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FLOOD MODELLING OF THE DEZ RIVER BASIN, IRAN, USING THE WATERSHED MODELING SYSTEM SOFTWARE

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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By

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September 2008

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Faculty: Engineering

Flood is one of the natural disasters which can take place in many areas. In this research, a framework which integrates the Geographic Information System (GIS) with the Watershed Modelling System (WMS) for flood modelling was developed. It also interconnects the terrain models and the GIS software, with standard hydrological and hydraulic models, including HEC-1, HEC-RAS, etc. The Dez River Basin (about 16213 km²) in Khuzestan province in Iran was the study area in view of the frequent occurrences of severe flash flooding. Three storms which had caused floods in, January 1993, March 1993 and December 2001 were chosen to examine the modelling framework. The WMS is found to be capable of flood modelling and producing flood map. Hydrologic models can be integrated with HEC-RAS for a complete flood plain analysis in the WMS Package. The model consists of a rainfall-runoff model (HEC-1) which converts excess precipitation to overland flow and channel runoff; watershed parameters are calibrated manually to perform a good simulation of discharge at three sub-basins. Also statistical analysis had been done for

hydrologic model and the model efficiency found to be 50%- 97%. Steady state flow simulation was performed in HEC-RAS model through the river channel network based on the HEC-1, peak hydrographs. Error in prediction of water surface levels was found to be less than 5%. Based on hydrologic and hydraulic simulations, Flood hazard maps for floods recorded January (1993), March (1993) and December (2001) are produced for the Dez River Basin based on the state-of-the-art GIS in the WMS software. Finally, a sensitivity analysis of the model parameters was performed and the most sensitive parameters identified are Curve Number (CN) and initial rainfall abstraction (STRTL) respectively. The modelling framework presented in this study demonstrates the accuracy and usefulness of the WMS software for flash flooding control in semi arid region. The results of this research will benefit future modelling efforts by providing validated hydrological software to forecast flooding on a regional scale. This model was designed for the Dez River Basin, and this regional scale model could be used as a prototype for the model applications in other areas.

Keywords:

WMS, GIS, Rainfall-Runoff, flood modelling, Flood hazard map

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

PEMODELAN BANJIR DEZ RIVER BASIN, IRAN, DENGAN MENGGUNAKAN PERISIAN WATERSHED MODELING SYSTEM

Oleh

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Banjir adalah salah satu dari kejadian bencana alam yang melanda banyak tempat. Dalam kajian ini, satu rangkakerja untuk permodelan banjir akan dibangunkan yang menggabungkan Sistem Maklumat Geografi (GIS) dan Watershed Modeling System (WMS) dan hubungkait antara model rupabumi dan perisian sistem maklumat geografi beserta piawaian komersial hidrologi dan perisian-perisian hidraulik termasuk HE-1, HEC-RAS dan sebagainya. Lembangan Sungai Dez (lebih kurang 1613 km2) terletak di Wilayah Khuzestan, Iran telah dipilih sebagai lokasi kajian memandangkan ia sering mengalami banjir kilat yang agak serius. Sebagai kajian kes, 3 situasi hujan yang telah mengakibatkan kejadian banjir pada, Januari, 1993, Mac, 1993 dan Disember, 2001 telah dipilih untuk menguji rangkakerja yang dibentuk. WMS berpaya untuk digunakan dalam permodelan banjir dan boleh menghasilkan peta risiko banjir. Model hidraulik boleh diintegrasikan dengan HEC-RAS untuk analisa lembangan sungai yang lengkap menggunakan pakej WMS. Model tersebut terdiri dari model hujan-air larian (HEC-1) yang berupaya untuk

mengira lebihan hujan kepada air larian permukaan dan aliran dalam saluran; parameter lembangan ditentukur secara manual untuk menghasilkan simulasi kadar luahan pada 3 sub-lembangan. Dah juga analisis statistik telah dijalankan untak model hidrologik dah model teresbut menunjukkan kecekapannya adaiah dari 50% - 97%.Simulasi aliran seragam dilakukan dengan model HES-RAS untuk rangkaian sungai berdasarkan HEC-1, hirdograf puncak.Ralat dalam jangkaan aras permukaan air adalah kurang daripada 5%. Sebagai tambahan, peta-peta zon banjir untuk Lembangan Sungai Dez berdasarkan keputusan model hidraulik tela dilakarkan pada januari (1993), March (1993) dan December(2001) dengan menggunakan GIS digabungkan dalam perisian WMS. Akhirya, ujian kepekaan parameter model telah dilakukan untuk mengenalpasti parameter yang terpenting yang memberikan impak keputusan kepada model tersebut. Rangkakerja permodelan yang dijelaskan didalam kajian ini menunjukkan ketepatn dan kegunaan perisian WMS untuk mengawal kejadian banjir kilat. Hasil kajian ini adalah diharapkan boleh mendatangkan manafaat untuk usaha permodelan banjir dengan menyediakan perisian hidrologi yang tepat untuk meramal banjir dengan skala yang besar. Model yang dibangunkan untuk lembangan Sungai Dez, adalah diharapkan dapat digunakan sebagai prototaip untuk digunakan di lokasi lain.

Kata Kunci:

WMS, GIS, Hujan-larian, Permodelan banjir, Peta risiko banjir.

DEDICATION

This dissertation is dedicated

to my parents … your essence is in everything I accomplish.

to my husband for his love and patience.

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I certify that an Examination Committee has met on 25 September 2008 to conduct the final examination of **Seyedeh Sara Sadrolashrafi** on her **Master of Science** thesis entitled "**Integrated Modelling for Flood Mapping for Arid Region Using Watershed Modelling System**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

……..……

SEYEDEH SARA SADROLASHRAFI

Date: 23 February 2009

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LIST OF ABBREVIATIONS

Abbreviations	Meaning
1-D	One-dimensional
2-D	two dimensional
A	Area
Arc/Info	Ames Research center/Information
ASCII	American Standard Code for Information Interchange
AT	total flow
B	top width of the water surface
c	The wave celerity
CAD	Computer-assisted dispatch
cfs	Cubic feet per second
cms	Cubic Meter per second
CN	Curve Number
CRWR	Center for Research in Water Resources
DEM	Digital Elevation Model
DOS	Disk Operation System
e.g.	Exempli gratia
Eq	Equation
ESRI	Environmental System Research Institute
ET	Evapotranspiration
FAST	Fourier Amplitude Sensitivity Test
FEMA	Federal Emergency Management Agency
FIS	Federal Inspection Station

g	gravitational acceleration
GEO	Geospatial
GIS	Geographic Information System
H&H	Hydrologic&Hydraulic
he	energy head loss
HEC	Hydrologic Engineering Center-1
HMS	Hydrologic Modelling System
i.e	That is
K	conveyance for subdivision
KW	Kinematic Wave
M	Side slope of channel
MIKE	Anecdotally attributed to Michael B. Abbott
mo	transmissivity decay
n	Manning roughness coefficient
NEXRAD	Next-Generation Radar
NOAA-AVHRR	National Oceanic and Atmospheric Administration - Advanced Very High Resolution Radiometer
P	average rainfall excess
PDM	Probability Distributed Model
PRCPA	Sub-basin average total precipitation
PRCPN	Total precipitation gage
PrePro	preprocessor
Q	sub-basin outflow
QPK	peak flow
R	hydraulic radius for subdivision

RAS	River Analysis System
RSA	Regional Sensitivity Analysis
RTIMP	Percentage of drainage basin impervious
S_0	Bed Slope
SAM	Spatial data management and comprehensive Analysis System
SCS	Soil Conservation Service
S_f	Friction slope
Sr0	initial moisture in root zone
STRTL	Initial rainfall abstraction
TIN	Triangulated Irregular Networks
TLAG	the lag time in hours from the beginning of rainfall to the centroid of runoff hydrograph
TOPAZ	TOpographic PArametriZation
TPEAK	Time to Peak
TR	Technical Release
To	Transmissivity decay parameter
U(j)	ordinate of the unit hydrograph
USA	United States of America
USACE	US Army Crop Engineers
USDA-ARS	United State Department of Agriculture-Agricultural Research Service
UTM	Universal Transverse Mercator
V	average velocities
WD	Base width of the channel
WMO	World Meteorological Organization