Challenges in Implementing Integrated Catchment Management and Sustainable Stormwater Solutions in Bangkok, Thailand

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Abstract

By reviewing related studies, published journal articles, research and government reports, this study explored the challenges in water governance, focused on the planning for Integrated Catchment Management (ICM) and stormwater Source Control (SC) in Bangkok and its catchment. The review revealed implementation barriers, and eight categories of challenge: fragmented roles and responsibilities; technocratic bureaucracy; limitations of the regulatory framework; financial barriers; physical barriers; challenges of integrated knowledge; an uncoordinated institutional framework; and limited community and stakeholder involvement. The understanding of barriers to ICM planning and SC approaches is crucial for developing strategies that diminish barriers and increase the implementation of alternative solutions.

Keywords: Bangkok; Integrated Catchment Management; stormwater source control; water governance

Introduction

The aim of this study was to explore the governance issues regarding ICM planning and sustainable stormwater management in floodplain cities, using Bangkok as a case study. In recent decades, anthropogenic land-use change has resulted in the conversion of natural areas into impervious surfaces and caused negative impacts on river water quality and quantity in floodplain cities. Traditional stormwater management often directs runoff to streams and rivers. Untreated stormwater runoff in the catchment has caused the impairment of waterways, resulting in the degradation of ecosystem functions. In Thailand, ongoing urbanization and increasing impervious surface areas have contributed to water pollution throughout the lower Chao Phraya River and Bangkok area. Greenpeace International (2011) claimed that this is one of the most degraded rivers in Thailand, mostly contaminated by domestic, agricultural and industrial wastewater in the Chao Phraya River Basin (CPRB), especially in the lower river around which Bangkok is located.

Stormwater, which also creates flooding, is a crucial part of the urban water cycle. Conventional stormwater management treats stormwater as a nuisance and a risk rather than as a resource. It collects and conveys it via pipes or other infrastructure to alleviate flood events, with little concern for receiving rivers (van Roon, 2007). This contributes to water quality degradation, and biodiversity depletion in urban streams and coastlines (Segaran et al., 2014). Bangkok's stormwater is typically either directly discharged to rivers, or transported through combined sewers to wastewater treatment plants (WWTPs). Rapid drainage of stormwater from built-up areas to WWTPs, instead of its infiltration, has resulted in combined sewer overflows (CSOs) and increased river pollution. Moreover, rapid economic and urban growth over decades has brought an influx of migrants, loss of farmland and rapid environmental deterioration. Growing urbanization and industrialization since 1950

has resulted in the conversion to urban use of paddy cultivation areas in the floodplain of the lower Chao Phraya delta (Emde, 2012). These anthropogenic land-use changes plus coastal erosion of the delta have also caused overflows and floods on the Bangkok floodplain (Emde, 2012; Prajamwong & Suppataratarn, 2009). A sustainable approach is necessary, combined with overflow drainage options, to solve flooding and restore water quality and landscapes in Bangkok.

Figure 1 (Left): Topographic Map of Thailand (Suksawang, 2012)

Figure 2: (Right): Map of the Chao Phraya River Basin (Kmusser, 2013)

The application of ICM planning and SC solutions through holistic approaches including institutional and legal frameworks, water resource management, and land-use planning, can contribute to environmental quality improvement in floodplain cities. ICM takes into account the interactions between the management of land-use, water and other natural resources in a catchment (Ashton, 2000). SC approaches recognize holistic long-term methods and use functions of natural features to minimize stormwater generation and contamination. They involve the restoration, reduction, re-use, and recycling of water. They also enhance the potential for runoff reduction and pollutant removal through retrofitting the hydrological regime in association with various green facilities (USEPA, 2013).

SC approaches can be practiced by managing the stormwater from the individual level through the neighbourhood level and expanding to the whole catchment level. At the individual level, SC approaches take into account managing household water runoffs. The application of rain gardens together with green roofs and grass swales may capture and direct rooftop runoff away from storm sewers and treat runoff onsite, which can significantly reduce the load of combined sewer overflows (CSOs). Treated stormwater also reduces the demand for water supply as it can be used for various non-potable purposes at the household level such as gardening and car washing. (Chang, 2010). At the neighbourhood level, SC solutions primarily focus on managing street pavements and bioretention swales in terms of stormwater quality and quantity (Marsalek & Schreier, 2010). At the catchment level, they also take into account the whole water balance to enhance the potential for runoff reduction and pollutant removal through retrofitting the hydrological regime in association with various green facilities including bioswales, constructed wetlands, and bioretention ponds (Chang, 2010).

ICM planning and SC solutions can guide planners to create comprehensive and sustainable practices for managing stormwater quantity and quality in floodplain cities. Urbanization leads to negative environmental impacts if water governance is not well managed in conjunction with economic growth. Awareness of the weaknesses within institutional frameworks and management capacities are essential to justify embracing ICM as a means to maintain the environment in a sustainable manner.

Methods

The challenges in water governance were explored in this study, focusing on ICM and SC practices, by analyzing practices in Bangkok and its catchment. Apparent gaps in the literature were explored and an effort has been made to review related studies generally published as journal articles, plus research and government reports. Moreover, some recommendations were addressed on how to overcome or achieve the effective reduction of some barriers, particularly building governance capacity, through land use planning, effective governance arrangements, legal frameworks, financial incentives, and public participation processes.

Results and Discussion

The most persistent challenges for dealing with sustainable stormwater management can be attributed to governance failures rather than resource-based issues (Pahl-Wostl et al., 2012). To deal with this, effective governance for water resources management requires integration of social and physical processes within catchment boundaries (Lebel et al., 2005). Thus, there is a need to raise the understanding of stormwater SC jointly, within socio-economic and ecologic dimensions.

Although the multiple advantages of SC practices have been demonstrated in other countries, the degree of implementation for these approaches in Thailand is still low. To identify the barriers, results from comprehensive reviews were subsequently distilled into eight major "challenge" categories: fragmented roles and responsibilities; technocratic bureaucracy; regulatory framework limitations; financial barriers, physical barriers; challenges of integrated knowledge; uncoordinated institutional framework; and limited community and stakeholder involvement.

Institutional Barriers: Fragmented Roles and Responsibilities

Since the late 1990s, growing concerns regarding the need for environmental protection have emerged as public interest issues in Thailand. In response to water-related issues, the application of ICM first appeared there in the 1990s (Takeda & Putthividhya, 2015). However, the official ICM approach has been focused on supporting the public interest in and overcoming flood and drought issues only, rather than also addressing clean water protection. Catchment based decision-making institutions have emerged since about 2000, from a relatively centralized structure at national level, and have expanded both citizen engagement and the development of participatory processes (Jacobs et al., 2010).

The establishment in 2002 of a regulatory agency, The Department of Water Resources (DWR) of the Ministry of Natural Resources and Environment (MoNRE), with core activities to promote ICM (Anukularmphai, 2010), may be considered the most significant institutional reform for overcoming fragmentation. The formation of a catchment organization with a specific environmental mandate can be seen as an opportunity for water resource management that reflects the catchment context.

Although ICM has been developed to address and resolve issues of water governance, the legal responsibilities of government agencies often overlap, resulting in complications and confusion in catchment management. There are more than 30 government agencies, at all administrative levels, involved in water resource management. Each typically works separately and operates on the basis of its own objectives and priorities. This has frequently resulted in inter-agency conflict. Institutional fragmentation is considered one of the main barriers to achieving ICM.

The separation of the management of individual natural resources, has largely resulted from legislation relating to management of individual resources – e.g., land, water, forests, coasts, fisheries and marine resources, and their environments – thus empowering each agency to be responsible for each resource absolutely. Lack of coordination between agencies frequently causes conflict, inefficient management, and destruction of natural resources in catchment areas.

Technocratic Bureaucracy

Traditionally, human-centered approaches derive from techno-centrism. Infrastructure is broadly perceived as the best solution to overcome the impacts of floods most of the time. Lebel et al. (2010) stated that the emphasis on infrastructure in conventional stormwater management, when trying to reduce flood exposure risk, has been promoted by politicians and experts to protect Bangkok and neighboring provinces from floods. Although technology provides humans with greater ability to dominate nature and disturb environments through their activities, it comes hand in hand with huge responsibility. Governmental misjudgment in exercising its authority leads to ecological degradation within its jurisdiction, e.g., dam construction that can potentially harm and alter the ecosystems of an entire catchment.

In the case of the CPRB, it was argued that most of the floodwater is generated in the upper catchments, flows into the lower catchment, and discharges into a large downstream area in Bangkok and its vicinities (Komori et al., 2012). To reduce downstream flooding during the wet season, the river level is generally managed by upstream dams that store runoff. UNESCO (2003) stated that over the previous sixty years, 3,000 reservoirs have been constructed in Thailand to minimize flood risks, to store water for discharge in the dry season, to supply water for industrial and urban use, and to take advantage of the agricultural potential of the country.

To minimize the risk of flooding in Bangkok, dykes were built to protect further floodplain development in high flood-risk areas. These flood protection systems, extending around 77 km, have been constructed by the Department of Drainage and Sewerage (DDS), including the dykes from the northern to eastern parts of Bangkok and flood barriers along the Chao Phraya River to protect the city (ADB, 2012).

Unsustainable stormwater practices and large projects weaken ecosystems. They lead to ecological destruction and negative impacts to human health, as noted. Thus, to achieve environmental sustainability, all members of society must place the value of nature and ecological responsibility at the top priority level.

Regulatory Framework Limitations

Although ICM planning already exists in Thailand, the fragmented government and legal systems still lack the hierarchy to pursue it. As discussed, the stormwater management policy

and ICM planning has been dominated by a technocratic government. The current ICM planning regime has also been applied flexibly to include the various institutions and structures of authority engaged in environmental management.

ICM policy has been declared a key part of the national agenda since 2007. Several projects have been carried out to increase public awareness on water resources management, and legislation governing the use of natural resources such as land, forestry and minerals has been enacted over several decades. However, according to World Bank (2011), no comprehensive water legislation – i.e., a specific national act or statute – has been released yet. Although the concept of ICM has been included in a number of national policies, legislation to implement the water policy remains inefficient.

There is also a redundancy of laws in enforcement, especially in the fines, sanctions and obsolescence. Some laws have been promulgated for a long time, without revision to make them appropriate to the current situation, thus causing problems in enforcement (DWR, 2014a). Currently, there are a large number of separate water-related laws implemented by several government agencies within nine ministries, but those laws still do not cover all aspects of water resources management.

With respect to legislation related to stormwater management, there are no direct and immediate legal sanctions to prevent environmental harm caused by unsustainable stormwater practices. Instead there is a general responsibility under general environmental laws. As described by DWR (2014b), although there are more than 200 ministerial regulations under the Building Control Act B.E. 2522 (1979), the requirements for drainage systems and stormwater management, have not been recently discussed in the Bangkok ordinances on building codes under the Act.

Financial Barriers

One of the main barriers for implementing stormwater SC practices is related to the high and upfront costs. Economic comparisons for SC practices are presented in a number of publications (Bettess, 1996; FHWA, 2000; Barbosa et al., 2012). Although environmental issues are recognized as important, because they affect the well-being of the wider public, the budget allocated for environmental development remains low, reducing the success of environmental and natural resource conservation operations. This is because environmental budgets are separated from, for example, drainage budgets when the latter could be spent in a way that resulted in improvements in environmental quality as well as drainage capacity. Combining budgets can increase financial efficiencies rather than environmental costs being an addition.

Insufficient budget also becomes the major cause of ineffective environmental management at local government level. Although the amount and proportion of local revenues is currently increasing steadily, it is still considered very low compared to the total revenue of central government. Thus, it does not meet the minimum requirement of the Determination of Plan and Steps in Decentralization of Authority to the Local Administrative Organization Act B.E. 2542 (1999) that requires the proportion of local revenue to be not less than 35% of total central government revenue.

Financial incentives and public subsidies are the main factors determining the probability of adoption of sustainable stormwater systems. Public financial support to promote the installation of sustainable stormwater approaches also creates a cost-effective opportunity for

communities to consider in their efforts to minimize CSOs. Financial incentives to promote SC installations have been introduced in some municipalities in the US – e.g., Portland (PBES, 2006; Greenroofs, 2014), Washington D.C., Philadelphia, and New York (Garrison & Hobbs., 2011). Limited financial support may reduce motivation for implementing some sustainable stormwater practices that are valuable. Thus, economic incentives would be a good solution for their implementation.

Physical Barriers: Constraint of Land Use and Available Spaces

Another cause of low implementation of sustainable stormwater approaches in Bangkok is related to the constraint of land use, drainage areas and available spaces. Although the idea of stormwater SC practices has been increasingly grounded in the research and science of sustainability in several countries, these practices have not been widely adopted or implemented in highly urbanized areas in Thailand. This is partly because of a belief that there is insufficient open space and land costs are too high, thereby acting as a disincentive to install or retrofit devices into urban landscapes.

Promotion of SC practices can be facilitated by the use of devices in small spaces, including setback distance areas, along roadsides, urban voids, road islands, spaces under bridges, toll ways, deck spaces of commercial buildings, rooftops, and recess areas, by all parties in both the public and private sectors. According to Segaran et al. (2014), the combinations of parks and series of sustainable stormwater devices are important to reduce urban runoff and improve stormwater quality. The potential role of retrofitting SC approaches into existing parks and land networks has been shown in the improvement of stormwater quality, particularly nitrogen removal, in an urbanized catchment in Adelaide, South Australia.

Public parks provide opportunities for integrating SC approaches for medium- to high-density residential developments. As the constraint of high prices for competing urban land-uses poses threats to and resistance against the adoption and implementation of SC strategies, introducing SC strategies within parks may mitigate public resistance due to reduced public costs of storm water management. Establishing SC devices off site at nearby parks can not only improve river quality in an urban catchment but also provide the additional benefit of reducing urban stormwater runoff.

The Challenge of Integrating Knowledge

The implementation of ICM planning and stormwater SC practices has not been promoted extensively in Bangkok due to a lack of shared knowledge in the various sectors, lack of continuity of networking and cooperation, associated with inadequate support, personnel and funding. Some stormwater SC systems lack ongoing maintenance, making them dilapidated and non-functional.

Several methods of stormwater solutions still rely on agency specific strategies that fit within their areas of responsibilities. The lack of unity in water management policy and plans resulted from various laws, which overlap but are not comprehensive, leading to enforcement or control difficulties. This causes confusion in law enforcement because it takes much time in diagnosis and interpretation, and threatens the opportunity to deal with water problems. DWR (2014a) noted that the different and unsystematic data and information systems of many agencies also resulted in difficulties in plan implementation. Water resource management has been seen as an isolated issue rather than focusing on a holistic water system that could be managed as part of catchment development. The potential impacts of

stormwater runoff on water quality in receiving rivers are not yet well understood in Thailand.

To enhance the awareness and knowledge of ICM planning, champions or advocates are seen as important. Champions are people who strongly believe in the value of ICM practice and serve as the driving force to achieve the ICM identified goals (Anukularmphai, 2010). Moreover, they also have the responsibility to ensure external funding for sustainable water practices in catchments (Bos & Brown, 2012).

Anukularmphai (2010) noted that experience-based knowledge from advocates is critical to support decisions about water resource management. The needs for consistency, patience, and continuous efforts by advocates or campaigns are equally important in the lengthy process of pursuing goals through an effective implementation of ICM process and to avoid derailment. Prominent and respected persons as advocates and champions are important to accelerate the ICM process, and to be able to link community stakeholders, decision makers, and other relevant networks in complex and bureaucratic systems.

Uncoordinated Institutional Framework

Effective coordination at all levels of the bureaucracy and cross-sectoral agencies is necessary to deal with the complex issues of urban stormwater management. Closed organizational cultures or lack of coordination between organizations are likely to be a barrier to staff involvement in policy formulation and ongoing monitoring.

In Thailand, the major roles in water resources management are the responsibility of the Royal Irrigation Department (RID), including providing sufficient water and allocating water equitably for all users, preventing river water pollution, balancing water source uses within catchments, and preventing and relieving flooding. The Office of the Ombudsman (2011) stated that RID was the initial agency in charge of water management, especially for agricultural use. Due to economic growth and industrial expansion under the National Plans for Economic and Social Development, the responsibility of RID has become wider and more complex in order to balance the water management for industrial and agricultural uses, as well as maintaining ecosystems.

Lebel et al. (2010) noted that the RID and municipalities bear the major responsibilities for managing stormwater issues. RID also has a significant role in catchment management, which has been supported by DWR. However, the Office of the Ombudsman (2011) claimed that the DWR and RID water management obligations are a duplication.

Successful coordination among various actors mainly relies on the important role of formal institutions through increasing cooperation within networks (Pahl-Wostl & Knieper, 2014). The enhancement of ICM planning will require a transformative change through strengthening cross-sectoral collaboration and changing the ways that government agencies operate. Strengthening collaboration and coordination between agencies can be enhanced by integrated management across land and water-related agencies within the Bangkok Metropolitan Authority (BMA). Moreover, the coordination of relevant agencies, including those of central government, responsible for land and water resource management, local government bodies located in the catchment, and the needs and support from all land and water-related agencies across the country are important to make sustainable stormwater measures more effective.

Limited Stakeholder Involvement and Public Participation

Thailand has realized the importance of public participation and implemented it in several aspects. The Thai Government has given priority for participation in both national and local administrative organizations. This can be seen in the Thai constitutions promulgated in B.E.2540 (1997 AD) and B.E.2550 (2007), both of which require public participation in several circumstances. However, the understanding and implementation of participation processes is still patchy.

There still seems to be a lack of cooperation and learning from local expertise. GWP (2013) revealed that construction plans are often prepared from central government perspectives in Bangkok, especially by consultants and the City Planning and Public Works departments in each province. The planning of a stormwater protection system such as a dyke, flood ways, or a water diversion system is typically the effort of government agencies, and local people are not involved.

To improve the way in which issues in public participation processes are handled, norms in planning will have to shift from technical conventional instruments towards sustainable stormwater management, and local organizations will need to cooperate with higher administrative levels and vice versa. Reforming education, raising learning activities and workshops, and strengthening water-related institutions are very useful tools in enhancing learning processes and pushing for ICM implementation.

Dealing with persistent governance issues requires clear purpose to support and strengthen formal and informal societal networks. This could be achieved by persuading a number of multi-stakeholder partnerships to share their perspectives and knowledge on the issues. A large and diverse group of stakeholders is critical to putting ICM into practice at various levels.

Conclusion

Managing water resources in a catchment for sustainable development is both a technical and a governance challenge. A shift towards more sustainable water management practice has become a major concern in Thailand, due to ongoing river degradation and technology-based approaches. However, support for ICM and SC practices is unlikely to be a high priority within catchments as there is limited government directive to respond to stormwater management concerns.

A large variety of government agencies is involved in water resource management. Several measures are being implemented as stand-alone interventions by single departments. Existing development plans still lack integration and coordination with plans and projects in the upstream areas of the Bangkok urban area. The lack of cooperation between agencies has become the primary problem for achieving ICM planning in the country. Holistic and integrated land and water management planning beyond a single local government area is necessary.

Responses to stormwater management are often based on technical practice with insufficient, often zero, attention to catchment management regarding land-use changes upstream, rapid transformation of building in downstream flood plain areas, and changes in stormwater regimes. Structural measures are not adaptable to future needs. Although there are enormous opportunities to minimize environmental problems, too little attention has been paid to

sustainable management approaches. A policy on SC measures through the creation of green facilities for environmental improvement has not yet been launched for Bangkok but could lead to great improvement.

A major shift in the implementation of non-structural measures including institutional arrangements, land-use planning, and building the capacities of local authorities and communities for proposing and implementing adaptation measures through ICM planning is required. To achieve the goals of sustainable management, institutional arrangements will require a transformational change through promoting a collaborative mechanism among relevant agencies in the catchment. A transition to a new system needs to include clarifying responsibilities and accountabilities of existing authorities, especially of local government, groups of water users, and catchment organizations. Sustainable stormwater management requires more than technical quick-fixes; long-term adaptive planning approaches particularly SC measures should also be considered to provide an opportunity for enhancing resilient ecological systems.

Incorporating structural measures into an adaptive practice, rather than focusing on an optimal engineering design is necessary. Central and local government, NGOs, experts, and relevant private sector actors need to play important roles in integrating adaptive practices, and enhancing awareness programming and education for local communities. Stakeholders will need to be proactive in adaptation, through determining sustainable stormwater practices and incentive programmes for urban green facilities. The policy-makers will also need to create long-term policies and allocate sufficient resources to invest in adaptive stormwater solutions in the catchment areas.

References

Anukularmphai, A. (2010). *Implementing integrated water resources management (IWRM): based on Thailand's experience.* http://cmsdata.iucn.org/downloads/implementing_iwrm__rm_changes_130510___2_.pdf (accessed 5 April 2015)

Ashton, P. (2000). *Integrated Catchment Management: Balancing Resource Utilization and Conservation*. African Water Issues Research Unit *Occasional Paper*, (5). http://awiru.co.za/pdf/astonpeter.pdf (accessed 15 August 2013)

Asian Development Bank [ADB]. (2012). *Good Practices in Urban Water Management: Decoding Good Practices for a Successful Future.* National University of Singapore. http://reliefweb.int/sites/reliefweb .int/files/resources/good-practices-urban-water-management.pdf (accessed 25 May 2013)

Barbosa, A. E., Fernandes, J. N., & David, L. M. (2012). Key issues for sustainable urban stormwater management. *Water research*, *46*(20), 6787-6798.

Bettess, R. (1996). *Infiltration drainage: manual of good practice*. London: Construction Industry Research and Information Association.

Bos, J. J., & Brown, R. R. (2012). Governance experimentation and factors of success in socio-technical transitions in the urban water sector. *Technological Forecasting and Social Change*, *79*(7), 1340-1353.

Chang, N. B. (2010). Hydrological connections between low-impact development, watershed best management practices, and sustainable development. *Journal of Hydrologic Engineering*, *15*(6), 384-385.

Department of Water Resources (DWR). (2014a). *Department of Water Resources and Role in Thailand's Water Management.* Ministry of Natural Resources and Environment.

Department of Water Resources (DWR). (2014b). *Conservation measures for the rehabilitation and maintenance of water sources.* Ministry of Natural Resources and Environment.

Emde, G. (2012). *Flooding in Thailand's*
Chao Phraya River Basin. http://mysite.du.edu/~gemde/ pdfs/Fundamentals_Chao PhrayaRiverBasinFlooding.pdf (accessed 20 August 2013)

Federal Highway Administration [FHWA]. (2000). *Stormwater Best Management Practices in an Ultra-urban Setting: Selection and Monitoring.* Federal Highway Administration n. FHWA-EP-00-002. U.S. Department of Transportation, Washington, 287 pp.

Garrison, N., Hobbs, K. (2011). Rooftops to Rivers II: Green strategies for controlling stormwater and combined sewer overflows. *Natural Resources Defense Council, New York, NY*, 1-134.

Global Water Partnership [GWP]. (2013). *National Stakeholder Consultations on Water: Supporting the Post-2015 Development Agenda. Thai* Water Partnership. http://www.gwp.org (accessed 19 June 2013)
Greenpeace. (2011). *Pollution concerns in flooding situation.* http://www.greenpeace.org/seasia/th/news/blog1/blog/37568/ (accessed 19 September 2013)
Greenroofs. (2014). *Industry Support.* http://www.greenroofs.com/Greenroofs101/ industry_support.htm (accessed 30 November 2014)
Jacobs, K., Lebel, L., Buizer, J., Addams, L., Matson, P., McCullough, E., & Finan, T. (2010). Linking knowledge with action in the pursuit of sustainable water-resources management. *Proceedings of the National Academy of Sciences*, 200813125.
Kmusser. (2013). *Chao Phraya River*. http://en.wikipedia.org/wiki/Chao_Phraya_River (accessed 8 June 2014)
Komori, D., Nakamura, S., Kiguchi, M., Suzuki, S., Kawasaki, A., & Oki, T. (2012). Characteristics of the 2011 Chao Phraya River flood in Central Thailand. *Hydrological Research Letters*, *6*, 41-46.
Lebel, L., Garden, P., & Imamura, M. (2005). The politics of scale, position, and place in the governance of water resources in the Mekong region. *Ecology and Society*, *10*(2), 18.
Lebel, L., Sinh, B., Garden, P., Hien, B., Subsin, N., Tuan, L., & Vinh, N. (2010). Risk Reduction or Redistribution? Flood management in the Mekong region. *Asian Journal of Environment and Disaster Management*, *1*(1), 23-39.
Lebel, L., Li, L., Krittasudthacheewa, C., Juntopas, M., Vijitpan, T., Uchiyama, T., & Krawanchid, D. (2012). Mainstreaming climate change adaptation into development planning. *Bangkok: Adaptation Knowledge Platform and Stockholm Environment Institute*, 8.
Marsalek, J., & Schreier, H. (2010). *Innovation in stormwater management in Canada: the way forward*. Canada Mortgage and Housing Corporation. https://secureweb.mcgill.ca/water2010/sites/mcgill.ca.water2010/files/Article-Marsalek_and_Schreier.pdf (accessed 26 September 2013)
Pahl-Wostl, C., & Knieper, C. (2014). The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes. *Global Environmental Change*, *29*, 139-154.
Pahl-Wostl, C., Lebel, L., Knieper, C., & Nikitina, E. (2012). From applying panaceas to mastering complexity: toward adaptive water governance in river basins. *Environmental Science & Policy*, *23*, 24-34.
Portland Bureau of Environmental Services (PBES). (2006). Combined Sewer Overflow Program Progress Report. *In*: Montalto, F., Behr, C., Alfredo, K., Wolf, M., Arye, M., & Walsh, M. (2007). Rapid assessment of the cost-effectiveness of low impact development for CSO control. *Landscape and Urban Planning*, *82*(3), 117-131.
Prajamwong, S., & Suppataratarn, P. (2009). Integrated Flood Mitigation Management in the Lower Chao Phraya River Basin. In *Expert Group Meeting on Innovative Strategies Towards Flood Resilient Cities in Asia-Pacific 2009 MEETING DOCUMENTS*. http://203.150.225.233/archives/download/idrc/2007_Integrated%20Flood%20Mitigation%20Management%20in%20the%20Lower%20Chao%20Phraya%20River%20Basin.pdf (accessed 19 June 2013)
Segaran, R. R., Lewis, M., & Ostendorf, B. (2014). Stormwater quality improvement potential of an urbanised catchment using water sensitive retrofits into public parks. *Urban Forestry & Urban Greening*, *13*(2), 315-324.
Suksawang, W. (2012). Holistic Approach for Water Management Planning of Nong Chok District in Bangkok, Thailand. http://escholarship.org/uc/item/3mf6k4d5.pdf (accessed 10 April 2014)
Takeda, M., & Putthividhya, A. (2015). Perspectives on Dry-Season Water Allocation Characteristics and Resilience to Climate change Impacts in Chao-Phraya River basin, Thailand. http://ascelibrary.org/doi/pdf/10.1061/9780784479162.106 (accessed 16 June 2015)
The Office of the Ombudsman. (2011). *Final Report on Flood Management in Thailand.* Office of the Ombudsman, Thailand.
UNESCO. (2003). *The 1st Report, Water for People, Water for Life*, Part V: Pilot Case Studies: A Focus on Real-World Examples, Chapter 16 - Chao Phraya River Basin, Thailand*; Office of Natural Water Resources Committee of Thailand (ONWRC).* http://webworld.unesco.org/water/wwap/wwdr/wwdr1/ table_contents/index.shtml (accessed 25 June 2013)
United States Environmental Protection Agency [USEPA]. (2013). *Low Impact Development (LID)*. http://water.epa.gov/polwaste /green/ (accessed 23 May 2013)
Van Roon, M. (2007). Water localisation and reclamation: Steps towards low impact urban design and development. *Journal of environmental management*, *83*(4), 437-447.
World Bank. (2011). *Thailand environment monitor: integrated water resources management - a way forward.* Washington, DC: World Bank. http://documents.worldbank.org (accessed 23 July 2013)