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RESEARCH ARTICLE

Water governance and the quality of water services in the city of Melbourne

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ABSTRACT
Integrated water resources management (IWRM) was reviewed in the city of Melbourne. Melbourne performs well and shows a good level of commitment to sustainable solutions. The city scores highly in areas such as water efficiency, wastewater efficiency, i.e., energy recovery, and climate change commitments related to heat and water scarcity. Nearly 30% of houses in Melbourne have installed rainwater tanks and plans to increase the use of stormwater have recently been published. Energy efficiency of buildings, nutrient recovery (especially phosphate) from wastewater, as well as sewage sludge recycling are topics for improvement. A transparent governance structure has been set up in a reaction to the 'Millennium Drought' and success has come from many organizations working together to a common goal. This is the secret of Melbourne's success and can be used as an example for other cities in the world.

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1. Introduction

The management of fresh water resources is of critical importance to the social, economic and political well-being of a society. Stresses exerted on the world's water resources by the increasing demand of growing populations with changing consumption patterns, the damage to water quality from pollution as a result of poor environmental management, and climate change are placing water increasingly higher on the international agenda (European Commission, 2012; UNEP, 2012). These megatrends pose urgent water challenges particularly in cities (Chong, 2014; Engel et al., 2011; MacDonald et al., 2014; SIWI, 2012; Van Leeuwen, 2013).

Developing sustainable urban infrastructure benefits not just the environment, but can also boost economic growth and social stability. The United Nations Environment Programme (UNEP) stressed the need to transition to resource-efficient technologies in cities and most of the investments are predicted in the area of water infrastructure (UNEP, 2013).

Melbourne is the capital and most populous city in the state of Victoria, and the second most populous city in Australia. Melbourne is a city with a moderate rainfall pattern and receives on average approximately 600 mm of rainfall per year. According to the Food and Agriculture Organization of the United Nations (FAO, 2013) water withdrawal in Australia is predominantly for agriculture (7.359 km^3), municipal purposes (3.520 km^3) and industry (2.400 km^3). The total withdrawal per capita per year in Australia is 1152 m^3, leading to a total fresh water withdrawal in Australia of 4.58% of the total renewable water resources. In the decade known as the 'Millennium Drought' between 1998 to 2007, Victoria experienced rainfall 14 per cent below average and recorded temperatures 0.4 °C warmer than the 30 year average (City of Melbourne, 2015). The challenges of integrated water resources management (IWRM) under a changing and uncertain climate became starkly apparent during this 'Millennium Drought' (Chong, 2014).

The author was engaged by the Office of Living Victoria (OLV, 2014a) to undertake a sustainability assessment of IWRM for the city of Melbourne which was chosen as a case study because it represents a city with a moderate rainfall pattern, affected by climate change (Van der Steen, 2011). Furthermore, the recent 'Millennium Drought' served as a wake-up call, turning Melbourne from a reactive into a proactive city concerning water and climate adaption, with concomitant changes in water governance in a relatively short period of time.

2. Materials and methods

2.1. City Blueprint methodology

A strategic planning process consists of a number of phases, the outcomes from which are reviewed on a regular basis (Figure 1). This process is shown as a logical sequence of steps although in reality there is a great deal of reiteration and revisiting of the different phases (Philip et al., 2011). In this paper the focus is on the first step in the strategic planning process, i.e., the baseline assessment. This baseline assessment of IWRM has been carried out following the interactive City Blueprint® process as described by Van Leeuwen et al. (2012). Data for the city of Melbourne were collected in April 2013. The 12 members of the project team were representatives of the following organizations: Yarra Valley Water, City West Water, South East Water,

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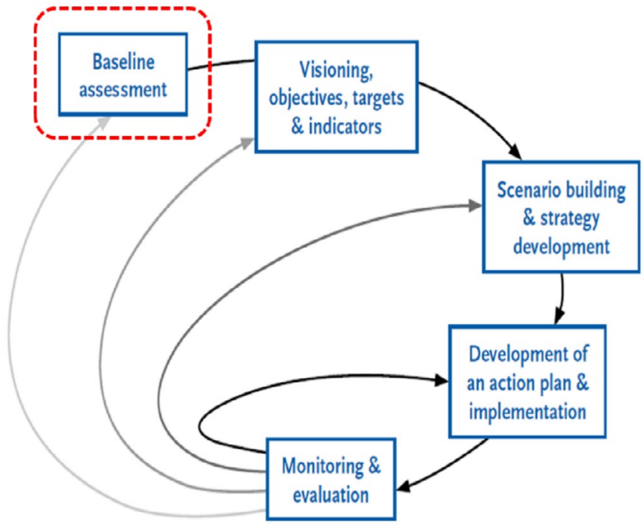

Figure 1. The strategic planning process for Integrated Water Resources Management. Modified after Philip et al. (2011).

Table 1. Short summary of the City Blueprint method.

Goal	Baseline assessment of the sustainability of IWRM
Indicators	Twenty-four indicators divided over eight 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	Blue City Index®, the 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

Melbourne Water, Department of Environment and Primary Industries and Office of Living Victoria. Their data were collected using a detailed questionnaire (European Commission, 2015). Based on these data from the stakeholders, the 24 indicators were scored by the author of this manuscript. These data, as well as data collected from public websites in Melbourne and Victoria, were used to circulate a first draft report to the stakeholders with an invitation for comments and corrections. This draft report was discussed and edited in interactive sessions with the stakeholders in Melbourne in May 2013 and finalized within a week after these sessions.

The City Blueprint comprises a set of 24 dedicated indicators divided over eight categories, i.e., water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness and governance including public participation (Van Leeuwen, 2013). In the City Blueprint analysis (European Commission, 2015) the water security indicators (indicators 1-3) are defined according to the Water Footprint Network (Hoekstra et al., 2011; Mekonnen & Hoekstra, 2011). The City Blueprint methodology is shortly summarized in Table 1. The indicator selection process has been described in Van Leeuwen et al. (2012) and developed further in a learning-by-doing process (Van Leeuwen, 2013; Van Leeuwen & Chandy, 2013). In order to provide full transparency about the indicators, the data sources, the scoring method and the calculation methods for each of the 24 indicators, a 30-page City Blueprint questionnaire is provided on the website of the European Innovation Partnership on Water (European Commission, 2015).

2.2. *Water governance*

Water governance takes numerous aspects, interests and actors into account (Philip et al., 2011) and can be defined as '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' (UNDP, 2013). 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. In order to assess water governance in Melbourne, use has been made of the reference framework of the Organization of Economic Co-operation and Development (OECD, 2011), summarized in Table 2.

Table 2. The OECD multi-level governance framework: key co-ordination gaps in water policy (OECD, 2011).

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.

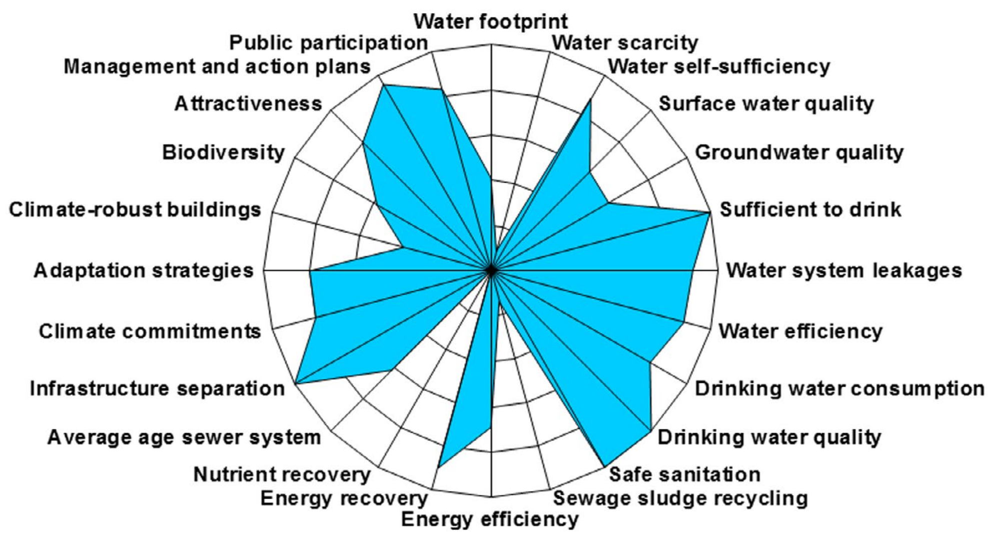

Figure 2. City Blueprint® of the city of Melbourne. The range of the scores varies from 0 (centre of the circle) to 10 (periphery of the circle). Further details are provided in the text and supporting information (European Commission, 2015). The BCI for Melbourne is 7.0.

3. Results

3.1. Drinking water sources

Almost all water used in Melbourne today comes from rivers and reservoirs. This is about 10 times the amount of groundwater or recycled water, and over 70 times the amount of rainwater and stormwater currently used in Melbourne. Only limited rainfall that falls within a city is collected. Instead it runs off roofs and hard surfaces becoming stormwater. There are many opportunities to increase the use of these alternative sources of water since around 80% of Melbourne's drinking water comes from remote closed water catchments in native forests, i.e. the Yarra Ranges and around 20% of the drinking water comes from lowland water sources. Melbourne has a protected water catchment. Melbourne also has 100% population coverage for drinking water (Melbourne Water, 2015).

The impact of climate change is predicted to make reduced rainfall an ongoing reality for Melbourne and make the incidence of droughts more frequent and severe (City of Melbourne, 2015). As a result of the recent record period of severe drought, i.e., the 'Millennium Drought' (Chong, 2014), Victoria has also constructed a desalination plant to supply water to Melbourne's supply network. The Victorian Desalination Plant will be able to provide Melbourne with a secure, rainfall-independent source of water. The plant can supply up to 150 million m^3 of high quality drinking water each year. Until now, the desalination plant has not been used (Melbourne Water, 2015).

Melbourne's total water consumption has been reduced to 88.2 m^3 per person per year. This has been the result of a long campaign in Melbourne to save water and also provides an explanation for the high score of Melbourne for water efficiency (Figure 2). Melbourne scored well in the drinking water related indicators, as a result of its high quality drinking water, relatively low per capita consumption and comparatively low levels of leakage.

The quality of the supplied water is excellent (Table 3 and Figure 2). Frequent water quality testing takes place across the water supply network and uses HCCPA (Hazard Analysis and Critical Control Points) in common with the food and pharmaceutical industries worldwide. Detailed information on drinking water quality, drinking water guidelines, and annual reports of the three water retail businesses (City West Water, South East Water and Yarra Valley Water) in Melbourne are provided on the website of Melbourne Water (2015).

The average age of the distribution system is 37 years and the number of mains failures 8206 which is 33.6 per 100 km. The water losses in the system are significant (with 11% unaccounted for water, of which 9% is leakage) and are higher than in e.g. the

Table 3. Key data for drinking water and wastewater for the city of Melbourne.[a]

Drinking water		Wastewater	
System input volume (GL per year)	700	Number of properties connected (x 1000)	1680
Population coverage (%)	100	Collected sewage (m^3/inhabitant per year)	NA
Authorised consumption (GL per year)	360	Length of combined sewers (km)	0
Consumption (m^3 per person per year)	88.2	Length of stormwater sewers (km)	22,000
Service connections x 1000	1674	Length of sanitary sewers (km)	22,090
Water losses (m^3) per connection and year	23.8	Wastewater treated (GL)	349
Water losses (%)	11	Total sludge produced in STPs (ton DS per year)	70,091
Quality of supplied water	99.99	Sludge going to landfill (ton DS per year)	971
Average water charges ($/$m^3$)	1.35	Sludge thermally processed (ton DS per year)	971
Mains length (km)	24,458	Sludge stockpiled (ton DS per year)	68,149
Average mains age	37.1	Energy costs (million $)	5.6
Number of mains failures	8206	Average age of the sewer system (year)	38
Mains failures per 100 km	33.6	Sewer blockages	4008
Asset turnover ratio	0.00023	Sewer blockages per 100 km	18

Notes: [a]1GL = 10^9 L = 10^6 m^3 and DS is dry substance.

city of Amsterdam (5.4%) but much lower than in other cities, as average losses have been reported of 21% for 45 cities (Van Leeuwen & Sjerps, 2015a; Van Leeuwen et al., 2015).

3.2. Melbourne's water and waste water systems

3.2.1. Drinking water supply

Melbourne's water supply system is a complex interconnected system of 10 storage reservoirs, over 40 service reservoirs, 160,000 hectares of catchments and a transfer system comprising hundreds of kilometres of pipelines, tunnels and aqueducts (Kularathna et al., 2011). The supply system consists of over 24,000 km of water mains with a level of leakage that is low by international standards. Around 36 million m^3 is lost annually from the system, representing around 9% in a typical consumption year. This is significant, but losses have been reduced as a result of vigorous active leakage control and pressure management, and rapid burst repairs (Gan & Purss, 2010).

Melbourne's storage reservoirs have a combined storage capacity of 1810 million m^3, the largest of which is the Thomson Reservoir located east of Melbourne with a capacity of 1068 million m^3. The yield from all catchments is capped by legislation to 576 million m^3 per year. Catchment water is traditionally a cheap source of water for the city due to the minimal need for transfer pumping or treatment but, being climate dependent, can be highly variable in quantity. Up to 33 million m^3 groundwater per year is licensed for use, primarily for irrigating market gardens and golf courses (Victorian Government, 2013). There has been an increasing use of recycled water sourced from sewage for garden irrigation, toilet flushing and laundry in new housing developments (Melbourne Water, 2015). Melbourne's annual water use is around 390 million m^3 of potable water plus around 21 million m^3 of recycled water. Stormwater harvesting and reuse is estimated at around 5 million m^3 per year.

3.2.2. Waste water

Melbourne's wastewater system is a collection, transport and treatment system. There are no combined sewers in Melbourne, which leads to a 100% separation of this infrastructure. 100% of Melbourne's population is covered by adequate wastewater collection and treatment. Melbourne scored well for safe sanitation, but scored low in terms of nutrient recovery from wastewater (Figure 2).

The majority of Melbourne's wastewater is treated at two large sewage treatment plants; the Eastern Treatment Plant located to the south east at Bangholme; and the Western Treatment Plant, located to the west of the city at Werribee. Together they treat 90% of Melbourne's wastewater. The Western Treatment Plant now services 50% of Melbourne. It generates enough energy to be energy self-sufficient, converting around 75% of solids into biogas (predominantly methane) and can produce high quality (Class A) recycled water (Melbourne Water, 2015). The Werribee site is now also recognised as a Ramsar wetland of international significance. The Eastern Treatment Plant treats about 40% of Melbourne's sewage, generates 25% of the energy needed to run the plant, and all of the water achieves Class A quality, making it suitable for unrestricted non-potable use. The remaining balance of about 10% of Melbourne is serviced by 19 smaller treatment plants. The average age of Melbourne's wastewater infrastructure is about 38 years and the total number of sewer blockages is 4008 equivalent to 18.4 blockages per 100 km. The energy costs for Melbourne's wastewater system are $5.6 million (Table 3).

Historically, the city has stockpiled most of its biosolids. However, Melbourne has been exploring re-use alternatives. Overall, Melbourne scored high for energy recovery but nutrient recovery currently does not take place. Currently, there is hardly any use for sewage sludge, with almost all sewage sludge stockpiled on land, leading to a low score for sewage sludge recycling (Figure 2).

3.3. Environmental quality and attractiveness

3.3.1. Quality and biodiversity of rivers and creeks

Stormwater pollution is the biggest problem facing rivers and creeks. Each year about 500 million m^3 of water containing litter and other harmful pollutants enters Melbourne's rivers, creeks and bays via stormwater drains (Melbourne Water, 2015). Melbourne Water and the local councils all play a role in managing Melbourne's drainage system. Melbourne Water manages large drains and waterways and councils look after smaller stormwater infrastructure.

Healthy and valued waterways are integrated within the broader landscape and enhance life and liveability (Melbourne Water, 2015). Waterway management focuses on seven key waterway values: amenity, birds, fish, frogs, macro invertebrates, platypus and vegetation. While some rivers and creeks have a 'very high' rating for particular values, the current condition of many of the rivers and creeks have a 'medium' to 'very low' rating for values such as birds, vegetation and fish (Melbourne Water, 2015).

3.3.2. Quality of groundwater

The primary regulatory control of groundwater quality rests with the Environment Protection Authority (EPA) of Victoria. EPA has in place a State Environment Protection Policy (SEPP) called 'Groundwaters of Victoria' (EPA, 1997). This SEPP sets a 'beneficial use' of groundwater, based on segments of salinity, for various applications of groundwater. In future, groundwater will be more important in Melbourne through its use for aquifer storage and recovery of recycled water.

3.3.3. Attractiveness

Attractiveness in this context has been defined as 'Surface water supporting the quality of the urban landscape as measured by the community sentiment/well-being within the city'. The overall attractiveness of Melbourne has been scored at 8. In Melbourne, the Yarra River supports considerable recreation and tourism, providing the setting for a range of beside-water activities such as walking, running, cycling and picnicking as well as sports, festivals and major events each year (Victorian Government, 2013). However, in areas to the west of Melbourne, there is still much work to be done to improve the water in the landscape and green the suburbs.

3.4. Water governance in Melbourne

Since January 1995, metropolitan Melbourne has received its water and wastewater services from a wholesaler (Melbourne Water) and three retail water businesses (City West Water, South East Water and Yarra Valley Water). All four water companies are public entities owned by the State Government of Victoria. Melbourne Water owns and operates the water supply catchments, water treatment plants, transfer systems and large sewage treatment plants. Water retailers own and operate the distribution and reticulation systems and some local sewage treatment plants. Water retailers purchase bulk water from Melbourne Water in accordance with a Bulk Water Supply Agreement that specifies quantity, quality and pressure at interface points. Each retailer operates exclusively within a designated area of Melbourne.

In 2012, the Office of Living Victoria was set up to drive reform in the urban water sector, particularly in the area of integrated water cycle management with the clear objective to turn Melbourne into a water sensitive city (Ferguson et al., 2012). The decision was made to adopt network governance and a whole-of-water-cycle strategic framework. Network governance refers to the need for a range of organisations and agencies to work together to implement the new whole-of-water-cycle management planning approach. From these plans it appears that the overall commitments to adaptive, multifunctional, infrastructure and design for IWRM in Melbourne are very high.

Furthermore a Living Victoria Fund has been set up for smart local water projects. The external collaboration is good. In fact, Living Victoria, which was the Government's 2010 election commitment to urban water reform, also reaches out to the public. The policy is an integral system approach to planning and servicing urban water needs, including potable water, stormwater, wastewater, the environment and urban amenity.

In recent years IWRM in Melbourne has improved greatly, as indicated by improvements in the planning and management of Melbourne's water system, the establishment of a nationally coordinated research program (the CRC for Water Sensitive Cities), closed water supply catchments, reductions in water consumption by about 40% over the last 10 years, installation of rainwater tanks in 30% of houses over the last 15 years and leakage reduction in the water supply network Furthermore, third pipe systems are now a normal option for providing reticulated services to new subdivisions, where economically viable. Melbourne now has 1000s of homes with such services and envisages that over the next 10 years that this will rise to about 100,000+ homes. Melbourne is involved in a stormwater harvesting project within an urban catchment to treat the water for potable use at Kalkallo; an innovative project of international significance (Sustainable Melbourne, 2015). Since 2011, regulations have required all new homes built in Melbourne to meet a 6-star standard of water and energy efficiency. This requires the installation of water efficient showers, tapware, toilets and either a rainwater tank or a solar hot water heater (Building Commission Victoria, 2012)

4. Discussion

4.1. Methodological aspects

The City Blueprint® is an effective and efficient manner to benchmark cities with regard to the sustainability assessment of their IWRM. The ultimate aim is to establish a network (learning alliance) of cities to share their best practices to improve the sustainability of IWRM in their city/municipality/region (European Commission, 2015). Advantages and limitations of the method have been described in detail (Van Leeuwen & Sjerps, 2015b). Until now we have analysed 45 cities with the City Blueprint approach and followed a learning-by-doing approach based on the constructive feedback from cities (European Commission, 2015; Van Leeuwen et al., 2015). In stakeholder discussions in Melbourne, recommendations have been made to better separate the IWRM performance of cities from general trends and pressures that cannot be managed directly by cities, such as the water footprint indicators 1–3 . As a result a thorough review has been carried out to implement these and other comments from cities (Koop & Van Leeuwen 2015a,b).

4.2. The challenges for Melbourne

4.2.1. Population growth

According to the Australian Bureau of Statistics 2013, Melbourne's residential population will more than double in the next 40 years leading to an estimated population of 6.8 million in 2056 (with 6.1–7.9 million as low and high estimates). This is in line with predictions of the United Nations (UN). Currently, 52% of the human population lives in cities, and by 2050 this will be 67%. In developed countries this will even rise to 86% by 2050 (UN, 2012). Urban areas in the world are expected to absorb all of the population growth over the next four decades. With rapid population growth, water withdrawals have tripled over the last 50 years and are predicted to increase by 50% by 2025 in developing countries (SIWI, 2012; UNESCO, 2012). Competing demands for scarce water resources may lead to an estimated 40% supply shortage by 2030 (Addams et al., 2009). Recently, the World Economic Forum identified the water supply crisis as one of the top three global risks for both the impact and likelihood. This is caused by the decline in the quality and quantity of fresh water combined with increased competition among resource-intensive systems, such as food and energy production (World Economic Forum, 2014).

4.2.2. Climate change

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, such as water (Hoekstra & Wiedman, 2014). In many cases this is related to bad water governance practices (OECD, 2011). Melbourne has just come out of the 'Millennium Drought', a period of severe drought (Chong, 2014) and the local authorities realize that another drought will be inevitable (City of Melbourne, 2015). This means that the focus of Melbourne is on water, especially with the added pressures of high population growth, and the need to provide for livability. The challenges in Melbourne are serious and an illustration of these global trends (EEA, 2012; UNEP, 2012; World Economic Forum, 2014).

4.2.3. Infrastructure

The predicted population growth for Melbourne and climate change will have significant financial consequences in terms of investments needed for housing and sustainable infrastructure. With the projected population growth of approximately 2.5 million people in the next 40 years, a household occupancy of 2.44 (Table 3) and an average property price of $300,000, the investments for housing for the next 40 years can be roughly estimated at approximately $300 billion. When other facilities such as offices, sport facilities, schools, churches, hospitals, parks and industrial production facilities, as well as infrastructures for water systems, energy, roads and other transport systems (e.g. public transport, air and sea ports) are added, this figure will probably double. Thus, a roughly estimated $600 billion of investments are needed for the next 40 years for Melbourne. Developing sustainable urban infrastructure benefits not only the environment, but can also boost economic growth and social stability (UNEP, 2013). UNEP stressed the need to transition to resource-efficient technologies in cities. The estimated investments, especially the investment for water, are significant. At the global level an estimated $41 trillion is required to refurbish the old and build new urban infrastructure over the period 2005–2030, of which $22.6 trillion is related to water systems (UNEP, 2013).

4.3. The City Blueprint of Melbourne

Cities vary considerably with regard to the sustainability of IWRM (Van Leeuwen 2013). The variability has been captured in the Blue City Index®, the arithmetic mean of 24 indicators comprising the City Blueprint® with a theoretical minimum score of 0 and a maximum score of 10. With a BCI of 7, Melbourne has been rated one of the world's most liveable cities, ranking above average in water. This is a relatively high score, compared to the 45 cities that have been assessed so far (Van Leeuwen et al., 2015). The residents of Melbourne have helped cut water consumption by 40% over the last decade, as a result of a long campaign in Melbourne to save water. This explains the relatively high score of Melbourne for its water efficiency (Figure 2). The quality of the water supplied in Melbourne is excellent. The average age of the water distribution system is 37 years and the number of mains failures is about average. Water losses in the system are significant. The use of stormwater is crucial for Melbourne. It is important to note that the volume of stormwater runoff is greater than the amount that is actually used. Finding the lowest cost solution of capturing this water and storing it for use at another time of year is the real challenge. Rainwater tanks, greywater treatment systems or on-site wastewater treatment systems may provide viable options for uses such as toilet flushing and watering of small green spaces. Depending on the purpose of the building (residential, commercial) the quantities of greywater and wastewater available for reuse can vary considerably. Non-potable water is supplied through an additional set of pipes, often referred to as a third pipe scheme (Government of Western Australia, 2013).

New suburbs in Melbourne that use third pipe systems use about 30% less potable water than a conventional housing development. 'Recycled water' generally refers to fully treated effluent from sewage treatment plants. Recycled water is a secure alternative water source that, when treated as required, is fit for a range of purposes (Melbourne Water, 2015).

4.4. Water governance

There is a clear objective to turn Melbourne into a water sensitive city (Brown et al., 2009; Ferguson et al., 2012). The reforms of the Office of Living Victoria are intended to change the way that Melbourne uses rainwater, stormwater and recycled water and provide for Victoria's next major augmentation. Looking at the challenges for Melbourne and at the changes that have taken place over the last years to meet the political goals for Melbourne related to IWRM (City of Melbourne, 2015), it can be concluded that the performance of Melbourne as a reaction to the 'Millennium Drought' is impressive. This transition process is unique although a very recent political decision abolished the Office of Living Victoria.

The development of the City Blueprint approach started in 2011 and at that time no use was made of the OECD multi-level governance framework (OECD, 2011). Nevertheless, a comparison with the seven key co-ordination gaps of the OECD as presented in Table 2 is very interesting. In fact, it shows that water governance in Melbourne is very well organized on all these seven aspects and these aspects are discussed shortly. The administrative gap (gap 1) seems to be absent. Much has been done to bridge the information gap as adequate information on IWRM issues is available on high quality websites accessible to all stakeholders (e.g. Melbourne Water, 2015; Victorian Government, 2013). Policy gaps were bridged as a well-coordinated transparent multi-stakeholder process has been used to develop strategic plans for IWRM that included consultation with customers and stakeholders on many aspects of IWRM (OLV, 2014b).

Capacity gaps were prevented as a relatively small group of internal and external experts with complementary skills were pooled or worked together allowing for sufficient scientific, technical and policy expertise. Furthermore significant investments have been made by the Australian government to set up cooperative research centres for water sensitive cities (CRC, 2015). Adequate funding has also been provided for the development and implementation of these plans.

As the decision was made to adopt network governance, i.e. a range of organisations and agencies working together to develop and implement the new whole-of-water-cycle management planning approach, the participants were also working towards a clear common objective. Transparency is key as the reasoning that is behind policy processes needs to be accessible. Network governance also facilitates clear accountability as it also acknowledges that each institution has its own area of responsibility and authority through which actions in the whole-of-water-cycle management plans will be implemented. This is also supported by the view of UN Secretary-General Ban Ki-moon on World Water Day 2015: 'The onset of climate change, growing demand on finite water resources from agriculture, industry and cities, and increasing pollution in many areas are hastening a water crisis that can only be addressed by cross-sectoral, holistic planning and policies – internationally, regionally and globally.'

5. Conclusions

Water governance in Melbourne has been reviewed based on (1) many documents available on transparent websites of e.g. the Victorian Government and Melbourne Water, and (2) the interactive City Blueprint analysis with the involvement of many stakeholders from Melbourne. Melbourne performs well and shows a good level of commitment to sustainable solutions. The city scores highly in areas such as water efficiency, wastewater efficiency, i.e., energy recovery, and climate change commitments related to heat and water scarcity. Nearly 30% of houses in Melbourne have installed rainwater tanks and plans to increase the use of stormwater have recently been published. Energy efficiency of buildings, nutrient recovery (especially phosphate) from wastewater, as well as sewage sludge recycling are topics for improvement.

The decision to set up a relatively small central network governance structure in Melbourne to drive reform in the urban water sector and a whole-of-water-cycle strategic framework has been crucial. Success has come from many organizations working together to a common goal. This network governance structure is quite unique and can be an example for many cities in the world.

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References

Addams, L., Boccaletti, G., Kerlin, M., & Stuchtey, M. (2009). *Charting Our Water Future: Economic frameworks to inform decision-making*. 2030 Water Resources Group. London: McKinsey & Company.

Australian Bureau of Statistics (2004). *Household Use of Information Technology Australia*. Melbourne: Commonwealth of Australia.

Australian Bureau of Statistics (2013). *Population Projections, Australia, 2012 to 2101*. Melbourne: Commonwealth of Australia.

Brown, R.R., Keath, N., & Wong, T.H.F. (2009). Urban Water Management in Cities: Historical, Current and Future Regimes. *Water Science and Technology*, 59, 847–855.

Building Commission Victoria (2012). *What you need to know about 6 star*. Melbourne: State Government Victoria.

Chong, J. (2014). Climate-readiness, competition and sustainability: an analysis of the legal and regulatory frameworks for providing water services in Sydney. *Water Policy*, 16, 1–18.

CRC (2015). *CRC for Water Sensitive Cities*. Retrieved from http://watersensitivecities.org.au/ [Accessed 12 January 2015].

City of Melbourne (2010). *WSUD Guidelines: Applying the Model WSUD Guidelines, An Initiative of the Inner Melbourne Action Plan, Melbourne*. Retrieved from http://www.melbourne.vic.gov.au/Sustainability/SavingWater/Documents/WSUD_Guidelines.PDF [Accessed 26 April 2013].

City of Melbourne (2015). *Drought and reduced rainfall*. Retrieved from https://www.melbourne.vic.gov.au/Sustainability/AdaptingClimateChange/Pages/Drought.aspx [Accessed 26 May 2015].

European Commission (2012). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. A Blueprint to Safeguard Europe's Water Resources COM/2012/0673 final. Brussels: European Commission.

European Commission (2015). *European Innovation Partnership on Water*. Brussels, Belgium: European Commission. City Blueprint Action Group. Retrieved from http://www.eip-water.eu/City_Blueprints [Accessed 26 March 2015].

EEA (2012). *Urban adaptation to climate change in Europe: Challenges and opportunities for cities together with supportive national and European policies*. Copenhagen: European Environment Agency.

EPA Victoria (1997). *State environment protection policy (Groundwaters of Victoria)*. Victoria Government Gazette, No. S160. Melbourne: AGPS Publications.

Engel, K., Jokiel, D., Kraljevic, A., Geiger, M., & Smith, K. (2011). *Big cities big water big challenges: Water in an urbanizing world*. Berlin: World Wildlife Fund.

FAO (2013). *Aquastat: Global information system on water and agriculture*. Rome: Food and Agricultural Organization of the United Nations.

Ferguson, B., Frantzeskaki, N., Skinner, R., & Brown, R. (2012). *Melbourne's transition to a water sensitive city*. Melbourne: Monash University.

Gan, K., & Purss, C. (2010). Reducing non revenue water in a retail water company. AWA OzWater Conference, 8-10 March 2010, Brisbane, Australia. Brussels: European Commission.

Government of Western Australia (2013). *Community scale (third pipe) options*. Retrieved from http://www.water.wa.gov.au/Managing+water/Recycling/Waterwise+community+toolkit/Non-drinking+water+supply+options/Community+scale+%28third+pipe%29+options/Building+scale/default.aspx [Accessed 26 April 2013].

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., & Mekonnen, M.M. (2011). *The Water Footprint Assessment Manual: Setting the Global Standard*. London: Earthscan.

Hoekstra, A.Y., Mekonnen, M.M., Chapagain, A.K., Mathews, R.E., & Richter, B.D. (2012). Global monthly water scarcity: Blue water footprints versus blue water availability. *PLoS ONE*, 7 (2), e32688. doi: 10.1371/journal.pone.0032688

Hoekstra, A.Y., & Wiedman, T.O. (2014). Humanity's unsustainable environmental footprint. *Science*, 344 (6188), 1114–1117.

Koop, S.H.A., & Van Leeuwen, C.J. (2015a). Assessment of the sustainability of water resources management: a critical review of the city blueprint approach. *Water Resources Management*, in press. doi:10.1007/s11269-015-1139-z

Koop, S.H.A. and Van Leeuwen, C.J., 2015b. Application of the improved city blueprint framework in 45 municipalities and regions. *Water Resources Management*, 29 (13), 4629–4647.

Kularathna, M., Baker, B., & Ennor, S. (2011). Interactive optimisation modelling using OPTIMISIR to support Melbourne water supply operations. 19th International Congress on Modelling and Simulation, 12-16 December, Perth, Australia. Perth: The Modelling and Simulation Society of Australia and New Zealand.

MacDonald, R.I., Weber, K., Padowsk, J., Flörke, M., Schneider, C., Green, P.A., Gleeson, T., Eckman, S., Lehner, B., Balk, D., Boucher, T., Grill, G., & Montgomeryi, M. (2014). Water on an urban planet: urbanization and the reach of urban water infrastructure. *Global Environmental Change*, 27, 96–105.

Mekonnen, M.M., & Hoekstra, A.Y. (2011). *National water footprint accounts: the green, blue and grey water footprint of production and consumption*, Volumes 1 and 2, Value of Water Research Report Series No. 50. Delft: UNESCO-IHE Institute for Water Education.

Melbourne Water (2015). *Enhancing life and liveability; Website of Melbourne Water*. Retrieved from http://www.melbournewater.com.au/ [Accessed 7 January 2015].

OECD (2011). *Water Governance in OECD Countries: A multi-level approach*. Paris: Organisation for Economic Cooperation and Development.

OLV (2014a). *Office of Living Victoria*. Retrieved from http://www.livingvictoria.vic.gov.au/ [Accessed 30 September 2014].

OLV (2014b). *Office of Living Victoria. Developing the Metropolitan Whole-of-Water-Cycle Strategic Framework 2014-2024*. Retrieved from http://www.mav.asn.au/policy-services/environment/water/Pages/default.aspx [Accessed 27 May 2015].

Philip, R., Anton, B., & van der Steen, P. (2011). *SWITCH Training Kit: Integrated Urban Water Management in the City of the Future, Module 1*. Retrieved from http://www.switchtraining.eu/ [Accessed 28 May 2013].

SIWI (2012). *Facts and Figures*. Stockholm: Stockholm International Water Institute. Retrieved from http://www.siwi.org/media/facts-and-statistics/ [Accessed 8 December 2012].

Sustainable Melbourne (2015). *Stormwater harvesting and reuse in Kalkallo (Victoria)*. Retrieved from http://www.sustainablemelbourne.com/models/stormwater-harvesting-reuse-kalkallo-vic/ [Accessed 26 May 2015].

UN (2012). *World Urbanization Prospects: the 2011 revision*. New York, NY: United Nations.

UNDP (2013). *User's guide on assessing water governance*. Oslo: United Nations Development Programme.

UNEP (2012). *Fifth Global Environment Outlook: Environment for Development*. Geneva: United Nations Environment Programme.

UNEP (2013). *City-Level Decoupling: Urban resource flows and the governance of infrastructure transitions*. A report of the working group on cities of the International Resource Panel. Nairobi: United Nations Environment Programme.

UNESCO (2012). *Facts and Figures: Managing Water Under Uncertainty and Risk*. United Nations World Water Development Report 4, United Nations World Water Assessment Programme. Retrieved from http://unesdoc.unesco.org/images/0021/002154/215492e.pdf [Accessed 20 December 2012].

Van der Steen, P. (2011). Application of sustainability indicators within the framework of strategic planning for integrated urban water management. Sustainable Water Management in the City of the Future. UNESCO-IHE Institute for Water Education. Retrieved from http://www.switchurbanwater.eu/outputs/pdfs/W1-1_CALE_MAN_D1.1.7_Indicators_Manual.pdf [Accessed 7 January 2015].

Van Leeuwen, C.J., Frijns, A., Van Wezel, A., & Van de Ven, F. (2012). City Blueprints: 24 indicators to assess the sustainability of the urban water cycle. *Water Resources Management*, 26, 2177–2197.

Van Leeuwen, C.J. (2013). City Blueprints: baseline assessment for water management in 11 cities of the future. *Water Resources Management*, 27, 5191–5206.

Van Leeuwen, C.J., & Bertram, N.-P. (2013). Baseline assessment and best practices in urban water cycle services in the city of Hamburg. *Blue Facts – International Journal of Water Management*, (8), 10–16.

Van Leeuwen, C.J., & Chandy, P.C. (2013). The city blueprint: experiences with the implementation of 24 indicators to assess the sustainability of the urban water cycle. *Water Science and Technology: Water Supply*, 13 (3), 769–781.

Van Leeuwen, C.J., & Sjerps, R. (2015a). The City Blueprint of Amsterdam: an assessment of integrated water resources management in the capital of the Netherlands. *Water Science & Technology: Water Supply*, 15 (2), 404–410.

Van Leeuwen, K., & Sjerps, R. (2015b). Istanbul: the challenges of integrated water resources management in Europa's Megacity. *Environment, Development and Sustainability*, in press. doi:10.1007/s10668-015-9636-z

Van Leeuwen, K., Koop, S.H.A., & Sjerps, R. (2015). City Blueprints: baseline assessments of water management and climate change in 45 cities. *Environment, Development and Sustainability*, in press. doi:10.1007/s10668-015-9691-5

Volunteering Australia (2012). *State of Volunteering in Australia*. Retrieved from http://www.volunteeringaustralia.org/files/4PT7KWX63A/State_of_Volunteering_in_Australia_2012.pdf [Accessed 21 May 2013].

Victorian Government (2013). *Sustainable management of Victoria's groundwater resources*. Retrieved from http://www.vic.gov.au/ [Accessed 7 May 2013].

World Economic Forum (2014). *Global Risks: An Initiative of the Risk Response Network*, 9th (ed.). Geneva: World Economic Forum.