COASTAL EROSION MANAGEMENT IN MALAYSIA

IR. OOI CHOON ANN

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IR. OOI CHOON ANN
Director of Coastal Engineering Division
Department of Irrigation and Drainage
Jalan Sultan Salahuddin, 50626 Kuala Lumpur
Malaysia

Abstract. The coastal zone of Malaysia has special socio-economic significance. It supports a large percentage of the population (about 70%) and it is also the centre of economic activities encompassing urbanisation, agriculture, fisheries, aquaculture, oil and gas exploitation, transportation and communication, recreation, etc. In response to the increasingly serious problem of coastal erosion in many parts of the country that threatens the livelihood and property of the coastal communities of Malaysia, the Government of Malaysia commissioned the National Coastal Erosion Study (NCES) in 1984. The study which was completed in 1986 revealed that of the 4,809 km of shoreline in Malaysia, about 1,390 km (29%) were subjected to erosion of varying degrees of severity. Based on the consideration of the rate and imminence of erosion and the economic values of the human activities threatened, coastal erosion sites have been classified into the following three groups as follows: (a) Category 1 - Critical: Areas suffering from coastal erosion where shore-based facilities are in imminent danger of loss or damage; (b) Category 2 - Significant: Areas where shore-based facilities are expected to be endangered within five to 10 years if no remedial action is taken; and (c) Category 3 - Acceptable: Erosion areas that are generally undeveloped with consequent minor economic loss if erosion continues unabated. In cognizance of the consequences of coastal erosion which has become an important economic and social issue, the Government of Malaysia has since 1987 adopted a two-pronged strategy (short term and long term) for the control of coastal erosion as recommended by the NCES. The main objective of the short term strategy which is construction focused and reactive in nature is to protect existing facilities and properties in the Category 1 or Critical Erosion Areas subjected to the test of economic viability. The long term strategy, on the other hand, is management focused and aims to obviate the need for expensive protective works in the future. This is achieved by according due consideration to the consequences of coastal erosion in the planning and development of projects within the coastal zone through an integrated and coordinated development strategy and plans. This paper describes the coastal erosion problem in Malaysia and highlights the short and long term approaches that are being adopted for its management and control.

Introduction

Malaysia is situated between latitudes 1° and 7° north and longitudes 107° and 119° east. It comprises two regions, Peninsular Malaysia and the States of Sabah and Sarawak (collectively referred to as East Malaysia) on the northern part of the Borneo Island, which

are separated by 640 km of South China Sea. The total land area is 330,400km^2 while the shoreline totals approximately 4,809 km.

Peninsular Malaysia abuts the South China Sea on the east and fringes the Straits of Malacca on the west. The South China Sea is the largest expanse of water incident on the Malaysian Coast, including East Malaysia, while the Straits of Malacca is a narrow waterway separating the peninsular from the island of Sumatra, Indonesia.

Geographically, the South China Sea allows an unobstructed passage for over-water wind movement with a fetch length ranging from 360 km on the north to 1,250 km towards the south to act directly on the eastern shoreline of Peninsular Malaysia. On the other hand, the average fetch length over the Straits of Malacca is only about 130 km.

The coastal zone of Malaysia has a special socio-economic significance. It supports a large percentage of the population (about 70%) and it is also the centre of economic activities encompassing urbanisation, agriculture, fisheries, aquaculture, oil and gas exploitation, transportation and communication, recreation, etc. In response to the increasingly serious problem of coastal erosion in many parts of the country that threatens the livelihood and property of the coastal communities of Malaysia, the Government of Malaysia commissioned the National Coastal Erosion Study (NCES) in 1984. The study which was completed in 1986 revealed that of the 4,809 km of shoreline in Malaysia, about 1,390 km (29%) were subjected to erosion of varying degrees of severity. Based on the consideration of the rate and imminence of erosion and the economic values of the human activities threatened, coastal erosion sites have been classified into the following three groups as follows:

a) *Category 1 - Critical*
   Areas suffering from coastal erosion where shore-based facilities are in imminent danger of loss or damage;
b) *Category 2 - Significant*
   Areas where shore-based facilities are expected to be endangered within 5 to 10 years if no remedial action is taken; and
c) *Category 3 - Acceptable*
   Erosion areas that are generally undeveloped with consequent minor economic loss if erosion continues unabated.

The distribution of erosion areas (incorporating the latest updating in 1996) is given in Table 1 while the locations of critical erosion sites are shown in Figures 1a and 1b.

The economic and social consequences of coastal erosion and the concern generated have increased rapidly as the use of coastal lands intensifies. Of the critically eroding sites, agriculture features by far as the most dominant human activity, followed by housing, transportation and recreation. This is because the majority of the land use in the coastal area is agriculture-related.

Most of the agriculture land along the west coast of Peninsular Malaysia is seriously threatened. Bunds which exclude sea-water ingress have been breached by wave attack. The tidal flooding that follows bund breach can penetrate as far as two kilometres inland damaging crops such as coconut, cocoa, oil palm and paddy and reducing the soil fertility for future crops thereby affecting production and income.

In some areas, residential and commercial housing have been or soon will be damaged or destroyed by coastal erosion. Such endangered facilities include both permanent and temporary housing, international class hotels, private houses, schools and other public establishments. These structures were initially sited behind sandy beaches or tidal mud-flats which provided protection from incoming waves. As the fronting beach or mud-flat receded,

water depth in front of these structures became deeper, thus allowing bigger waves to break directly on the beach scarp and accelerating erosion. Structure foundations were undermined leading to collapse of the structures.

In other areas, coastal erosion has damaged coastal roads resulting in delayed or interrupted travel and serious inconvenience. In extreme cases, land communication link is severed and traffic has to be rerouted to an alternative road while the severed road has to be relocated further inland.

Erosion has destroyed some beaches and has drastically reduced the usable area of many others. Though presently, some of these beaches may only be lightly used, the demand for recreational facilities is projected to increase. When recreational beaches on which resorts and tourist centres depend on are destroyed, less people will visit the beaches resulting in a decline of occupancy rate and dwindling of related spin-off business activities. Hence coastal erosion can start off a snowballing effect leading to a downturn in the tourism industry.

Causes of erosion

The shoreline is the interface between land and sea. This is, however, not a fixed or stationary line since it is affected by the tide and wave regimes which vary with time. A natural shoreline can therefore accrete or erode depending on the prevailing forces of nature and coastal processes. A stable coastline is one where its mean position remains unchanged over a period of time. This is also described as in a state of equilibrium.

As pointed out in the NCES, a major cause of coastal erosion is due to development activities on the coastline or coastal zone that are not properly planned or sited. Typical examples are:

a) Interruption of longshore sediment transport by engineering works such as land reclamation, dredging of navigational channels and construction of port and harbours, groynes, breakwaters, jetties etc.;
b) Removal of natural vegetation such as mangroves resulting in the loss of a natural media to dissipate the wave energy;
c) Reduction of sediment supply to the coast caused by engineering works in rivers such as dams, barrages, sand mining from river bed etc.; and
d) Unregulated or uncontrolled dredging and sand mining activities in near shore areas.

Coastal erosion control strategy

In cognizance of the consequences of coastal erosion which has become an important economic and social issue, the Government of Malaysia has since 1987 adopted a two-pronged strategy (short term and long term) for the control of coastal erosion as recommended by the NCES. The main objective of the short term strategy which is construction focused and reactive in nature is to protect existing facilities and properties in the Category 1 or Critical Erosion Areas subjected to the test of economic viability. The long term strategy, on the other hand, is management focused and aims to obviate the need for expensive protective works in the future. This is achieved by according due consideration to the consequences of coastal erosion in the planning and development of projects within the coastal zone through an integrated and coordinated development strategy and plan. The short-term plan hence requires structural solutions such as the construction of sea-walls, revetments, breakwaters, sand nourishment etc., whilst the long-term plan aims to control

coastal erosion and its negative impact through instituting non-structural measures such as land use planning and control.

At present there are altogether 72 critical erosion areas with a total length of 226 km. The length of individual areas ranges from 200 m up to 3,500 m. The number, extent and type of coastal protection works are determined by site-specific detailed analysis. A budget of RM400 million has been allocated for the implementation of coastal protection works in these areas. Implementation of the coastal protection works are carried out in stages based on priority in order to maximise the benefits from limited financial resources. To date, construction works for 26 sites have been completed while 15 are in various stages of construction. Works for the remaining critical erosion areas are expected to be completed by the end of the Seventh Malaysia Plan (Year 2000).

In addition, in the critical erosion areas, plans for further development are coordinated and reviewed to ensure that the proposed development are compatible with the prevailing natural coastal processes. This is to ensure that the new development or facilities will neither be subjected to the hazard of coastal erosion nor adversely impact existing facilities through interference with the natural coastal processes.

There are currently 65 areas with a total length of 228 km in the significant erosion category. Although important economic and social activities are carried out in these areas, such activities are presently not threatened by coastal erosion but may be so within the next five to ten years. The coastal erosion control plan for these areas will be confined to periodic review of the erosion problem, and updating of the status of erosion for reclassification purposes as it is not economically feasible as yet to build any protective works. These reviews will be at three to five years' interval and consist primarily of reconnaissance surveys. The plan also requires development of non-structural measures to ensure proper consideration of the causes and consequences of erosion for any new facilities to be added to these areas. The objective of this element of the plan is to limit the need for protective structures for any new facilities.

A total of 77 areas are in the acceptable erosion category. Erosion in these areas which aggregate more than 940 km in length has no serious consequences because the areas are generally undeveloped. If future developments in these areas properly anticipate the consequences of erosion, no protective works should be needed in the near future. The coastal erosion plan required for these areas are mostly non-structural measures. It can be achieved by instilling in developers the need both to understand the causes and consequences of erosion and to ensure that the planned facilities are compatible with these causes and consequences. In this respect the plan also aims to preclude the need for protective works and prevent improper interference with the natural coastal processes.

Institutional arrangements

Following the completion and recommendation of the NCES, the Government acted promptly in 1987 to create and develop suitable institutions to oversee, to coordinate and to implement the strategies and proposals under the coastal erosion control masterplan. This included the establishment of the National Coastal Erosion Control Council (NCECC) and the Coastal Engineering Technical Centre (CETC) in DID.

The NCECC was formed in 1987 as a policy formulation body to plan and coordinate the coastal erosion control programme involving the Federal and State Governments, and the private sector. The responsibilities of the Council are as follows:

a) Prepare national guidelines on the preparation of a coastal erosion control programme;

b) Prepare national guidelines on the distribution of financial responsibility for the coastal erosion control programme;
c) Determine general procedures and coordinate development in the coastal zone with the aim of reducing the need of constructing coastal erosion control structures in the future;
d) Determine standards for the design and implementation of coastal erosion control structures based on technical and economic factors;
e) Prepare the necessary legislation for effective management and development of the Coastal Zone; and
f) Formulate and establish the necessary coastal erosion control institutions.

The membership of this Council comprises representatives from the Implementation Coordination Unit (ICU), the Economic Planning Unit, Ministry of Finance, Ministry of Science, Technology and the Environment, Ministry of Agriculture, the Public Works Department, Town and Country Planning Department, Department of Irrigation and Drainage, Sabah State Government, Sarawak State Government, representatives from two State Governments in Peninsular Malaysia (two years' term on a rotation basis), and Professional Institutions and Universities. The Director General of ICU is the Chairman of the Council.

The Department of Irrigation and Drainage was given the responsibility of setting up the CETC which is presently also known as the Coastal Engineering Division (CED) of DID. The CED is responsible for the following:

a) To implement coastal erosion control works for critical erosion areas. This includes planning, feasibility studies, detailed design, construction supervision and monitoring the performance of completed works.
b) To provide technical support to the NCECC.
c) To provide technical advisory services to other government departments and agencies in the processing of development applications in the coastal zone.
d) To maintain a coastal engineering database to support the planning and design of coastal engineering works in the country.

Legislative measures

The existing legislation is sufficient to control the problem of coastal erosion in the long term. The Environmental Quality Act, 1974 - Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 requires all developers who propose to initiate any of the prescribed activities listed under the Schedule of the Act to carry out an environmental impact assessment (EIA) study. The Schedule covers not only activities in the coastal zone but also includes any upstream development that exerts an influence on the coastal environment and coastal morphology. For smaller scale coastal development that does not fall within the ambit of the above legislation, the Government has issued an Administrative Circular No. 5/1987, which requires all development plans within the coastal zone to be referred to the CED of DID for technical comment and advise. With the concurrent and complementary implementation of the two mechanisms cited above, the need for *ad hoc* coastal erosion protection will hopefully be obviated in the future.

Guidelines for development

As a tool for coastal erosion management, the CED has developed guidelines on erosion control for development projects in the coastal zone. Development projects in the coastal

zone are classfied broadly into four categories namely, shore front development, back shore development, land reclamation and sand mining and river mouth dredging. The overriding principle in these guidelines is that there should be minimal or no disturbance to the existing coastal processes. Where the proposed development eg. land reclamation can interfere with the equilibrium of coastal processes resulting in coastal erosion/siltation problems, damage to marine eco-systems and water pollution, a proper impact evaluation study using appropriate technology commensurate with the nature and scale of the development project will be required. Some of the general guidelines formulated so far are as follows:

i) Muddy coasts

A setback of 400 metres measured form the seaward edge of mangrove vegetation/forest should be left as a buffer zone. However, no development should be allowed in areas where mangrove vegetation/forest have been gazetted as permanent forest reserve under the National Forestry Act 1984.

ii) Sandy coasts

Structures in sandy coastal areas should have a setback of at least 60 m from the Mean High Water Line. This is to take into account the seasonal changes in the coastline. Sand dunes that act as reservoirs of beach sand usually occur within this 60 m belt and this will prevent damage of the dunes as well. Development should not be encouraged on sand spit as this is also a dynamic area and experiences have shown that these areas have a high potential for erosion.

The above setback limits are not entirely dependent on the current stability of the coastline or classification. They are considered as good management or engineering practices for shoreline development in recognition of the dynamic nature of coastal processes and the potential risk of shoreline erosion which requires substantial funds for their redress.

iii) Sand mining

Extraction of sand along the coast can result in erosion. Sand that is in the dynamic near shore zone should not be extracted as this sand plays an important role in the sediment budget of the area. Reduction of sand in this area can cause erosion along the coast. As a general rule, sand mining is not permitted in near shore areas which are less than 1.5 km from the Mean Low Water Line or has a water depth of less than 10 m (from the Lowest Astronomical Tide) whichever is further from the shore.

Data collection

Reliable field data concerning the coastal environment are necessary for designing mitigation measures against coastal erosion. These data need to be made available prior to the commencement of planning and design. As is usually the case in most countries, relevant coastal and shoreline data in Malaysia are currently collected by many government departments, agencies, private sector organisations, university scientists and consultants. Moreover, except for tidal elevation and shore-based wind data, data on other important parameters such as waves and currents are hardly collected and if they are, the collection programme is tailored to a specific site and of short duration.

To coordinate coastal and shoreline data collection activities and to ensure that duplication of efforts was avoided between agencies, the NCECC authorised the establishment of the Coastal Engineering Data Collection Committee in August 1989. The committee which is made up of all institutions that are involved in collecting data useful for coastal engineering is headed by CED. Towards this end, the CED currently plays the role of

a national data bank of coastal information that is entrusted with the archival, retrieval and dissemination of such data to potential users.

The CED has also initiated a long-term coastal data collection programme. Since 1987, the shore-based Littoral Environment Observation Programme where near shore casta enginering data such as incident wave height, period and direction, wind speed and direction, current speed and direction, beach slope and beach forms are visually observed on a daily basis by shore-based observers using simple hand held instruments. On a larger time scale, periodic beach profiling, which registers profile changes over time, is also conducted.

Other current efforts include the on-going project entitled "Institutional Strengthening for Shoreline Management" which will equip the Ced with state-of-the-art management and analytical tools for shoreline management and includes the setting up of a data management system incorporating Geographical Information System (GIS). Among others, the project will (i) review the existing data collection program and database management system which includes hardware, software and other related application systems at the CED and other relevant government departments and agencies, (ii) identify the data required for effective shoreline management and develop a data collection program and database management system and (iii) design and document a data model for implementation on GIS which takes account of the data available with the data collection programme, the data needs of the numerical and physical modelling tools at CED and the present and future planning and design needs.

Long term measures for managing the coastal erosion problem

Coastal erosion, albeit its current importance, is only one of the many coastal issues afflicting the Malaysian coastal zone. In light of increasing incidences of coastal erosion, river mouth siltation, natural resources depletion and environmental degradation in many of the more developed coastal areas of the country, the need for an integrated approach to coastal resources management has become a pressing concern as well as a necessity. While the Government is currently implementing various short term measures to address specific issues and problems in coastal areas, it recognises the necessity to implement long term strategies and plans emphasising on proper planning and control of future developments in the coastal zone. A national policy for management of coastal resources and coastal zone should be formulated based on a comprehensive inventory survey and assessment of land and natural resources, projected demand for socio-economic development and the need and sensitivity of the environment.

Efforts in this direction are the South Johore Coastal Resources Management Plan (SJCRMP) and the formulation of a National Coastal Zone Management Policy. The SJCRMP which was carried out as a pilot project in 1987-1991 under ASEAN-USAID funding, addressed the urgent need for a comprehensive coastal resources management plan in order to achieve the twin goal of economic development and coastal resource conservation. The pilot project formulated a comprehensive, multi-sectorial and sustainable coastal resources management plan for a host of coastal concerns which include mangroves, aquaculture, coastal pollution, coastal erosion and sand mining. The drafting and formulation of a National Coastal Zone Management Policy is a three-year (1996-1999) project under the Danish Cooperation on Environment and Development (DANCED). The project is estimated to cost RM14 million of which the Danish Government's contribution is estimated at about RM11 million. The output of the project is the formulation of the National Coastal Zone

Management Policy and the formulation of guidelines for the coastal zone development plans for the states of Penang, Sabah and Sarawak.

Concluding remarks

Coastal erosion control requires a carefully formulated plan to determine the allocation of the limited financial resources available to the Government. Protecting every kilometre of eroding coast in Malaysia will be a strain financially and will not achieve much in the development of the country. Thus, the strategy adopted in managing coastal erosion in Malaysia is to provide immediate structural protection in identified critical areas while at the same time regulating development in the coastal zone to reduce the need for future protection works.

The implementation of the National Coastal Erosion Control Plan requires direction from the highest authority. Thus the National Coastal Erosion Control Council was formed to fulfill this role. The Council, chaired by the Implementation and Coordination Unit of the Prime Minister's Department, is made up of all the relevant agenceis and organisations that are involved in the management of development in the coastal zone. The Coastal Engineering Centre or Coastal Engineering Division of DID, provide the technical advise to the Council.

Legislative measures to control large scale development in the coastal zone is considered adequate with the existence of the Environmental Quality Act 1987 that requires Environmental Impact Assessment to be carried out on prescribed activities. However, to complement this, and to ensure that all development activities within the coastal zone are examined, the Administrative Circular 5/1987 requires all development plans in the coastal zone to be referred to CED for comments. For this purpose several guidelines for development projects in the coastal zone have been formulated.

The cost of engineering works for control of coastal erosion is high. Hence, in addition to the short term measures of implementing engineering works to address the critical erosion areas, it is necessary to institute long term strategies based on a pro-active approach to ensure that all future developments in the coastal-zone do not further aggravate the erosion problem or become the victim of coastal erosion. For this purpose, it is necessary and timely to develop a national coastal resources management policy and the supporting coastal zone management plans based on a good understanding of the coastal processes involved, the environment, state-of-the-art technology and past and proven experience. Eventually, the aim should be towards a well-managed coastal zone. The pilot project in South Johore and the upcoming DANCED's project to formulate a Coastal Resources Management Policy would be good models to follow. Multi-disciplinary approach towards managing the resources within the coastal zone will bring long term benefits to the communities within the coastal zone and to the country as a whole.

Table 1. Distribution of coastal erosion areas in Malaysia

State	Length of coastline (km)	Category 1 (km)	Category 2 (km)	Category 3 (km)	Total length of eroding coastline (km)	(%)
Perlis	20	4.4 (3)	3.5 (1)	6.4 (4)	14.3 (8)	71.5
Kedah	148	22.6 (13)	2.6 (2)	12.4 (6)	37.6 (21)	25.4
Pulau Pinang	152	36.7 (8)	19.1 (5)	1.1 (1)	56.9 (14)	37.4
Perak	230	20.8 (3)	26.3 (2)	93.1 (4)	140.2 (9)	61.0
Selangor	213	55.3 (9)	32.9 (8)	66.1 (3)	154.3 (20)	72.4
N. Sembilan	58	2.0 (1)	9.6 (5)	12.9 (1)	24.5 (7)	42.2
Melaka	73	9.2 (3)	22.1 (3)	3.0 (1)	34.3 (7)	47.0
Johor	492	18.8 (7)	53.2 (9)	165.7 (13)	237.7 (29)	48.3
Pahang	271	9.6 (8)	2.8 (2)	107.8 (8)	120.2 (18)	44.4
Terengganu	244	20.0 (6)	12.8 (5)	122.4 (10)	155.2 (21)	63.6
Kelantan	71	5.0 (3)	10.9 (6)	37.6 (5)	53.5 (14)	75.4
W.P. Labuan	59	0.0	5.5 (4)	25.1 (2)	30.6 (6)	51.9
Sarawak	1,035	9.0 (3)	22.8 (11)	13.7 (7)	45.5 (21)	4.4
Sabah	1,743	12.8 (5)	3.5 (2)	279.2 (12)	295.5 (19)	17.0
TOTAL	4,809	226.2 (72)	227.6 (65)	946.5 (77)	1,400.3 (214)	29.1

Notes: Figures in ( ) represent the number of sites
Category 1 - Critical Erosion Areas
Category 2 - Significant Erosion Areas
Category 3 - Acceptable Erosion Areas

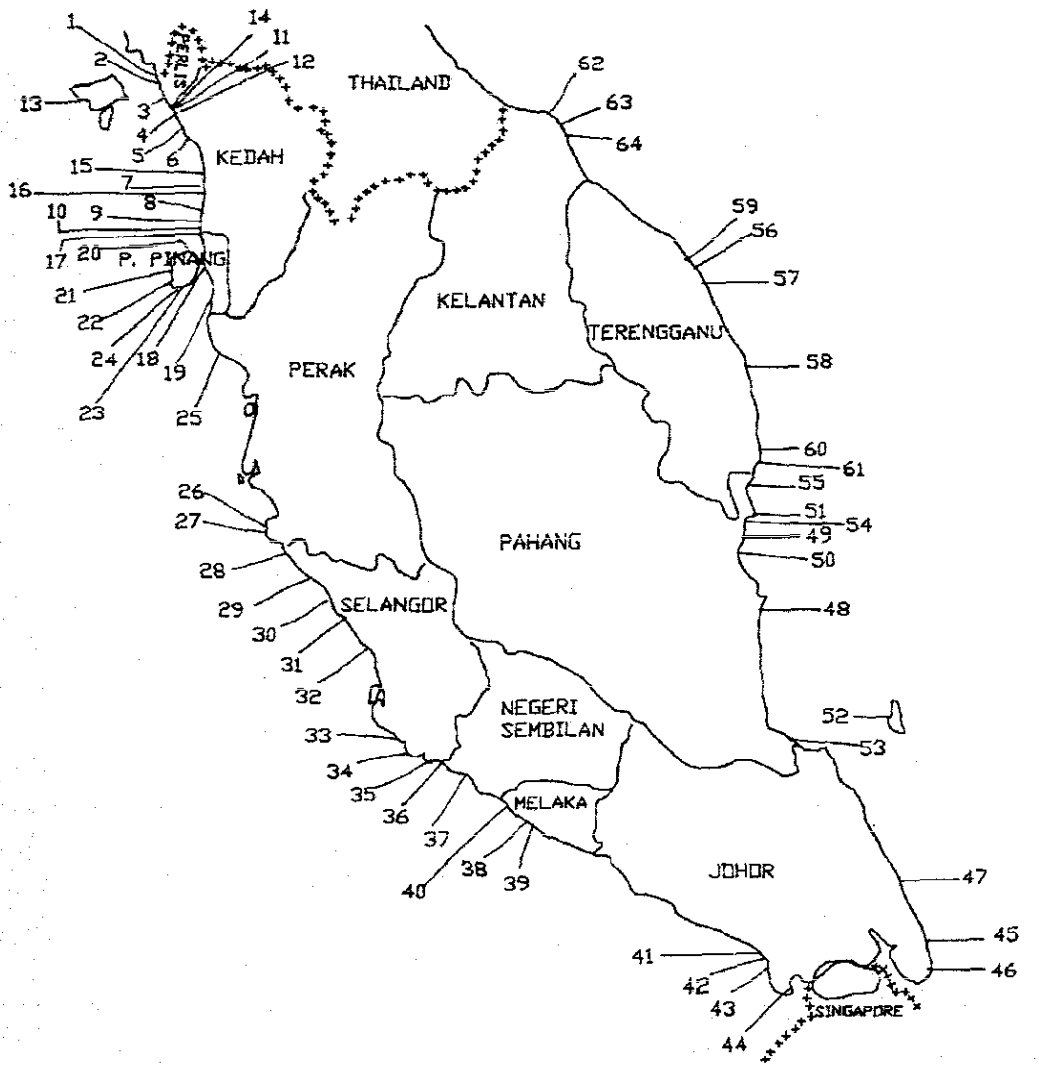

Fig. 1a. Critical erosion areas in Peninsular Malaysia

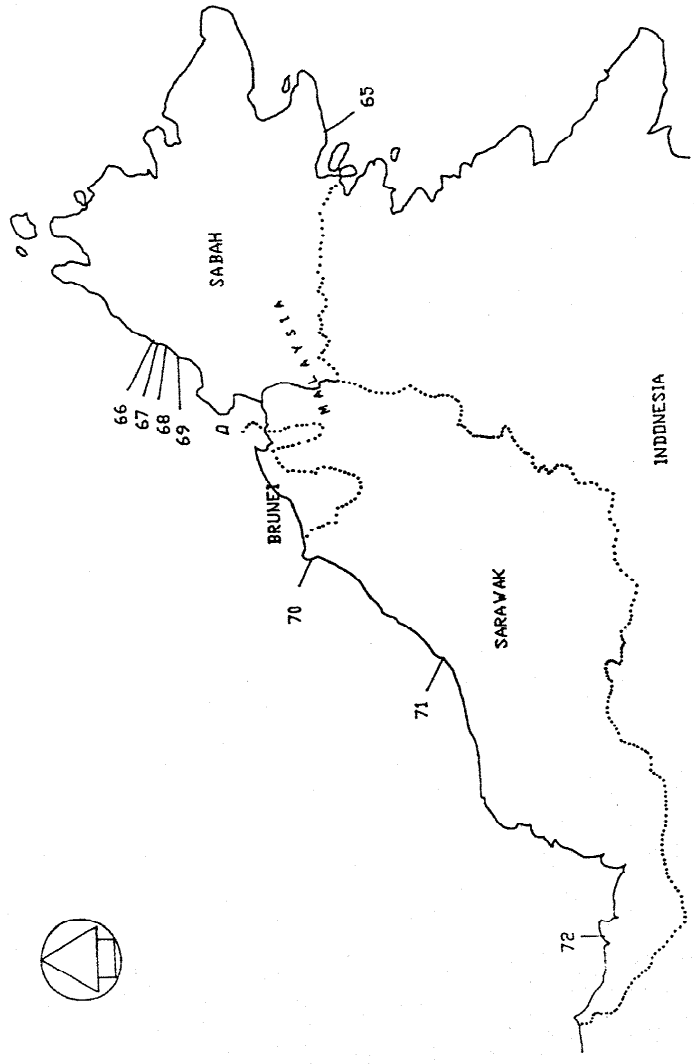

Fig. 1b. Critical erosion areas in Sabah and Sarawak.

Tourism, pollution and the marine environment in Malaysia

LIM LI CHING
Scientific Officer, WWF Malaysia
Locked Bag No. 911, Jalan Sultan P.O.
46990 Petaling Jaya, Malaysia

Abstract. Tourism is one of the largest sectors in terms of foreign exchange earnings for Malaysia, with tremendous economic potential. Malaysia's island and coastal tourist destinations are extremely popular, but are facing increasing pollution threats from inappropriately planned tourism, which are destroying the very resource that initially attracted tourists. Sources of pollution from marine and coastal related tourism include construction activities, inadequate sewage and solid waste disposal facilities, recreation-related facilities such as boats and golf courses, and chemicals and detergents used in maintenance operations. Major pollutants are sediments, sewage, solid waste, nutrients, synthetic organic chemicals, oil and pathogens. Their impacts are extensive, and include sedimentation, eutrophication, harm to ecosystems and living resources, human health effects, impairment of recreation activities and tourism image, as well as wider negative economic impacts. Best practice in controlling and minimising marine pollution from tourism must addresss all aspects of policy, legislation and administrative frameworks to be truly effective. Only then can marine and coastal related tourism be made environmentally, economically and socially sustainable.

Introduction

Tourism is fast gaining grounds as a top income earner globally, and Malaysia is no exception. Tourism has been identified as the third largest sector in terms of the country's foreign exchange earnings (Ismail Ibrahim, 1995). Malaysia, with a coastline of about 4,800 km, has bountiful coastal areas and offshore islands which attract millions of visitors annually. In addition, reef-related tourism which relies on coral reefs as an attraction, is a major revenue earner. However, the carrying capacities of coastal and island tourist destinations are often exceeded, and pollution problems arise, with consequent detriment to the marine environment. It is crucial that the balance btween tourism developlment and environmental protection is sustained through appropriate planning and environmental management. Thus far, there has been a lack of a clear government policy covering pollution from tourism and its impacts. Malaysia's offshore islands are already promoted internationally even before the necessary laws, management plans, facilities and manpower are in place (MCRST, 1992).

The three entities of tourism, pollution and the marine environment not only impact on each other, they are also interdependent. Figure 1 illustrates this relationship.

Inappropriately planned tourism leads to marine pollution. Since the attraction of coasts and islands lies in the natural environment, unpolluted waters and healthy marine

ecosystems, notably coral reefs, this would result in severe repercussions on the tourism industry. Should tourism development in these areas be unsustainable, it might sadly bring about the situation whereby tourism destroys tourism. On a larger scale, pollution from tourism leads to a degradation of the marine environment and its ecosystem functions. Knock-on effects on local communities which depend on the marine environment and its resources ultimately occur. Other economic activities such as fisheries will also be adversely affected.

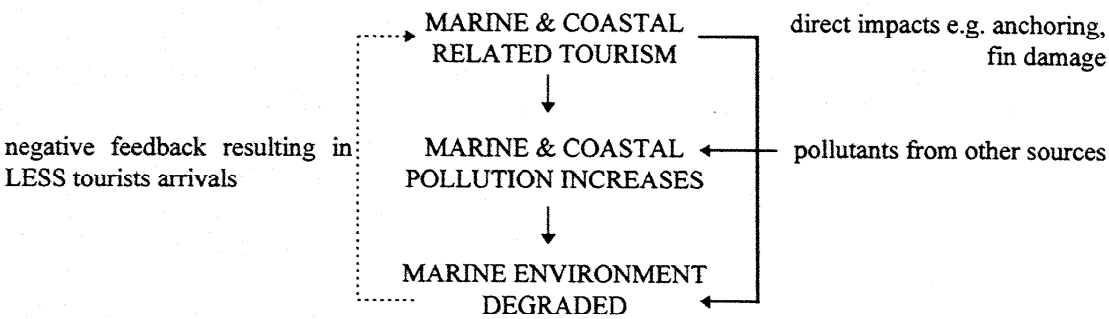

Fig. 1. The relationship between tourism, pollution and the marine environment

Sources and types of marine pollution from tourism

Marine pollution sources from coastal and island tourism can be roughly related to three general categories (see Fig. 2):

(a) Resorts/hotels/accommodation facilities
Construction: land clearing and construction of facilities (leading to sedimentation).
Facilities: solid waste disposal, sewage disposal, desalination plants.
Maintenance: detergents and chemicals, oils from cooking and generator equipment.

(b) Recreation activities
Water sports: jetskiing/waterskiing, boats and repairing of boats resulting in pollution from oils, and chemicals, litter from recreationists.
Golf: fertilisers and pesticides, freshwater inputs from watering.

(c) Infrastructure and support services
Construction: roads, airports, jetties (leading to sedimentation).

Consequently, over time, the above activities contribute to the following types of pollutants (see Fig. 2):

Sediments

In coastal and island tourist areas, increases in coastal erosion leading to sediment transport can be attributed to tourism expansion and development, specifically the clearing of forested areas for hotel and resorts, the construction of hotels and resorts, as well as the construction of related infrastructure such as airports, roads and jetties. Furthermore, improper shoreline development that does not consider setbacks, can result in sedimentation (White, 1991).

Sewage

With the expansion of the tourism industry in coastal areas and islands, there have been inadequate measures to effect sewage disposal, often resulting in the discharge of untreated sewage into the sea. This is largely due to the absence of, or inadequate, sewage treatment facilities. Although large resorts usually have treatment facilities, smaller accommodation operators do not have the finances to provide such facilities, and usually rely on septic tanks for sewage disposal. Organic matter is broken down by bacterial action within the septic tank, with the overflow draining into the soil. This however may not be the best practice option available, and often inadequately treated sewage still finds its way into coastal waters.

Solid waste

It is estimated that over 6 million tonnes of garbage enter the sea every year, and non-degradable, floating materials such as plastics are washed up on beaches almost everywhere in the world (UNEP, 1992). In Malaysia, solid waste disposal facilities on islands especially, are sorely lacking. Much of the waste is inadequately disposed of, often in scattered rubbish dumps, and during the monsoons end up being washed into the sea. Furthermore, the lack of dustbins and collection services compound the problem, as does bad local and tourist attitudes concerning littering.

Nutrients

Nutrients are elements that are essential for primary production, and commonly, this refers to nitrogen and phosphorus. If present in excess, nutrients can have detrimental effects on marine ecosystems. One of the main sources of nutrient inputs to the marine environment is sewage, as a result of poor practices in disposal. Even if sewage is treated, this may not necessarily mean that nutrients are removed, as nutrient stripping only occurs at tertiary treatment level, a process which is uncommon. Furthermore, golf courses at coastal and island tourist destinations contribute to nutrient inputs to the marine environment via run-off fertilisers. Detergents with phosphate are also a source of nutrients.

Synthetic organic chemicals

Synthetic organic chemicals which enter the marine environment can cause both acute and chronic effects in marine biota. Of primary concern are persistent organic pollutants (POPs) which are mainly anthropogenic in origin. They are toxic and persistent chemicals; the very reason for their widespread use is their stability, which is precisely the quality which causes their slow degradation. POPs are typically lipophilic, enabling them to bioconcentrate, bioaccumulate and biomagnify in marine fauna. POPs also persist bound to sediments, releasing them long after the actual pollutant input has occurred. Examples of pesticides that are POPs are dieldrin, DDT, toxaphene, and chlordanes. Pesticides are used on golf courses to maintain the large expanses of grass. It has been estimated that for every one golf course in Asia, an average of 1,500 kg of chemicals are used annually, and this amount is seven to nine times more than that used in farming (Anonymous, 1993).

Oil

Oil pollution from tourism is mainly linked to transport fuels, and attributed to inadvertent leakages from ferries and boats. Boats are used for transferring visitors, diving and snorkelling trips, and as transportation means to other parts of an island. Oil also enters the marine environment when irresponsible boat operators desludge or dispose of spent fuel into the sea. Furthermore, the lack of electricity supply on some islands necessitates the use of diesel-run generators. This may cause pollution if leakages occur during transportation and transfer of the fuel.

Pathogens

Pathogenic micro-organisms can enter the sea via insufficiently treated sewage. The lack of adequate sewage disposal systems in many tourist areas is to blame. Pathogens not only render coastal waters unsafe for recreational uses due to the potential human health effects, they also affect human beings directly if contaminated fish and shellfish are consumed.

Impacts of marine pollution from tourism

The impacts of marine pollution from tourism are extensive; a summary is presented in Fig. 2.

Sedimentation

Land clearing for tourism development, construction of hotels and supporting infrastructure causes increased sediment loads to the marine environment. High amounts of suspended solids hinder photosynthesis in zooxanthellae symbiotically associated with coral polyps, decreasing reef productivity. The productivity of other autotrophs such as phytoplankton and seagrass is also affected. In addition, silt, when settling, can kill coral polyps by inhibiting feeding and respiration. High sediment levels also interfere with the clearing capacity of filter feeders (Salm &Clark, 1984), and affect respiration. A further effect of sedimentation is the sublethal impact which reduces coral growth for several years before death occurs. While corals can repel small amounts of sediments, increased amounts of sediment require increasing amounts of energy to be expended; energy which would otherwise be used for other important biological functions (Dodge & Vaisnys, 1977).

Eutrophication

Eutrophication is the process of nutrient enrichment in water bodies. Nutrients such as nitrogen and phosphorus enter the marine environment naturally, and are essential for plant growth. However, anthropogenic activities upset this equilibrium; sources of excess nutrients attributed to tourism include sewage inputs, organic waste, fertiliser run-off and detergents. Nutrient enrichment is more likely to occur where there is insufficient mixing of waters to dilute and disperse inputs, such as sheltered coastal waters and semi-enclosed bays (Irving, 1993). Although eutrophication increases marine productivity initially, there is often an overall decrease in biodiversity as opportunistic species outcompete pollution-sensitive ones. Changes in planktonic species composition occur, which may have subsequent knock-on effects throughout the food web. Increased nutrients also promote the growth of algae, which outcompete corals. Algal blooms may be toxic, and can lead to mass mortality of benthic invertebrates. Extensive blooms prevent light from reaching photosynthesising species, decreasing productivity. As a bloom dies, it can smother benthic communities, as well as result in anoxic conditions as it decomposes. In shallow, semi-enclosed basins, this can further lead to fish and invertebrate kills (Pullen & Hurst, 1993).

Harm to marine and coastal ecosystems and living resources

Tourism can also bring in problems like increased generation of solid waste. Solid waste that is disposed of in the sea, or inadequately disposed of such that it ends up in the sea, has adverse impacts. Plastic strapping and packaging bands can entangle marine mammals and large fish, restricting movement, respiration and feeding (Pullen & Hurst, 1993). Plastic bags smother reefs, and can suffocate and strangle birds, turtles and mammals. Death can also be brought about by accidental ingestion of litter, for example, leatherback turtles may mistake plastic bags for jellyfish on which they feed.

Pesticides may selectively destroy or damage elements of zooplankton or reef communities; planktonic larvae are particularly vulnerable (Salm & Clark, 1984). These chemicals may bioaccumulate in animal tissues and affect physiological processes. In addition, herbicides may interfere with basic food chain processes by destroying zooxanthellae, free-living phytoplankton, or seagrass communities. There has been evidence of Persistent Organic Pollutants (POPs), such as organochlorine compounds and some pesticides, acting as endocrine disrupters, with consequential drastic effects (WWF UK, 1995). If these chemicals are present during early stages of foetal development, they may trigger a cascade of often irreversible biochemical changes that adversely affect the nervous, immune, endocrine, reproductive and digestive systems.

Coral reefs are sensitive to oil and hydrocarbon damage, especially if oil comes into direct contact with corals (Wells & Price, 1992). Some compounds that oil contains are toxic; e.g. polycyclic aromatic hydrocarbons (PAHs) are potentially carcinogenic. Oil pollution from tourism tends to be minor, but there is a risk of long-term chronic effects, and there is increasing evidence that chronic exposure causes significant effects on species and ecosystems.

Human health effects

Pathogens which enter the sea via insufficiently treated sewage may cause health effects in swimmers. Recent epidemiological studies have shown a link between bathing in seawater contaminated with pathogens of faecal origins, and diseases (GESAMP, 1990). Levels in excess of the interim marine water quality standards in tourist areas such as Pulau Pinang and Port Dickson have been recorded and associated with acute incidences of gastrointestinal infection. Diseases can also be transmitted through contaminated seafood; these include typhoid, paratyphoid, viral hepatitis, salmonellosis, and seafood poisoning leading to paralysis and intoxication by *Vibrio parahaemolyticus* (ESCAP, 1992).

Chemicals used to improve soil in golf courses include zeolite, which consists mainly of silicic acid, aluminium oxide and iron oxide which are potentially carcinogenic. Also, toxic soil coagulating agents used to strengthen the foundation of artificial lakes in golf courses contain acrylamid, which can contaminate groundwater and cause poisoning and disorders of the central nervous system (Anonymous, 1993). In the US at least one human death has been linked to the use of pesticides on golf courses, and a high rate of breast cancers has been recorded among women golfers. A survey of golfers and caddies listed out health complaints such as eye irritations, skin diseases, allergies, rashes, disorders of the ear, nose and throat, respiratory illnesses, and asthma, all of which were attributed to the chemicals used in golf courses (Anonymous, 1993).

Endocrine disruption by POPs which mimic hormones have been demonstrated in wildlife (WWF UK, 1995), and these effects may possibly extend to humans. Already disorders of the human male reproductive tract are increasing alarmingly - development disorders have doubled in the past 30-50 years while sperm counts have halved - and oestrogenic pollutants may be responsible (WWF UK, 1995). POPs have also been implicated in reduced immunity in infants and children, developmental abnormalities, neurobehavioral impairment and cancer and tumour induction or promotion.

Impairment to recreation activities

Discharge of untreated or partially treated sewage into the sea renders the water quality unsuitable for recreational purposes and thus defeats the primary objective of a recreational resort (Tan, 1995). If the criteria or standards for safe recreational use are exceeded, polluted areas will have to be closed. Also, high sediment loads decrease water visibility, adversely

affecting the attraction of reefs as a diving site. In addition, solid waste that settles on reefs is aesthetically displeasing and creates dissatisfaction among reef users. Algal blooms caused by eutrophication also pose problems as unsightly scum formation may accumulate on beaches.

Tourism image marred

The pollution of beaches and coastal waters, especailly that which is visible, will ultimately lead to visitor dissatisfaction. If these problems are not immediately addressed, there is the danger of a decline in the credibility and reputation of a tourist destination. Once an area becomes polluted, social carrying capacity is easily reached as tourists become dissatisfied. As a result, the number of tourists to that particular place will decline. Consequently, the tourism industry is affected negatively.

Wider negative economic impacts

Marine pollution from tourism can also have wider negative economic impacts. For example, land clearance for tourism development often destroys mangroves, as well as causes siltation and consequent destruction of mangroves and corals. Other pollutants attributed to tourism also destroy these vulnerable habitats. The fisheries sector is dependent on the well-being of coral reefs and mangroves, as these are breeding and feeding grounds for fish and invertebrates of commercial importance. Contamination of shellfish beds by sewage can lead to a loss of export earnings from fish and shellfish as well as a loss of fishermen's livelihoods (Koe & Aziz, 1995). Furthermore, changes in fish community composition due to changes in prey communities as a result of pollution may have ramifying effects; the replacement of one fish species by another less desirable species, for example, has potential economic repercussions for small-scale fishing communities.

Coral reefs and mangroves also play an important role in shoreline protection. Should they be destroyed, the ensuing loss of their role in preventing coastal erosion would have serious economic repercussions. For example, a land reclamation project in the Maldives led to the loss of an area of reef, and hence its role as a natural breakwater was curtailed. An artificial breakwater was built to prevent flooding, which cost US$12.5 million per km to build (Wells & Edwards, 1989).

Best practice in controlling and minimising pollution from tourism

Some of the main contributory factors to marine pollution from tourism include a lack of proper tourism development planning, a lack of integrated approaches to pollution prevention and control, inadequate existence and enforcement of laws and a lack of education and awareness regarding marine pollution from tourism. These constraints will have to be overcome to ensure that tourism development in coasts and islands does not impact negatively on the marine environment.

Best practice in controlling and minimising marine pollution from tourism should address policy, legislative and administrative frameworks to be truly effective. Some measures are summarised in Table 1 and Figure 3.

Conclusion

Tourism is increasing in economic importance in Malaysia, and the marine and coastal environment plays an integral part in promoting tourism. The government, in its efforts to expand the tourism industry in the country, has allocated funds largely for the provision and expansion of infrastructure and facilities required to support the growth of the tourism sector.

However, if tourism development is to be made economically sustainable, it must also be made environmentally and socially sustainable. The impact of marine pollution from inappropriately planned tourism threaten the tourism industry, as well as other important sectors such as fisheries. The control and minimisation of marine pollution from tourism must be seen as beneficial, not only for the protection of the marine environment and marine biodiversity, but for the benefit and sustainability of the tourism sector itself. Addressing pollution from tourism will ultimately enhance tourism growth.

There must be concerted efforts to ameliorate existing pollution problems, and to put into place preventive and precautionary measures to control pollution from tourism. An integrated approach to the management of tourism in coastal and island areas is essential, given its cross-sectoral nature. Administrative, institutional and legislative provisions must be in place, coupled with adequate enforcement and monitoring capabilities. National legislation must complement and strengthen regional and international agreements, as well as specify action plans at the local level. All these challenges must be overcome to ensure that marine pollution from tourism does not destroy or undermine the marine environment and its values, including tourism.

Table 1. Best practice in controlling and minimising marine pollution from tourism and means to achieve this.

Best Practice	Recommendations
Appropriate policies	* formulate sound policies that incorporate consideration for the conservation of the environment and its natural resources. * adopt national policies like the National Conservation Strategy, the National Environmental Policy, the National Ecotourism Plan and the National Policy on Biological Diversity * requires political will and commitment at the highest levels of government * reconcile economic and environmental considerations * address pollution within the broader context of sustainable development and the conservation of nature and natural resources * implement, enforce and ensure compliance with policies
Tourism development and planning guidelines	* include environmental clauses for conservation in agreements and contracts for tourism development projects * ensure compatibility with the overall development plan of an area * adhere to the mandatory use of Environmental Impact Assessments * evaluate the necessity of having golf courses on islands and coasts, and consider carrying capacity and potential impacts on marine ecosystems * ensure environmentally sound land use practices * establish measures to control, reduce and prevent coastal erosion and siltation * set construction guidelines spelling out zones such as prohibited zones, and setback or buffer zones * limit tourist facilities to low density and low rise types of development
Environmental codes of conduct in tourism	* formulate environmental codes of conduct for tourism that are specific, positive and action-oriented

Table 1 continued

	* accept responsibility for environmental damage and take corrective action where necessary * promote and reward outstanding environmental performance * monitor, report and evaluate the implementation of codes * provide adequate administrative support
Precautionary, anticipatory and preventive approaches	* treat root causes of pollution and not just the symptoms * apply precautionary, anticipatory and preventive approaches in the project planning and implementation stages * endorse minimising pollution at source by legislative means * implement incentives and disincentives for minimising pollution at source * recognise that pollution prevention at the onset willl help reduce subsequent pollution amelioration and disposal costs * adopt the precautionary principle within the framework of integrated pollution prevention and control
Environmental Impact Assessment (EIA)	* require EIAs for any specific capital development projects occurring within the tourism industry, such as hotels, service sector amenities, recreational facilities, and other associated types of development activities * integrate EIAs in the planning stage and in the formulation of coastal resource management policies, programmes and plans * undertake site selection as a first stage in the environmental assessment of a tourism development project by carrying out a screening process using easily applied criteria or guidelines * review legislation to either change the framework of EIA requirements itself, or work within the existing framework by supplementing EIAs with sound, adequate development plans and guidelines * assess EIAs for tourism related projects within the overall existing framework and guidelines for land use and development in an area, district or State * incorporate EIAs into a framework for consultation with stakeholders directly and indirectly impacted by proposed policies or projects * include monitoring and auditing programmes in EIAs to ensure follow up and implementation of recommendations
Integrated Coastal Zone Management (ICZM)	* manage activities in the coastal zone in a unified way, while considering the interests of different users * undertake activity or development in an environmentally sound manner, giving full consideration to the protection of marine and coastal ecosystems, habitats and species * ICZM should cover areas of land and sea, and be multi-disciplinary in nature * integrate the policies and programmes relating to the different demands on the coastal zone

Table 1 continued

	* needs an appropriate legal framework, a viable and environmentally sound zoning system and an interdisciplinary approach to planning and management * take into account traditional, cultural and historical perspectives, and conflicting interests and uses * formulate integrated policies that coordinate the allocation of uses in the coastal zone * regulate inappropriate activities that have destroyed coastal ecosystems * establish a single body or authority to effect the coordination of all the various laws pertaining to coastal zone development, areas and resources * coordinate various relevant local, national and regional government agencies * review and evaluate ICZM plans, while taking into account lessons learnt from previous programmes * develop a coastal management plan and formulate a Coastal Resources National Policy
Marine Parks	* advocate holistic and integrated approaches in planning and management * embrace the concept of island ecosystem management which advocates the management of marine habitats, coastline features and terrestrial habitats as one unit * establish unalienated land on the islands as State Parks * protect smaller coastal areas whose adjacent marine resources are in dire need of protection and manage as an integral part of the Marine Park * zone sea and land areas to define what uses are limited, to what extent, and by what means * restrict further development to areas which are already developed, instead of opening up new areas for development * use Marine Parks as an education and awareness raising tool
Involvement of stakeholders	* involve all stakeholders in the planning and management of coastal and island tourist areas, as well as in the process of implementation, monitoring and review * ensure community consultation and participation, especially in Marine Park islands * adopt a bottom-up, people centred approach to management * conduct training courses on subjects ranging from leadership, education and public awareness, to resource management and legal matters * accommodation, tour, boat and dive operators should play a part in ensuring that the marine environment is conserved and protected so that ultimately they safeguard their livelihoods * adhere to best environmental practices in everyday operations and maintenance

Table 1 continued

	* accommodation, tour, boat and dive operators should help educate and raise awareness of tourists * involve the private sector, which often has the financial backing to help implement sound actions and clean technologies * ensure that privatisation runs smoothly and incorporates environmental and social considerations * encourage public participation in the formulation of policies, plans and strategies * promote scientific data collection, monitoring and evaluation, and research on functions of marine ecosystems and resources, impact of threats, and mitigating measures
Interagency coordination and cooperation	* promote an integrated policy and decision-making process * formulate new laws and regulations or amend existing laws and regulations to promote better coordination among agencies involved in sustainable tourism development * encourage interagency cooperation and coordination at every level of government * outline clearly jurisdictions and responsibilites so that the roles different agencies play are well defined, and complement each other * establish a single body that have the overall management authority over the usage and development of coastal resources and land in an area * facilitate the exchange of information and data on coastal tourism development within and outside the country * promote regional cooperation in the preparation of national guidelines for integrated coastal zone management and tourism development
Education and awareness	* educate and increase awareness about the marine environment among islanders, visitors and officials * target key groups of politicians, government agencies and other decision-makers, local communities, tourists, fishermen, schools and other educational institutions as well as the media * focus on appreciating the natural environment, as well as provide practical alternatives to the disposal of domestic wastes and sanitary maintenance * facilitate access to information * promote training and capacity building for local authorities and Marine Park staff * utilise Marine Park Centres as the focus for comprehensive marine education and awareness programmes * consider differences in social roles when developing information displays * encourage dive operators and dive masters to raise awareness of the marine environment, as well as provide practical tips to divers

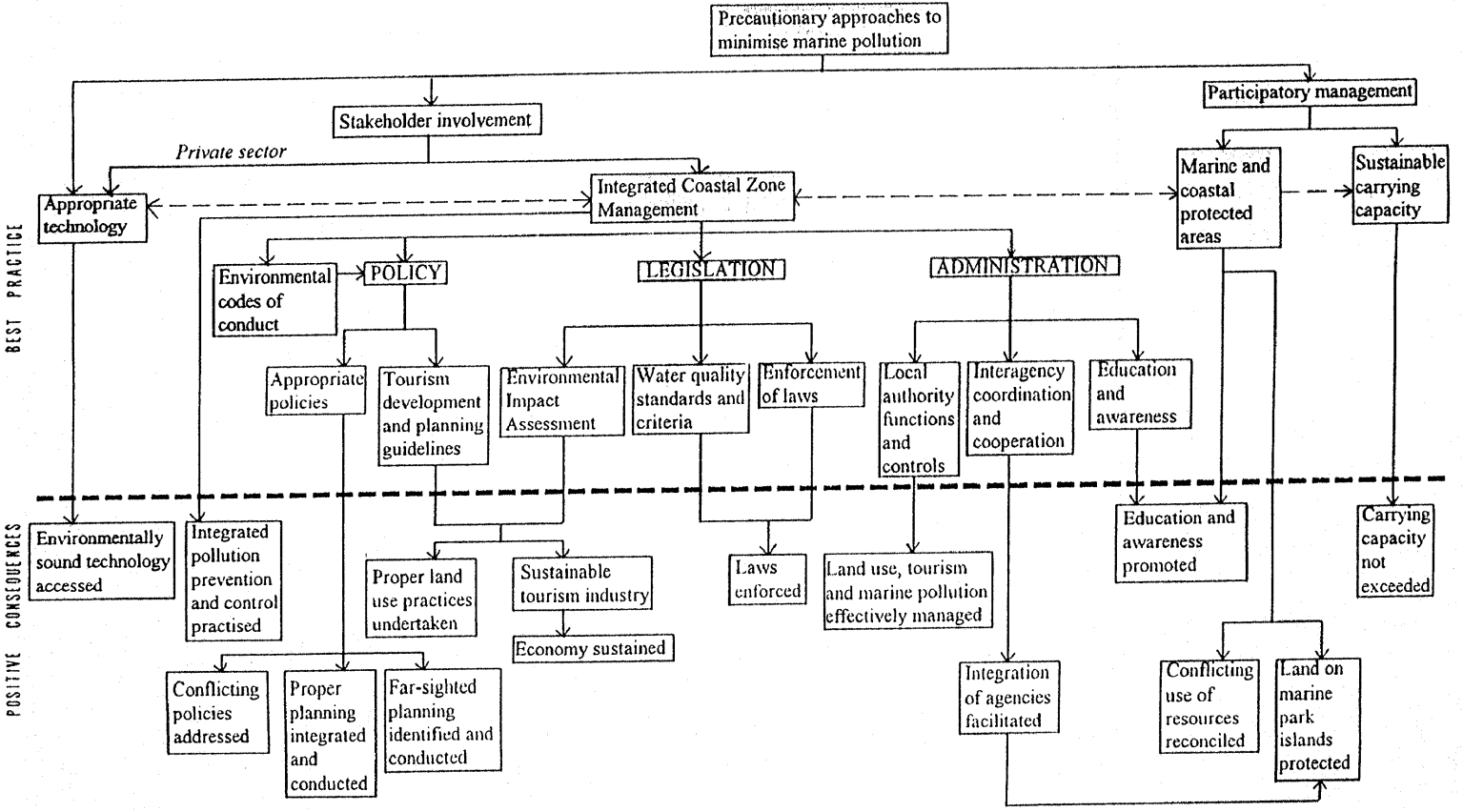

Fig. 3. Legal framework analysis showing contributory factors and challenges that are positively addressed when best practice is utilised to control and minimise marine pollution from marine and coastal related tourism.

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