Urban Water Cycle Processes, Management, and Societal Interactions: Crossing From Crisis To Sustainability

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ABSTRACT

The present paper highlights a combined research project between three universities i.e. Universiti Sains Malaysia (USM), Universiti Teknologi MARA (UiTM) and Universiti Tenaga Nasional (UNITEN) in dealing with the water quality aspect of water security in Malaysia. Five subprojects were created to enhance the sustainability issue of water demand and supply. It is expected that the project as a whole will innovate new approaches and issues in urban water management in Malaysia.

INTRODUCTION

Malaysia faces serious challenges in urban water management. In terms of stormwater management, even with the introduction of MSMA in 2000 (Urban Stormwater Management Manual for Malaysia), many new technologies have yet to be studied in depth especially the interrelation between water quantity and quality. Water pollution originates from many human-induced actions such as effluents from industrial wastewater, land use changes and urbanisation. There is an emerging transdisciplinary approach that utilises the understanding of relationships between hydrological and biological processes to improve water quality, biodiversity and sustainable development at the catchment scale. The approach implementation is based upon restoration and optimisation of the ecosystem. This approach is based on three fundamental, i.e., synergising catchment water cycle and dynamic of its biotic component, harmonizing

existing and planned hydrotechnical solutions with ecological biotechnologies, and integrating complementary synergistic measures of all scales.

Despite being touted as a "water-rich" country, the water equation in Malaysia has radically changed from one of relative abundance to one of relative scarcity. Population explosion, rapid urbanisation, agricultural expansion, industrialisation, tourism and other developments are imposing excessive demands and pressures on our water resources. At the same time, water availability is depleted by pollution. All these seriously threaten Malaysia's water security. Traditionally, water problems in the country is tackled with the Water Supply Management (WSM) approach which is based solely on technology without addressing the human issues that are really the root causes of these water problems. Water Demand Management (WDM) has been shown to be highly effective in many countries and Malaysia can, and must adopt WDM. Even a small 10 % of water savings can effectively reduce pressures on our water systems and defer construction of new water infrastructures, thereby saving the country CAPEX. This is the rationale for embarking on the study of urban WDM vis-à-vis WSM.

METHODOLOGY

The proposed project (Figure 1) puts forward the concept of sustainability in urban water management. The aim is to tackle urban water issues in a holistic manner by focusing on the critical issues related to providing an integrated solution framework so that water remains as a renewable and accessible resource not only for current population, but also for the future generations. This proposed programme brings together a collaborating group of experts and researchers with proven track records from major institutions of higher learning. The programme consists of 5 research projects (with a total proposed fund of RM13.7 million over a 5-year research period) that tackles specific problems/ challenges in the supply and demand of water in urban environment from all fronts.

On the technical front, the program introduces 3 research projects to tackle the water shortage and pollution issue through fundamental research in stormwater bioretention (Project 1) and wetland (Project 2) facilities, as well as wastewater treatment technologies (Project 4). There are many benefits in the application of bioretention and constructed wetlands including hydrology regulation, water treatment, and replenishment of water resource (especially critical in drier months when source of water is scares) (e.g. Le Coustumer et al (2007); Lucas and Greenway (2008); Hatt et al. (2007, 2008); Davis (2005); Davis et al. (2008); Thowsdale and Simcock (2011); Schueler (1992); Brix (1993); Donovan et al. (2000); and Hunt and Doll (2000)). The present design guides are directly borrowed from oversea (not technically proven in Malaysia) resulting in poor performance and facility failure. The research will reinvestigate the fundamentals of hydrology, hydraulic, environmental science and soil-water-plant relationship, to establish design guides that are conclusive and integrated. This will create facilities that not only function to treat stormwater, but are able to provide self-sustainability, increase river base flow recharge, and subsequently secure

long term future of water supply sources. Project 4 will first investigate the characteristic of various industrial wastewater, then study how effective (or ineffective) current technology is in treating poly-aromatic hydrocarbons (PAHs), where they have been found accumulating in soil, plant, animals, groundwater and marine organism (van Stempvoort & Biggar, 2008; Phillips, 1999; Fismes et al., 2002; Meudec et al., 2006; DouAbul et al., 1997). New technologies will be innovated using hybrid of several cutting edge technology. By discharging cleaner effluents, we are able to protect environment, diversify source of water supply and cut cost of water supply treatment

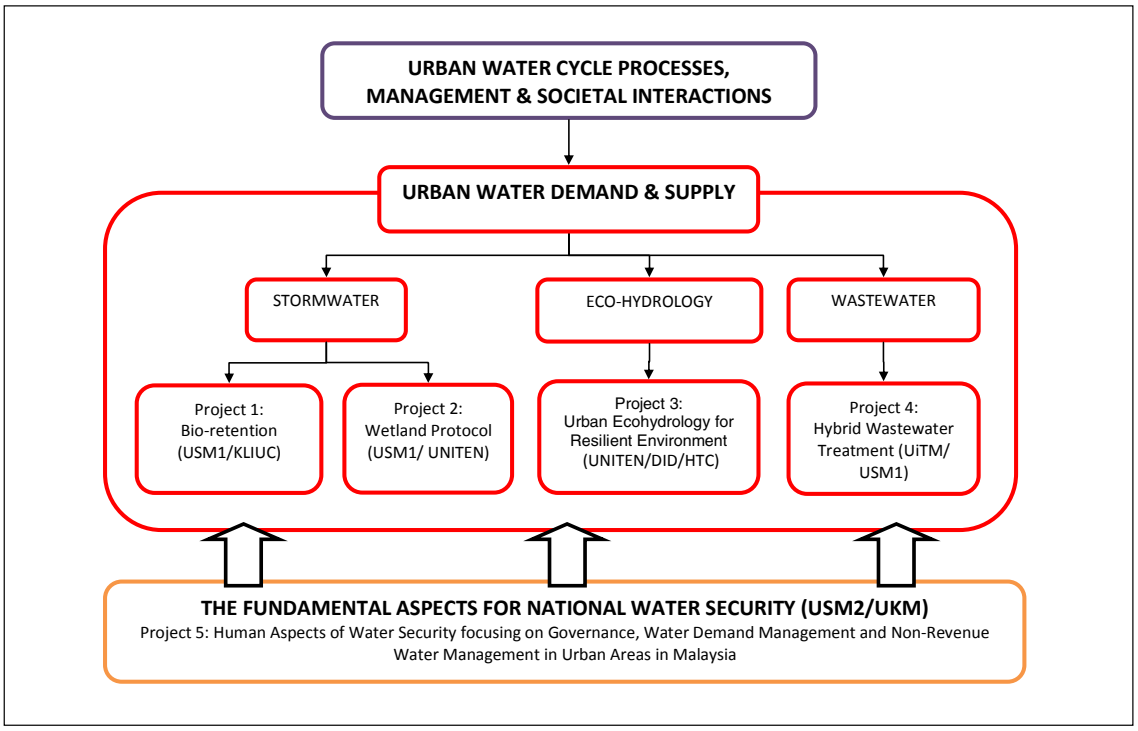

Figure 1: Layout of research projects in the proposed project

Project 3 concentrates on the Management front related to urban water issues. The solutions to most urban water issues will be sought by applying urban ecohydrology, ecohydraulics, integrated urban water management, and finally the knowledge management through an information system Decision Support System UCOREN. Environmental issues will be scientifically addressed by achieving synergy among the project researchers through joint investigations, development, implementation, and dissemination of findings and strategies, assessing impacts of and responses by scenarios of relevant drivers, quantifying cost-effectiveness of resilience measures through innovative tools, and by novel use of ecosystem properties to enhance environmental resiliency and achieve the maximum ecological potential. Extension of the urban water infrastructure to ecological measures, which is typical for the ecohydrology approach (Sven, 2001), is expected not only to improve the environmental

quality but also to lower costs of mitigation and increase economic benefits to the society.

The final front of urban water issues is the social aspect, which will be tackled by Project 5. This study discard the conventional structural (supply) approach to solve critical urban water issues, and instead concentrate on studying the fundamentals and subsequently seek solutions to urban water issues through the societal or demand side of the equilibrium. This study examines: the fundamental ethics, beliefs, and practices related to water, poverty and water, gender and water, all of which is central to a deeper understanding of the causes of water problems and to discover the solutions that are deeply rooted in human society (Chan, 2011, 2012); Models of Water Governance and Models of Water Supply Management (WSM) versus Water Demand Management (WDM); Human aspects of Non-Revenue Water (NRW), Cost Recovery; Tariff Restructuring and Willingness to Pay. A triangulation strategy combining various research methods will be used.

Figure 2 links the projects into 3 major disciplines that are essential for establishment of an integrated urban water management. All 5 proposed projects dig deep into the fundamental of each related discipline to provide solution to corresponding urban water issue(s) and challenge(s). First, on the technical front, 3 projects are proposed. Project 1 and 2 related to investigation of fundamentals and development of design guide bioretention and constructed wetlands for stormwater quantity and quality controls based on Malaysian condition. Project 4 tackles ineffective wastewater treatment by introducing novel hybrid technology in targeting not only common pollutants, but also micro-pollutants often missed by conventional treatment system. These three projects provide solution to the increasing water quality issue, which threatens the source of our water supply, i.e. natural surface freshwater. Furthermore, both bioretention and constructed wetland has the ability to provide hydrological control and could encourage stormwater reuse.

Project 3 is a pilot study on application of eco-hydrology and eco-hydraulics in managing urban water at catchment scale. This project investigate the fundamentals of interactions between water and nutrient cycles, but more importantly, explore the potential of applying this knowledge to manage urban water through an integrated management framework that incorporates technical know-how and human-centered supported by a Decision Support System (DSS). This project will be a showcase for what this program is trying to achieve ultimately.

Project 5 emphasize on the societal interactions related to urban waters. The study will explore in depth society perception, behavior and ethics in consumption of water at a scale never before attempted in Malaysia. As society is the root of the demand that dictate the amount and quality of supply, understanding and managing societal needs and demand can be crucial in relief critical water scarcity issues in urban areas particularly big cities.

These five projects cover three fronts of solving urban water issues; i.e. technical, management and social science, and are co-related and inter-dependant. Tackling arising urban water issues is no longer a problem that can be solved with a

direct and mono-perspective approach. Instead, trans-disciplinary research and solution is the key to achieve short term water crisis relief and long term urban water management sustainability.

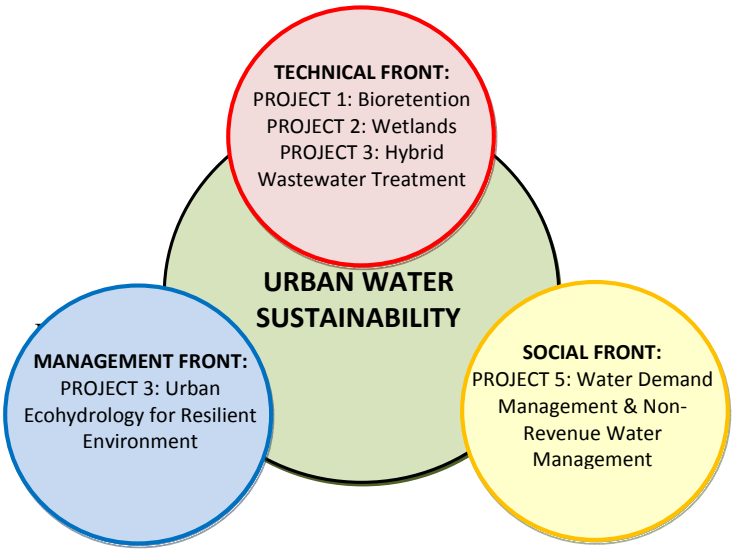

Figure 2: The projects links for establishment of an integrated urban water management

CONCLUSIONS

It is hoped that through such thorough research of fundamentals from multi-discipline perspective, urban water issues can be resolved and the nation could move further forward with a secured and sustainable source and supply of clean and fresh water.

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