Oil Spill Management via Decision Support System

Shattri MANSOR and Seyedeh Zahra POURVAKHSHOURI, Malaysia

Key words: Oil spill management, Geographical Information System (GIS), Decision Support System (DSS), Urban Planning.

SUMMARY

Oil pollution is one of the most important imbalancing problems affecting, specially, marine coastal environments in all over the world. Study in the field of integrated management in both inland and marine authorities, oil pollution prevention and cleanup, and using computer facilities, like Geographical Information System (GIS) and decision support system (DSS) for management plans are among the challenges, which attract the attention of many researchers. And building ease to decision making is one interesting case in this information-based century.

Main sources for oil pollution and spillage are resulting from exploitation, extraction, transportation and / or disposal activities. In the case of occurrence of oil pollution in any environment, the first activity shall be determination of priorities for protection against the pollution. Prioritization is based on environmental sensitive areas location, spillage point and its distance from the ecological and human resources areas, kind and amounts of occurred oil pollution, in addition to the time of pollution which, influence the decision making process in both Coastal Area Management and Urban Development Planning.

Making a multi-criteria decision support system, briefly, is the main aim of this project to advise the user for choosing the most reasonable method for prevention, control, and/ or cleanup way against the oil spills pollution. It will be an advisory service to determine the priorities in emergency response conditions, that was planned according to the coastal sensitive areas in the Malaysian coastlines.

Oil Spill Management via Decision Support System

Shattri MANSOR and Seyedeh Zahra POURVAKHSHOURI, Malaysia

1. INTRODUCTION

Oil spills are serious environmental disasters often leading to significant, long-term impacts on the environment, ecology and socio-economic activity of area. World-wide from 1978 to 1995, there were more than 4100 major oil spills of 10,000 gallons or more (Etkin & Welch, 1997). Several serious oil spill incidents also have taken place since 1995, notably examples like Sea Empress in which approximately 5000 tons of oil reached the UK coastline (Li, et. al. 2000). Oil spills also have many inland examples in industrialised cities. For example a city like Toronto, has an average 300- 500 oil spills per year with an average total volume of about 160,000 L/year (Li, 2001).

Different contaminated sites have different characteristics depending on pollutants' properties, hydrological conditions, and a variety of physical, chemical, and biological processes. Thus, the methods selected for different sites vary significantly. The decision for a suitable method at a given site often requires expertise on both remediation technologies and site conditions (Geng, et al., 2001). Management of emergencies, resulting from natural or man-made disasters, requires enough information as well as experienced responders both in technical and co-ordination matters. In this way, a great amount of information should be used to improve the management of the emergency, which generally means making the best decision at the right moment (Hernandez & Serrano, 2001).

Including more than 4670 km coastal borders with valuable mangrove swamps, shrimp prawns, birds' breed and nesting areas, turtles egg laying as well as recreation and tourist resorts, has formed Malaysia as a big and important of coastal natural resources. Malaysia's coastal waters also experience oil pollution from bilge pumping, as well as from tank cleaning, which leads to dumping of oil and sludge by ocean going vessels. Collisions and groundings of ocean-going tankers also cause oil pollution. All these encouraged the researchers to create an intelligent system for assisting the managers in process of decision making in the case of oil spill happening.

2. OIL SPILL DECISION MAKING AND GIS

Decision-making is a complex process, influenced by many factors, both human and non-human. Academic research in the Decision Support System (DSS) field dates from the work of Gorry and Scott-Morton in 1971 (Keenan, 1997). A DSS may be defined as an integrated, interactive and flexible computer system that supports, not replace, all phases of decision-making with a user-friendly interface, data and expert knowledge (Fabbri, 1998).

In recent years geographical information systems (GIS) have been increasingly used in conjunction with oil spill modeling tools as a means of integrating and pre-processing spatial data inputs to the numerical modeling and for post-processing and visualization of the modeling outputs. The integration of GIS and environmental modeling is now widely accepted as desirable, if not essential. Of considerable discussion and research has been the level of coupling achievable or desirable between GIS and environmental models (Li, 2000).

Some, but by no means all, recent DSS textbooks are including GIS as a component of management support systems (Fabbri, 1998). GIS software provides a link between the interface and database to allow the user to easily query spatial data. Or even it can be used as a Decision Support System (DSS) generator to create Spatial Decision Support Systems (Keenan, 1997).

The ability of GIS to handle much larger database and to integrate and synthesize data from a much wider range of relevant criteria than might be achieved by manual methods; encouragement for the development and use of standards for coastal data definition, collection, and storage; the use of a shared database, to facilitate updating of records; and ability to model, tests, and compares alternative management scenarios, before a proposed strategy is imposed on the real world (Bartlett, 2000), made it a suitable program to produce the DSS engine for this project.

Some of the information, e.g. geographical, ecological, legal, containment, and clean-up equipment, and environmental sensor locations, can be acquired and organized in advance, typically through a GIS. Other types of information, e.g. winds, waves, currents, vessels traffic, and fishing fleet operations, must be dealt with in real time (Douligeris et al. 1995).

Decision Support System (DSS) serves a central role in all aspects of tactical operations. We tried to wrap traditional methods of DSS, GIS, database systems and interface shells, in an intelligent Decision Support System which can connect these in a higher level and provide a number of services. The results from case studies indicate that the expert system can help the environmental engineer to identify the optimal alternatives for pollution prevention and cleanup method selection processes and thereby help to reduce the costs for cleaning practices.

3. OIL SPILL MANAGEMENT AND URBAN PLANNING

Oil spills in industrialized cities pose a significant threat to their urban water environment. The degree of success in clean up and spill management is dependent on the urban development planning. Considering the adverse impacts of this kind of pollution in urban waters, it is important to develop an effective pollution prevention and control plan for the cities. A Geographic Information System (GIS) planning model can help to characterize oil spills records and determine preventive and control measures available and needed in city. Additionally, the graphical capability of GIS allows users to integrate environmental features and spill characteristics in the management analysis (Li, 2001).

In this regard, installing a database including all oil pollution records with exact geo-referenced locations should be compiled. This database also must include the attributes of each record such as spill volume, oil type, location, road type, sector, source, cleanup percentage in each case, and environmental impacts. So, in any new case can use the previous experience.

Of course, urban planning also needs the information about the sensitive points, especially underground water and sewage routes, which can be threatened in the case of any pollution. Indeed, the required equipments, network access and stock places of materials and equipments, the traffic pick hours and the emergence routs, which can be accessed during any disaster happening time have to be clarified.

4. METHODOLOGY

Considering the proposed contingency plan scheme in this project illustrates Decision Support System constitutes the central nucleon of this plan, which receives all information from different groups of contingency team. Decision Support System provides an easily understandable assistance for non-technical decision makers to be able to find the best managing method in the least time.

Comparing the various DSS models indicates they classify the user duties under these categories: defining the present condition of environment, identifying the conflicts or problems that environment face to them, and introducing the alternative solutions. According to this classification, the duty of DSS of oil spill management project also was considered as shown in figure 1. It shows the general model suggested for in hand project for oil spill management and figure 2 displays the more developed design for it (Pourvakhshouri & Mansor, 2003).

Knowledge engineering for constructing the decision support system on oil spill management involves three stages: knowledge acquisition, conceptual design, and system implementation. In the knowledge acquisition phase the objects and decision processes were clarified and determined. In the conceptual design stage, the knowledge was formalized and represented with various representation methods, such as decision trees and fuzzy membership functions. Then the formalized knowledge was represented in production rules in the knowledge base of the system.

Regarding to the project's proposed aims, some criteria such as: - availability of more data with manageable volume; having the environmental sensitivity in both natural and human activity form; expose to oil related activities with pollution occurrence history; were considered for choosing the primary study area. So, the study area has been selected in the Straits of Malacca from Pontian Kechil Johor Baru to Melaca Town (as can be seen in Fig. 3).

If the system is described simply, it can establish a linkage between spilled oil characteristics and location, shoreline sensitivity (based on physical, biological, and human activity resources), and also the different clean-up methods. This linkage is provided by a GIS program, which works as a friendly user tool.

5. CONCLUSION

Since spill response actions are to be carried out with all deliberate speed, in the milieu of independent agents it becomes critical that the individual elements of the system be able to provide suggestions in real (event) time, even in the absence of complete, totally reliable situation knowledge. We would like to provide a reasonable 'any-time' deduction mechanism so that in all but the most extreme cases some reasonable action can be put forward.

ACKNOWLEDGEMENT

This work was funded by IRPA grant from the Ministry of Science and Technology, Malaysia.

REFERENCES

Bartlett, D.J. 2000. Working on the frontiers of science: Applying GIS to the coastal zone. Book of "Marine and coastal geological information systems". pp. 11-24. UK

Douligeris, C. et al. 1995. Development of OSIMS: an oil spill information management system. Spill Science & Technology Bulletin, Vol. 2, No. 4, pp. 255-263.

Etkin, D.S., & Welch, J. 1997. Oil spill intelligence report international oil spill database: trends in oil spill volumes and frequency. Proceedings 1997 International Oil Spill Conference, pp. 949-952.

Fabbri, K.P. 1998: A methodology for supporting decision making in integrated coastal zone management. Journal of Ocean & Coastal Management. 1998: vol. 39, pp. 51-62.

Geng, L.; Z. Chen; C.W. Chan; G.H. Huang. 2001. An intelligent decision support system for management of petroleum contaminated sites. Expert System with Applications. Vol. 20, pp. 251-260.

Hernandez, J.Z.; J.M. Serrano. 2001. Knowledge-based models for emergency management systems. Expert Systems with Applications, Vol. 20, Issue 2, pp. 173-186.Elseviet Science Ltd.

Keenan, P. 1997: Using a GIS as a DSS generator. Department of Management Information Systems, University College Dublin, Working paper MIS 95-9, 1997.

Li, J. 2001. A GIS planning model for urban oil spill management. Water Science and Technology: a journal of the international association on water pollution research. Vol. 43, Issue 5, pp. 239-244.

Li, Y.; Brimicombe, A.J.; Rlphs, M.P. 2000. Spatial data quality and sensitivity analysis in GIS and environmental modeling: the case of coastal oil spills. Computers, Environment and Urban Systems, Vol. 24, Issue 2, pp. 95- 108.

Pourvakhshouri, S.Z.; S. Mansor. 2003. Decision support system in oil spill cases (literature review). Disaster Prevention and Management, Vol. 12, No. 3, pp. 217- 221.

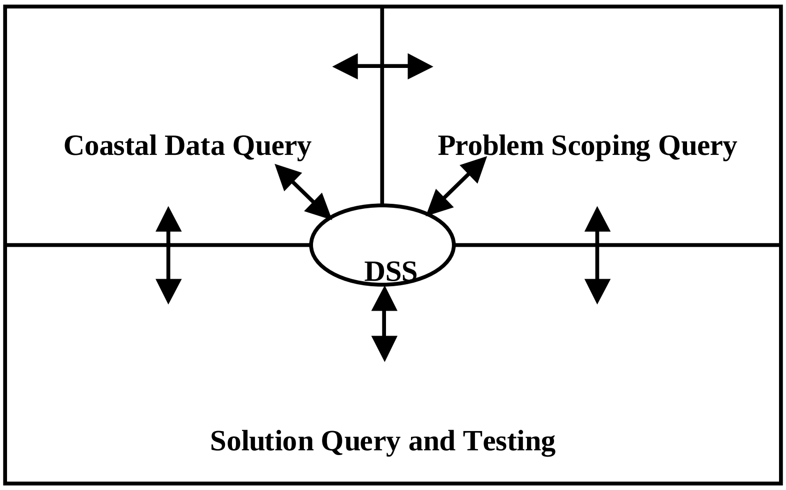

Fig. 1: Suggested simple model for Oil Spill Management

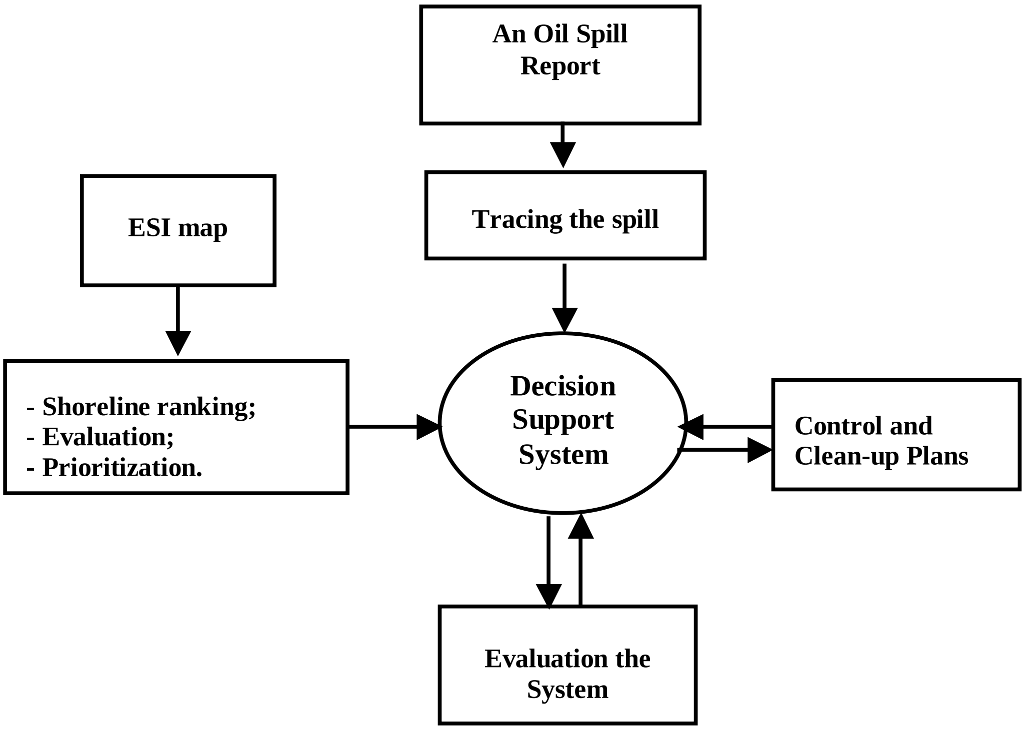

Fig. 2: Proposed Decision Support System in oil spill management plan

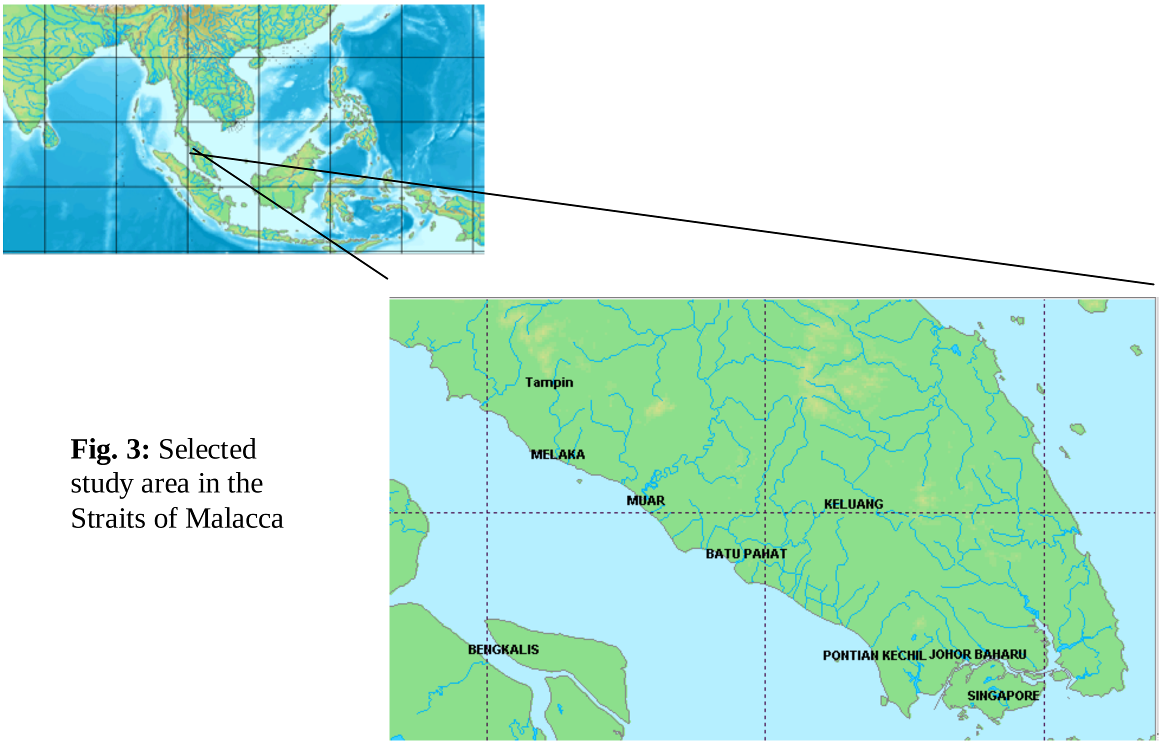

Fig. 3: Selected study area in the Straits of Malacca

BIOGRAPHY

Dr. Shattri Mansor, is the head of the Spatial and Numerical Laboratory, Institute of Advanced Technology, Universiti Putra Malaysia. Dr. Shattri maintains a diverse research interest including image processing, remote sensing, GIS and visualization. His major research effort includes feature extraction from satellite imagery, spatial decision support system for fish forecasting, oil spill detection and monitoring system.

Dr. Shattri has published over 150 articles in journals and conference proceedings. Dr. Shattri holds membership to various organizations and institutions. He is currently an executive committee for Malaysian Remote Sensing Society, an executive committee for the Institution of Surveyors Malaysia (LS Division), member of IEEE. He is currently the Editorial Board member of the Journal of the Malaysian Surveyor and Malaysian Journal of Remote Sensing and GIS.

Seyedeh Zahra Pourvakhshouri, Iranian PhD student in Institute of Advanced Technology, University Putra Malaysia, is working on GIS-based decision support system for oil spill management in the Straits of Malacca, Malaysia.

S. Zahra Pourvakhshouri has gotten her Bachelor and Master of Science in Geology from University Teacher Training and Tehran University, both in Iran capital city, Tehran. She has more than 30 published papers in journals and conferences and 10 years working experience in Marine research Bureau, Department of Environment in Iran.

CONTACTS

Assoc. Prof. Dr. Shattri Mansor
Head, Spatial & Numerical Modeling Laboratory
Institute of Advanced Technology
Universiti Putra Malaysia
43400 Serdang
Selangor
MALAYSIA
Tel. + 603 8946 7543
Fax + 603 8656 6061
E-mail: shattri@eng.upm.edu.my

Seyedeh Zahra Pourvakhshouri
Institute of Advanced Technology,
University Putra Malaysia
43400, Serdang,
Selangor
MALAYSIA
Tel. + 603 7347 1577
Fax + 603 8656 6061
E-mail: zp@itmail.upm.edu.my
Web site: www.geocities.com/zp_45/information_system.html