UNIVERSITI PUTRA MALAYSIA

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By

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Faculty : Engineering

Flash flood occurring from fast development and socio-economic growth within Klang Valley has imposed a huge strain impact onto the entire urbanized areas. Accurate techniques in ascertaining flood estimation and prediction would normally be able to propose beneficial solutions in counteracting the phenomena. However, this would require up to date reliable data and effective hydrological modeling coupled to socio-economic studies. These types of studies is time consuming and costly. Complex models produce large quantities of result and difficult for people without specialized backgrounds to understand. New modeling techniques and computer visualization would improve the timeliness and accuracy of hydrological analysis and flood forecasting. With the limited data, complex hydrological approaches could be accomplished.

This study intends to illustrate the capability of MIKE 11 GIS to simulate the flood map for Sungai Kayu Ara in modeling the flood mapping. Direct runoff hydrograph could be generated from the rating curve to be used

as the input data in preparing the simulation for the flash flood. Crucial ground survey data as one of the significant criteria in producing reliable flood elevation profile is examined.

The study also shows that Geographical Information System (GIS) is capable to integrate spatial data and applying spatial simulation from limited data. It is able assist in the understanding of the flooding physical processes and in facilitating the decision-making. The flood simulation can further be modeled with changes in land-use and curve numbers features pertaining to the future development growth.

In achieving the above objective, flood modeling was carried out on Sungai Kayu Ara catchment area. In the process MIKE 11 GIS was used as a database and data processor. The available hydrological (rainfall and water-level) data acquired from the data of 1996 to 1998, were used to produce the flow simulation during the time of the storm event. This result of the study shows that it is possible to use limited hydrological data to map the flash flood using MIKE 11 and MIKE 11 GIS. However, ground survey data with cross sectional intervals of 75 m to 100 m used in the study was found to be insufficient to provide adequately the elevation profile and further refinement is neccessary.

Abstrak tesis yang dikeluarkan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

APPLIKASI MODEL MIKE 11 GIS BAGI MEMODELKAN BANJIR DI TADAHAN SUNGAI KAYU ARA

Oleh

SABARIAH BINTI ARBAI

Oktober 2002

Pengerusi : Profesor Madya Dr. Noordin b. Ahmad

Fakulti : Kejuruteraan

Pembangunan yang pesat dan pertumbuhan sosio-ekonomi telah mengakibatkan kejadian banjir kilat di sekitar Lembah Klang. Ini telah memberikan kekangan impak yang lebih tinggi lagi ke atas keseluruhan kawasan-kawasan membangun. Dalam mempastikan kejituan jangkaan banjir, teknik yang tepat bagi menangani fenomena sedemikian berkeupayaan memberikan cadangan penyelesaian yang bermenfaat. Namun, ia memerlukan kewujudan data yang 'reliable' dan model hidrologi yang 'efektif' di gandingkan kepada kajian-kajian sosio-ekonomi. Kajian-kajian tersebut perlu memakan masa dan perbelanjaan yang tinggi. Model yang kompleks menghasilkan kepelbagaian keputusan. Ianya sukar untuk difahami oleh kebanyakan masyarakat yang tiada latarbelakang khusus. Teknik model yang baru berserta visualisasi komputer boleh mempertingkat keberkesanan dari segi masa dan ketepatan analisa hidrologi. Dengan data yang terhad, pendekatan hidrologikal yang kompleks dapat dicapai.

Kajian ini berhasrat memaparkan keupayaan MIKE 11 dan MIKE 11 GIS untuk mengsimulasikan dan memetakan banjir bagi kawasan Sungai

Kayu Ara dalam model pemetaan banjir. Hidrograf larian terus (direct runoff hydrograph) boleh dijana daripada lengkung kadaran sungai (rating curve) bagi dijadikan sebagai data input di dalam menyediakan simulasi bagi banjir kilat. Bagi menghasilkan profil paras banjir yang 'reliable', model tersebut sangat perlu kepada data ukur di tapak yang mana begitu mustahak. Maka kriteria dan kepentingan data tersebut juga perlu dikaji.

Sistem Maklumat Geografi [SMG] berupaya mengintegrasi data ruang (spatial) bagi membantu memberikan kefahaman proses fizikal banjir dan sebagai pemudahcara kata-putus. Ianya dilakukan melalui simulasi ruang dari data yang terhad. Selanjutnya, simulasi banjir ini boleh di modelkan terhadap perubahan di dalam guna-tanah dan nombor lengkung yang dihasilkan dari pertumbuhan pembangunan.

Dalam mencapai objektif-objektif di atas, banjir di kawasan tadahan Sungai Kayu Ara telah dimodelkan dimana MIKE 11 GIS digunakan sebagai pengkalan data serta memproses data. Data hidrologi (data hujan dan aras air sungai) di antara tahun 1996 hingga 1998 telah di gunakan untuk melakukan simulasi sewaktu hujan lebat dalam tempoh tersebut. Hasil kajian menunjukkan bahawa penggunaan data hidrologi yang terhad untuk memeta banjir kilat boleh dilakukan melalui MIKE 11 dan MIKE 11 GIS. Data ukur yang telah digunakan di dalam kajian ini adalah dari data tapak dengan sela keratan rentas sungai antara 75 m dan 100 m. Ianya adalah didapati tidak memadai untuk memberi profil ketinggian aras air sungai yang wajar dan perlu kepada ketelitian selanjutnya.

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Sabariah bt Arbai

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LIST OF ABBREVIATIONS

GIS	Geographical Information Systems
JPS	Jabatan Pengairan dan Saliran (Drainage and Irrigation Department)
DHI	Danish Hydraulics Institute
ESRI	Environmental Systems Research Institute
NAHRIM	National Hydraulic Research Institute of Malaysia
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
MACRES	Malaysian Centre of Remote Sensing
MRSO	Malaysian Rectified Skew Orthomorphic
GPS	Global Positioning Systems
MSMA	Stormwater Management Manual for Malaysia (Manual Saliran Mesra Alam)

GLOSSARIES

Catchment

The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.

contour

A line connecting points of equal surface value.

contour interval

The difference in surface values between contours.

Curve number (CN):

A numerical representation of a given area's hydrologic soil group, plant cover, impervious cover, interception and surface storage derived in accordance with Natural Resource Conservation Service methods. This number is used to convert rainfall depth into runoff volume. Sometimes referred to as Runoff Curve Number.

remote sensing

Acquiring information about an object without contacting it physically.

Methods include aerial photography, radar, and satellite imaging.

Stage

The height of a water surface above an established datum. Used interchangeably with gage height.

spatial data

Information about the location and shape of, and relationships among, geographic features, usually stored as coordinates and topology.

CHAPTER I

INTRODUCTION

1.1 General

Flood or the water accumulation during storm, generates a large amount of runoff which overtops the river bank and flows onto the floodplain, inundating the low-lying areas. Malaysia, as a tropical country, is obviously subjected to heavy rainfall concentrated in short duration during certain months in a year (Junaidah et al., 1998). Heavy rainfall also causes high runoff peak flow, in short duration leading to flash flood occurrences.

Fast land development and urbanization process will cause tremendous hydrological impacts due to land cover changes. It also leads to an increase in peak runoff and/or a decrease in time of concentration. Peak values could predict flood as it depends upon the coefficient of rainfall-runoff. Soil curve number (CN) is closely related to the coefficient of rainfall-runoff, by a direct assumption whereby CN values could be divided by 100 to obtain the coefficients (JPS, 1999; Bedient and Huber, 1987). These parameters depend highly on the land-use of a particular area and its changes (Chow et al., 1988). Urbanization from land-use changes results to a decrease in the infiltration capacity and increase in the resulting runoff. Increase in the density of buildings from industrialization process also

contributes to an increase in pollution concentration levels in the atmosphere. This disturbs the environment and affects the hydrological cycle.

Previous studies indicated that an increase in rainfall intensity and flood frequency is caused by urbanization and industrialization (Rustam et al., 2000; Annon., 1994). Flood prevention and rehabilitation work would require great efforts and carrying out continuous studies to catalyze the achievement of sustainable environment. Klang Valley's green areas are reported to have been reduced by 21% between 1988 and 1998 due to forest clearing, conversion of plantations into development projects and lack of co-ordination during the planning stage (New Straits Times, May 2nd 2001).

1.2 Flood Severity and Urge to Overcome Flood Problem

Flood effects may cause death and traffic disruptions. Although the severity due to flood in Malaysia is not as serious as that in Bangladesh, but damages on infrastructures, commercial value losses and lives threat have insisted large annual expenses to control floods (Chan, 1995). Flood studies could contribute to counteracting effects of hydrological changes and provide a better drainage system without affecting the infiltration capacity. They should also conform to the latest guidelines such as the Urban Stormwater Management Manual for Malaysia Volume 4 (DID, 2000). Obviously, critical impacts of flash flood are serious especially on urbanized areas of high socio-economic growth and rapid land-cover change. Developing and improvising

models is an endless process, requiring data preparation and most likely, the results could only be obtained through complicated procedures and expenses. Nevertheless, it is beneficial to educate the public to make them well-informed and hence assisting them to participate in working out the flood problems. The profile output from flood through hydrological data processing would enhance a better representation and would assist authorities to improve their contingencies preparation for public alarms.

1.3 Problem Statement

A complete solution for flood problem in Malaysia has not actually been met. Nevertheless, all parties involved in planning, decision-making and managing the development are to conform to the sustainable environmental requirement. To date, no standard approach or technique of flood management has been collectively adopted by participating agencies, since each has individual respective areas suitability and limitation of application. New modeling techniques, radar technologies and computer visualization facilities, hold significant promise for improving flood forecasts and warnings. However, the situational condition could only be described from ground survey information.

Flood modeling is applicable in simulating historical flood events using hydrological (rainfall / water level) data. These data combined with the river ground survey data produce very significant flood mapping and would be very understandable for everyone.

Flood mapping from real-time storm events will assist in producing a more precise prediction of future events. The thesis is a study of an alternative flood modeling technique by using MIKE-11 GIS and incorporating ground-based verification.

1.4 Objective of the Study

The objective of the study is to use the MIKE 11GIS Model to simulate the flood map for Sungai Kayu Ara Catchment.

1.5 Significance of the Study

This study has its significant contribution to Malaysian environment especially to assist relevant departments in modeling flood. It would also be able to highlight the possibility of producing a flash flood from the direct runoff generated from the rating curve relationship of the water level to the discharge. A preliminary hydrological data preparation of the rainfall event would be done. It also utilises the processed spatial data from remote sensing to classify land-use and to predict soil curve number of the respective land-use area. This is useful for determining the calibration flood peak discharge. This study also makes use of the river ground survey data. This study would elucidate in better understanding of the physical processes and would be able to assist in decision-making. This study would assist relevant department to highlight flood problem with better contingency preparation.

1.6 Scope of Work

The whole process involves several stages beginning from the literature reviews, then to data processing and analysis, which involve processes in handling hydrological data, river ground data and image capturing. The identified data are processed and utilized for simulation input to produce intermediate output. Interpolation would be performed to link the simulation output into GIS flood model using ARCVIEW inter-phase software known as MIKE 11-GIS. The scope include the following:

1) Identification of study area which includes i) topographical data acquisition, ii) scanning and digitizing of river network, road, sub-catchment division and iii) ground river data collection and information extraction from surveyors drawings.

2) Processing hydrological data by performing i) rainfall data analysis for current storm events and return periods and ii) river data analysis;

3) Determination of direct runoff hydrograph, the hydrodynamic data input for MIKE 11 flood simulation;

4) Image processing from Spot Panchromatic data involving image data capturing and land-use identification deriving soil curve numbers for the catchment. Computation of peak discharge using Soil Conservation Services (SCS) method for calibration;

5) Application of MIKE11, performing procedures of i) data input for river network, cross-section, boundary conditions, time series, and ii) the simulation of flood elevation profile;

6) Applying MIKE11-GIS for i) DEM display of river network from image data, ii) data retrieval from flood simulation, iii) flood mapping, by developing the link between MIKE 11 GIS and MIKE 11. Subsequently, this would enable the creation of Flood Map and displaying the Animation file developed.

1.7 Thesis Structure

A total of five chapters were covered in this thesis. Chapter I consists of the general introduction, problem statement and objectives of the study. Chapter II presents the literature review of previous studies related to the research. It concisely explains on the terms and issues related to the study.

Chapter III explains the methodology of the work carried out to achieve the objectives of this study. It covers a brief description of the site investigation carried out on the study area, the background description of the study area and explanation related to urban catchment. This chapter also describes on the data collection and processing. It also describes on preparing the flood model for Sungai Kayu Ara elaborating on the file creation for the flood simulation and data input. This chapter also elaborates the simulating process carried out using MIKE 11 application to produce the flood elevation profile for Sungai Kayu Ara. This chapter also explains the process carried out to link the flood simulation result into MIKE 11 GIS for the flood map generation.