FORMULATING A RAINWATER AND STORMWATER MANAGEMENT MODEL

BY

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ABSTRACT

Despite the numerous theories concerning stormwater management, a classificatory system that offers clear classification of all its components has yet to be introduced. What appears to be a general neglect of the relationship between rainwater and stormwater with the hydrology cycle have undermined the ability of stormwater management to manage problems such as flood, water pollution and ecosystem degradation. To remedy this problem, this research aims to reconstitute the components of stormwater management. To this end, two objectives are formulated, namely (i) to identify and explore the components of stormwater management, and (ii) to determine the relationship between the identified components of stormwater management and the hydrology cycle. The research is approaches qualitatively through the use of online journals, forum discussions, and e-mail interviews as methods of data collection. The collected data was then subjected to six steps of comparative analyses. The research found that the terminology of stormwater management needed to be changed to Rainwater and Stormwater Management (RSM) as it is more holistic. Subsequently, an RSM model was proposed consisting of a sequence process of three components; (i) hydrology cycle and its biophysical elements, (ii) concepts, and (iii) strategies. The first component consists of seven hydrology cycles (interception, infiltration, surface runoff, depression storage, evapotranspiration, groundwater flow and interplay), which function through vegetation, soil, topography and water bodies. The second and third components comprise of 12 concepts and 20 strategies; listed in priority order based on their relationship with the hydrology cycle. The revised aim of the proposed RSM model is to conserve and restore the health of the watershed by replicating more hydrological cycles in the concepts and strategies. The revised objectives of the RSM are (i) to improve rainwater management to optimize the hydrology cycles and to reduce stormwater, (ii) to improve stormwater management by reducing the quantity and improve the quality of stormwater, and (iii) to optimize the multifunctional of hydrology cycles in RSM strategies.

ملخص البحث

على الرغم من وفرة نظريات إدارة مياه الأمطار المختلفة، الا انه لا يوحد تصنيف واضح لمكوناتها. اضافة لذالك, قلة المناقشات المقدمة في مياه الامطار و جريان المياه مع الدورة المائية الهايدرولوجيه جعلت الغاية والاهداف لادارة جريان المياه اقل نجاحا في ادر المشاكل الناجمة من جريان المياه كالفيضانات, تلوث المياه و تدهور النطام البيئي. وبالتالي, يهدف هذا البحث لدراسة مكونات نظرية مياه المطار وادارة المجاري المائية. تم صياغة ثلاثة اهداف رئيسية هي (أ) تحديد مكونات نظرية مياه المطار وادارة المجاري المائية, (ب) لاستكشاف تفاصيل هذه المكونات, (ت) و لتوضيح علاقة الدورات الهيدرولوجية مع التفاصيل المستكشفة لهذه المكونات. تم استخدام المجلات المتوفره عبر النترنت, ومنتديات النقاش و المقابلات عبر البريد الاكتروني كمنهاج لجمع البيانات لهذا البحث النوعي. وقد تم استخدام خطوات التحليل المقارن الستة لتخليل البيانات. وبناء على ذالك, فان البحث حدد ن مكونات نظرية مياه المطار وادارة المجاري المائية من خلال عملية تسلسلة من ثلاثة عناصر, (أ) الدورة الهيدرولوجية و عناصرها المادية,(ب) المفاهيم, و (ت) الاستراتيجيات. اول المكونات السبعة للدورة الهيدرولوجية (الاعتراض, تسلسل, الجريان السطحي, كساد التخزين, التبخر والنتح, تدفق المياه الجوفية و حرك المياه السطحية) هي عملها من حلال الغطاء النباتي, التربة, التضاريس والاشكال المائية.اما المكون الثاني والثالث فقط احتويا على اثنا عشر مفهوما و عشرون استراتيجية تم تحديدها وادرجها حسب الاولوية في العلاقة مع الدورة الهيدرولوجية. وظافة لذلك, فقد تم تحيد الاهداف والغايات المنقحة لمكونات نظرية مياه المطار وادارة المجاري المائية. الهدف من التنقيح لاجل حفظ واعادة خزن التجمعات المائية الصحية من خلال اكثر تكرار للدورات الهدرولوجية في مفهوم واستاتيجية نظرية مكونات مياه الامطار وادارة المجاري المائية. الهداف المنقحة هي (أ) لتطوير ادارة مياه الامطار من اجل تحسين الدورات الهيدرولوجية و الحد من مقدار الجريان المائي, (ب) لتحسين ادارة المجاري المائية من خلال التقليل من عددها وتحسين من نوعية المجداري المائية, و (ت) ولتحسين الاداء الوظيفي للدورة الخيدرولوجية من خلال استراتيجية نظرية مكونات مياه الامطار وادارة المجاري المائية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Built Environment.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Mohd Faiz Bin Musa

Signature…… Date ……

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Signature Date

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It is hope that my research could benefit to the public and the person involved in rainwater and stormwater management. *Insyaallah.* Lastly, I pray to Allah that all of us can achieve the balance in every development which can meet the need of human and nature. *Amin.…*

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LIST OF ABBREVIATIONS

BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
CIRIA	Construction Industry Research and Information Association
DID	Department of Irrigation and Drainage Malaysia
EPA	Environmental Protection Agency
LID	Low-Impact Development
MaSMA	Manual Saliran Mesra Alam
RSM	Rainwater and Stormwater Management
SUDS	Sustainable Urban Drainage Systems
WSUD	Water Sensitive Urban Design

CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

This chapter sets out to provide an overview of the structure of the research. Subchapter 1.1 provides a background of study concerning stormwater management. In subchapter 1.2, problems and issues regarding to stormwater management were discussed. Subsequently, in subchapter 1.3, two research questions were stated based on the problem statement identified. Next, subchapter 1.4 listed the aim and objectives of the research. Then, limitation of research was stated in subchapter 1.5 followed by the significance of the research in subchapter 1.6. Meanwhile, subchapter 1.7 discussed the structure of the whole research. Lastly, subchapter 1.8 summarized the chapter 1 of the research.

1.1 BACKGROUND OF RESEARCH

In the background of research, researcher elaborates two perspectives about stormwater. First is the causes and impacts of stormwater where the researcher identifies what factors causes the stormwater to happen and what are the impacts towards the urban environment. Second, researcher elaborates the differences between conventional stormwater management and sustainable stormwater management.

1.1.1 Causes and Impacts of Stormwater

Flash flood, river pollution and soil erosion are common environmental impacts of excessive amount during seasonal rain and rapid urbanization in Malaysia. The rapid

urbanization in Malaysia cities is in terms of conversion of forest or agricultural land to commercial, residential and institutional landuse. Moreover, most urbanized cities like the capital city of Kuala Lumpur, Georgetown and Johor Bahru are developed along the main river where geographically situated in low-lying area of the downstream river basin. This makes the cities as flood prone areas, all the flowing rivers are polluted and the soil is susceptible to erosion (Department of Agriculture, 2006; Ishak Haji Omar, n.d.).

Ahmad Sanusi Hussin (2005), Marsh (2005) and Day and Dickinson (2008) claimed that all the environmental incidents that inflicted damage and lost on live, cost, infrastructure and the environment are related to the alteration of natural hydrology cycle in urban ecosystem. For example, the clearance of tree, change (flatten) of the topography and change of pervious (permeable for rainwater and surface runoff to infiltrate into the soil) cover to impervious (impermeable) cover caused large discharge of stormwater events at high frequencies. This means a decrease in the rate of interception by plants and infiltration into the soil which consequently increases the rate of volume and speed of surface runoff into the river. The excessive amount of surface runoff is known as stormwater. The present of stormwater reduces the ability of the river to contain the mass volume of surface runoff (stormwater) in a short period of time. Consequently, it causes an overflow of river and flood the nearby area.

1.1.2 Conventional Versus Sustainable Stormwater Management

Conventional practices of stormwater management involved increasing the number of drainage and river modification such as broadening, deepening, straighten, structured and diverting the river which is ineffective in mitigating the impacts of stormwater in

urban settings. The modification of river involves the use of concrete material. These approaches of stormwater management are known as conveyance approach. The use of concrete material in river modification and drainage addition only makes the stormwater problem become worse as it increases the amount of stormwater into the river within a short period of time (Department of Irrigation and Drainage, n.d.). Moreover, problems like erosion of riverbanks, reduce of water quality and degradation of river habitat also happen through river modification and drainage addition (Marsh, 2005).

Instead of conveyance approach which channels the stormwater into urban drainage and transports it into the river, there is another sustainable approach to reduce the stormwater volume and rate and simultaneously increase interception coverage of precipitation and infiltration rate of rainfall into the soil (Department of Irrigation and Drainage, n.d.). The sustainable management of stormwater can be achieved through sustainable landscape design or green infrastructures which are currently practiced in United Kingdom, United States of America, Australia, Japan and other European countries. The approaches came with various terms such as Sustainable Urban Drainage Systems (SUDS), Low-Impact Development (LID) and Water Sensitive Urban Design (WSUD). All the sustainable landscape design or green infrastructure approaches have the same aim which is to replicate the natural hydrology cycle into the site design through landscaping.

The approaches focus on how to use and integrate landscape elements with stormwater management techniques. The approaches are based on the source control mitigation concept to reduce the production of stormwater by increasing the infiltration rate of rain water into the soil to sustain the carrying capacity of the river during precipitation. Moreover, the approaches apply the non-structural measures and

focus on the landscape elements such as plants and soil in order to mimic the natural hydrology cycle as sustainable stormwater management. The benefits of sustainable landscape design or green infrastructures are less cost of construction and maintenance, aesthetic enhancement of urban image, rehabilitation of the urban ecosystem, robustness in use of space and user friendly (Department of Irrigation and Drainage, n.d.).

1.2 PROBLEM STATEMENTS

Naturally, there are three factors that control infiltration and surface runoff in the hydrology cycle which are land cover (vegetation and land use), soil composition and texture and surface inclination (slope) as stated by Marsh (2005). Changes in these three factors change the runoff coefficient in urban ecosystem up to 90 to 100 percent ($c = 0.9 – 1.0$) compared to a forest which range from 10 to 20 percent of runoff coefficient. In urban area, less vegetation covers to intercept the precipitation, less green spaces with impaired soil texture and profile make it less permeable for precipitation to infiltrate and massive impervious cover such as buildings, roads, parking lots, solid pavements and storm sewers result in high stormwater discharge and contribute to a drastic increase in the coefficient of runoff (Chia Chong Wing, 2004; Ahmad Sanusi Hussin, 2005; Day & Dickinson, 2008; Marsh, 2005).

1.2.1 Local Issues on Stormwater Management

There are various major flood events throughout Malaysia in the year of 1926, 1948, 1963, 1965, 1967, 1969, 1971, 1973, 1979, 1983, 1988, 1993, 1996, 1998, 1999, 2000, 2003, 2005, 2006 and 2007 (Chia Chong Wing, 2004; Ahmad Husaini Sulaiman, 2007; Ismail Abustan & Nabsiah Abdul Wahid, 2012). The flash flood had