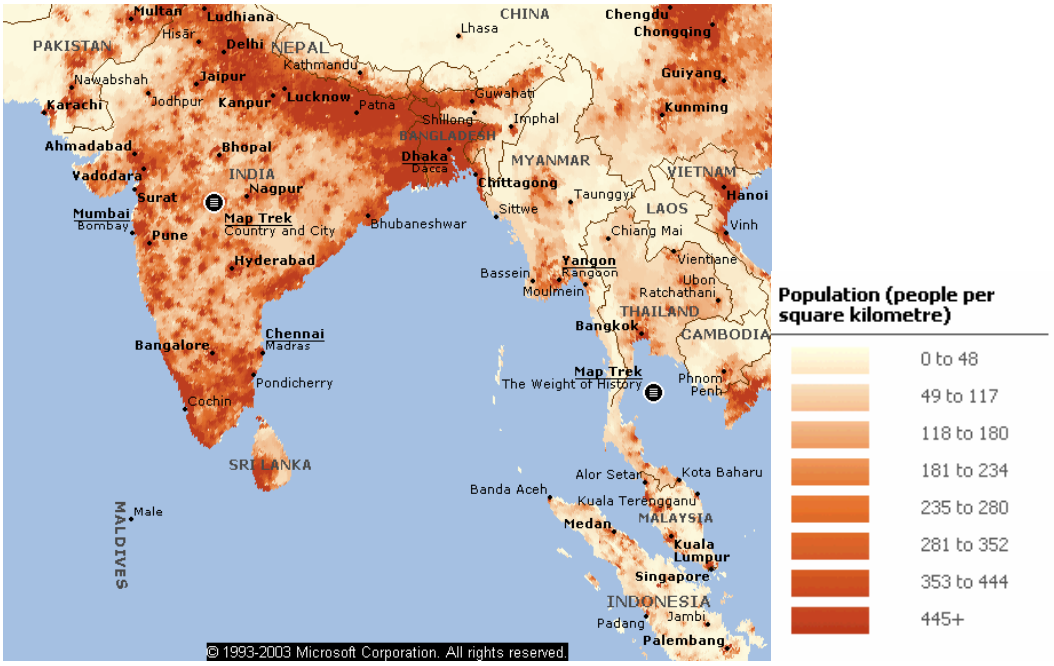
Issues of land-based pollution of transboundary significance include several pollution categories and two important pollution processes operating in the region.

Transboundary pollution categories: There are really only three main land-based pollution categories of transboundary significance in the region, with many of the other issues identified in the region largely being components or processes associated with them (Table 9, Table 14). These are sewage, agriculture (including aquaculture) and industry, with the additional priorities and largely related issues of sediments and POPs. Sediment mobilisation is heavily associated with sewage and agriculture, but is also connected with deforestation, urbanisation and aquaculture. POPs are associated with agriculture and industry, but are also associated with sewage and aquaculture. To simplify this discussion, the issues are discussed below for each sector inclusive of all the related pollution issues that arise with each.

Sewage is probably the most important issue in the BOBLME region in terms of land-based transboundary pollution. With large population sizes, increasing tourism, poor collection and treatment facilities even in the largest cities, and a vast network of rivers to collect and transport the effluent, a considerable quantity of sewage must enter the

Bay of Bengal every day. There is little by way of systematic monitoring information to provide information on the movements of sewage into the bay, and little information on its effects on coastal and marine ecosystems, or the time taken before it either joins the Indian Ocean or the rates at which it attenuates on the way. The components in sewage can include a wide array of liquid wastes including organic matter, nutrients, metabolised drugs, medical wastes, cytotoxic, antibiotic and hormone mimicking materials, bacteria, viruses and worms, chemicals such as detergents and a significant quantity of sediments. Sewage often also includes a wide array of chemicals normally associated with smaller industries. Of particular concern from a transboundary perspective are the sheer quantities that are probably entering the bay, the public health risk this poses and the content of suspended materials and nutrients which are known to affect coastal ecosystem health. Bangladesh and India are probably the most important countries from this perspective. Both countries have large population sizes and centres in the region through which major rivers flow into the Bay of Bengal (Figure 4).

Figure 4: Population distribution in the Bay of Bengal region



Pollution from agriculture and aquaculture is a transboundary issue affecting all of the countries in the region except Maldives, where the sector is limited, and possibly Myanmar where it is still largely extensive in nature. The liberal use of artificial fertilisers and pesticides in the region and an increasing intensification of farming and aquaculture methods means that large quantities of eroded topsoils, nutrients, POPs and

other chemicals are being released into the environment. The fate and ecological effect of these pollutants in the Bay of Bengal are poorly documented and understood, but reported localised problems of eutrophication, hypoxia and algal blooms are likely to be related. The effects of nutrient enrichment from sewage and agriculture may be difficult to separate, since organic and inorganic nutrient enrichment can lead to shifts in plankton structure, algal overgrowth and/or high biological oxygen demand. Because aquaculture is increasing and leading to similar problems of pollution, it should be included in this category.

The transboundary effects of industrial pollution relate to downstream effects of heavy metals, plastics, chemicals, oils, sediments and other organic and inorganic wastes entering the waterways and eventually the coast. Included in industry, should be ports where they include industrial facilities and logging which increases the loss of topsoils. There is some evidence of heavy metal accumulation and some oil damage in the Bay of Bengal, but the full extend of damage related to industrial pollution either in the Bay or upstream is not known.

Transboundary pollution processes (mobilisation): Central to an analysis of land-based pollution *sources*, is the need to examine polluting *processes* occurring in the BOBLME region. The most important of these are the transfer of pollution across country boundaries largely through rivers, and the mobilisation of pollutants generated on land by run-off, rivers, floods, tides and groundwater.

Several rivers flow from India, through Bangladesh and into the Bay of Bengal. The Ganges-Brahmaputra-Meghna river system is probably the most significant of these as it passes through some of the most densely populated, farmed and industrialised areas on earth. Further, some of these rivers are connected through catchments and tributaries to areas of Nepal, Bhutan and China. The problems of addressing inherited pollution along these rivers are likely to be large.

The most important pathways for pollution transfer from land-based sources are run-off, rivers and floods. Run-off and rivers are active most of the year and constantly collect pollution from sources many kilometres away from the Bay. Given that pollution loads are high, and that serious ecosystem damage of the rivers has undoubtedly occurred, the natural rates of attenuation have probably been compromised. Episodic floods, particularly in Bangladesh, probably mobilise sediments, solid and liquid wastes of all

types that do not normally find their way into the sea through rivers. Their effect may be catastrophic because it is infrequent and not part of the daily tolerance to 'normal' levels of pollution. Floods may lead to periodic widespread hypoxia, smothering and other effects in coastal ecosystems, not often noticed because of the social problems occurring at the same time. Clearly floods cannot be prevented, but a consideration of these events in planning and EIA could minimise the materials they mobilise. Tides, storm surges and groundwater discharges are likely to be of greatest significance in coastal areas, particularly in Maldives and Sri Lanka.

3.3 Prioritisation of transboundary issues in order of regional severity

The most important transboundary issues in the region in order of priority are:

1. Sewage;
2. Agriculture and aquaculture;
3. Industry;
4. Rivers and run-off;
5. Floods; and
6. International rivers.

Priorities 1-3 – Sewage, Agriculture/Aquaculture & Industry: Prioritisation among numbers 1-3 is relatively arbitrary in the sense that the relative importance of each of sewage, agriculture and industry has not been established by quantitative means. Environmental monitoring (see later) would identify priorities among these three sources and where effort should best be spent.

Priority 4 – Rivers and run-off: Rivers and run-off are priority 4 because, although not actually generators of pollution, they are the main mechanism by which pollutants generated even far away from the coast find their way to the sea. Run-off and rivers were discussed by most of the BOBLME countries (except Maldives) as part of the pollution problem in the region. Coupled with monitoring, actions taken to clean up rivers will benefit countries in general, and the Bay of Bengal, Andaman Sea and Straits of Malacca in particular.

Priority 5 – Floods: Episodic pollution mobilisation through floods may be a significant and catastrophic source of pollutants into the coastal areas. Actions taken to limit mobilisation of pollutants and attenuate them on site between floods is likely to benefit the entire region.

Priority 6 – International rivers: Special focus should be given to international rivers that collect pollutants and convey them to the Bay of Bengal from upstream countries, some of which are not BOBLME members. The major focus here would be on rivers such as the Ganges-Brahmaputra-Meghna system.

3.4 Root causes

The root causes of the major issues identified for land-based sources of pollution in the BOBLME region include human and natural factors, some of which lead to the generation of pollutants, and others which modify its fate after production. The most important of these are human population size and distribution, poor general understanding of the effects of human activities on the ecological life-support systems on which they depend, insufficient scientific and technological capacity and funds to use them, and intrinsic characteristics of countries that act to amplify pollution problems by mobilizing and delivering them far from their original sources.

Human Population: Although the rate of human population growth has been decelerating in recent years (Section 2.4), the population in the BOBLME region is still growing from its large base of around 1.5 billion. With densities reaching up to 1036 people per km^2 (Maldives) and averaging 379 people per km^2 for the entire region, pressure on the environment is close to the highest in the world. The sheer number of people living in the region is probably the most important root cause of the land-based pollution issues that arise there. Dealing with the sewage and other pollution produced on a daily basis, and changes we can expect with improving lifestyles as development continues are key determinants to the effects of land-based pollution in the sea.

Poor large-scale awareness: How people deal with issues of pollution on an individual, government, private sector, national and regional level rests on their basic understanding of the issues as individuals. That is, the better the large-scale awareness of issues of land-based sources of pollution in the general population, the better we could expect people, authorities and the media to respond to them and be able to take action. People can take responsibility for their own choices and will put pressure on authorities for better controls if they understand the issues. In turn, politicians know they can act on an issue with the support of the public if all are informed and will *value* the action taken. For example, in Bangladesh, the media are often slow to respond to pollution events (such as spills or accidents) and don't give coverage of chronic

pollution. When there have been reports of accidents in the ship breaking industry, including loss of human lives and fish kills, there was little public reaction (Hossain 2003). This example probably shows lack of understanding by both the media and the public and is a common situation throughout the region. Recent advances have been made in improving the understanding of environmental issues in the region (e.g. BOBP publications and others), but the process needs to be on-going and long term.

Low GDP per capita: Low GDP per capita usually also means there will be little money available for public spending. A small cash economy, combined with large population base, means especially that governments are unable to obtain the resources they need for promoting activities not directly related to development. Under these conditions, pollution and other environmental concerns can be seen as a luxury for rich countries, rather than the support base for all countries.

Insufficient scientific information: Scientific information on the state of the environment, sources of pollution and capacity to assimilate pollutants is generally lacking in the region. There have been some studies on condition of rivers, groundwater and coastal areas, but these have been *ad hoc* and discontinuous. Without comprehensive information on, for example, 'hotspots' and information on how much rivers transport and how much they attenuate before reaching the sea, authorities can not possibly address the most pressing issues with the resources available to them. That is, any current management of pollution in the region is occurring blindly. The exception is Malaysia that has a river basin monitoring programme that has the capacity to examine hotspots and monitor changes in river ecosystems.

Lack of affordable and/or appropriate technology: Most of the pollution problems in the BOBLME region could be improved with appropriate technology and best practices. This includes sewage treatment, the reduction and treatment of industrial waste and changes in (recently-acquired) farming practices. At present, very little of the sewage produced in the region is subject to any treatment before discharge, despite the availability of many approaches and levels of sewage treatment available worldwide. This problem is of course, in turn connected with limitations in financial resources and overcrowding. Many of the cities in the region have not been able to afford to install sewage systems and there is little available land for tertiary treatment systems that require ponds or swamps. Industry has not had the information or incentives to treat waste, let alone explore options for cleaner production. The problems arising in

connection to agriculture and aquaculture are because people have moved towards increasing yields through intensification, abandoning older, cleaner practices. There is evidence this is changing, with a move towards organic farming and aquaculture (Section 4.1).

Economic gradients and industry: Industries are relocating to the countries in the BOBLME region from more developed parts of the world to take advantage of cheaper production costs, related to lower labour costs and ultimately, more relaxed pollution standards. The basing of industries in Asia has been increasing in recent years, encouraged by governments because of the income and jobs they bring to the country. Unfortunately, while money flows into a country, the costs of hosting these industries include environmental damage through pollution. Most damage to the environment is undervalued and not included as part of the overall costs and benefits of doing business, so while there are benefits on one hand, these could actually be resulting in larger, unrecognised losses to fisheries and other values.

Intrinsic characteristics of countries: The BOBLME countries have been selected because they encompass the watersheds that feed into the Bay of Bengal, Andaman Sea and Malacca Straits areas. Several of the large countries are in high rainfall / monsoonal areas, with a lot of low-lying land and swamps and/or are subject to frequent storms and floods. These innate characters mean that they are subject to large amounts of water moving across them through run-off, rivers, floods, groundwater, tides and storm surges, mobilising sediments and other pollutants and moving them across the country and into the sea, even from hundreds of kilometres inland. Added to this is the fact that some of the larger rivers in the region are international, crossing between countries within and from outside the BOBLME. These characteristics mean mobility and a strong mechanism linking land-based activities with the sea.

4. Current attempts to address common and transboundary land-based pollution issues in the region

There are at least 105 local and national initiatives, programmes and environmental acts (National Reports) and there are 37 international treaties in force in the BOBLME region that relate to land-based sources of pollution (Annexes 2 & 3). It is very likely that this seriously underestimates local and NGO programmes that do not appear in international reports and were not listed in the National Reports. A listing of all programmes mentioned in the National Reports is given in Annexe 3 and is not repeated here. The focus in this section is on programmes that either demonstrate good practices or policies that could be examined, adapted and adopted throughout the region to address the most important issues of land-based pollution.

4.1 Local initiatives

Organic Agriculture: The extent of organic farming in 5 of the BOBLME countries is still low, but increasing (SOEL 2003, Yussefi & Willer 2003) (Table 10). Indonesia leads the field in terms of land area, with a total of 40,000 ha of organic farms, while Sri Lanka leads in terms of percentage of agricultural land under organic methods. There are several initiatives focused on further developing organic agriculture in the countries of the BOBLME region. One of these, Oxfam, (Organic Monitor 2003, Oxfam 2003a,b) is working on promoting organic methods for growing tea (Sri Lanka), vegetables (Indonesia) and other produce, such as spices (India). Although Kerala is not in the Bay of Bengal watershed and not part of the LME, its demonstration of organic farming is an important one. Farmers in the state are switching over to organic farming in view of the damage caused by chemical fertilisers and pesticides to fields, with the village of Karnuapuram now a 100% organic farming village, exporting spice to Germany, UK and USA. There are also plans to establish the world's largest organic spice processing factory and an organic tea factory in the area.

Table 10: Extent of organic farming in some of the BOBLME countries

Country Organic	Date	# Farms	% of all Farms	Organic Hectares	% of Agricultural Area
India	2001	5,661		41,000	0.03
Indonesia	2001	45,000		40,000	0.09
Malaysia	2001	27		131	0.002
Sri Lanka	2001	3,301		15,215	0.65
Thailand	2001	940	0.02	3,429	0.02

Sewage waste recycling in aquaculture: This programme operating in West Bengal uses sewage waste to grow algae and plankton to feed finfish in aquaculture. The programme has resulted in reduced sewage loads in the Hugli-Matlah estuary and has since been adopted into the Ganga River Action Plan.

Sponsoring by tourist resorts: Some of the tourist resorts in Maldives are sponsoring nearby local communities to clean up the litter on their islands (Ali 2003). In addition to increasing the tourism value of the area by keeping it clean, these kinds of programmes serve to improve awareness of pollution issues.

Local water quality monitoring: In Sri Lanka, the Pavithra Ganga Programme undertakes water quality monitoring in the Kelani River (Joseph 2003). The monitoring information is used as part of a reactive management system to identify sensitive areas and take mitigatory actions.

4.2 National programmes & initiatives

Malaysia's policy on transboundary issues: Malaysia's National Policy on the Environment (2002) specifically states that the country will fully cooperate with its neighbours on transboundary environmental issues and adopt practical measures to minimise the occurrence of transboundary pollution and industrial accidents. This policy is an important one because it establishes the framework on which ecosystem-based management of the LME can operate, and should be adopted by all BOBLME countries.

Common effluent treatment plants: Large-scale manufacturers and tourist facilities often have their own effluent treatment facilities, but smaller industries and operators tend to dump their wastes because they do not know how they could limit the generation or how they could dispose of wastes, don't have the space for treatment plants and/or have insufficient financial resources (SOE South Asia 2001). Realising this problem, India developed the concept of Common Effluent Treatment Plants (CETP) in the 1990's. This idea is now accepted in a number of other countries in the region, but requires development and effective implementation.

River or river basin monitoring: Malaysia has been at the forefront initially in river (1988-1994) and lately river basin monitoring in the region. Since 2000 its River Basin Water Quality Programme has provided coverage of 120 river basins with 931 sites

used to identify hotspots for management. This is the most comprehensive ambient water quality monitoring programme in the region, and taken together with the DOE's coastal monitoring is a powerful basis for integrated management of water-carried pollution from land-based sources.

Monitoring of the sea: There have been several initiatives in India that have included monitoring of coastal waters. These include the COMAPS (Coastal Ocean Monitoring & Prediction System) and ICARM (Integrated Coastal & River Basin Management) and Sustainable Development Indicators programmes designed to identify hotspots and allow for reactive management to ensure ecosystem health (Sampath 2003). Malaysia has had a programme of coastal pollution monitoring carried out by DOE at 153 locations around the country. The important aspect of these programmes is that they are large-scale, covering a large number of sites and examining a range of variables.

Indonesia's clean river programme: In order to alleviate the increasing pollution problems nationwide, the Ministry of Environment office developed a Clean River Program in 1989. The project was started in eight provinces, which had major pollution problems, including NAD, North Sumatra and Riau Provinces. At a later stage, implementation will be expanded to other provinces.

Polluter pays: Pollution charges, on emissions or on products that when used or disposed of cause pollution, have recently been introduced into Asian countries (SOA South Asia 2001). It is not clear which of the BOBLME countries have adopted this principle, or to what extent.

Rewarding good tourism: A Maldives and World Bank initiative finances beach-side resorts that agree to install sewage treatment plants and roof-top gardens of endemic flora irrigated with treated effluent. In addition to this, the Maldives Government gives yearly awards (Green Resort Award, Green Globe Award & Tour Operators Environment Award) to encourage good practices. These have been so successful that resort owners have become competitive in trying to win them (Joseph 2003).

Clean Industry Development: Sri Lanka in partnership with ADB has a clean industry development project. This includes the development of policies, strategies and actions integrating cleaner production in industrial development, design, operation and awareness.

Industrial Parks: Sri Lanka has developed a policy of aggregating highly polluting industries into allocated areas termed industrial parks. This would be an advantage if strict controls treatment and disposal of wastes is applied in each area.

4.3 Regional programmes

GPA and the South Asian Seas and East Asian Seas Programmes: The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) and its partnership with the UNEP Regional Seas Programme operate in the BOBLME region with governments, international organizations, NGOs and the private sector to address many of the issues of land-based sources of pollution. These programmes are to be implemented through the existing South Asian Seas and the East Asian Seas Programmes, which unfortunately splits the BOBLME into two parts, an issue that needs to be addressed if the mechanism is to be used for this LME approach. The important aspects of the programmes for this discussion are its clearinghouse mechanism, the formation of partnerships, organisations and groups focused on particular pollution categories and mechanisms for developing actions plans and mobilising funding (see Section 6.7).

4.4 International treaties and programmes

Organic Aquaculture: An international technical and trade conference was held in June 2003 in Ho Chi Minh City on the latest developments in organic aquaculture and sea farming, including production, processing, markets and technological developments. This involved industry representatives, government officials, academics and potential investors. The most relevant topics covered were organic shrimp farming in Ecuador and Vietnam, economics of organic aquaculture, markets and the development of standards (Infofish 2003). Technology for hatchery production, feeds, rearing and processing without the use of 'chemical' polluting methods appear to be available. Given that the BOBLME countries are important aquaculture producers, involvement in this area would have important ramifications in terms of pollution.

International treaties. These are fundamentally about common and transboundary issues operating at global or regional scales and have in the past achieved significant changes in the way that countries view and manage pollution (e.g. Montreal Protocol 1987 and Kyoto Protocol 1997). Although international environmental treaties are no guarantee that parties can or will enact the strategies and obligations they have agreed to, they do

at a minimum raise awareness and provide mechanisms that can be used by countries to address the issues at hand. Such mechanisms include the promotion of dialogue, creation of institutions, funding, scientific resources and steps to be taken.

BOBLME countries are party to a number of environmental treaties relevant to the limitation and management of land-based pollution sources (Table 11 and Annexe 3). A total of 131 diverse environmental treaties are in force in the region, with countries involved either as signatories or parties (CIESIN-ENTRI 2003). Although many environmental treaties attempt to cover the wider issues relevant to their area of interest, around 36 of the total could be considered most directly relevant to issues of land-based sources of pollution to coastal and marine environments (Annexe 3). Many of these focus on radiation (15 signed by Indonesia) and other hazardous substances (17 by Sri Lanka), such as oil and mining. Few treaties are focused on other forms of land-based pollution, and only one on transboundary movements (Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Basel 1989: all countries are parties except Myanmar). In addition to the absence of any treaty that focuses specifically on the flow of land-based pollution to the marine environment and transboundary movements, the number of relevant treaties in common in the region is low. Only 5 treaties (of 36) are common to all BOBLME countries, with 6 of the agreements being unique and 14 being in common for 2-4 of the countries (Figure 5). If treaties dealing with land-based sources of pollution and transboundary movements in the region are to have any chance of being effective, all of the countries will need to be party to them.

Figure 5: Treaties in common for BOBLME countries
This graph shows the amount of overlap in the environmental treaties to which BOBLME countries are signatory or party of the 36 considered most relevant to land-based sources of pollution. The degree of overlap is low, with all countries being party to only 5 of the relevant agreements.

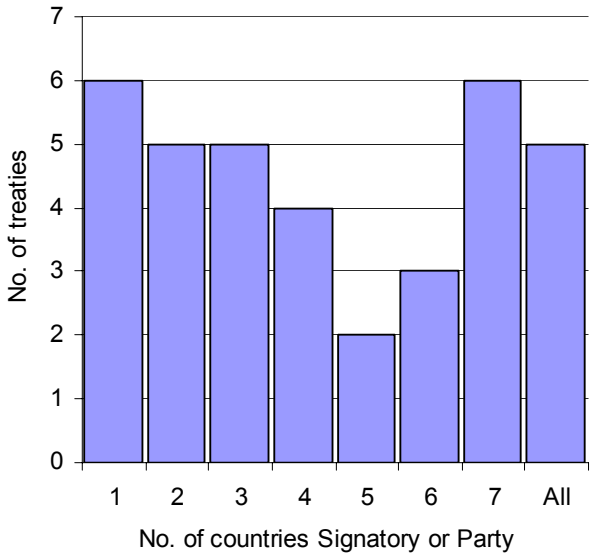


Table 11: Thematic summary of international environmental treaties of BOBLME countries
The number of treaties to which each BOBLME country is signatory or party in major thematic areas relevant to the control of land-based sources of coastal and marine pollution. Note that a single treaty may be represented in more than one thematic area.

Subject of treaties (Signatory or Party)	BD	IN	ID	MY	MV	MM	LK	TH
Soil quality / pollution	2	1	2	2	0	1	2	1
Seawater quality / pollution	7	18	13	16	9	9	16	8
Hazardous substances	11	16	15	14	13	8	17	11
Radiation	9	9	15	12	4	9	9	10
Non-renewable resources use / mining	0	4	3	3	2	2	3	2
Land use / land use planning	1	6	2	6	0	1	3	4
Wastes (general)	3	4	8	7	4	4	6	6
Renewable energy sources and energy conservation	1	3	2	2	1	2	2	1
Legal and institutional questions	13	17	14	16	10	13	16	13
Environmental conservation (general)	6	5	3	1	4	1	3	2

5. Impediments to the development of solutions to transboundary issues in BOBLME countries

5.1 Knowledge gaps

There are two types of knowledge gaps in the region pertaining to pollution. There is a real lack of scientific information required for managing and reducing pollution in the region. This includes information on pollution hotspots, and on how and where pollution is attenuated on land, in rivers and in the sea. There is also a perceived lack of information. This is information that does exist, but is not widely known or available in the region, or is not in a useable form. This type of information includes knowledge on clean technologies for industry and treatment of wastes, and best practices for agriculture and aquaculture.

Basic information: Information on the extent and types of pollution in the Bay of Bengal LME, including the sea, coastal zones of the region, rivers, land and other ecosystem elements, is fragmentary at best. Although there are several national initiatives aimed at monitoring the coast (India, Malaysia) and rivers (Malaysia), for most countries information comes from *ad hoc* sources. Without the ability to see which areas are most polluted ('Hot spots') and by which pollution types (nutrients, silt, heavy metals etc) determining the most important sources of pollution that will require action is largely guesswork. Although we may be able to guess at how much pollution is actually produced by land-based sources, we have no information on how much is mobilised, or how much is metabolised on land and in rivers and how much actually reaches the sea. There is similarly little information on where pollution goes once it enters the Bay of Bengal. From the known current circulation patterns (Sherman et al. 1998) it may be that persistent pollution entering the Bay of Bengal in the west from India and Bangladesh would tend to flow towards the countries on the eastern side.

Standards: In many BOBLME countries there are still knowledge gaps for the establishment of allowable limits of toxic discharge (e.g. Malaysia). Having permissible limits to discharges, however, addresses only part of the problem since even if discharge rates are low, if there are enough industries or people discharging them, environmental limits can still be exceeded. There is a need to establish the relationships between specific activities, the types and amount of pollutants they discharge and attenuation rates or carrying capacity of receiving environments. Without this

information it is difficult for even the best-equipped institutions to enforce permissible limits and polluter pays policies. For example, the Shipbreaking industry in Bangladesh has three institutions controlling it. Despite this attention there is almost no consideration of environmental issues, including limits on importation of ships or the pollution produced (Hossain 2003).

5.2 Policy distortions, clashes and overlaps

Most of the policy distortions that lead to poor management of land-based sources of pollution and the actions needed to manage it are located in the laws, rules and policies that govern the various sectors and development in general. They are also formed through corruption and poor large-scale awareness.

In the BOBLME region, as in the rest of the world 'environment' is lower priority than development *if they clash*. That is, governments place a high priority on development, often ignoring or failing to factor-in the hidden environmental costs. For example, waste trading would have brought measurable foreign exchange into Bangladesh and India in the late 1980's through the 1990's, but the environmental costs would have been borne without mention of their monetary value to the country. The losses incurred in the deal could have included problems with human health, loss of natural resources and loss of ecosystem resilience and services. Environmental losses are a way of transferring costs to other sectors (transfer pricing).

There is great diversity in the quality of governance and patterns of corruption in the BOBLME countries (Transparency International 2003). Lack of political commitment often demoralizes and weakens the capabilities of enforcement (Joseph 2003). Corruption and the restriction of NGOs, the media and freedom of information are major impediments to attempts to address the wider problems of ecosystem management, and especially those of pollution, which does not bring revenue and is seen as limiting to development. In terms of Transparency International's Corruption Perceptions Index (CPI), the region does not fare well (Table 12). Bangladesh has the lowest worldwide score, while the best score in the region, achieved by Malaysia is only 5.2, around half of that attained by the least corrupt countries. Indicator values have been improving over the period since 2001, but may still not be at a level that would tend to support widespread commitment by public and private sectors to ecosystem management, or a wider context to development in general.

Table 12: Transparency International's Corruption Perceptions Index 2001-2003
Sources WRI 2003 and http://www.transparency.org; 10=least corrupt; 0=most corrupt; values are CPI and (Rank).

Country	CPI 2001	CPI 2002	CPI 2003
Finland (best)	9.9	9.7 (1)	9.7 (1)
Bangladesh (worst)	0.4	1.2 (102)	1.3 (133)
India	2.7	2.7 (71)	2.8 (83)
Indonesia	1.9	1.9 (96)	1.9 (122)
Malaysia	5.0	4.9 (33)	5.2 (37)
Maldives	-	-	-
Myanmar	-	-	1.6 (129)
Sri Lanka	-	3.7 (52)	3.4 (66)
Thailand	3.2	3.2 (64)	3.3 (70)

5.3 Institutional weaknesses

Institutional weaknesses include issues of overlapping or clashing mandates, poorly framed laws, insufficient information to operate, poor human capacity, and insufficient funding allocations to undertake required tasks. These issues tend to lead to poor enforcement of environmental laws. For example, in Sri Lanka over 50% of shrimp farms are illegal.

Conflicts and overlaps in mandates: There are in the BOBLME countries a large number of provisions regarding environmental and resource management, which can lead to conflicts among agencies and confusion among stakeholders because they clash or overlap among the implementing institutions (Joseph 2003). Unclear mandates require constant coordination and collaboration among agencies to prevent conflicts; and if coordination occurs, lead to inefficiencies in having to spend resources on constantly determining jurisdiction. For example, in Sri Lanka the legal provisions of the Marine Pollution Prevention Authority (MPPA) overlaps with other legislation. For managing marine pollution, the area of jurisdiction and linkages to MPPA of the Central Environment Authority (CEA) is not properly defined, and leads to a lack of integration of funding and manpower at field level. There are also overlapping responsibilities on pollution between the Coast Conservation Department (CCD) which is responsible for pollution activities in the Coastal Zone, and MPPA's mandate for ship-based and shore-based maritime activities. There are also problems of *non*-linkage. Contingency planning adopted by CPC for transferring petroleum products from ships to shore-based storage has no linkage with the National Oil Spill Contingency Plan (NOSCP). Sri Lanka's solution to these problems has been the appointment of 8 committees on Environment Policy & Management, linked to a coordinating committee on Integrating

Environment & Development. How successful these are in coordinating the various government bodies, authorities and non-government stakeholders is not clear.

Poorly-framed laws. Laws that do not provide 'sufficient teeth' to the agencies concerned ensure that they cannot carry out the regulatory responsibilities expected of them (Joseph 2003). This may include laws that do not provide for sufficient disincentive for breaking them (such as low fines), laws that do not acknowledge ecological relationships (often in turn related to poor large-scale awareness), and those that do not empower the community where they should. For instance, provisions under the Coast Conservation Act in Sri Lanka are limited to a very narrow strip of land and prevent the Coast Conservation Department from exerting any influence over activities outside of it. Activities such as sand mining outside the 2 km limit, the operation of lime kilns outside the 300 m limit and over-exploitation of mangroves outside the coastal zone may cause considerable adverse impacts on the coastal environment and its resources. There is also lack of necessary provisions to empower the community, such as Community Coordinating Committees set up under the Special Area Management process (Joseph 2003). The Environmental Protection Act 1986 in India is a counter example in which the public have specifically been empowered to take action and report any activities that threaten environmental quality.

Lack of involvement of local government: In Sri Lanka, the Provincial Councils have shown very little initiative to become actively involved in natural resource management. The only significant exception being the adoption of a Provincial Environment Act and the establishment of a Provincial Environmental Authority by the North Western Provincial Council (Joseph 2003). Although 13th Amendment to the Sri Lankan Constitution was adopted in 1987, implementation in the form of provincial council involvement has been week. Reasons for this include confusion over the division of power between the central and provincial governments and lack of technical capacity among the provincial staff.

Poor capacity for enforcement: The lack of trained personnel to implement policies and enforce regulations is a pressing problem at enforcement and local government levels. In Malaysia, and probably all of the BOBLME countries, local councils are usually small, lack professional staff, and are often pre occupied with water bill collections and public complaints (Omar 2003). Enforcing pollution limits does not bring in revenue and is a drain on local capacity. In most of the countries, the equipment and funding

necessary for effective enforcement are not available to the institutions. Further, there is an inadequate flow of information required for planning among users at national, provincial and local levels occurs, even if there is a large amount available (Joseph 2003). In some cases, this is from failure to share, and in others it is because the data are kept in inefficient forms, not readily retrievable.

Petty corruption: Enforcement officers are often poorly paid, busy with other work or are pressurized by local politicians and other vested interests, either by threat of losing their jobs or through bribes. Enforcement is a stressful job, particularly in small communities where law-breakers might be well-known to enforcers. A strong negative correlation has been found between civil servant wages and levels of petty corruption (in Madagascar, Transparency International 2003). There are no Bribe Payer's Index (BPI) values for most of the BOBLME countries, but out of 21 countries examined around the world, Malaysia scored a BPI value of 4.3 out of a maximum (best case value) of 10 (Table 13). If patterns in the rest of the world are any indication for what might be happening in BOBLME countries, the sectors most polluting in the region (namely public works / construction (sewage), agriculture, and heavy manufacturing) are associated with the best and worst levels of bribery (Table 13).

Table 13: Transparency Internationals' Bribe Payer's Index (BPI) 2002
Source http://www.transparency.org ; 10=low bribery; 0=high bribery; data are for only limited countries, and averages for sectors in 21 countries.

Country	BPI 2002	Rank
Australia	8.5	1
Malaysia	4.3	15
Agriculture	5.9	
Light manufacturing	5.9	
Fisheries	5.9	
Information technology	5.1	
Forestry	5.1	
Civilian aerospace	4.9	
Banking & finance	4.7	
Heavy manufacturing	4.5	
Pharmaceuticals / medical care	4.3	
Transport / storage	4.3	
Mining	4.0	
Power generation / transmission	3.7	
Telecommunications	3.7	
Real estate / property	3.5	
Oil & gas	2.7	
Arms & defence	1.9	
Public works / construction	1.3	

5.4 Other impediments

The final group of impediments to actions that might address issues of land-based pollution in the region are concerned with the underlying assumptions that drive how people act and approach issues. Identifying these is of utmost importance since they are the filter through which the public, institutions, the private sector and governments act. Following are some of the often unarticulated underlying assumptions that were found in National Reports, or in other programmes being implemented in the region.

Environmental conservation is the duty of the government: In the National Report for Thailand, the important point was made that people believe that environmental conservation is a duty of the government (Juntarashote 2003). If people believe that environmental action is entirely up to government, they will be unlikely to take steps to conserve resources and limit pollution in their day-to-day activities. Further, this assumption will manifest in organizations and industry which will not consider it their duty to prevent pollution or take environmentally-sound actions.

Preventing pollution is all about limiting effluent discharges: It was clear from the National Reports that most governments in the region have been focusing on effluent discharges as a way of managing pollution. This manifestly does not work if it is the only approach used and conditions have continued to worsen. This is not only because of poor enforcement, but also because 'controlled' discharges can still overload an ecosystem if there are enough of them. The approach also does not take into account interactive ecosystem effects. That is, the effects of a pollutant can be magnified if it enters an environment already polluted with other things, which is physically damaged, or undergoing natural stresses such as floods. An ecosystem management approach to pollution requires a shift from this limited thinking on pollution management to a broader one that examines the dynamic relationships between discharged pollutants, the receiving and mobilising environments and rates of attenuation.

Functional ecosystem units are wrongly identified: In at least some of the BOBLME countries the responsibilities of federal, state and local governments are divided among sectors and/or geographic boundaries that do not suit an ecosystem approach. For example, in Malaysia, State Governments manage land, and riverine areas, while the Federal Government manages maritime and estuarine areas. This creates problems for planning and management because ecosystems cross these boundaries.

Lack of awareness that the ecosystem service of pollution attenuation is a 'resource': There is a general lack of awareness of environmental issues in the public, particularly in regard to the serious consequences of resource degradation (Joseph 2003), and the fact that pollution attenuation is a resource. One result is that few people assist in the enforcement of standards or the legal processes, despite at least in India, being legal empowered to do so. In many cases, prosecutions fail on technical grounds or the lack of sufficient evidence. People in the BOBLME region do not generally understand that the attenuation of pollution is a vital national resource, as important as any fishery or agriculture. This ecosystem function has always operated in the background, without conscious involvement by people. Now that it is becoming overloaded and in danger of damage, an understanding of this ecosystem service is urgently-needed.

NGOs have not taken up the pollution challenge: Day-to-day pollution is not an issue that attracts the kind of attention given to environmental concerns such as endangered species, coral bleaching, deforestation, oil pollution and radioactive wastes. Of course, these are significant issues that require attention. There is, however, a general quiet among NGOs in the area of pollution, unless it pertains to direct impacts on protected areas and critical habitats where pollution constitutes only a small part of projects.

Community participation: Communities are not sufficiently aware of the links between the ecosystem and their livelihoods, with the result that they do not use their social capital to coexist with it. In Sri Lanka for example, communities have not formed cohesive and active organizations capable of influencing policy makers (Joseph 2003). As a result, the level of participation of communities in management is generally inadequate.

6. Priority actions for addressing issues of land-based pollution

Effective ecosystem-based actions need to integrate social, economic and environmental concerns, the so-called 3 pillars of sustainable development. The actions needed are broad and need to approach the main issues from different angles, including changes in the way people think, through to empirically analysing the problems of pollution, and making interventions at a range of governmental and geographic scales. The most important aspect of these actions is that they should be coordinated among the BOBLME countries, and that the region's people and governments work at acting together to manage the LME of which they are part. Most of the actions suggested below are unlikely to work if applied by only one country, without the support of people, or without the support of at least some of the remaining actions. Although the actions focus on the priority issues identified in Section 3.3, they themselves are not arranged in any priority order.

6.1 Reanalysis and on-going monitoring of the situation

Action 1: Reanalysis of terms for pollution: There was much confusion in the National Reports in the way that pollution and its components were named, leading to poor identification of issues and options for addressing them. This confusion is also evident in the general literature on pollution. It is suggested that in any future analysis of pollution categories to be used for defining actions at any level, a system for identifying components is used. In Table 14a the highest priority pollution source identified for the region, sewage, has been reanalysed to identify the main sectors, activities, mixtures and components with which it is associated. Doing this clarifies that there is really no main sector that controls it; shows that it is connected to a range of activities or processes such as urbanisation and floods; includes several pollution mixtures such as medical wastes; and a range of active components of concern to human and environmental health. Doing this forces us to fully identify the problems and allows the placement of priorities on the various parts that contribute to them. For example, floods as mobilisers of pollution were rarely mentioned in the National Reports. Where issues overlap, as shown in Table 14b, the reanalysis shows where actions can be combined because they cover several of the old pollution source categories. For example, one of the concerns for tourism in the region is in regard to sewage disposal, an issue that could be addressed more generally.

Table 14: Reanalysis of the BOBLME priority areas for land-based sources of pollution

(a) Sewage only

SOURCES			
SECTORS	**ACTIVITIES**	**MIXTURES**	**ACTIVE COMPONENTS**
	Population	**Sewage**	Nutrients
	Urban development	Medical wastes	Sediments
	Coastal migration	Pharmaceuticals	Antibiotics
	Port Development	Biohazards	Viruses, bacteria & worms
	Tourism	Turbid waters	Radioisotopes
	Leaching		POPs
	Tides		Hormone mimics
	Floods		Cytotoxic drugs

(b) The three priority transboundary pollutant sources (Section 3.3)

SOURCES			
SECTORS	**ACTIVITIES**	**MIXTURES**	**ACTIVE COMPONENTS**
Agriculture / aquaculture	Population	**Sewage**	Nutrients
Industry	Urban development	Medical wastes	Sediments
	Coastal migration	Pharmaceuticals	Antibiotics
	Tourism	Biohazards	Viruses, bacteria & worms
	Intensive farming	Fertilizers	Radioisotopes
	Intensive aquaculture	Pesticides	POPs
	Habitat destruction	Effluents	Hormone mimics
	Deforestation	Turbid waters	Cytotoxic drugs
	Forestry		Plastics
	Disruption of coastal processes		Heavy metals
	Port Development		Hydrocarbons
	Leaching		Toxic chemicals (acids etc)
	Tides		
	Run-off		
	River flows		
	Floods		
	Groundwater movements		
EMISSIONS	**PROCESSES**	**MIXES**	**EFFECT**
Focus on policies	Focus on processes producing pollution	Focus on pollutant mixes	Focus on effect of pollutants

Action 2: Monitoring: In order to detect widespread patterns, short and long term trends, sources and the impacts of pollution from land-based sources in the BOBLME region, it will be necessary to establish a region-wide monitoring and information programme. This information would be used to identify pollution hot-spots for urgent attention (see Action 3). Monitoring needs to include coastal areas and rivers and be repeated at regular intervals (perhaps twice yearly) to detect any improvements or worsening of the situation so that priorities can be shifted accordingly. This action was ranked as top priority by Myanmar. A monitoring programme, similar to Malaysia's river basin programme could be expanded through cooperation to all countries in the region and be used for regional and national purposes, including research where it is needed. The variables selected for monitoring need to indicate the condition of the waters in terms of the three source priority areas of sewage, agriculture / aquaculture and industry, and be able to differentiate them as far as possible. The purpose of the

Regional Pollution Monitoring Programme would be to identify pollution hotspots, areas of pollution sinks and adjust effort to addressing the most pressing issues in each country for the benefit of the region as a whole.

6.2 Sectoral and cross-sectoral interventions

Action 3: Use results of monitoring to target pollution 'hotspots' and manage adaptively: The results of monitoring would be used to adapt management of land-based sources of pollution to focus on the most urgent issues in the region. Although based on likely outputs and mobilisation by rivers, it would appear that Bangladesh and India might have the most impact on the Bay of Bengal in terms of pollution from land-based sources, the results of monitoring would be able to target 'hotspots' empirically. With repeated monitoring, results could also be used to adapt management actions and measure the amount of improvement attributable to actions. Malaysia has progressed the furthest in this with its River Basin Monitoring Programme that was able to show improvements in pollution levels over a period of time.

Action 4: Collect and treat sewage: This action is of course the most widely recognised, yet the most widely neglected in the region. Projects are urgently-needed at every scale within countries to start the process of treating sewage before it enters the environment. This includes any mechanisms from household to city level and will require the efforts of individuals, businesses, NGOs, government and industry. Where possible aerobic systems should be used and nutrients, sediments and other wastes converted to less polluting forms before effluents are released, requiring more than primary treatment. India's common effluent treatment plants might provide a good model.

Action 5: Investigate better methods for agriculture and aquaculture: Chemical agriculture and aquaculture are relatively recent practices in the region, resulting from the need to increase yields. There are now initiatives in the BOBLME countries for organic agriculture, with India, Indonesia and Sri Lanka leading the way. There are also initiatives around the globe for promoting organic aquaculture. These and other farming practices that actively reduce or eliminate the need for chemical fertilizers and pesticides, including antibiotics should be investigated. NGOs such as Oxfam are interested in promoting better farming methods.

Action 6: Promote clean production in industry: Instead of relying on end-of-pipe treatment for reducing pollution, there is now a move in developed countries towards preventative measures to minimize pollution. This involves reducing wastes during the production process, rather than dealing with them after they are formed. Changes *inside the factory* in management, operations, equipment and even the products themselves are needed (SOE South Asia 2001). In many countries manufacturers are not aware of the measures they could take to reduce excess process inputs, utilize non-product outputs, and meet environmental standards, often with financial benefits. Governments in the BOBLME region should consider incentives for promoting clean production as part of their overall strategy for pollution abatement.

Action 7: Standardise and enforce effluent standards for industry: Effluent standards probably exist in all BOBLME countries, but are effectively enforced in none of them. Effluent standards should be harmonised in the region and a system of self monitoring through environmental management plans (EMPs) established through consultation with industry groups. Sri Lanka's Industrial Parks and Clean Industry Development Programme (with ADB) are two relevant models. Industries located in parks could establish common treatment facilities and management and monitoring plans. Polluter Pays principles need to be investigated further as an additional mechanism for reducing industrial pollution. Incentives for clean industry, including awards, green labelling and incentives should be investigated as a priority.

Action 8: Reduce and treat industrial wastes: The treatment of industrial wastes needs to be incorporated into the cost of production, where at present they are being borne as environmental damage and do not appear on the industrial balance sheet. Industries in the region need to have access to technology to reduce waste production and treat those wastes they cannot avoid. EIAs and EMPs are important mechanisms in this process, and put responsibility for limiting pollution on the manufacturer. With so much industry already established in the region, EMPs should be examined as a mechanism for improving existing activities. Through a regional coordinating mechanism, there is also a need to establish links with groups outside the region to gain better access to clean technology.

Action 9: Promote common effluent treatment plants: The idea of common effluent treatment plants as developed in India could be used separately for treatment of sewage and for industrial wastes. The cost of treatment for individual households or industries

is high, and the task of building sewerage for a whole town or city at once is too high for local or provincial governments with limited resources. By focusing on an intermediate scale for facilities it may be possible to work through the problem incrementally.

Action 10: Reward best practices: While enforcement has a role in reducing pollution, there has been a move world-wide to address enforcement issues through voluntary compliance, green labelling and incentives for best practices. This approach has already been shown to work for the tourist industry in Maldives, where annual green tourism awards have become the focus of competition among resort owners. This approach can be used in all polluting sectors and at local government level, including local councils, industry, tourism, agriculture and aquaculture.

6.3 Local level institutional mechanisms

Action 11: Engage Community groups and NGOs in pollution: NGOs have not so far focused on pollution in the BOBLME region. There is scope for them and other community groups to take more of a role in large-scale awareness, as watchdogs, and for bringing small-scale innovative technology to communities. Small projects on aerobic common sewage treatment systems, better farming and aquaculture methods and awareness are urgently-needed.

6.4 National level mechanisms

Action 12: Use EIAs and EMPs to limit damage: Many of the problems of pollution associated with industry, aquaculture, treatment plants, tourism and other developments could be minimised through proper use of EIAs and EMPs. The use of EIAs was Myanmar's second priority recommendation for controlling impacts of aquaculture on the marine environment, including mangrove areas. The development of a common set of EIA and EMP procedures and standards for the region, together with monitoring of the environment, would quickly begin to reduce pollution loads. It would also allow for better adaptive management because the pollution outputs would be controlled and better understood.

Action 13: Improve enforcement: It is doubtful that further laws governing pollution are needed in the region. Instead, governments should actively consider all options for improving their enforcement of environmental standards, including polluter-pays,

voluntary and incentive schemes. Environmental laws should, as in India, empower citizens with the ability to take action and report industries that are polluting the environment.

Action 14: Empower local governments: Local governments need better capacity and incentives to undertake their role as local pollution managers. National governments need to consider ways of increasing human capacity, improving working conditions to reduce petty corruption and maintain skilled workers (e.g. improve salaries, create a career structure for advancement), and improve the facilities and funding base for operations (e.g. allowing more revenue to be collected and used locally).

6.5 Mechanisms for improving the understanding of transboundary issues and stimulating collaboration in the region

Action 15: Build large-scale awareness: One of the most effective ways of providing the basis for action on issues of land-based pollution in the region is through spreading awareness and empowering people. Armed with sufficient information, it has been argued that people will be better able to take decisions on their own and will initiate actions beneficial to themselves and the local environment (SOE South Asia 2001). Added to this idea would be the caveat that actions would be taken only as long as they did not compromise economic and social position, or that people could see real benefits of taking environmental action. Nevertheless, awareness of the problems can lead to solutions, changes in the way people do business, and provide the fuel for the actions of governments. In Maldives, government and community-initiated activities have proliferated with an increase in awareness of the issues confronting many local communities (Ali 2003). Large-scale awareness means programmes in schools, media campaigns, professional organizations (e.g. to keep up with technological developments), NGOs, stakeholder groups (such as farmers, planners, foresters), mediated through all levels of civil society. The areas in which large-scale awareness would be most beneficial in terms of land-based sources of pollution are in the areas of:

- Rapid population growth, urbanization and the concept of carrying capacity;
- Farming practices focusing on more sustainable methods and reducing reliance on fertilizers and pesticides; and
- Mechanisms and technologies for reducing, recycling and disposing of wastes at all levels from individuals, to industry and government.

Large-scale awareness and capacity-building campaigns can be initiated at the local through to national level by governments, NGOs and other mechanisms with assistance from intergovernmental organizations. In the BOBLME region, and consistent with the LME approach, such initiatives should be regionally and globally cooperative in the sharing of information, resource materials and case studies.

6.6 Regional mechanisms

Action 16: Establish a Bay of Bengal Commission ('BOBCOM'): All of the governments in the region should consider agreeing to work together on transboundary issues. This could include setting up a regional organisation to coordinate efforts and share information, using selected conventions and taking a more regional view on managing issues of a transboundary nature. This could be initially a voluntary intergovernmental commission much like the Indian Ocean Tuna Commission (IOTC), established by the BOBLME countries to coordinate management of the large marine ecosystem. Perhaps later it could become an entity operating on behalf of the countries through a treaty. The role of the Commission would be to coordinate efforts of the countries to manage their LME, coordinate monitoring, scientific work and technology transfer functions and seek funding for activities. The Commission could work with Global mechanisms such as GPA and the Convention on EIA in a Transboundary Context, using them as vehicles for the establishment of regional cooperative mechanisms. Some if not all of the mechanisms listed below might best be addressed through a BOBCOM.

One of important functions of a BOBCOM would be to share and support the collection of scientific information needed for management of land-based pollution. Government officials, community representatives, NGOs and academics from the region need the opportunity to get together to share their experience and approaches annually. Successes and failures could be shared for refining approaches in the future. Other forms of cooperation may include promoting regional planning, exchanging scientific information, discussing social and economic concerns, developing capacity to meet the region's needs and make approaches for raising funds. Monitoring of effluents, emissions and the quality of waters in rivers, coastal and sea areas (Action 2) needs to be a coordinated effort, to a single agreed design and techniques, and reported among countries regularly so that adaptive management decisions can be taken. Regional data

collection and sharing can be an important part of national management of a resource, in this case, pollution attenuation.

Action 17: Establish regional standards: Environmental legislation which refers to emissions, quality of the receiving environments, EIAs, EMPs and other regulations (such as standards for treatment of sewage etc) needs to be harmonised throughout the region. Further, methodologies for training and water quality monitoring and pollution control need to be standardised to support and enforce the common environmental standards developed for the region. To manage pollution in the LME, it is necessary that similar standards apply in each country so that there is no tendency for 'dirty' industries to migrate from one to another to avoid the costs of pollution control, and that the best practices are in use throughout. Standards need to be enforced provincially, nationally and regionally. Focusing on regional hotspots would be less efficient if standards in those areas were the reason for them being 'hot'. For the region to be able to undertake ecosystem management, standards for emissions and acceptable levels of pollutants in the environment need to be re-examined in the context of ecosystem health of the entire LME.

Action 18: Establish Task Forces focused on key areas: One of the benefits of having a BOBCOM would be to establish cooperative working groups in the key areas relating to land-based pollution sources in the region, and in that way tapping in to the facilities available through GPA. The key areas are:

- Regional Monitoring & Standards Task Force;
- Sewage Task Force;
- Agriculture & Aquaculture Task Force;
- Industry task Force; and
- Water mobilisation task Force (rivers, run-off, floods and international rivers).

These working groups would focus on coordinating efforts among countries, seeking better technologies and advising public and private sectors, communities and other groups on how well actions are working. Such cooperative initiatives have been used in the past. For example, two South Asian Association for Regional Cooperation (SAARC) Summits (in Kathmandu 1987 and Islamabad 1988) were used by the South Asia countries to discuss and later commission studies on natural disasters and the greenhouse effect (SOE South Asia 2001).

There is a shortage of technology that can generate environmentally friendly substitutes, and/or provide options for better sewage disposal, agriculture and aquaculture and cleaner production. The BOBLME countries have large numbers of 'dirty industries', some of the larger of which are now moving towards ecolabelling and ISO14000 (SOE South Asia 2001), but many of the medium to small industries are poorly informed or unable to meet the costs of implementing environmental management systems. These smaller industries need to be informed and to gain access to state-of-the-art and clean technologies they can afford to use. There needs to be better communication with industry leaders in other countries and regions, and access to funds and training to encourage industries to adapt newer approaches, particularly if newer approaches are more costly than the older polluting technologies.

The working groups could also be involved in working through existing information clearinghouses (e.g. GPA) which will need to be easily accessible and in a form targeted at the end users. They should also support initiatives on research and development.

Action 19: Manage international rivers: Neighbouring countries with common water resources (e.g. rivers which carry pollution) need to coordinate pollution control and development activities, and together ensure tolerance levels are not exceeded. Bangladesh has 57 rivers that receive waters from India (53) and Myanmar (3) (SOE South Asia 2001). India's network of rivers comes in from countries outside the BOBLME region. These countries are the distal cause of probably significant pollution inputs to the Bay. The Joint River Commission of India and Bangladesh is responsible for resolving all river-sharing issues, but so far only the 1996 agreement for sharing waters of the Ganga River in Farraka is in force, and requires additional involvement by Nepal (SOE South India 2001). For the BOBLME region, individual agreements between neighbouring countries are likely to be inefficient and poorly enforced, so this action would best be implemented through a BOBCOM.

6.7 Global mechanisms

There are several global programmes and treaties which provide mechanisms for institutional support, funding, and the sharing of information and technology that would assist BOBLME countries to meet their ecosystem management goals in terms of land-based pollution sources.

Action 20: Better use of the mechanisms of GPA: In response to an increasing awareness that the world's oceans are under serious threat from land-based activities, 108 governments and the European Commission declared a commitment to protecting the marine environment from the adverse effects of land-based activities. The resulting Global Programme of Action for the Protection of the Marine Environment from Land-based activities (GPA) (Washington, 1995) was formed with a UNEP secretariat. Myanmar is the only BOBLME country not to have signed this agreement.

The GPA approach is multi-sectoral and comprehensive and has been taken to reflect a move by governments to strengthen collaboration and coordination of all agencies with relevant mandates through participation in a global programme. The GPA is designed to be a source of conceptual and practical guidance to be drawn upon by national and/or regional authorities for devising and implementing sustained action to prevent, reduce, control and/or eliminate marine degradation from land-based activities. The focus is on facilitating the duty of states to:

- Identify and assess problems related to food security, poverty, public health, marine resources, ecosystem health, economic and social benefits; severity and impacts of pollutants; physical alteration and degradation of habitats; and vulnerable or critical habitats;
- Establish priorities for action for issues identified above;
- Set management objectives for priority problems;
- Identify, evaluate and select strategies for addressing problems;
- Develop criteria for evaluating effectiveness of strategies and measures.

The implementation of the GPA is primarily the task of Governments, in close partnership with all stakeholders including local communities, public organizations, non-governmental organizations and the private sector. National and regional programmes of action will be used for successful implementation, with assistance from the UNEP Secretariat of the GPA, and its partners. Instrumental in this implementation process are the UNEP and other regional seas programmes and the GPA information and data clearing-house (UN-GPA Website 2003).

In addition to the National Programmes of Action, governments declared their intention to simultaneously cooperate on a regional basis with Regional Programmes of Action. The UNEP Regional Seas Programme and the other regional seas programmes and organizations provide an integrated framework for national action programmes, and

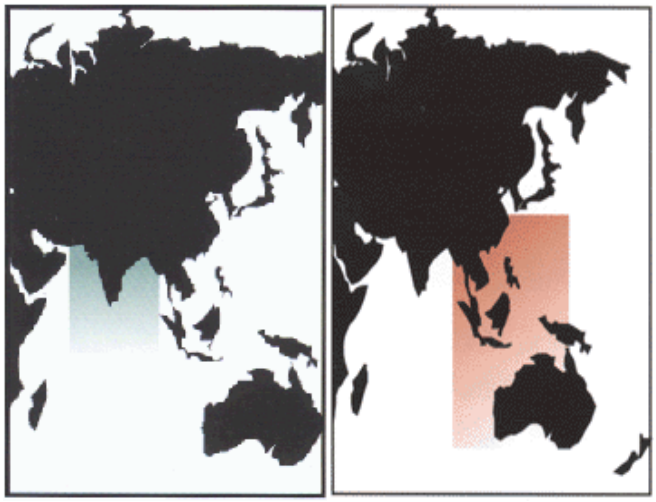
some priority areas have been identified. Of relevance here are the South Asia and East Asia Regional Seas Programmes.

The GPA mechanism has several areas relevant to the BOBLME Programme:

- Clearinghouse mechanism to mobilize experience and expertise, including scientific, technical and financial cooperation and capacity-building;
- Assistance with preparation of National and Regional Programmes of Action;
- Mobilising financial resources; and
- Coordination through GPA Secretariat (UNEP).

A problem with the GPA-UN Regional Seas approach is that it is based on a regional grouping of countries which is fundamentally not ecosystem-based. The two relevant Regional Seas programmes are the South Asian and East Asian Regional Seas, which essentially bisects the Bay of Bengal Large Marine Ecosystem and omits Myanmar (Figure 6). This means that the programmes straddle several LMEs.

Figure 6: Focus of the South Asian (left) and East Asian (right) Regional Seas Programmes.



Action 21: Consider using Espoo Convention 1991 for EIA: None of the BOBLME countries are parties to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo 1991). This agreement stipulates the obligations of parties to assess the environmental impact of certain activities at an early stage of planning including public participation and a consideration of public health. The purpose is to reduce and control significant adverse transboundary environmental impact from proposed activities (UNECE EIA 2003). The convention provides guidance on the types of developments that would lead to transboundary impacts, how

EIAs should be carried out, and on country cooperation. It does not provide for any technical or funding assistance to parties. The convention highlights the types of developments that are likely to have transboundary components and could provide information relevant to BOBLME countries. It is not suggested here that BOBLME countries necessarily become parties, but that some of the information and procedures in the convention could be adapted. Relevant to land-based pollution, topics include: oil refineries, power stations, iron and steel, chemicals, trading ports, waste-disposal installations, pulp and paper manufacturing, mining and deforestation of large areas.

Action 22: Use mechanisms of the Basel Convention 1989: All of the BOBLME countries are parties to the Convention on the control of transboundary movements of hazardous wastes and their disposal (Basel 1989), except Myanmar (Annexe 3). The mechanisms of this convention could be used by the region to address issues of management and disposal of hazardous wastes, and control waste trading in the region.

7. Location of proposed actions

Most of the Actions proposed in Section 6 are either applicable within each country, or are region-wide actions that require the BOBLME countries to work together towards common goals. A few of the actions identified here can be focused in one or a few of the countries because either the country is a big polluter in that area, it has made the most advances in addressing the problem, or its local conditions mean that effects are amplified compared with other countries. A summary listing of all Actions and where they might best be implemented is given in Annexe 4.

7.1 Actions that achieve maximum demonstration and replication

Thailand might be the best location for innovative activities related to aquaculture because it has the most shrimp farms in the region (Jayasinghe 1997) and a high enough GDP per capita to support regulatory actions, research and development. Using the experience gained by shrimp farmers in the country, methods for establishing self-cleaning and/or organic farms suitable for the region could be developed and replicated elsewhere.

India is identified as the best country for the location of a BOBCOM. The reasoning behind this is that the country has the largest population, a well-developed decentralised government structure and may be one of the largest contributors to pollution in the Bay of Bengal (together with Bangladesh). It also shares international rivers with Bangladesh and several other countries and has made progress on establishing treaties for managing transboundary problems with pollution. The Government of India also has a tradition of contributing resources to regional and international processes.

7.2 Actions located for greatest mitigation and prevention effect

Bangladesh is probably the country in which any actions will have the widest, most significant effects in relation to reducing land-based sources of pollution in the Bay of Bengal. The particular features of Bangladesh that support this view are:

- It has the lowest ESI and CPI values of the region, and low EVI/EDI values (Table 15) indicating that it probably has the lowest levels of environmental sustainability and highest risk of (vulnerability to) further environmental damage;
- The entire coastline is on the Bay of Bengal;

- Bangladesh occupies the head of the bay position where (i) the residence time of waters may be greatest (needs to be examined) and (ii) it receives waters already polluted by other countries in the region from the west (India) through clockwise circulation during January-July, and possibly also from Myanmar, Thailand and others and possibly through anti-clockwise circulation during August-December (Hossain 2003).
- It receives pass-through pollution through rivers from India, the Himalayas and Myanmar;
- The country has floods which may result in catastrophic inputs to the sea;
- The geography is low-lying and characterised by a large network of rivers; and
- Rapid urbanisation, high population density and growth rates mean that problems will compound rapidly if actions are not taken now.

The main actions that would be best taken in Bangladesh include treating sewage (Action 4), improving agriculture and aquaculture (Action 5), cleaning up industry (Actions 6 & 8), promoting common effluent treatment plants (Action 9) and establishing an international rivers programme (Action 19) (Annexe 4). Any of these actions taken in Bangladesh are likely to improve overall ecosystem conditions in the entire LME and benefit the remaining countries in the region.

Table 15: Human development (HDI), environmental sustainability (ESI) and vulnerability index scores (EVI) for BOBLME countries.
ESI = Environmental Sustainability Index (YCELP 2001) [Best=80.5 Finland, Lowest=24.7 Haiti]; EVI = Demonstration Environmental Vulnerability Index (Kaly et al. 2003) followed by (Rank position of 235 countries) [Least Vulnerable=1; Highly vulnerable=7]; EDI = Environmental Degradation Sub-index of the EVI with same scale. HDI=Human Development Index (HDR 2003) followed by (Rank position of 175 countries) [Best=0.944 (1), Lowest=0.275(175)].

Index	Bangladesh	India	Indonesia	Malaysia	Maldives	Myanmar	Sri Lanka	Thailand
ESI	39.50	40.90	42.60	49.70	-	-	49.80	45.20
EVI	3.58 (43)	3.87 (20)	3.3 (76)	3.15 (96)	4.21 (4)	2.75 (143)	3.35 (65)	3.05 (109)
EDI	4.06	4.41	3.31	3.06	3.29	3.56	4.00	3.00
HDI	0.502 (139)	0.590 (127)	0.682 (112)	0.790 (58)	0.751 (86)	0.549 (131)	0.730 (99)	0.768 (74)

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Annexes

Annexe 1: Comparison of land-based pollution sources in BOBLME countries

Sources: *EVI Database 2003 (mostly WRI 2000-2001, CIA 2001; see Kaly et al 2003).

Sector	Category	Indicators of pollution	Bangladesh	India	Indonesia	Malaysia	Maldives	Myanmar	Sri Lanka	Thailand
Domestic	Sewage	Sewage	✓	✓	✓	✓	✓	✓	✓	✓
		Sewage treatment	poor	poor	poor	poor	poor	poor	poor, limited to Colombo	poor
		~Urban - Access to improved sanitation 2000 (%pop)	71%	61%	69%	ND	100%	84%	97%	96%
		~Rural - Access to improved sanitation 2000 (%pop)	41%	15%	46%	98%	41%	57%	93%	96%
	Solid wastes	Solid wastes	✓	✓	✓	✓	✓	✓	✓	✓
	Urbanisation	Urban development	✓	✓	×	✓	✓	×	✓	✓
Agriculture / Aquaculture	Pesticides	*Pesticides used (t/y) 1996	1,450	74,054	2,726	45,493	ND	162	11,820	22,816
		*Pesticide use as g/ha cropland 1996	176	436	88	5,982	ND	16	6,261	1,116
	Fertilizers	~Fertilizers used (t,000/y) 1999	1,300	18,372	2,659	1,521	ND	157	259	1,802
		~Fertilizer intensity kg/ha/yr cropland 1999	154	108	86	200	ND	15	136	100
		~Total cropland (million ha)	8.4	169.7	31.0	7.6	0.003	10.1	1.9	18.0
	Aquaculture	Main aquaculture	Prawns / shrimps	ND	Shrimps, fish	Fish, tiger prawns, shellfish, seaweed	ND	Tiger prawns, Tilapia, freshwater fish, cage fish	ND	Shrimps
		~Aquaculture production t/y 2000 (incl freshwater)	657,121	2,095,072	993,727	167,898	ND	98,912	12,360	706,999
		Extent of aquaculture (ha)	200,000	ND	23,000 ****	~16,000	ND	49,300	ND	ND
Industrial & Infrastructural	Industry	Top polluters	Paper, textiles, tanneries	Chemicals, steel, textiles, fertilizers	Oil/gas, fertilizers, paper, palm oil, rubber, agroindustries	Food, chemicals, rubber, textiles & leather	ND	ND	Textiles, food, metals, rubber	Food processing

Sector	Category	Indicators of pollution	Bangladesh	India	Indonesia	Malaysia	Maldives	Myanmar	Sri Lanka	Thailand
		Number of polluting industries	1,200 (1997)	185 (?)	ND	2,759	ND	ND	494	ND
		Ship breaking (# companies)	>150	ND	✗	✗	✗	✗	✗	✗
	Roads	Roads	✗	✗	✗	✓	✗	✗	✗	✗
	Ports	Port developments	✓	✓	✗	✓	✓	✗	✗	✗
Mining	Mining		✗	✓ (minor)	✓	✓ (minor)	✓	✗	✓ (minor)	✓ (minor)
		*Total production (1996-2000) t/y	0	200	0	0	0	0	0	29,920
		Production (from National reports)	ND	ND	7.2 Mt	ND	ND	ND	5.5 Mt	ND
		*Main products	-	Uranium	Sn, bauxite, urea, kaolin, granite, sand	Sn, sand	Corals, sand	-	Sand, coral	Tungsten (from other areas?)
Tourism	Tourism		✗	✓ (minor)	✓	✗	✓✓	✗	✓	✓
		*Tourists / yr (average 1996-2000) (millions)	ND	ND	4.90	7.41	0.43	0.20	0.38	8.34 (20 mill/y Andaman Area Nat Report)
		Tourists as % resident population	ND	ND	2.31%	33.32%	138.71%	0.44%	2.02%	13.76%
		*Tourists / yr / sq km (average 1996-2000)	ND	ND	2.70	22.60	1434.44	0.31	5.83	16.33
Other	Siltation / sedimentation		✓	✓	✓	✓	✓	✗	✗	✗
		Sediments to sea from main rivers (t/yr)	2.2 billion	ND	ND	ND	None	ND	ND	ND
		*Percent original*** forest	7.9%	20.5%	64.6%	63.8%	ND	40.6%	18.1%	22.2%
	POPs	POPs (includes pesticides)	✓	✓	ND	✓	ND	ND	ND	ND
		Number registered pesticides (agriculture + public health)	338	ND	ND	ND	ND	ND	ND	ND
		POP pesticide use (ton/y)	7200 (1994)	ND	3,802 ****	ND	ND	ND	ND	ND
		POPs detected in marine organisms/sediments	Yes, very high	ND	Yes, very high	ND	ND	ND	ND	ND
	Radioactive	Radioactive substances	✗	✗	✗	✗	✗	✗	✗	✗
	Haze	Haze (indirect)	✗	✗	✗	✓	✗	✗	✗	✗
	Dumping	Untreated wastes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Monitoring & enforcement		✓	✓	✓	✓	✓	✓	✓	✓
		Enforced National standards for effluent emissions	No	No	No	No	No	No	No	No
		Monitoring of the sea	No	Some	Some	Some	No	No	Some	Some

Sector	Category	Indicators of pollution	Bangladesh	India	Indonesia	Malaysia	Maldives	Myanmar	Sri Lanka	Thailand
		Monitoring of rivers / estuaries / tidal waters	Some	Some	Some	Yes	-	No	Some	No
		Monitoring floodwaters	No	No	No	No	No	No	No	No
		Monitoring of groundwaters	Some	No	No	No	No	No	Some	No

* EVI Database, ~WRI 2003, ^CIA 2003, all other data sourced from country reports
** Including the coast of rivers
*** Percent is in relation to original cover 8,000 years ago, assuming current climatic conditions
**** East Sumatra / Malacca area only
✓ Seen as a widespread problem in National Report; × Not seen as a problem in National Report; ND = No data; t = metric tonnes; ton=US tons?; Mt=megatonnes (million tonnes); 'Improved' sanitation = Connection to a public sewer, septic tank, pour-flush latrine, simple pit latrine or ventilated improved pit latrine. This is not necessarily the same as 'sanitary'

Annexe 2: Summary of local and national initiatives aimed at addressing pollution

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
Local	India	West Bengal	Sewage waste in aquaculture	Use sewage waste and fertilizer to grow algae and plankton to feed finfish	Reduced sewage loads in Hugli-Matlah estuary. Adopted into Ganga River Action Plan
Local	Malaysia	Range	Local By-laws	Control earthworks, earth removal, mining, sanitation and solid waste disposal	
Local	Maldives	?	Sponsoring by Tourist Resorts	Sponsoring initiatives for solid waste disposal in neighbouring inhabited island	Stewardship leading improvements in surrounding areas
Local	Sri Lanka	1997-2000, 2000-2004	Hambantota Integrated Coastal Zone Management Project (HICZMP) Phases I & II (CCD, NORAD, SDA, MFOR)	Promotion of ICZM in Hambantota: planning, awareness. Includes Coastal and marine pollution monitoring programme	NGOs and CBOs involved
Local	Sri Lanka	2000-2004	Hikkaduwa Coastal Zone Management Project (NWSDB, Hikkaduwa Pradeshiya Saba, AusAID)	Improve Hikkaduwa. Solid & liquid waste management & systems. Pipe borne sewerage system, Solid wastes, Community building	
Local	Sri Lanka	2000-2005	North – East Community Restoration and Development Project (NECORD) (Provincial council, ADB, GTZ)	Improve living conditions of people affected by conflict. Includes small scale community level projects on sanitation	
Local	Sri Lanka	?	Shrimp Farmers Association	Improve information exchange and methods	
Local	Sri Lanka	?	Sustainable Township Programme (under Real Estate Exchange Limited)	Inadequate sanitation for under-served settlements in Colombo.	Focuses on under-served settlements
Local	Sri Lanka	?	Pavithra Ganga Programme (CEA)	Water quality monitoring system in Kelani river and Take mitigatory measures to prevent pollution	Project is to be extended to Maha Oya. Identifies sensitive areas. Feedback mechanisms. Authority to act
Local	Thailand	?	Action plan for environmental quality management at Provincial level	Encourage awareness, precaution and protection, recovery and rehabilitation, research	Focuses on decentralisation to provinces
Local (Atoll)	Maldives	?	Atoll / Island initiatives	Education & awareness, coastal management & defence, waste management	Initiatives are not one-size fits all and focus on local perceived needs

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
Local / National	Sri Lanka	?	Water Quality Monitoring	Authority to monitor water quality in the Coastal Zone and to regulate discharges from development activities. Carried out on ad hoc basis by at least 7 government agencies, universities and institutes. Includes BOI, CEA, CCD, NARA, NWSDB, SLRDC, ITI	Though many agencies are mandated, there is no coordination or any institution mandated with legal responsibility for regular water quality monitoring in the near shore waters, lagoons/estuaries and inland in the Coastal Zone
Local / National	Thailand	Phangnga Bay, 1999	Interdisciplinary Methodologies for the Sustainable Use and Management of Coastal Resource Systems (ASEAN-EU Cooperation Program Phase II)	ICZM. Status of natural resources, environment, activities, issues, existing laws	
Local / National	Thailand	Phangnga Bay	Coastal Zone Environment and Resources Management Project (CZERMP) Phase III (ASEAN AAECP)	Promote SD of coastal areas. Establishment of National Environment & Resource Information Centre	
National	Bangladesh	1995	NEMAP: National Environment Policy and Action Plan	Management and minimisation of pollution form industry	Not enforced
National	Bangladesh	1997	ECR: Environment Conservation Rules	Critical areas, permits, standards, emissions	
National	Bangladesh	1998	Policy on Shrimp Culture Development in the National Fishery Policy	Rotational culture, incentives, infrastructure, capacity, insurance, zoning, ICZM, participation	
National	Bangladesh	1999	NWP: National Water Policy	Development and safety of water resources	
National	Bangladesh	2001	NWMP: National Water Management Plan	To operate NWP. Management, clean water, protection of water ecosystems (Environment & Aquatic Resources)	No emphasis on restoration or management of threatened areas; Lack of involvement by experts
National	Bangladesh	1995, 2000	Environment Conservation Act + Amendment	Conservation, improvement, control of pollution	
National	Bangladesh	1997-2002	Fifth 5-year Plan	Implementation and enforcement of environmental law through Polluter Pays	
National	Bangladesh	?	WQS: National Water Quality Standards		
National	India	1974	Water (Prevention and control of pollution) Act	Control pollution, restore quality through State Pollution Control Boards	One focus is on restoration of water quality
National	India	1986	EPA: Environment Protection Act	Environmental quality, national pollution control and abatement, standards for discharges, accident safeguards, zonation for industry, creation of Authorities	Allows any person to take action and report, Requires EIAs for certain developments

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	India	1990	COMAPS: Coastal Ocean Monitoring & Prediction System	Status & trends in coastal & marine environment quality, strategies for maximising economic benefits, sustainable use, 82 locations, collection & analysis of data, 25 variables (physical, chemical & biological), health of seas	Identifies Hot spots, Institutions strengthened, has online public grievance system
National	India	1991	CRZ: Coastal Regulation Zone Notification (in EPA)	Regulation and prohibition of activities in coastal areas. Depending on category, restricts industry, hazardous substances, effluent treatment plants, landfills, mining, other permissible activities require environmental clearance	An ICZM approach, Management plans used
National	India	1996	Chemical Accident (Emergency Planning, Preparedness and Response) Rules	Statutory back up for establishment of Crisis Group in districts and states with Major Accident Hazards Installations (MAH), information to public, definition of MAHs	Identification of high risk industries, public information
National	India	1997	ICMAM: Integrated Coastal & Marine Area Management (support from World Bank)	Strengthening Environmental Monitoring and Compliance	
National	India	1998	Bio-Medical Wastes (Management & Handling) Rules	Management of medical wastes	
National	India	2000	Municipal Solid Waste Rules	Management of municipal wastes (MoEF), includes treated medical wastes, but not industrial	Includes options for recycling and composting
National	India	?	Sustainable Development Indicators Related to Oceans and Seas (Department of Ocean Development)	Waste assimilation capacity, monitoring, modelling, management plans, pollution from land-based sources	Monitoring of health of seas allows for remedial measures and control
National	India	?	ICARM: Integrated Coastal & River Basin Management	Ensure stability & productivity of aquatic ecosystems in a given coastal region through sustainable economic and social development of the region and its associated river basin.	Recognises link between freshwater systems and marine environment
National	India	1934, 1976	The Petroleum Act and The Petroleum Rules	Import, transport, storage, production, refining, blending	Accident management
National	India	1986-1992	Monitoring of Indian Coastal Waters (Dept Ocean Development & Pollution Control Board & National Institute of Oceanography)		

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	India	1989, 1994, 2000	Manufacture Storage and Import of Hazardous Chemicals Rules + Amendments (Environment Protection Act)	Manufacture, Storage and Import of Hazardous Chemicals Rules. Prevention of major industrial accidents and harmonisation of control measures and agencies	Focus on prevention
National	India	1989, 2000	Hazardous Wastes (Management and Handling) Rules + Amendment	Control of generation, collection, treatment, transport, import, storage, disposal through State Pollution Control Boards and State DOEs	
National	Indonesia	1945	National Guidance Act	Responsible use of natural resources in relation to carrying capacity and welfare of people	
National	Indonesia	1993	State Policy guidelines		
National	Indonesia	1997	Environmental Management Act		
National	Indonesia	?	Environmental Impact Assessment		
National	Indonesia	?	Clean River Programme		
National	Indonesia	?	Small scale industries impact control		
National	Indonesia	?	Environmental Damage Control		
National	Indonesia	?	Marine and Coastal Pollution Control		
National	Indonesia	?	Hazardous Waste Management		
National	Indonesia	?	Clean City Program		
National	Indonesia	?	Cleaner Production Development		
National	Indonesia	?	Implementation of Coastal Spatial Layout and Land-use Plan		
National	Indonesia	?	Establishment of National Coastal Water Quality Standards	Standards for shipping and ports, industry, hydrocarbons, coral mining, degradation of habitats, aquaculture, agriculture, tourism, transport	
National	Indonesia	?	10 National Steps towards environmental Management	Guidelines for Indonesia environmental policy and strategies	Considers carrying capacity, raises environmental quality, community participation
National	Malaysia	1985	Coastal Pollution Monitoring (DOE)	Coastal water quality, 153 locations, chemical and bacteriological monitoring	Direct information on environmental health
National	Malaysia	1987	EIA: Environmental Impact Assessment Regulations		
National	Malaysia	1997	IRBM: Integrated River Basin Management (DOE)	Management of whole river system from headwaters to sea	Sungai Trengganu River used as model for other states to emulate.

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	Malaysia	2000	River Basin Water Quality Programme	931 water-monitoring stations in 120 river basins	Results showed improvements in water quality. Lost direct comparisons with previous data.
National	Malaysia	2002	National Policy on the Environment	Achieve a healthy and productive environment. Harmonise economic goals with environment imperatives	Malaysia will fully cooperate with neighbouring countries on transboundary environmental issues and adopt practical measures to minimise the occurrence of transboundary pollution and industrial accidents
National	Malaysia	1974, 1979	EQA: Environmental Quality Act	Limits to allowable pollutant levels for land and sea-based sources as specified under EIA legislation. Pollution prevention, abatement and environmental enhancement. Palm oil, rubber, sewage & industrial effluents, waste treatment & disposal, EIA	
National	Malaysia	1988-1994	River Water Quality Programme (DOE)	116 rivers, 892 sampling stations monitored around country. Status & trends in river water quality. Range of physical, chemical indicators	Developed water quality index. Monitoring of river conditions. Stopped after 1994. Results showed status and trends
National	Malaysia	Under development	National Coastal Zone Policy	Protect marine resources, address issues of multiple use conflicts, streamline the legislative & administrative responsibilities of state and federal agencies	
National	Malaysia	under review	Soil and Conservation Act	Soil erosion, air and water pollution related to land clearing	
National	Malaysia	?	Environmental Depository	Compilation of environment statistics	Centralisation of information needed for management
National	Maldives	1989	1st National Environment Action Plan	Institutional and capacity building, Information collection on status of the environment	
National	Maldives	1993	Environment Protection Law	Broad mandate for holistic legal approach to all matters concerned with the environment. Transboundary chemicals and EIA	Deals with transboundary chemical movement
National	Maldives	1996	Health Master Plan	Access to safe water, adequate sanitation, effective waste disposal	

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	Maldives	1999	2nd National Environment Action Plan	Issues & threats from local and global causes, including pollution	
National	Maldives	2000	Aitken Spence & Company, Limited (IFC, WB Assistance)	Finances beach-side resorts that will install sewage treatment plants and roof-top gardens of endemic flora irrigated with treated effluent	Incentive scheme (rather than penal scheme), Good use of pollutant
National	Maldives	?	Green Resort Award, Green Globe Award & Tour Operators Environment Award	Encourage environmental considerations in resort operations and provisions	Reward of good practices in the tourism industry. Has made resorts competitive
National	Maldives	NGO	Tourist Industry Association	Environmental awareness and influencing government policy	
National	Maldives	NGO	Public awareness programmes	A range of NGOs, radio, TV	Mass media used to get message across
National	Myanmar	1927	The Waterpower Act	Prohibits pollution of public waters for obtaining energy and mining purpose	
National	Myanmar	1951	The Factories Act	Controls factories involved with chemicals, particularly hazardous or toxic chemicals	
National	Myanmar	1977	The Territorial Sea and Maritime Zone Law	Prevention of marine pollution	
National	Myanmar	1989	The Law Relating to Aquaculture	Prohibits causing water pollution	
National	Myanmar	1989	The Law Relating to the Fishing Rights of Foreign Fishing Vessels	Prohibits causing water pollution	
National	Myanmar	1990	The Pesticide Law	Monitors and controls the selection, storage, transportation and use of pesticides.	
National	Myanmar	1990	The Myanmar Marine Fisheries Law	Prohibits causing water pollution	
National	Myanmar	1991	Freshwater Fisheries Law	Prohibits causing water pollution	
National	Myanmar	1994	National Environment Policy	Harmony and balance between environment and development through the integration of environmental considerations into the development process	
National	Myanmar	1994	The Mines Law	Control safe disposal of waste, tailing and fumes	
National	Sri Lanka	1981	Marine Pollution Prevention Act No. 59 (MFOR, MPPA)	Prevention, reduction and control of pollution in Sri Lanka waters. National Oil Spill Contingency Plan. Penalties for any form of marine pollution.	MPPA does not cover land-based sources
National	Sri Lanka	1981	Natural Resources, Energy & Science Act No. 78 (MST, NSF)	Establishment of National Science Foundation. Scientific & technological research & policy	Technical advice available to Minister

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	Sri Lanka	1990	EPL: Environment Protection License for Industry	EPL must be obtained. Stipulates standards & criteria for the industry to discharge its wastes	
National	Sri Lanka	1990	CZM Plans: Coastal Zone management Plans (CCD)	Manage coastal habitats. Banning coral mining, permits, education, awareness, planning, monitoring, research, coordination	Pollution is little addressed
National	Sri Lanka	1993	EIA Procedure	Mitigation incorporated at early stage of a project	
National	Sri Lanka	1999	Aitken Spence & Company, Limited (IFC, WB Assistance)	Finances beach-side resorts that will install sewage treatment plants and roof-top gardens of endemic flora irrigated with treated effluent	Incentive scheme (rather than penal scheme), Good use of pollutant
National	Sri Lanka	2002	Clean Industry Development Project (International Resource Group, ADB)	Policies, strategies and actions integrating cleaner production in industrial development, design & operation, awareness	
National	Sri Lanka	2003	Coastal Zone Management Plan (CCD)	Plan of Action to control coastal erosion, pollution, degradation of coastal habitats, fisheries and aquaculture and special area management	Seeks cooperation from all stakeholders
National	Sri Lanka	1980, 1988	National Environment Act No. 47 + Amendment No. 56 (MENR)	Environment protection and management. Section 23 concerns discharge of waste. Regulatory powers through EIA and EPL (see below)	
National	Sri Lanka	1996, under development	Hazardous Waste Management System		
National	Sri Lanka	2000-2003	Institutional Strengthening of the Oil Spill Contingency Management (INSTCOM) (MFOR, MPPA, Norway)	Implement the National Oil Spill Contingency Plan (NOSCP) & strengthen oil spill contingency management	Institutional strengthening
National	Sri Lanka	?	IP: Industrial Parks	To relocate and concentrate highly polluting industries in one area. 19 currently established	It is not clear how aggregating industry reduces pollution
National	Sri Lanka	?	National Solid Waste Management Strategy		
National	Sri Lanka	?	NEAP: National Environmental Action Plan (MENR)	Policy initiative on natural resource management	
National	Sri Lanka	?	CEPOM: Committees (8) on Environmental Policy and Management (CEA)	Resolve the conflicts and issues of various agencies involved in environmental affairs. Government, NGOs and other stakeholders	Addresses problem of institutional overlaps and multisectoral nature of environmental concerns
National	Sri Lanka	?	CIEDP: Committee on Integrating Environment and Development (CEA)	Coordinator for the 8 committees of CEPOM	Addresses problem of institutional overlaps and multisectoral nature of environmental concerns

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	Sri Lanka	?	NWSDB: National Water Supply & Drainage Board	Good quality water and adequate sanitation in rural and urban areas	
National	Sri Lanka	Selected sites / 2000-2005	Coastal Resources Management Project (CRMP) (CCD, MFOR, ADB, Netherlands)	Enhance environmental protection & poverty reduction. Erosion control, environment and resource management, water quality improvement, solid waste and sanitation. Institutional strengthening (MFOR/DFAR/CCD)	
National	Sri Lanka	Selected sites / 2000-2005	Conservation of Bio-diversity through Integrated Collaborative Management in the Rekawa, Ussangoda and Kalametiya Coastal Ecosystems (CCD, MFOR, UNDP)	Conservation & sustainable use of biodiversity. Includes monitoring programme on activities likely to have adverse impacts on the conservation and sustainable use of biodiversity	Collaborative management system, actively involving local communities, NGO's and government agencies
National	Thailand	1997-2016	Policy and Prospective Plan for Enhancement and Conservation of National Environment Quality (NEC)	Balance economic, social development & environment. Reserve not less than 160,000 ha mangrove forest. Maintain coastal ecosystems	Focus on balancing three pillars of sustainability
National	Thailand	1999-2003	Action plan on conserving and rehabilitating marine resources and the environment	Conservation & rehabilitation. Sustainable use. Coordinate with ASEAN member countries on environment protection & problem solving	Includes monitoring of environmental quality
National	Thailand	1999-2006	Environmental Quality Management Plan	Action long-term policies & guidelines (3-5 years). Common guidelines for ministries, departments and provinces for harmonized work plans/projects and budgets	
National	Thailand	2002-2006	Environmental quality management framework	Improve efficiency of resources and environment management. Capacity building of local people & participation of stakeholders	
National	Thailand	?	National Economic and Social Development Plan (9th)	Sustainable utilization of natural resources and the environment through public participation. Reform the natural resources and environment management system, with public participation. Manage & protect natural resources, monitor the environmental conditions and pollution point sources. Improve seawater quality to meet the national standard	Correction of water quality that does not meet standards
National	Thailand	?	Implementation under the ASEAN Working Group on Coastal and Marine Environment (AWGCME) (OEPP)	Management & protection of coastal and marine environment in ASEAN region. ASEAN Strategic Plan of Action on Environment	

Initiative level	Country	Location / Year	Name	Purpose	Strengths / Weaknesses
National	Thailand	?	Implementation under the ASEAN Sub-committee on Marine Science and Technology (SCMSAT) (OEPP)	Baseline information, formulation of Regional Framework on Integrated Management, guidelines for management among the ASEAN member countries	
National / International	Bangladesh	1992	NEP: National Environment Policy and Action Plan (Rio Summit 1992)		

Annexe 3: International Environmental Treaties of BOBLME countries

List of International Environmental Treaties to which BOBLME countries are either S=Signatory or P=Party. Shaded treaties are those most relevant to the control of land-based sources of coastal and marine pollution.

Year	Treaty	Location	BD	IN	ID	MY	MV	MM	LK	TH	Common
1919	Constitution of the International Labour Organisation	Versailles	P		P	P		P	P		5
1920	Treaty Regulating the Status of Spitsbergen and conferring the Sovereignty on Norway	Paris		P							1
1921	Convention and Statute on the Regime of Navigable Waterways of International Concern	Barcelona								P	1
1924	International Agreement for the Creation of an International Office for Dealing with Contagious Diseases of Animals at Paris	Paris		P	P			P		P	4
1925	Protocol for the Prohibition of the Use in War of Asphyxiating Bacteriological Methods of Warfare	Geneva	P	P	P	P	P		P	P	7
1933	Convention relative to the Preservation of Fauna and Flora in their Natural State	London		P							1
1940	Statute of the International Institute for the Unification of Private Law	Rome		P							1
1944	Agreement of the International Bank for Reconstruction and Development	Bretton Woods	P	P	P	P	P	P	P	P	All
1944	Agreement of the International Monetary Fund	Bretton Woods	P	P	P	P	P	P	P	P	All
1944	Convention on International Civil Aviation Annex 16 - Aircraft Noise	Chicago	P	P	P	P	P	P	P	P	All
1945	Constitution of the United Nations Educational Scientific and Cultural Organization	London	P	P	P	P	P	P	P	P	All
1945	Constitution of the Food and Agriculture Organization of the United Nations	Quebec	P	P	P	P	P	P	P	P	All
1945	Charter of the United Nations	San Francisco	P	P	P	P	P	P	P	P	All
1946	Constitution of the World Health Organization	New York	P	P	P	P	P	P	P	P	All
1946	International Convention for the Regulation of Whaling	Washington		P							1
1947	General Agreement on Tariffs and Trade	Geneva	P	P	P	P		P	P	P	7
1947	Convention of the World Meteorological Organization	Washington	P	P	P	P	P	P	P	P	All
1948	Agreement for the Establishment of the Asia-Pacific Fishery Commission	Baguio	P	P	P	P		P	P	P	7
1948	Convention on the International Maritime Organization	Geneva	P	P	P	P	P	P	P	P	All
1949	Convention on Road Traffic	Geneva	P	P		P			P	P	5
1951	International Plant Protection Convention	Rome	P	P	P	P			P	P	6
1954	International Convention for the Prevention of Pollution of the Sea by Oil 1962 and 1969	London	P				P		P		3
1956	Statutes of the International Centre for the Study of the Preservation and Restoration of Cultural Property	New Delhi		P		P		P	P	P	5
1956	Statute of the International Atomic Energy Agency	New York	P	P	P	P		P	P	P	7
1956	Plant Protection Agreement for the Asia and Pacific Region	Rome	P	P	P	P		P	P	P	7
1956	Protocol to the International Convention for the Regulation of Whaling	Washington		P							1

Year	Treaty	Location	BD	IN	ID	MY	MV	MM	LK	TH	Common
1957	International Convention relating to the Limitation of the Liability of Owners of Sea-going Ships	Brussels		P							1
1958	Convention on Fishing and Conservation of the Living Resources of the High Seas	Geneva			S	P			S	P	4
1958	Convention on the Continental Shelf	Geneva			S	P			S	P	4
1958	Convention on the High Seas	Geneva			P	P			S	P	4
1958	Convention on the Territorial Sea and the Contiguous Zone	Geneva				P			S	P	3
1958	Optional Protocol of Signature concerning the Compulsory Settlement of Disputes	Geneva			S	P			P		3
1958	Convention on the Recognition and Enforcement of Foreign Arbitral Awards	New York	P	P	P	P			P	P	6
1959	Convention Placing the International Popular Commission within the Framework of the Food and Agriculture Organisation of the United Nations	Rome		P							1
1959	The Antarctic Treaty	Washington		P							1
1960	Convention Concerning the Protection of Workers against Ionising Radiations (ILO No. 115)	Geneva		P					P		2
1960	Articles of Agreement of the International Development Association	Washington	P	P	P	P	P	P	P	P	All
1962	Convention on the Liability of Operators of Nuclear Ships	Brussels		S	S	S					3
1963	Agreement concerning the voluntary contributions to be given for the execution of the project to save the Abu Simbel Temples	Cairo		P		P					2
1963	Agreement establishing the African Development Bank	Khartoum		P							1
1963	Agreement for the establishment of a Commission for controlling the desert locust in the eastern region of its distribution Area in South-West Asia	Rome		P							1
1963	Treaty Banning Nuclear Weapon Tests in the Atmosphere Outer Space and under Water	Washington	P	P	P	P		P	P	P	7
1964	Agreed measures for the Conservation of Antarctic Fauna and Flora	Brussels		P							1
1965	Agreement establishing the Asian Development Bank	Manila	P	P	P	P	P	P	P	P	All
1966	International Convention on Economic Cultural Rights	New York		P					P		2
1966	International Convenant on Civil and Political Rights	New York		P					P	P	3
1967	Agreement establishing the Southeast Asian Fisheries Development Centre	Bangkok				P				P	2
1967	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Moon and other Celestial Bodies	London	P	P	S	S		P	P	P	7
1967	Amendment of the Plant Protection Agreement for the Asia and Pacific Region	Rome	P	P	P	P		P	P	P	7
1968	Agreement on Administrative Arrangements for the Perk Thnot (Cambodia) Power and Irrigation Development Project	New York		P							1
1968	Agreement on the Rescue of Astronauts and the Return of Objects launched into Outer Space	Washington		P		S	P	S		P	5
1968	Treaty on the Non-Proliferation of Nuclear Weapons	Washington	P		P	P	P	P	P	P	7
1969	International Convention on Civil Liability for Oil Pollution Damage	Brussels		P	P	P	P		P		5
1969	International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	Brussels	P						P		2
1969	Vienna Convention on the Law of Treaties	Vienna				P		P			2

Year	Treaty	Location	BD	IN	ID	MY	MV	MM	LK	TH	Common
1970	Agreement concerning the voluntary contributions to be given for the execution of the project to save the Temples of Philae	Cairo		P							1
1971	Convention Concerning Protection against Hazards of Poisoning Arising from Benzene (ILO No. 136)	Geneva		P							1
1971	Convention on Wetlands of International Importance especially as Waterfowl Habitat	Ramsar	P	P	P	P			P	P	6
1971	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil thereof	Washington		P		P		S			3
1972	International Convention for Safe Containers (CSS)	Geneva		P	P						2
1972	Convention on the International Regulations for Preventing Collisions at Sea	London	P	P	P	P	P	P	P	P	All
1972	Convention concerning the Protection of the World Cultural and Natural Heritage	Paris	P	P	P	P	P	P	P	P	All
1972	Convention on the Prohibition of the Development Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction	Washington	P	P	P	P	P	S	P	P	All
1972	Convention on International Liability for Damage caused by Space Objects	Washington		P	P				P		3
1973	International Convention for the Prevention of Pollution from Ships (MARPOL) - Annex V (Optional) = Garbage	London				P			P		2
1973	Agreement concerning the Voluntary Contributions to be given for the Execution of the Project to preserve Borobudur	Paris		P		P					2
1973	Convention on International Trade in Endangered Species of Wild Fauna and Flora	Washington	P	P	P	P		P	P	P	7
1974	International Convention for the Safety of Life at Sea (SOLAS)	London	P	P	P	P	P	P	P	P	All
1975	Convention on Registration of Objects Launched into Outer Space	New York		P	P						2
1976	Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques	Geneva	P	P					P		3
1976	Protocol to the International Convention on Civil Liability for Oil Pollution Damage	London		P			P				2
1976	Protocol to the International Convention on the Establishment of an International Fund of Compensation for Oil Pollution Damage	London		P							1
1977	Protocol Additional to the Geneva Conventions of 12th August 1949 and relating to the Protection of Victims of International Armed Conflicts (Protocol I)	Bern	P				P				2
1977	Protocol Additional to the Geneva Conventions relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II)	Bern	P				P				2
1978	International Convention on Standards of Training Certification and Watchkeeping for Seafarers	London	P	P	P	P	P	P	P	P	All
1978	Protocol relating to the International Convention for the Safety of Life at Sea (SOLAS Prot.)	London		P	P	P		P			4
1978	International Convention for the Prevention of Pollution from Ships as modified by the Protocol of 1978	London		P	P			P			3
1978	International Convention for the Prevention of Pollution from Ships (MARPOL) - Annexe IV (Optional): Sewage	London							P		1
1978	International Convention for the Prevention of Pollution from Ships Hazardous substances carried in packaged form	London							P		1
1979	Amendment to the Convention on International Trade in Endangered species of Wild Fauna and Flora (Art. XI)	Bonn		P	P						2
1979	Convention on the Conservation of Migratory Species of Wild Animals	Bonn		P					P		2

Year	Treaty	Location	BD	IN	ID	MY	MV	MM	LK	TH	Common
1979	Agreement governing the activities of States on the moon and other celestial bodies	New York		S							1
1979	International Plant Protection Convention (1979 Revised Text)	Rome	P		P	P					3
1979	Constitution of the United Nations Industrial Development Organization	Vienna	P	P	P	P	P	P	P	P	All
1979	Convention on the Physical Protection of Nuclear Material	Vienna			P						1
1980	Convention on the Conservation of Antarctic Marine Living Resources	Canberra		P							1
1981	Articles of Association of the South Asia Cooperative Environment Programme	Colombo	S	S			S		S		4
1982	United Nations Convention on the Law of the Sea	Montego Bay	S	P	P	P	S	P	P	S	All
1982	Protocol to amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat	Paris		P		P			P	P	4
1983	Amendment to the Convention on International trade in Endangered Species or Wild Fauna and Flora (Art. XXI)	Gaborone		P					P		2
1983	International Tropical Timber Agreement	Geneva		P	P	P		P		P	5
1983	Statutes of the International Centre for the Genetic Engineering and Biotechnology	Madrid	P	P	S				P	S	5
1984	Agreement of the Protection of Confidentiality of Data related to Deep Sea-bed Areas for which application of Authorisation has been made	Geneva		P							1
1985	ASEAN Agreement on the Conservation of Nature and Natural Resources	Kuala Lumpur			P	S				P	3
1985	Convention for the Protection of the Ozone Layer	Vienna	P	P	P	P	P	P	P	P	All
1986	Convention on Conditions for Registration of Ships	Geneva			S						1
1986	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	Vienna	P	P	P	P			P	P	6
1986	Convention on Early Notification of a Nuclear Accident	Vienna	P	P	P	P		P	P	P	7
1986	Convention on the Law of Treaties between States and International Organizations or between International Organizations	Vienna				S					1
1987	Protocol on Substances that Deplete the Ozone Layer	Montreal	P	P	P	P	P	P	P	P	All
1987	Amendments to Articles 6 & 7 of the Convention on Wetlands of International Importance especially as waterfowl Habitat	Regina	P		P						1
1988	Agreement for the Establishment of the Network of Aquaculture Centres in Asia and the Pacific	Bangkok	P	P		P		P	P	P	6
1989	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Basel	P	P	P	P	P		P	P	7
1989	International Convention on Salvage	London		P							1
1990	Agreement on the Organisation for Indian Ocean marine Affairs (IOMAC)	Arusha			P				P		2
1990	Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	London	P	P	P	P	P	P	P	P	All
1990	International Convention on Oil Pollution Preparedness Response and Co-operation	London		P		P					2
1991	Protocol to the Antarctic Treaty on Environmental Protection	Madrid		P							1
1992	Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Copenhagen			P	P			P	P	4
1992	Protocol to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	London							P		1
1992	United Nations Framework Convention on Climate Change	New York	P	P	P	P	P	P	P	P	All

Year	Treaty	Location	BD	IN	ID	MY	MV	MM	LK	TH	Common
1992	Convention on Biological Diversity	Rio de Janeiro	P	P	P	P	P	P	P	S	All
1993	Agreement for the Establishment of the Indian Ocean Tuna Commission	Chiang Rai		P					P	P	3
1993	Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas	London						P			1
1993	Convention on the Prohibition of the Development, Production and their Destruction [of Hazardous Substances]	Paris	P	P	P	S	P	S	P	S	All
1994	International Tropical Timber Agreement	Geneva		P	P	P		P		P	5
1994	Agreement to Establish the South Centre	Geneva		P	P	P			P		4
1994	Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982	New York		P	P	P	P	P	P		6
1994	International Convention to Combat Desertification in those Countries Experiencing Serious Drought and or Desertification	Paris	P	P	P	P		P	P		6
1994	Convention on Nuclear Safety	Vienna	P	S	S						3
1995	Protocol to the Treaty on Southeast Asia Nuclear Weapon-free Zone	Bangkok			P	S		S		S	4
1995	Treaty on the Southeast Asia Nuclear Weapon-free Zone	Bangkok			S	P		P		P	4
1995	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin	Chiang Rai								P	1
1995	Agreement for the Implementation of the Provisions of the United Nations Convention on the law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks	New York	S		S		P		P		4
1996	Comprehensive Nuclear Test - Ban Treaty	New York	S		S	S	S	S	S	S	7
1997	Kyoto Protocol to the United Nations Framework Convention on Climate Change	Kyoto			S	S	P			S	4
1997	Convention on the Prohibition of the Use Production and Transfer of Anti-Personnel Mines and on their Destruction	Oslo	S		S	P	S			P	5
1997	International Plant Protection Convention (1997 Revised Text)	Rome	P								1
1997	Convention on Supplementary Compensation for Nuclear Damage	Vienna			S						1
1997	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	Vienna			S						1
1998	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Rotterdam			S						1
	Signatory		5	4	16	9	4	6	6	7	
	Party		53	89	61	66	35	45	68	58	
	Total		58	89	77	75	39	51	74	65	

Annexe 4: Summary of suggested actions and their location

Action	Description	Implemented	Coordinated	Available models	LOCATION for Innovation & Demonstration	LOCATION for Mitigation & Prevention
Action 1	Reanalysis of terms	Regionally	-	-	-	-
Action 2	Monitoring	Nationally	Regionally	(a) Malaysia's River Basin Monitoring Programme	-	All countries
Action 3	Target pollution hotspots	Nationally	Regionally	(a) Malaysia's River Basin Monitoring Programme	-	As identified
Action 4	Collect and treat sewage	Locally	Nationally	(a) India's common effluent treatment plants	-	Bangladesh
Action 5	Better methods for agriculture and aquaculture	Locally, Nationally	Regionally	(a) Organic farming in Indonesia and Sri Lanka; (b) FishInfo for assistance with organic aquaculture; (c) Aquaculture Authority in India	Thailand (the most shrimp farms) (Jayasinghe 1997)	Agriculture: BD, IN, MY, LK, TH. Aquaculture: BD, ID, TH, IN
Action 6	Clean production in industry	Nationally	Regionally	-	-	Bangladesh, Malaysia
Action 7	Effluent standards for industry	Locally, Nationally	Regionally	(a) Sri Lanka's Industrial Parks; (b) Sri Lanka's ADB Clean Industry Development Project; (c) Polluter Pays	-	All countries
Action 8	Reduce & treat industrial wastes	Locally	Nationally, Regionally	(a) Sri Lanka's Industrial Parks; (b) Sri Lanka's ADB Clean Industry Development Project; (c) Polluter Pays	Bangladesh - investigate EMPs applied to existing industries to reduce pollution	Bangladesh, India
Action 9	Promote common effluent treatment plants	Locally	Nationally, Regionally	(a) India's common effluent treatment plants	Bangladesh - Common effluent treatment plants in communities and industrial areas	Bangladesh
Action 10	Reward best practices	Locally, Nationally	Nationally, Regionally	(a) Maldives Tourism Awards	-	All countries
Action 11	Community groups & NGOs	All levels	Regionally		-	All countries
Action 12	EIAs & EMPs	Nationally		(a) Espoo Convention 1991	-	All countries
Action 13	Improve enforcement	All levels	Regionally		-	All countries
Action 14	Empower local governments	Nationally	Nationally		-	All countries
Action 15	Build large-scale awareness	All levels	Regionally		-	All countries
Action 16	BOBCOM	Regionally	-	(a) IOTC and others	India	-
Action 17	Regional standards	Nationally	Regionally		-	All countries
Action 18	Task forces	Regionally	-		-	Float among countries
Action 19	International rivers	Regionally	Regionally	(a) Joint River Commission India-Bangladesh	Bangladesh	Bangladesh
Action 20	GPA 1995	Nationally	Regionally	-	Myanmar to sign	All countries
Action 21	Espoo 1991	Nationally	Regionally	-	All countries to sign?	All countries
Action 22	Basel Convention 1989	Nationally	Regionally	-	Myanmar to sign	All countries

Annexe 5: Summary of pollution issues in individual BOBLME countries

Each of the eight BOBLME countries saw their pollution problems from different perspectives, as might be expected in a region with such diverse social and economic structures. In their national reports, the countries tended to categorise pollutants in different ways, pooling some sources, dissecting others into great detail and missing others obviously of some significance in the country. Some of the differing perspective in the reports can be attributed to the confusion caused by different and incomplete systems of labelling used by organizations and authors (Section 2.1) and partly because almost all of the established pollution categories have large overlaps. Nevertheless, general patterns and conditions specific to countries did emerge. The summaries below represent the problems as each country currently perceives them.

A5.1 Bangladesh

The main issues in terms of land-based sources of pollution reported by Bangladesh are domestic wastes, industrial pollution, agricultural pollution, ship breaking, coastal aquaculture, siltation and persistent organic pollutants (POPs) (SOE Bangladesh 2001, Hossain 2003). Rapid population growth, improper use of land, poor resource management, and uncontrolled discharges of pollution from industries and vehicles are seen as the major issues affecting the environment of the country (SEO Bangladesh 2001).

Urbanisation and domestic pollution: The capital city of Dhaka is among the fastest growing cities in the world with an average population growth of 6% per year (SOE Bangladesh 2001). Most of the cities and coastal settlements of Bangladesh do not have any kind of waste treatment facilities and effluents of domestic wastes (mostly sewage) either directly or indirectly find their way into rivers and the sea (Hossain 2003). With a national average human population density of almost 1000 per km^2 (Annexe 1) and some 54% of the population living within 100km of the coast (EVI Database 2003), the problem of mobilized domestic wastes entering the sea is a large one, and rapid population growth is expected to accentuate the problem in the future. (Majumdar 1998). About ¼ of the country's population lives in urban areas, and nearly ¼ of those live in the capital and largest city of Dhaka which has an average human density of a staggering 87,200 people per km^2 (Majumdar 1998). Though Dhaka is located some 170km inland, it is seen as an important contributor to the pollution of the Bay of Bengal through the Buriganga River (Hossain 2003). The large coastal cities of

Chittagong and Khulna are seen as major contributors of pollution to the sea via the Karnaphuli and Passur rivers. In Khulna and Chalna Port raw sewage and other wastes are further mobilised by tidal movements.

The amount of solid (municipal) wastes generated in the country appears to be related to socio-economic factors. In Dhaka, the values for high, medium and low income families are 2.33, 1.26 and 0.46 kg/family/day (DCC 1999 in Hossain 2003). The per capita solid waste generation of high income earners may be much higher than 5 times that of low income earners if families also tend to be smaller, suggesting that the problem will compound with increasing population and quality of life. The disposal of solid waste generated in Dhaka city is calculated to require 110 hectares of land per year. It is expected that by the year 2015, the total waste generated in Dhaka city will be about 8,000 tons per day, requiring about 292 hectares of land annually for disposal (Sinha and Enayetullah, 1997 in Majumdar 1998). Only 42% of the solid waste generated in Dhaka city is estimated to be collected by the municipal authorities. By some estimates, 50% of the people living within the city use of dustbins, 20% roads, 20% drains, and the remaining 10% open grounds for disposing off solid waste (MacDonald et. al. 1992 in Majumdar 1998). Uncontrolled and open dumping clog the urban drainage system and cause frequent floods probably mobilising further effluents which find their way into the river. Much of the solid waste generated in Dhaka city consists of organic food remains (80-85%), paper (5.5%), plastics (1.7%), clothes (1.8%) and glass / metal / construction materials (6.4%). The composition of wastes in commercial areas is similar in character, with slightly more glass / metal / construction materials (Majumdar 1998). Leachates from landfill sites in Dhaka (BUET 2000 in Hossain 2003) are a potent mix of chemicals with extremely high faecal coliform counts and high metal concentrations. There is no information on where these leachates travel, or on the condition of the groundwater, soil and rivers near them.

The total amount of solid wastes (and their leachates) and liquid wastes produced in the country and that could either directly or indirectly find their way to the coast of the Bay of Bengal has not been estimated. Probably 2/3 of the area of the country is connected to the Bay of Bengal via rivers, floods and surface run-off driven by up to 3.6m of rainfall per year (wettest areas). Knowing the total amount of wastes generated does not tell us very much about how much is mobilised into rivers or carried to sea. Natural attenuation of wastes would occur along this path, and there are few estimates of the final input to the Bay of Bengal, or the assimilative capacity of either the land or rivers

on the way. Some water quality tests of four major river systems namely, the Karnaphuli, Buriganga, Sitalalkhaya and Bhairab have shown that water of these rivers are highly polluted, mostly with organic loads.

Industrial pollution: Industrialisation began in Bangladesh in the 1950's and by 1997 contributed 5.7% of GDP, most of the growth during this time being unplanned with little consideration of environmental consequences (SOE Bangladesh 2001). Approximately 4.5% of its industries are considered polluting, and employ approximately 1.2 million workers (Hossain 2003). The most important areas of the country in terms of industrial pollution are Dhaka, Chittagong (coastal) and Khulna (~100km inland), the same cities likely to be contributing significantly in terms of domestic pollution. Industrial activity in Dhaka is approximately 3 times higher than in Chittagong or Khulna and in all three cities results in the discharge of untreated wastes. The most polluting industries are considered to be paper and pulp, textiles and tanneries (SEHD 2002 in Hossain 2003), with the sugar, food, fish and distillery industries also contributing heavily. Over the last decade there has also been a sharp growth in the textile industry. The wastes can include solids and liquids and may include ammonia, chromium and other heavy metals, phenols, plastics, pharmaceuticals, acids, alkalis and other organic and inorganic waste materials (Task Force, 1991 in Hossain 2003).

The Government of Bangladesh has developed standards for some of the effluents of polluting industries (GOB 1997 in Hossain 2003) but these are regularly exceeded and there appears to be no self-regulation. There is some limited information on the levels of heavy (Hg, Pb, Cr, As and Cd) and other metals (Al, Fe) found in the groundwaters of Chittagong and in the surface waters of the Bay of Bengal which in all cases exceeds the 'standard[3] allowable concentrations' (ESCAP 1988 in Hossain 2003). The total biological oxygen demand (BOD[4]) load in the Bay of Bengal from domestic and industrial sewage in the SE part of Bangladesh carried by the Karnaphuli River System was estimated in 1985 to be around 20,000 kg/day (ESCAP 1988) and was expected to quadruple by the year 2000 (Hossain 2003). Although there is relatively little information on the results of pollution in the groundwaters, rivers and seas of Bangladesh, the information that does exist indicates that the news is not good.

[3] It is not clear which authority set these standards, or for what level of contact they were designed: Primary contact or other.

[4] In ppm or mg/l is a measure of the oxygen used by microorganisms to decompose organic material in water. Very good=1-2ppm; Fair=3-5ppm; Poor=6-9ppm; Very poor/polluted>100ppm.

Ship breaking: This is an industry that began around 50 years ago and which is focused on dismantling and salvaging materials from ships, including cargo-carriers and oil tankers. The last 20 years has seen this industry boom, with more than 150 companies established in Chittagong and Khulna (Hossain 2003). In addition to damaging intertidal habitats and localized deforestation, the industry is associated with pollution by oil, petrol and other hydrocarbons, garbage, sewage, scrap metals, foam and other plastics, wood and PCBs (a group of POPs) (Hossain 2003). These pollutants directly enter the coastal and marine environments through dumping, rain and tides.

Agriculture & aquaculture: Pesticides have been used in farming in Bangladesh since 1957 and have now become widespread with 12,000-15,000 t/y being used (SOE Bangladesh 2001). If an estimated ¼ of all pesticides used reaches the coast (ESCAP, 1988 in Hossain 2003), the amount presently entering the Bay of Bengal could now be exceeding 400,000[5] tonnes/year (EVI Database). Fertilizer use is also thought to be increasing, with around 1.1 million tonnes being used per year (1995-1997, EVI Database). There are no estimates of how much of the fertilizers used find their way to the sea.

Most of the coastal aquaculture in Bangladesh appears to be of prawns, shrimps (salt to freshwater[6] species), turtles and crabs. In 2001-2002 shrimps contributed 89% of the export earnings of the country from the fisheries sector, derived from 33,000 tons of processed product (Hossain 2003). About 93,014 tonnes of shrimps/prawns is produced per year in marine, brackish and freshwater ponds, with about 76% coming from extensive and 24% from intensive aquaculture. The total area under currently production is approximately 170,000 ha being used for the production of *Penaeus monodon* the black tiger prawn (40,000 farms) and 30,000 ha for the production of the freshwater prawn *Macrobrachium rosenbergii* (105,000 farms). The list of chemicals, soil and water treatments, medicines, pesticides, feed additives, and hormones being used in the aquaculture industry in Bangladesh is large, and their effects once released into surrounding ecosystems undocumented (FAO 1987 in Hossain 2003). The aquaculture industry in the country has been increasing at the rate of about 20% p.a. for the last 15 years (Hossain 2003).

[5] This figure contrasts sharply with that given in Hossain 2003 of around 4 billion tones/year from the BBS 1997 Yearbook of Agriculture Statistics, a figure likely to be in error.

[6] The terms 'prawns' and 'shrimps' are used interchangeably around the world to cover salt and freshwater species. It is not clear which species are referred to in the report Hossain 2003.

Siltation (and turbidity): According to (Mirza and Shahjan 1987 in Hossain 2003) a total of around 2.2 billion metric tons of sediments is carried to the sea each year by the Ganges-Brahmaputra river system. This figure does not however give us any indication of how much of the sediments transported are mobilized naturally and how much caused by human activities and would therefore be considered a form of pollution. Siltation and increased turbidity of the coastal and marine areas of the Bay of Bengal probably result not only from elevated river inputs, but also run-off, floods (⅓ of the country floods each year) and some tidal movements. The main causes are deforestation, earthworks associated with coastal development projects and the rapid expansion of other land use practices (e.g. aquaculture). For example, the flattening and scarping of hills and foothills in the Chittagong region must have changed the sedimentary process of the area in the recent years (Hossain 2003). With only 7.9% of its original forest cover remaining (WRI 2000-2001), Bangladesh has had the greatest deforestation of all the BOBLME countries.

POPs: In 1992 the number of pesticides registered for use in Bangladesh was 253 for agriculture and 85 for public health use (Sattar 1985 in Hossain 2003). The import of most organo-chlorine pesticides (OCPs) was banned 10 years ago, but some are still being used in the sugar industry and for mosquito control. There are also reports that banned OCPs are being sold on the black market where they are hidden in a range of formulations, and that some are being used in fish processing plants (Hossain 2003). It is thought that as much as 1,800 tons of OCP pesticides could be entering the Bay of Bengal each year (BUP 2001 in Hossain 2003). This may be worsened by the spreading by wind of pesticides during application so that they are later picked up over a wide area by rain (Duursma & Carrol 1996 in Hossain 2003). The consistent presence of high concentrations of a range of POPs (PCBs and pesticides) in fish and shrimp species in the Bay of Bengal and estuaries (Hossain 1989, 1994, 2001, Hossain et. al. 1994 in Hossain 2003) shows that the chemicals are a huge problem and are clearly entering and bioaccumulating in the ecosystem.

Effects on environmental quality: The rivers in Bangladesh play an important role in transferring pollution generated in highly populated and industrialized areas of the country down to the sea. The worst of these are the Buriganga River and the Sitalakhya River (east of Dhaka) (SOE Bangladesh 2001). The Buriganga River appears to be polluted by tanneries operating in the Hazaribagh area and during the dry season can attain dissolved oxygen (DO) levels that are near-zero. The main sources of pollution in

the Sitalakhya River are a urea fertilizer factory, oil terminal and industrial units on its bank or nearby. This river, plus the Balu and Turag rivers (the latter also affected domestic wastes) all have been found to attain near-zero DO levels in some sections and times of the year (DOE in SOE Bangladesh 2001). The groundwaters in the country are also showing signs of pollution in the form of arsenic levels which exceed national guidelines in 6% of the wells across the country.

A5.2 India

The main issues in terms of land-based sources of pollution reported by India are domestic, industrial and agricultural wastes, with increasing urbanisation, siltation nutrient pollution, and pollution by POPs, (Sampath 2003). In India's SOE Report (SOE India 2001) hazardous and municipal solid wastes are identified as one of the five national environmental priorities.

Domestic pollution (sewage): Between 3.5 and 4.7 billion litres of sewage are produced per day, about 80% of which is collected through underground or open canal sewage systems. A small proportion of this is treated, but the rest is disposed of in its raw form either directly into coastal waters, or into rivers and estuaries (Sampath 2003). At an outfall in Chennai, on the coast of the Bay of Bengal, low levels of dissolved oxygen and high *E. coli* (faecal bacteria) counts have been found (2.8 million colonies[7]) (Sampath 2003). Zero dissolved oxygen values have been reported as far out to sea as 500m in coastal areas and in other water bodies (Sampath 2003).

Legislation and standards for the disposal of sewage exists, but the standards are rarely met, with few sewage treatment plants having been installed by municipalities. There is a general shortage of funds and preferential allocation to water supply and drainage. It has been difficult to obtain private sector involvement because of difficulties in collecting fees for the service. Sewage which finds its way into rivers is addressed under the National River Conservation Plan (NRCP). The Ganga Action Plan is already operational for treatment of waste arising from the river Ganga and its tributaries. The scheme has been partially successful and there is an expectation that it will be replicated for other rivers (46 towns, 18 rivers, 10 states). The aim of the programme is to improve the water quality of the rivers and reduce BOD levels to 3mg/l or less (Sampath 2003).

[7] Units were not given. Units for faecal coliforms, including *E. coli* are usually colonies per 100ml of water.

Solid wastes: The rate of generation of solid wastes in urban centres has outpaced population growth in recent years (SOE India 2001) and reliable estimates of the quantity of solid wastes generated in various cities and towns are not easily available (Vel 2003). It has been estimated that coastal populations generate about 0.5 kg/capita/day of solid wastes, summing to about 17 billion tonnes/day (Sampath 2003). It is expected that the per capita generation of municipal solid wastes will increase up to 945 gm per day by 2047 (Vel 2003). Sixty percent of the waste is collected by municipal authorities and corporations, with the remainder being thrown into uncontrolled landfills. In Mumbai the private sector has become involved in solid waste collection and disposal with encouraging results (Sampath 2003).

Industrial pollution: Industrial wastes account for 25% of wastewaters and over 50% of the pollution load from land-based sources (Sampath 2003), with the largest quantities of hazardous wastes being generated by the petrochemical, pharmaceutical, pesticides, paint & dyes, petroleum, fertilizer, asbestos, caustic soda, inorganic chemicals and general engineering industries (SOE India 2001). About 120 million tons of industrial solid wastes and 4.4 million tonnes of hazardous wastes are produced in the country each year (Vel 2003). The major industrial areas in the eastern states of India are located in Chennai, Calcutta, Cuddalore, Visakhapatnam and Paradeep. The most important industries from a pollution perspective include chemical, steel, textile and fertilizer plants, though pharmaceutical and automobile plants are also common. These probably generate around 2.62 million m^3 of effluent and 20 tonnes of solid wastes per day (Ramachandran 2001 in Sampath 2003). It is thought that the larger industries are treating their waste before discharging it, but there is no evidence given to support this view. Small and medium-sized industries are probably discharging their wastes into creeks and sewers, including sediments and heavy metals (Hg, Cd, Pb), which have in turn been found in the coastal sediments of Tamil Nadu and Andhra (Sampath 2003). Shipbreaking is associated with chronic problems with oil spills.

The primary causes of industrial pollution are seen as being related to outdated and inefficient technologies which generate large amount of waste; the presence of concentrations of large unplanned industrial conglomerations; the absence of appropriate zoning regulations; the presence of large number of small scale industries which escape land use and environmental regulations; a lack of resources for implementing pollution control programmes; poor enforcement of those pollution

control laws that exist; and uncontrolled storage and dumping of solid and hazardous wastes (Sampath 2003).

Nuclear power: Nuclear power is generated in plants located in the costal areas at Tarapur and Kalpakkam. So far, there have been no reported losses from these plants, and wastes are being handled according to international regulations (Sampath 2003). The only form of pollution currently being recorded in relation to nuclear power generation is of heated water. Up to 50% of the heat generated is released to the coastal marine environment, resulting in localized damage to organisms.

Agriculture & aquaculture: The main crops grown in India are rice, wheat and other cereals, consuming almost 80% of the water harvested from rivers and underground. According to Sampath (2003) nearly 75 kg of (N and P) fertilizers per hectare are used in the country (Planning Commission 1999 in Sampath 2003), and this figure is comparable to the 50 kg/ha national average given in WRI 2000-2001 (EVI Database). The rivers Hugli, Mahanadhi, Subernarekha, Krishna and Godavari delta have been associated with reports of eutrophication of coastal waters.

Most of the pesticides being used in the country belong to the phosphorous, carbonate and synthetic pyrethroid groups, with about 0.45 kg/ha/yr being applied (Note the EVI Database figure using WRI 2000-2001 data is an estimated 0.2 kg/ha/yr averaged over the entire land area). There is decreasing use of organochlorine pesticides in India, so that residues of DDT and other OCPs in coastal fishes is apparently low.

Mining: Approximately 200 tonnes of Uranium per year are mined in India (Annexe 1) and Zircon being mined along the Tamil Nadu and Orissa coasts. Neither of these forms of mining are currently seen as major issues of land-based sources of pollution in India.

Tourism: Tourism is seen as a relatively minor issue in terms of land-based pollution sources. Coastal tourism in India is popular only along a few stretches of the coast and is centred in Tamil Nadu. Most tourism along the coastline in Kanyakumari, Rameswaram, Chennai, Visakhapatnam, Puri and Dhiga is in the form of day tourists visiting beaches, and is associated with litter problems (Sampath 2003). There are currently no estimates of the total number of tourists visiting the country each year (Annexe 1) or the number of days stayed, so it is difficult to estimate the contribution of this sector to land-based pollution sources in the country.

Ports & coastal structures: There are 12 major ports and a large number of minor ports along the Indian coastline handling materials electronic goods to oil (Sampath 2003). The total volume of crude oil handled in 9 of the major ports during the 1996-97 was estimated to be around 51 million tonnes. This was associated with chronic oil pollution problems through operational discharge of waste (rather than accidental spills), mostly by medium and small ships where installation of oil-water separators is not mandatory (Sampath 2003).

Breakwaters, often part of port facilities result in erosion/accretion and sediment resuspension problems. These processes are significant along the east coast where littoral drift is very strong (Sampath 2003). Disruptions in longshore drift can also lead to secondary pollution problems when accretion closes off channels and reduces flushing of estuaries (e.g. Mahanadhi Estuary at Paradeep, Orissa Coast).

Siltation: The Hugli River transports around 20 million tonnes of sediments to the Bay of Bengal per year, with sediments distributing as far away as the Andaman Islands.

Nutrients: There has been an increase in both the frequency and persistence of algal blooms in coastal waters and enclosed sea areas over the past 20-30 years (Sampath 2003).

POPs: Persistent organic pollutants are not extensively used in India, though DDT does appear to be in use to control insect-borne epidemics (Sampath 2003).

Effects on environmental quality: The Central Pollution Control Board (CPCB) has monitored water quality of all the important rivers in India. For almost all of the rivers monitored, the total coliform counts are far above standards for drinking (0 / 100ml) or for bathing (<500 / 100ml) (Vel 2003).

A5.3 Indonesia

The main land-based sources of pollution reported by Indonesia for the Malacca Strait area (Sumatra provinces of Nanggroe Aceh Darussalam (NAD), North Sumatra, and Riau are most relevant) were accelerated run-off and sedimentation, oil pollution, sewage, pesticides and industrial pollution (Holmgren 1994, Purnomohadi 2003).

Domestic pollution (sewage): The east coast of Sumatra with a population of almost 11 million people (1994) probably loads the Malacca Straits with a BOD of 167,292 ton/y,

COD of 381,425 ton/y, total Nitrogen of 74,425 ton/y and total Phosphorus of 7,361 ton/y (Purnomohadi 2003 using estimates of Mahbub et al. 1990, assuming 60% of sewage reaches the Malacca Strait through rivers). There is a requirement for large cities in Indonesia to install wastewater treatment plants, but to date only Medan and Batam have done so in Sumatra. The sixth Five year Development Plan (1994 - 1999) proposes that most cities be provided with wastewater treatment facilities.

Solid wastes: Surveys carried out in various cities in Java indicate that 60 to 80% of solid waste is collected and either recycled or transported to dump sites or incinerators. Outside of Java presumably in the east Sumatra area, the management of solid wastes in cities is less controlled because of a lack of facilities and infrastructure (Purnomohadi 2003).

Industrial pollution: Industrial wastes have increased steadily and rapidly in the last 10-15 years. In 1987 Soegiarto (in Purnomohadi 2003) noted that industrial wastes in Indonesia were limited and localized, compared to other sources of pollutants. Many industries have recently developed in eastern Sumatra, mostly based on natural resources such as oil and natural gas, fertilizers, paper mill, palm oil, crumb rubber and other agroindustries. These result in the creation of a wide range of pollutants such as organic materials, heavy metals, nutrients, hydrocarbons, POPs, thermal pollution and sediments (Dahuri and Pahlevi 1994 in Purnomohadi 2003). Most of the industries are located in coastal areas or along major river systems, and although all industries are required to have wastewater treatment plants, most discharge their effluents directly to the receiving waters.

As a result of industrial discharge, many of the rivers in Sumatra are considered to be moderately to heavily polluted. High heavy metal (Cu, Hg, Ni, Zn and Pb) concentrations found in the sediments around the Pakning and Siak Rivers, Riau Province (Dahuri & Pahlevi 1994, Abdullah et al., 1994 in Purnomohadi 2003) probably arise from pulp and paper mills, palm oil mills and oil industries. The levels found in sediments exceeded national water quality standards by between 1 and 3 orders-of-magnitude for bathing, swimming and mariculture. Although this information presents a bleak picture of the environmental conditions in these areas, it is difficult to assess levels found in *sediments* against standards for *water* quality.

Oil pollution in the area is seen as largely a land-based problem, most common around densely populated areas such as large cities. The main activities leading to pollution are the use of petroleum fuels and lubricating oil for transportation and industrial activities, the direct discharge of municipal and industrial wastes containing refined and partly weathered oils through sewers and rivers, and the discharge of effluents generated during the production and processing of crude oil (i.e. at oil production platforms and refineries) (Purnomohadi 2003). The oil concentrations in the water column along the East Coast of Sumatra ranged up to 6,300 μg/l in 1979 (Soegiarto 1982, Dahuri and Pahlevi 1994 in Purnomohadi 2003). The levels recorded in the Siak River were 1,200-9,600 μg/l, which is higher than seen in Jakarta. Hydrocarbon pollution can end up on beaches as 'tar balls', with beaches considered to be 'polluted' when tar levels reach 10 g/m. At 100 g/m they are considered unusable (UNEP 1990 in Purnomohadi 2003). Between 1982-84, beach tar levels at sites in the Riau Archipelago were recorded at around 15.4 g/m strip, and were derived from weathered crude oils, including 20% from tanker oil sludge and 13% from fuel oil residues (Bilal 1990, Chua 1997 in Purnomohadi 2003). There is no later information on whether the levels of hydrocarbon pollution might be increasing.

Agriculture & aquaculture: The lowland areas of the east Coast of Sumatra are used extensively for agriculture, including plantations, to produce rice, rubber, palm oil and pineapple. North Sumatra and Riau Provinces have the largest areas of palm oil plantations in the country. The associated use of fertilizers, herbicides, pesticides, rodenticides and fungicides is thought to be increasing. In 1994 usage of these agrochemicals was around 3,780 tons of insecticides and 22 tons of herbicides used along the East Coast of Sumatra (Dahuri and Pahlevi 1994 in Purnomohadi 2003). There is little information on the management of agricultural wastes, how much of these chemicals find their way into the coastal waters of the east coast of Sumatra, or their impacts on the environment, but there is some information for a few of the rivers. In the Siak River, concentrations of between <0.03-0.71 μg/g of DDT, 0.03-11.17 μg/g of Endrin, 0.03-1.40 μg/g of Dieldrin; 0.04-8.17 μg/g of Aldrin, < 0.002-0.36 μg/g of Heptachlor, 0.09 and 3.15 μg/g of Endosulfan-I, and 0.02-2.14 μg/g of γ-HCH have been recorded. The levels of pesticide residues were higher in the sediments than in the water column (Hutagalung et al. 1996 in Purnomohadi 2003).

Brackish water pond culture of shrimps and milkfish and cut from mangrove forest dominates the aquaculture efforts in the provinces of Indonesia that border the Malacca

Straits. In 2000 the total area under brackish water shrimp production was more than 23,000ha (reduced from 46,400 in 1999), resulting in the production of more than 37,000 tonnes of shrimp (Directorate General of Aquaculture 2000 in Purnomohadi 2003). There is little information on the nature or spread of pollutants produced by aquaculture in the area. Mariculture of fishes (potential of 550ha), shellfish (17,000ha) and seaweeds (1,700ha) are currently being developed in the Riau Archipelago, in particular around Batam and Bintan Islands.

Mining: Tin, bauxite, urea, kaolinite, granite and sand are the primary mining industries in the East Sumatra provinces (Table 16). In 1989 the production of tin from the Riau Archipelago was 3,109 tons, with an estimated reserve of between 1.64 and 3.48 million tonnes onshore and offshore in the Malacca straits (Sujitno 1974, Harris 1978 & MacDonald 1981 in Purnomohadi 2003). Bauxite production, mainly at Bintan Island totalled 1.2-1.32 million tons in 1981-1993 (Burbridge et al. 1988 and Statistical Office of Riau Province 1995 in Purnomohadi 2003).

The pollution associated with mining varies according to the resource being mined, methods of producing ores, refining, stockpiling, handling wastes and transporting. Granite and sand are relatively benign polluters on a small scale, though can be associated with increases in run-off, sedimentation and turbidity at larger scales. In Riau, there are now 140 companies sand mining, only 2 of which have carried out any kind of impact assessments (Purnomohadi 2003), and possibly none of which have an environmental management plan in place. Kaolinite is a clay mineral and although not toxic, can lead to widespread increases in turbidity if it escapes to water. Urea, bauxite and tin are associated with toxic pollution, but little information is available on how these are being handled in Riau.

Table 16: Latest available production figures for main types of mining in East Sumatra / Malacca Straits area, Indonesia.
Data are from sources in Purnomohadi (2003).

Resource	Production (latest) (tons)	Year	Known reserves (tons)
Tin	3,109.50	1989	1.64-3.48 million
Bauxite	1.32 million	1993	
Urea	1.6 million	1983	
Kaolin	161,478 m^3	1980	
Granite	2.68 million	1993	
Sand	1.45 million (Riau)	1993	

Tourism: Medan, Batam and Bintan are the most important tourist destinations in the Malacca Straits area. Medan had 264,515 international and 1.2 million domestic visitors in 1994, which represented a 3-fold increase over the decade (1984-1994). By 1994, Medan also had 17,430 rooms and 133 hotels. Bantam and Bintan Islands are located in a growth triangle and each now receive more tourists per year than Medan. The international tourists in the area could now be over 1 million per year, a large proportion of the 4.9 million average for the country (1996-2000) recorded by WRI (EVI Database). This represents a significant effective increase in the resident human population of the East Sumatra area (around 11 million in 1994), with associated demands on infrastructure and effects on pollution levels.

A5.4 Malaysia

The parts of Malaysia relevant to this discussion are the littoral states of the West Coast of the Peninsular fringing the Straits of Malacca. This includes the states of Perlis, Kedah, Penang, Perak, Selangor, Negeri Sembilan, Malacca and West Johore. The main land-based sources of pollution that affect the BOBLME area are from domestic sources, urbanisation, and industrial processing leading to problems with sediment run-off, wastes and heavy metals (Omar 2003). There are also indirect effects on the pollution of water from haze, which converts to acid rain. In 1993, the organic pollution load from domestic sewage accounted for 67%, agriculture and industrial waste 22%, manufacturing 7% and agroindustries 2.7% of the total pollution load found in rivers (WQI 2001 in Omar 2003).

Domestic pollution: One of the main causes of water pollution to the Malacca Straits area of Malaysia is from land-based sources is seen as the rapid urbanisation of the west coast of the Malay Peninsula, together with and the location of the three largest cities in that part of the country. The west coast has 59% of the country's population and only 20% of its area, so population densities are relatively high at over 370 people/km^2 (the national average is 67.7 people/km^2, EVI Database). Wastewater is collected by a system of sanitary sewers and treated at municipal plants, but adequate systems for treatment and disposal of sewage are generally lacking and sewage is mostly discharged directly into rivers or the sea (Keizrul & Muhamed 1998 in Omar 2003). According to the DOE (1994 in Omar 2003) the organic pollution load discharged to the environment as sewage almost doubled between 1989 and 1993, and accounted for 67% of the total in 1993. As a percentage, this had actually declined from 1989, indicating increasing contributions by other sectors (agroindustries, manufacturing and agriculture).

Industrial pollution: A total of 80% of the industrial water discharged in Malaysia comes from food and beverage processing, chemical plants, rubber manufacturing and textile & leather products. In turn 79% of the country's industries are located in the states adjacent to the Malacca straits (DOE 1994 in Omar 2003). Rivers in the highly industrialized states of Penang, Perak, Selangor, Malacca and West Johore appear to be the most affected by these wastes (Omar 2003).

Agriculture & aquaculture: The main contribution to land-based pollution by agriculture is seen as arising from livestock wastes, pesticides and fertilizers. Approximately 45.5 million tonnes of pesticides (1996) and 1.2 million tonnes of fertilizers (1995-7) were being throughout the country in the mid-to-late 90's (EVI Database). There is no information of how much of this finds its way into the waters of the Malacca Straits. Coastal aquaculture activities centred on fishes and shellfish are located mainly in sheltered coastal waters of the Straits of Malacca and may be adversely affected by agricultural pollution and heavy metals. There have been incidents of food poisoning associated with cultured mussels and cockles, though there is not much information on the pathways through which this might be occurring (Omar 2003).

Little is known about the quantitative contributions of aquaculture to the pollution load of the coastal and marine areas of the Malacca Straits. Semi-intensive and intensive culture of finfish (groupers, sea bass, snappers) and prawns has often been associated with eutrophication of coastal waters and the spread of disease. The problem is seen as resulting from poor management of aquaculture effluents (Omar 2003). Given that aquaculture is seen as an important area for development and that an estimated 491,559 hectares of land and water bodies are suitable for aquaculture (Lim and Chuah 2003 in Omar 2003), information on the potential for pollution is urgently needed.

Mining: Alluvial tin and sand are mined in the Malacca Straits area and are associated with land degradation, silted waterways and landslips. There is, however, little information on the contribution of mining as a source of pollution.

Siltation: Urbanization, deforestation and industrial site developments have resulted in the high sedimentation of rivers in the western states of the Malay Peninsula. There are presumed to be resulting heavy loads of sedimentation emptying into the rivers, but sediment are not specifically identified in the DOE River pollution studies (see 2.4.4.6).

Effects on environmental quality: Under a previous Malaysian Water Quality Programme carried out by the Department of Environment up until 1994, pollution levels in rivers were monitored to determine their pollution loads from municipal, industrial and agricultural wastes. Monitoring of biological and chemical characteristics of the water was carried out at 892 stations in 116 rivers throughout the country. The results were compared against national water quality standards (Omar 2003). By 1994 14% of the rivers were considered 'polluted' and 55% 'slightly polluted' using an overall measure of quality, the Water Quality Index (WQI) (DOE Malaysia 1994 in Omar 2003). The main pollutants detected were suspended solids and ammoniacal nitrogen (NH_3-N). The results also showed a deterioration in water quality over the period since 1988. In the period 1995-2000 this role was taken over by a private company, and results do not seem to be available. In 2000 DOE resumed data collection, but altered the format from river to basin-based reporting, reducing the ability to make comparisons over time. In the new dataset, 931 sites were monitored in 120 river basins, with 53% found to be 'clean', 33% 'slightly polluted' and 15% 'polluted' on the WQI scale (Omar 2003). Although sites may not be directly comparable, the broad picture this gives is one of a general improvement in water quality of Malaysian rivers. The improvements were attributed to a slowdown of economic activities after the Asian Financial Crisis, relocation of pig farms away from rivers and a general improvement in public environmental awareness.

A5.5 Maldives

The main land-based sources of pollution reported by the Maldives were solid and liquid domestic wastes, urbanisation, tourism and some effects of sand and coral mining (Ali 2003). With space being extremely limited, industries few, tourism very important and rivers absent, the issues of land-based sources of pollution are markedly different in the Maldives than all others in the BOBLME region. The Maldives has had the fastest human population growth rate in the region over the past decades (3.8% through 80s and 90s, dropping to 1.9% in 2000). Growth of the economy was also rapid through this period at about 10-15% per annum. There is little information on the contribution of industry to land-based sources of pollution in the Maldives.

Domestic pollution: Sewage and other nutrient discharges are reported to be affecting the reef and the water quality on many islands. Tourist facilities are required to dispose of sewage outside the reef in the open sea, with only some of them able to provide

primary treatment before disposal (Ali 2003). Traditional sewage systems on many islands are being replaced by piped discharges to dispose of the waste out to sea. These may be effective where a fast-flowing reef channel is utilised, but financial and technological constraints often limit the efficiency and safety of such developments (Ali 2003).

The quantity and nature of solid waste generated In the Maldives has changed rapidly and expanded from largely decomposable household wastes to non-degradable materials such as plastics, cans, bottles, and more hazardous forms such as batteries and medical wastes (Ali 2003). All of the islands have a problem with space for the disposal of solid wastes, so that in Male an off-shore landfill was developed, while in some of the other islands, waste is disposed of in confined areas on the reef flat. These methods of disposal are augmented by a requirement that all tourist facilities install incinerators and compactors to help reduce the waste load. The impacts of dumping wastes, particularly hazardous ones, in the coastal environment are not known, though problems with heavy metals are expected (Ali 2003).

Urbanisation, Ports and Harbours: Harbours have been developed on 83 of the 200 inhabited island and are associated with secondary pollution effects from siltation, stagnation and poor flushing of wastes they receive.

Agriculture & aquaculture: Seaweed culture has been tried in the Maldives, but despite the favourable environment and several attempts, little success has been made so far (Ali 2003). Generally, this kind of extensive culture is associated with little pollution.

Mining: Coral and sand mining in the Maldives dates as far back as 500B.C (Ali 1991 in Ali 2003) and became popular for building materials for at least 300 years. With the development of tourism in the early 1970's a construction boom set in, and corals and sand were used for resorts, public buildings, private housing, land reclamation, jetties, groynes, airports and road construction. Through government intervention and increasing popularity of hollow cement blocks for building, coral mining was reduced, by the late 1990's, to non-significance (Waheed et al. 2003, Ali 2003). In contrast, the demand for sand has continued to increase. The pollution effects of harvesting and transporting such large quantities of coral and sand for such a long period are unknown, but assumed to be very limited, thanks to the methods used (Ali 2003).

Tourism: Fisheries used to be the dominant sector of the economy until 1985, when tourism industry overtook fisheries in terms of its contribution to GDP.

Siltation:
The reef flats in the Maldives are dredged and reclaimed for urban and port developments, mostly using backhoe excavators. These result in siltation on the adjacent reefs, but effects are seen as short-term with variable levels of recovery (Ali 2003).

A5.6 Myanmar

The Myanmar coastal zone is divided into three areas from north to south, the Rakhine Coast, the Ayeyawady (Irrawaddy) Delta and the Tanintharyi Coast. Many rivers flow into the coastal areas through each state, including the Mayu and Kaladan rivers in the Rakhine area, Ayeyarwady, Sittaung and Thanlwin rivers in Delta area and the Ye, Tanintharyi and Dawei rivers in the Tanintharyi coastal area. Most municipalities, industries and agriculture discharge waste into these and other nearby rivers without treatment, but not directly into the sea. There is little information on domestic and industrial pollution and its effects in the country, and little information on the condition of near-shore waters.

Agriculture & aquaculture: A total of 220,000 tons of fertilizers and 520 tonnes of pesticides were used in the coastal states of Myanmar in the 1996-97 period (Myint 2003), particularly in areas where rice is commercially grown (Ayeyarwady, Yangon and Mon areas). The figure for pesticides differs markedly from that given by WRI, where more than 162,000 tonnes of pesticides are used per year nationally (EVI Database). Use of agrochemicals is minimal in the Rakhine and Tanintharyi areas and appears to be mostly an issue through the Ayeyawady Delta area. The most common fertilizers currently used in the coastal states are Urea (53,000 tons), Triple Super Phosphate (15,000 tons), Muriate of Potash (6,700 tons) and a small amount of compound fertilizers (8,500 tons). About 2,800 million tonnes of gypsum is also used in Mon State. In terms of pesticides, the highest usages were recorded in Mon State (45,000 litres of liquid and 13,033 kg of powder), Ayeyarwady coastal zone (12,555 litres/5,226 kg) and in the Yangon Division (350,000 litres/92,100 kg) in the year 1996-97. Tanintharyi utilized the least amount during that same period of 2,200 litres and about 600 kg of pesticides.

Inland aquaculture was initiated by the Department of Fisheries in the 1950s with the introduction of *Tilapia*, carp, and other freshwater fish. Despite promising potential, there were only about 3,000 ha of fish ponds established by 1989. In contrast, coastal aquaculture is growing rapidly and is seen as a major source of pollution to the coastal and marine environments. There may be anywhere between 27,306-49,000 ha of shrimp ponds (largely placed in concerted mangrove areas) currently operating in the country (Myint 2003). Cage culture of grouper and sea-bass were initiated in 1999-2000, with encouraging results, but has not yet become an established industry. There is no information on the nature and extent of pollution arising from these activities, though problems with nutrients, organic and sediment loads, anoxic conditions and algal blooms are among the effects expected.

Tourism: Tourism is one of the fastest growing sectors in the country, but is still at an early stage in comparison with neighbouring countries. In the period 1980-2000 the number of tourist arrivals in the country increased 10-fold to over ¼ million tourists per year (Immigration & National registration Department in Myint 2003).

Effects on environmental quality: Very few studies have been carried out on the levels of pollution in the rivers of Myanmar (Myint et al.1994 in Myint 2003), despite the recognition that dumping of all kinds of wastes into rivers is almost customary.

A5.7 Sri Lanka

Coastal waters in Sri Lanka are polluted due to release of untreated or partially treated solid wastes and effluents from industries, tourist resorts and aquaculture, sewage and agriculture (Joseph 2003). These pollutants are often released into rivers and from there find their way to the sea.

Domestic pollution: Sewage pollution is a major problem in some of Sri Lanka's coastal waters due to the direct discharge of untreated municipal sewage onto land and groundwaters and to waterways. Colombo is one of the few cities in Sri Lanka with a sewerage system (100 years old, inadequate and in need of repair). There is a growing urban population in coastal areas. In 2001 the Colombo Municipal Council Area had a population of 642,163 (Mubarak 2000 in Joseph 2003). Even back in 1992 only 19% of the population of the city was served by sewers and 59% had on-site facilities. Twenty-two percent of the population had little or nothing by way of sewage disposal systems,

resulting in the release of 138 t/day of raw sewage into the city's waterways (Joseph 2003).

About 2,694 t of solid waste is collected daily in the country, with most of it coming from coastal towns. Though the issue is more prevalent in urban areas, it is rapidly also becoming a problem in rural areas, with local authorities finding it difficult to find suitable sites for safe disposal. There is little or no infrastructure for collection and disposal, and waste is often disposed of at open dumps, sometimes in low-lying marshy lands within the coastal region. There is also the problem of garbage littering beaches near squatter settlements and tourist resorts, and indiscriminate solid waste dumping within the shore area.

Industrial pollution: About two-thirds of Sri Lanka's industrial plants are located within the coastal region, primarily in the Greater Colombo Metropolitan Area (Jayakody & Maldeniya 2003). Industrial effluents that have undergone little or no treatment are frequently discharged into near shore waters, lagoons, estuaries and rivers and can be mobilised further through run-off, seepage and floods. Most of the industries located in the coastal areas of Sri Lanka are considered either medium or low polluting. In 1994 Sri Lanka had 336 industries with a high or medium pollution potential in the Coastal Zone (Mubarak, 2000 in Joseph 2003), with those contributing most to water pollution being textiles, paper, tanning, metal finishing and engineering, paints, chemicals, cement, food and beverages and distilleries. Small Industries that deal with coconut fibre retting also have highly localized impacts on water pollution as they result in high BOD and COD values. There are 2 Export Processing Zones (of 9 in the country) and 9 Industrial Park (of 30 in the country) located in the coastal region (Ministry of Enterprise Development in Joseph 2003).

Agriculture & aquaculture: Pesticide, nutrients and the pollution of ground water are the major issues related to agriculture. The use of fertilizers in Sri Lanka has increased from 20,000 t of NPK during 1950-51 to 525,651 t in 1995 (compared this with results published by WRI of only 209,568 in 1995-7, EVI Database), and 612,000 t in 1999. The annual average use of fertilizer in Sri Lanka is estimated to be 77 kg/ha, about 2-8 times higher than in other Asian countries (MOENR 2002, Central Bank 2000 in Joseph 2003). Over 11 million tonnes of pesticides were used in 1996, at a national average loading of 183 kg/km^2/y, the highest average loading among the BOBLME countries

(Annexe 1, EVI Database). Some of the chemicals used for pesticides, including herbicides and fungicides, are POPs.

Much of the coastal pollution in the North Western Province has been attributed to *ad hoc* development of aquaculture leading to the discharge of high amounts of effluents from shrimp ponds. High levels of nitrates and phosphates released from shrimp farms into the coastal waters have caused eutrophication of nearby watercourses in the region and pollution of ground water. Shrimp farm effluents reaching the Dutch Canal are high in total suspended solids (200-600 mg/l) and have high BOD levels (60-180 mg/l). These effluents cause heavy siltation in the canal increasing turbidity. High sulphides and ammonia levels in these waters are also attributed to shrimp farm effluents (Corea et al 1995 in Joseph 2003).

Mining: The main forms of mining are of fossil and living corals, and beach and river sand. Although these have significant effects on critical habitats and erosion, they are seen as of relatively less significance in terms of pollution. It is likely that river sand mining would have impacts on the turbidity and sedimentation of river waters entering the coastal zone. Coral mining probably also has effects on resuspension of sediments in the coastal waters when off-shore coastal protection has been diminished.

Tourism: About 70% of tourist hotels are located within the coastal region of Sri Lanka. Pollution of waters and beaches has been noted most major tourist centres along the south and southwest coasts of the country, particularly in relation to larger hotels and the associated formation of squatter settlements.

Effects on environmental quality: Over 100 rivers radiate to the sea through the Coastal Zone in Sri Lanka (Jayakody & Maldeniya 2003). High pollution loads have been reported in inland rivers and in estuaries which have been connected to domestic, agriculture and industrial wastes (Joseph 1999 in Joseph 2003) and have lead to fish kills in the highly polluted lagoons and estuaries. High BODs and levels of ammonia, nitrates, coliforms, suspended solids and phosphates have been found. He also reported increasing eutrophication of lakes (such as Kandy and Gregory Lakes), irrigation reservoirs and channels resulting from the excessive usage of fertilizers. A similar pattern is emerging for groundwaters. Cultivated areas of the Kalpitiya and Jaffna peninsulas, have groundwaters with high nitrates and chloride concentrations (Manchanayake & Bandara 1999, Mubarak 2000 in Joseph 2003). The National

Aquatic Resources Research and Development Agency found that the Wellawatta canal in Colombo acts as a conduit for the discharge of 9000 plastic and polythene items daily to the adjacent coastal waters. These are thought to be reducing the effective area of the adjacent prawn bed (Jayakody & Maldeniya 2003).

Sedimentation is leading to the degradation of Lankan lagoons, with several estuaries and lagoons having decreased in size. Between 1956 and 1981 the area of Negombo Lagoon decreased by 791 ha (Jayakody & Maldeniya 2003).

A5.8 Thailand

Land-based sources of pollution contributed directly to the BOBLME area by Thailand is limited to the southern peninsular part of the country, between Myanmar and Malaysia, and which borders the Andaman Sea with about 740 km of coastline. This covers six provinces, Ranong in the north, through Phangnga, Phuket, Krabi and Trang, and Satun in the south (Juntarashote 2003). In the past half century, the provinces along the Andaman Sea coast have rapidly developed in agriculture, industry, tourism and other service sectors. Little information is available on the status of most of the pollution sources in the country. Though it is acknowledged that they are probably resulting in negative environmental impacts, sea water quality in the Andaman Sea area is still considered good.

Agriculture & aquaculture: Intensive shrimp farming is practiced around the Andaman Sea coast. These farms are high-yielding, using chemicals for growth rate acceleration and disease protection. Wastewaters are discharged directly into the coastal areas (Juntarashote 2003).

Mining: Marine tin mining is not currently active on the Andaman coast, but is expected to lead to widespread effects on coastal and marine environments through siltation should it resume.

Effects on environmental quality: It is thought that seawater quality is still good in the Andaman Sea area, but that some estuaries are showing signs of pollution (Juntarashote 2003). The northern coastal waters of the Andaman Sea area from Ranong to Phuket are influenced by deep sea upwelling, have high salinity and low productivity (Limpsaichol et al. 1987 in Juntarashote 2003). In contrast, the waters in the southern part from Phuket to Satun appear to be more influenced by surface run-off, have lower salinity, higher total suspended solids, and higher nitrate, phosphate and productivity

values (Wium-Andersen 1977 and Limpsaichol et al. 1987 in Juntarashote 2003). The Pollution Control Division found that the heavy metal content and total bacteria count generally met the national standard for sea water quality in the Andaman Sea between May 2002 and March 2003, but that the total coliform bacteria counts exceeded the standard in tourist areas (PCD 2003 in Juntarashote 2003). This study did not however provide any insights into other indicators of water quality, most of which would be more likely to have widespread ecosystem consequences.