



USING COASTAL ENVIRONMENT SENSITIVITY INDEX MAP AS A TOOL FOR INTEGRATED COASTAL ZONE MANAGEMENT

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ABSTRACT

Integrated Coastal Zone Management (ICZM) becomes a necessary and important issue since the coastal areas have been extensively developed resulting in critical environmental problems. Geographic Information System (GIS) has been applied as a useful and practical tool to query, analyze and display geographically referenced information in support of decision making process especially coastal zone management. The sensitivity index approach capability of the GIS is an efficient tool for environmental planning and pollution prevention as well as to create the Coastal Environment Sensitivity Index (CESI) map.

The CESI map is developed by prioritizing sensitive and vulnerable characteristics and features of the coastal resources. It consists of physical and biological resources (e.g. mangroves, coral reefs), social and economic environment (e.g. recreational sites, aquacultural areas) and ecological environment (e.g. breeding ground, endangered species habitats). The CESI map is not only used for oil spill response, but also for various tasks on ICZM i.e. policy planning of the critical coastal environment maintenance, the conservation and protection of critical habitats/resources. In addition, it is very useful for pollution control and contingency planning against marine disasters and for environmental restoration and rehabilitation. It is also applicable for strategic environmental impact assessment. The main objective of the CESI map is to serve as a quick reference for oil spill responders and coastal zone managers.

Pollution Control Department is currently undertaking a project titled “Coastal Sensitivity Mapping Project with its Application for Pollution Surveillance and Contingency Planning”. The expected outputs are the up-to-date coastal environment database in GIS and three CESI maps for coastal zone management, pollution surveillance and contingency planning. The concept of using the maps for strategic environmental impact assessment will be introduced and promoted.



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Coastal areas have been utilized for various activities such as human settlement, fishery, industry, aquaculture, amenity, and agriculture. Such activities affect their environmental quality because of the wastes and the over-exploitation of resources. The areas face complicated problems such as conflicts of use, pollution, loss of natural resources and degrading quality of the coastal environment. Integrated management of the coastal zone is, therefore, vital for the conservation of the natural resources, economic development and minimizing pollution. Generally, the integrated coastal zone management (ICZM) is defined as the 'integrated planning and management of coastal resources and environments in a manner that is based on the physical, socio-economic and political interconnections both within and among the dynamic coastal systems (Sorensen, 1997). Nowadays, the ICZM is no longer an option, but a necessity for sustainable utilization of coastal resources.

ICZM as a system of governance inherently concerns managing a human dimension that is inconsistently meshed upon a variable, but unyielding physical reality [1]. A tool, which takes into account the value and utility of economic and social considerations together with the physical value of the coast, is required for effective management. Sustainable coastal zone management absolutely depends upon effective strategies whereby efficient management may be achieved with a realistic understanding of the potential for coasts to undergo change over a range of time scales. The inability to address this last issue is a major problem for ICZM. Decision-makers and managers need tools to assess the implications of physical coastal dimensions. The vulnerability and sensitivity index becomes an important tool for ranking the coastal status for an efficient and effective management.

The vulnerability and sensitivity index has been presented as a tool to aid ICZM. It is a measure of the potential for loss of the physical, economic and social value of a given site. When the coastal environmental sensitivity index (CESI) was first introduced by Grundlach and Hayes in 1978, it was primarily created for oil spill responses. The original map contained information on the oil spill vulnerability index based on physical and geological characteristics of a coastline. Since its introduction, the CESI has been further developed and enhanced for application for other purposes such as habitat sensitivity ranking.

The coastal environment consists of physical, social, economic and ecological components. The physical components are the natural resources and the shoreline features such as mangroves, coral reefs, seagrass beds, sandy beach, rocky shore, mud flat. The social and economic components are the human use resources such as recreational sites, aquacultural areas, environmental protected areas and fishing grounds. The ecological components are the areas/resources, which are ecologically critical such as breeding grounds, re generating areas, endangered species habitats etc. Given the large number of features in the coastal areas are involved, a database is needed for compilation, storage and classification of the data based on the main components of the coastal management strategy. Additionally, the maps and the database form an advanced tool for identifying and presenting coastal conditions as well as highlighting degraded areas that need immediate attention.



Since the 1980's CESI maps have been produced in geographic information system (GIS), a method, which is now accepted worldwide. GIS is a powerful tool for handling, capturing, storing, editing, retrieving, analyzing, updating, presenting and reproducing geographic information. The advantage of GIS is that it enables digital maps to be generated in various formats. Large quantities of data can be maintained and retrieved at great speeds, and low cost. The ability to manipulate the spatial data together with attribute information and also to integrate different types of data in a single analysis at high speed cannot be matched by any manual method. The ability to rapidly perform the complex spatial analyses provides a quantitative as well as a qualitative advantage [2]. In this coming new millenium, in the world of high technologies, high economic competition and strongly global environmental concerns, precise and up-to-date information is required for decision making and policy planning. Especially in term of environmental planning, pollution prevention and pollution management, the GIS-based CESI map is very useful and efficient for supporting in-time decision making process necessary for ICZM.

The GIS-based CESI map could be used as an important and useful tool for other purposes such as:

- *Land use planning and zoning*

The CESI map provides an efficient and convenient inventory of coastal resources. It can be used by land use planners to resolve or compromise conflicts on the multi-utilization of coastal areas. Zoning serves two main purposes in coastal conservation: a) *custodial*- for nature reserve (e.g. diving, nature study, fishing, protection of breeding areas), and b) *regulatory*- for programs and coastal land use planning, to designate certain areas for particular uses (e.g. hotel, aquaculture, navigation, greenbelt, commercial fishing, nature reserve) [3]. Zones are also established to identify the areas for pollution control where certain and appropriate mitigation measures could be implemented for the sustainable use of coastal resources.

- *Policy planning*

In environmental and other planning activities, quantitative measures are often required since the environmental aspect must be balanced against other interests. A very useful feature for the GIS-based CESI map is the capability to combine and overlay different information types. This is a powerful tool that makes it easy for policy planners and decision-makers to analyze the impact of policy decisions and what if scenarios. As it based on up-to-date and large amount of data, CESI is beneficial for policy planning at local, national and regional levels, and could minimize conflicting coastal development in the long-term.

- *Pollution controlling and contingency planning against the marine accidents*

The CESI map contains supporting information for making decision and planning to deal with marine pollution and incidents. The map illustrates the level of impacts from marine pollution point sources on the coastal environment. It is also possible to predict the degree of potential damage on each features arising from future activities.

- *Planning for environmental restoration and rehabilitation*

The updated and complete information of the coastal environments in the CESI database is advantageous in planning for coastal restoration and rehabilitation. It is possible to use GIS options to simulate and demonstrate the different planning alternatives.

Implementing CESI in Thailand

Thailand has 2,614 km of coastline along the Andaman Sea and the Gulf of Thailand (South China Sea). There are 24 provinces which border on the sea and where about 70% of population lives within a few kilometers from the coast. Inappropriate coastal land use has an adverse impact on coastal resources. For instance, many mangrove forests were replaced by various developments, but mainly for aquaculture, resulting in their decline from 0.4 million hectare in 1961 to 0.16 million hectare in



1999. Meanwhile, rock and sand beaches and mud plains were developed as wharves, recreation areas, and settlements. The coastal resources in many provinces have been heavily utilized for economic development, particularly tourism and aquaculture. Although Thailand derived economic benefits from these activities, this partly uncontrolled development has created environmental problems and threats to the coastal resources. A number of programs and projects have been implemented to minimize these problems [4].

At present, the Pollution Control Department (PCD) is undertaking a project entitled “Coastal Sensitivity Mapping Project with its Application for Pollution Surveillance and Contingency Planning” which is jointly funded by the Swedish International Development Agency (SIDA) and the Royal Thai Government. The objectives of the study are to i) update the coastal environment database in GIS along the coast of Thailand; ii) prepare a CESI map based on the updated database; iii) formulate guidelines and appropriate techniques for using CESI maps for pollution surveillance and contingency planning; and iv) use it as a tool for strategic environmental impact assessments. The GIS-based CESI maps produced under this project will be used to support PCD’s responsibility for responding and managing oil spills, for integrated coastal zone management, and evaluating the impacts from national level development projects.

Before producing the CESI map, the coastal environment database needs to be updated. The existing database of PCD, compiled from the previous projects, is being updated and complimented by satellite imageries, aerial photos, ground survey data and publications. Satellite imageries are mainly used to update the maps as they can be reproduced in various scales, and they provide temporal and spatial information. It is a highly cost-effective method for covering large areas. Ground survey will be conducted to verify features in some areas. The updated database will be produced in GIS using the ArcInfo program. Definition of each environmental feature will also be provided for easier understanding. The GIS-based CESI map will be created at a 1:100,000 scale.

The CESI map commonly forms an effective and integral part of oil spill response plans. It has been used in the planning and executing procedures of oil spill events. For example, in USA, the NOAA has developed an extensive GIS-based data set for spill planning and response in the form of environmental sensitivity index (ESI) maps so as to reduce the environmental consequences of both spill and cleanup efforts. The CESI map in oil spill response is used to identify vulnerable coastal locations before a spill occurs so that protection priorities can be established and cleanup strategies could be identified. Although the CESI map is used worldwide for oil spill response, it can be applied for a wide range of purposes.

There are numerous existing sensitivity ranking systems which, are customized for specific purposes. There is currently no standard or guideline for sensitivity ranking systems. Many countries in Southeast Asia have already established sensitivity ranking systems for their specific use, for example (Appendix A):

- Indonesian Marine Environmental Sensitivity Ranking for Oil Pollution;
- Proposed Marine Habitat Sensitivity Ranking System for Indonesia;
- Vulnerability Index – Eastern Coastal Malaysia;
- Coastal Environment Sensitivity Index for Vietnam.

In Thailand, developing a new ranking system is based by modification of the existing ranking systems and incorporating comments from Thai experts in various disciplinary fields. After adopting the new system, the environmental features will be given an index in term of its sensitivity and vulnerability to marine pollutants and prioritizing of the coastal environmental resources. At the end of the project, three sets of GIS-based CESI maps will be created for oil spill response, coastal zone management, and identifying impacts from other pollutants. Effort will be focused on CESI for oil spill response and consequently this map will be the most extensive and detailed.



CESI for Oil Spill Response in Thailand

As the use of petroleum products increases, so does the risk of oil spill and leakage to the marine environment. There were 82 oil spill accidents between 1973-1998 in Thai waters. Such accidents have been shown to cause severe damage to the environment, ecosystems, and natural resources. As a result, in 1982 the Committee on Prevention and Combating of Oil Pollution was set up through the Prime Minister's Regulation on the Prevention and Combating of Oil Pollution to formulate a policy for prevention and response to oil spills. In 1995, the Regulation and the Committee were revised and a National Oil Spill Response Plan was put in place. The objectives of the National Plan are to assign responsibilities to involved agencies, set up strategies and guidelines for the operations, raise the awareness of Thai's organizations, and to coordinate efforts in prevention and combating oil spills. The Royal Thai Navy and Harbor Department are the core government agencies, which act as the Operating Unit responsible for coordinating with the Supporting Units to carry out the response plan by providing man power, oil spill equipment, and relevant information. Supporting Units under the National Plan involve various government agencies and are responsible for providing various technical, legal, administrative and field support to the Operating Unit. PCD's responsibilities are set out in the National Plan as follows;

- Prediction and monitoring of oil spill movement and behavior.
- Identification and classification of sites sensitive to oil spill.
- Technical and scientific support on spill clean-up and environmental recovery.
- Advice and monitoring of chemical dispersants used in oil spill response.
- Assessment of damages to the natural environment caused by the spill.
- Assistance on the assessment of claims for compensation for damages arising from the spill.

As PCD currently lacks the tools to enable it to fulfill its responsibility it needs a GIS-based map as part of the input to its mathematical model used to predict oil spill movements. With the aid of the model, impacted areas and response strategies can be identified. Such supporting data is vital to enable prompt response and so minimize the impact of the spill on natural resources. In cases where there is a deficiency of oil spill combating equipment to protect the affected shoreline, prioritizing of resources is needed based on sensitivity and vulnerability of the sites. The CESI map combined with the predictions from the model will assist in prioritizing the coastal areas, which need protection from spillage. The CESI maps for oil spill response would provide PCD an efficient and effective way for in-time support so vital to protect the coastal and marine resources [5].

The Thai coastal database is categorized into four groups, for purpose of the oil spill response namely: physical features, ecological features, human features and contingency planning features (Table 1). A ranking system and index for each coastal feature is currently being formulated.

CESI for Integrated Coastal Zone Management

Overall purpose of ICZM is to provide the best long-term sustainable use of coastal natural resources and continuous maintenance of the most beneficial natural environment. ICZM provides a basis for sustainable use of resources, biodiversity preservation, protection against natural hazards, pollution control, enhancement of welfare, development of sustainable economy, and optimum multiple use.

Thailand is facing a problem in utilization of coastal areas for multiple purposes. The conflict in land use has caused difficulties in mitigating the impacts. If areas were classified according to their resource sensitivity and carrying capacity, probably the problem would be easily solved. For example, the rapid expansion of shrimp farming areas along coastal zone without consideration of the carrying capacity of the area has led to adverse environmental impacts such as water quality deterioration and disease outbreak. Some shrimp farmers thus moved to inland paddy field areas. Due to innovations enabling shrimp cultivation in low salinity waters, inland shrimp farming has undergone rapid expansion resulting in many social conflicts between shrimp and rice farmers. As saline wastewater



was discharged into the rice field and waterways, thus posing a threat to rice and fruit production, government authorities became seriously concerned with the long-term environmental impacts. In 1997, the government declared a ban inland shrimp farming [6].

Had specific areas been set aside for shrimp farming, the conflict in land use would not have been so serious. At the moment, government authorities are requested to identify the areas for aquaculture activity. PCD is in the process of developing CESI map to aid site identification. The CESI map for ICZM purposes will be created by combining sensitivity to marine pollutants and the importance of the coastal resources. The coastal features are divided into four categories namely: physical resources, biological resources, human use value and quality of life value (Table 2). Each resource will be assessed either as ecologically, economically or socially important. In turn the level of importance will be classified as high, moderate or low. The resultant sub-categories will be as follows:

- High ecologically important area, i.e. coral reef, seagrass, mangrove forest
- Moderate ecologically important area, i.e. muddy beach
- Low ecologically important area, i.e. sandy beach
- High economically important area, i.e. oil refinery, platform, commercial port
- Moderate economically important area, i.e. aquaculture area
- Low economically important area, i.e. fishing port
- High socially important area, i.e. sacred/historical site, tourist/recreation site
- Moderate socially important area, i.e. urban area
- Low socially important area, i.e. village area

The CESI map is useful for feasibility study of coastal development projects as it can indicate where the sensitive resources are located and provide guidance to the developer or inspector on where the investigation emphasis should be placed. The map could be used for environmental planning process on a provincial scale so as to avoid or minimize conflicts in utilization of coastal resources. Then, the integration of each provincial environmental plan by policy planners is one way to achieve the appropriate and efficient coastal zone management.

Established land use zoning in Thailand is based on land capacity. However, since urban planning and land use control in coastal areas have not been well implemented, the CESI map created under this project could be used as a guide to improve coastal land use management. The CESI map not solely for pollution prevention, but can also be applied to environmental conservation. Normally, carrying capacity varies depending on areas, resources and timing. It is generally determined by analyzing many factors such as: physical and ecological environment, economic investment, and social satisfaction. The coastal resources database of the CESI map can be used with the ecological investigations to define utilization zonings and environmental carrying capacity of a given area. This approach would help to clearly identify a balanced mix of activities that are in harmony with the local culture, relate to tourism, and yet emphasize environmental conservation [7].

The EIA process is one of the tools for integrated coastal zone planning. The most important part of the EIA is the estimation of impacts from the identified sources of pollution and recommendation of suitable measures for preventing or minimizing the detrimental effects to the environment. However, sometimes it is difficult to establish whether a project is feasible or an EIA is required. In such case ICZM based on CESI maps could be used to assist with the decision making. In particulars, CESI maps could be used for site selection and to determine the need for an EIA. The CESI map provides a valuable guide to the importance of the coastal resources/environments and their sensitivity to potential environmental impacts.

It is worth noting that CESI maps are not always the appropriate tools for EIA investigations. This is because they are usually developed for a specific purpose in each case study, one that may not relate to elements subject to an EIA. For example, the CESI maps for an oil spill cannot be used for the EIA



of a dam construction project as the criteria for evaluating the sensitivity of the coastal environments to oil pollution are different from those to dam construction. Some areas may not be sensitive to oiling, but they may have a high heritage value, for example historical and religious sites.

Typically, the GIS approach in CESI is used as part of environmental impact studies. It could also be customized and simplified for use by high level decision makers who often lacks the time and motivation to become familiar with data handling technology and analysis. Such customized applications could be installed on personal office computers or downloaded via modem to notebook computers with the minimum of instructions. The database could also be customized to suit a specific situation when a task force commander needs immediate access to the information whilst being far from the office.

The CESI map for ICZM purpose developed under this project will be highly beneficial for national policy planning and integrated coastal zone management in Thailand.

CESI Map for Other Pollutants

In planning and management, the flexibility of a digital database is one of its major assets. By using a GIS-based map, new information that is related to a specific problem could easily be added and combined with the existing data to create a new digital data set. The updated maps could be easily and rapidly distributed to stakeholders for comments, further analysis or use in planning operations.

There are many pollution point sources, which generate many and discharge a wide range of pollutants to the environment, including:

- Oil and floating pollutants
- Dissolved toxic, pathogenic and organic pollutants
- Sediment particle and suspension pollutants
- Elevated temperature effluent
- Physical Destruction.

The output from this project, will include GIS-based CESI maps, which show the impact of five different types of pollutants check list for possible impacts from each type of pollutant will also be indicated as shown in Table 3. If possible the effects of, other additional types of pollutant will be developed in the future.

Future Target

Thailand should be applying the most up-to-date information technology for environmental care, especially for coastal zone management. The integrated use of remote sensing and GIS techniques can not only improve the quality of geographic information to support decision and policy making processes, but also provide a cost effective tool for resolving environmental problems. The CESI map created as part of this project will contain useful information, which could be used as a quick reference for oil spill responders, pollution controllers and coastal zone managers. It is envisaged that eventually, the database and CESI map will be used as a tool for marine spill response planning, both for coordination on a national level and for on-site command. Further work will focus on increasing the information resolution down to a local level by using high resolution imageries and radar data such as SPOT, IRS, Radarsat or ERS. The aim will be to enhance the quality and reliability of the information in order to support coastal zone management and to improve the performance of coastal environmental surveillance, monitoring program and operation.

It should be noted that the success of ICZM depends not only CSEI maps for providing information to coastal managers, but also on an effective legal and administrative framework being in place. Before any plan is developed, it is important to agree which issues will be addressed and at what levels of priority, through a process of discussions between the stakeholders. The combination of top-down and



bottom-up approaches is essential in order to ensure adequate public participation in the planning process [8].

References

1. Loriane Mc Fadden. 1999 Vulnerability Analysis: A Tool for 21st Century Integrated Coastal Zone Management. Coastal Zone 99 Conference Abstracts. San Diego, USA.
2. Stan Aronoff. 1995. Geographic Information Systems A Management Perspective. 4th edition, WDL Publications, Ottawa, Canada.
3. Clark, John R. 1996. Coastal Zone Management Handbook. CRC Press, Inc.
4. Office of The National Environment Board. 1992. The Integrated Management Plan for Ban Don Bay and Phangnga Bay Thailand, Ministry of Science Technology and Environment, Thailand.
5. Sudto Amnaj. 1998. Information System for Supporting Oil Spill Combating Strategies. Thesis of Master Degree. Mahidol University, Thailand.
6. Suksomjit M. 1999. A Suitable Method to Reduce the Waste from Shrimp Culture. Paper Prepare for The Integrated Environmental and Water Management Course. VKI, Horsholm, Denmark.
7. Thailand Institute of Scientific and Technological Research. 1998. Study to Determine the Pattern of Marine Ecotourism Management, Tourism Authority of Thailand, Thailand.
8. Office of Environmental Policy and Planing. 1997. Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, 1997-2016. Ministry of Science Technology and Environment, Thailand.
9. Frankel, Ernst G. 1995. Ocean Environmental Management. Prentice-Hall, Inc.
10. Grundlach, E.R., M.O. Hayes. 1978. Vulnerability of Coastal Environments to Oil Spill Impacts. Marine Tech. Soc. Tour. 12(4): 18-27.
11. Halls, J., J. Michel, S. Zengel, J.A. Dalin, J. Petersen. 1997. Environmental Sensitivity Index Guidelines. National Oceanic and Atmospheric Administration (NOAA), USA.
12. Pollution Control Department. 1998. Oil Spill Environmental Recovery Plan, Prepared under a Project on 'Development and Verification of Mathematical Model for Prediction of Oil Spill Movement'.
13. Permanand Nasihgh and Shari Jurawan. 1999. Environmental Sensitivity of Tropical Coastline (Trinidad, West Indies) to Oil Spill. Spill Science & Technology Bulletin, Vol. 5. No.2, page 101-172.
14. S.A. Drury. 1998. Images of the Earth A Guide to Remote Sensing. 2nd edition, Oxford University Press, Oxford Science Publications, New York, USA.
15. Bo Rindgard. 1999. Coastal Environment Sensitivity and Coastal Environment Sensitivity Index for Oil. Workshop on Coastal Sensitivity Mapping Project with its Application for Pollution Surveillance and Contingency Planning. Pollution Control Department, 10-11 August 1999, Bangkok, Thailand.
16. K.G. Hellstrom. 1999. Relevance of Sensitivity Classification System for Other Pollutants than Oil and Use of Environmental Sensitivity Maps/Databases for ICZ Planning. Workshop on Coastal Sensitivity Mapping Project with its Application for Pollution Surveillance and Contingency Planning. Pollution Control Department, 10-11 August 1999, Bangkok, Thailand.
17. National Oceanic and Atmospheric Administration. Environmental sensitivity Index. <http://www.csc.noaa.gov>
18. European Union for Coastal Conservation. Pan-European Code of Conduct for Coastal Zones. <http://www.eucc.nl/cstlcod/ccode/>



Table 1 : Database Features for Coastal Environment Sensitivity Index to Oil Pollution

Physical Features	Ecological Features	Human Features	Contingency Planning Features
1. Mud Flat	13. Mangrove Area	25. Tourist / Recreational Site & Beach	44. River
2. Sand Flat	14. Coral Reef	26. Sacred/Historical Site	45. Canal
3. Sandy Beach	15. Seagrass Bed	27. Salt Pan	46. Other Water Body
4. Muddy Sand Beach	16. Seaweed Bed	28. Aquaculture	47. Helipad
5. Sandy Gravel Beach	17. Pollution Control Area	29. Intensive Fishing Ground	48. Road
6. Gravel Beach	18. Environmental Protected Area	30. Village	49. Railway
7. Rocky Beach	19. Rare/Endangered Species Site	31. Urban Area	50. Airport
8. Cliff	20. Lagoon	32. Industrial Area	51. Break Water
9. Shoreline Slope	21. Peat Swamp forest	33. Deep Sea Port	52. Shipping Lane
10. Muddy Beach	22. Marsh	34. Commercial Habour	53. Lighthouse
11. Shoreline Exposure	23. Estuary	35. Fishing Port	54. Anchorage
12. Delta Formation	24. Forest	36. Recreational Port	55. Buoy
		37. Habour Limit	56. Bathymetry
		38. Water Intake	57. Oil & Gas Platform
		39. Dock	58. Bottom Sediment
		40. Ferry	59. Oil & Gas Terminal
		41. Pier & Jetty	60. Oil & Gas Depot
		42. Groin	61. Oil Refinery
		43. Rip Rap	62. Gas Separation
			63. Oil Spill Equipment Stockpile
			64. Pipeline Route
			65. Cable Route
			66. Tidal Zone



Table 2 : Database Features for Integrated Coastal Zone Management

Physical Resources	Biological Resources	Human Use Values	Quality of Life Values
1. River	32. Rare/Endangered Species Site	50. Aquacultural Area	96. Tourist / Recreational Site & Beach
2. Canal	33. Mangrove Area	51. Agricultural area	97. Sacred / Historical Site
3. Other Water Body	34. Coral Reef	52. Salt Pan	98. Religious Site
4. Bare Soil	35. Seagrass Bed	53. Village	
5. Mud Flat	36. Seaweed Bed	54. Urban Area	
6. Sand Flat	37. Forest	55. Industrial Area	
7. Sandy Beach	38. Grassland	56. Irrigation Canal	
8. Muddy Sand Beach	39. Bush Land	57. Dam/Reservoir	
9. Sandy Gravel Beach	40. Peat Swamp Forest	58. Pollution Control Area	
10. Gravel Beach	41. Marsh	59. Environmental Protected Area	
11. Rocky Beach	42. Lagoon	60. Military Practice Area	
12. Muddy Beach	43. Estuary	61. Marine Dumping Ground	
13. Cliff	44. Nursing Ground	62. Mining Area	
14. Bathymetry	45. Feeding Ground	63. Land Fill Site	
15. Bottom Sediment	46. Breeding Ground	64. Helipad	
16. Shoreline Slope	47. Dominant Species	65. Road	
17. Shoreline Exposure	48. Plankton	66. Railway	
18. Erosion Process	49. Benthic Fauna	67. Airport	
19. Delta Formation		68. Deep Sea Port	
20. Tidal Zone		69. Commercial Harbour	
21. Rainfall		70. Fishing Port	
22. Water Quality		71. Recreation Port	
23. Water Sampling Station		72. Harbour Limit	
24. Sediment Sampling Station		73. Shipping Lane	
25. Tissue Sampling Station		74. Anchorage	
26. Wind Direction and Speed		75. Oil & Gas Platform	
27. Current		76. Buoy	
28. Water Depth		77. Rip-Rap	
29. Water Level		78. Break Water	
30. Air Temperature		79. Dock	
31. Water Temperature		80. Ferry	
		81. Pier & Jetty	
		82. Groin	
		83. Fishing Ground	
		84. Water Intake	
		85. Oil & Gas Terminal	
		86. Oil & Gas Depot	
		87. Oil Refinery	
		88. Gas Separation	
		89. Oil Spill Equipment Stockpile	
		90. Pipeline Route	
		91. Cable Route	
		92. Hotel and Resort	
		93. Power Plant	
		94. Flood Protection	
		95. Lighthouse	



Table 3 : Possible Impacts from 5 Pollutant Types

Database Features	Oil & Floating Pollutants	Dissolved Toxic/ Pathogenic/ Organic	Sediment Particle/ Suspension	Temperature	Physical Destruction
1. River/Canal/Other Water Body/ Irrigation Canal		Y	Y	Y	Y
2. Mud Flat	Y		Y		Y
3. Sandy Beach	Y		Y		Y
4. Muddy Sand Beach	Y				
5. Sandy Gravel Beach	Y				
6. Gravel Beach	Y				
7. Rocky Beach	Y				
8. Muddy Beach	Y		Y		Y
9. Bottom Sediment		Y	Y		Y
10. Rare/Endangered Species Site	Y	Y	Y	Y	
11. Mangrove	Y	Y	Y	Y	Y
12. Coral Reef	Y	Y	Y	Y	Y
13. Seagrass Bed	Y	Y	Y	Y	Y
14. Seaweed Bed	Y	Y	Y	Y	Y
15. Peat Swamp Forest					Y
16. Marsh	Y				Y
17. Lagoon		Y	Y		Y
18. Estuary	Y	Y	Y	Y	Y
19. Fisheries Ground	Y	Y	Y	Y	Y
20. Dominant Species	Y	Y	Y	Y	Y
21. Plankton	Y	Y	Y	Y	Y
22. Benthic Fauna		Y	Y	Y	Y
23. Aquaculture		Y	Y	Y	Y
24. Salt Pan	Y		Y		Y
25. Village		Y			Y
26. Urban Area		Y			Y
27. Industrial Area		Y			Y
28. Environmental Protected Area	Y	Y	Y	Y	Y
29. Port	Y		Y		
30. Shipping Lane	Y		Y		Y
31. Anchorage	Y		Y		Y
32. Oil & Gas Platform	Y				Y
33. Oil & Gas Facility	Y				Y
34. Pipeline Route					Y
35. Cable Route					Y
36. Hotel and Resort	Y	Y	Y		Y
37. Power Plant			Y	Y	
38. Tourist / Recreation Site & Beach	Y		Y		Y
39. Sacred / Historical Site	Y		Y		Y
40. Religious Site	Y				Y



Appendix A

Indonesian Marine Environmental Sensitivity Ranking to Oil Pollution

In 1984, Indonesia developed a marine environmental sensitivity index with assistance from the Government of Canada. A national oil spill vulnerability map was produced by Salm and Halim.

Sensitivity Ranking	Habitat	Oil Spill Sensitivity Characteristics
1*	Coral Reefs	Delicate coral-algal symbiosis and diverse associated coral reef flora and fauna; recovery of coral from severe oiling may take up to 5-10 years or 20-25 years for re-establishment of complete reef ecosystem; sensitive to dispersants
2	Mangroves	Important nursery areas for commercial fish and shrimp species and supports detritus-based food chain; protects shoreline from erosion; oil may persist in mangrove habitat, especially where tidal flushing is reduced; recovery may take several years; sensitive to dispersants
3	Estuaries	Important productive habitat for aquatic organisms; high socio-economic importance in larger estuaries; difficult to adequately mitigate oil spills in estuaries
4	Tidal Flats	Productive biological habitat; high organic matter content of sediment will increase persistence; natural clean-up recommended
5	Seagrass Beds	Productive habitat and diverse associated flora and fauna ⁷ usually located in subtidal and not affected directly; contaminated bottom sediments may cause damage; recovery may take several years; sensitive to dispersants
6	Upwelling Zones	Nutrient-rich water support concentrations of pelagic and benthic organisms; sensitive to dispersants
7	Sandy Shores	Impacts vary according to substrate type, etc.
8	Rocky Shores	Wave action and tidal flushing reduce the impacts associated with oil spills

* 1 is the most sensitive.



Proposed Marine Habitat Sensitivity Ranking System for Indonesia

In 1993, the Environmental Management and Development in Indonesia Project (EMDI) proposed a new marine environment sensitivity ranking, which incorporates the existing Indonesian system and the American Petroleum Institute system. The proposed system also incorporates habitat grouping instead of a linear ranking series.

Sensitivity Ranking	Habitat Type
High	Mangrove Forest Coral Reef (intertidal*) Seagrass Meadow (intertidal) Sheltered Mud Flat Sheltered Rocky (carbonate or volcanic) Intertidal Special Use (e.g. endangered species, tourist resort, coastal village, marine protected area)
Medium-High	Seagrass Meadow (subtidal*) Coral Reef (subtidal)
Medium	Open Water (enclosed bays/habours)
Low-Medium	Exposed Sandy/cobble Beach
Low	Exposed Rocky Intertidal Swamp Forest (Landward of Mangrove Forest) Open Water (not enclosed) Soft Bottom Subtidal

* Intertidal and subtidal in this table, refer to water depth up to 5 and more than 5 meters below low water spring tide respectively, because of Indonesia's enclosed seas.



Vulnerability Index – Eastern Coastal Malaysia

Thai-Eng (1984) has developed an oil spill vulnerability index for eastern peninsula Malaysia. The Index relates largely to shoreline characteristics, special community types (e.g. mangroves), species (e.g. sea turtles) and habitat utilization (e.g. fish migration routes) strongly influence index values.

Vulnerability Index	Habitat	Habitat Characteristics
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Intertidal (littoral) Habitats

10*	Saltwater Swamps (Mangrove swamps)	Soft bottom, muddy, sandy mud; biologically productive; tidal influence; salinity 25 ppt
9-10	Freshwater/Brackish water Swamps (Nipa/Mangrove & Nipa only Swamp)	Partially intertidal; soft bottom, muddy, sandy mud; moderately productive; tidal influence reduced; salinity 1 to 25 ppt
8-9	Mudflats	Usually exposed at low tide; muddy or sandy bottom with fine silt; biological rich; tidal influence; salinity 20 to 30 ppt
5-9	Sandy Beaches	High wave energy; biologically non-productive; nesting grounds for marine turtles; salinity > 32 ppt
2-3	Beaches	Sandy; high wave energy; biologically non-productive; salinity > 32 ppt
1-2	Rocky Shores	High wave energy; moderately rich in animal diversity; salinity > 32 ppt

Subtidal (sublittoral) Habitats

7-8	Marine-influenced lagoons	Depth 1 to 5 m; marine if lagoon shallow & exposed to sea water inlets; biologically rich; salinity 29 to 33 ppt
6	Tidal Estuaries	Marine influence pronounced; soft bottom, muddy or sandy mud; biologically rich; low runoff from rivers; salinity 15 to 32 ppt
5-6	River-influenced Lagoons	Shallow, 1 to 2 m. deep; soft or sandy; freshwater influence; salinity 1 to 15 ppt
4-5	Bays	Shallow, 1 to 2 m.; soft bottom with mud & silt; tidal & wave influence; salinity 25 to 33 ppt
4-5	Coral Reefs	Moderately deeper water > 6 m.; seldom exposed, high energy; salinity 34 ppt
4	Tidal Estuaries	Marine and freshwater influence pronounced; environmental conditions highly variable; soft bottom, muddy or muddy sand; moderately rich; high runoff from upstream; salinity 15 to 33 ppt
1	Open Coasts	Deep; high wave energy; turbulent; shifting sand; salinity > 33 ppt

* 10 is the most vulnerable



Coastal Environmental Sensitivity Index for Vietnam

The Coastal Sensitivity Mapping Project(1996), as part of Vietnam National Marine Pollution Control Programme (VNMPCCP), developed CESI ranking system considering sensitivity of coastal environments in term of interaction of the oil with ecological habitats, coastal geology and agricultural practice.

Sensitivity – CESI	Coastal Resource Classification	Shoreline Classification
High	Mangroves Freshwater Marsh Saltwater Marsh Dense Agriculture – Rice Dense Agriculture – Mixed Aquaculture Village	Sheltered – Coarse sand beach Mixed sand/gravel beach Gravel beach
Medium-High	Mud Flat Salt Pan Lagoon Small River and Stream Broad River Fresh Water Body Urban Area	Medium – Coarse sand beach Mixed sand/gravel beach Gravel beach Sheltered – Silt/mud beach Tidal flat Fine grained sand beach
Medium	Forest – Dense Sedge Plantation Sparse Agriculture Industrial Land Commercial Harbor Airport	Medium – Silt/mud beach Tidal flat Fine grained sand beach Sheltered – Rocky shore Cliffs Rock wave-cut platform Human modified beach Exposed – Coarse sand beach Mixed sand/gravel beach Gravel beach
Low-Medium	Sand Flat Forest – Sparse Grassland/Bushland	Medium – Rocky shore Cliffs Rock wave-cut platform Human modified beach Exposed – Silt/mud beach Tidal flat Fine grained sand beach
Low	Barren Land	Exposed – Rocky shore Cliffs Rock wave-cut platform