INCORPORATING A FLOOD MODELLING FIELD APPLICATION IN A GIS TRAINING MODULE FOR MID CAREER PROFESSIONALS

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ABSTRACT

In order analyze and solve complex real life issues Geographical Information Systems (GIS) require to support sophisticated models that runs on different other platforms. Therefore, the GIS training has become a challenging affair and requires the incorporation of not only the concepts & use but also the limitations & need if GIS to ensure the provision of reliable alternative solutions for resource managers and planners. Therefore in the GIS training modules, it is of utmost importance to look at real life problems. This would ensure that the training programs would not only build the capability in the use of GIS but also expose the users to the realities at the field level applications. Assessment of flood inundation in GIS is a challenging task because of the dynamic nature of the problem and the need to consider the water surface elevation in identifying the inundated area. Water flow over the surface of the earth and across the river profile differences need to be considered to identify the spread of water during such events. This necessitates the modeling of flood inundation considering spatial and temporal variations to look at either loosely or tightly coupled model systems. In order to keep up with the emerging challenges from real life needs, Geographical Information Systems (GAC) has incorporated the modeling of flood inundation problem in the Phrae City in Thailand in its forthcoming training program in Disaster Management using GIS.

1. INTRODUCTION

Geographical Information Systems (GIS) are now well recognized as powerful tools in evaluating, managing and monitoring of resources considering their spatial distribution. In the last decade the use of GIS in resource management and strategic planning has increased dramatically. Reaping full benefits of spatial analysis necessitates the development of human resources to facilitate the development of management alternatives within capabilities in GIS environments. Most of the present day off-the-shelf GIS have the capability of performing simple analysis within their own systems. However, with the GIS gaining popularity among managers, the requirements from spatial databases become challenging and as a result problem solving often cannot be confined to a particular system. To analyse and solve complex issues require many GIS to support more sophisticated models that require different other platforms for computations to be done at desirable levels. In this backdrop, the GIS training has become a challenging affair which requires the incorporation of not only the concepts & use but also the limitations & needs to ensure the provision of reliable alternative solutions for resource managers and planners. Assessment of flood inundation in GIS is a challenging task because flood water flow over the surface of the earth and across the river profile need to be considered to identify the spread of water during such events. Often it is

not possible to consider the entire computation needs in most of the off the shelf software. As such, this necessitates the modelling of flood inundation considering spatial and temporal variations to look at either loosely or tightly coupled model systems. GAC of the Asian Institute of Technology is a center dedicated for training in GIS and Remote Sensing. This center targets to enhance the capability of GIS of users in the Asian region and hence the persons who reach the center vary from the technical personnel who build databases to senior managers who make decisions in identifying investment priorities. The participants who could be considered as mid career professionals range from those who are well exposed to computer applications but having less management exposure, to well experienced personnel in taking technical decisions but have the desire to use today's technology for their day to day management activities. Therefore, the contents of training programs range from basics of GIS to advanced specific applications. At the same time the GAC in all its training programs allocate more than half of its time for hands-on training and always target case studies to suit the specific group of trainees. In order to keep up with the emerging challenges from real life needs GAC for its forthcoming training program in Disaster Management used the modelling of flood inundation problem in the Phrae city in northern Thailand.

2. OUTLINE

The training module on flood monitoring using GIS allocates time for lectures on the concepts, methods and key concerns of floods and GIS. In the schedule of training, most of the lectures are spaced for the mornings while the hands-on targets the afternoon sessions. Each trainee is given a training material consisting of lecture contents, hands on steps, and a few selected supplementary reading materials. A main resource person supported by one or two others conducts hands-on training. Training groups are restricted to a maximum number of 20. The objective of the hands on work of GIS training module for Disaster Management is to expose and familiarise a trainee in identifying the flood inundation zones and extract information for associated planning and management activities. A loosely coupled modelling approach is used for Training. This would enable the users to gain a better understanding of the option of using different models for flood simulation, spatial data input, and analysis & display. Spatial data prepared using off-the-shelf GIS software is to be fed to the spatially distributed hydrological model developed at the University of Tokyo (Herath, Dutta and Wijesekera 2002). Results from the model are then to be transferred to the GIS Software for display, analysis and interpretation.

2.1 Lecture Contents

In the module lectures that could be categorised as GIS related are, the Introduction to GIS and potential of spatial applications on GIS, Mathematical modelling concepts, Modelling in GIS, Needs of field verification, Triangular Irregular Networks (TIN), Grids and creation of Digital Elevation Models (DEM). Lectures in the program that target the awareness of flood modelling, exposes the participants to floods and their characteristics, river flow and overland flow behaviour and the governing factors, principles water flow over flat and sloping terrain, flood mitigation and flood plane management, flood risks, flood damage assessments, flood modelling, important watershed parameters and ways to estimate etc. A key point in the temporal modelling in present day GIS is the need to couple with other models which could carryout temporal analysis while using the potential of GIS for data input, editing, analysis and output generation. In this training module, a loosely coupled

approach is targeted. Therefore the lecture emphasis is also given to the coupled modelling approach, its strengths and weaknesses.

2.2 Hands-on Training

The hands-on training incorporated in the module includes preparation of input data using GIS for modelling purposes. Exporting GIS information to external simulation models, external simulations and importing results to GIS for visualisation & analysis, and scenario simulations. Preparation of input data includes the creation of DEM from map contours, river network generation and importing attributes to vector data etc. Exporting GIS data to in the hydrologic model includes the hands-on work on understanding the data formats, exporting ASCII data and further data manipulation using external programs. Simulations in the hydrologic model target the trainees to get accustomed to the preparation of additional data such as flow data, understanding the parameters and the related concepts, and paying attention to the modelling concepts and governing equations. Once the computations in the hydrologic model is complete, the exporting of results to a GIS for visualisation and analysis is incorporated in the hands-on training module. Once initial process of working with the hydrological model and export and import of data are familiar to the trainees, then they would be given opportunity to carryout editing of features in the GIS, perform rerun of model and comparison between scenario developed by the trainees to suit practical needs.

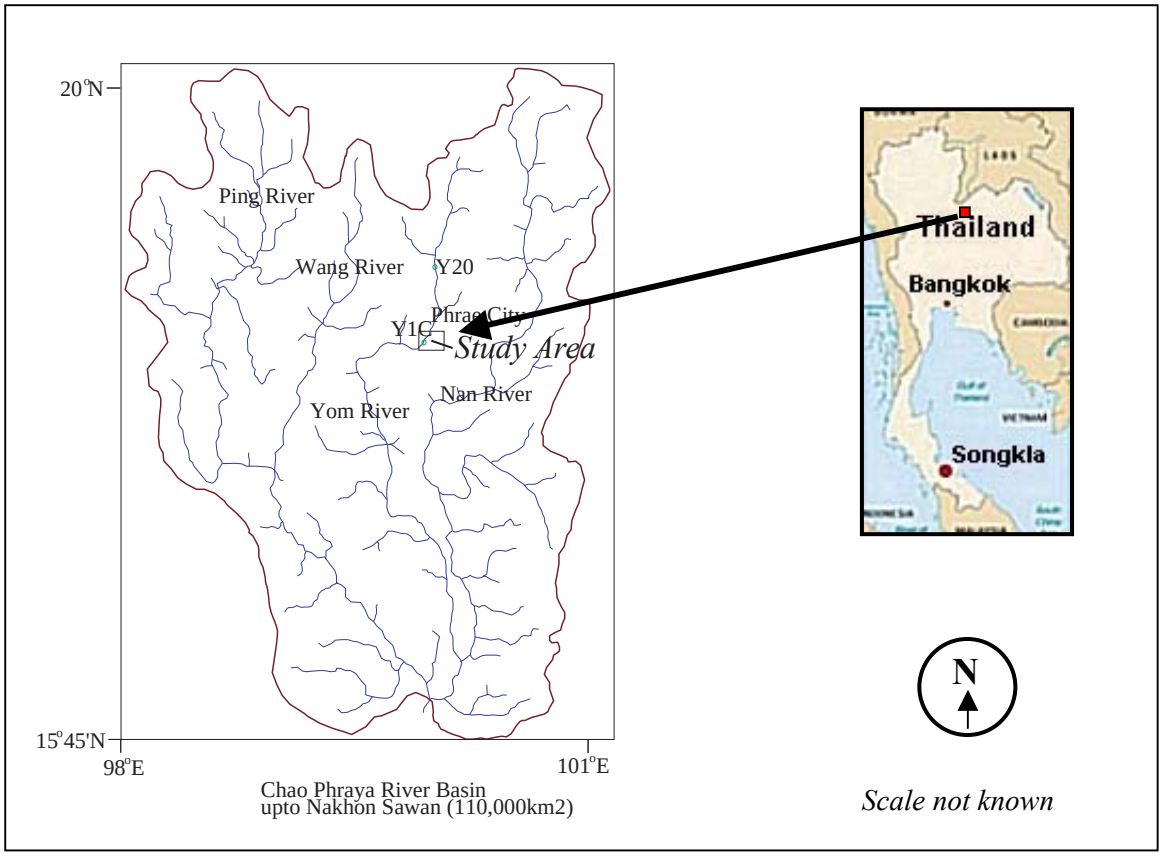

Figure 1: Study Area Selected for the Training Module Case Study

3. DESCRIPTION OF THE MODULE

3.1 Case Study

The Yom river basin of north-central Thailand was selected as the study area for the real life case study of training module, because the Phrae city(~9km^2) by the side of the river Yom periodically gets inundated by floods, causing significant loss to the community and the economy of the country (Figure 1). Flooding is a frequent occurrence in this city and in general floods occur 3-5 times a year. Topography of the city is rather flat, and gently sloping towards the river except for an elevated strip on the Northern side which appear as a remnant of an earth bund that was in place to protect part of the city. At present this feature does not indicate continuity and it is said that though it protects the inner city from most of the floods, the people experience significant problems in removing water once large floods flow over some of the lower elevated sections of this strip. In 1995, the city had undergone floods that had caused an economic loss of nearly 16 million US$. The river gauging station (Y1C) which is located just below the Phrae city, has a total watershed area of 9838 square kilometres. 1:50,000 topographic maps of the watershed, river cross sections, hourly rainfall and streamflow data, 1:4,000 maps of the city area with contours at 0.5 meter interval were available for the preparation of the training module. Field visits were done to the city, and to gauging stations while making GPS measurements to familiarise the study area.

3.2 Preparation of DEM and River Network

The elevation data of 1:50,000 topographic maps were too coarse to identify the inundation details to be of practical value. Since adequate details of elevation data were available only in the city area, spatial modelling of flood inundation was confined to the extent of the city that had elevation data at a finer resolution. Yom watershed boundary between Y1C & Y20, contours, roads and the buildings in the Phrae city area were digitised from the available maps and then registered into the GIS database. The available contour maps were of not very high quality and hence professional judgement was required to ensure the set up of a reasonable contour database. TIN model of the city area was prepared using the contour and road information available. Two DEM for the study area at 50m and 100m cell grid resolution was constructed. These DEM at different cell grid resolution indicated that the features such as roads, elevated strip of land around the city was not well represented due to their small aerial coverage. The land surface of the study area was reconstructed while forcing the generated DEM to reflect the feature values irrespective of its areal representation.

The river network data preparation is done by converting the vector river data to a grid and creating a flow order grid. External information on riverbed levels is incorporated using the river longitudinal profile. Finally the river cross section information is attached to the river information at each grid. This training program is to expose the participants to the advanced spatial modelling capabilities on a GIS. Therefore the module is not intended to spend much time on digitising maps or key board entry of flow and rainfall data. Sample data sets which are portions from real application were prepared for the trainees to receive a rapid training on extraction of contour, roads and building data from maps to different data layers of GIS, registration and adding contour values are attributes.

3.3 Preparation of Parameters and Modelling

Other than the spatial data developed in the GIS, it is necessary to input other information such as hydrographs, stage-discharge relationships, soil layer information, roughness parameters etc., to carryout flood modelling. The training module in its attempt to provide participants with the maximum opportunity to model different scenario, incorporated a user interface to facilitate easy parameter modifications in the hydrologic model. This interface incorporates a user manual for the operation of the flood simulation model and facilitates easy input and modification of model parameters. The hydrologic model used in the training module is the distributed hydrologic model of the University of which consists of two components where one is to analyse the river flow and the other to compute overland flow hydraulics and hydrology (Herath, Dutta and Wijesekera 2002, Dutta, Herath and Wijesekera 2002). Details of the data sets used, modelling concepts, data deficiencies, concerns of spatial resolutions and boundary conditions were dealt in detail in the above work.

3.4 Data Import to GIS

The output from the hydrologic model needs to be imported to the GIS for visualisation and interpretation. Data files such as those pertaining to different flooding situations are to be exported by the trainees to identify the representation of the flooding scenario. In this module the trainees are to use the available data for initial simulations to identify the needs and sufficiency of the digital elevation model. As an initial exercise the trainees are guided to look at a specific situation in the Phrae city, where the data resolution masks an earth bund which plays a very important role in the identification of inundation area. In this exercise the participants are exposed to the probable data deficiencies and also to the constraints related to the spatial resolution used in computations.

3.5 Verification of Outputs

Modelling efforts are always tied to assumptions and estimation of model parameters. Therefore it necessitates calibrating and verifying the model prior to using it for meaningful practical applications. The training module has incorporated the importance and the methods of carrying out such computations. The required data types and desired data set sizes are also important aspects included in the training. However the collected data does not provide an opportunity to numerically perform the verification of flood simulation. Instead, the information obtained from site visits, a rational look at input data and subsequent discussions with Royal Irrigation Department officials were used to qualitatively verify the results. These efforts expose the trainees to the realities of practical applications while teaching the need to settle for the next best solution with an understanding of the compromises.

3.6 Option Study and Output Generation

The outputs of flooding sequence on GIS show the possibility of restricting the flood with the construction of a dyke. In the training module, the participants are to modify the DEM of the study area to define modifications to a dyke partially protecting the city from floods. With the modifications in place and while exposing the participants to the needs of data transfer between the GIS and the hydrologic model, the trainees are taught to carryout

model reruns. Outputs of the no-action scenario and the management intervention option are compared to identify the differences in both, flooding extents and the duration. These efforts require periodical visualisation of outputs on the GIS and hence strengthen the data exchange and modification capability of the trainees. Also this part is considered as very important for the training module because the interest of the mid career professionals are mostly on the practicality of incorporating and studying the effect of management options in a spatial domain. The training module exposes the participants to various other options that could be exercised effectively on a GIS. Possibility of identifying evacuation paths, locations of flood relief centers, computing the cost of dykes, identifying the dykes to suit different design flood events, effects of dredging river sections on inundation are some activities that could be carried out effectively with the already established GIS.

4. DISCUSSION AND CONCLUSIONS

Real life applications such as modelling floods need very specialised treatment of physical phenomena using appropriate models incorporating applicable governing equations to enable realistic results. The present training module is an effort to disseminate the important concepts that are associated with floods along with the need and methods to incorporate such issues when using the strengths of GIS to handle spatial information.

The present work on flood disaster mitigation is on the efforts of training mid career professionals in the use of GIS for temporal modelling. It is commonly known that the off the shelf GIS software often have constraints in handing temporal computations to satisfy the needs of most practitioners. Therefore it is very important to expose the trainees to the potential of GIS and computer mathematical modelling for realistic resource management with minimum needs of spatial and temporal lumping. This training module has incorporated the important issues that are associated with the need to couple GIS with other systems that could effectively handle temporal concerns.

The important concepts of calibration and verification of models, that are often neglected by most professionals is incorporated into the module and given a very significant emphasis. The training module covers the ways and requirements to ensure proper model verification and emphasises the proper modelling techniques while indicating the opportunities to strike a balance while considering the availability of information.

Input data for computations is one of the most important components of analysing a given situation and their quality requirements depend on the user needs. In most situations modellers are faced with instances where that data available are either not satisfactory or imperfect. The module targets teaching of the very important aspect that available input data can be utilised to obtain extremely useful information.

In coupled modelling efforts, one of the important concerns are the ease of data export and import between GIS and subject specific models. Therefore, the training module provides adequate opportunity for the trainees to get accustomed to the data transfers formats and process during the hands-on sessions.

The training module covers theoretical aspects of both floods and GIS commencing from basics and covering the advanced concepts. The hands on module also enable both beginners and advanced users to gain sufficient practice. Participants are encouraged to

prepare map products to suit their individual work backgrounds. This training module had successfully incorporated a broad approach to cater to the different demands of the mid career professionals.

Model developed and used for the training module needs more improvements to be used as a tool that could match most of the needs of the flood managers. The effectiveness of the model has to be determined by applying the model for more events while acquiring adequate data for calibration and verification.

5. ACKNOWLEDGEMENT

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6. REFERENCES

Herath, S., Dutta, D. and Wijesekera, S., 2002. *Use of spatial information in flood disaster mitigation- Case study of Phrae City of Yom river basin, Thailand*, Proceedings of the International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences, Hanoi, Vietnam, 25-28 Sept., 2002

Herath, S., Dutta, D. and Wijesekera, S., 2002, *Understanding the Impacts of Spatial Data Resolution in Flood Risk Modeling - A Case Study In Yom River Basin, Thailand* – Proceedings of the International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences, Hanoi, Vietnam, 25-28 Sept., 2002