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The Challenges of Water Governance in Ho Chi Minh City

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ABSTRACT

Population growth, urbanization, pollution, and climate change pose urgent water challenges in cities. In this study, the sustainability of integrated water resources management in Ho Chi Minh City (HCMC) was evaluated using the City Blueprint approach. The City Blueprint is a set of 24 dedicated indicators divided over 8 categories (i.e., water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness, and governance including public participation). The analysis showed that the rapid increase of water use for urban, industrial, and agricultural activities in HCMC has resulted in depletion of groundwater and severe pollution of both groundwater and surface water. Surface water quality, groundwater quality, biodiversity, and the sanitation of domestic and industrial wastewater are matters that need serious improvement. Current and future water supply in HCMC is at risk. HCMC can cope with it, but the 7 governance gaps as described by the Organisation for Economic Co-operation and Development (OECD) are major obstacles for HCMC. Rainwater harvesting, pollution reduction, as well as wastewater reuse are among the practical options. Wastewater reuse could lower the water stress index to 10%. The window to do this is narrow and rapidly closing as a result of the unprecedented urbanization and economic growth of this region. *Integr Environ Assess Manag* 2015;X:000–000. © 2015 SETAC

Keywords: Blue City Index City Blueprint Climate change Water pollution Water stress index

INTRODUCTION

Water challenges in cities

Many cities have achieved high levels of protection against droughts, floods, or water pollution, and a vast majority of city dwellers enjoy reliable water services (OECD 2015). Management of freshwater resources is of critical importance to healthy social, economic, and political well-being of a society. Stresses exerted on the world's water resources driven by urban growth, competition among water users, water pollution as a result of poor environmental management, and climate change are placing water increasingly higher on the international agenda Hoekstra and Wiedman 2014; World Economic Forum 2014). These megatrends pose urgent water challenges, particularly in cities (van Leeuwen 2013; Chong 2014; MacDonald et al. 2014; OECD 2015).

In many parts of the world, water systems have been unable to keep up with the rapid urbanization. Cities, by their nature, spatially concentrate the water demands of many people into a small area, which by itself would increase stress on finite supplies of available freshwater near cities (Grant et al. 2012; van Leeuwen 2013; McDonald et al. 2014). The UN estimates that between 2011 and 2050, the world population will grow from 7 to 9.3 billion and that the population in cities will increase from 3.6 to 6.3 billion, whereas the number of people living in rural areas will decline. This means that the growth in the world population will be absorbed by cities (UN 2012; van Leeuwen 2015). This will be accompanied by strong growth in urban water demands, especially in East and West Africa, Latin America, and Asia (Dobbs et al. 2011, 2012).

To create awareness and to ensure sustainable futures for cities, we have developed a rather simple baseline assessment methodology to assess Integrated Water Resources Management (IWRM) in cities (van Leeuwen et al. 2012). This baseline assessment or City Blueprint® can be used as a first step to benchmark IWRM in cities (Philip et al. 2011; van Leeuwen and Chandy 2013; van Leeuwen 2015) and may help: 1) to communicate a city's IWRM performance and exchange experiences, 2) to select appropriate water supply and sanitation strategies, and 3) to develop technological and nontechnological options as future alternatives for the water cycle, where several possible changes in the use of technology, space, and socioeconomic scenarios can be introduced. This should finally lead to: 4) a selection of measures, including an evaluation of their costs and benefits under different development scenarios, and how to integrate these in long-term planning on urban investments (van Leeuwen 2013; EIP Water 2015; OECD 2015).

We have currently assessed 45 municipalities and regions with the City Blueprint, with a focus on cities in Europe (EIP Water 2015). To illustrate the challenges of water in a rapidly growing city in Asia, and to stress the relevance of good water governance in general (OECD 2011), we have carried out a detailed assessment of Ho Chi Minh City (HCMC) in Vietnam.

Ho Chi Minh City

Ho Chi Minh City is a delta city and the biggest city in Vietnam. HCMC is vulnerable for flooding as a result of land subsidence, high rainfalls and climate change (Vo 2007a; Tyler and Fajber 2009; Dan et al. 2011; VCAP 2015). HCMC is a

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transport hub of the southern region and has the largest port system and airport in Vietnam. The city center is 50 km from the East Sea. HCMC covers 0.6% of the total area of South Vietnam but has 8.3% of the total population (Dan et al. 2007). The land area of HCMC is 2095 km^2 and the average population density is 3719 persons per km^2 in 2012 (Statistical Office in HCMC 2013). The city's official population has increased from 3 million people in 1975 to 7.16 million in 2009 and 7.79 million people in 2012 (Statistical Office in HCMC 2013). The current city's population is expected to grow to 9.2 million in 2020 and 10 million in 2025 (Triet and Phu 2014).

By the year 2010, there were 15 industrial zones (IZs) with a total area of 3677 ha that included 3 export–import processing zones and 12 industrial estates (Phi 2011). Over 1200 industries were active in the IZs. Besides, there were about 1200 industries located in 52 industrial clusters (ICs) and 33 small-scale ones (SMIs) located in the residential areas. The area of ICs and SMIs will be 1140 ha in 2020 (HIDS 2010). There were approximately 190 000 trade units, 60 000 hotels, restaurants and over 400 medium and large scale markets, 81 supermarket chains, 18 luxury shopping malls, and many modern fashion or beauty centers in 2012 (Statistical Office in HCMC 2013). In 2007, the city's gross domestic product (GDP) was estimated at 14.2 billion US$, or approximately 2112 US$/capita, and accounting for 21.3% GDP of the country (JICA 2011). Export–import turnover through HCMC ports is 36 billion US$, or 40% of the national total. Table 1 provides some basic data for the water service area of Ho Chi Minh City.

Water resources of HCMC

The wet season in HCMC is from May to November and contributes to approximately 80% to 85% of the annual rainfall. Heavy rains occur in June and September (250–330 mm/month) with maxima up to 683 mm (Dan et al. 2007). HCMC is an example of the paradox of water availability as it has too much water in the wet season but too little during the dry season and water scarcity increases even further with escalating demand and needs (Vo 2007a).

Table 1. Basic data for the water service area of Ho Chi Minh City

Resident population ($\times$1000) of HCMC[a,b]	7792
Household occupancy[c]	3.1
Catchment area Dau Tieng reservoir (km^2)	2700
Catchment area Tri An lake (km^2)	15 000
Annual average rainfall (mm)[d]	1821
Daily average air temperature (°C)	28
Population density Vietnam (inhab/km^2)[d]	271
TRWR per capita (m^3/y)[d]	9853
Total freshwater withdrawal as % of TRWR[d]	9.259

[a]Statistical Office in HCMC (2013).
[b]The city's population is expected to grow to 22 million in 2025 (Dan et al. 2011).
[c]Data from UNDP (2010).
[d]Total renewable water resources. National data for Vietnam according to FAO (2014).

Water supply in HCM is provided by the Dong Nai River, the Saigon River, groundwater, and rain water (Dan et al. 2007). Water demand for domestic and industrial purposes in HCMC was 2.5 million m^3 in 2009 and is estimated at 4.75 million m^3 in 2025 (Nga 2006; HIDS 2010). The main users in HCMC are residents, industries and services (Dan et al. 2007). For agricultural purposes water is used from the irrigation canals network of Saigon and Dong Nai Rivers and from storm water in the rainy season. Groundwater is not suitable for irrigation because of its high iron concentrations and low pH (Dan et al. 2007).

The Saigon Water Supply Company (SAWACO) is responsible for the exploitation, treatment, and distribution of water in HCMC. The volume of piped water in 2010 under SAWACO's management was 1 500 000 m^3/d, of which 1 300 000 m^3/d was produced at 3 surface water treatment plants using raw water from the Saigon and Dong Nai Rivers and 200 000 m^3/d was produced at groundwater treatment plants (Dan 2013a).

The aim of this article is to evaluate the sustainability of IWRM of HCMC using both a static assessment (City Blueprint), as well as a more dynamic assessment based on the Water Stress Index (WSI). Finally, options are discussed to improve water management of HCMC. The study is part of the City Blueprint Action of the European Innovation Partnership on Water of the European Commission (EIP Water 2015).

METHODS

City Blueprint

A set of indicators, that is, the City Blueprint, has been developed to assess the sustainability of IWRM (van Leeuwen et al. 2012; van Leeuwen 2013). The City Blueprint comprises a set of 24 dedicated indicators divided over 8 categories, that is, water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness, and governance including public participation (EIP Water 2015). The indicators are scored on a scale between 0 (very poor performance) to 10 (excellent performance).

Data gathering was standardized by means of a questionnaire with 24 questions in 5 headings: 1) general information, 2) drinking water, 3) wastewater, 4) environmental quality, biodiversity, and attractiveness, and 5) governance (EIP Water 2015). A short summary of the methodology is provided in Table 2. A full description of the methodology, the indicators, the data sources, the scoring methodology, and sample calculations for each of the 24 indicators is provided in the City Blueprint Questionnaire that can be downloaded from the web site of the European Innovation Partnership on Water of the European Commission (EIP Water 2015).

A critical discussion about the strengths and limitations of the City Blueprint methodology is provided in van Leeuwen and Sjerps (2015). The baseline assessment is part of a strategic planning process and provides the framework that facilitates the shift to more integrated policies, governance structures, practices and choice of technology for more sustainable water management (Philip et al. 2011). IWRM is complex, has a wide scope, and many stakeholders are involved. Therefore, the scope of the City Blueprint needs to reflect this and must cover a broad range of aspects.

The collection of information for HCMC was carried out by the authors. Comments on the preliminary scoring were provided by 3 experts. The results were presented to several

Table 2. Summary of the City Blueprint methodology

Goal	Baseline assessment of the sustainability of IWRM
Indicators	24 indicators divided over 8 broad categories:
	1. Water security
	2. Water quality
	3. Drinking water
	4. Sanitation
	5. Infrastructure
	6. Climate robustness
	7. Biodiversity and attractiveness
	8. Governance
Data	Public data or data provided by the (waste) water utilities and cities based on a questionnaire for IWRM
Scores	0 (concern) to 10 (no concern)
BCI	Arithmetic mean of 24 indicators which varies from 0 to 10
Stakeholders	Water utility, water board, city council, companies, NGOs, etc.
Process	Interactive with all stakeholders involved early on in the process

stakeholders (representatives of municipalities, water utilities, wastewater utilities, and water boards) on the preliminary assessment and information during site visits of HCMC. The comments of the experts and stakeholders were included in the final reporting. The overall score of the sustainability of IWRM of the city is expressed as Blue City Index (BCI). The BCI is the arithmetic mean of the 24 indicators comprising the City Blueprint and has a theoretical minimum and maximum of 0 and 10, respectively.

Water stress index

The water stress index (WSI) defines water scarcity in terms of the total water resources that are available to a population. The WSI is the ratio (%) of total water demand and fresh water available (Angelakis et al. 2003). Water stress is considered low at values less than 10%. Freshwater availability becomes a constraint for sustainable development, and that huge investments are needed to supply sufficient freshwater at values in the 10% to 20% range. At WSI values above 20%, comprehensive IWRM efforts are needed to allocate water, to balance supply and demand, and to prevent conflicts between competitive uses and users (Angelakis et al. 2003). The WSI data for HCMC were taken from Dan et al. (2011).

RESULTS

Surface water quality

HCMC is home to many small and medium enterprises (SMEs). According to Vo (2007a), there are 30 000 SMEs and more than 800 large scale factories from export processing zones and industrial parks. Most enterprises are not equipped with wastewater treatment facilities, leading to a daily production of 260 tons of solid waste, including 25 tons of hazardous waste. Rivers are extremely polluted. It is estimated that industrial wastewater effluent in HCMC accounts for 20% to 30% of the total flows in Vietnam's river systems (Vo 2007a). Major industrial contributions to water pollution are chemical, oil refining, and food processing industries. The deterioration of water quality in the Saigon-Dong Nai river system is increasing at an alarming level as a result of daily discharges of 200 000 m^3 of industrial wastewater and 17 000 m^3 of hospital effluent. It is estimated that only 40% of this wastewater is treated (Vo 2007a). Many urban canals and creeks are polluted and serve as sinks for untreated domestic sewage and industrial wastewater. During the rainy season, the situation of canal systems is increasingly aggravated as a result of storm water (i.e., additional pollution from urban and agricultural runoff). High concentrations of heavy metals and persistent organic pollutants (POPs) such as PCBs and DDT were detected in sediments in the canals of HCMC (Vo 2007a). This is in line with the information as reported by FAO (2014) for Vietnam: "Although data on water quality are poor, recorded evidence shows the pollution level is increasing for surface water, groundwater and coastal waters. Although the quality of the upstream river water is generally good, downstream sections of major rivers reveal low water quality. Most of the lakes and canals in urban areas are fast becoming sewage sinks." This is why the indicators for surface water quality and biodiversity have been scored with 3 and 1, respectively (Table 3).

Triet and Phu (2014) reported water quality upstream of Saigon river, which has been used as raw water for clean water supply systems for Binh Duong, Tay Ninh provinces, and HCMC. Water was polluted by high ammonia, COD, and Mn concentrations that exceeded surface water quality standards. To reduce these pollutants in the finished water and for disinfection, large volumes of Cl were used in surface water treatment plants, leading to the formation of disinfection byproducts (Trang et al. 2012). Their potentially carcinogenic properties are of great concern to human health. In addition, also endocrine disrupting compounds (EDCs) were detected in Saigon River and canals in HCMC that might pose significant risk to aquatic organisms (Hong et al. 2012; Dan 2013b).

Groundwater quality and quantity

Population growth, urbanization, and high economic growth are the drivers of unsustainable abstraction of groundwater in HCMC. The current total abstraction volume for HCMC is 520 000 m^3/day. HCMC is facing the risk of groundwater depletion and its further environmental consequences such as salt water intrusion, aquifer pollution and land subsidence (Vo 2007a). Similar information has been provided by Pittock (2014). He reports that HCMC relies for approximately 35% on groundwater as percentage of the total water supply. Groundwater quality is not only being worsened by salt water intrusion but also from point and nonpoint source pollution (Vo 2007a). Thus, the management and protection of aquifers is a pressing task for HCMC. Water at the depth from −5 to −10 m is unusable for domestic purposes because of bad odor and high bacterial densities. Furthermore, nitrate, nitrite, and ammonia concentrations have exceeded Vietnamese standard levels. The presence of several organic and inorganic contaminants was identified at depths between −30

Table 3. City Blueprint scores of HCMC

Nr	Indicator	Score
1	Water footprint	8.3
2	Water scarcity	9.1
3	Water self-sufficiency	9.4
4	Surface water quality	3.0
5	Groundwater quality	2.0
6	Sufficient to drink	8.4
7	Water system leakages	5.9
8	Water efficiency	4.0
9	Drinking water consumption	9.3
10	Drinking water quality	8.0
11	Safe sanitation	1.2
12	Sewage sludge recycling	0.0
13	Energy efficiency	5.0
14	Energy recovery	0.0
15	Nutrient recovery	0.0
16	Average age sewer system	8.5
17	Infrastructure separation	0.1
18	Climate commitments	7.0
19	Adaptation strategies	7.0
20	Climate-robust buildings	7.0
21	Biodiversity	1.0
22	Attractiveness	8.0
23	Management and action plans	7.0
24	Public participation	0.3

and −40 m. HEPA (2011) showed that high total Fe concentrations, salinity (above 1000 mg/L as NaCl) and ammonia (above 5 mg/L as N) were found in suburban areas near intake points. Similar information on groundwater pollution has been provided Nga (2006), DWRPIS (2008), and Dan et al. (2011). This information on groundwater pollution in HCMC has resulted in a low score for the groundwater quality indicator (indicator 5; Table 3).

Wastewater treatment

Wastewater treatment in most residential areas in HCMC, both new and old ones, is an exception. This increases both water pollution and the risk of water-borne diseases. Dan et al. (2007) have reported on the Saigon River. This river received 76.2% of the total volume of domestic wastewater and had a 5-d biochemical oxygen demand (BOD5) amount of 243 tons BOD/day, mainly caused by oil and grease. Downstream, the Dong Nai River received 15% of the total volume of domestic wastewater and approximately 18% of total pollutant loads. Most other effluents are not adequately treated either (see next section). Sludge from treated sewage is not allowed to be used for agriculture and this leads to a score of 0 for sewage sludge recycling. This is probably caused by high concentrations of POPs, heavy metals, and pathogens. According to Vo (2007a), there is a 12% sewage access for HCMC and therefore the score for indicator 11 is 1.2 (Table 3). These data are in line with the scarce information for Vietnam as provided by the FAO (2014). The FAO reports the total volume of collected and treated wastewater to be 10% of the total produced municipal wastewater. Parts of the sewage systems in HCMC are 50 years or older. However, over the last years, considerable investments have been made to renew the sewer systems (van Buren 2010). Therefore, the expert score for the average age has been set at 15 years leading to a score of 8.5 (Table 3). At present, all industrial zones in HCMC have central wastewater treatment plants, which daily generate approximately 240 000 m^3 of treated wastewater (Dan et al. 2013).

Drinking water supply

Information on drinking water in HCMC is provided by Vo (2007a). Water supply coverage in HCMC increased from 52% in 1997 to 84% in 2004, but the proportion of households in HCMC connected to the main water supply system is still low as a considerable number of households still obtains water from wells (34%) or small private water providers (19%). We have used the figure of 84% to calculate the score for indicator 6 of the City Blueprint (Table 3). The water distribution network of HCMC has a total length of 32.811 km (Dan et al. 2007).

Information on water system leakages is not clearly reported for HCMC, but the World Bank IBNET database (IBNET 2014) provides a nonrevenue water estimate of 41%, leading to a provisional score of 5.9 as all other water is billed (100%). Dan et al. (2007) estimated the water loss at 35% to 37%. For the calculation, we used the information from IBNET (2014). Drinking water consumption in HCMC is 167 $L \cdot cap \cdot d^{-1}$. This leads to a score of 9.3 for indicator 9 (Table 3).

Drinking water quality is generally good, when prepared from surface water (Dan et al. 2007), but drinking water prepared from groundwater may have a questionable quality (see section on groundwater quantity and quality). Trang et al. (2012) have shown that the use of high Cl doses at the Saigon water treatment plant together with high organic contaminants of the raw water (2.9–4.1 mg/L TOC) resulted in high risk of trihalomethanes formation (THM). The average total THM concentration of treated water at the Saigon water treatment plant was 156 ±58 μg/L. Even though total THMs of the whole treatment process did not exceed the Vietnamese drinking water quality standards, these values were higher than the allowable values of European Union drinking water quality standards. Therefore, the score for drinking water quality for HCMC was set at 8 (Table 3).

City Blueprint of HCMC

In the City Blueprint assessment, national data are used for surface water quality, groundwater quality, and biodiversity (van Leeuwen 2013; EIP Water 2015). This leads to a BCI of 5.4 for HCMC. When local data are used for environmental quality a more accurate but also lower score for the BCI of HCMC would be obtained (5.0). The overall results of the baseline assessment of HCMC are shown in Figure 1 and Table 3. The analysis shows that the rapid increase in the use of water for urban, industrial, and agricultural activities in

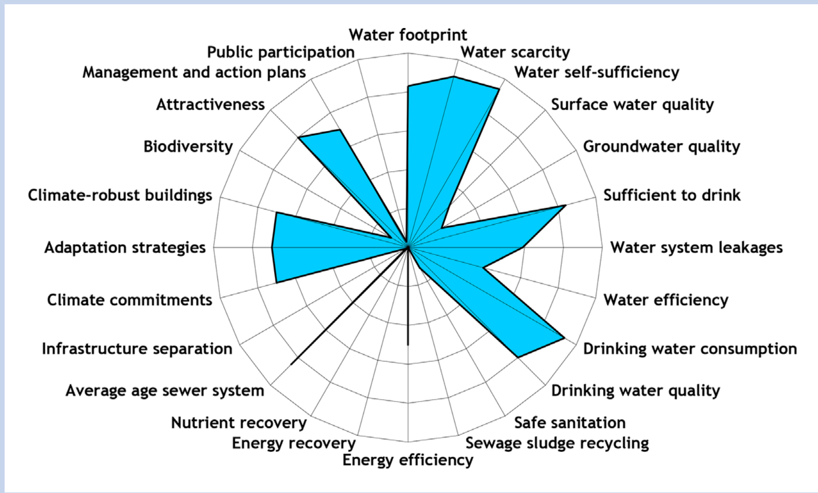

Figure 1. The City Blueprint of HCMC based on 24 indicator scores. The range of the scores varies from 0 (center of the circle) to 10 (periphery of the circle). Further details are provided in the text. The BCI of HCMC based on local information for surface water quality, groundwater quality, and biodiversity is 4.98.

HCMC leads to the depletion of groundwater and pollution of groundwater and surface water. Surface water quality, groundwater quality, biodiversity, as well as the sanitation of domestic and industrial wastewater are priority topics that need serious improvement. Pollution on its own reduces the number of options for water use. It seriously hampers the ecological quality of the water systems of HCMC and many crucial ecosystem services, one of which is the provision of drinking water. The pollution of surface and groundwater also seriously affects drinking water quality and supply and presents a risk to human health.

In 45 municipalities and regions assessed so far (EIP Water 2015), the BCI varied from 3.5 to 8.5. Cities with BCIs greater than 7.5 are: Amsterdam (8.0), Berlin (7.8), Hamburg (7.6), Helsinki (7.9), Helsingborg (8.5), Jerusalem (7.6), Kristianstad (8.0), Malmö (7.6), and Stockholm (7.7). Cities with BCI values lower than 5 are: Belém (Brazil; 3.6), Dar es Salaam (Tanzania; 4.1), and Kilamba Kiaxi (Angola; 3.5). Malta had a low BCI score (4.9). A plot of the BCI of all municipalities and regions assessed so far versus government effectiveness, one of the governance indicators of the World Bank confirms the challenges of HCMC (Figure 2) (World Bank 2013a).

Water stress index

In a recent study by Dan et al. (2011), they assessed the development of the WSI of HCMC and neighboring provinces in the Dong Nai river basin in the period 1995 to 2025. The results are provided in Table 4. They demonstrated that overexploitation of groundwater in HCMC for domestic and industrial lowers the groundwater table and has major implications for the quality of groundwater as a result of salt intrusion. It also leads to water shortage during the dry season in HCMC. Surface water quality is seriously affected by untreated wastewater discharge and huge freshwater exploitation from industrial, residential, and agricultural activities of provinces in the upstream of Saigon and Dong Nai rivers. Dan et al. (2011) have convincingly demonstrated that HCMC is under water stress as the WSI of Dong Nai River basin gradually increased from 7% (1995) to 13% (2010). The WSI is predicted to increase even further to 23% in 2025. This shows that

- Cities in the river basin are currently under water stress and water stress will soon become critical; this will also affect the hydro power supply of these cities.
- Environmental quality will further decrease accompanied by increasing health risks.
- Water stress will negatively impact local economic development and human well-being in general.

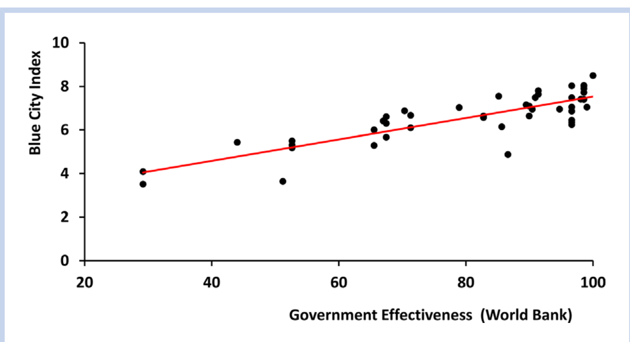

Figure 2. The relation between the BCI and government effectiveness for 45 municipalities and regions (World Bank 2013a; EIP Water 2015).

Table 4. WSI of HCMC and neighboring provinces in Dong Nai river basin[a]

Items	Unit	1995	2000	2010	2025
Population	Million	7.8	8.8	13.4	22
Renewable freshwater availability per capita	L/capita/d	5058	4483	2944	1715
Total water demand	Million m^3/y	0.99	1.80	1.88	3.31
Total water demand per capita	L/capita/d	347	360	384	394
WSI	%	6.9	8.0	13.0	23.0

WSI, Water Stress Index.
[a]Dan et al. (2011).

DISCUSSION

The City Blueprint and WSI analysis

The City Blueprint analysis provides a static picture of the sustainability of IWRM for HCMC. The WSI analysis for HCM puts this "snapshot" in much more perspective, as it provides a prediction of the future developments of HCMC and the neighboring provinces in the Dong Nai river basin. These results are in line with observations of the World Bank for Vietnam, and more specifically, for HCMC. According to the World Bank (2013a), rapid economic growth in Vietnam over the last 10 years, and its associated industrialization, urbanization, as well as increased exploitation of natural resources, has created significant pressures for the environment. Environmental degradation and habitat destruction is emerging as a barrier to growth, development, and human health and well-being. The most visible water problems occur in and around cities where environmental pollution is high and competition for surface water and overexploitation of groundwater reserves are common. The case study of Ho Chi Minh City as presented in this article is an example, but similar developments are taking place in Beijing and Tianjin, Shanghai, Manila, Jakarta, and Bangkok. These megacities are examples of the challenges in Asia, in particular with regards to IWRM (World Bank 2013b).

Water governance in HCMC

To tackle the challenges of IWRM in HCMC, the focus needs to be on water governance. Water governance takes numerous aspects, interests, and actors into account (Philip et al. 2011). The following definition for water governance was adopted (UNDP 2013) "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society and for different purposes." Water governance covers the mechanisms, processes, and institutions by which all stakeholders—government, the private sector, civil society, pressure groups—on the basis of their own competences, can contribute their ideals, express their priorities, exercise their rights, meet their obligations, and negotiate their differences.

To assess current water governance aspects in HCMC, use can be made of a reference framework of the Organization of Economic Co-operation and Development (OECD) as presented in Table 5.

Gaps in water management in Vietnam are observed in many reports. FAO (2014) concludes that the water sector in Vietnam lacks IWRM. It shows no overall integrated strategy and action plan both at the national and regional basin level. Similar conclusions have been drawn by Perrett (2008) in a study on water governance and pollution around HCMC. Perrett (2008) concluded that there are systemic water governance issues in HCMC and Vietnam. These issues include poor communication between farmers and government officials, limited farmer participation in water management, a lack of integration between government agencies, little government accountability and transparency, and water management priorities that favor economic growth over environmental health. Recently, there were at least 10 ministries, 15 central committees and general departments, and many scientific institutes and organizations all dealing with the water sector (Hansen and Phan 2005; Tyler and Fajber 2009). The structure of decision-making in these institutions lacks horizontal integration. In Vietnam, steps have been taken to build shared knowledge and strengthen horizontal planning linkages between the water management institutions (Hansen and Phan 2005).

Similar conclusions were drawn by Vo (2007a, 2007b). He concluded that ineffective management is anchored in fragmented management practices that result from inadequate institutional frameworks and arrangements and inadequate regulations. Weak enforcement of law and inadequate cooperation between local authorities in HCMC and their counterparts in neighboring provinces, as well as different perceptions of the stakeholders, limited public involvement and financial constraints are other governance gaps. Citizens have little knowledge about water issues in their city and their accessibility to information on water resources is limited. Vo (2007a, 2007b) also expressed serious concerns about the training, experience, and expertise of many government officials and noted a lack of consistent data and information on water. This lack of adequate water governance is also

Table 5. The OECD multilevel governance framework: The 7 key coordination gaps in water policy[a]

1. Administrative gap	Geographical "mismatch" between hydrological and administrative boundaries; this can be at the origin of resource and supply gaps
2. Information gap	Asymmetries of information (quantity, quality, type) between different stakeholders involved in water policy, either voluntary or not
3. Policy gap	Sectoral fragmentation of water-related tasks across ministries and agencies
4. Capacity gap	Insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.) as well as relevant strategies
5. Funding gap	Unstable or insufficient revenues undermining effective implementation of water responsibilities at subnational level, cross-sectoral policies, and investments requested
6. Objective gap	Different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organizing the water sector)
7. Accountability gap	Difficulty in ensuring the transparency of practices across the different constituencies, mainly due to insufficient users' commitment, lack of concern, awareness, and participation

[a]OECD (2011).

demonstrated in Figure 2. It shows that HCMC still has a long way to go on the transition toward a water-wise or water-sensitive city (Brown et al. 2009).

CONCLUSIONS

The world's environmental challenges have intensified. There has been a rapid deterioration across many environmental domains, and in some cases, breaching of safe planetary boundaries with respect to environmental issues (Hoeksta and Wiedman 2014). HCMC is such an example of a city in the fastest growing region in the world (Dobbs et al. 2012). The current and future water crisis in HCMC is mainly a water governance crisis (OECD 2011) (Table 5).

Many political, policy, and practical suggestions to improve the sustainability of IWRM of HCMC have already been provided by a variety of international organizations (World Bank 2013b, 2013c) and the scientific community (Dan et al. 2007, 2011; Vo 2007a, 2007b). Wastewater reuse could lower the WSI to 10% (Dan et al. 2011). Wastewater reuse, rainwater harvesting, as well as pollution reduction are among the practical options, which have to be embedded in an overarching integrated mid-term, city-level strategy.

A long-term, city-level strategy is also needed to make HCMC more robust to climate change and to increase the resilience of its natural, social, and economic systems (ICEM 2009; OECD 2015). However, the window to develop and implement a promising city-level strategy is narrow and rapidly closing. HCMC, as well as Beijing and Tianjin, Shanghai, Manila, Jakarta, and Bangkok are prime examples of the region's megacities with major IWRM-related problems (World Bank 2013b). These cities are all examples of the unprecedented urbanization and economic growth in this continent of the world (Dobbs et al. 2012; van Leeuwen 2014) and an illustration why the water crisis now ranks number 1 in the top 10 risks in terms of impact, as reported by the World Economic Forum (2015).

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