TOOL DEVELOPMENT FOR DYNAMIC GIS APPLICATION FOR WATERSHED MANAGEMENT CASE STUDY OF THE THIMBIRIGASYAYA WARD OF THE COLOMBO MUNICIPAL COUNCIL AREA

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Department of Civil Engineering

University of Moratuwa
Sri Lanka

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Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science

Department of Civil Engineering

University of Moratuwa
Sri Lanka

July 2012

Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where the acknowledgment is made in text.

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The above candidate has carried out research for the Masters thesis under my supervision

…….. ……..

Professor N.T.S.Wijesekera Date

Tool Development for Dynamic GIS Application for Watershed Management Case Study of The Thimbirigasyaya Ward of The Colombo Municipal Council Area

Abstract

Diversion of surface runoff from housing allotments directly into stormwater drainage network along roads is a common phenomenon in urban areas which leads to the urban flooding. When urban land changes are made for development, the natural hydrology undergoes changes usually leading to high surface runoff and often flash floods. Calculating the effect of modifications and quickly proposing an optimum solution becomes a difficult task not only to non-technical persons but also to some technical persons. Screening of existing tools identified that there is no single tool which could dynamically capture the land modifications and perform hydrological calculations to manage stormwater from urban lands.

Main objective of the present research was to develop a dynamic user-friendly GIS tool which would capture key land parcel changes and perform calculation of stormwater generation by looking at both pre and post development scenarios. Accordingly a user friendly Dynamic GIS tool which enables on-screen modification of a land allotment was developed for computation of a composite land parcel runoff coefficient. Then the tool was extended to incorporate a hydrologic model to perform a comparison of before and after modification and then to extend the tool for incorporation of a detention tank model for management of generated stormwater. Thimbirigasyaya ward of the Colombo Municipal Council area in the 162 hectares having 1405 land parcels was the study area.

The development methodology included, requirement identification, literature survey, conceptual design, coding, testing, modification and product delivery. In the conceptual design, the tool design was carried out for land authorities to optimize development alternatives jointly with the owner. Therefore the tool demanded a high level of user friendliness.

Through a detailed literature survey, soil, slope and Landcover were identified as the key parameters governing stormwater generation from a land parcel modification. Hydrologic modeling computations within the tool were based on the rational formula, unit hydrograph theory and tank model concept. Detention storage for stormwater management was based on the research monograph of Wijesinghe and Wijesekara (2010). Split, merge and adjust operations were incorporated to the tool to carryout land modifications. Summative and formative evaluation techniques were used to achieve user-friendliness and accuracy of the tool.

A lookup table cited in Perera & Wijesekera (2010) for runoff coefficient computation was embedded in the tool. Tool is capable of following modifications to this lookup table as and when new research findings are known. In the land modification component the tool facilitates on-screen modifications of land parcels and updating of hydrological parameters. GIS model combines the layers and supporting data such as runoff coefficients, rainfall etc to compute the time series of stormwater generated from each land.

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Tool developed by the present work develops a hydrograph and permits a user to incorporate dimensions of a detention pit to observe its effect on stormwater generation. This enables a land owner and a manger to identify a suitable detention pit for the intended land modifications. Unavailability of Graphic User Interface (GUI) guidelines for GIS and the lack of suitable spatial data security algorithms that could be used with confidence, influenced the present work to contribute and develop new techniques.

As main results of the work, a user friendly accurate dynamic GIS tool, capable of land management in relation to stormwater, a step by step user manual, guidelines for GUI development and contributions towards security algorithm could be mentioned. Visualization of land modifications; dynamic change capability of parameter selection, design rainfall and detention pit sizes; and visual presenting the effect of detention pit incorporation are unique features of the tool which increases the user friendliness for non-GIS decision makers.

The development of a single tool which provides Hydrologic-GIS capabilities for urban property management activities through the capabilities of identify optimum solutions is a contribution towards successful GIS applications for land and water management.

Due to the possession of "Muscle" to rationally manage urban land parcels, the name "Geographic Information Systems to Manage Urban Stormwater Considering Land Enhancement" abbreviated as "GIS2MUSCLE" is given to the tool contributed from the work.

This study through development and testing, satisfactorily concluded that a user friendly dynamic GIS tool enabling on-screen land and attribute modifications had been developed to user satisfaction while achieving 100% accuracy. Developed tool which enables the visualization of prior and post scenarios of land development has the capabilities to successfully handle the dynamics of both stormwater generation and process of land management. Present work also concluded that in order to achieve user friendliness and user satisfaction, it is necessary to incorporate an iterative design process with careful consideration of visual clarity, consistency, compatibility, informative feedback, explicitness, appropriate functionality, flexibility and control, error prevention and correction, user guidance, user support etc., with respect to tool development.

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Dedication

To my second elder sister, Himali Chandima who exemplarily showed me how to learn under pressure. She scarified all her wealth to my higher education. I am indebted to her for life.

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This Tool Development for Dynamic GIS application for Watershed Management (Case study of the Thimbirigasyaya ward of the Colombo Municipal Council area) was supported by University of Moratuwa Senate Research Grant Number 126.

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The author owes his loving thanks to wife, sons and his daughter. They have sacrificed a lot for author's research. With their encouragement and understanding this work could be completed achieving very high quality.

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LIST OF ABBREVIATIONS

Abbreviation	Description
API	Application Programming Interface
CMC	Colombo Municipal Council, Sri Lanka
DAC	Discretionary Access Control
ESRI	Environmental Survey and Research Institute
FORECALT	Forest Road Erosion Calculation Tool
GIS	Geographic Information System
GIS2MUSCLE	Geographic Information System to Manage Urban Stormwater Considering Land Enhancement
GNOME	GNU Network Object Model Environment
GUI	Graphic User Interface
HCI	Human Computer Interconnection
HEC	The Hydrologic Engineering Center – US Army
LMT	Land Management Tool
LRS	The Land Records System
MAC	Mandatory Access Control
MSHFlexGrid	Microsoft Hierarchical Flex Grid Control
ORDBMS	Object Relational Database Management System

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RBAC	Role Based Access Control
RDBMS	Relational Data Base Management System
SCS	Soil Conservation Service
SDE	Software Development Environment
SHA	Secure Hash Algorithm
SOLARIS	Soil and Land Resource Information System
SRDI	Soil Resource Development Institute of Bangladesh
SWMM	Stormwater Management Model
SUH	Synthetic Unit Hydrograph
UDA	Urban Development Authority, Sri Lanka
VB	Visual Basic 6.0 Programming language

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