The city blueprint: experiences with the implementation of 24 indicators to assess the sustainability of the urban water cycle

Cornelis J. van Leeuwen and Philipo C. Chandy

ABSTRACT

A set of indicators, i.e. the city blueprint, has been developed to assess the sustainability of the water cycle (SWC). 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. The city blueprint can be used as a first step or quick-scan to benchmark the SWC in cities and may help: (1) to communicate a city's SWC performance and exchange experiences, (2) to select appropriate water supply and sanitation strategies, (3) to develop technological and non-technological options as future alternatives for the water cycle, where several possible changes in the use of technology, space and socio-economic 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. So far, a city blueprint has been made for the city of Rotterdam. This study reports on three other cities, i.e. two Dutch cities (Maastricht and Venlo) and one city in a developing country (Dar es Salaam in Tanzania). Experiences so far and further plans will be discussed.

Key words | cities of the future, Dar es Salaam, indicators, Rotterdam, water scarcity

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INTRODUCTION

According to the United Nations Environment Programme (UNEP 2007), climate change, population growth and increased consumption, coupled with urbanization, are all placing increased pressure on water management. Competing demands for scarce water resources may lead to an estimated 40% supply shortage by 2030 (2030 Water Resources Group 2009). There are currently over 300 cities in the world exceeding 1 million inhabitants and 21 mega cities – a metropolitan area with a total population in excess of 10 million people. According to the United Nations (2008), 50% of the human population lives in cities, and by 2030 this will be 60% (Figure 1). In developed countries this will rise to 82% by 2030. Probably, this global water challenge can best be addressed at the local level, e.g. in cities, optimizing the role of the civil society, which is crucial (European green city index 2009).

Changes in demography, including the aging population, socio-economic factors, climate change, biodiversity, energy use, water supply and consumption, as well as ageing infrastructures for e.g. water supply, distribution and treatment (Cohen 2007; Brown 2009; Deltares 2009; Charlesworth 2010; Ernstson *et al*. 2010) ask for a thorough understanding of the various possibilities to build towards a sustainable water cycle (SWC). Different scenarios to improve urban water supply, in the context of already well developed and equipped cities, have to be evaluated in respect to different aspects of sustainability, i.e. efficient use of water, energy and nonrenewable resources, climate change, safety, biodiversity, green space, recreation, human and environmental

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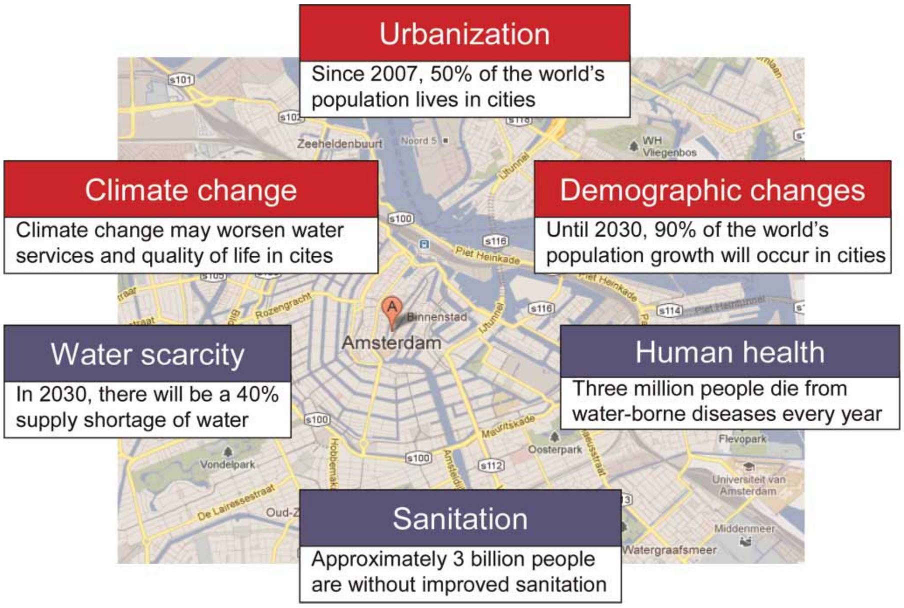

Figure 1 | Megatrends pose urgent challenges in cities.

health, public participation, compliance to (future) legislation, transparency, accountability and costs (Frijns *et al.* 2009; Verstraete *et al.* 2009).

As pointed out by the European Environment Agency (EEA), the achievement of European Union (EU) water policy goals appears far from certain due to a number of past and emerging challenges (EEA 2010). The Blueprint to Safeguard Europe's Water (European Commission 2011) will be the EU policy response to these challenges. It aims to ensure good quality water in sufficient quantities for all legitimate uses. The challenges will predominantly reside in cities (European green city index 2009; Engel *et al.* 2011).

Although there are approaches for the assessment of the sustainability of countries (Van de Kerk & Manuel 2008) and cities (European green city index 2009), it was a great surprise to find out that dedicated frameworks for the assessment of the sustainability of the water cycles in cities do not exist. This was the reason why we have recently developed the City Blueprint (Van Leeuwen *et al.* 2012). City blueprints are quick scans for the evaluation of the actual situation in cities, involving all stakeholders, as a first step in the strategic planning process for SWC (Philip *et al.* 2011). It is the first step towards gaining a better understanding and addressing the challenges of SWC (Figure 2). City blueprints will enable the SWC of cities to be compared, and stimulate the exchange of success stories (best practices) between cities to address the enormous challenges involved in implementing sustainability (Goudie 2009). In this way cities can become part of the solution.

MATERIALS AND METHODS

Scope of the city blueprint

Urban water management is complex. It has a wide scope and many stakeholders are involved. Therefore, the scope of the city blueprint needs to reflect this and cover a broad range of aspects such as water security, water quality, drinking water, sanitation, infrastructure, biodiversity and attractiveness, as well as governance (Table 1). Based on a literature study that covered scientific publications and a variety of national and international policy documents and included a variety of approaches to assess the SWC, i.e. water footprints (Hoekstra & Chapagain 2007; Mekonnen & Hoekstra 2011), urban metabolism (e.g. Barles 2010), ecosystem services (e.g. Costanza *et al.* 1997), and indicator-approaches (e.g. Van de Kerk & Manuel 2008; European

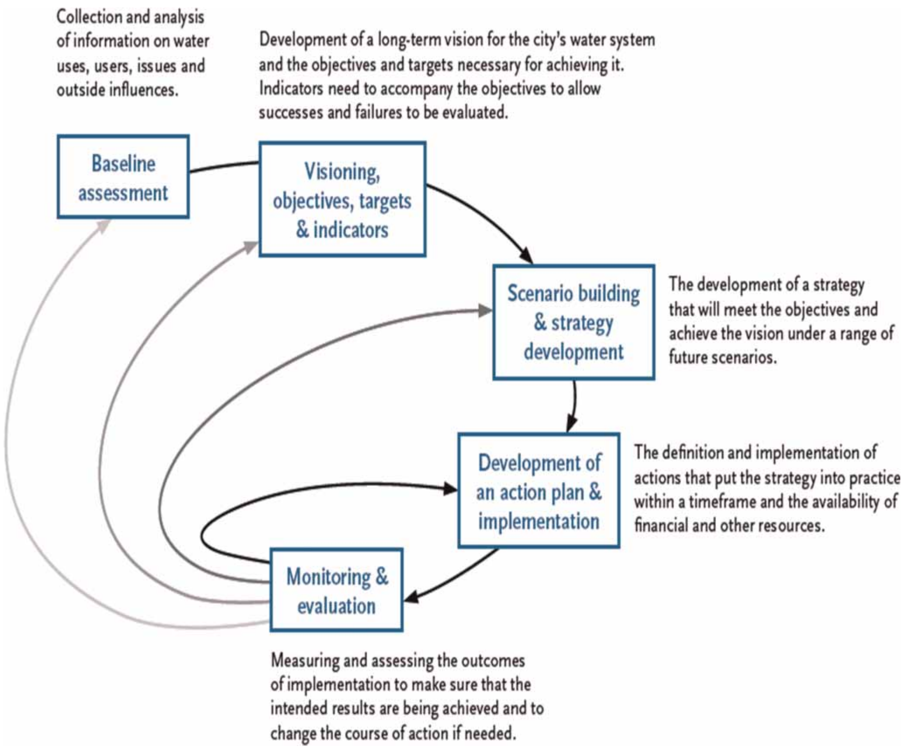

Figure 2 | The strategic planning process for SWC according to SWITCH (Philip *et al*. 2011).

green city index 2009), a proposal was made for the city blueprint (Van Leeuwen *et al*. 2012).

Requirements

The following requirements were established:

1. Scope: city blueprints should comprise water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness, as well as governance.
2. Data availability: data must be easily obtainable from public sources.
3. Approach: a quantitative approach is the preferred option in which expert panel scores can also be included.
4. Scale: indicators for city blueprints need to be scored on a scale between 0 (very poor performance which requires further attention) to 10 (excellent performance which requires no additional attention).
5. Simplicity: calculations and scoring of the indicator values need to be relatively easy.
6. Comprehensibility: results need to be interpreted and communicated relatively easily, not only to experts but to politicians and the public too, preferably in one graphic image such as a spider web, without the need for an in-depth knowledge of the applied methodology.
7. Workability: data collection, further selection, calculations and graphical representation of the results need to be doable, i.e. to be completed in a couple of days.

Calculation of the city blueprint

The indicators of the city blueprint are summarized in Table 1. Detailed information about the methodology, sources of information and calculations for each of the 24 indicators for the city of Rotterdam are provided in Van Leeuwen *et al*. (2012) and the accompanying supporting information. In this publication we have made two major changes to our previous work: we have applied min–max normalization for the indicators 1, 9 and 24, and we have used more recent data provided by Mekonnen & Hoekstra (2011) for the calculation of the water security indicators. As in the previous publication, the lack of city-specific data forced us to calculate three indicators (1–3) of the city blueprint on the basis of national data (Table 1). We have also used

Table 1 | Indicators of the city blueprint[a]

Indicator	Description
Water security	
1. Total water footprint (N)	Total volume of freshwater that is used to produce the goods and services consumed by the community (Hoekstra & Chapagain 2007; Hoekstra *et al.* 2011; Mekonnen & Hoekstra 2011)
2. Water scarcity (N)	Ratio of total water footprint to total renewable water resources (Hoekstra & Chapagain 2007; Hoekstra *et al.* 2011; Mekonnen & Hoekstra 2011)
3. Water self-sufficiency (N)	Ratio of the internal to the total water footprint. Self-sufficiency is 100% if all the water needed is available and taken from within own territory (Hoekstra & Chapagain 2007; Hoekstra *et al.* 2011; Mekonnen & Hoekstra 2011)
Water quality	
4. Surface water quality	Assessment of the water quality preferably based on international standards for e.g. microbial risks, nutrients, BOD and organic/inorganic micro-contaminants (European Commission 2000)
5. Groundwater quality	Assessment of quality preferably based on international standards for e.g. microbial risks, nutrients, BOD and organic/inorganic micro-contaminants (European Commission 2006)
Drinking water	
6. Sufficient to drink	Percentage of city population, with potable water supply service (UN 2007; Global city indicators facility 2008; Sustainable Society Foundation 2010)
7. Water system leakages	Percentage of water lost in the distribution system (European green city index 2009)
8. Water efficiency	Assessment of the comprehensiveness of measures to improve the efficiency of water usage (Jenerette & Larsen 2006)
9. Consumption	Domestic water consumption per capita (liters/day) (Global city indicators facility 2008)
10. Quality	Percentage of drinking water meeting the WHO water quality guidelines or the EU Drinking Water Directive (European Commission 1998; Global city indicators facility 2008; Sustainable Society Foundation 2010; EBC 2011)
Sanitation	
11. Safe sanitation	Percentage of city population served by wastewater collection and treatment (UN 2007; Global city indicators facility 2008; European green city index 2009; Sustainable Society Foundation 2010)
12. Sewage sludge quality	Percentage of sewage sludge that can be safely used in agriculture based on organic/inorganic micro-contaminants (Vinjé *et al.* 2007; De Graaf *et al.* 2007a, b; Fewtrell & Kay 2008)
13. Energy efficiency	Assessment of the comprehensiveness of measures to improve the efficiency of wastewater treatment (UN 2007; European green city index 2009)
14. Energy recovery	Percentage of wastewater treated with techniques to generate and recover energy (Daigger 2009; Frijns *et al.* 2009; Verstraete *et al.* 2009)
15. Nutrient recovery	Percentage of wastewater treated with techniques to recover nutrients, especially phosphate (Cohen 2007; Frijns *et al.* 2009; Verstraete *et al.* 2009; Daigger 2009)
Infrastructure	
16. Maintenance	Percentage of infrastructure for wastewater collection, distribution and treatment younger than 40 years (RIONED 2010)
17. Separation of wastewater and stormwater	Percentage of separation of the infrastructures for wastewater and stormwater collection (Tredoux *et al.* 1999; UN 2007; Sustainable Society Foundation 2010; EBC 2011)
Climate robustness	
18. Local authority commitments on climate change	Assessment of how ambitious and comprehensive strategies and actual commitments are on climate change (Global city indicators facility 2008; European green city index 2009; Australian Conservation Foundation 2010; Forum for the future 2010)

(*continued*)

Table 1 | continued

Indicator	Description
19. Climate change adaptation measures	Assessment of measures taken to protect citizens against flooding and water scarcity, including sustainable drainage (Deltares 2009; Nederlof *et al*. 2010)
20. Climate-robust buildings	Assessment of energy efficiency for heating and cooling, including geothermal energy (Charlesworth 2010)
Biodiversity and attractiveness	
21. Biodiversity	Biodiversity of aquatic ecosystems according to the WFD (European Commission 2000)
22. Attractiveness	Water supporting the quality of the urban landscape as measured by community sentiment within the city (Costanza *et al*. 1997; European green city index 2009)
Governance	
23. Management and action plans	Measure of local and regional commitments to adaptive, multifunctional, infrastructure and design for SWC as demonstrated by the ambition of the action plans and actual commitments (Fleming 2008; Brown & Farrelly 2009; European green city index 2009)
24. Public participation (N)	Proportion of individuals who volunteer for a group or organization as a measure of local community strength and the willingness of residents to engage in activities for which they are not remunerated. Public participation is an indicator of stakeholder equity in the planning process (EFILWC 2006; Brown 2009; Brown & Farrelly 2009; European green city index 2009)

[a]All indicators are at the level of the city, except for indicators 1–3 and 24 which are based on national (N) data.

national data for the calculation of indicator 24, i.e. public participation based on the data provided by the European Foundation for the Improvement of Living and Working Conditions (EFILWC 2006). All other calculations are identical to the methodology used for the city blueprint calculations of Rotterdam (Van Leeuwen *et al*. 2012).

In a few cases the requirements of scale and comprehensibility necessitated the transformation of the original data. For instance, the total water footprint of the Netherlands is 1,466 m^3/yr/cap and slightly above the world average of 1,385 m^3/yr/cap (Mekonnen & Hoekstra 2011). This value was transformed using min–max normalization using data from the Democratic Republic of Congo (552 m^3/yr/cap) as minimum and Niger (3,519 m^3/yr/cap) as maximum values, respectively. These data are provided in Appendix VII of Mekonnen & Hoekstra (2011). The value for the Netherlands thus becomes $(1466–552)/3519–552) = 0.30805$. In order to transform this into a 'concern score' on a scale of 0–10, we arrive at a score of $(1–0.30805) \times 10 = 6.92$ for the Netherlands. In other words, the total water footprint in the Netherlands is about average and this is reflected in a score of 6.9.

Information on voluntary participation in Tanzania is not well documented, but does exist at low levels of the community, e.g. village water committees, water users associations in the catchment and community owned water supply organizations (COWSO), which is also the case for Dar es Salaam. The index of voluntary participation (by country) was not available for Tanzania as only information was provided on European countries (EFILWC 2006). Therefore only a rough estimate for Tanzania could be provided. This estimate was obtained from the relation between the internet use in 2003 (%) and the index of voluntary participation in 2004 as provided in the report of EFILWC (2006). Based on this information (Figure 3), internet use by country (URL1) and the fact that approximately a doubling of internet use took place in the last 8 years, the

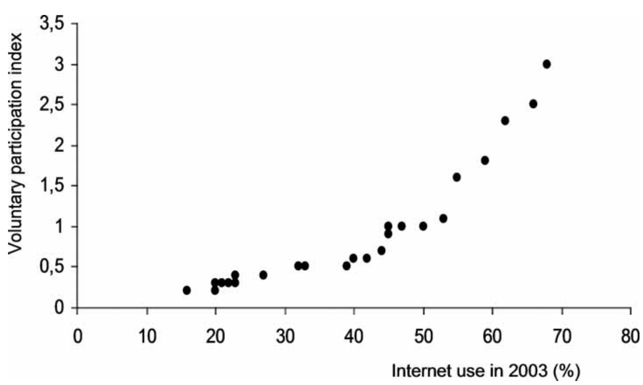

Figure 3 | The relation between internet use and the voluntary participation based on data provided by EFILWC (2006).

internet connectivity for Tanzania in 2003 was estimated to be approximately 5%, leading to an estimated score for voluntary participation of 0.3 (on a scale from 0–10), using min–max normalization with 0 as minimum and 3.0 (the EFILWC score for Sweden) as maximum.

The process

Integration is most successful when there is a process of interaction rather than a one-way delivery of knowledge on the doorstep of the policy maker (Ison *et al*. 2011). Rather than collecting information ourselves, as in the case of the cities of Rotterdam and Dar es Salaam, the stakeholders (representatives of municipalities, water utilities, wastewater utilities and water boards) were asked to complete a questionnaire in an interactive manner. This interactive multi-stakeholder approach to problem formulation (Van Leeuwen 2007), assessment and evaluation of SWC as applied for the cities of Venlo and Maastricht was much more effective, as it underlined the connectivity between the technical, economic and sociopolitical processes (Ison *et al*. 2011; Godden *et al*. 2011).

RESULTS

Cities in the Netherlands

Based on the publication of the city blueprint for Rotterdam (Van Leeuwen *et al*. 2012), KWR Watercycle Research Institute was asked to provide city blueprints for another two cities. These Dutch cities, Maastricht and Venlo, are situated along the river Meuse in the province of Limburg. A different approach was taken however. Rather than collecting information ourselves, as in the case of the city of Rotterdam (Van Leeuwen *et al*. 2012), the stakeholders (representatives of municipalities, water utilities, wastewater utilities and water boards) were asked to complete a questionnaire in an interactive manner. The assessment and evaluation of Maastricht and Venlo were done in an interactive and interdisciplinary manner taking a bottom-up approach (Van Pelt & Swart 2011) in accordance with the principles and management strategies of the implementation challenge approach as applied in the former Dutch Ministry of Housing, Spatial Planning and the Environment (VROM 1992). Not surprisingly, the results of the scoring were quite similar to those of Rotterdam, as all three cities are in the same country, situated on the same downstream water bodies (Klauer *et al*. 2012), with many similarities for most indicators (Table 2). The updated city blueprint for Rotterdam is provided in Figure 4.

The spider web presentation of the calculations provides a quick scan of the concerns, which in the case of the cities Rotterdam, Maastricht and Venlo are the water self-sufficiency, sewage sludge quality, nutrient recovery, energy recovery and biodiversity. Lessons from soil pollution incidents (Zoeteman *et al*. 1981) have shown that groundwater quality may be at risk. Unfortunately, this could not be confirmed due to insufficient data in the cities. As the water security parameters were estimated on the basis of information for the Netherlands (Mekonnen & Hoekstra 2011) and all three Dutch cities greatly depend on the river Meuse, it is only natural that water security and water quality issues can only partly be dealt with by the city of Rotterdam and also need to be addressed at national and international levels (Klauer *et al*. 2012).

Dar es Salaam (Tanzania)

Mekonnen & Hoekstra (2011) provide data on the average water footprint of Tanzania of 1,026 m³/yr per capita. The water scarcity for Tanzania is 37% and the water self-sufficiency (93.2%) is relatively high. These and other data are shown in the city blueprint for Dar es Salaam (Figure 5). Surface water pollution is a major problem. In Dar es Salaam, domestic waste is the most serious source of pollution. The waste generated by 15% of the city residents who are connected to the sewer system is discharged into the sea untreated. As a result, coastal waters, especially in the vicinity of the Dar es Salaam harbor, are heavily polluted. Discharge of untreated sewage in Dar es Salaam has resulted in high faecal and total coliform levels in coastal waters (Mohammed 2002). Msimbazi River and Creek are also among the most polluted water bodies in Dar es Salaam. The river and creek receive large quantities of untreated domestic wastes from the city's residents in addition to industrial wastes from various industries. The river and creek receive such pollutants as dyes and paint

Table 2 | City blueprints for Dar es Salaam (Tanzania) and three cities in the Netherlands

Parameter	Dar es Salaam	Rotterdam	Maastricht	Venlo
Water security				
1. Total water footprint	8.4	6.9	6.9	6.9
2. Water scarcity	6.3	7.4	7.4	7.4
3. Water self-sufficiency	9.3	0.5	0.5	0.5
Water quality				
4. Surface water quality	4	4	3.5	4
5. Groundwater quality	5	6	5	5
Drinking water				
6. Sufficient to drink	6	10	10	10
7. Water system leakages	7[a]	9.4	9.5	9.5
8. Water efficiency	2	10	7	6
9. Consumption	9.0	10	9.1	9.1
10. Quality	4	9.9	10	10
Sanitation				
11. Safe sanitation	5.6	9.7	9.9	9.9
12. Sewage sludge quality	2	0	0	0
13. Energy efficiency	0	7	6	6
14. Energy recovery	0	5	4	4
15. Nutrient recovery	0	0	0.05	0.05
Infrastructure				
16. Maintenance	2	6.8	7	7
17. Separation of wastewater and stormwater	0	7	6	8
Climate robustness				
18. Local authority commitments on climate change	2	9	7.5	7.5
19. Climate change adaptation measures	2	9	8	8
20. Climate-robust buildings	2	8.5	7	7
Biodiversity and attractiveness				
21. Biodiversity	2	3	3.5	4
22. Attractiveness	5	6	7	7
Governance				
23. Management and action plans	2	7.8	7.5	7.5
24. Public participation (N)	0.3	7.7	7.7	7.7

[a]According to the UN (URL2), the current estimate for non-revenue water in Dar es Salaam is 60% of which 30% is leaked.

wastes and strong alkalis (from textile factories), oil and tars (from vehicle depots and power stations) and organic wastes (from breweries and meat plants). Other industrial and agricultural chemicals that pollute the river and creek include heavy metals, polychlorinated biphenyls (PCBs), cyanides, pesticides, and detergents (Mohammed 2002). Similar information is provided in a recent study (African green city index 2011). Mwanza city has efficient sewage treatment, but this is an exception in Tanzania. Most cities in Tanzania have inadequate sewage treatment facilities. Invariably, waste from these cities/towns is discharged untreated into the environment, mainly into coastal waters via local sewer networks and rivers. In most cities and towns, sewer networks are either non-existent, inadequate or in an advanced state of disrepair (Mohammed 2002). Unfortunately, Dar es Salaam is no exception (African green city index 2011). The highly polluted rivers in Dar es Salaam are not used as sources of water for the city. The main surface water sources for Dar es Salaam are upper and lower Ruvu River and River Mzinga. In those intakes there are well established water treatment plants.

According to Napacho & Manyele (2010), there is a significant difference for deep and shallow (<5 m deep) wells in terms of nitrate content, most of the shallow wells shows higher nitrate content exceeding the World Health Organization (WHO) limit. Based on these findings and the fact that there is no system for the collection and treatment of stormwater, it can be expected that shallow groundwater is polluted with many other contaminants as a result of leaching. The Authority which has the mandate to supply water in the city, i.e. Dar es Salaam Water Supply and Sewerage Authority (DAWASA) is not allowed to drill any shallow wells. In case the Authority wants to supplement groundwater for surface water, they drill boreholes. Most of the shallow wells in the city are privately owned.

Dar es Salaam has a high level of non revenue water (NRW). NRW is water that has been produced and is 'lost' before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example, through theft or metering inaccuracies). The current estimate for NRW in Dar es Salaam is 60% of which 30% is leaked (URL2). An estimated 90% of the city inhabitants of Dar es Salaam

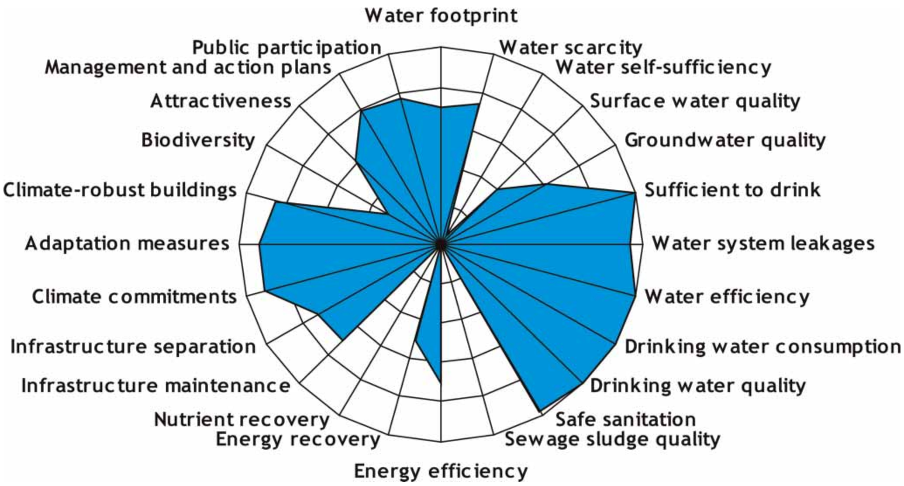

Figure 4 | The city blueprint of Rotterdam based on 24 indicator scores. The range of the scores varies from 0 (center of the circle) to 10 (periphery of the circle). Further details are provided in the text.

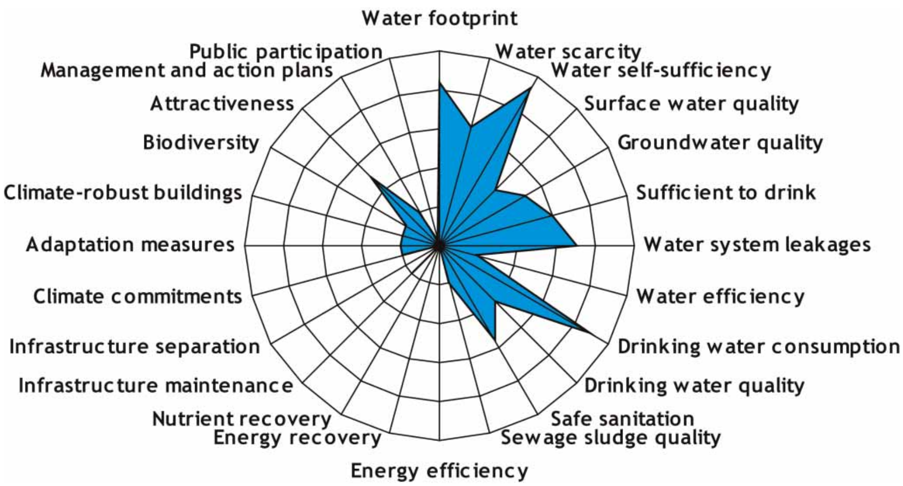

Figure 5 | The city blueprint of Dar es Salaam based on 24 indicator scores. The range of the scores varies from 0 (center of the circle) to 10 (periphery of the circle). Further details are provided in the text.

have access to potable water (African green city index 2011). In the report on Dar es Salaam, the African green city index study refers to poorer districts in the city receiving water only on a weekly basis. Napacho & Manyele (2010) stated that during the rainy and dry season potable water scarcity becomes a major issue leaving many residents to seek other alternative drinking water resources. During these times of adversity many residents succumb to various diseases such as malaria, gastroenteritis, and cholera. The Government has an action plan in place for Dar es Salaam City that by 2015 there will be no water problem in the city. These plans include construction of the Kidunda dam, boreholes in Kimbiji and Mpera, and upgrading both lower and upper Ruvu infrastructure including water treatment plants. Based on these considerations the score for indicator 6 has been set at 6 (Table 2 and Figure 5).

Dar es Salaam does not have a strategy aimed at encouraging efficient water consumption, neither does it enforce water pollution standards on local industry nor promote public awareness about healthy sanitation practices. Overall the ambitions regarding water quality, drinking water, sanitation, infrastructure and climate robustness are low. Waste and sanitation are the main challenges (African green city index 2011). This is reflected in the scores (Table 2 and Figure 5).

DISCUSSION

Despite the many challenges in the implementation planning and engineering of sustainability (Goudie 2009), there is no clear set of indicators to asses the sustainability of the urban water cycle. We therefore developed the city blueprint: a set of 24 indicators that enable a quick scan to be made of the sustainability of the urban water cycle (Van Leeuwen *et al.* 2012). This quick scan or baseline assessment is an initial collection and analysis of information to gain up-to-date knowledge on water issues, the urban water system, main actors and legal and institutional frameworks relevant for water management (Figure 2). The city blueprint approach is identical to the approach of the European green city index (2009) and African green city index (2011), but with a more specific focus on the sustainability of the urban water cycle. The choice of indicators for the city blueprint is by definition subjective. There are hundreds of options for other indicators and a variety of methods to quantify them. For example, we deliberately left out the economic indicators at this stage, but this information is available for many utilities in Europe from e.g. the European Benchmark Co-operation (EBC 2011). We have not addressed salt water intrusion due to groundwater overexploitation, although this may be relevant in many countries (EEA 2010). However, we have addressed the energy efficiency of wastewater treatment, although this use is only a relatively small fraction of the total use of energy in the water cycle. So the proposed 24 indicators are subjective and by no means exhaustive and need to be further discussed, developed and applied for many cities in a process of learning-by-doing, as in the case of the European green city index (2009).

The quality of the presented city blueprints depends on the quality of the underlying data. Therefore, the search for adequate input data is the greatest challenge, but it is doable, even in developing countries as shown by Siemens (African green city index 2011). For instance, we have estimated voluntary participation for Tanzania on the basis of the voluntary participation index (VPI) developed for Europe (EFILWC 2006). We have estimated the VPI for Tanzania on the basis of the relation between the VPI and internet use (Figure 3) by means of interpolation, knowing that the Internet use of Tanzania predicted for 2003 is outside the range of Internet use data for the European counties as provided in the report of EFILWC (2006). Unfortunately, there are no other reliable approaches to estimate the VPI.

The inexorable rise in demand for water to grow food, supply industries, and sustain urban and rural populations has led to a growing scarcity of freshwater in many parts of the world. This places considerable importance on the accuracy of indicators used to characterize and map water scarcity worldwide, which are currently not optimally addressed in the city blueprint approach (Hoekstra & Mekonnen 2011; Hoekstra *et al.* 2012). On the other hand these aspects need to be put in perspective too. First of all, city blueprints are quick scans for the evaluation of the actual situation in cities, involving all stakeholders, as a first step in the strategic planning process for SWC (Figure 2). Secondly 'It is the mark of an instructed mind to rest easy with the degree of precision which the nature of the subject permits and not to seek an exactness where only an approximation of truth is possible' (Aristotle, quoted in Van Leeuwen 2007). The conclusion is that these developments leading to more accurate predictions on water scarcity, need to be included in our future work on city blueprints, once the data are available.

The difference between Rotterdam (Figure 4) and Dar es Salaam (Figure 5) is striking. Water self-sufficiency in Tanzania is high compared with the Netherlands, but awareness, public participation, and ambitions in the areas of drinking water and sanitation seem to be low. This is also reflected in the African green city index (2011), where Dar es Salaam ranks well below the average overall in the African cities. According to Songo (2002), the city receives inadequate water supply from Ruvu river to meet only about 48% of the daily demand and it has been experiencing a chronic water shortage since the beginning of the 1980s. About 50% of the demand is obtained from groundwater sources through public and private boreholes, shallow wells and open hand dug wells, all drilled within the urban zone (Songo 2002). Many residents drink water of dubious quality from several of these wells (Napacho & Manyele 2010).Without a plan or strategy to improve the city's environmental affairs, the majority of city inhabitants are unlikely to see a rise in their environmental living standards (African green city index 2011) and this is why Tanzania is one of the focal points of UNEP in areas of drinking water, chemicals and pesticides, and water pollution (URL2; Van Leeuwen 2012). Recently, the Tanzanian government has established an action plan for Dar es Salaam to improve the access to safe drinking water.

Transforming cities to become water aware will require a major social and technical overhaul of conventional approaches (Brown *et al*. 2009). Fleming (2008) made this very clear: 'Ultimately the design, function and sustainability of cities are a function of aspiration, imagination and choice, which is why sustainability is more a socio-political than an environmental issue. We will get what we will choose as a society, whether through passive inaction or proactive design.' The city of Hamburg is a good example of a city who has put this into practice (Fiedler 2011; German green city index 2012).

Floods, water scarcity and droughts have enormous environmental, social and economic impacts. Insufficient water quality levels pose threats for public health and biodiversity and the supply of safe drinking water and sanitation still poses problems, both within Europe and outside. To sustainably manage the increasing pressures on water resources, new and innovative approaches are needed (European Commission 2012). This is why we are currently assessing city blueprints of several European cities. From a methodological point of view these case studies are needed to arrive at a more definitive set of indicators, where the challenge will be to strike a balance between what we need and the data that is available. From a science-policy point of view it is essential to demonstrate that quick scans of the SWC of European cities are doable and can contribute to more sustainable urban water cycles. Awareness of these challenges, the involvement of the civil society (European green city index 2009), and the focus on cities (Figure 1), particularly in developing countries (African green city index 2011), is essential to address the global challenges that were recently discussed and reported by e.g. the European Commission (2011, 2012), EEA (2010) and UNEP (2007).

CONCLUSIONS

- The city blueprint is an interactive multi-stakeholder method and process. It can be used as a first step or quick-scan to benchmark the sustainability of the urban water cycle and facilitates awareness and receptiveness to the current water challenges.
- The city blueprint process can play a role in our work on cities of the future, i.e. in creating the capacity to accommodate the growing water-related needs of cities in the context of fixed or diminished resources and competition for water between food, cities, energy and industry.
- City Blueprints may help: (1) to communicate a city's SWC performance and exchange experiences, (2) to select appropriate water supply and sanitation strategies, and (3) to develop technological and non-technological options as future alternatives for the water cycle.
- City blueprints are a snapshot and can be made in a couple of days. The obvious limitation is that the assessment is static and not dynamic. For instance in the case of Dar es Salaam we were informed about the need for Dar es Salaam to provide more drinking water in the very near future, as the population is expected to double in size in the next decade. This information has not been included in the calculations but has been provided as additional information in this publication.
- In some cases, simplifications and assumptions have been made to quantify the indicators. This should be borne in mind when critically evaluating the results. However, the process of comparing cities and highlighting best practices in cities, is the ultimate goal as communication with all stakeholders, public participation and implementation are what matters (Brown 2009; European green city index, 2009; Van Leeuwen *et al*. 2012).
- Further case studies on cities are needed to implement and test the approach in practice by following the 'learning by doing' approach. This will require a clear questionnaire and an expert panel process as used for the European green city index (2009). This has been done and a total of 13 cities have now been assessed in a European research project TRUST (Transitions to the Urban Water Services of Tomorrow).

- The focus on cities is essential to address the water-related challenges as recently published by the European Commission (2011, 2012), EEA (2010) and UNEP (2007).

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