Oil Spill Response Information System : Strategies to Response to An Oil Spill

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Abstract--**Oil spills are a major environmental concern especially in the coastal regions. The accidental oil spills can pollute the coastal environment and damage marine life. Various response systems have been developed. This paper reports the progress of a research work on the development of a software tool for the purpose of responding to oil spills. This tool consists of three main modules:- the Oil Spill Trajectory Model (OSTM), the GRID system, and the decision trees as the strategies to response to oil spills. The development the OSTM was based on number of components: wind, currents, advection and spreading. The GRID system was developed for the purpose of visualizing oil spill movement. The Decision Tree module was developed as a strategy to response to oil spill. In this study, the software tool was developed using Microsoft Visual Basic and an ActiveX MapObjects. Tests on the software tool was made using data of the coastal region of Larut Matang, Perak in Malaysia. The results of the test show that the software tool is capable of providing responses based on time intervals before the oil spill reaches the coast.**

Keywords- GIS, OSTM, The decision trees as the strategies to response to oil spills.

I. INTRODUCTION

Oil spills are a major environmental concern especially in the coastal regions. The accidental oil spills can pollute the coastal environment and damage marine life. Various response systems have been developed. According to [1], there are five options for response action to an oil spill incident: (i) no action other than monitoring the oil slick, (ii) containing or recovering the oil at sea, (iii) chemical dispersion at sea, (iv) shore clean up and (v) a combination of response options. But [2] includes "in situ burning" to the above mentioned options. However, what is usually important is the choice of the most appropriate option with respect to the geographical location of the spill.

Several response tools have been developed. Generally, the tools only use GIS technology to display oil spill scenario [3]. The analytical capabilities of the technology in the processing and analyses of spatial data have been overlooked. This paper reports the progress of a research work on the development of a software tool for the purpose of responding to oil spills. This tool consists of three main modules: the Oil Spill Trajectory Model (OSTM), the GRID system, and the decision tree as the strategy to response to oil spills. Tests on the software tool was made using data of the coastal region of Larut Matang, Perak in Malaysia. The results of the test show that the software tool is capable of providing responses based on time intervals before the oil spill reaches the coast.

II. METHOD

2.1 Oil Spill Trajectory Model (OSTM)

Oil spills are subjected to a complex array of physical, chemical and biological processes. [4] categorizes the processes into (1) those relates to the location of oil spill layers, and (2) oil layers compositional change and mass lost. Advection and spreading are the two processes that have direct relationship with oil spill location. Whereas processes that concern with compositional changes and mass lost are evaporation, dispersion, dissolution, emulsification, biodegradation, oxidation and sedimentation.

Advection is a physical process that involves the drifting of the surface oil slick and the subsurface oil. Advection happens due to surface current and wind. The process is the main mechanism to determine the oil trajectory location. On the other hand, spreading is the horizontal movement of the surface oil slick due to the imbalance of forces of inertia, gravity, viscousity and interfacial tension. This process is very crucial especially at the early stage of the oil trajectory. The processes were taken into consideration during the mathematical model development.

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2.2 The Mathematical Model

Most oil spill model uses a simplified linear superposition technique [5]. This technique describes oil layer transportation speed as the summation of transportation vectors due to current, tides, wind and waves. [6] uses the technique to form a mathematical model that describe the central transfer position of oil spill:

$$\mu = \alpha V_w + \beta V_c \quad (1)$$

Where μ = oil layer movement vector.
V_W = wind speed vector.
V_C = surface current speed vector.
α = wind parameter function.
β = current parameter function.

For areas that are influenced by tides, [7] recommended the use of tidal data instead of surface current. In this case, the parameters have to be suitable to the area concerned. [6] also states that "Ekman effect" will sometimes occur and the effect describes the oil spill diversion. The direction for the diversion could be toward the left or right and the magnitude is between 08 to 258.

A number of theories have been proposed for the process of mechanical spreading in open waters [8]. These theories have facilitated the determination of oil spill radius. The purpose of the radius is to simplify the determination of oil spill size. In this study, formula (2) which was originally put forward by Fay but later expanded by [9] was used :

$$A = 2.27\,[(\rho_w - \rho_o)/\rho_o]^{2/3}\, V^{2/3}\, T^{-1/2} + 0.04[(\rho_w - \rho_o)/\rho_o]^{1/3}\, V^{1/3}\, W^{4/3}\, T \quad (2)$$

Where A = Oil spilled size.
ρ_w = water density.
ρ_o = oil density.
V = Oil spilled volume.
t = time.

2.3 A Decision Tree

When oil spill occurred, a decision on the type of response has to be made. The decision is usually influenced by several factors: (i) the type of oil spilled, (ii) the determination of oil spill trajectory for certain interval of time, (iii) aerial reconnaissance to obtain detail description of oil spill, (iv) determination of resources under threat, and (v) information to those that will be affected. These factors will always influence the choice of option for response action. Figure 1 shows the decision tree developed for this study.

III. DEVELOPMENT OF SOFTWARE TOOL

File design represents the initial step to the development of OSTM and the decision tree. The files consist of spatial and attribute files. Figure 2 shows the relationship of spatial entities. The figure shows that there are four spatial files : (i) layer (00) – Spatial Grid for wind, tides and waves, (ii) layer (01) – Sea; (iii) layer (02) – Land; and (iv) layer (03) – Sea depth. The attribute file consists of wind speed vector for both horizontal and vertical direction, the current speed vector also for the vertical and horizontal direction and waves. The OSTM, the combination of equation 1 and 2, was incorporated in GIS. The final model of OSTM was developed using Microsoft Visual Basic 6.0 and MapObjects.

The spatial files were formed using AutoCad before being converted in ArcView files. In the formation of Grid files, the study used MapBasic Programming tool. The size of this grid is 8 km square. The OSTM operates on the basis that the spill moves from one grid square to another. When oil spill movement happened the oil spill position is arranged to be on the next grid square. Therefore the spill movement is arranged based on the attribute data of each grid square. Figure 3 shows the oil spill movement produced by the developed OSTM.

Figure 4 and 5 show the option on how to respond to the oil spill when the decision tree program was activated. The implementation of the decision tree program was based on diagram in figure 1. However, the decision tree program could only function if adequate data and information are made available.

IV. CONCLUSIONS

Oil Spill Trajectory Model (OSTM) and Decision Tree are required for formulating a strategy to response to an oil spill incident. In this study, the model and the decision tree were developed using MapObjects and MS Visual Basic. Spatial and attribute data were used to provide spatial and graphical visualization of the spill movement for a given time interval. The tests show that the software tool is capable of providing responses based on a given time interval before the oil spill reaches the coast.

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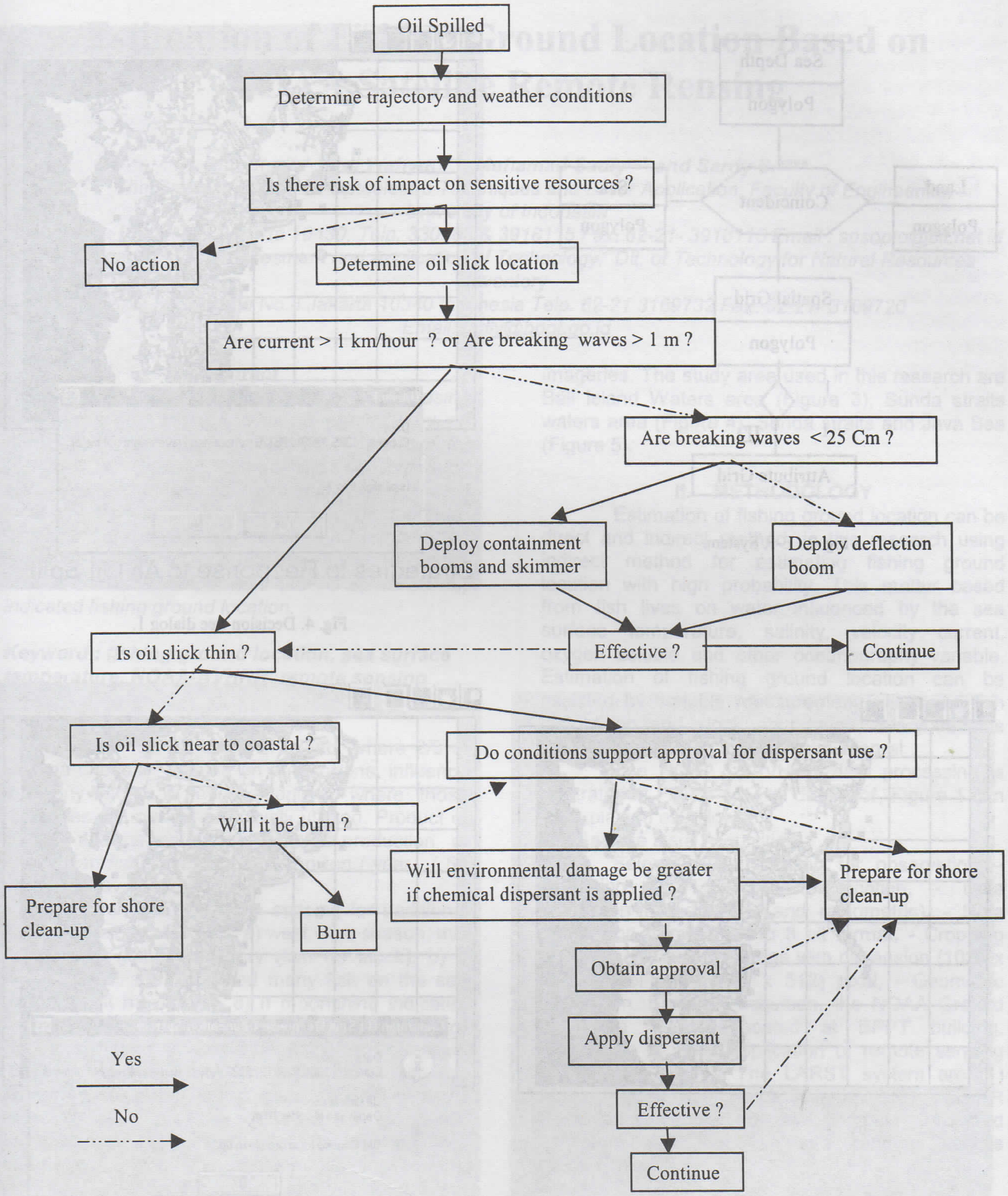

Fig. 1. Oil Spill Response Decision tree.

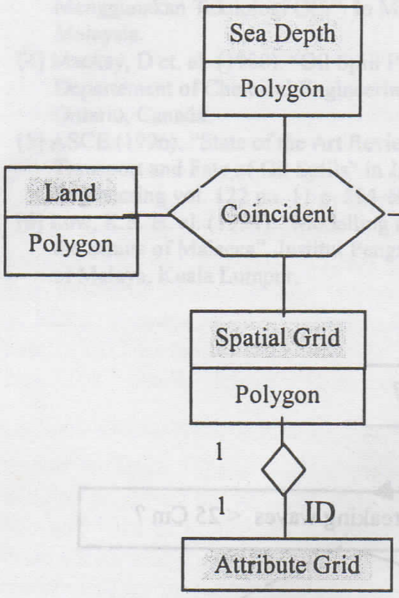

Fig. 2. E-R System.

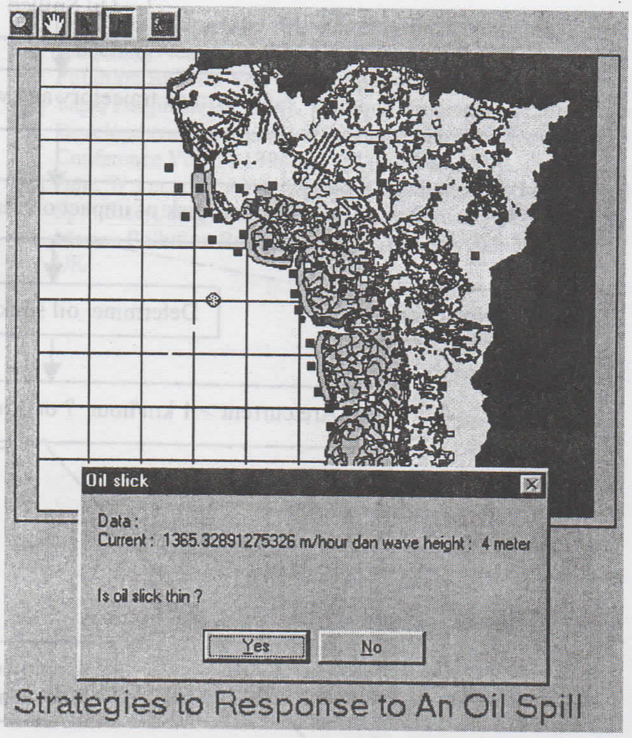

Fig. 4. Decision tree dialog 1.

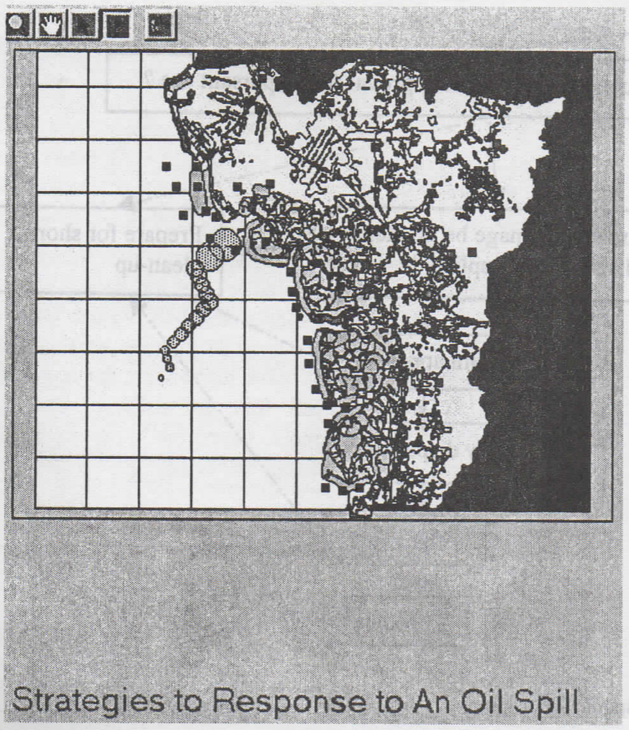

Fig. 3. Oil spill trajectory.

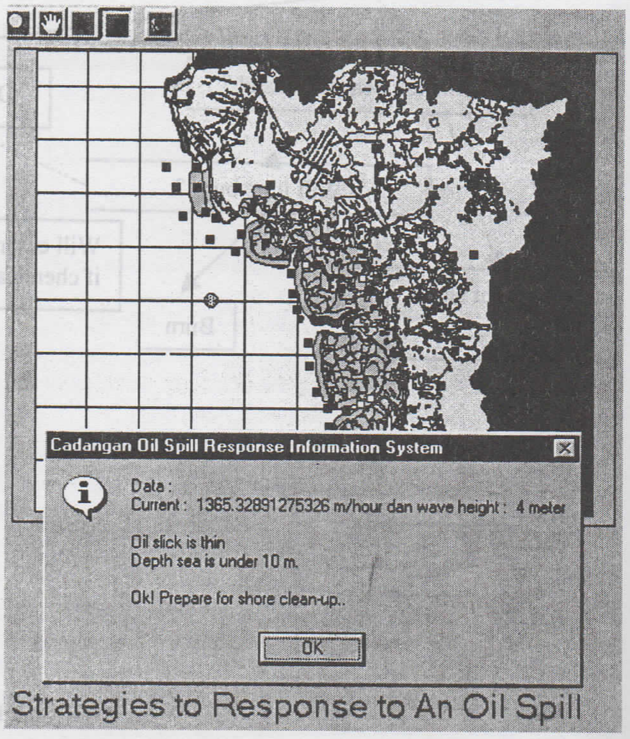

Fig. 5. Decision tree dialog 2.