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EIP Water. City Blueprints® of 30 cities and regions.

KWR Watercycle Research Institute

EIP Water. City Blueprints® of 30 cities and regions. Interim report June 2014

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EIP Water. City Blueprints® of 30 cities and regions.

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Summary

Cities are centres of creativity and innovation and the drivers of our economies (Dobbs, 2011 and 2012). Smart cities are water wise cities that take sustainability into account (European Commission, 2013, Van Leeuwen, 2014). Megatrends, e.g. population growth, urbanization, water use, water scarcity and flooding as a consequence of climate change, as well as water pollution, pose urgent water challenges in cities (Van Leeuwen, 2013; Figure 1). This interim report presents City Blueprints, i.e., baseline assessments of the sustainability of Urban Water Cycle Services (UWCS) for 30 cities and regions in 22 different countries, mainly in Europe. The assessments may differ slightly from previous publications because better and/or more recent data/information has been used. This is true for the cities Amsterdam, Dar es Salaam, Hamburg, Manresa, Malmö as well as Malta. New cities that have been included are: Belém (Brazil), Berlin (Germany), Bologna (Italy), Copenhagen (Denmark) and Eindhoven (Netherlands). The calculations have been performed for 30 cities/regions. The City of Pisa is included in the report, but excluded from the calculations as too many data are missing. Potential new cities to be included at a later stage are Fez (Morocco), Barcelona (Spain) and Bethlehem (Palestine).

The City Blueprint® methodology has been developed as part of the institutional research of KWR Watercycle Research Institute in the context of Watershare®: sharing knowledge in the water sector (http://www.kwrwater.nl/watershare/). The methodology has been applied in the EU Research Project TRUST (http://www.trusti.net/) and has further been elaborated as contribution to the European Innovation Partnership on water (EIP Water), as part of the City Blueprint Action Group: http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions. In fact, much of the work has been done by colleagues in the cities who completed the City Blueprint questionnaires for the baseline assessment of their cities and regions.

Recently, the World Economic Forum (2014) 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. Safety is another issue and many cities are at risk (UN, 2012). The present City Blueprint interim report shows this for a number of cities and also confirms the findings of a previous publication for 11 cities. Cities vary considerably with regard to the sustainability of the UWCS (Van Leeuwen, 2013). The variability has been captured in the Blue City Index® (BCI), the arithmetic mean of 24 indicators comprising the City Blueprint with a theoretical minimum score of 0 and a maximum score of 10. The indicators have been subdivided into eight broad categories, i.e. (1) water security, (2) water quality, (3) drinking water, (4) sanitation, (5) infrastructure, (6) climate robustness, (7) biodiversity and attractiveness and (8) governance. The BCI varied from 3.5 to 8.0.

Cities with BCIs greater than 7.5 are: Amsterdam (8.0), Berlin (7.8), Hamburg (7.6) and Malmö (7.6). Cities with BCI values lower than 5 are: Kilamba Kiaxi (Angola; 3.5), Belém (Brazil; 3,6) and Dar es Salaam (Tanzania; 4.1). Although correlation coefficients (r) are no cause-effect relationships, cities with the best BCI are cities:

- With an active civil society expressed as Voluntary Participation Index (EFILWC, 2006; r=0.65, n=30)
- With high UWCS commitments (r=0.85, n=30)
- In countries with a high Gross Domestic Product (r=0.82, n=30)
- In counties with a high Governance Effectiveness (World Bank, 2012; r=0.84, n=30)

The most important result from this study is that the variability in sustainability among the UWCS of the cities offers excellent opportunities for short-term and long-term improvements, provided that cities share their best practices (Table 5 and Figure 15). Cities can learn from each other! The reports of the different cities and regions are presented in Annex 3 of this report at: http://www.kwrwater.nl/watershare/city-blueprint.aspx?id=7572. The main challenge now is to set up a Blue or Smart City network, to collaborate and to translate the baseline assessments into long-term programmes with actions to improve the UWCS of cities in order to address the water challenges ahead of us. This report shows that even cities that currently perform well, can still improve their UWCS. Of course, this would depend on many other factors, such as socio-economic and political considerations, and is ultimately the responsibility of the cities themselves.

Overview

This interim report is an update from a previous EIP Water report and has the following structure:

Chapter 1 provides the introduction to urban water cycle management.

Chapter 2 provides the scope, method, the data sources and the process of assessing the sustainability of UWCS.

Chapter 3 describes the results. It puts cities in their regional and/or national context and describes in more detail indicators for which it has not been easy to obtain adequate local information, i.e. water scarcity, surface water quality, biodiversity and groundwater quality and voluntary participation. For this information it was necessary to obtain regional or national data.

The main part of the report is Annex 3 in which the information is presented based on the completed questionnaires from the cities and regions involved and regional/national information provided in public sources. In Annex 3 maximum use has been made from the information provided in previous reports (Van Leeuwen and Marques, 2013; van Leeuwen, 2013). The assessments provided in Annex 3 may differ slightly from previous publications because other, more recent data or information has been used. The formats of the reports of the cities and regions as presented in Annex 3 differ as some reports are based on detailed analysis of the UWCS (e.g. Melbourne), a combination of questions from the TRUST and City Blueprint questionnaires, or quick scans based on the City Blueprint questionnaire only.

The discussion is provided in Chapter 4, whereas the main conclusions are presented in Chapter 5.The discussion is provided in Chapter 4, whereas the main conclusions are presented in Chapter 5.

Acknowledgements

We would like to thank all collaborative teams (see table below) involved the assessment of their cities and regions by completing the TRUST or City Blueprint questionnaire for the baseline assessment of the sustainability of UWCS. (Annexes 1 and 2). We would also like to thank our sponsors. This work has been carried out as institutional research of KWR Watercycle Research Institute in the context of Watershare®: sharing knowledge in the water sector (http://www.kwrwater.nl/watershare/) and has been sponsored by the Dutch drinking water industry (VEWIN). The City Blueprint methodology has been applied in the EU Research Project TRUST (Transitions to the Urban Water Services of Tomorrow; http://www.trusti.net/) and has further been applied in the context of the TKI Research Programme in the Netherlands (sponsored by Siemens, Brabant Water and Witteveen en Bos, the Netherlands). Within the TKI project, the City Blueprint has been extended by Witteveen en Bos (Elisabeth Ruigrok and Rob Nieuwkamer) with a societal cost benefit analysis. This was applied for the cities Amsterdam and Eindhoven (The Netherlands), and has been reported separately in May 2014. This interim report summarizes all the work done so far as contribution to the European Innovation partnership on water (EIP Water), as part of the City Blueprint Action Group: http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions.

Collaborative teams:

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Contents

1 Introduction

The economic power of cities is enormous (Dobbs et al., 2011 and 2012). Smart cities (European Commission, 2013) should be water wise as the cost of water infrastructures is enormous and exceeds all other infrastructures (UNEP, 2013). It is estimated that a total of US$41 trillion is required to refurbish the old (in mainly developed country cities) and build new (mainly in the developing country cities) urban infrastructures over the period between 2005 and 2030. Over 50 per cent (US$22.6 trillion) would be required for water systems, US$9 trillion for energy, US$7.8 trillion for road and rail infrastructure, and US$1.6 trillion for air- and sea-ports (UNEP, 2013). In Europe it is crucial to link the activities of the European Innovation Partnership on water (EIP Water) with the EIP on Smart Cities and Communities. The management of freshwater resources and related services is of critical importance to healthy social, economic and political well-being of a society. Stresses exerted on the world's water resources by the increasing demand from growing populations with changing consumption patterns and the destruction of water quality from pollution as a result of poor environmental management, are placing water increasingly higher on the international agenda, including that of climate change (European Commission, 2011).

Effective water resource management and developments impacting on water resources are recognised as key components of environmentally sustainable development. The negative consequences of poor water resource management on socio-economic development are more frequently arising. This is clearly apparent in the agricultural and other water-sensitive industries. However industries where water is less evident in the supply chain, and even other sectors such as energy, are becoming increasingly aware of the risks and consequences associated with a potentially unreliable water resource (UNEP, 2007; 2030 Water Resources Group, 2009; African green city index, 2011).

The European Union (EU), through the European Commission (EC) and the EU Member States, has made a significant contribution to the international debate on the impending world water crisis and the measures needed to address it. Their support has contributed to efforts at the international level with other state actors, through the UN system and in inter-ministerial councils, to promote new initiatives in water resource management (e.g. European Commission, 2011; European Commission, 2012a). The Blueprint to Safeguard Europe's Water (European Commission, 2012b) 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 (Figure 1; European green city index, 2009; Engel *et al.*, 2011).

Changes in urbanization, 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, water distribution and water treatment (UN, 2012; Ernstson *et al.*, 2010; Charlesworth, 2010; Cohen, 2007; Brown, 2009; Deltares, 2009) ask for a thorough understanding of the various possibilities to build towards a sustainable water cycle. 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 non-renewable resources, climate change, safety (adaptation strategies related to flooding and water scarcity), biodiversity, green space, recreation, human and environmental health, public participation, compliance to (future) legislation, transparency, accountability and costs (Frijns *et al.*, 2009; Verstraete *et al.*, 2009).

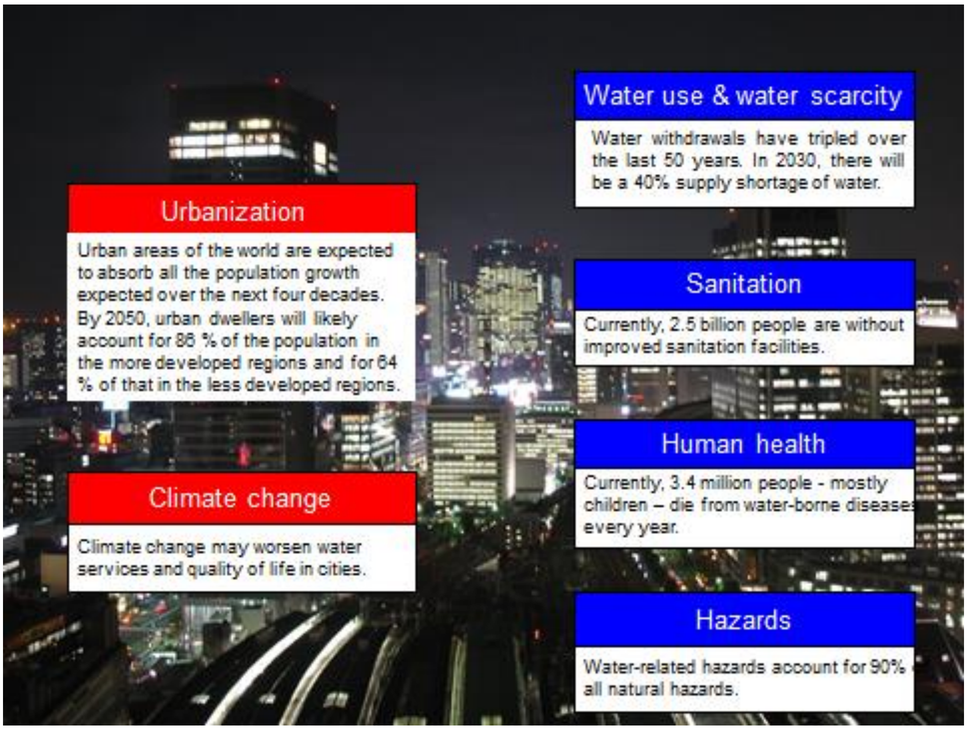


Figure 1. Megatrends pose urgent challenges in cities (Van Leeuwen, 2013).

The main objective of the City Blueprint action under the EIP Water is to support regions, cities, water authorities and utilities in Europe in formulating and implementing appropriate urban water governance actions in order to enhance urban water cycle services. We aim to deliver knowledge to support urban water cycle services (UWCS) towards a sustainable and low-carbon water future without jeopardising service quality. We hope to do this through research that drives innovations in governance, modelling concepts, technologies, decision support tools, and novel approaches to integrated water, energy, and infrastructure asset management. There is no single or clear pathway for the adoption of sustainable practices for water utilities, cities, or any other organization involved in UWCS. Cities are the main problem holders and also need to play a key role in defining long-term goals and action plans for sustainable UWCS. In the context of this action it has been decided to obtain data from contact persons in cities and regions in order to enable a quick scan of the sustainability of UWCS. The quick scan is a baseline assessment which:

- Provides stakeholders in cities and regions with a basic insight in the current status of the sustainability of their UWCS;
- Enables stakeholders to internally reflect upon the current status in terms of possible consequences for future UWCS management;
- Enables stakeholders to share the results with other colleagues, to discuss potential improvements and to learn from each other's experiences.

2 Materials and methods

2.1 Cities and regions

In this report the following cities, regions and countries are included: Algarve (ALG, Portugal), Amsterdam (AMS, Netherlands), Ankara (ANK, Turkey), Athens, (ATH, Greece), Belém (BEL, Brazil), Berlin (BER, Germany), Bologna (BOL, Italy), Bucharest (BUC, Romania), (Copenhagen (COP, Denmark), Dar es Salaam (DAR, Tanzania), Eindhoven (EIN, Netherlands), Genova (GEN, Italy), Hamburg (HAM, Germany), Ho Chi Minh City (HCM, Vietnam), Istanbul (IST, Turkey), Jerusalem (JER, Israel), Kilamba Kiaxi (KIL, Angola), Lyon (LYO, France), Maastricht (MST, Netherlands), Malmö (MLM, Sweden), Malta (MLT, Malta), Manresa (MAN, Spain), Melbourne (MEL, Australia), Oslo (OSL, Norway), Pisa (PIS, Italy), Reggio Emilia (REG, Italy), Reykjavic (REY, Iceland), Rotterdam (ROT, Netherlands), Scotland (SCO, United Kingdom), Venlo (VNL, Netherlands), Zaragoza (ZAR, Spain).

2.2 Scope of the analysis

Urban water management is complex. It has a wide scope and many stakeholders are involved. Therefore, the baseline assessment of cities and regions 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. Sustainability assessment of urban water cycle services includes the main dimensions of social, environmental, economic and the supporting dimensions of assets and governance sustainability (Table 1).

Table 1. Objectives and assessment criteria of the UWCS sustainability dimensions (Van Leeuwen and Marques, 2013).

Dimension	Objectives	Assessment criteria
Social	S1) Access to urban water services S2) Effectively satisfy the current users' needs and expectations S3) Acceptance and awareness of UWCS	S11) Service coverage S21) Quality of service S22) Safety and health S31) Willingness to pay
Environment	En1) Efficient use of water, energy and materials En2) Minimisation of other environmental impacts	En11) Efficiency in the use of water (including final uses) En12) Efficiency in the use of energy En13) Efficiency in the use of materials En21) Environmental efficiency (resource exploitation and life cycle emissions to water, air and soil)
Economic	Ec1) Ensure economic sustainability of the UWCS	Ec11) Cost recovery and reinvestment in UWCS (incl. cost financing) Ec12) Economic efficiency

		Ec13) Leverage (degree of indebtedness) Ec14) Affordability
Governance	G1) Public participation G2) Transparency and accountability G3) Clearness, steadiness and measurability of the UWCS policies G4) Alignment of city, corporate and water resources planning	G11) Participation initiatives G21) Availability of information and public disclosure G22) Availability of mechanisms of accountability G31) Clearness, steadiness, ambitiousness and measurability of policies G41) Degree of alignment of city, corporate and water resources planning
Assets	A1) Infrastructure reliability, adequacy and resilience A2) Human capital A3) Information and knowledge management	A11) Adequacy of the rehabilitation rate A12) Reliability and failures A13) Adequate infrastructural capacity A14) Adaptability to changes (e.g. climate change Adaptation) A21) Adequacy of training, capacity building and knowledge transfer A31) Quality of the information and of the knowledge management system

These criteria were developed in TRUST (Van Leeuwen and Marques, 2013). The 24 indicators for the City Blueprints have been selected based on a literature study that covered scientific publications, a variety of national and international policy documents on several approaches to assess the sustainability of UWCS, i.e., water footprints (Hoekstra and Chapagain, 2007; Mekonnen and Hoekstra, 2011), urban metabolism (e.g. Barles, 2010), ecosystem services (e.g. Costanza *et al.*, 2002), and indicator-approaches (e.g. Van de Kerk and Manuel, 2008; European green city index, 2009). Details are provided in Annex 1 and several publications (Van Leeuwen *et al.*, 2012; Van Leeuwen and Chandy, 2013; Van Leeuwen, 2013).

2.3 Requirements

The following requirements were established for the calculation of the City Blueprint:

- Scope: the baseline assessment should comprise: water security, water quality, drinking water, sanitation, infrastructure, climate robustness, biodiversity and attractiveness, as well as governance.
- Data availability: data must be easily obtainable.
- Approach: a quantitative approach is the preferred option in which expert panel scores can also be included.

- Scale: indicators 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).

- Simplicity: calculations and scoring of the indicator values need to be relatively easy.

- 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.

- Workability: data collection, further selection, calculations and graphical representation of the results need to be doable, i.e. to be completed in about 3 days.

2.4 Data and calculations

Detailed information about the methodology, sources of information and calculations for each of the 24 indicators are provided in previous publications (Van Leeuwen *et al*., 2012; Van Leeuwen and Chandy, 2013; Van Leeuwen, 2013) and Annex 1. A summary is provided in Figure 2. In this report, the lack of city-specific information forced us to use regional or national sources of information. This was particularly relevant for information related to surface water quality, groundwater quality and biodiversity of aquatic ecosystems. Furthermore, Indicator 12 (Annex 1) focuses on the percentage of total sewage sludge that is recycled (thermally processed or applied in agriculture) and indicator 16 reflects the average age of the infrastructure for wastewater collection and distribution. This is a rough estimate as maintenance of sewer systems is dependent amongst other things on the soil type, the pipe construction materials, the soil type, pipe depth, pipe thickness and bedding conditions (Ugarelli *et al*., 2009). Furthermore indicator 19 covers climate change adaptation strategies, or in short: “adaptation strategies”.

The requirements of scale and comprehensibility necessitated the transformation of the original data (Van Leeuwen *et al*., 2012 and Van Leeuwen and Chandy, 2012). For instance, the total water footprint of the Netherlands is 1466 m^3/yr/cap and slightly above the world average of 1385 m^3/yr/cap (Mekonnen and 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 (3519 m^3/yr/cap) as maximum value, respectively. These data are provided in Appendix VII of Mekonnen and Hoekstra (2011). The value for the Netherlands thus becomes (1466-552)/3519-552) = 0.308. In order to transform this into a ‘concern score’ on a scale of 0-10, we arrived at a score of (1-0.308) x 10 = 6.92 for the Netherlands. In other words, based on the information provided by Mekkonnen and Hoekstra (2011), the total water footprint in the Netherlands is about average and this is reflected in a score of 6.9.

The voluntary participation index (by country), was not available for the cities outside the European Union (EFILWC, 2006). Therefore only estimates for these countries could be provided. These estimates were obtained from the relation between the internet use in 2003 (%) and the voluntary participation index (VPI) in 2004 (EFILWC, 2006) as described in Van Leeuwen and Chandy (2012) and Chapter 3 of this report.

If, despite the attempts of the partners in the cities and regions, the search for local, regional or national data in public sources, no input data could be provided for the calculations of the indicator values, estimates based on expert judgements or ‘educated guesstimates’ have been used.

The formats of the reports of the cities and regions as presented in Annex 3 differ as some reports are based on detailed analysis of the UWCS (e.g. Melbourne), a combination of questions from the TRUST (Transitions to the Urban Water Services of Tomorrow) and City Blueprint questionnaires, or quick scans based on the City Blueprint questionnaire only.

Goal	**Baseline assessment** of the sustainability of UWCS of cities
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 UWCS
Scores	0 (concern) to 10 (no concern) **(Blue is good)**
BCI	Arithmetic mean of 24 indicators which varies from 0 to 10 **(in parentheses)**
Stakeholders	Water utility, waste water utility, water board, city council, NGOs
Process	Interactive with all stakeholders involved early on in the process

Figure 2. Summary of the City Blueprint assessment methodology and process.

2.5 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 (Appendix 1) in an interactive manner. This interactive multi-stakeholder approach to problem formulation (Van Leeuwen, 2007), assessment and evaluation of UWCS as applied for the cities of Venlo and Maastricht (Van Leeuwen and Frijns, 2012; Van Leeuwen *et al*., 2012) was much more effective, as it underlined the connectivity between the technical, economic and socio-political processes (Godden *et al*., 2011; Ison *et al*., 2011; Van Leeuwen and Chandy, 2012). Therefore, this interactive approach has been used for almost all cities.

3 Results

3.1 The context of cities and regions

The goods-and-services that cause the highest environmental impacts through their life cycles have been identified as housing, food and mobility (UNEP, 2007). For food and beverages, the majority of environmental impacts are related to agricultural or industrial production activities. Agriculture accounts for more than 70 percent of global water use. This, together with land degradation, decreases agricultural productivity, resulting in lower incomes and reduced food security. Freshwater bodies have a limited capacity to process the pollutant charges of the effluents from expanding urban, industrial and agricultural uses. Water quality degradation can be a major cause of water scarcity. Excessive use of nutrients and pesticides in agriculture may harm the hydrologic system because runoff cannot be filtered or slowed down before being distributed into other bodies of water. As a result, the amount of water that infiltrates is decreased and the amount of storm water runoff increases. This then creates more problems such as erosion, flooding, and destruction of habitat. Water security and environmental quality (Figure 3) are among the important factors that provide the context of cities and regions related to UWCS.

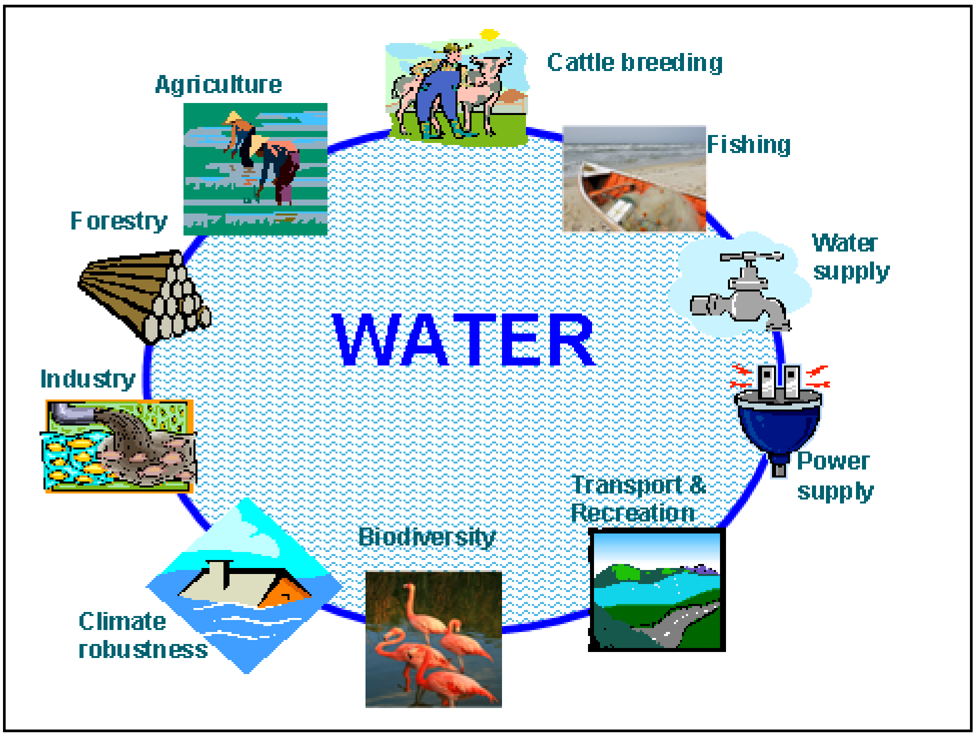


Figure 3. Urban water cycle services demonstrate that competing needs for water lead to trade-offs in practice (Van Leeuwen et al., 2012).

This is the reason why information was gathered on water scarcity, surface water quality, biodiversity of surface water and (shallow) groundwater quality. As voluntary participation of the civil society is crucial for the sustainability of cities (European green city index, 2009), this and the other aspects will be described in more detail below.

Water scarcity

Water scarcity has been addressed in many policy papers of the United nations (UN), the Food and Agricultural Organization (FAO), the European Commission and reports from industry and the European Environment Agency (EEA). There are a variety of methods to illustrate water scarcity and water exploitation. The EEA has used the water exploitation index (WEI), which is the annual total water abstraction as a percentage of available long-term freshwater resources (Figure 4). The warning threshold, which distinguishes a non-stressed area from a water scarce region, is around 20 %, with severe scarcity occurring where the WEI exceeds 40 %. However, this indicator does not fully reflect the level of stress upon local water resources: this is primarily because the WEI is based on annual data and cannot, therefore, account for seasonal variations in water availability and abstraction.

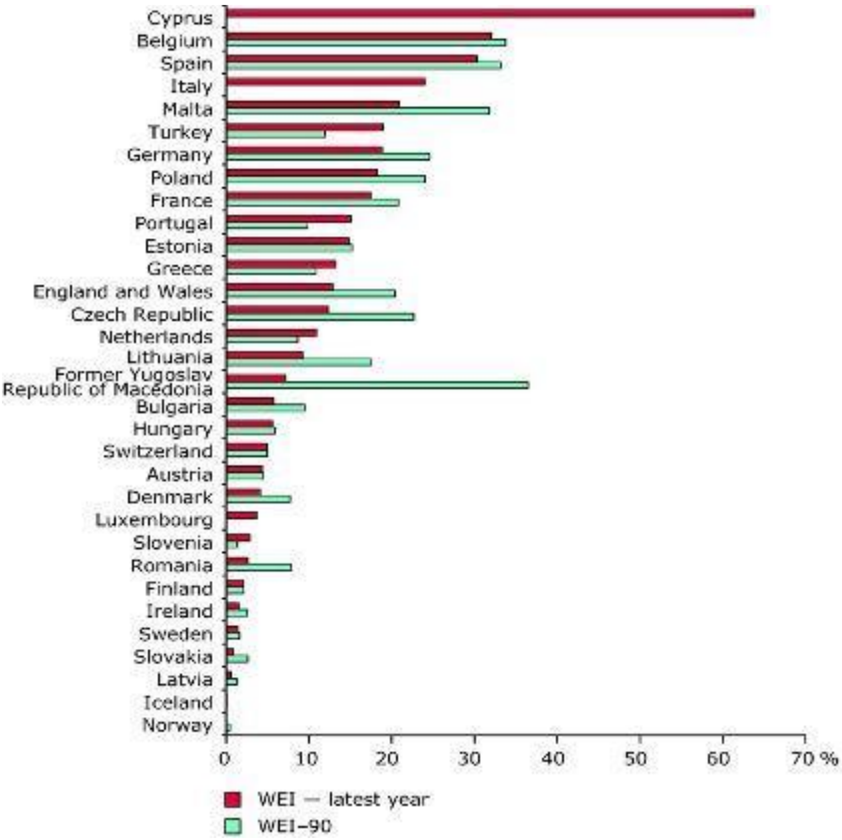


Figure 4. The water exploitation index (WEI) according to the EEA (2011).

Similar information is provided in the Aquastat database of FAO (2012). The FAO Aquastat database provides the total freshwater withdrawal as percentage of the actual renewable water resources (ARWR) per country as indicator for the pressure on water resources. For Germany, Italy and Spain these values are relatively high, respectively 21, 23.7 and 29 % (Figure 4).

The Water Footprint Network (WFN, 2012) provides water statistics for nations. The water footprint of a nation is defined as the total amount of water that is used to produce the goods and services consumed by the inhabitants of the nation. Since not all goods consumed in one particular country are produced in that country, the water footprint consists of two components: (1) The internal water footprint, i.e. the water use inside the country, and (2) The external water footprint, i.e. the water use in other countries. The traditional water-use statistics show the water supply per sector (domestic, agriculture, industry). The approach has always been supply and producer oriented. The water footprint concept has been introduced to have a demand and consumer oriented indicator as well, including not only the water used within the country but also the virtual water import. The nature of the WFN approach is totally different from the traditional water statistics as provided by FAO. In the analysis of cities and regions we have used both approaches, i.e. the information from WFN (Indicators 1-3 in Annex 1b) as well as the information from the FAO Aquastat database (see Annex 3).

Another approach may be to look at the number of months during the year in which the blue water footprint exceeds blue water availability for the world's major river basins, based on the period of 1996-2005 (Hoekstra *et al.*, 2012):

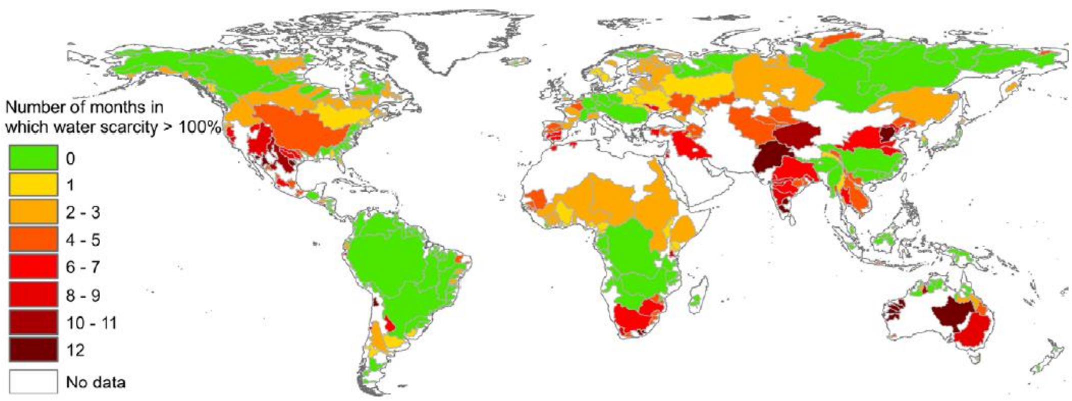


Figure 5. Number of months during the year in which the blue water footprint exceeds blue water availability for the world's major river basins, based on the period of 1996–2005. Blue water availability refers to natural flows (through rivers and groundwater) minus the presumed environmental flow requirement (Source: Hoekstra et al., 2012).

Surface water quality

Many different physical, chemical, and biological parameters can be used to measure water quality. Unfortunately, this information is neither easily accessible nor available for most countries. The 2010 Environmental Performance Index (EPI) Water Quality Index (WQI) uses three parameters measuring nutrient levels (dissolved oxygen, total nitrogen, and total phosphorus) and two parameters measuring water chemistry (pH and conductivity). These parameters were selected because they cover issues of global relevance (eutrophication, nutrient pollution, acidification, and salinization) and because they are the most consistently reported. The data were taken from the United Nations Global Environmental Monitoring System (GEMS) Water Programme, which maintains the only global database of water quality for inland waters, and the European Environment Agency's Waterbase, which has better European coverage than GEMS. These national data were used as input for the calculation of the scores for surface water quality (indicator 4 of the City Blueprint; Annexes 1 and 2).

Biodiversity of surface water

The decline in the quantity and quality of surface water is impacting aquatic ecosystems and their services. Based on the very limited responses on the questionnaires for biodiversity it was decided to use information collected by the EEA for the assessment of the biodiversity of fresh surface waters. This is basically information summarized at the regional level (Figure 6). Based on Figure 5, the following scoring was applied: >90% = score 1; 70-90 % score 2; 50-70% score 4; 30-50% score 6; 10-30% score 8; <10% score 10; No information was available for Oslo, but an expert judgement estimate of 6 has been given. The scores for cities in other countries have been obtained from the information on effects on ecosystems from the environmental performance index (2010).

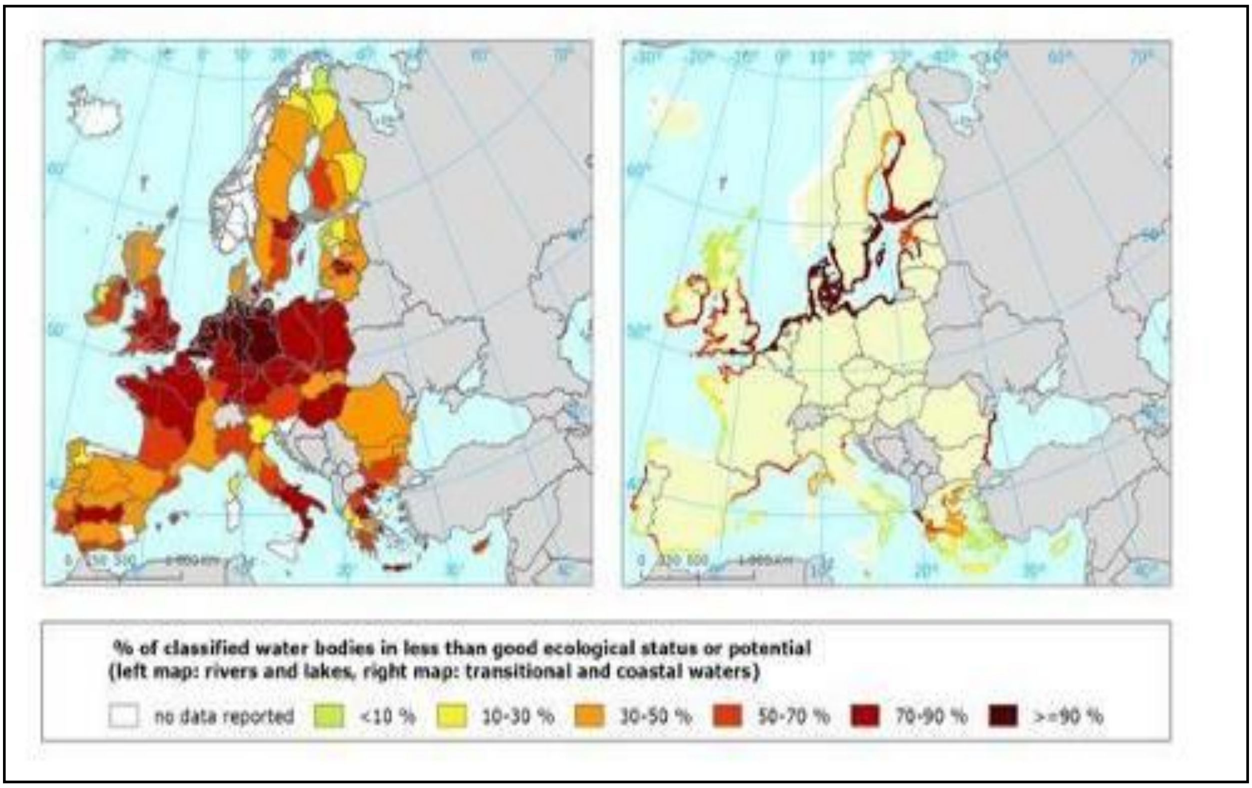


Figure 6. Ecological status of water bodies in Europe according to the European Environment Agency (EEA).

Groundwater quality

The similar lack of information provided in the responses on the questionnaires also necessitated the use of information collected by the EEA for the assessment of the shallow groundwater based on the data provided in their Water Framework Directive (WFD) groundwater viewer:
http://www.eea.europa.eu/themes/water/interactive/soe-wfd/wfd-ground-water-viewer

Governance and voluntary participation

According to the Dutch water sector (http://www.dutchwatersector.com/web/governance), good management of water resources- universally identified as a key aspect of poverty reduction, agriculture and food security – has proven, in practice, as difficult to achieve as it is eagerly sought. According to the UNDP (2004), "water governance encompasses the political, economic and social processes and institutions by which governments, civil society, and the private sector make decisions about how best to use, develop and manage water resources". Questions 28-35 of the TRUST questionnaire (Annex 1) encompass governance aspects. We have also added another indicator (public participation; indicator 24) and used national data for the calculation of this indicator based on the data provided by EFILWC (2006). The reason for this was the striking relation between the ranking of cities based on the European green city index (2009) and the voluntary participation index. It basically shows how important civil society is (Figure 7). People matter and this is probably also relevant for UWCS. One quote from this report summarizes it adequately: "The individual decisions of cities' inhabitants are, collectively, more powerful than their governments' ability to intervene". For most European countries the VPI has been provided in the report of EFILWC (2006), but for other countries the VPI was estimated based on the internet connectivity as presented in Figure 8.

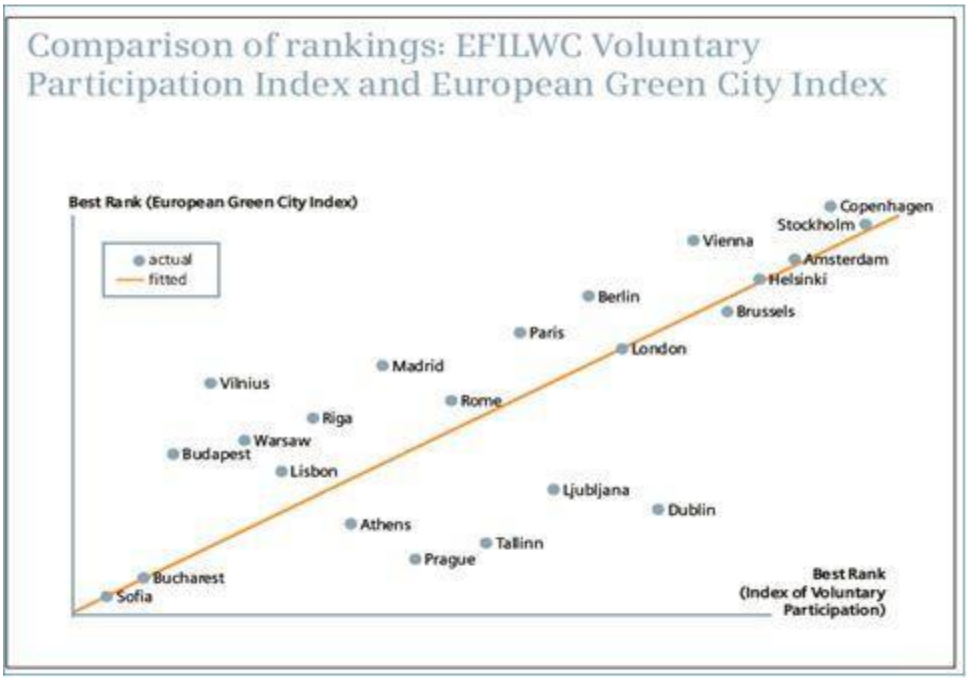


Figure 7. The relation between the index of voluntary participation (VPI) and the ranking according to the European green city index (2009).

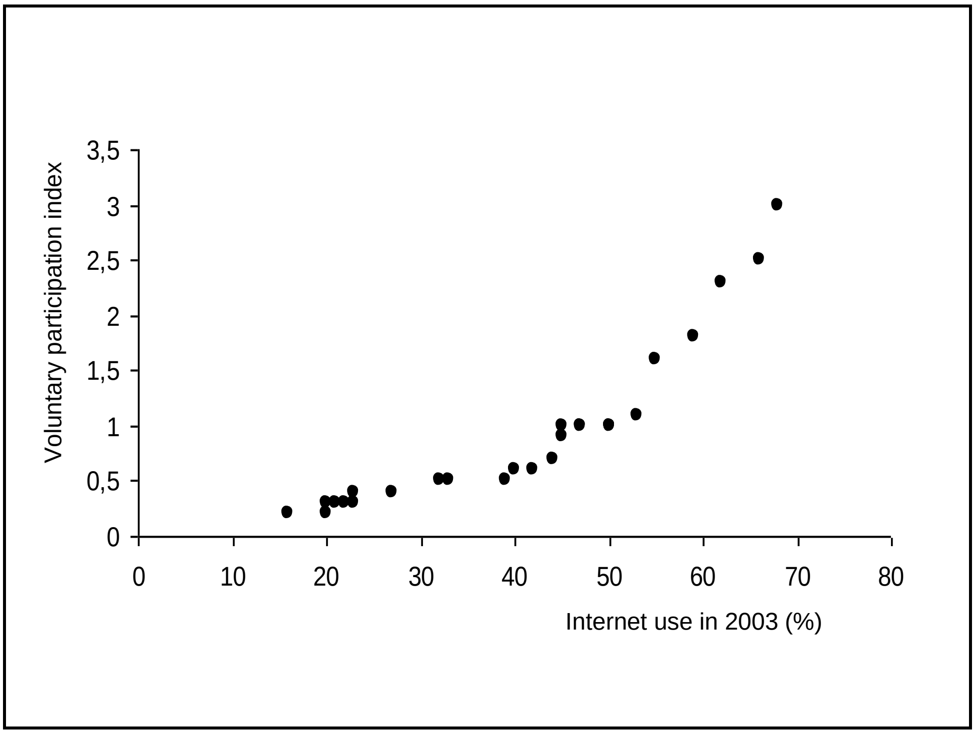


Figure 8.The relation between internet use and the VPI (Van Leeuwen and Chandy, 2012).

3.2 Comparison of UWCS of cities and regions

The information from the City Blueprint questionnaire (Annex 2) has been used to make short reports of the cities and regions. These reports of the cities and regions are presented in Annex 3.

Drinking water

Detailed information has been provided for 11 cities via the TRUST questionnaire (Annex 1) and has been adequate to score most parameters for these cities (Van Leeuwen and Marques, 2013). The most extensive evaluation was carried out for the city of Melbourne (Annex 3). In general, the water quality and population coverage for drinking water services of the European cities was excellent. Prices varied from € 0.45 (bulk water in Algarve) to €1.77 in Hamburg (excl. VAT). Drinking water consumption varied considerably. In Hamburg and Amsterdam the consumption was about 50 m^3 per person per year, whereas the consumption in Algarve was about three times higher (146 m^3 per person per year). The asset turnover ratio could not be reported for all cities and for those cities for which this information was available it varied from 0.15 (Oslo) to 3.37 (estimate for Reggio Emilia). Knowledge about acceptance of alternative water resources was absent in most cases. The mains average age for the 11 cities studied in the TRUST project (Van Leeuwen, 2013) varied from 11 (Algarve) to 55 year in Oslo and Reggio Emilio, although the latter figure is a rough estimate. The mains failures varied from 0.46 (Algarve) to 117.5 (Reggio Emilia).

Water consumption and water scarcity

As presented in the materials and methods section, different parameters can be used to describe water use and water scarcity. Some of these indicators are presented in Table 2 and Figures 4, 5 and 9. Please note that all these parameters, except drinking water consumption, are based on data for countries and not for cities.

Table 2. Indicators for water use and water stress for countries and drinking water consumption in cities/regions as reported in Van Leeuwen and Marques (2013).*

Indicator	ALG	ATH	REG	AMS	HAM	OSL	SCO	BUC	ROT	KIL	DAR
FAO-TWW per capita (m^3/year)	812	841	790	639	391	622	213	320	639	43	145
WFN-TWF of national consumption per capita (m^3/year)	2505	2338	2303	1466	1426	1423	1258	2297	1466	1589	1026
FAO-TWW as % of ARWR	12.3	12.7	23.7	11.7	21	0.77	8.82	3.25	11.7	0.43	5.38
Drinking water consumption (m^3 per capita per year)	146	106	59	50	53	124	97	58.7	45	36	68

**TWW= Total Water Withdrawal; TWF=Total Water Footprint; ARWR = Annual Renewable Water Resources.*

For the comparison of countries and cities also the water exploitation index as shown in Figure 4 is important. Another representation of the WEI is given in Figure 9.

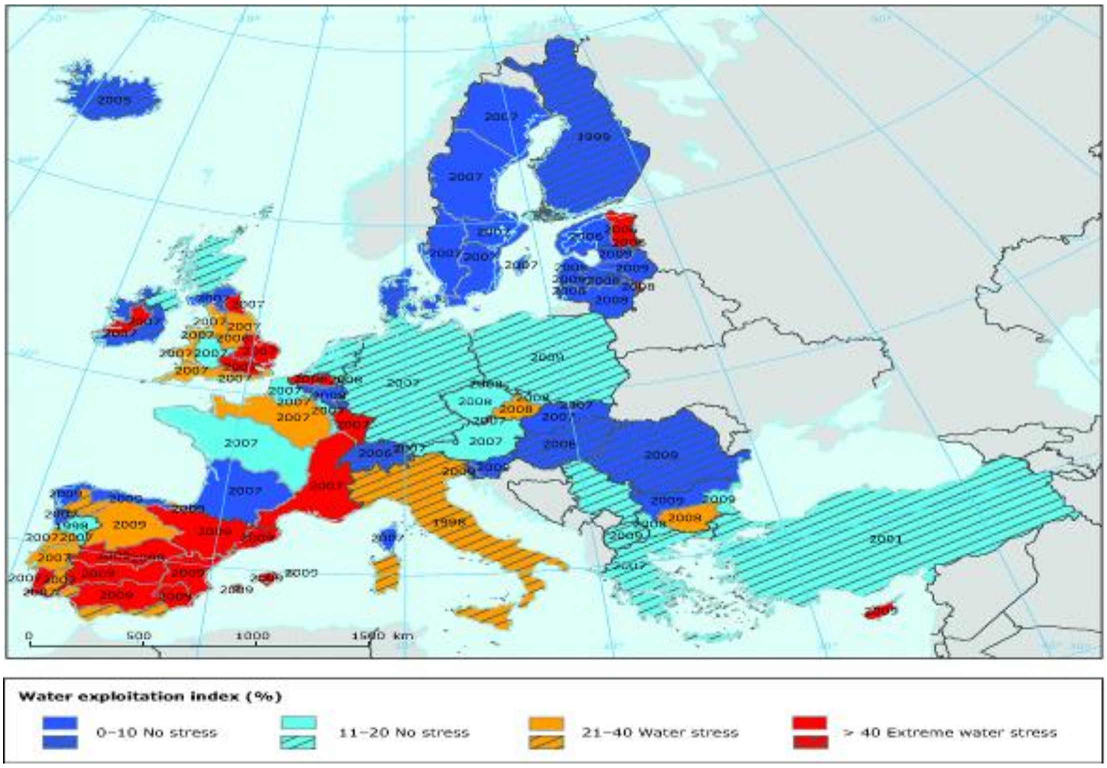


Figure 9. The water exploitation index (%) in Europe (source: EEA).

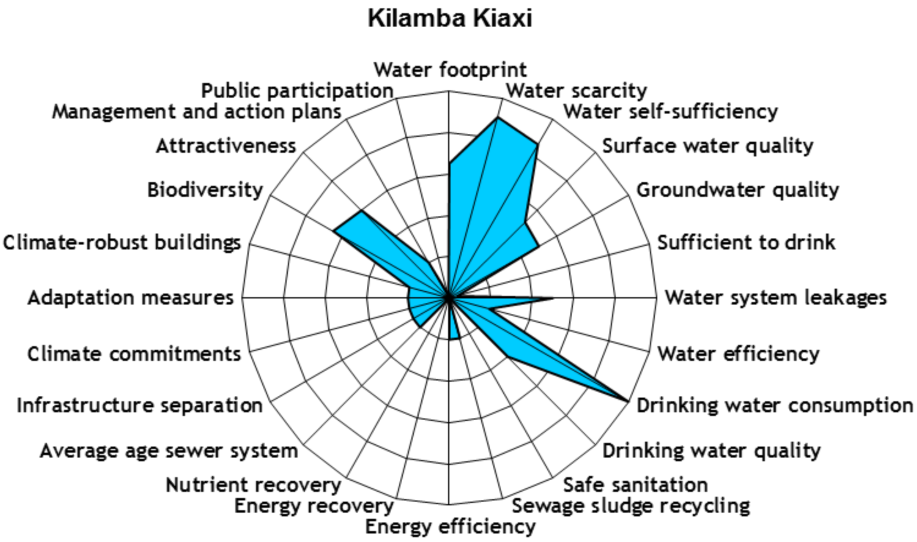
Waste water

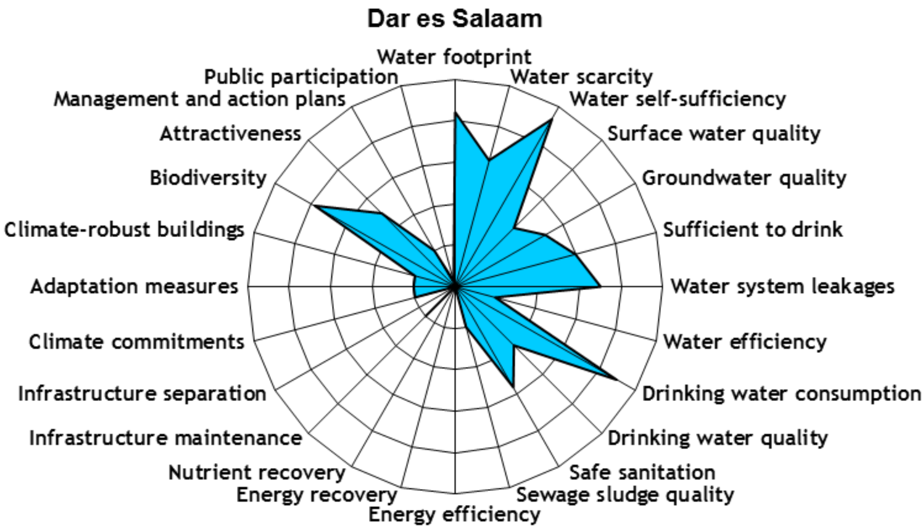
For the waste water services in Europe, the population coverage varied from 80 % (Pisa) to about 100 % for Oslo, Malmo and Malta). Waste water treatment remains a serious challenge for Dar es Salaam, Ho Chi Minh city and Kilamba Kiaxi. Most of the systems were collection, transport and treatment systems. Energy recovery from waste water takes place in all European cities except the cities in Algarve, Pisa and Bucharest. It is absent in cities in developing countries. Nutrient recovery is an exception and only takes place in Amsterdam, Lyon, Manresa, and Reggio Emilia. Unfortunately, no information is available for Scotland for both energy and nutrient recovery from waste water. Therefore, these indicators have been scored with 0. For the 11 cities studied in the TRUST project (Van Leeuwen and Marques, 2013), the total energy costs varied from € 0.7 million (covering 325,000 connections) to € 23.6 million in Scotland (covering 2,460,000 connections). The energy costs per connection varied from € 0.44 (Oslo) to € 19.6 (Athens).

Most cities process their sewage sludge thermally, but some cities in e.g. Scotland, Ankara, the city of Jerusalem, Reggio Emilia, Manresa, Genova, and the cities in Algarve, apply major volumes their sewage sludge in agriculture. In some places in Scotland and in the Algarve small fractions of the sewage sludge is going into landfill. In Bucharest, Istanbul all sewage sludge is going into landfill. The average age of the sewer system varied from 11 (Algarve) to 55 years (Oslo). The number of sewage blockages (in the 11 cities as studies in the TRUST project; Van Leeuwen and Marques, 2013) varied from 0.5 (per 100 km) in Algarve to 577 in Bucharest. The separation (lengths of sanitary and stormwater sewers divided by the total length of the sewer system, including the combined sewers) showed a large variation. It varied from 0% for Algarve to 100 % for Ankara, Jerusalem and Melbourne.

City Blueprints

A simple diagram has been made to highlight the most important features of the UWCS in cities. We have called this diagram the City Blueprint (Van Leeuwen *et al.*, 2012) in line with the European Commission's "Blueprint to Safeguard Europe's Water Resources" (European Commission, 2012b). The information of the questionnaires has been transformed into scores for 24 indicators, comprising the so-called City Blueprint (Van Leeuwen, 2013) The results for all cities and regions of TRUST are presented in Annex 3. Examples of eight cities with increasing BCI values are presented in Figure 10.





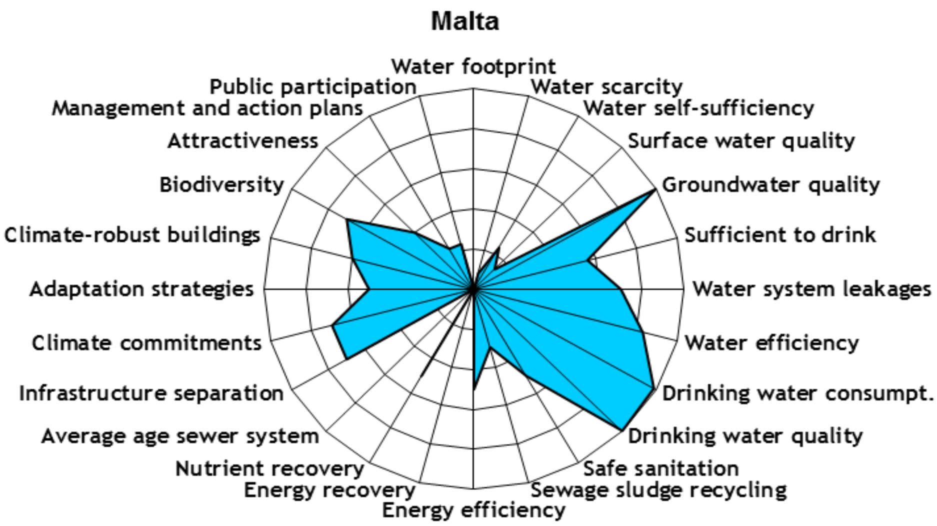
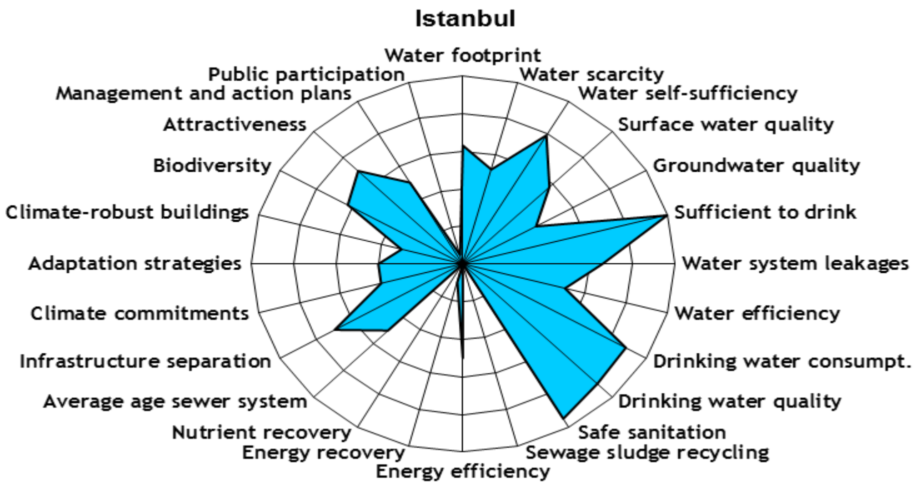
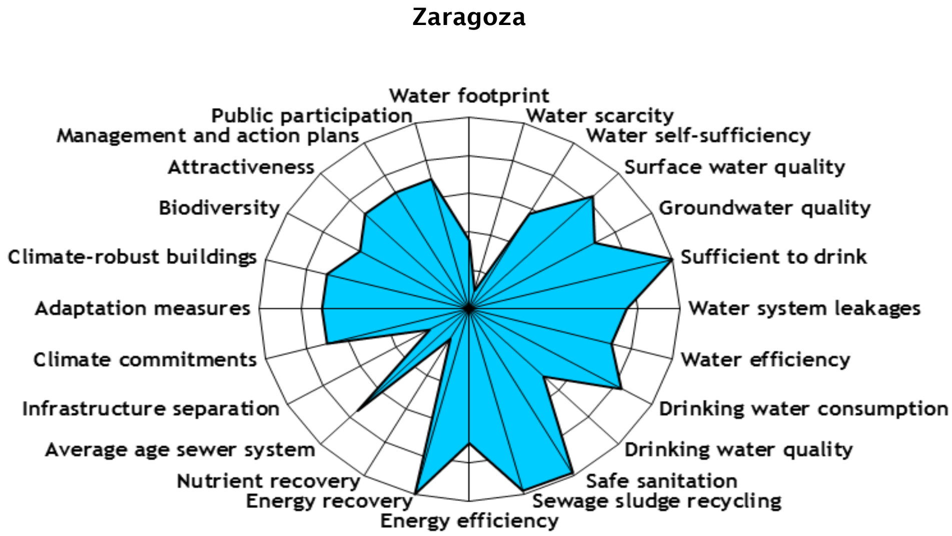


Figure 10. City Blueprints of 8 cities with increasing BCI values. Kilamba Kiaxi (BCI of 3.5), Dar Es Salaam (BCI of 4.1), Malta (BCI of 4.9), Istanbul (BCI of 5.2), Zaragoza (BCI of 6.6), Melbourne (BCI of 7.0), Malmö (BCI of 7.6) and Amsterdam (BCI of 8.0).





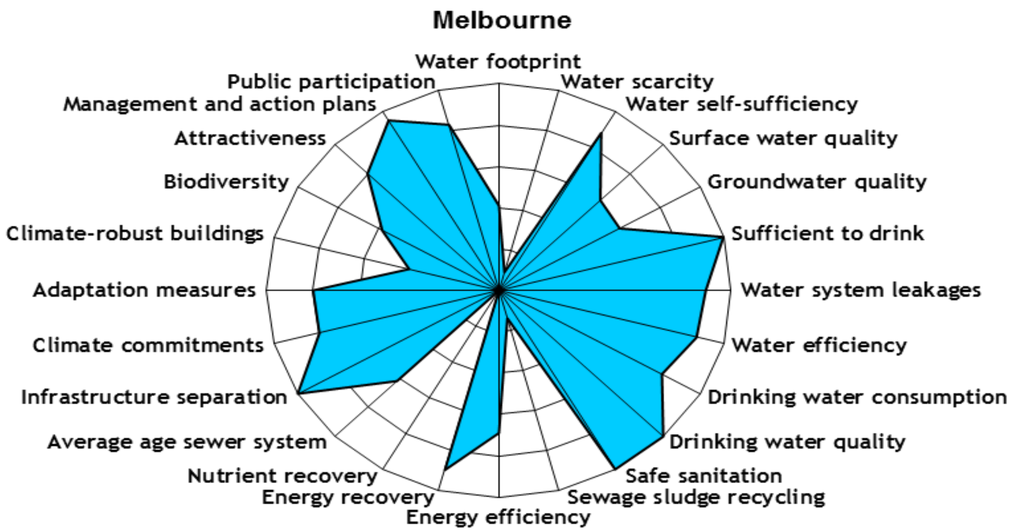
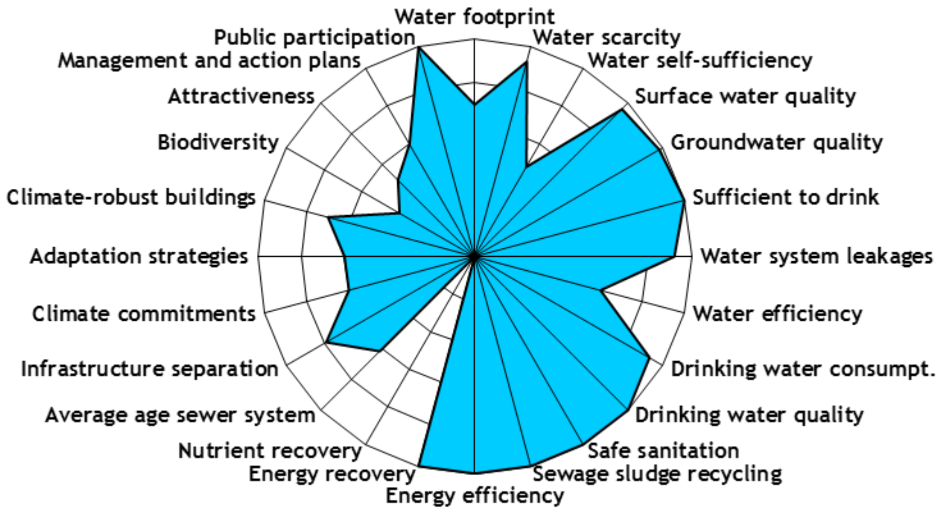


Figure 10. City Blueprints of 8 cities with increasing BCI values. Kilamba Kiaxi (BCI of 3.5), Dar Es Salaam (BCI of 4.3) Malta (BCI of 4.8), Istanbul (BCI of 5.2), Zaragoza (BCI of 6.6), Melbourne (BCI of 7.0), Malmö (BCI of 7.6) and Amsterdam (BCI of 8.0).

Malmö



Amsterdam

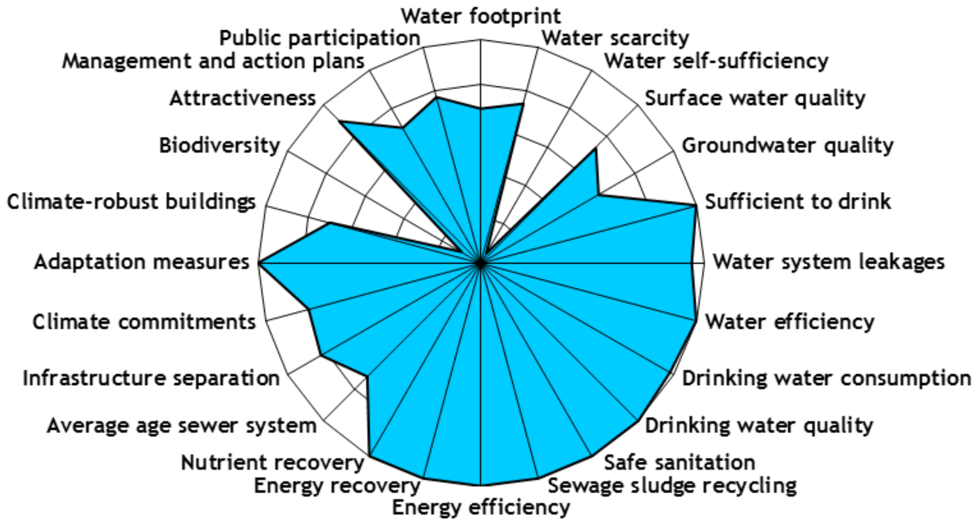


Figure 10. City Blueprints of 8 cities with increasing BCI values. Kilamba Kiaxi (BCI of 3.5), Dar Es Salaam (BCI of 4.3) Malta (BCI of 4.8), Istanbul (BCI of 5.2), Zaragoza (BCI of 6.6), Melbourne (BCI of 7.0), Malmö (BCI of 7.6) and Amsterdam (BCI of 8.0).

Blue City Index® (BCI)

The Blue City Index® (BCI) is a simple indicator for the performance of the individual cities regarding the sustainability of their urban water systems. The BCI is the arithmetic mean of the 24 indicators comprising the city blueprint. These data are given in Table 3 below, together with some other indicators such as the scores for the commitments for UWCS (indicator 23), the VPI (voluntary participation index) according to the EFILWC (2006), and the GDP per capita (in international dollars for 2012 as reported by the International Monetary Fund (IMF, 2012). Comparisons were also made with some governance indicators according to the World Bank (2012) such as the GE (government effectiveness), RQ (regulatory quality) and RL (rule of law) as described by Kaufman *et al.* (2010). The RL is a national indicator capturing perceptions of the extent to which agents have confidence in and abide by rules of society, and in particular the quality of contract enforcement, property rights, the police, the courts, as well as the likelihood of crime and violence (Kaufman *et al*., 2010).

Table 3. Summary information about the BCI, UWCS management and action plans (indicator 23) for cities and regions and various national indexes from the IMF and the World Bank. Abbreviations: see text.

City/Indicator	BCI	UWCS	VPI	GDP 2012	GE	RQ	V&A	RoL
Algarve	5,8	6,0	1,0	25958	81,3	75,6	78,2	82,5
Amsterdam	8,0	7,0	7,7	43339	96,7	96,2	97,6	97,2
Ankara	6,0	5,0	0,5	18551	65,1	65,6	40,8	56,9
Athens	6,4	5,0	1,3	26041	62,2	68,4	67,3	63,5
Belém	3,6	0,0	0,3	14551	50,2	54,6	60,7	51,7
Berlin	7,8	10,0	3,3	42700	93,3	92,3	93,4	91,9
Bologna	6,3	7,0	1,7	34926	66,0	74,6	73,9	62,1
Bucharest	5,2	6,0	0,7	18063	43,5	68,9	57,8	55,9
Copenhagen	7,0	8,0	8,3	42775	99,0	97,6	99,1	98,1
Dar es Salaam	4,1	2,0	0,3	1683	28,2	36,8	41,7	34,6
Eindhoven	6,4	7,0	7,7	43339	96,7	96,2	97,6	97,2
Genova	5,3	3,0	1,7	34926	66,0	74,6	73,9	62,1
Hamburg	7,6	10,0	3,3	42700	93,3	92,3	93,4	91,9
Ho Chi Minh City	5,4	7,0	0,3	4998	44,5	27,3	9,5	37,9
Istanbul	5,2	5,0	0,5	18551	65,1	65,6	40,8	56,9
Jerusalem	7,2	10,0	1,7	31345	86,1	85,2	65,9	77,7
Kilamba Kiaxi	3,5	2,0	0,2	7474	15,3	18,7	17,1	7,1
Lyon	7,2	7,0	3,0	36785	87,6	83,3	89,6	90,0
Maastricht	6,9	7,5	9,0	43339	96,7	96,2	97,6	97,2
Malmö	7,6	6,0	10,0	42866	98,6	99,0	99,5	99,1
Malta	4,9	4,0	2,3	28955	85,1	89,0	86,7	87,7
Manresa	6,2	6,0	1,7	32134	82,3	78,0	79,6	83,4
Melbourne	7,0	9,5	8,3	43818	94,3	97,1	96,2	94,8
Oslo	7,4	7,0	10,0	66141	98,1	71,9	100	100
Reggio Emilia	6,6	6,0	1,7	34926	66,0	74,6	73,9	62,1
Reykjavik	7,0	8,0	10,0	39097	90,0	81,3	94,8	92,4
Rotterdam	7,0	8,0	7,7	43339	96,7	96,2	97,6	97,2
Scotland	6,2	6,0	3,3	35722	91,9	94,7	92,4	92,9
Venlo	6,9	7,5	9,0	43339	96,7	96,2	97,6	97,2
Zaragoza	6,6	7,0	1,7	32134	82,3	78,0	79,6	83,4

Like in the European green city index (2009), there is a positive and significant relation ($p = \leq 0.0001$) between the performance of the cities/regions regarding their water services (BCI) and the VPI (Figure 11). The Pearson correlation coefficient (r) is 0.65. The BCI also correlates very significantly with the UWCS commitments of the cities/regions ($r = 0.85$; Figure 12) and the GDP ($r = 0.82$; Figure 13). The BCI is also positively correlated with all governance indicators of the World Bank, for instance the government effectiveness ($r = 0.84$; Figure 14). Further analysis of other World Bank Indicators has not been performed as in a previous study all World Bank indicators for the subset were strongly correlated (van Leeuwen, 2013). This is shown in Table 4, where also another World Bank indicator has been included, i.e. voice and accountability (VA).

Table 4. Pearson correlation matrix for the indicators for 30 cities in 22 different countries.

	BCI	VPI	UWCS	GDP-IMF	GE	RQ	VA	RL
BCI	X	0,65	0,85	0,82	0,84	0,76	0,72	0,81
VPI	0,65	X	0,48	0,79	0,74	0,64	0,75	0,75
UWCS	0,85	0,48	X	0,62	0,69	0,62	0,52	0,66
GDP	0,82	0,79	0,62	X	0,88	0,81	0,90	0,87
GE	0,84	0,74	0,69	0,88	X	0,92	0,90	0,98
RQ	0,76	0,64	0,62	0,81	0,92	X	0,91	0,93
VA	0,72	0,75	0,52	0,90	0,90	0,91	X	0,94
RL	0,81	0,75	0,66	0,87	0,98	0,93	0,94	X

VA captures perceptions of the extent to which a country's citizen are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media (Kaufman et al., 2010). These high correlations are demonstrated for e.g. RL and GE (0.98) and RL and RQ (0.93).

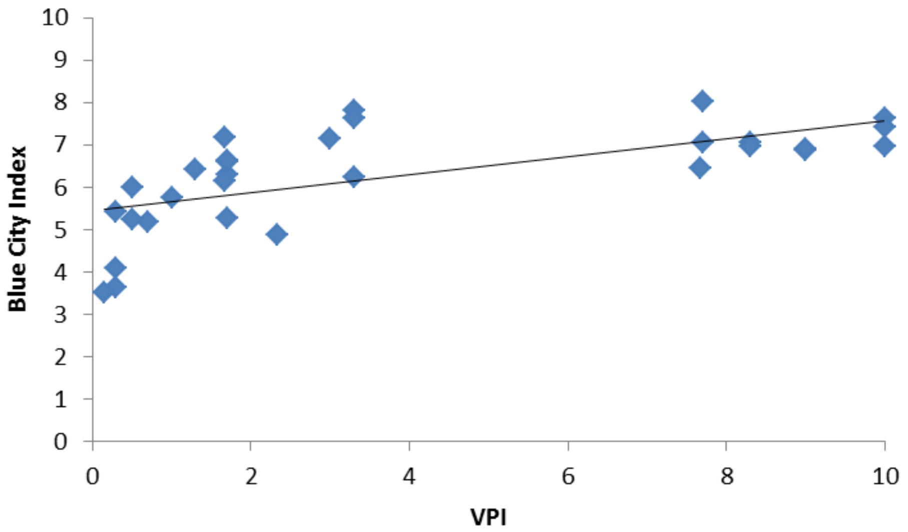


Figure 11. The relation between the BCI (Blue City Index®) and Voluntary Participation Index (VPI).

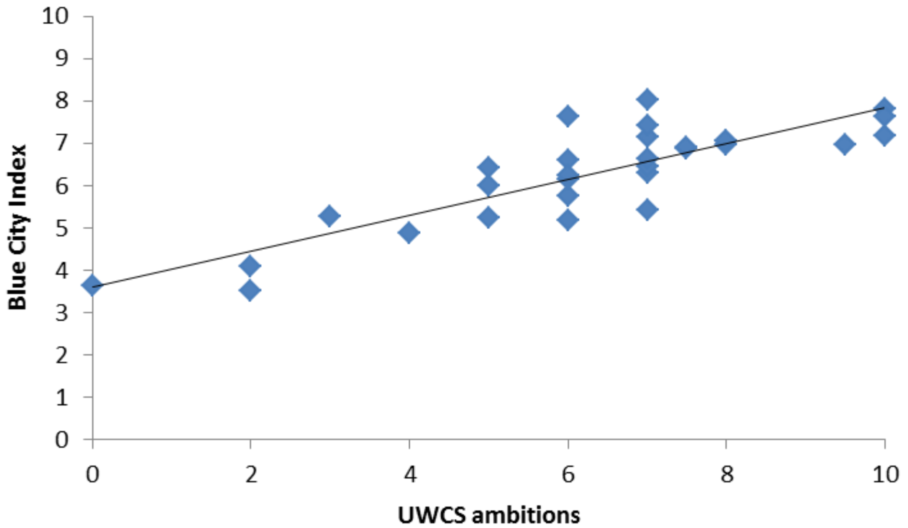


Figure 12. The relation between the BCI (Blue City Index®) and UWCS commitments (indicator 23).

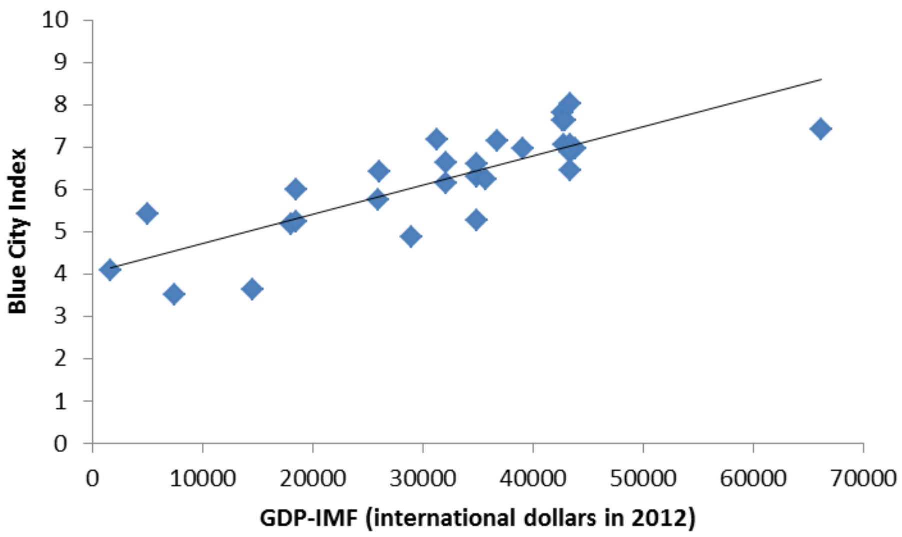


Figure 13. The relation between the BCI (Blue City Index®) and the GDP per capita according to the IMF.

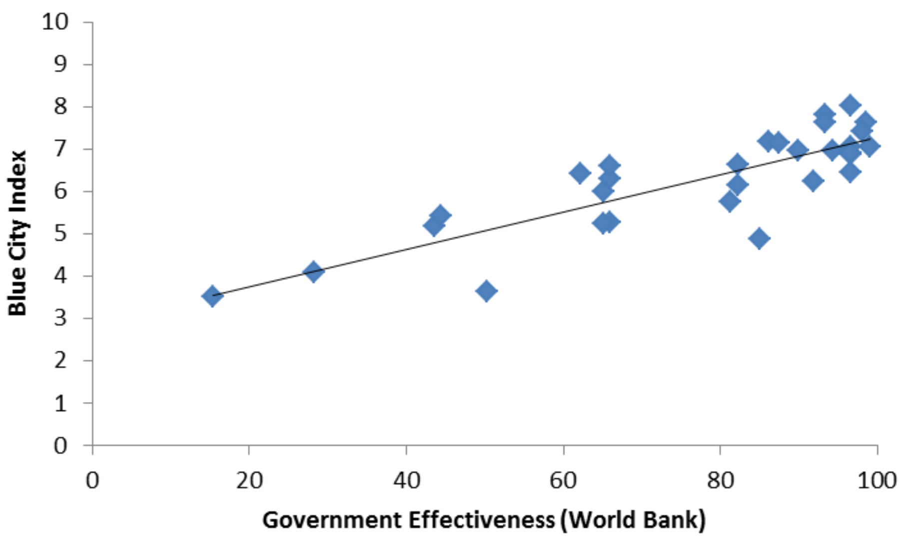


Figure 14. The relation between the BCI (Blue City Index®) and government effectiveness.

3.3 Implementation of best practices

The global urban water challenges are high and the fastest route to failure in the transition towards sustainable cities would be to sit and wait for e.g. the ultimate technological breakthroughs in water technology. This is not at all necessary as many advanced technologies are currently available and implemented in many cities. The main challenge is to start the discussion with all stakeholders and to translate the baseline assessments into action. These actions may include further refined assessments on certain priority aspects of the UWCS based on this baseline assessment, or direct actions to improve the UWCS of cities in order to address the challenges ahead of us.

The most important result from this baseline assessment is that cities can learn from each other. This is shown in Table 5. In Table 5 the City Blueprint indicators are listed together with the best performing cities. In the third column the best score per indicator is given, to indicate what the current best practices are. In order to illustrate this further, a theoretical City Blueprint is provided in which all the best practices (best scores from Table 5) are given. This is shown in Figure 15. It should be noted directly that the implementation of "best practices" for some of these indicators – such as the water scarcity related indicators (1-3) is easier said than done, as these are based on national data and are determined by large-scale climatic, geological and hydrological processes. On the other hand, almost all indicators can be influenced directly at the level of the city, provided that other aspects are taken into consideration as well (Figure 16).

Table 5. Indicators, best performing cities and highest score per indicator for 30 cities.

	Indicator	Lowest score	Best score	Best performing cities
1	Water footprint	3,4	8,4	DAR, HCM
2	Water scarcity	0,0	10,0	BEL, HCM, KIL, MLM, OSL, REY
3	Water self-sufficiency	0,1	9,4	BEL, DAR, HCM
4	Surface water quality	2,4	10,0	BEL, MLM, OSL, REY
5	Groundwater quality	1,3	10,0	MLM, OSL, REY
6	Sufficient to drink	0,4	10,0	AMS, ANK, ATH, BER, BOL, COP, GEN, HAM, IST, JER, LYO, MAN, MEL, MLM, MLT, MST, OSL, REY, ROT, VNL, ZAR
7	Water system leakages	5,0	9,8	AMS, BER, COP, EIN, HAM, MLM, MST, REY, ROT, VNL
8	Water efficiency	1,0	10,0	AMS, BER, BOL, HAM, JER, REG, ROT
9	Drinking water consumption	1,9	10,0	EIN, KIL, MST, MLT, ROT, VNL
10	Drinking water quality	4,0	10,0	ALG, AMS, ATH, BER, BUC, EIN, HAM, JER, LYO, MEL, MLM, MST, OSL, REG, SCO, VNL
11	Safe sanitation	0,0	10,0	AMS, COP, EIN, MEL, MLM, MLT, OSL, REY
12	Sewage sludge recycling	0,0	10,0	AMS, ATH, BER, EIN, HAM, LYO, MAN, MLM, MST, OSL, REG, ROT, VNL
13	Energy efficiency	0,0	10,0	AMS, BER, HAM, MLM
14	Energy recovery	0,0	10,0	AMS, ATH, BER, COP, HAM, MAN, MLM, ZAR
15	Nutrient recovery	0,0	10,0	AMS, LYO, REG
16	Average age sewer system	2,0	9,0	ALG, ATH, HCM, REY
17	Infrastructure separation	0,0	10,0	ANK, JER, MEL
18	Climate commitments	2,0	10,0	BER, HAM, JER
19	Adaptation strategies	0,0	10,0	AMS, BER, HAM, JER, ROT
20	Climate-robust buildings	0,0	10,0	BER, HAM, REY
21	Biodiversity	1,0	10,0	BEL, DAR, HCM, REY
22	Attractiveness	0,0	10,0	BER, COP, HAM
23	Management and action plans	0,0	10,0	BER, HAM, JER, MEL
24	Public participation	0,2	10,0	MLM, OSL, REY

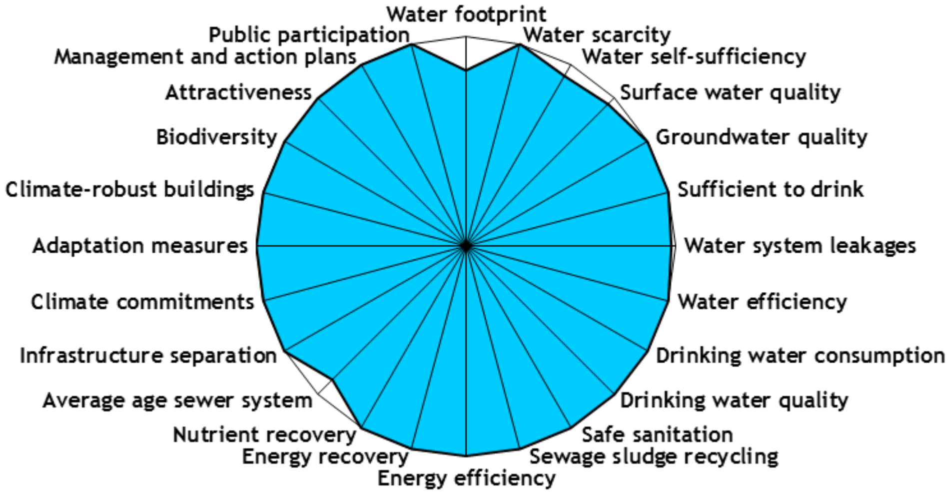


Figure 15. City Blueprint of a theoretical city that has implemented all the best practices (best scores as listed in Table 5) currently available in all cities presented in this report. It shows that cities can learn from each other and that active exchange of "best practices", can significantly improve the sustainability of UWCS of cities. The BCI is 9.8.

4 Discussion

4.1 Methodological aspects

The key characteristics of a good indicator are: (1) easy to access, (2) easy to understand, (3) timely and relevant, (4) reliable and consistent, (5) credible, transparent and accurate, and (6) developed with the end-user in mind (Norman *et al.*, 2010). The choice of indicators for the TRUST Questionnaire and the city blueprint (Annex 1) are per definition subjective. There are many options for other indicators and a variety of methods to quantify them. However, the selected questions and indicators provide for a good overview of the key sustainability issues in UWCS. The quality of input data has been a major issue. The baseline assessment of the TRUST cities has shown that the choice of the indicators is driven by the availability, quality and comparability of the input data. The survey responders have provided the most reliable data for the UWCS. In a couple of cases no local information could be provided, and assessments were based on regional or national information. In some cases there was no information at all and expert judgement scores or best professional "guesstimates" have been provided. For instance, the water security, environmental quality and VPI data have been obtained from regional or national data sources. Depending on the size of the country and the regional differences in e.g. precipitation, soil type, pollution and social aspects, the use of these regional/national data may lead to serious errors in the assessment of the local situation.

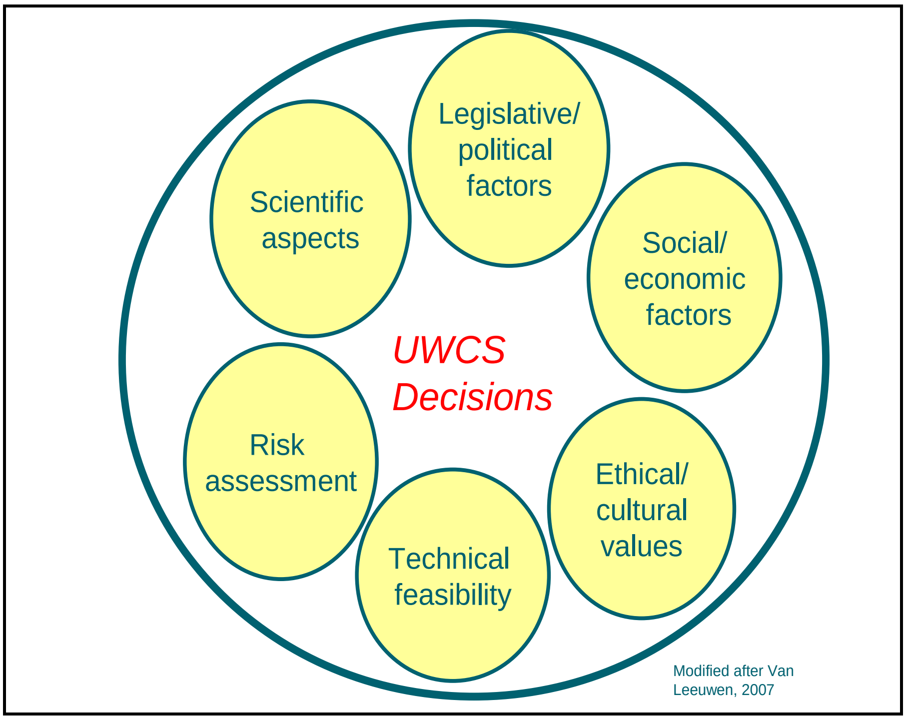


Figure 16. Elements of UWCS decision-making.

Retrospectively, it would have been better to modify the TRUST questionnaire (Annex 1). Certain questions could have been deleted whereas in other cases more refined information is needed. For instance, question 32 (climate change) can mean different things to different people. It may implicitly address related, but totally different issues such as: (1) concrete greenhouse gas reduction targets, (2) safety; i.e. adaptation strategies and measures against flooding, (3) safety; i.e. measures to combat water scarcity, (4) measures to increase green cover (park, trees and agricultural surfaces in urban areas) to reduce the "heat island" effects. Answers on this question have been used to score indicators 18 (climate commitments) and 19 (safety). Cities may put different priorities to these aspects.

We have followed a learning by doing approach. All cities have now been assessed in a similar manner and this may lead to minor changes compared to our previous publications. The assessments of the cities are dependent on data availability and data quality (Van Leeuwen, 2013). Unfortunately, no harmonized local data were available on water security, surface and groundwater quality, biodiversity and public participation. This has forced us in the direction of using regional or national information. The clear consequence of this is also that no absolute values should be attached to the environmental quality data. Most likely the cities are more polluted and show a greater lack of biodiversity than national/regional data would suggest. The use of national or regional information on environmental quality as used in this report may lead to serious overestimations of local environmental quality as cities are often sources of pollution. The use of local information rather than national data on e.g. water quality for a variety of cities leads to much lower scores. This is summarized in Table 6. Especially in those cities were waste water treatment is nearly absent, e.g. in Ho Chi Minh City and Dar es Salaam, severe surface water pollution can be observed.

Table 6. Difference between the score of indicator 4 (surface water quality) based on local information and information of the EPI water quality index score at a national level.

City	Local score	EPI Water Quality Index
Amsterdam	6,0	7,3
Ankara	4,0	5,8
Athens	4,0	7,7
Dar es Salaam	4,0	8,5
Ho Chi Minh City	3,0	7,3
Istanbul	4,5	5,8
Melbourne	6,0	6,2
Maastricht	3,5	7,3
Rotterdam	4,0	7,3
Venlo	4,0	7,3

In other words the scores as provided in the current report on environmental quality are probably too optimistic and are real underestimations of the actual environmental quality of the cities. Furthermore, many water pollutants have not been accounted for. The 2010 EPI Water Quality Index uses only three parameters measuring nutrient levels (dissolved oxygen, total nitrogen, and total phosphorus) and two parameters measuring water chemistry (pH and conductivity). These parameters were selected because they cover issues of global relevance (eutrophication, nutrient pollution, acidification, and salinization) and because they are the most consistently reported. The consequence of this is that important groups of chemicals such as persistent organic pollutants (POPs), persistent bioaccumulating and toxic chemicals (PBTs), endocrine disrupters and many other groups of micropollutants have not been addressed at all. Again, this may lead to a serious underestimation of the actual pollution status in cities. Pollutants in many of Europe's surface waters have led to detrimental effects on aquatic ecosystems and the loss of aquatic flora and fauna. Clear downward trends in water quality determinants related to urban and industrial wastewater are evident in most of Europe's surface waters, although these trends have levelled in recent years (EEA, 2010). This is also reflected in the low scores for the biodiversity of surface waters in this report.

While water is generally abundant in much of Northern Europe, water scarcity and droughts continue to affect some areas. Water scarcity and droughts have direct impacts on citizens and economic sectors. Activities with high water demand, such as irrigated agriculture, tourism and the use of cooling water, are heavily affected by water scarcity. Over-abstraction is causing low river flows, lowered groundwater levels and the drying-up of wetlands, with detrimental impacts on freshwater ecosystems. In this report three approaches have been used to describe water scarcity. These aspects have been explained in Section 3.1. The approach from the Water Footprint Network is totally different from the traditional water statistics as provided by FAO. This is why we have also provided the FAO statistics and the data from WFN in the graphs of the city blueprints (indicators 1-3). The 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. The current indicators do not optimally address these complexities. (Hoekstra *et al.*, 2012; Hoekstra and Mekonnen, 2011). Further information on water scarcity for Europe is also provided by the WEI as presented in Figures 4 and 9. In the resolution adopted at the beginning of

July 2012 by the European Parliament on the implementation of the EU water legislation, MEPs notably "recall that about 20 % of water in the EU is lost due to inefficiency, so that improving efficiency in the use of water resources is key to sustainable water management and, in particular, to dealing with the problems of water scarcity and drought; and emphasise the nexus between energy production, energy efficiency and water security". This is probably the reason why during the most recent European Green week the statement was made that "We have a water governance crisis rather than a water crisis".

4.2 Results and limitations of the assessment

The City Blueprint assessment is a quick scan and proposed as a first step of gaining a better understanding of UWCS and the challenges ahead. This has been accomplished. The inherent limitations are that the baseline assessment does not cover all aspects of the UWCS. Some aspects of UWCS are addressed very generally. The assessment is also snapshot. It is a picture and, therefore, does not address long-term trends in UWCS stress and adaptations. So the assessment is static and not dynamic. For instance in the discussion with the city of Oslo, we were informed about the need for Oslo to provide more drinking water in the very near future. Similar information was obtained from the city of Dar es Salaam in Tanzania where 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 the short city reports as provided in Annex 3. Finally, care should be taken to attach absolute value to the results. The City Blueprint and the city reports in Annex 3 can be used as a preliminary decision support tool and information, but other aspects need to be included as well (Figure 16; Van Pelt and Swart, 2011). When these limitations are taken into account, the baseline assessment provides stakeholders in cities and regions with a basic insight in the current status of the sustainability of their UWCS. It enables stakeholders to internally reflect upon the current status in terms of possible consequences for future UWCS management and to share the results with other colleagues, to discuss potential improvements. Most importantly, the assessments can be used to learn from each other's experiences. Although there are clear differences among the UWCS of the cities in this report, the most important conclusion from this study is that cities can learn from each other (Figure 15). The learning potential would theoretically allow an increase in the range of BCI scores from 3.5 (Kilamba Kiaxi) and 8.0 (Hamburg and Malmö) to 9.70 (Figure 15). We hope and expect that the results of this baseline survey of UWCS will be used to:

1. Update the assessment with local information on surface water and groundwater quality, as well as biodiversity
2. Refine parts of the assessment, with tailor-made in-depth studies and advanced models, if necessary
3. Communication: raise/improve awareness (particularly in communicating with the public)
4. Identify long-term targets and priorities for your city. Collaborate with other cities, learn from them and explore options for improvement of UWCS for your city.
5. Enable informed and transparent decision-making and allocate the budgets with the stakeholders
6. Monitor and measure progress and compare outcomes with the targets set.
7. Stimulate the exchange of best practices for UWCS, so that other cities can learn from your experiences (Makropoulos *et al.*, 2012; UNEP, 2008; Figure 15).

4.3 Measures

Hundreds of millions of people in urban areas across the world will be affected by climate change. The vulnerability of human settlements will increase through rising sea levels, inland floods, frequent and stronger tropical cyclones, and periods of increased heat and the spread of diseases. Climate change may worsen the access to basic urban services and the quality of life in cities. Most affected are the urban poor – the slum dwellers in developing countries (UN Habitat, 2010). This probably also holds for Europe, where climate change is projected to increase water shortages, particularly in the Mediterranean region. Many best practices in the context of UWCS have been summarized by Makropoulos *et al.* (2012). Specific measures related to water scarcity have been summarized by UNEP (2008), the EU TRUST project (http://www.trust-i.net/downloads/index.php?iddesc=66) and in a short presentation published on the EIP website of the City Blueprint Action Group (http://www.eip-water.eu/working-groups/city-blueprints-improving-implementation-capacities-cities-and-regions), whereas water management options related to climate change have been presented by De Graaf et al. (2007a,b).

5 Conclusions

Smart cities are water wise cities. The baseline assessments of 30 cities presented in this report (see red box in Figure 17) showed that cities vary considerably with regard to the sustainability of the UWCS. We have tried to capture this in individual city reports (Annex 3 of this report) and in the Blue City Index® (BCI), the arithmetic mean of 24 indicators comprising the City Blueprint (Van Leeuwen *et al.*, 2012; Van Leeuwen, 2013). The BCI varied from 3.5 (Kilamba Kiaxi) to 8.0 (Amsterdam). Although correlation coefficients are no cause-effect relationships, cities with the best BCI are cities that demonstrate leadership and have a budget to implement UWCS actions. These cities have:

- An active civil society expressed as VPI (r=0.65)
- High UWCS commitments (r=0.85)
- Are located in countries with a high GDP (r=0.82) and
- High governance effectiveness (r=0.84)

Ultimate technological breakthroughs in water technology are not the prerequisite for sustainable integrated water resources management. The main challenge is to start the discussion with all stakeholders, to enhance public participation, and to translate the baseline assessments into visioning, scenario building and strategy development (Figure 17) and, finally into actions to improve the UWCS of cities in order to address the challenges ahead of us (Figure 18). On the other hand, technological improvements are necessary, certainly when the costs are low and these technologies become affordable for those countries with lower GDPs, as these are the countries where population growth and water demand is high and the global water governance crisis will be felt very seriously (Dobbs et al., 2012; Figure 19).

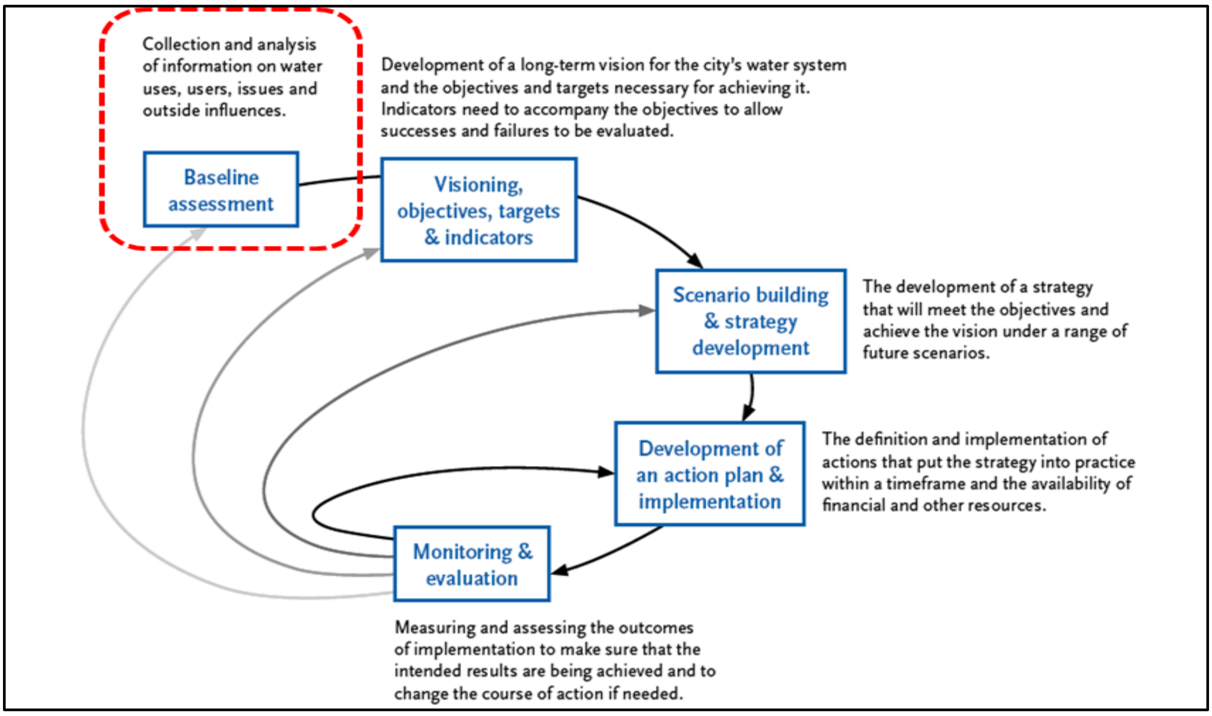


Figure 17. The City Blueprint is a baseline assessment and just the first step of a long-term process to improve the sustainability of the UWCS. Source: Philip et al., 2011.

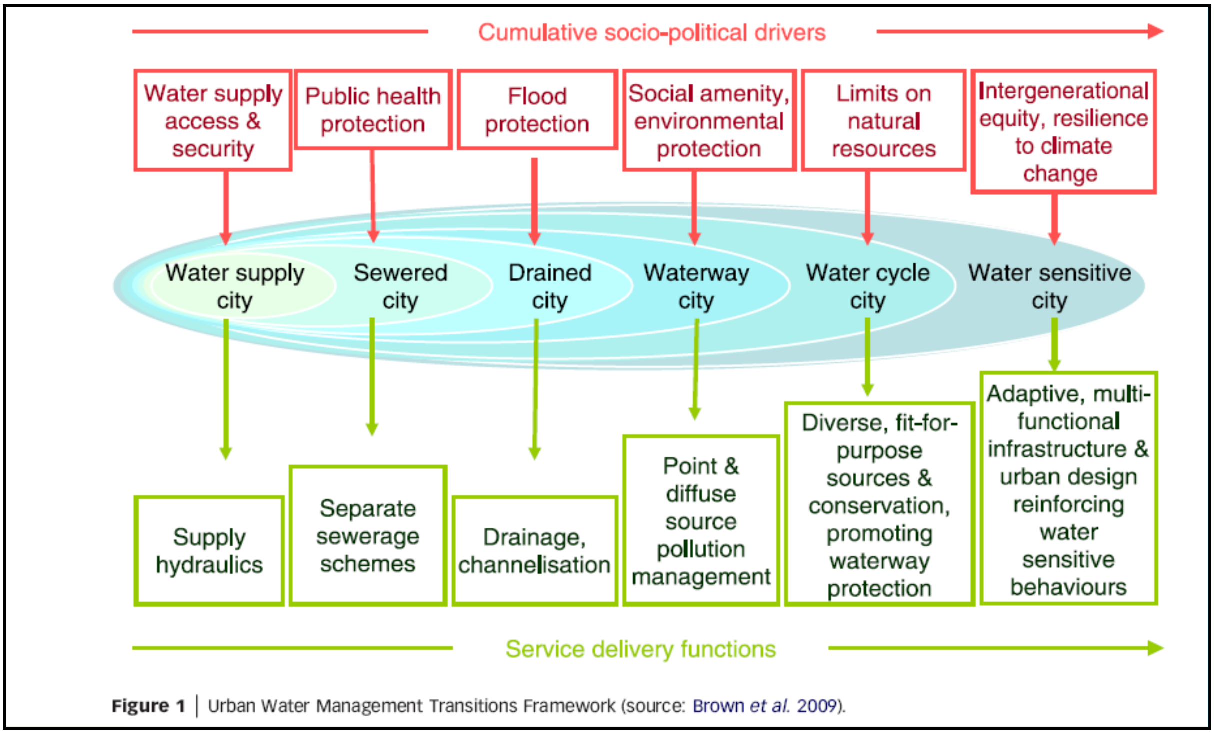


Figure 18. Transitions of UWCS in cities according to Brown et al. (2009).

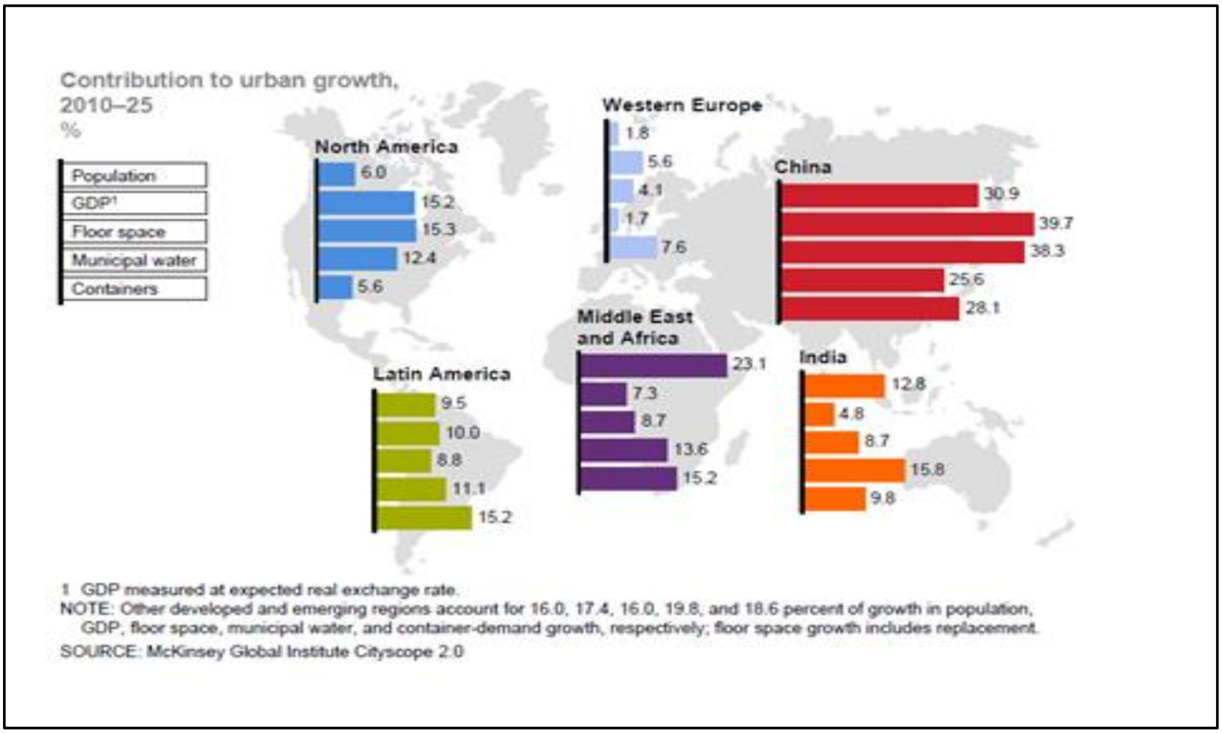


Figure 19. Expected growth between 2010 and 2025 (Dobbs et al., ®®

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Annexes

Annex 1a. Indicators of the City Blueprint (Van Leeuwen *et al.*, 2012; Van Leeuwen and Chandy, 2012; Van Leeuwen, 2013)[a]

Indicator	Assessment criterion	Description
Water security		
1. Total water footprint (N)	En11	Total volume of freshwater that is used to produce the goods and services consumed by the community (Hoekstra and Chapagain, 2007; Hoekstra *et al.*, 2011;Mekonnen and Hoekstra, 2011)
2. Water scarcity (N)	En11	Ratio of total water footprint to total renewable water resources (Hoekstra and Chapagain, 2007; Hoekstra *et al.*, 2011; Mekonnen and Hoekstra, 2011)
3. Water self-sufficiency (N)	En11	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 and Chapagain, 2007; Hoekstra *et al.*, 2011; Mekonnen and Hoekstra, 2011)
Water quality		
4. Surface water quality (N)	En21	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 (N)	En21	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	S11	Percentage of city population, with potable water supply service (Global city indicators facility, 2008; Sustainable Society Foundation, 2010; UN, 2007)
7. Water system leakages	A12	Percentage of water lost in the distribution system (European green city index 2009)
8. Water efficiency	En11	Assessment of the comprehensiveness of measures to improve the efficiency of water usage (Jenerette and Larsen, 2006)
9. Consumption	S11	Domestic water consumption per capita (liters/day) (Global city indicators facility, 2008)
10. Quality	S22	Percentage of drinking water meeting the WHO water quality guidelines or the EU Drinking Water Directive (EBC, 2010; European Commission, 1998; Global city indicators facility,

		2008; Sustainable Society Foundation, 2010)
Sanitation		
11. Safe sanitation	S22	Percentage of city population served by wastewater collection and treatment (European green city index, 2009; Global city indicators facility, 2008; Sustainable Society Foundation 2010; UN, 2007)
12. Recycling of sewage sludge	En21	Percentage of total sewage sludge that is thermally processed and/or applied in agriculture.
13. Energy efficiency	En12	Assessment of the comprehensiveness of measures to improve the efficiency of wastewater treatment (European green city, index 2009; UN, 2007)
14. Energy recovery	En12	Percentage of wastewater treated with techniques to generate and recover energy (Daigger, 2009; Frijns *et al.*, 2009; Verstraete *et al.*, 2009;)
15. Nutrient recovery	En21	Percentage of wastewater treated with techniques to recover nutrients, especially phosphate (Cohen, 2007; Daigger, 2009; Frijns *et al.*, 2009; Verstraete *et al.*, 2009)
Infrastructure		
16. Average age	A11	Average age of infrastructure for wastewater collection and distribution
17. Separation of wastewater and stormwater	A13	Percentage of separation of the infrastructures for wastewater and storm water collection (EBC, 2010; Sustainable Society Foundation, 2010; Tredoux *et al.*, 1999; UN, 2007)
Climate robustness		
18. Commitments to climate change	A14	Assessment of how ambitious and comprehensive strategies and actual commitments are on climate change (Australian Conservation Foundation, 2010; European green city index, 2009; Forum for the future, 2010; Global city indicators facility, 2008)
19. Climate change adaptation measures	A14	Assessment of measures taken to protect citizens against flooding and water scarcity, including sustainable drainage (Deltares, 2009; EEA, 2012; Nederlof *et al.*, 2010)
20. Climate-robust buildings	A14	Assessment of energy efficiency for heating and cooling, including geothermal energy (Charlesworth, 2010)
Biodiversity and attractiveness		
21. Biodiversity (R)	En21	Biodiversity of aquatic ecosystems according to the WFD (European Commission, 2000)
22. Attractiveness	S21	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	G31	Measure of local and regional commitments to adaptive, multifunctional, infrastructure and design for UWCS as demonstrated by the ambition of the action plans and actual commitments (Brown and Farrelly, 2009; European green city index, 2009; Fleming, 2008;)
24. Public participation (N)	G11	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 (Brown, 2009; Brown and Farrelly, 2009; EFILWC, 2006; European green city index, 2009)

[a] All indicators are at the level of the city or region. If this information was not available regional (R) or national (N) data were used.

Annex 1b. TRUST Questionnaire

No	Name	Definition	IWA-Code	Unit	Value
	General Information				
A	City / Region	Name of the city or region			
B	Resident population	Total population who lives on a permanent basis in the area served by the water undertaking, at the reference date.	E5	persons	
C	Household occupancy	Resident population / total number of dwelling units (houses + apartments)	CI79	persons/household	
D	Supply area (drinking water)	Area that can or is intended to be served by the distribution network	CI14	km2	
E	Catchment area (waste water)	Extent of area receiving the waters feeding a part or the totality of a drain runoff or channel/sewer network		km2	
F	Annual average rainfall	Annual average rainfall (average for the past 30 years)	CI86	mm/year	
G	Daily average air temperature	Average daily air temperature of the year (averages for the past 30 years)	CI89	°C	
	Drinking Water				
1	Raw water quality source types				
1a	Upland surface water sources (an impounding reservoir situated at relatively high altitude with little or no development in the upstream catchments)	Annual abstraction of upland surface water / total annual abstraction x 100	CI95	%	
1b	Lowland surface water sources (a direct river abstraction, possibly with some storage. The upstream catchments may be well developed for agricultural and industrial uses)	Annual abstraction of lowland surface water / total annual abstraction x 100	CI96	%	
1c	Natural springs and wetlands sources	Annual abstraction of natural springs and wetlands water / total annual abstraction x 100	CI97	%	
1d	Well water sources	Annual abstraction of well water / total annual abstraction x 100	CI98	%	
1e	Borehole water sources	Annual abstraction of borehole water / total annual abstraction x 100	CI99	%	
1f	Saline and brackish water sources	Annual abstraction of saline and brackish water / total annual abstraction x 100	CI100	%	
1g	System input volume	The water volume input of the global system during the assessment period (here: 1 year)	A3	m3/year	

2	Population coverage	Percentage of the resident population that is served by the undertaking.	QS3	%	44
3	Authorised consumption	Total volume of metered and/or non-metered water that, during the assessment period (here: 1 year), is taken by registered customers, by the water supplier itself, or by others who are implicitly or explicitly authorised to do so by the water supplier, for residential, commercial, industrial or public purposes. It includes water exported.	A14	m3/year	
4	Service connections	Total number of service connections in the supply area, at the reference date	C24		
4a	Average household consumption	calculated automatically (A14/C24)	A14/C24	m3/year	**#DIV/0!**
5	Water losses	Water losses per connection and year. This indicator is adequate for urban distribution systems.	Op23	m3/ (connection*year)	
5a	Water losses	Water losses (%); calculated automatically (Op23xC24)/A14 x 100		%	
6	Quality of supplied water	self-estimate: number of drinking water tests complying with the applicable standards or legislation * 100 / total number of tests of drinking water carried out	QS18	%	
7	Average water charges for direct consumption	Ratio between the water sales revenue for direct consumption and billed water.	G57	€/m3	
8	Mains length	Total transmission and distribution mains length (*service connections* not included). Mains that are not yet in use or have been put out of service on a permanent basis shall not be accounted for. Only mains that distribute treated water should be provided.	C8	km	
9	Average mains age	Average mains age for the global supply system based on the age of each mains and its length	CI53	years	
10	Number of main failures		D28	1/year	
10a	Main failures per length	calculated automatically (D28*100/C8)		1/(100 km*year)	**#DIV/0!**
11	Knowledge about acceptance of alternative water resources	Has there been an inquiry of the city population on the willingness to accept other water sources for city and domestic uses different from drinking water			
		a) Reclaimed rainwater		yes OR no	
		b) Non controlled groundwater		yes OR no	
		c) Reuse of treated waste water		yes OR no	
		d) Desalinated water		yes OR no	
		e) Other (specify)		yes OR no	
		f) In general (specify)			
12	Asset turnover ratio	Service revenues / total assets, during the year; Total assets are the sum of intangible assets (including goodwill and net value of licences and rights), tangible assets (including net value of water undertaking plants and net value of other assets), financial assets (including net value of financial investments) and current assets, regarding the water supply service, at the end of the fiscal year.	wFi45		

	Wastewater				
13	Type of waste water system, i.e. classification of the wastewater system depending on the type of service it is aimed for	a) Collection		yes OR no	
		b) Collection and transport		yes OR no	
		c) Collection, transport and treatment		yes OR no	
		d) Transport		yes OR no	
		e) Transport and treatment		yes OR no	
		f) Treatment		yes OR no	
		g) Other		specify	
14	Percentage of population covered by:	a) Waste water collection	wE4	%	
		b) Waste water treatment	wE2	%	
15	Number of properties connected	Number of properties connected to the sewer system managed by the utility. In apartment buildings, each household (property) is counted as one separate property.	wC28	No.	
16	Collected sewage (m3)	Collected sewage per inhabitant per year	wF1	(m3/inhabitant)	
17	Sewer system length	a) Length of combined sewers managed by the utility		km	
		b) Length of stormwater sewers managed by the utility		km	
		c) Length of sanitary sewers managed by the utility		km	
18	Wastewater treated (m3 per year)	a) Wastewater treated by wastewater treatment plants or by on-site system facilities that are the responsibility of the wastewater utility	wA2	m3	
		b) Wastewater treated with techniques to generate and recover energy		m3	
		c) Wastewater treated with techniques to recover nutrients, especially phosphates		m3	
19	Sludge (per year)	a) Dry weight of sludge produced in wastewater treatment plants managed by the utility	wA13	ton DS	
		b) Dry weight of sludge going to landfill	wA17	ton DS	
		c) Dry weight of sludge thermally processed	wA18	ton DS	
		d) Dry weight of sludge disposed by other means than wA17 and wA18	wA19	ton DS	
20	Energy costs (per year)	Total cost of energy regarding the wastewater service. Income from power generation out of biogas (from sludge or wastewater fermentation) must be deducted from energy costs	wG11	local currency	
21	Average age of the sewer system	Average age of the sewer system based on the distribution of ages and lengths		years	
22	Sewer blockages (per year)	Number of blockages that occurred in sewers. Blockages are caused by an obstruction that interferes with the flow of wastewater in a pipe, channel. Pumping station blockages shall not be included. Include blockages in service connections only where these are the responsibility of the wastewater utility.	wD38	No.	

	Environm. quality, biodiversity and attractiveness			
23	Surface water quality	Assessment of the quality of the main fresh surface water(s) in the city (microbial contamination, N, P, BOD and (an)organic priority pollutants). Please use as much as possible information from reports that have been provided by the national reporting agency for the EU Water Framework Directive (WFD). Please provide information on:(a) the type of surface water and (b) the number of surface water tests complying with the applicable standards or legislation/total number of tests of surface water quality carried out (x100).	Type and %	
24	Receiving water quality	Assessment of the quality of the surface water(s) in the city on which the (effluent of the) waste water is discharged. In some case this is the same surface water as mentioned under question 23. The assessment should be based on microbial contamination, N, P, BOD and (an)organic priority pollutants. Please use as much as possible information from reports that have been provided by the national reporting agency for the EU Water Framework Directive (WFD). Please provide information on:(a) the type of surface water and (b) the number of surface water tests complying with the applicable standards or legislation/total number of tests of surface water quality carried out (x100).	Type and %	
25	Biodiversity of surface water	Assessment of the ecological quality of the main fresh surface water(s) in the city according to the WFD based on information on algae, macrophytes (waterplants), macrofauna and fish according to the WFD procedures. Provide one score between 0 (extremely bad) to excellent (10)	No.(0-10)	
26	Quality of shallow groundwater	Assessment of the quality of shallow (< 10 m) groundwater based on the EU Groundwater Directive or other international standards (WHO) for nutrients, BOD and organic/anorganic micro-contaminants. Self-estimate: number of groundwater tests complying with the applicable standards or legislation / total number of tests of groundwater quality carried out (x100).	%	
27	Attractiveness	Surface water supporting the quality of the urban landscape as measured by the community sentiment/well-being within the city. Self assessment based on information (policy documents, reports or research articles, or documents related to water-related tourism that deal with the sentiment of the citizens. Please provide score between 0 (no role) to 10 (water plays a dominating role in the well-being of citizens).	No. (0-10)	
28	Water efficiency	Assessment of the plans, measures and their implementation to improve the efficiency of water usage by e.g. water saving measures in taps, toilets, showers and baths, water efficient design, or behavioral changes. Self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). The following scores are proposed: Score = 0, if no information is available on this subject Score = 1, if limited information is available in a national document Score = 2, if limited information is available in national and local documents Score = 3, if the topic is addressed in a chapter in a national document Score = 4, if the topic is addressed in a chapter at the national and local level Score = 5, if a local policy plan is provided in a publicly available document	No.(0-10)	

		Score = 6, as 5 and the topic is also addressed at the local website. Score = 7, if plans are implemented and clearly communicated to the public Score = 8, as 7 plus subsidies are made available to implement the plans Score = 9, as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local community. Score = 10, as 9 and the activity is in place for ? 3 years.			
29	Wastewater efficiency	Assessment of the plans, measures and their implementation to improve the efficiency of waste water treatment. Self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). Scoring methodology as in No 28		No.(0-10)	
30	Energy recovery	Assessment of the plans, measures and their implementation to generate and recover energy from waste water. Self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). Scoring methodology as in No 28		No.(0-10)	
31	Nutrient recovery	Assessment of the plans, measures and their implementation to apply techniques to recover nutrients, especially phosphate. Self assessment based on information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). Scoring methodology as in No 28		No.(0-10)	
32	Climate change	Assessment of the plans, measures and their implementation to protect citizens against flooding and water scarcity related to climate change (e.g. green roofs, rainwater harvesting, safety plans etc.). Self assessment based on information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). Scoring as in No.28		No.(0-10)	
33	Energy efficiency	Assessment of energy efficiency for heating and cooling of houses and buildings, including the use of geothermal energy. Self assessment based on information from public sources (national / regional / local policy documents, reports and websites of actors, e.g. water companies, cities, provincial or national authorities).Scoring as in No.28		No.(0-10)	
34	Commitments for SUWM	Measure of local and regional commitments to adaptive, multifunctional, infrastructure and design for Sustainable Urban Water Management (SUWM) as demonstrated by the ambition of the action plans and the actual commitments by local authorities or utilities. Self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities). Scoring as in No. 28		No.(0-10)	
35	External collaboration	Measure of local. regional, national and international cooperation on SUWC.Self assessment based on information from public sources such as international / national / regional / local policy documents, reports and websites of all actors (e.g. water companies, cities, regional, or (inter)national authorities).			

35a		Type. The following scores are proposed: Score = 1, if local collaboration includes governmental organizations only. Score = 2, if the collaboration also includes NGO's; Score = 3 if collaboration also extends to industry/private companies; Score = 4, as 3 but also research organisations are involved; Score = 5 as 4, but also citizens are involved.		No.(1-5)	
35b		Level. The following scores are proposed: Score = 1, if collaboration is restricted to the local level. Score = 2, if the collaboration extends to the regional level; Score = 3 if collaboration also extends to national level; Score = 4, as 3 but also international (EU) collaboration takes place; Score = 5 as 4, but also global collaboration takes place (e.g. UN or OECD).		No.(1-5)	
36	Highlights of your city	What are the highlights of your city regarding SUWM? List maximum 3 examples that you consider clear highlights (plans, programmes, infrastructures, achievements related to SUWM) from which other cities can learn.			