STUDY ON THE CATCHMENT SCALE DISASTER MANAGEMENT SYSTEM USING GIS TOOLS

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***ABSTRACT*:** It is important to establish a catchment disaster management for understanding flood and landslide risk in mountain areas. Sustainable catchment disaster management should be based on an appropriate understanding of catchment processes including flood hydrology, flood routing, hydrogeology and geomorphology, and the ability to predict flood and landslide through modeling the effects of flood defense, land use change and etc. The catchment disaster management system must own a powerful capacity to deal with many types of information and a large amount of data. In such a case, geographic information system (GIS) technique is the ideal analysis software and management tool to build the disaster management system. This study is exploring solutions to the flood problems and trying to address the processes of flood through the catchment management system using GIS tools. The GIS based simulation tool was developed to simulate runoff for the example area and several storms were used to test the model. The simulation GIS tool calculated the peak discharge and runoff with acceptable accuracy for the object catchment. In summary, the main goal of this study is to provide a GIS management tool to help users to achieve a better management of the disaster in the mountain area.

***KEYWORDS*:** catchment scale, disaster management, GIS

1. INTRODUCTION

In recent years, many regions in the world have experienced considerable changes in meteorological conditions and land use, which led to increased flood level and frequency. These extreme floods caused severe disasters such as loss of life, property and resources but these adverse effects can be prevented or at least, minimized and also the future development and planning might be more feasible if the occurrence and magnitude of the flood can be predicted and managed systematically (Halina wati Hirol ,et al, 2002). As it is known that floods often occurs when a rainstorm generates a large amount of runoff that overtops the banks of a watercourse and flows onto the flood plain which is a desirable place to locate homes and business. And these high flows or floods generally cause damages and sometimes, injuries and deaths (Hoggan, 1989). Being the main part of floods, storm runoff in catchment is first of all critical so that it is important to construct a catchment disaster management to understand better flood and landslide risk in mountain areas. The formulation of a sustainable water management plan involves a multi- disciplinary scientific approach and profound study of the local region's characteristics such as hydrologic, geologic, socio economic, etc(I. Zacharias, E. Dimitriou, Th.Koussouris,2005). And also understanding natural disturbance regimes on the environment and eliminating the new forth-coming nuisances from human interventions are crucial foundations for designing catchment disaster management systems (Nakamura et al., 2000).

Recently the integration of environmental models with geographic information system (GIS) has been discussed by many authors (Goodchild et al., 1992, 1993, 1996; Fotheringham and Rogerson, 1994; Fischer et al., 1996; Longley and Batty, 1996). Information transfer is undertaken automatically either via pre and post-processor routines added to the external model or through a common graphic user interface (Lieste et al., 1993; El Kadi et al., 1994; Tim and Jolly, 1994; Sui and Maggio, 1999). Catchment disaster management system analysis can also be greatly helped by the utilization of the advance GIS technology which presents a consistent environment for data management, query and visualization for building risk analysis and decision support systems that provide integrated access to otherwise incompatible external analytical tools (Burrough and McDonnell, 1998). Incorporation of

Table 1. Data name, type and spatial attribute which are used in this study

Data name	Data type	Spatial attribute
Meteorological data	Gauging station, monitoring site	Point
Topographic data	Elevation, slope, hillshade, etc.	Grids
	Elevation contour, catchment boundary	Line
Hydrological data	Stream, river, lake, etc.	Line
	Flow direction, catchment area	Grids
	Rainfall, runoff, evapotranspiration	Grids
Geological data	Urban area, solid geology	Polygon
	Slope line, etc.	Raster (grid)
Land use data	Land use boundary	Vector (shape file)
	Soil number	Attribute table
Agriculture data	Agriculture boundary	Line
	Land cover	Grids
Social-economic data	Statistical information	Girds
Base map	View figures, etc.	Image

catchment models into a GIS has improved matters by streamlining data input and providing better interpretation of model outputs (David Pullar, Darren Springer, 2000). It is the most advanced technologies which give excellence opportunities for the application of spatial analysis and an established natural resource management tool which is classified as an information technology to solve various spatial problems (Tim et al 1996). Furthermore, the contribution what GIS can make to many aspects of catchment management project is becoming increasingly recognized (Ashton et al., 1995; Howard et al., 1995; Bende 1997; Webb et al, 1998; Montgomry et al., 1998). It provides spatial information to the disaster management system and therefore, complex spatial analysis of problems could be carried out. Furthermore, outcome of analysis offers alternative decision-making.

On the other hand, estimating specific catchment hydrologic properties is a difficult task, requiring much good comprehension of the particular water system, profound knowledge of the geologic and geomorphologic conditions and full series of relevant data. Future water demands were calculated by elaborating statistical data concerning annual increase rates for the main water consumptive economic activities (agriculture, tourism, industry) and for the area's population (I. Zacharias, E. Dimitriou, Th. Koussouris, 2005).

The aim of the work is to present a general disaster management system (DMS) for offering an ideal platform for coupling the diverse hydrological simulation model and social-economic analysis components. This is demonstrated by the development of DMS that integrates a GIS with hydrological and hydraulic models. The DMS performs the mechanical functions to identify the object catchment, prepare dataset for it, run various models and visualize the results of theirs.

2. MATERIAL AND METHODS

2.1 Data List

GIS technology has the ability to capture, store, manipulate georeferenced data (Singh and Fiorentino, 1996) and has emerged as powerful and sophisticated means to manage vast amounts of geographic data. So database preparing is the most important step of all. Data input is the operation of encoding the data and writing them to the DMS database. In order to run DMS simulations in the study area, representative datasets were constructed for the modules. Type of data that have been considered in this study is tabulated in Table 1. Other data sets may also be added to the DMS, either derived from these core data sets or supplied by the other available data sets. Table 1 provides a comprehensive summary of the current content of the DMS database. All dataset are manipulated with GIS and some other sub-models. GIS contains both geometric data, which contains both coordinates and topological information with attributive data that contains the information describing the properties of geometrical objects such as points, lines and areas.

2.2 Construction of DMS

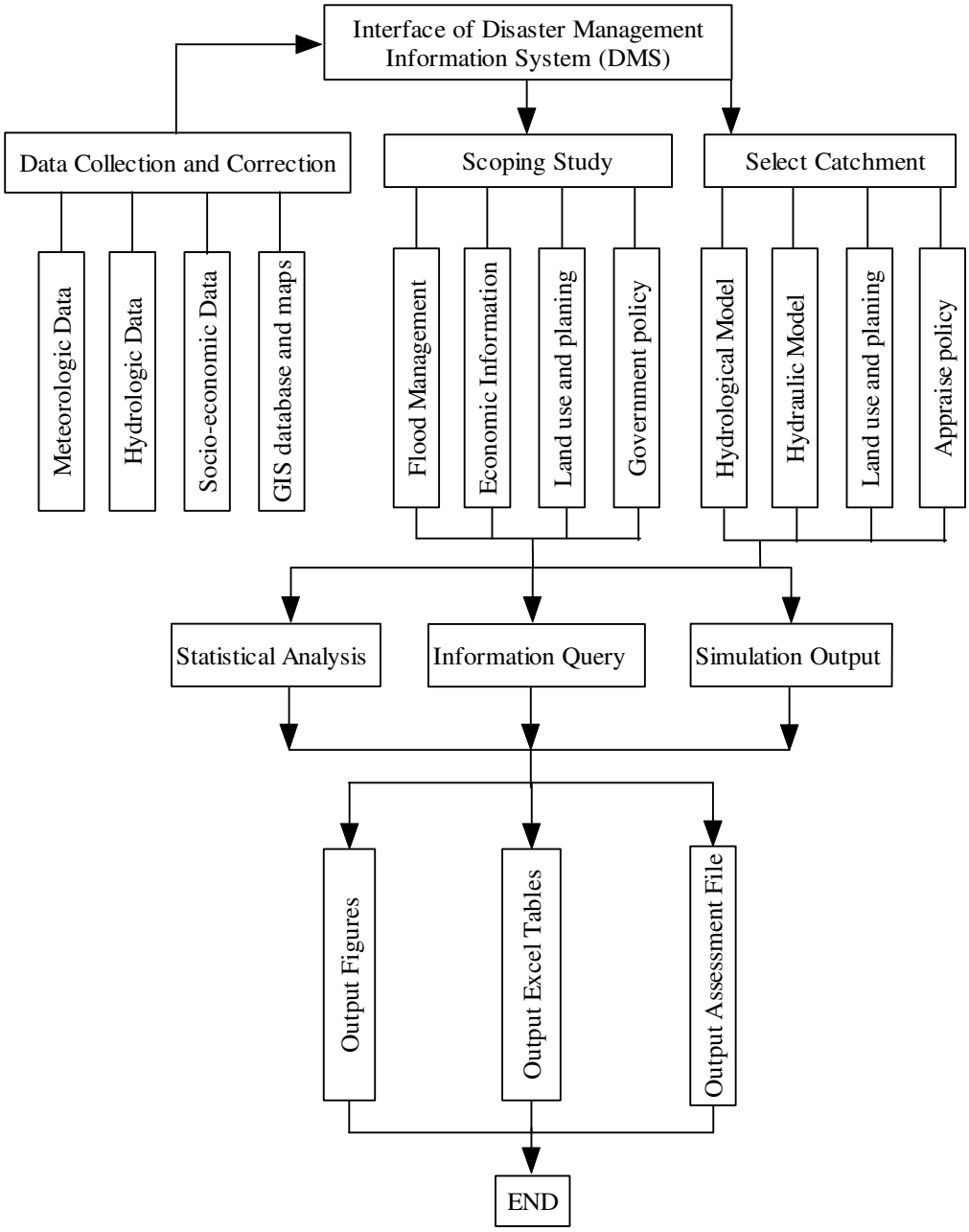

Fig.1 Flowchart of Disaster Management System

Disaster management system will serve as a platform for practical applications of geographic information and runoff simulation model. To develop the DMS system, a flow chart is required to give a general view on the steps and phases that must be taken, which is shown in Fig.1.

All the necessary components for the construction of a sustainable water management scheme were quantified. System integration problems include the identification of a framework within which the external component models can be linked. The integration of these independent component modules within a single Graphical User Interface (GUI) was central to the successful development of DMS as a powerful tool for addressing the issues regarding the best use for catchment water management. The GUI provides menu options that control the status of the active project dictionary.

Following the release of ArcView (V.3.x, ESRI-Environmental Systems Research Institute Inc.), the convenient and small desktop GIS can be compiled with our own sub-models which have the ability to combine the most useful data sets and functions with efficiency and flexible output control options. In this

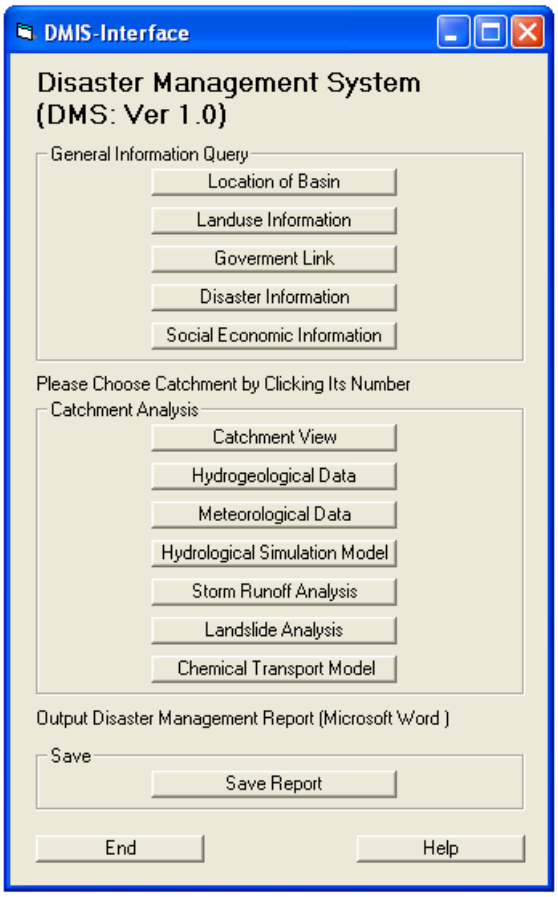

Fig.2 Schematic of main components for the integrated Disaster Management System.

study the disaster management system analysis is also proceeding by using the GIS packages (Arc View 3.x), and the outputs are obtained via graphic and attribute tables. The necessary datum for the model have been collected including the area's grid codes, meteorological data, topography and land use map, which was all preprocessed with GIS tools.

3. APPLICATION AND EXAMPLE

3.1 Interface of DMS

The interface is written in Visual Basic (VB) programming language, which is an object oriented programming language and supports the GIS technology of ESRI products. The VB programming language is one of the best technologies developed in recent years and VB sub-models can be called and integrated with GIS products. Also in the DMS some of the hydrological and hydraulic simulation models are also written in VB programming language. Thus the VB interface of DMS may be more convenient and be full of function with other sub-models for hydrological and hydraulic simulations. These controls include the creation of a new simulation that prompts for the selection of the catchment region to be analyzed. Each time a new simulation is started, a corresponding project dictionary is created. There are options to save a copy of the active project dictionary that is written to files thus enabling simulations to be stored at any time. This capability is essential as a single simulation can take some time to complete. A saved project dictionary can be loaded into DMS so that a simulation can be restarted with previous data. Conversely the active project dictionary can be closed resulting in the removal of the associated datasets from the DMS application. Finally the contents of the active project dictionary can also be viewed. Users can select a catchment of interest from the TNT map and the next interface containing the chosen site will display various options, which are defined to the simulation of hydrology analysis in this catchment.

3.2 TNT, 3D view and contour line

The catchment of interest can be chosen from the map which is displayed in the DMS interface and the catchment elevation data can be identified to generate triangular terrain map and three dimensional perspective view. The example TNT view is shown in the Fig.3. TNT view is a completely integrated system for visualizing and interpreting geospatial project materials of all kinds. These materials can represent an endless variety of information, such as maps, drawings, parts diagrams, floor plans, databases, satellite images. TNT view allows us to combine, display, and interpret these project materials. Other options can also be chosen to view some specific graphic overlay in the map display. As an example, the elevation contour map and three-dimensional view map can also be generated from the digital elevation mesh that are shown in Fig.4 and Fig.5. From the three dimensional map and elevation contour map the catchment outline can be easily delineated.

3.3 Application example

In this study an example data set has illustrated the simulation results of rainfall-runoff analysis in catchment scale. The disaster management information system may include many hydraulic and hydrologic simulation models, which provide the ability to analyze the disaster in catchments, such as flood, soil erosion and landslide from storm events.

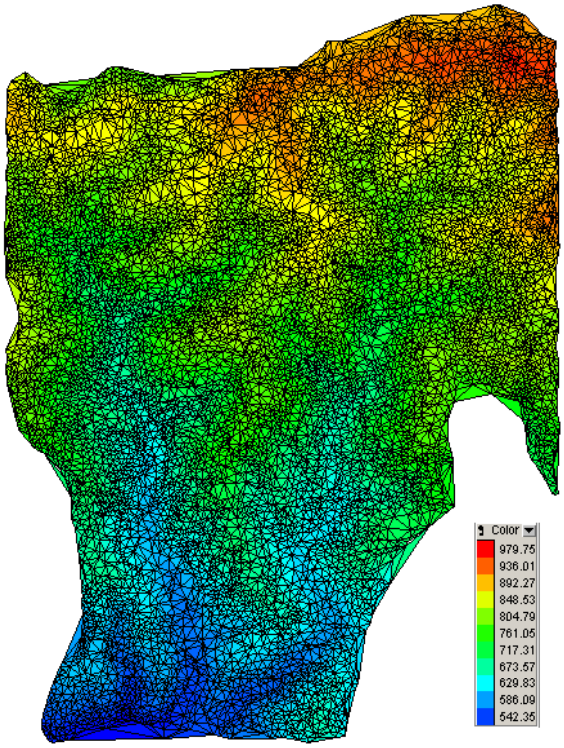

Fig.3 TNT Figure based on the digital elevation map

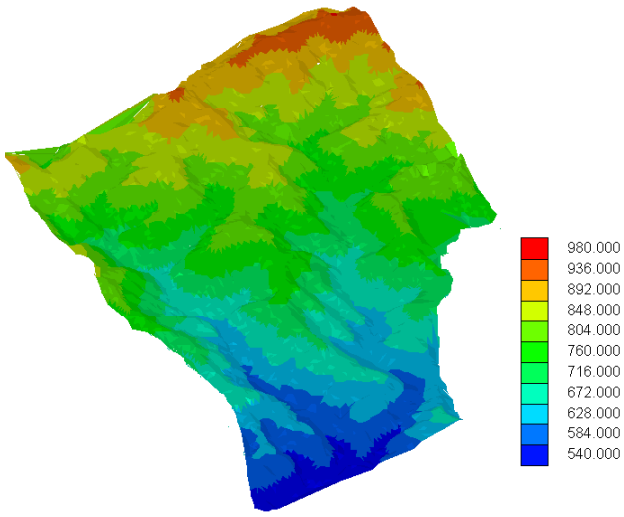

Fig.4 Three dimensional view of catchment

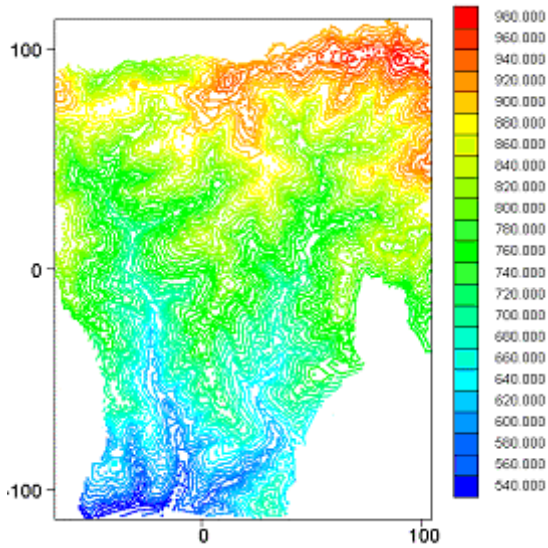

Fig.5 Contour line of elevation map

The example application results of storm runoff simulation are shown in the Fig.6. The meteorological data, precipitation data, land use data, catchment's geographical data have been input into the hydrological model. The discharge data will be output from the hydrological model. From the Fig.6, the simulated discharge agrees well with the measured one. The proposed model is a desirable simulation tool for the storm runoff analysis. And also this result is just a part of disaster management system for catchment scale. Other functions such as landslide, chemical transport and basin flood evaluation, etc, will be the important features in the whole DMS designation in future.

4. CONCLUSIONS

This study is light on theory, and heavy on application of the most widely used management information system (MIS), geographic information

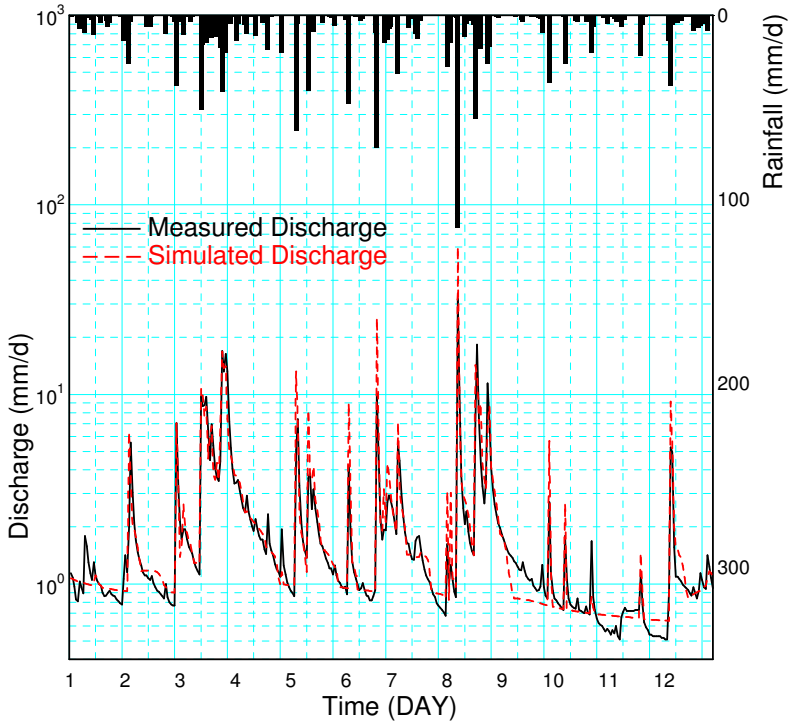

Fig.6 Simulation Results of Runoff Analysis

system (GIS) and runoff simulation model to the disaster management system in catchment scale. The final focus of the management is to make the detailed quantitative analysis and management scheme of catchment response to precipitation by linking with the models of surface water runoff, flood routing and storm hydrograph analysis. And storm water quality modeling will be a topic for this management system in the future. As a useful tool for integrated catchment scale disaster prevention system, the developed interface can endorse many advanced hydrological and hydraulic simulation model which employing the advanced computer assisted technology to the management of disaster prevention. Also the flexibility of the interface for further modification and updating is an added advantage with the interface. The proposed interface is a useful tool for prediction of hydrological process in catchment scale. The GIS approach to watershed analysis, by integrating digital data sets, field data and modeling tools, can assist all catchment managers to gain a better understanding of catchment processes and thereby facilitate better decision making. Such tools and models in the disaster management information system might include hydrological and hydraulic models such as erosion risk model, water quality model and ecological models. This could, however, be a significant development for the study in the future.

ACKNOWLEDGMENT:

The authors want to thank the graduate and undergraduate students in the laboratory of Hydrology for Environment Engineering in Ehime University. The authors are grateful to their support.

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