LEARNING POTENTIAL TRANSFORMATION PRACTICES FOR WATER SENSITIVE PLANNING FOR CITIES IN A TROPICAL CONTEXT

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ABSTRACT

Cities that are undergoing rapid urbanization experience increased vulnerability. Communities living in those urban areas are exposed to unprecedented environmental issues and impacts of climate change. These challenges necessitate a resurgence of urban planning methods and applications. Contemporary planning practices need to incorporate the concepts of 'livable cities/communities' for delivering cities of the future. Despite well-informed concepts, real solutions seem elusive, particularly in tropical cities. Consequently, environmental changes have been increasing, endangering communities and natural resources through increasing climate change impacts of extreme weather events, floods, and drought.

Although the concepts of water sensitive planning and designs are not new, they have shaped northern and southern hemisphere urban environments in association with different water management issues and perspectives. For example, Low Impact Development (LID) that focuses on approaches to managing storm water is a pioneering and significant initiative implemented by the USA in the 1990s. Considerable innovation in stormwater infrastructure design also existed in Germany around this time. Later, the concept has been extended to other parts of Europe and in Australasia integrating water sensitive elements and methods across developing urban landscapes. These methods have incorporated different perspectives of urban water management issues and outcomes, and urban design, using various concepts such as Water Sensitive Urban Design (WSUD) and Low Impact Urban Design and Development (LIUDD).

Despite recent attention on these concepts from tropical urban designers and managers, it is not yet known how water sensitive planning practices can contribute to the delivery of livable tropical cities and communities. Considering the need to optimise urban water-related outcomes for tropical cities, this study explores the potential of water sensitive planning practices to create a better future for Colombo, Sri Lanka. Case studies of water sensitive and urban design methods from other selected countries will support recommendations.

KEYWORDS

Climate variability impacts, Water sensitive planning practices, Tropical cities

PRESENTER PROFILE

H.M.I.D.P. Jayawardena is a doctoral candidate in planning studying at the University of Auckland, New Zealand. This research paper partially examined aspects of his literature review and the case study of the doctoral research.

1 INTRODUCTION

Heightened urbanization occurring in many cities has created unprecedented challenges for towns and cities mainly due to higher growth of population. The United Nations indicates that by 2030 the proportion living in cities will have increased to about 60%, resulting in substantial challenges around resource use in major urban centers. The 'Planning sustainable cities: global report on human settlements' report (United Nations Human Settlements Programme, 2009) affirms the need for innovative urban planning practices to provide methods and tools for dealing with these unprecedented challenges, especially within the urban environment.

In recent decades, the role of urban development and planning has become important for searching for concepts to manage modern cities. These include livable cities, resilient cities, compact cities, and green cities. Indeed, all these concepts emphasise important aspects, roles and needs that should be focused on in planning modern cities, because planners have neglected those aspects in doing planning for many years.

When pressure on urban growth is increasing, key environmental issues related to urban growth are also simultaneously increasing among cities in the developing context. For example, the most common issue is the rising impacts of climate change, resulting in extreme weather events, bringing floods and droughts in recent decades. These events are causing damage not only to the environment but also in the socio-economic sectors amongst countries mainly in tropical regions. As adaptation to climate change becomes more pressing, searching for actions that enable the moderation of potential impacts of climate change within vulnerable cities seems highly significant among practitioners (Lindseth, 2005).

There are a number of studies that have been undertaken that have focused on climate change impact adaptation practices, recognizing the need for protecting human services and settlements in urban areas. At the same time, there are studies that considered climate change impacts focusing on the efficacy of water sensitive urban design and planning practices for cities, looking at problems related to the scarcity of water resources (Brown & Clarke, 2007; Gilliland et al., 2013; Wilson, 2006). However, research is limited on water sensitive planning practices that could optimise adaptation to climate change for emerging cities in the tropics.

Therefore, this study focuses on this research gap, searching for potential Water Sensitive Planning Practices (WSPP) that can be applied within cities in tropical contexts. Colombo city in Sri Lanka will be considered as the major case study. Colombo has experienced water related problems, mainly from floods, which have been generated during excessive rainfalls in the last decades. To investigate this research question two objectives were established for the study. Firstly, understanding the potentials for WSPP in the study area, and secondly, identifying possible transformation practices for implementation of WSPP in the study area.

As explained above, a case study approach of a scientific inquiry was employed as the research method in order to understand the potential of, and possibilities for implementing WSPP in Colombo. A qualitative method of analysis was deemed appropriate to analyse the case study of Colombo which is one of the rapidly developing cities in the tropical environmental context of the South-Asian region. Details of Colombo and the research procedure will be further discussed in subsequent sections of the research paper.

2 THEORETICAL FRAMEWORK AND THE RESEARCH PROCEDURE

Concepts of WSPP are now being adopted in many countries around the world to achieve sustainable water-related outcomes. Urban water management practices and spatial planning can be inherently recognized as two interconnected disciplines essential for developing urban policies and practices (Woltjer, 2009). Given water's critical role in cities. Integrating WSPP into developing water systems provides opportunities for responding to urban environmental problems.

However, exploring potential water sensitive elements that can be applied within the tropical urban environment, and to identify how to incorporate them into developing planning outcomes are major challenges. Meeting the challenges of intensified integration of urban nature is important to cities of the future. This requires a resurgence of urban planning practices in which urban planners show responsibility for working within these principles to achieve sustainable water-related urban outcomes.

2.1 WATER SENSITIVE PLANNING PRACTICES

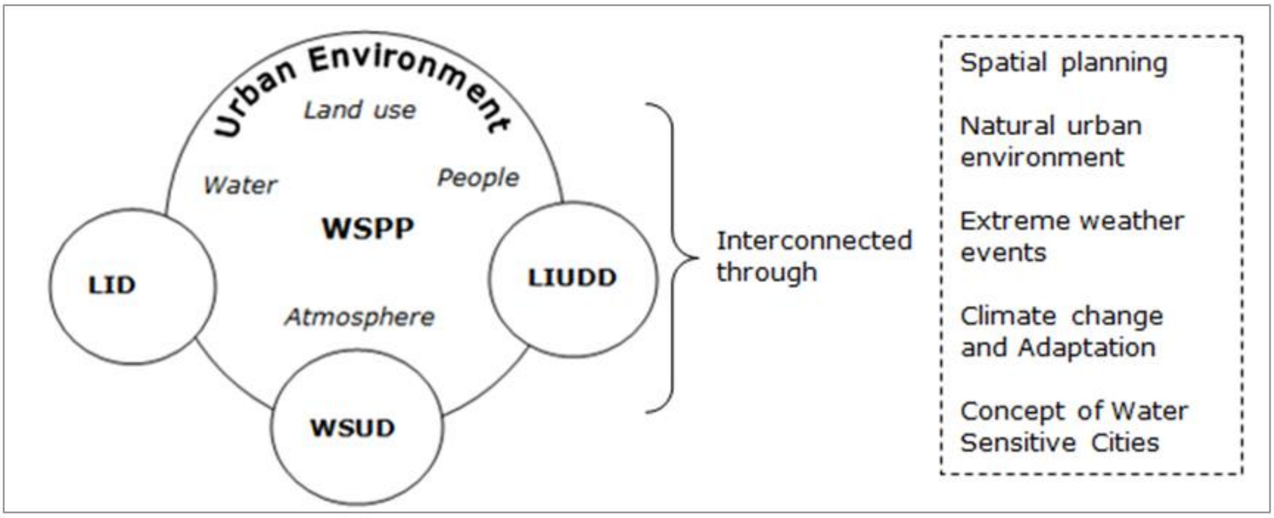
Typically, cities in a tropical climate have impending matters related to the impacts of climate change (Shah & Ranghieri, 2012). Meanwhile, the current sense of urgency on searching for potential responses to featured climate change issues within the tropical context implies the need of searching for long-term and more resilient approaches instead of examining short-term solutions (Ensor, 2011). Much is known about the role of urban development and planning practices for shaping our urban environment to create quality spaces for inhabitants. In essence, in this study, WSPP have been recognized as integrated planning strategies to develop links within urban nature and the spatial environment, to understand how water sensitive components can contribute to urban amenities. Subsequently, these amenities will help to manage future disaster risks and extend the capacities of inhabitants to appreciate water sensitive elements that respond to climatic extremes in urban areas.

The literature related to urban water suggests how closer links can be evolved between urban elements such as water, land use, atmosphere and humanity to create effective transitions to overcome water-related urban problems. Here, urban problems mainly refer to unprecedented water-based environmental challenges created by climate change and extreme weather events.

WSPP are not new, and they have been founded in similar but unique approaches and concepts to water based planning that are being adapted by countries in northern and southern hemisphere urban environments (Brown, et al, 2009; Dolman, et al, 2011; van Roon, 2011). Low Impact Development (LID), Water Sensitive Urban Design (WSUD), and Low Impact Urban Design and Development (LIUDD) are such examples, which provide enormous support to help shape water management issues in urban areas using planning, urban design and landscape guidelines.

Figure 1 shows, the basis of water sensitive planning within this research study. The study necessitates a reflective examination of WSPP for views and approaches that are currently similar in practice to be facilitated as best paths. The challenge of establishing these best paths highlight the need for making links between land use, water, atmosphere and the people in the urban environment. Concepts related to water sensitive planning describe these associations, which planners are then required to deal with through strategic actions, establishing closer links between nature and the urban development.

Figure 1: Conceptual integration of water sensitive planning practices considered for the study



Development of water sensitive design methods and practices interconnected through spatial planning provides new ways to promote sustainability and resilience within urban environments (Brown, Keath, & Wong, 2009; van Roon, Dixon, & van Roon, 2005; Wong, Brown, & Deletic, 2008). Spatial planning provides multi-disciplinary approaches to improve the design of planned urban environments, which ultimately provides benefits to all its users. Further, spatial planning is dealing with aspects such as managing population and building density, and decision making in regards to urban landscapes and land use structures. These aspects provide directives to regulate urban spaces through creation of planning guidelines, statutory and other necessary design frameworks. Such comprehensive planning directives can influence how water-sensitive design characteristics in the urban environment minimise damage to water related resources through conventional urban development. Examples include development of impervious surfaces, control of runoff volumes, catchment management, climate change adaptation and management of extreme weather events. Hence, emerging spatial planning practices provide very important aspects that have to be considered for minimizing the impacts of urbanization, and safeguarding the local natural resources including water in urban environments.

LID is a pioneering initiative that focused on stormwater management in the urban context, implemented by the USA in the 1990s (Dietz, 2007). WSUD and LIUDD are urban water management practices that already possess water-sensitive planning elements, developed in Australasia. The WSUD framework is a well-established approach that mainly focuses on alternative urban water management practices in Australian cities. WSUD considers the management of all parts of urban water interconnected through a nature-oriented framework (Hoyer, Dickhaut, Kronawitter, & Webber, 2011), and examines the potential opportunities to transition urban stormwater management practices from drainage-based cities to water-sensitive cities (Brown, Keath, & Wong, 2008). In parallel to this view, the LIUDD framework has been developed in the New Zealand urban context to address stormwater management practices using a sustainable development approach. Principles of LIUDD consider methods for avoiding a range of adverse ecological effects that typically occur during urban development, and it aims to minimize such effects through alternative planning and urban design practices interoperated with spatial planning (van Roon & van Roon, 2009).

2.2 THE RESEARCH PROCEDURE

The aim of the study is to identify possible and potential transformational practices for water sensitive planning for cities in a tropical context. These concerns were explored by reviewing the literature, case studies, and analysing project reports and planning documents that are leading to the implementation of WSPP in several countries. The idea of reviewing documents was to gain insights into how such countries have utilised environmentally sensitive planning and design approaches to overcome urban water-related problems. As described in the preceding section, this review process involved consideration of LID, WSUD and LIUDD concepts that have been taken into practice.

The study involved a cross-case comparative analysis, including the review of several cases using documents to learn concepts and practices potentially applicable to the major case study (Schwandt, 2007). Documents were selected from countries that exercise urban water sensitive planning practices to overcome problems, including case studies from USA, Australia, New Zealand and Malaysia. To learn potentially transferable lessons from such case studies, the study focused on urban water related issues that can be improved through water sensitive planning methods and practices that might contribute to Colombo. The study identifies WSPP that can improve the quality and problems of urban water while preserving the urban ecological systems and the quality of life of the people. WSPP were reviewed based on the three criteria as follows:

1. Planning/design approaches and important ecological drivers that support local ecosystem services to optimize urban water management cycles; mainly stormwater runoff
2. Elements that help with conveyance in the ecological environment that are sensitive to ‘water’, and that can be interconnected through spatial planning approaches for urban development
3. Authors’ local expertise, knowledge and reflections about the major case study

Subsequently, based on the three criteria given above, a SWOT analysis was undertaken in the case study to understand the complexities and to recognize the potentials for learning transferable lessons, by analysing existing situations, problems, trends and challenges regarding water and land use. Existing land use structure and the sensitivity to water were determined as crucial factors for the effectiveness of delivering WSPP.

2.3 THE CASE OF COLOMBO

Greater Colombo is a highly urbanized area, and is expected to be further urbanised throughout its suburbs, as it is the country’s commercial capital city. The total land area of Colombo Municipal Council (CMC) is 37.31 sq. km. According to the CMC, the residential population in CMC is over 640,000 and the floating population is around 500,000. CMC is the country’s’ largest Local Government Authority (LGA), and it has owned sources of revenue. Further, CMC is the only LGA in Sri Lanka with sewage facilities. The present sewer network was constructed between 1906 and 1913, serving an area of 2300ha targeting a threshold population of 373,500 by 1951 (Rafeek, no date). The current sewerage network has been subdivided based on two sections (northern and southern); the northern section (a larger portion) is connected to the Kelani River, and the southern section (a smaller portion) has been connected to the ocean near Wellawatta coast. However, Colombo has frequently over the last decade experienced a high intensity of rainfall. This has resulted in floods while temporarily damaging socio-economic and health conditions of urban livelihoods. According to Jayawardena (2006; as cited by Karunarathne, 2011), highly devastating flooding in the capital city of Colombo occurred on 4th June 1992 as a result of 493mm of rainfall during 12hrs which is equal to one-eighth of the annual rainfall of the city. More recently, in 2010, Colombo experienced 440mm of rainfall as the second highest recorded rainfall since 1992 (Ariyananda, 2013).

Colombo is a highly drainage based city, where severe problems have been occurring. These include an increase in flood hazards due to poor maintenance and insufficient storage capacities of micro and macro drainage systems, limited conveyance capacities due to solid waste, and blockages from floating debris. The Metro Colombo Urban Development Project (MCUDP) highlights that uncontrolled landfills and illegal encroachments of flood plains have reduced the storage capacity in the Colombo basin by about 30 percent during the last decade. In the meantime, the National Climate Change Adaptation Strategy for Sri Lanka 2011-2016 (Ministry of Environment, 2010) states that searching for innovative adaptation strategies is an urgent priority for Sri Lanka. The report further states that Colombo is facing unprecedented challenges due to the impacts of climate change variability, and therefore current urban development should focus on making climatic resilient strategies to support climatic adaptation activities.

Most commonly, water related problems in Colombo are created by localized issues. Inappropriate water management practices, natural geographical problems, uncontrolled urban sprawl, poor local infrastructure and services, lack of community participation and awareness are such common examples. The interconnected canal system in Greater Colombo is currently playing a wider role than historically, for management of stormwater within Colombo Urban Area. Therefore, integrated flood management solutions for Colombo have been identified as a serious need to respond to issues, and currently there are comprehensive planning approaches under preparation by several regulatory authorities.

MCUDP 2012-2017 (Ministry of Defence and Urban Development, 2012) is one of the major governmental strategies recently undertaken in Colombo. The primary objective of MCUDP is reducing physical and socio-economic damage due to flooding in the Metro Colombo Region and improving priority local infrastructure and services. There are three main components: (1) floods and drainage management and addressing flood related issues in Colombo (2) urban development, infrastructure rehabilitation, and capacity building for Metro Colombo Local Authorities (3) Implementation support for achieving effective outcomes of MCUDP.

Accordingly, to enable functions of water sensitive characteristics that improve the quality and the quantity of urban water, the author's PhD research is seeking approaches to integrate water considerations into urban planning and development of Colombo through water resource and land use planning. Hence, this approach is aiming to, firstly, identify potential water sensitive elements located in or close to the city that can enhance the city's socio-ecological functions, and, secondly, optimise them as accessible natural outlets for managing problems of stormwater or flood protection schemes of the city.

In the past, (sub)urban areas surrounding Colombo have acted naturally as flood retention basins during heavy rainfalls. There are low-lying areas, marshes and wetlands that connect the landscape in and adjacent to Colombo city (see Figure 2). At present, none of this natural landscape is intentionally utilised to optimise water retention capacities of Colombo. As a result, during heavy rainfalls it increases the collection and minimises the infiltration of rainwater. Therefore, the potential of the wetlands to facilitate stormwater treatment and detention needs to be optimized without compromising ecological priorities.

Figure 2: Some wetlands in Colombo

This involves identification of land use capabilities and their current conditions in order to understand intended designs and practices to deliver water sensitive planning outcomes to the city. Therefore, the research study area was extended beyond the central city, to include the land uses of Colombo suburbs. The whole study area includes seven Divisional Secretariat Divisions (DSDs) to cover the whole water catchment. They are Colombo, Kaduwela, Kolonnawa, Sri Jayewardenepura, Dehiwala, Thimbirigasyaya and Maharagama with a total catchment area of 21,667 ha. Since Colombo city is facing high urbanization, impacts of development are likely to negatively affect the surrounding urban environment. Table 1 indicates the structure of the land use distribution in the study area.

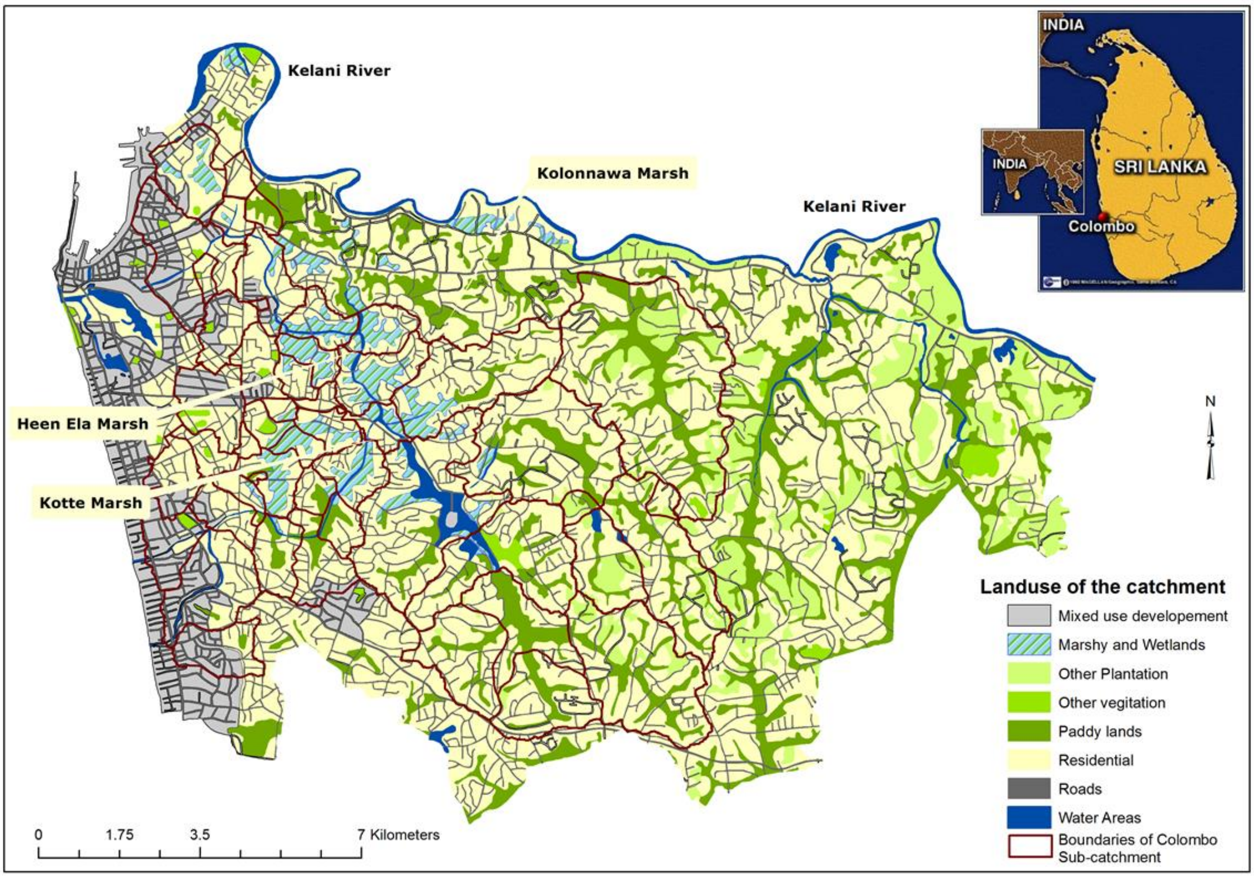
Table 1: Land use structure of the water catchment area considered for the study

Land use type	Area (Ha)	Percentage (%)
Mixed use development	2377.05	10.97
Marshy and Wetlands	759.16	3.50
Other Plantation (Coconut/Rubber)	1762.33	8.14
Other vegetation (Grass/scrubs)	217.73	1.01
Paddy lands	2920.54	13.48
Residential lands	10863.72	50.15
Roads	2242.28	10.35
Water Areas	518.87	2.40
Total	**21661.67**	**100.00**

Source: Urban Development Authority, Sri Lanka, 1996

The existing land use structure shown in Table 1 has effects that are important for the development of water sensitive planning practices in the study area. The area is comprised of both flat and low-lying terrain with natural wetlands, agricultural lands, and water areas. Colombo is a coastal city, which is geographically located about 1m above the Mean Sea Level. According to the Greater Colombo Flood Control & Environment Improvement Project of SLLRDC (1998-2005), Colombo Flood Detention Area is comprised of 400ha, which includes three major marshes named Kollonawa marsh, Kotte marsh and Heen ela marsh (Refer Figure 3).

Figure 3: Existing Water Sensitive Spatial Characteristics of the Catchment Area



Source: Author developed based on maps obtained from the Department of Surveying and SLLRDC in Sri Lanka

Figure 3 shows the locational distribution pattern of natural water sensitive characteristics identified and based on the land use structure of the catchment area. This study area was extended to enable examination of greater Colombo including adjacent suburbs to identify potential applications for water sensitive planning. Environmental features in the natural landscape are not isolated elements, therefore it is important to consider the range of potential water features that can optimise multi-functional water sensitive planning practices within the study area.

The northern boundary coincides with the Kelani River, which meets the ocean from the North Western coast. Along the coastal belt, approximately 10% of the area has been covered by commercial uses. The residential coverage is about 50% of the total land area. Nearly 20% of the land area is comprised of paddy, wetlands and marshes, and water areas. Therefore, incorporation of these features that contain ecological forms and aesthetic forms into urban development is important, especially, in the stage of site design and landscape planning. Table 2 represents present conditions and future prospects of the environmental landscape in Colombo seeking to create closer associations between urban development, water and land use planning. Examination of potential strengths, weaknesses, opportunities and threats (SWOT analysis) in the study area could help understanding of the opportunities that the urban system would provide for implementation of WSPP through spatial planning.

Table 2: SWOT Analysis of the case study area reflecting closer association between urban development, water and land use

	Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
1	*Environmental Condition* ▪ Located in the wet zone ▪ Availability of marshes that connect to streams, lakes and canals ▪ South western boundary is a coastal belt and northern boundary is the Kelani River ▪ Interconnected canal network that supports drainage of most of the surface runoff and then discharges to the Kelani River and to the ocean ▪ Availability of environmentally protected areas ▪ Includes Shallow aquifers on coastal sands and Laterite (Cabook) aquifer types in the area (Panabokke & Perera, 2005).	*Issues with water pollution* ▪ Both surface water and the ground water have been seriously polluted due to contamination by wastewater and other effluents received from industrial and domestic users. ▪ Health hazards and degradation of biodiversity in some environmentally sensitive areas ▪ Watercourses (canals, and lakes) located in and near urban centre are receiving large volumes of urban pollutants and organic effluents ▪ Insufficient maintenance of watercourses and sewerage drainage systems that result in blockage and aquatic plant growth ▪ Drainage system doesn't serve the present urban development density	*Available stormwater drainage system* ▪ Runoff reaches interconnected waterways, branches and small catchments throughout the region ✓ South: Major drainage basin from Nugegoda-High level road ✓ East: Thalangama-Hokandara watershed ✓ North: Kelani river flood bunds ✓ West: urbanized coastal belt ▪ Helps to attenuate surface runoff ▪ Runoff water collected through stream network outfalls to the Kelani river and the sea using the two gates located from the northern and southern boundaries.	*Run off water is causing serious threats to inland water bodies and natural biodiversity* ▪ Direct discharge of untreated drainage water from streets, parking lots, metal roof might include oils, bacteria, litter, sediments, fertilizers and foreign chemicals. ▪ Industrial waste and domestic effluents are mixing with natural streams. ▪ Fertilizers, industrial nutrients and other pollutants run off into nearby river and lakes causing algal blooms due to enriched nutrients ▪ Adverse effects for the quality of groundwater ▪ Threats to natural urban wetlands ▪ Streams and canals suffer from high eutrophication ▪ Breeding mosquitoes causing spread of diseases

2	*Availability of low lands where most of the lands are abundant paddy, marshes and wetlands* ▪ Three main marshes: Kolonnawa, Heen and Kotte are primarily supporting Flood Detention in Colombo Urban Area ▪ Most marshes are the best birding sites for endemic and migratory birds	*Lack of data and records about the value of the biodiversity on urban wetlands* ▪ Little data availability on the present conditions and biodiversity information of urban marshes and wetlands ▪ Disconnected relationship between wetlands and urban development	*Potential integration of nature and the urban environment* ▪ Recent wetland improvement projects such as biodiversity parks, butterfly gardens, recreational and pleasure areas ▪ Treated stormwater can be discharged to natural wetlands converting urban wetlands as green lungs for making cities resilience to climatic extremes	*Losses of biodiversity* ▪ Most of the marshes are at risks due to solid waste dumping, construction of unauthorized settlements and unplanned reclamation activities. ▪ Threats to endemic fauna and flora species living in wetland sites ▪ Health damage to urban inhabitants ▪ Degradation of natural environmental resources
3	*Availability of sound legal and institutional framework to manage stormwater and protect urban wetlands including environmentally sensitive areas*	*Lack of collaboration between institutional and regulatory authorities and frameworks* ▪ Unclear Responsibilities between vertical and horizontal line agencies for implementation of water management practices ▪ Lack of communication among institutions ▪ Governance and decision making issues related to maintenance and development of urban drains, watercourses and drainage channels for meeting urbanisation demands.	*Available and Proposed plans and policies* ▪ Environmental Management Strategy by Urban Development Authority ▪ Metro-Colombo Urban Development Project undertaken by SRLDCC for managing urban stormwater system and flood controls in Colombo funded by the World Bank ▪ Proposed Wetland Management Strategy by the SLLRDC and the implemented National Wetland Policy by the CEA ▪ Development planning	*Lack of coordination (institutional/legal) has created faster resource depletion* ▪ Overusing environment ▪ Unnecessary delays in planning and policy implementation practices ▪ Political interference for rationalising planning projects, policies and strategies between institutions for management and improvement of water and wetland resources ▪ Lack of directions on future growth

4	*Favourable tropical weather and climatic condition* ▪ Colombo occurs in the Wet Zone and usually receives 2,000 mm annual RF and 1900mm average annual RF (Rathnayake & Herath, 2005) ▪ Rainfall occurs throughout the year based on southwest, northeast and inter-monsoons ▪ No immediate impacts for water scarcity ▪ Support from national planning policies and governmental strategies for implementation of WSPP	*Lack of water management practices* ▪ New concepts of water sensitive planning practices haven't been implemented to meet unprecedented challenges ▪ Rainfall has decreased over the country during the last four decades ▪ Increased frequency of one day heavy rainfalls ▪ No proper urban water cycle management system has been implemented ▪ High temporal and spatial variability of one day heavy rainfall	*Potentialities exist for implementation of WSP and urban design practices* ▪ Availability of natural water features that can be enhanced through new concepts of water sensitive planning approaches ▪ Pre-historical evidence that shows a strong relationship between water and development of human settlement in the ancient cities in Sri Lanka	*Becoming a dangerous city for water due to vulnerability of disaster* ▪ Frequent occurrences of urban flash floods ▪ Urban flooding mainly caused due to inadequate stormwater management and related practices ▪ Natural detention capacities in low lying areas and riparian corridors has been lost ▪ Changes of rainfall pattern has affected groundwater recharge ▪ All water received mainly from precipitation
5	*Present urban development* ▪ Implementation of urban renewal projects ▪ Promote protection of natural environment and encourage green growth ▪ Removal of unauthorized constructions from urban wetlands and river bunds	▪ Increased the percentage of impervious surfaces & volume of stormwater runoff ▪ Promoted drainage based urban development ▪ High concentration of pollutants from impervious pavements and urban surfaces during rainfall	▪ Incorporation of water sensitive devices and methods within alternative land uses and through design minimisation of impervious surfaces in new developments and renewal projects ▪ Introduce catchment based development initially to low density housing areas	▪ Reduced groundwater recharge and infiltration rate from rainfall water ▪ Impervious surfaces produce high concentrations of pollutants ▪ First flush effect due to higher surface runoff

Source: Extracted using Colombo Urban Area Development Plan 1999, Government of Ceylon: South-West Coastal Area Water Supply, Sewerage and Drainage Project 1972, Sector Vulnerability Profile: Urban Development, Human Settlement and Economic Infrastructure (supplementary document to the National Climate Change Adaptation Strategy for Sri Lanka 2011-2016), First author’s field observations and experiences

3 DISCUSSION

The need of integrating urban water management, design and methods to minimise stormwater issues, can be achieved if it is interconnected through the delivery of land use planning, landscape architecture and urban design practices. This has been widely acknowledged by many professionals around the world. This encourages a holistic approach for delivering urban planning guidelines to incorporate WSPP in Colombo by addressing the minimization of the increasing effects of flooding and other extreme events within the urban area. Water sensitive urban development will provide a healthier and resilient ecological environment to the city. Instead of looking at stormwater as a likely risk for increasing urban hazards, it is necessary to integrate spatial planning into this process, enabling a perception of stormwater as a valuable resource to the urban system.

Accordingly, a set of initiatives were identified that can be proactively addressed within the context of Colombo, to address issues. For instance, initiatives were reflected in closer links between water and land use following the present development intensity, problems and challenges prevailing in Colombo.

In order to make sure of a sustainable delivery of stormwater practices through the process of water sensitive planning approaches, it is important to understand the multi-functional character of the existing land use structure. This understanding will enable realisation of the extent to which WSPP can help integrate the current landscape pattern to get rid the issues. This section provides an overview for possible transferable lessons based on pros and cons identified by the SWOT analysis given in Table 2.

POTENTIAL TRANSFORMATION PRACTICES FOR WSP IN GREATER COLOMBO

Implementation considerations of urban water management practices incorporate the idea of removing stormwater that is generated from urban spaces or development sites, and sending it to the nearest watercourse as quickly as possible to prevent floods or similar hazardous conditions in the urban area, avoiding potential damage to the ecosystem. Already understood is the need for an adaptive and multi-disciplinary approach to stormwater management that integrates social, environmental, physical and economical aspects to overcome a multitude of issues in present urbanized systems. Integration of land use structure to develop more water sensitive outcomes will improve planned urban development, thereby positively contributing to the enhancement of the overall performance of environmental characteristics of city. Hence, key problems were identified which are required to be addressed for augmentation of water sensitive planning practices in Colombo and these are summarized as follows. This augmentation is seen as very important since Colombo has a pipe-based drainage system. This system is increasingly questioned by many countries as an unsustainable way of addressing urban water management in urban systems (Brown et al., 2009). In addition, both structural and non-structural practices need to be addressed to encourage water sensitive planning practices to proceed in Colombo. Key problems are:

1. Lack of integration between urban water management practices with contemporary urban planning and land use development approaches
2. Malpractices of current stormwater management systems and limitations of natural wetlands
3. Clustered urban development at present increases impervious covers

4. The rate of precipitation exceeds the ability of rainfall infiltration to the ground
5. Urban water management issues/practices have to date been addressed by the traditional drainage systems in urban development
6. Current technical infrastructure and institutional structure still represents the past urban development niche

Considering the present stormwater issues as summarized in Table 2, the use of the treatment-train approach would be beneficial for stormwater management practices in Colombo. This could provide positive outcomes for controlling the volume of stormwater that is generated over a large area during the discharge in a peak runoff event. There is a high ratio of impervious to pervious area (approximately 95% in commercial developed areas and 25% to 40% in residential densities) in Colombo (Wijesekara, no date). Surface runoff from these surfaces creates vulnerability due to the speed of runoff, volume and the level of contamination. On the other hand, use of physical process as one ways of treatment methods for removal of pollutants provides benefits for urban stormwater management (Lloyd et al 2002). Therefore, incorporation of treatment-train approaches effectively reduces and prevents the level of pollutants that are entering and directly discharging into the downstream natural wetlands. In order to identify problems, Table 3 indicates some potentially transferable practices that can be incorporated to optimise water sensitive planning methods in Colombo.

Table No 3: Potential initiatives for WSPP in Colombo incorporated through spatial planning

Problem	**Rationale for WSP practices/Methods**	**Potential Transformative capacities in Colombo**
1	▪ Storm water management practices should be augmented by considering the ‘nature amenity’ ▪ People derive particular satisfaction by engaging with nature ▪ The need of combining water management practices into climatic impact adaptation for planning a resilient city ▪ Availability of natural urban wetlands (which are currently being neglected) that could enable delivery of water based urban design practices	Inclusion of transformational capacities into planning and policy phase through appropriate design criteria to improve implementation and operational process of urban water sensitive designs at all scales ✓ Appreciation of urban water sources during land use planning processes as an essential element for providing healthy urban environment ✓ Using urban development guidelines changing the average permeability levels permitted. This will increase the infiltration, minimize the volume, and rate of runoff
2	▪ Lack of co-operation in working with the nature’s cycles	Use of natural wetlands to treat stormwater runoff has limited capacities. Even though the catchment area is comprised of a studded network of natural wetlands, discharge of stormwater can be only acceptable if

		properly pretreating the stormwater. This is because; natural wetlands contained a highly biologically diversified fauna and flora system. Accumulation of untreated stormwater in natural wetlands can damage their functions and values.
	▪ Runoff from the developed catchments must be moderated, treated and returned before stored into natural wetlands to minimize biodiversity losses	✓ Constructed Stormwater Sediment Wetlands Stormwater wetlands are fundamentally different from natural wetlands, because they are specifically developed for treating stormwater runoff. Even compared to the natural wetlands constructed wetlands have lower biological diversity (EPA, 1999) Constructed stormwater wetlands can also be helpful to protect functions and values of natural wetlands by cleansing surface runoff before entering to natural wetlands. Direct discharge of runoff water can heavily destroy valuable species in natural wetlands, and also alter hydrology, water quality, and sediments or soil characteristics of the wetlands (EPA, 1999). Since Colombo consists of several natural water features such as streams, lakes, canals and wetlands, they can provide a major support during small to heavy rainfalls, minimizing increased peak runoff and intercepting the higher volume of water. Runoff entering to those sensitive areas may come mainly from highly developed urban catchments, particularly those that contain high levels of pollutants. This phenomenon might affect those water features vulnerable to pollution.
		✓ Urban development, especially in low-density urban areas should encourage site design based on catchment scales that are interconnected through comprehensive spatial planning approaches.
	▪ Uptake of ecological sustainability in the urban system that minimizes or avoids potential damages/impact on development	This process helps the uptake of LIUDD methods of design for the minimization of stormwater generation in the urban area. In addition, this will be influential in the control of the density of development while enhancing ecosystem services within valuable and vulnerable parts of the catchment (van Roon, 2011). Initially, this can be practiced when new residential developments are taking place, especially in suburbs, adjacent to upper catchment areas in the Colombo flood basin.
		✓ Enhancement of riparian protection/corridors During heavy rainfall, riparian protection gives several benefits to optimise water sensitive functions in water bodies, lakes and streams. For example filtering out

		pollutants/sediments from stormwater before inflowing to streams and lakes, protection of stream banks from erosion during floodwaters, supporting the natural biodiversity cycles and habitats (Wang et al., 2001) ✓ Planting native vegetation Riparian vegetation provides erosion protection near stream banks during heavy rainfalls to enhance resilience of stream network. At the same time, native plants have abilities to bend in currents and quickly recover after floodwaters subside during high flows (Ferguson, 1998)
3	▪ To optimize flows of stormwater and accumulated pollutants ▪ Retrofitting stormwater controls into urban planning approaches ▪ To minimize negative impacts on the water quality due to runoff ▪ To minimize overcharging the wetlands beyond their pollutant retention capacity	Increasing accumulation of polluted stormwater drained from urbanized catchments through urban drainage is damaging the natural environment including properties, urban agriculture and stream flows. To minimize these effects; ✓ Integration of water retention infrastructure to infiltrate or attenuate runoff (within new development projects/regenerating urban spaces) ✓ Use of areas for construction of Wet Detention Ponds/Stormwater Retention Ponds to minimize direct discharge of contaminated stormwater into natural wetlands and marshes. Wet detention ponds can help to control both the retention and treatment of contaminated storm water runoff (EPA, 1999). ✓ This might help to achieve overall health of urban streams and natural wetlands reducing pollutants flushed off roads, parking spaces, lawns in urban areas. ✓ Application of permeable pavements/ porous surfaces for development of low traffic areas including current/ future residential subdivisions and parking lots to reduce stormwater outflows and managing pollutant effects in site scales. This helps to direct rainfall through the surfaces infiltrating to the ground moisturizing the soil layer. Water quality (detection of both Copper and Zinc) of the infiltrated water through porous surfaces is higher than for surface runoff from asphalt areas (Brattebo & Booth, et al. 2003).
4	▪ Colombo is geographically located in a coastal belt where the land is 1 metre on average above MSL. Therefore, it has a	✓ The effect of continuous urban development has created increased peak runoff volumes simultaneously increasing the amount of pollutants entering through runoff. ✓ Due to an increase in impervious surfaces inclusion of

	high runoff level. ▪ Creates flooding ▪ The percentage of groundwater supply is 9.4% and the Percentage of surface water supply is 90.6% in 2005 (Panabokke & Perera, 2005)	on-site stormwater detention systems to new development sites as mandatory in order to obtain planning permits. ✓ The use of bioswales when designing urban infrastructures that are likely to be impervious covers in urban areas mainly in streets, parking lots and pavements. This will help to reduce the volume, velocity and pollutants that enter waterways. ✓ To reduce accumulation of the surface runoff, rain gardens and rainwater harvesting systems should be introduced to residential and commercial buildings as a mandatory building regulation in areas of urban catchments. ✓ Stormwater from rainwater tanks can be used for garden irrigation and as a substitute for toilet flushing (van Roon, 2011). Rain gardens can provide opportunities to promote native vegetation to be featured in the city. At the same time, it might help to filter the runoff water as an environmentally friendly filter with an aesthetic value.
5	▪ Remove the surface runoff water as quickly as possible during heavy rainfalls ▪ Need of improving water sensitive characteristics of the urban systems that leads to uptake of current water management practices and their functions ▪ To pay adequate attention to the quality or the quantity of the surface runoff water	✓ To upgrade over 50 years, an older micro-drainage system that potentially creates floods in the city using sustainable drainage infrastructure. Stormwater runoff in the central city is mainly from rainfall. In Colombo, the present micro drainage network is running parallel to urban streets, and it receives and conveys stormwater that is accumulated from urban surfaces such as building roofs, streets and other lots, and drained to the nearest water network. At the same time, this drainage network is connected with a traditional end-of-pipe approach, which is not adequately meeting the current volume of runoff generated by the excessive rain. ✓ In areas of new urban development incorporate sustainable urban drainage (SUDS) elements. Retrofitting can also be done in already developed areas by replacing or moderating its traditional micro type drainage converts using SUDS systems. By then, significant problems related to managing stormwater quantity will be benefitted positively (Wilson & Bray et al, 2004). ✓ Including or retrofitting capacities into urban development areas can help minimize the generation of higher volume of stormwater while minimizing the risks of frequent occurrences of flash floods in the city.

6	▪ They need to be modernized - advancing to meet present and future urban water management and planning regimes reflecting dynamic characteristics in development of the cities of the future	✓ Possible strategies to encourage interconnected role between local, regional and national level institutions for achieving planning related sustainable outcomes, instead of working as isolated entities when fundamentally similar decision are being made for development of water resources ✓ To ensure concerted collaboration among institutions and regulatory mechanisms at each stage of planning for achieving water sensitive transitions within urban development. ✓ Configuring existing governance reforms, policies and practices addressing strategies for planning water sensitive transformation to establish responsibilities within each level of institutions delivered through a multi-level governance approach. This reconfiguration will demonstrate how resilient water resource systems can be designed for overcoming challenges in future cities (Rijke & Farrelly, et al 2013).

Consequently, the need of re-formulating both the structural and non-structural measures to address transitioning to water sensitive planning is likely a more effective way to deliver positive outcomes to WSP in Colombo. At the same time, environmentally compatible urban development integrated with better landscape planning and the use of water sensitivity elements will enhance recreational values and aesthetic benefits to inhabitants. To achieve this, identification of potential water sensitive elements and drivers from the nature's cycles, and incorporating them into planning, urban development at early stages provides more sustainable, and nature oriented water sensitive urban development.

This will further overcome common urban and environmental problems, especially issues related to stormwater management, impact of urban pollution, impact adaptation to climate change, and minimise natural disasters. In addition, outcomes of WSPP will help to protect most of the wetlands, marshes and waterways that have been destroyed due to fast urban development.

4 CONCLUSIONS

In Sri Lanka, planning and policy objectives have already been formulated to establish adequate water management capacities to respond to the challenges of climate change. A sound institutional and legal framework has also been made to better align water resources management practices, in particular towards the need to achieve practicable strategies and outcomes.

Apparently, it has been identified that stronger and closer cooperation is required at the initial stage of development planning for formulation of findings and recommendations that are appropriated for delivering transformative strategies to adopt water sensitive planning outcomes. This cooperation should be taken at the catchment scale seeking the process of urban development and possible causes for environmental degradation to avoid potential damage through design and development. Therefore, planners have a critical role to identify and prioritise possible conflicts and to minimize them, meaningfully designing the site plans at the catchment scale. This can be achieved linking planning, ecological, and design aspects across catchment level and then transforming this into urban scales. This will help to integrate water sensitive planning practices at the initial stages of land use planning to successfully integrate water-environmental-development related outcomes in a sustainable manner.

It is important to optimise a variety of resources available from the natural ecosystem; such as use of wetlands, marshes, riparian parks, native vegetation and swale drains for stormwater quality control and runoff. At the same time, planning controls should be incorporated to protect riparian corridors from anticipated human induced damages. For example, prohibiting removal of native vegetation, avoiding tree cuttings, and assessing riparian status when issuing building permits. Prohibiting such development activities can potentially minimize damage of the natural habitat. Land use layout in Colombo has provided areas that can be optimised for sustainable stormwater management systems. The challenge is that these environmental features contain rich biological diversity such as in natural wetlands and riparian zones in the Kelani River. Therefore, treatment-trains should be created using neglected paddy lands that will treat stormwater, not at one location, but as multiple locations before discharging it into natural wetlands.

For meeting the current demands of urban sprawl in Colombo, many natural wetlands are currently being destroyed due to solid waste dumping and construction of unauthorized settlements. In addition, water networks including the Kelani River with the interconnected canal network provide a primary support to control stormwater runoff of the city. To appreciate the meaning of stormwater as an opportunity for the city, integration of water quality controls such as constructed wetlands and wet detention ponds is important to address water quality issues. This will provide aesthetic values and places for recreation as well. At the same time, sound operational frameworks of non-structural measures are needed to prevent these sites from further damage due to uncontrolled urbanization. As a result, they can be protected to realize water sensitive planning outcomes associated with spatial planning practices.

Replacement of traditional drainage/piped based approaches with more nature oriented design based approaches such as incorporation of principles, methods and practices from WSUD, LIUDD, LID and SUDS is important to overcome urban water resource management in Colombo. These newer concepts will enhance natural ecological services of the city while reducing negative impacts of urban development. At the same time, some of these concepts and practices are extremely useful for minimising flooding and other impacts that are increasing significantly due to the impact of climate change in Colombo.

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