Current State of Sustainability of Urban Water Cycle Services

TOWARDS A BASELINE ASSESSMENT OF THE SUSTAINABILITY OF URBAN WATER CYCLE SERVICES.
BASELINE ASSESSMENT OF THE SUSTAINABILITY OF URBAN WATER CYCLE SERVICES.

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TRANSITIONS TO THE URBAN WATER SERVICES OF TOMORROW

INTRODUCTION

This document presents an analysis of the current state of sustainability of Urban Water Cycle Services (UWCSs).

- In **Part I** of this deliverable, entitled '**Towards Baseline Assessment of the Sustainability of Urban Water Cycle Services**', a questionnaire is developed for this purpose.
- In **Part II**, entitled '**Baseline Assessment of the Sustainability of Urban Water Cycle Services**', the actual analysis of the current state of sustainability of UWCSs in TRUST cities and regions is presented. It shows how TRUST cities and regions are performing in different dimensions of sustainability. This could serve as a basis from which TRUST city and region stakeholders can discuss their vision and strategies as regards the transition to a sustainable UWCS.

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 265122.

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Current State of Sustainability of Urban Water Cycle Services

Part I – Towards a Baseline Assessment of the Sustainability of Urban Water Cycle Services

Deliverable 11.1

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Part I - Towards a Baseline Assessment of the Sustainability of Urban Water Cycle Services

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1. INTRODUCTION

The TRUST project aims to create co-produced knowledge that urban water utilities can use for planning and justifying transitions to sustainable urban water cycle systems. In D121 of the TRUST project, the various steps in such a planning process are presented (for details, see D121). For utilities, a logical first step for planning a transition is to define the organizational identity. This involves a definition of the internal system over which the utility has significant control and the transactional environment over which the utility does not have direct control but may influence others to change circumstances. After having defined the internal system and the transactional environment, a next step is to evaluate the current state of the internal system to create a reference point against which future changes towards a sustainable urban water cycle system (UWCS) can be assessed. This is a matter of answering the question 'Where are we now?'. The current Deliverable 11.1b – Part I presents a tool for the baseline assessment of the actual state of the UWCS that could support water professionals in utilities and other stakeholders in TRUST to creating a general insight into how cities score on dimensions of sustainability. Based thereon, these parties might discuss more detailed options for the evaluation of the current state and discuss the first steps towards the definition of a clear vision as regards the transition to a sustainable UWCS.

Various authors have pointed towards the complexity and enormous challenges for the sustainable urban water cycle (SUWC) (Fleming, 2008; Brown *et al*., 2010). There is no single or clear pathway for the adoption of sustainable practices for water utilities, cities, or any other organisation involved in the Urban Water Cycle System (UWCS). Equally, there is currently no consensus on how to assess the current situation as regards the sustainability of UWCS, although proposals were made by Van der Steen (2011) as part of the EU SWITCH project and by Van Leeuwen *et al*. (2012) recently.

In chapter 2, after a brief introduction, the concept of UWCS sustainability is presented, including a discussion on how to assess it. This chapter starts with the presentation of the concept of sustainability in broader terms. It then goes into the various dimensions of sustainability and gives an overview of the literature on UWCS sustainability. Finally, experiences across the globe involving the assessment of UWCS sustainability are presented.

In chapter 3, the dimensions, objectives, criteria and performance metrics for the UWCS sustainability are described. Associated with dimensions or the principles of UWCS sustainability, we defined its specific objectives. These objectives depend on the field where sustainability is being assessed. Therefore, we set out specific and elaborated objectives for the UWCS which can change in intensity according to the goals of water utilities and their stakeholders. There are criteria associated with each objective of the UWCS sustainability. Those objectives are achieved if the corresponding criteria are fulfilled. Finally, there will be metrics for each criterion (not only performance indicators but other metrics, such as best practices check lists, results of inquiries, etc) which will allow for its assessment.

Finally, in chapter 4, a short introduction is given to the questionnaire that has been developed. It links the dimensions of sustainability as given in chapter 3 with the (subjective) choices to arrive at a limited set of questions for the baseline assessment of the sustainability of UWCS in TRUST cities and regions. This questionnaire has been sent to the TRUST cities and regions and the completed questionnaires will be used to assess the sustainability of the UWCS of TRUST cities and regions.

2. SUSTAINABILITY OF UWCS

2.1. The concept of sustainability

In the late years of the 20th century the dominant paradigm of development was challenged. People became aware that the development of the economy might be compatible with environmental preservation and that economic progress could only be possible if environment protection and social inclusion were addressed. These ideas are associated with the concept of sustainable development. Sustainability can be defined in different ways and it has different meanings to different people. One of the most commonly used definitions is that of "Our Common Future", also known as the Brundtland Report, from the United Nations World Commission on Environment and Development (WCED, WCED, 1987, p.43). It defines sustainable as the '... development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations.' In a slightly different way, the International Union for the Conservation of Nature (IUCN) defines sustainability as the '... development that improves the quality of human life while living within the carrying capacity of supporting ecosystems' (IUCN, 1991, p.10). Both definitions focus on intergenerational equity, but the second one deals explicitly with the environment.

Sustainability is a fashionable word nowadays and it is used for several ends and in different contexts. Most organisations currently search for sustainable practices, although the issue is more often about knowing what is not sustainable than what is sustainable (AWWARF and CSIRO, 2007). Indeed, it is not clear how to become sustainable and how to measure the sustainability degree of a particular sector or activity, taking into account the stakeholders, the numerous metrics, the uncertainties and the trade-offs between them.

In the scope of UWCS the sustainability concept was firstly defined as '...being those water resource systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity' (ASCE and UNESCO, 1998). The emphasis of this definition is mostly on the environmental dimension of the UWCS, although the 'objectives of society' embrace also the economic and social dimensions. Urban water services have evolved significantly over time. Not long ago, water quantity, drinking quality and adequate pressure were per se conditions of an appropriate drinking water service. Today, they are not enough. Customers and society demand more. Water utilities should be efficient, effective and customer-responsive. In addition, they acknowledge themselves as organisations with a corporate social responsibility and therefore invest in community. The use of water resources for drinking water might have a small impact on the water footprint. However, other water uses (e.g. agricultural or industry), water pollution or even the lack of drinking water supply may have serious consequences for the daily life of residential and industry customers. Therefore, environment issues concerning UWCS are not a panacea and are also very relevant in other dimensions. They must be taken into account in an integrated way looking for the Integrated Water Resources Management (IWRM) or the Integrated Urban Water

Management (IUWM) and the life-cycle costs of the systems (Klugue, 2007). The multiple actors and stakeholders comprising several areas with multiple objectives and interests make governance issues (e.g. participation and transparency) in this scope to be very important as well.

Furthermore, due to the increasing cost of water (and wastewater) services and to the level of investment required and the need to reflect them into the polluter and user pay principles, economic and social dimensions are more and more fundamental issues. Urban water services are quite important for the social and economic cohesion of society. The population wishes to have sound and transparent drinking water services at affordable prices. Indeed, customers need to feel the value for money spent.

There is also an increasing awareness that sustainability of the communities and the cities (the so-called 'city of the future') call for the sustainability of urban infrastructure and particularly of urban water services. UWCS is a relevant part of the cities and not only needed for their liveability but also for their sustainability (Binney *et al.*, 2010). The central role of water in cities has been summarized elegantly by Fleming (2008) and is shown in Figure 1.

The UWCS face several challenges worldwide. According to UNEP (UNEP, 2007), the water issues are on the table for, at least, four major matters: scarcity (lack of water resources and freshwater), quality (lack of sanitation and adequate treatment), human health (the contaminated supply) and ecosystems (inadequate use of water resources). Although these problems are more common in the developing world, most of the main challenges and current trends are present or, at least, have impacts on both developed and developing countries, such as climate change, aging or growth of the population, governance, biodiversity, energy and resource consumption, infrastructure ageing and lack of investments and socio-economic factors, among others (Van Leeuwen *et al.*, 2011, 2012); Van der Steen, 2011). All these trends challenge current UWCS and are required to take into account when working on UWCS's sustainable development.

Furthermore, Brown *et al.* (2009) have clearly described a transition framework for UWCS, which is shown in Figure 2. In fact, Figures 1 and 2 summarize the challenges of the TRUST project.

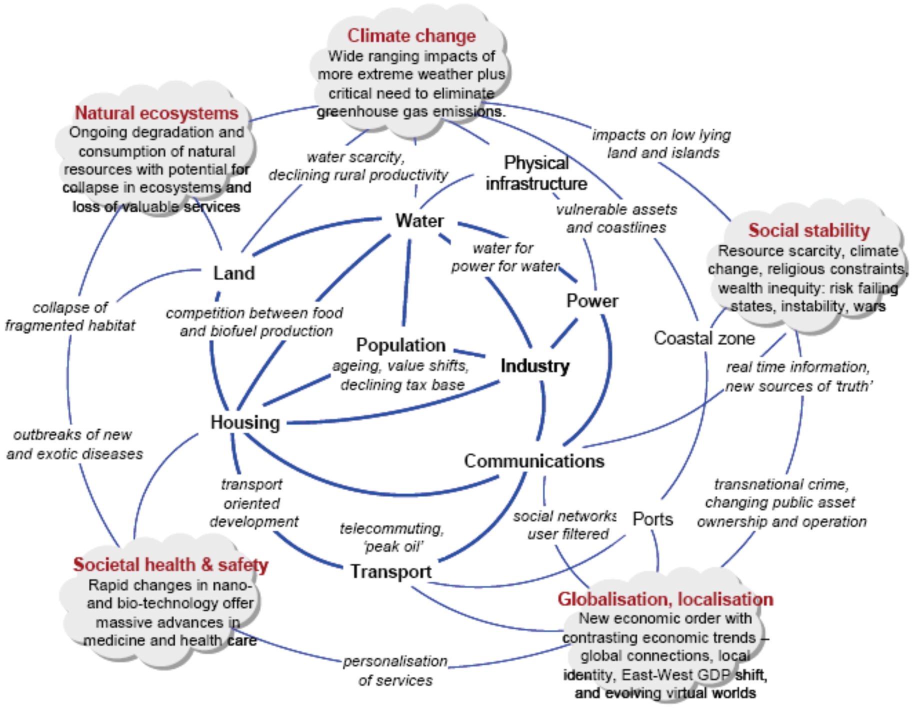

Figure 1: Clouds of change influencing the form and function of cities according to Fleming (2008).

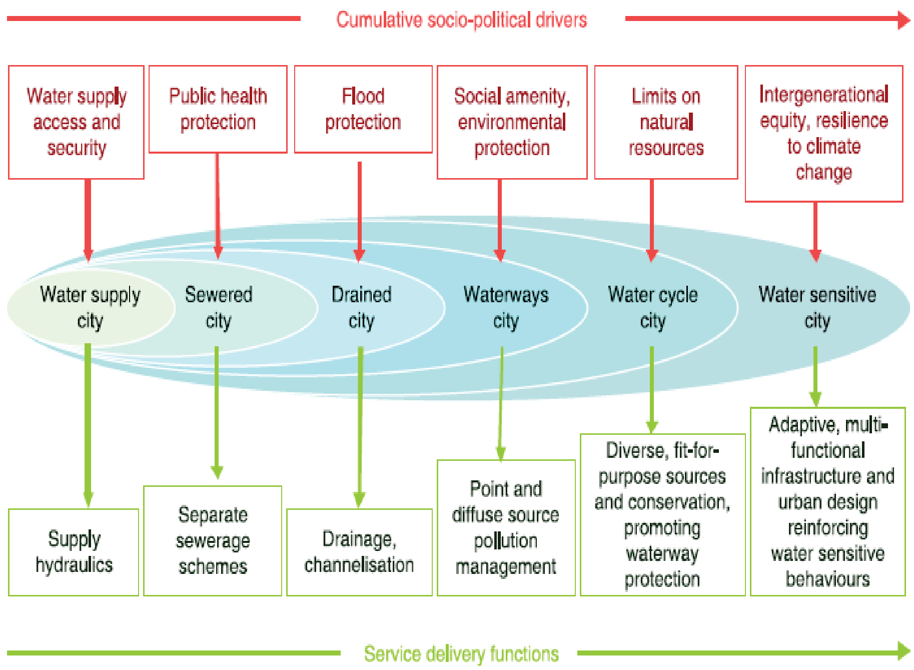

Figure 2: Urban water transition management according to Brown et al. *(2009).*

2.2. Dimensions of UWCS sustainability

The sustainability concept is frequently associated with the triple bottom line (TBL) approach, comprised by social, environmental and economic dimensions or principles. They correspond to the 'people, planet and profit' phrase referred to by Shell as sustainability or to the 'folk, place and work' of the planner Patrick Geddes. These dimensions can be seen as aggregated objectives relative to a particular sector that should be developed. Some authors call criteria to these dimensions which correspond to the 'set of factors that may be used to assess which of a range of options offers the greatest contribution to achieving sustainability objectives' (Ashley *et al.*, 2004). Nomenclature issues aside, the question is if the TBL approach is the most appropriate to deal with UWCS sustainability. We, like others, disagree at least partially. For example, Ashley *et al.* (2004) suggest the following dimensions of UWCS sustainability: technical, economic, environmental and social, and Murray *et al.* (2009) propose the economic, ecological, social, technical and human health dimensions. On the other hand, Sahely *et al.* (2005) categorise them into environment, economic, engineering and social, and the study of ASCE and UNESCO (1998) suggests as the major dimensions, the socio-economic, environmental, public health and management. Table 1 shows the dimensions of UWCS sustainability proposed by other authors in the literature.

The UWCS sustainability social dimension should include aspects related to the access to urban water services, the satisfaction of the users' needs and expectations, the public acceptance and the relevant role in the community of these services (Fleming, 2008). The UWCS environmental dimension concerns the impact of UWCS on living and non-living natural systems and encompasses the optimisation of the use of water, energy and materials and the minimisation of the downstream negative impacts. Other issues, such as biodiversity, could also be included. Finally, the UWCS sustainability economic dimension would include all the objectives related to economic and financial issues, such as the full cost recovery. In fact, it seems that the TBL approach is not enough to characterise the UWCS sustainability since technical (infrastructural) and governance aspects are also quite relevant. Even if they are not one end in themselves, they are instrumental and essential for the social, environment and economic dimensions and objectives of sustainability. The aspects related to the infrastructural sustainability are explicitly absent from the TBL approach and the ones related to governance, although making part of the three dimensions of the TBL, are not clearly specified, too. Infrastructural dimension, as the name suggests, is associated with the system of physical infrastructure and might encompass aspects concerning the system performance, its durability, reliability, flexibility and adaptability (Ashley *et al.*, 2002 and 2003) and, among other aspects, are quite associated with asset management. Governance is related to the rules of the game, the respect for those rules by the stakeholders, the transparency, their participation in the decision making process, particularly the customers, the effectiveness and efficiency of the measures taken and the quality of the accountability and adjustment mechanisms. The existence and alignment of city planning with the UWCS is also a relevant governance issue. Figure 3 highlights our concept of the UWCS sustainability and its dimensions. Assuming TBL as the skeleton of the UWCS, a common area corresponds to the infrastructural and governance dimensions without which the objectives of the TBL dimensions are not able to be achieved. Therefore, sustainable development in the UWCS requires that these dimensions are considered, at least to a certain extent, as instrumental for sustainability achievement.

Table 1 – Dimensions/criteria related to sustainability identified in the literature

Authors	Dimensions/Criteria
Foxon *et al.* (2002)	Economic; ecological; social; technical
Hellström *et al.* (2000)	Health and hygiene; social and cultural; environmental; economic; functional; technical
Spangenberg and Bonniot (1998)	Economic; environmental; social; human rights; society
Balkema *et al.* (2002)	Economic; environmental; technical; social; cultural
Hiessl *et al.* (2000)	Social; economic; ecologic
GRI (2006)	Economic; environment; social; human rights; society
UNCDS (2001)	Environment; social; economic; institutional

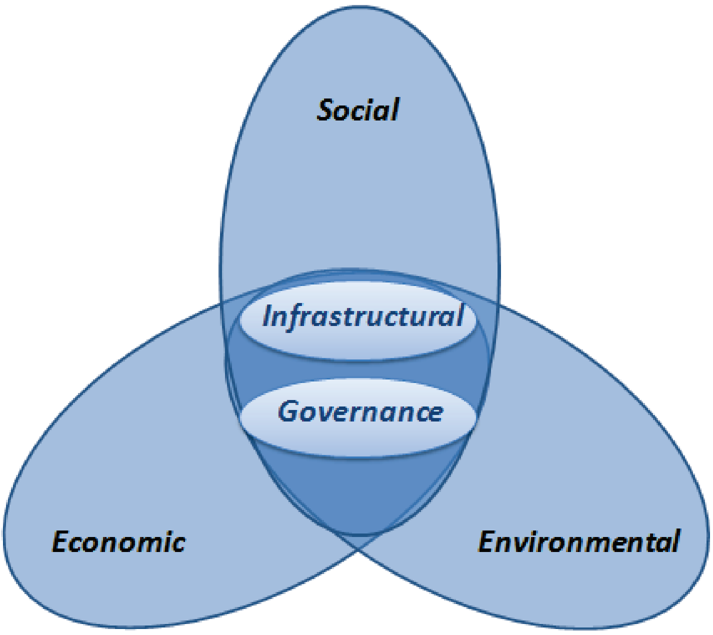

Figure 3: Dimensions of sustainability

Beyond the TBL approach of sustainability, there are several other frameworks related to it on which some comments will be made (AWWARF and CSIRO, 2007). One of them is the Natural Step (www.naturalstep.org) which defines a set of four conditions to help organisations to reduce the consumption of resources, improve the technology and foster the dialogue (Upham, 2000). Another one is the Natural Capitalism (www.natcap.org) which also defines four principles to achieve sustainability, including the increase of natural resources productivity, the use of biomimicry, the adoption of solution based-approaches and the investment in natural capital (Lovins *et al.*, 1999). Industrial Ecology, understanding the material and energy flows, takes into account all the industries as operating in a similar way to natural ecosystems, where the waste or by-products of one process is used as an input into another process (Ehrenfeld, 2004) and the Ecological Design Principles have as basis the ecology for design and, therefore, produce in a sustainable way (Todd and Todd, 1994). PSR or Pressure, State of Environment and Response seek to describe the casual chain of a particular effect considered as negative for sustainability (OECD, 1993). Some authors have also considered the sustainability assessment as the 'next generation' of environmental impact assessment (Sadler, 1999 and Pope *et al.*, 2004).

2.3. Literature on UWCS sustainability

The literature gathering and review is developed in detail in TRUST tasks WP1.1.2 and WP1.1.3. However, as it is the objective to develop a MCA framework for the assessment of UWCS, it is relevant to summarise the major studies carried out on UWCS sustainability.

One of the oldest studies referred to in the literature was undertaken by the Swedish Foundation for Strategic Environment Research (MISTRA). Table 1 shows the criteria and subcriteria adopted for UWCS sustainability, prioritised according to the impact on the water and wastewater systems (Hellström, 1998 and Hellström *et al.*, 2000). In addition, the project adopted also the metabolism model. The authors concluded that, at that time, there were few tools to evaluate the socio-cultural and functional criteria comparing with the remaining criteria.

In the Netherlands, a research project analysed the criteria used in the water sector in 15 publications for the comparison of technologies concerning sustainability (Balkema *et al.*, 2002). One more time the authors concluded that adequate attention was not given to the socio and cultural criteria. This proves the predefined idea that UWCS have been dealt with essentially in the technical scope. However, this circumstance has deeply changed in the last years. Based on the discussion made, the authors proposed a new set of sustainability criteria which are presented in Table 1.

Another Dutch project searched for the 'unsustainability' factors for urban water systems (Van Graaf *et al.*, 1997). They were categorised into four levels of priority from very important to less important. The aspects identified were used to simulate scenarios of their reduction for the year 2040.

Finally, the KWR Watercycle Research Institute and Deltares developed an indicator approach (City Blueprint) to assess the SUWC. The City Blueprint comprises elements of water footprints, urban metabolism, ecosystem services and indicators (van Leeuwen *et al.*, 2012). The research subdivided the indicators into eight broad categories, i.e. (1) water security following the water footprint approach as developed by Hoekstra (2003), (2) water quality, which includes both surface and groundwater, (3) drinking water, (4) sanitation, (5) infrastructure, (6) climate robustness, (7) biodiversity and attractiveness and (8) governance. A short description of the city blueprint indicators is provided in Table 2. This approach is currently applied in different Dutch cities using an interactive multi-stakeholder approach including all relevant UWCS stakeholders. Figure 4 presents the city blueprint of Rotterdam (van Leeuwen *et al.*, 2012).

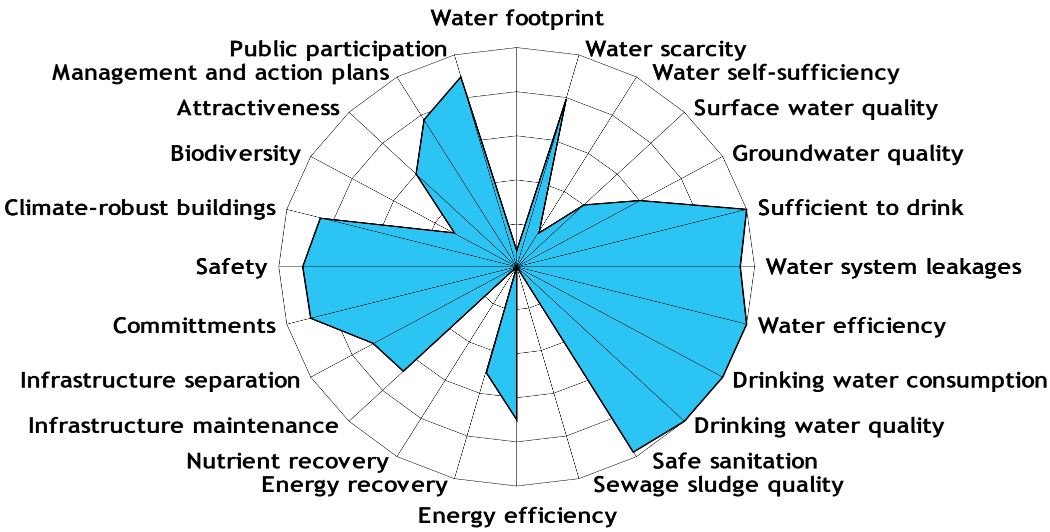

Figure 4: The city blueprint of Rotterdam based on 24 indicator scores. The range of the scores varies from 0 (centre of the circle; further attention is urgently needed) to 10 (periphery of the circle; excellent score).

The spider web presentation of the City Blueprint allows a "quick-scan" of the achievements and concerns and facilitates easy communication with UWCS stakeholders. In the case of the city of Rotterdam in the Netherlands these concerns are: the total water footprint, water self-sufficiency, sewage sludge quality, nutrient recovery, energy recovery and biodiversity. Also groundwater quality may be an issue because of insufficient information (preliminary score of 6). As the water security parameters were estimated on the basis of information for the Netherlands, and Rotterdam strongly depends on the rivers Meuse and Rhine, it is obvious that water security issues can only be partly dealt with by the city of Rotterdam and need to be addressed at the (inter)national level.

It was concluded that water management in cities is an integrated approach and stakeholders need to be receptive to the plans and their implementation, and therefore need to be involved right from the start of the UWCS assessment. As in the case of the European green city index (2009), the City Blueprint can play an important role in the assessment of the UWCS. The next steps to implement this approach, which at this stage should be seen as a proposal by KWR, should include the indicators presented in Table 2.

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- A further key stakeholder dialogue to refine the proposal as presented to decide on: (a) the spatial scale, (b) the indicators and their reference values, (c) the appropriate methodology, tools and data in order to quantify them (Van Leeuwen *et al*, 2012).
- Further case studies to implement and test the approach in practice by following the "learning by doing" approach. The preliminary scoring of the city of Rotterdam (Figure 4) confirmed the data limitations issue and highlighted the need to present the results in a comprehensive manner.
- A comparison of cities using this indicator approach. This will probably require a set of clear questionnaires and an expert panel process as used for the European green city index (2009).

The concept of water footprint was developed by Hoekstra in 1992 (Hoekstra, 2003) and consists in a comprehensive indicator of freshwater use which encompasses the direct and indirect use of a consumer and producer including its full supply chain (Hoekstra *et al*., 2011). The idea of urban metabolism is related to resource and material flow accounting where the stocks and flow paths of resource/material along with all the uses into certain boundaries are determined (Fischer-Kowalski and Habert, 1993) and the ecosystem services correspond to the benefits from a multitude of resources and processes that are supplied by natural ecosystems (Bolund and Hunhammar, 1999).

Table 2: Description of the indicators for the City Blueprint (van Leeuwen et al., 2012).

Water security	
1. Total water footprint:	Total volume of freshwater that is used to produce the goods and services consumed by the community
2. Water scarcity	Ratio of total water footprint to total renewable water resources
3. Water self-sufficiency	Ratio of the internal to the total water footprint. Self-sufficiency is 100% if all water needed is available and taken from within the own territory

Water quality	
4. Surface water quality	Assessment of quality based on international standards for e.g., microbial risks, nutrients, BOD and (an)organic micro-contaminants
5. Groundwater quality	Assessment of quality based on international standards for e.g., microbial risks, nutrients, BOD and (an)organic micro-contaminants

Drinking water	
6. Sufficient to drink	Percentage of city population, with potable water supply service
7. Water system leakages	Percentage of water lost in the distribution system
8. Water efficiency	Assessment of the comprehensiveness of measures to improve the efficiency of water usage
9. Consumption	Domestic water consumption per capita (liters/day)
10. Quality	Percentage of drinking water meeting the WHO water quality guidelines

Sanitation	
11. Safe sanitation	Percentage of city population served by waste water collection and treatment
12. Sewage sludge quality	Percentage of sewage sludge that can be safely used in agriculture based on (an)organic micro-contaminants
13. Energy efficiency	An assessment of the comprehensiveness of measures to improve the efficiency of waste water treatment
14. Energy recovery	Percentage of waste water treated with techniques to generate and recover energy

15. Nutrient recovery	**Percentage of waste water treated with techniques to recover nutrients, especially phosphate**

Governance	
23. Management and action plans	**Measure of local and regional commitments to adaptive, multifunctional, infrastructure & design demonstrated by the ambition of the action plans and the actual commitments**
24. Public participation	**Proportion of individuals who volunteer for a group or organization employed as a measure of local community strength and the willingness of residents to engage in activities for which they are not remunerated**

Lundin *et al.* (1999) and Lundin (2003) developed a set of sustainability indicators to assess progress of water and wastewater systems towards or away from sustainability. The indicators embrace environmental and technical factors and were chosen taking into account a number of principles.

The International Hydrological Programme together with the ASCE (ASCE and UNESCO, 1998) developed criteria and guidelines on water resource system sustainability. They acknowledged the multidisciplinary, multiobjective and multiparticipatory characteristics of water resource sustainability, highlighting that it includes economic, environmental, ecological, social and physical objectives.

As it is generally known, the inertia associated with administrative systems is probably one of the main obstacles to achieving a more sustainable urban water management. This has lead Brown (2008) to investigate the ability of local governments to practice sustainable management of UWCS in metropolitan Sydney (Australia). Brown (2008) proposed a typology of five organizational development phases for a sustainable urban water management (including the project, outsider, growth, insider, and integrated development phases) as a heuristic model and/or a capacity benchmarking tool for stakeholders. The results showed that both the political institutionalization of environmental concerns and the commitment to local leadership and organizational learning 'are key corporate attributes for enabling sustainable management'.

Also in Australia, Mitchell (2006) analysed the concept of IUWM as an important pillar for sustainability. A comprehensive process of urban water services, where drinking water supply and wastewater collection systems are the components of an integrated 'physical system', encompasses also the organizational framework and the surrounding environment. The author proved to be possible to implement the IUWM approach successfully being technically reasonable and acceptable to stakeholders. However, it can be improved, including the knowledge dissemination and sharing of learning, improving skills of a larger number of employees, and evaluating the performance of the IUWM systems and their technological components. The water recycling, the water efficiency programmes, and the water sensitive stormwater management are some of the available IUWM tools that are combined to result in the integrated total system solutions, required by urban communities. According to Mitchell (2006) the IUWM approach takes into account that: a) all components of the water cycle are deemed in an integrated system; b) all dimensions of sustainability are balanced; c) all stakeholders including all water users are involved; d) all water uses are addressed and e) all particularities of the local context are considered.

Taylor (2008) highlighted and discussed ten attributes of emergent leaders (also called 'champions') which are important agents that encourage and lead to processes of change, playing a key role in promoting a more sustainable urban water management. This research was intended to provide a 'platform of knowledge', and a set of practices, to support management strategies to be implemented in the water agencies, contributing to achieve more ''water sensitive cities'.

Resulting from the need for new actions to attain sustainable management of urban water systems, Bertrand-Krajewski *et al.* (2000) identified methodological issues associated with modelling, decision-making tools, definition of objectives, metrology and multidisciplinarity. For the authors they are necessary conditions for improving the knowledge on the indicators and criteria used in assessment methodologies for sustainability. They adopted two integrated approaches: one in the scope of time and space scales and the second in the field of multidisciplinarity. The authors identified three groups of methodological problems that hinder a proper assessment of the indicators and criteria, respectively the clear definition of objectives and operational objectives, the concerted and multidisciplinary measurements and the quality of the metrology.

In the UK, the concern about sustainability, in broad terms, is present in several documents (see, e.g. DETR, 1999). Water UK, the industry umbrella in the water sector, developed a set of 25 indicators to measure the water utilities progress towards environmental sustainability (Water UK, 2000). From then on, this organisation has computed a set of sustainable water indicators on an annual basis (see Water UK, 2010). Later, a research project called SWARD carried out by several English and foreign partners, mostly universities, developed a sustainable water services procedural guide (Ashley *et al.*, 2003 and 2004). This tool intends to help water utilities to make sustainable decisions. It distinguishes between principles, criteria and indicators of sustainability. According to the project, the criteria (dimensions) are categorised, as already mentioned, into economic, environmental, social and technical and each one of them into performance indicators.

In the US, a recent research reinforced the role of IWRM policy to increase the sustainability in water systems (Monsma *et al.*, 2009). A set of 20 performance metrics was developed to support financially and environmentally the sustainable path for the US water infrastructure. It includes the following elements: transparency, good governance, costs of development, security and emergency preparedness, stewardship, public outreach and stakeholder investment, full cost pricing, asset management, conservation and water efficiency, energy management, climate change mitigations and adaptation, modernised plant operations, watershed and regional optimisation, regulatory optimisation, affordability, advanced procurement and project delivery methods, environmental impacts, network optimisation, workforce management and research, and technological and managerial innovation.

EPA, in the US, (see http://water.epa.gov/infrastructure/sustain/) has been committed to promoting sustainable practices considering three different levels, respectively the sustainable water infrastructure in the base level relative to the sustaining of the infrastructure systems (collection and distribution systems, treatment plants and other infrastructure), sustainable water sector systems in an intermediate level embracing all aspects of the utilities and systems that provide water and wastewater services and, finally, the sustainable communities in the upper level where the role of water and wastewater services in furthering the broader goals of the community is promoted. Several workshops have been held and a large amount of documentation about sustainability issues in the UWCS, including best practices in particular issues, has been released (see, for example, for the reduction and optimisation of energy consumption, EPA 2008).

Some authors defend that the decision support framework for urban water management sustainability should incorporate adaptive management and integrated urban water management at the strategic and operational levels and that social learning and engagement is necessary for those purposes (Pearson *et al.*, 2010). Other authors point out the role of sustainability learning in natural resource integrated assessment and management (Tàbara and Pahl-Wostl, 2007) and the relevance of a more integrated and participatory management style (Pahl-Wostl *et al.*, 2007) and others state that the sustainable development is a process in which the essential feedback loops (Bagheri and Hjorth, 2007).

Rijsberman and van de Ven (2000) defined four different approaches to assess sustainable development, as follows: a) norms and environment: capacity approach; b) norms and people: ratiocentric approach; c) values and people: sociocentric approach; and d) values and environment: ecocentric approach. They argue that there are no objective solutions to complex problems and that the assessment of sustainability in urban water management should be based simultaneously on the four approaches referred to.

The sustainability of water and wastewater services is also a concern expressed in the ISO 24.500. Besides the definition of performance indicators for service improvement (and so for sustainability), the ISO 24.500 series makes reference to the 'sustainability of water and wastewater utilities' (in particular chapters) and to a 'sustainable development of the community'. In this regard, the utilities must 'address sustainable development, i.e. the ability for the community to grow and prosper within the environmental, infrastructural and economic resources available, without limiting the use of those resources by future generations.' Moreover, the ISO 24.500 states that the utilities should a) contribute to and implement sustainable water resources management policies and practices, b) contribute to development planning and resource allocation through consultation, provision of information and analysis in conjunction with appropriate institutions, c) contribute to public health and safety, and d) implement information and education of the community on these topics, particularly on the efficient use of water and pollution prevention.

Global Reporting Initiative (GRI) gained significance for the water utilities worldwide by producing a comprehensive sustainability reporting framework. This type of reporting revealed itself very important for the utilities since it makes utilities capable to manage their impact on sustainability development, showing them great ability to exert positive change on the state of the economy, and environmental and social conditions. The acceptability of this reporting is also linked to its capability to measure, track, and improve utilities' performance on specific issues; and, subsequently, reduce potential business risks (GRI, 2011). Moreover, GRI helps the utilities and other organisations to manage and promote transparency and accountability since all the information is in the public domain. Finally, performance can be monitored yearly, and/or compared to other similar utilities. Figure 5 shows the GRI reporting framework.

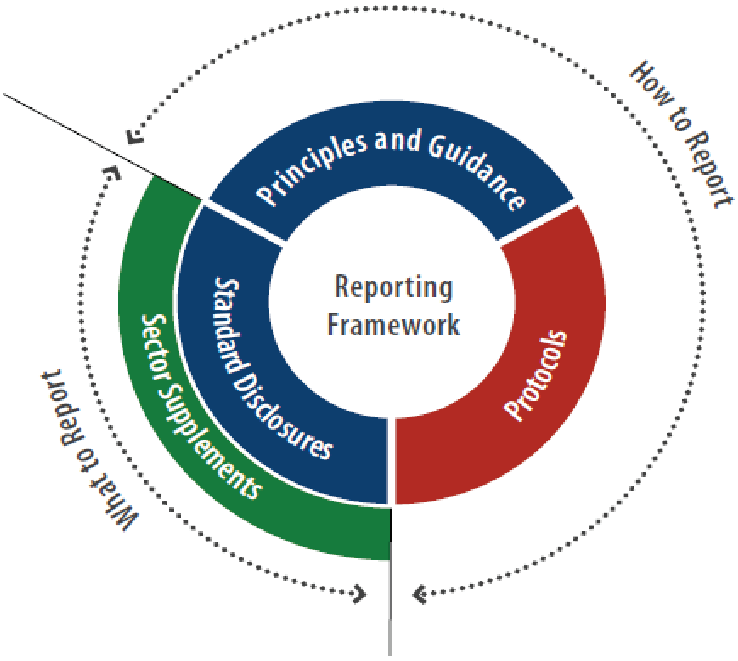

Figure 5: GRI reporting framework (GRI, 2011)

In addition to the SWARD research project already mentioned, several other projects have been developed, encompassing, at least in a certain way, the UWCS sustainability. One of them was the SWITCH project – Managing water for the city of the future (www.switchurbanwater.eu/). This project, carried out between 2006 and 2011, which includes 33 partners from 15 countries, had the major aim of challenging the current paradigm in the water sector and finding and fostering more suitable alternatives to manage urban water. SWITCH followed the IWRM approach and looked towards water management in the 'city of the future.' SWITCH also proposed to carry out things in a different way by developing action-orientated research in cities that were more demand-ed, reflecting their expressed needs. The SWITCH project adopted the social, economic and environmental perspectives of sustainability, a wide range of climatic, socio-economic and institutional situations, considering water as part of urban planning and the built environment from the present time to the 'City of the Future'.

Several publications and contributions for the literature were released with the EU project (see, for example, Jefferies and Duffy, 2011, van der Steen and Howe, 2009 or Van der Steen, 2011). However, the many relevant achievements of the EU SWITCH project are worth to be mentioned here. One of the SWITCH reports (van der Steen, 2011) has provided a typology of cities that may be relevant in the context of TRUST. Furthermore, Annex 1 of the report provides a long list of indicators relevant for UWCS. Van der Steen concluded that cities are different all over the world, and therefore also the challenges to achieve a sustainable urban water system. Indicators likewise will be different in the various cities. An indicator that may be relevant in one city may be irrelevant in another city. Though each city is different, one could group cities into certain categories, based on a number of city characteristics. He categorized cities according to the following characteristics:

- Cities where affordability of basic services is an issue
- Cities with strong capacity in the water sector
- Cities with a tropical rainfall pattern
- Cities with a moderate rainfall pattern, affected by climate change
- Cities with scarcity in water resources
- Cities with potential for reuse of treated wastewater

Furthermore he concluded that cities can be divided in 3 groups, each with a separate typology:

- Type 1 - Water management driven by basic service issues
- Type 2 - Water management driven by water scarcity
- Type 3 - Water management driven by climate change effects on rainfall patterns, flooding and water quality

Several publications and contributions for the literature were released with the EU project (see, for example, Jefferies and Duffy, 2011, van der Steen and Howe, 2009 or Van der Steen, 2011).

TECHNEAU (www.techneau.org/) is also an EU funded research project, which challenged the current state of affairs in the water sector to deal with present and future global threats and opportunities. Looking for the present solutions, it investigated new and improved technologies for the whole water supply chain, including flexible, small scale and multi-source supplies, using non-conventional resources like brackish ground water, treated wastewater and urban groundwater. TECHNEAU addresses these issues for both developed and developing countries. The sustainability concept is not explicitly used, although it is present in the whole project. Several TECHNEAU documents had been published (see, for example, van der Hoven and Kazner, 2009).

PREPARED Enabling Change is another EU project (www.prepared-fp7.eu/) which intends to show the technological preparedness of urban water services to adapt to the expected impacts of climate change. It includes 10 European cities. PREPARED will demonstrate that the UWCS can adapt and be resilient to the challenges of climate change. In addition, it will show that the technological, managerial and policy adaptation required might be cost effective, carbon efficient and exportable to other urban areas within Europe and the rest of the world. The project started in 2010 and will finish in 2015. Other projects, such as the WssTP - A Common Vision for the European Water Industry (www.wsstp.eu/) or the WATCH - Integrated Project Water and Global Change (www.eu-watch.org/) and the AquaStress (www.aquastress.net/) are also relevant and linked to the UWCS sustainability.

2.4. Worldwide experiences of UWCS sustainability assessment

Nowadays, the success of a water (wastewater) utility does not only take the provision of drinking water supply or the collection of wastewater with quality but also how its actions and decisions impact on people, places and associated resources, considering the short and long-term horizons. In this regard, the water utilities have begun to implement new approaches to evaluate themselves besides the economic performance. Some of them are related directly to the sustainability assessment, including the TBL approach, focusing on the financial, environmental and social performance, and other sustainability scorecards embracing also other dimensions. Notice that water utilities are not synonymous with UWCS but they are an important component of them and they are often the gear to implement the sustainability practices in UWCS.

Despite the fast adoption of sustainability scorecards among water utilities and UWCS in some countries, we notice that there are still few examples where this kind of procedure is adopted. One notable exception are the Australian water (wastewater) utilities which have had a pioneering position in this domain. We found other relevant case-studies in the US, the UK, Canada, Singapore, Philippines, Israel and in some European countries. As expected and understandable, in most developing countries sustainability is not a priority yet. Here, we highlight some Australian examples such as Sydney Water, Melbourne Water and Water Corporation Companies. Afterwards, we present other examples across the world including the EPAL (in Portugal), Water UK (the association of water and wastewater utilities in the UK), Watercare (in New Zealand), Public Utilities Board (Singapore), Manila Water (in Philippines), Tel-Aviv-Yafo urban water system (Israel), and Seattle and San Francisco Public

Utilities (in the USA). A summary of the research done and of the use of UWCS sustainability scorecards in the empirical world is presented in an ANNEX.[1]

Sydney Water (in Australia)

The Sydney Water Company applies the 'Sustainability Scorecard' whose objectives integrate the social, economic and environmental concerns of the company's performance. The Sustainability Scorecard, which is yearly reported, comprises the company's sustainability performance measurement. It measures performance through sustainability indicators and defines objectives for the metrics determined. The Sustainability Scorecard encompasses summary statements and progress ratings based on management evaluation of Sydney Water's performance against its sustainability indicators.

This methodology includes a set of performance indicators focused on serving customers (3 indicators), maintaining a water efficient city (4), providing clean and safe drinking water (2), contributing to clean beaches, oceans, rivers and harbours (4), optimising resource use (5), developing a safe, capable and committed workforce (5), and being an economically efficient business (4).

Table 3 shows the Sustainability Scorecard developed by Sydney Water.

Also in New South Wales (NSW), the NSW Office of Water and IPART (water regulator) apply a TBL approach for each water utility in order to provide a balanced view of the long-term sustainability. The TBL report include a summary of the utilities' compliance with the requirements of the 'best-practice guidelines and its performance for over 50 key performance indicators together with the state-wide medians.'

In NSW the water utilities are ranked (according to the quartile) and compared with similar (sized) utilities not only to identify the best practices but fundamentally to assist the utilities in quickly identifying any areas of apparent under-performance.

Table 3: Sustainability scorecard developed by Sydney Water

Objective	Performance assessment
Serving costumers	Customer satisfaction Social assistance Service quality and system performance
Maintaining a water efficient city	Reuse and recycling Water leakage Demand management Water drawn

[1] The review of empirically studies was focused predominantly in the English, French, Spanish and Portuguese speaking countries. It is possible that other language speaking countries, mostly in Europe use also UWCS sustainability scorecards.

Providing clean and safe drinking water	Water quality Customer satisfaction with water
Contributing to clean beaches, oceans, rivers and harbours	Wastewater treatment system discharge Breaches of statutory instruments Environment performance monitoring Trade waste agreements
Optimising resource use	Environment footprint Energy use By-products Waste minimisation Flora-fauna and heritage
Developing a safe, capable and committed workforce	Safety Capability Key behaviours Work-life balance Staff engagement
Being an economically efficient business	Profitability Return on assets and equity Debt service Infrastructure management

Moreover, the TBL report also includes a graphic presentation of the performance of the water utilities over the past 10 years for 15 key indicators, allowing for identifying and analysing trends over time. Each water utility based on TBL performance reports have to provide an Action Plan to the Council that addresses areas of under-performance.

Melbourne Water (in Australia)

The Melbourne Water also applies a TBL approach to evaluate solutions and strategies for the company. Regarding the financial aspects, it distinguishes the financial impact i) on the company; ii) on other companies; and iii) on local/regional economy. Concerning the environmental performance, it considers the iv) air; v) water; vi) land; vii) materials / resource use and waste. Finally, for the social impact, Melbourne Water takes into account the viii) water (consumptive use); ix) built environment; x) safety; xi) nuisance; xii) access; xiii) cultural heritage; xiv) reputation; xv) education; and xvi) jobs.

Water Corporation (in Australia)

Water Corporation (in Western Australia) has the responsibility to ensure a service provision with sustainable future, maximising economic, environmental and social benefits while minimising the environmental footprint. In this regard, the company focuses its annual performance evaluation on social performance [employment and workforce (8 indicators), public amenity (1), public health - safe drinking water (8), essential service provision (5) and demand – supply balance (2)], environmental performance [ecosystem protection (2), energy and greenhouse gases (4), materials use efficiency (1) and demand-supply balance (2)], economic performance [financial efficiency (8) and asset performance (3)], stakeholder performance [customer service (10) and shareholder accountability (1)]; and ethical and governance performance [compliance (4)].

Figure 6 shows the business principles of the Water Corporation.

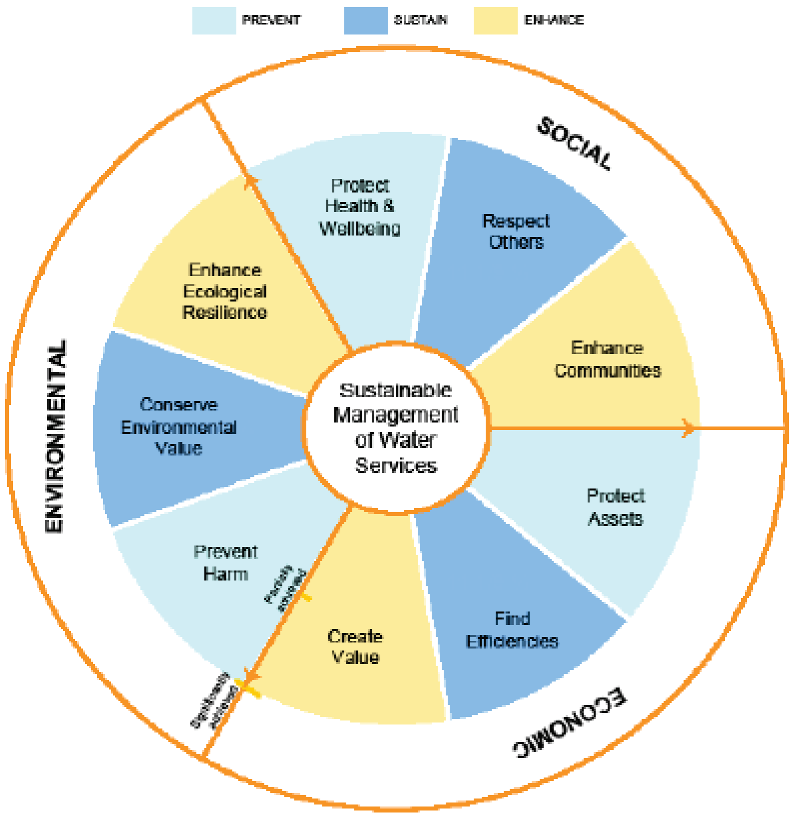

Figure 6: Water corporation business principles

EPAL (in Portugal)

In Portugal, EPAL (the Lisbon state company) has developed a sustainability report since 2005. It also adopted a TBL approach following the GRI methodology, evaluating its economic, environmental and social performance. Concerning the economic performance, EPAL calculates 9 performance indicators subdivided into economic (4), presence in the market (3) and indirect economic impact (2). For the environmental impact (24), it focuses on materials (2), energy (4), water (3), biodiversity (3), emissions, effluents and waste (10), product and service (2), compliance (1) and generalities (1). Finally, regarding the social performance (13), the analysis is based on employment (3), workers and company relationship (2), work safety and health (3), training (3) and equality (2).

Water UK (in the United Kingdom)

The Water UK also uses a system of integrated performance evaluation which includes 36 performance indicators covering 5 main sustainability dimensions, such as: customer experience (drinking water quality, low pressure supply, interruptions and sewer flooding);

climate change and energy (energy and emissions); natural resource protection (water abstraction, demand and leakage); sustainable consumption and production (water use, chemicals, sludge management and waste); and corporate governance, management and performance (cash interest cover, management systems for sustainability, public health, accidents, employment and investment).

Figure 7 shows the report card of the Water UK.

Watercare (in New Zealand)

Watercare (provides water and wastewater services in the Auckland region) sustainability performance measurement is aimed at 42 different targets within eight focus areas. These areas are a) safe and reliable water (7 indicators); b) healthy waterways (4); c) health, safety and well-being (7); d) customer satisfaction (4); e) stakeholder relations (3); f) sustainable environment (9); g) effective asset management (4); and h) sound financial management (4). These performance metrics are determined on an annual basis.

Indicator	Measure	Units	Result 09/10	Result 08/09	Progress
Company Water Use	Amount of water used, per 1,000 full time employees on water company sites	Megalitre per 1,000 Full Time Employees per annum	8.9	9.4	✔
Chemical Use in Water Supply	Chemicals used per Ml of water supplied	tonnes/ Megalitre	0.074	0.076	✔
Chemical Use in Wastewater Treatment	Chemicals used per Ml of wastewater treated	tonnes/ Megalitre	0.073	0.079	✔
Use of Aggregates	Aggregates procured from a recycled source	percentage	25.6	19.3%	✔
Sludge Management	Total wastewater sludge	thousands of tonnes of dried solids	1,698	1762	✔
Sludge Use	**Wastewater sludge sent for recycling (agriculture, land reclamation, other)**	**percentage**	**70.8%**	**84.3%**	✘
Non-sludge waste	Other waste recycled	percentage	67.3%	73.3%	✘
Cash Interest Cover	Sector cash interest cover ratio	Ratio	4.9	4.7	✔
Management Systems for Sustainability	Number of companies with certified or non-certified Environmental Management System (EMS) in place across all or part of their operations	count	18	14	✔
	Number of companies with certified or non-certified Quality Management System (QMS) in place across all or part of their operations	count	17	17	↔
	Number of companies with certified or non-certified Health and Safety Management System in place across all or part of their operations	count	20	19	✔
Contracts with Sustainability Criteria	Sustainability criteria and weighting used in contracts for goods and services	percentage (range)	0-75%	0 – 60%	N/A
Convictions for environmental and public health offences	**Number of convictions (sector total)**	**count**	**42**	**61**	✔
Reported Accidents	Major/fatal accidents to employees arising whilst undertaking water company related activities	count per 1,000 direct employees	1.20	1.36	N/A
Occupational Ill Health	Days lost due to occupational ill health (sector average)	days per direct employee	165.5	171.4	N/A
Employee Turnover	Employee Turnover (sector average)	percentage	9.4%	9.2%	✘
Employee Absence	Number of days lost through absence during the reporting year (sector average)	days per direct employee	7.4	7.6	✔
Community Investment	Total value of financial contributions to community during reporting year	£ thousands	8,742	10,363	N/A
Drinking Water quality	Compliance with drinking water standards, England and Wales	percentage	99.95%	99.96%	↔
	Compliance with drinking water standards, Scotland	percentage	99.78%	99.75%	✔
	Compliance with drinking water standards, Northern Ireland	percentage	99.74%	99.49%	✔
Low Pressure Supply	Number of properties in the UK with a low pressure supply	count	7,770	15,364 9,594 exc NIW	✔
Water Supply Interruptions	**Number of properties with interruptions to supply (> 6 hours in duration)**	**count**	**119,880**	**119,061**	✘
Risk of Sewer Flooding	**Number of properties at risk of sewer flooding at least once in every ten years**	**count per 100,000 properties**	**19.1**	**25.2 22.1 exc NIW**	✔
Incidents of Sewer Flooding	Number of properties actually affected by sewer flooding	count	6,476	6,022 6,019 exc NIW	✘
Total Energy Use	Energy used for operational purposes	Gigawatt Hours	9,012	8,650	✘
Renewable Energy Generation	Renewable energy generated by water and wastewater companies	Gigawatt Hours	665	742	✘
Renewable Energy Purchased	Renewable energy purchased by water and wastewater companies	Gigawatt Hours	187	767	✘
Greenhouse Gas Emissions	Total greenhouse gas emissions	Million tonnes CO_2e	4.95	5.07	N/A
Greenhouse Gas Emissions – water supply	**Greenhouse gas emitted in supplying water**	**tonnes CO_2e/ Megalitre**	**0.34**	**0.30**	✘
Greenhouse Gas Emissions – wastewater treatment	**Greenhouse gas emitted in wastewater treatment**	**tonnes CO_2e/ Megalitre**	**0.70**	**0.75**	✔
Water Abstraction - Total volume relative to licensed quantities	Total annual volume of water within abstraction licences	Megalitre/year	-4,813,787	3,594,014	✔
Water Abstraction – Total volume relative to licensed quantities (percentage)	Total annual volume of water within abstraction licenses	percentage	-40%	37.7%	✔
Water into Supply	Total volume of water put into supply	Megalitre/day	17,261	17,380	✔
Domestic Water Demand	Domestic water demand	litres/head/day	149.8	147.4	✘
Water Saved Through Demand Management Measures	Water saved through demand management measures (households and non-households)	Megalitre/day	18.4	61.0	✘
Total Loss from the Supply Network	Total leakage	Megalitre/day	4,251	4,341	✔
Relative Loss from the Supply Network	**Total leakage per 100 km of supply main (average)**	**Megalitre/day**	**1.03**	**1.06**	✔
Status of Sites of Special Scientific Interest (SSSIs)	SSSI land in target condition (England only)	percentage	96%	91%	✔
	SSSI features target condition (Scotland only)	percentage	70.3%	70.3%	↔

Figure 7: Report card of the Water UK

Tel-Aviv-Yafo urban water system (in Israel)

In Tel Aviv, the plan to provide a sustainable urban water system encompasses a set of 49 performance indicators, which are allocated to 13 distinctive objectives. For the water service, the objectives are: a) improving consumer service, b) information transparency, c) fairness and affirmative action to the city's southern and eastern sections, d) a reliable water supply to all the municipal customers, e) water quality, f) avoiding water supply and environmental contamination and advancing the removal of existing pollutants, g) avoiding waste of water and energy in the system, and, finally, h) development, operation and maintenance of the system at optimal costs. For the wastewater service, the aims are: a) connecting, collecting and transporting the sewage efficiently from all its producers, b) avoiding sewage related sanitary & environmental hazards (including sea and river pollution), c) avoiding contamination of the municipal sewage by hazardous industrial and commercial effluents, d) development, operation and maintenance of the system and optimal costs, and, ultimately, e) fairness and affirmative action to the city's southern and eastern sections. For the drainage service, the objectives are: a) managing the runoff within the city limits in a way that maximises its benefits and minimises damages, b) advancing the integration of municipal runoff within the management of the drainage basin runoff, c) reducing flood damages, including environmental damages, as a result of abnormal rain events, d) development, operation and maintenance of the system and optimal costs, and, ultimately, e) fairness and affirmative action to the city's southern and eastern sections. For each indicator, it was defined the 'desired value', the 'current value', and the '5-year target'.

Public Utilities Board (in Singapore)

Public Utilities Board (PUB) has two major programmes that assure the water service sustainability in Singapore, which are the 'Water for All' and the 'Conserve, Value, Enjoy'. In particular, the 'Water for All' encompasses the national sources of water (that is, local catchment, imported water, NEWwater – recycled water and desalinated water); while the 'Conserve, Value, Enjoy' instigate the principles of 'conserve water', 'value our water' and 'enjoy our waters'. Nowadays, NEWwater meets 30% of the national needs. Moreover, to ensure the service sustainability, the PUB: a) manages weather uncertainties and adaptation to climate change and b) develops 'Water Masterplan' to meet the water needs for the next 50 years, resulting in recommendations for the short, medium and long-term.

Manila Water (in Philippines)

Manila Water tries to maintain the service provided financially viable, socially responsible and environmentally sustainable. The water company developed a methodology based on these three concerns (TBL approach). In terms of financial performance the company evaluates the water sales, income, collection and manpower. Concerning the social dimension, the company assures the continuity, connection, and livelihood. Regarding the environmental sustainability, the company measures the water abstraction, energy, legal compliance and BOD removing.

Seattle Public Utilities (in United States of America)

Every year the Seattle Public Utilities department sets out performance objectives, which are included in a performance report card, to ensure that they are continuously improving while providing friendly and efficient customer service. The report card intends to show the meeting of the objectives set in terms of customer calls answered, water taste, water conservation, drinking water problems, sewer backups, wastewater problems and customer satisfaction (by means of 7 performance indicators).

San Francisco Public Utilities Commission (in United States of America)

The San Francisco Public Utilities Commission includes in its sustainability evaluation the compliance with a set of performance objectives including regulatory requirements (2), partnerships (1), quality of service (2), customer satisfaction, (2), agreements (1), accountability and transparency (1), financial performance (3), contracting out (3), technological innovations (1), assets maintenance (4), facilities improvement (2), affordability (3), billing (3), demand (1), integration of utility's strategic and sustainability planning, management and decision-making (2), risk assessment (1), security and emergency (1), greenhouse gas (2), water reuse and conservation (2), land management (2), energy (2), air emissions (3), inflows and effluent quality (2), in-house environmental impacts (4), environmental justice (2), community awareness (1), community partnerships (2), participation (1), community benefit programs (3), labour practices (1), employment health and safety (2), communication (1), employment expectations (2), leadership (1). These performance indicators are organised in 6 main groups which are governance and management, infrastructure and assets, customers, environment and natural resources, community and workplace.

3. OBJECTIVES, CRITERIA AND PERFORMANCE METRICS

3.1. Introduction

Taking into account the literature review and our expertise, this section proposes a UWCS sustainability scorecard which is associated with its dimensions, objectives, criteria and indicators (or other performance metrics). Note that the aim of this section (or of this document) is not to define in detail the performance metrics that assess the UWCS sustainability. This is a task of WP3.1 of the project TRUST. However, our proposal is presented for the purpose of recommending the MCDA approach to assess the UWCS sustainability. We discuss criteria and performance metrics adopted with people from WP3.1 and include some of the criteria and performance metrics used by them in a very draft proposal, in particular those concerning the social, environmental and economic dimensions.

3.2. Objectives

Associated with dimensions or the principles of UWCS sustainability, we defined its specific objectives. These objectives, in opposition to the dimensions that have a more transversal scope, depend on the field where sustainability is being assessed. Therefore, we set out specific and elaborated objectives for the UWCS which can change in intensity according to water utilities patterns and their stakeholders. Most of them are not found in other sectors but all of them embrace the TBL approach together with infrastructural and governance dimensions. Based on the literature and from discussion with experts, including other teams of the TRUST project (in particular the WP3.1), we defined 14 objectives for the sustainable UWCS. They are presented in figure 8.

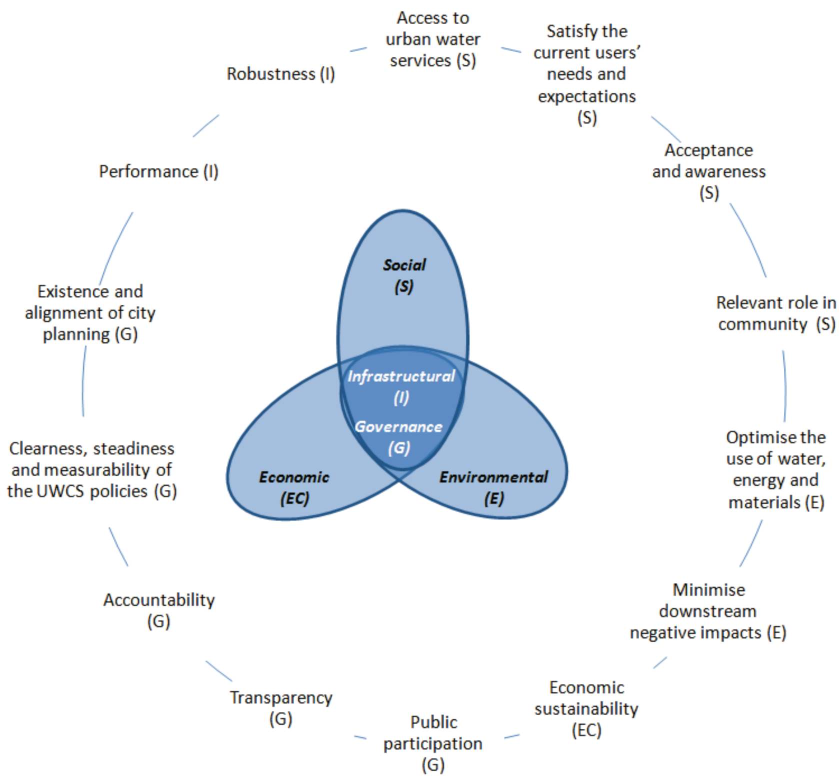

Figure 8: Objectives of sustainability of UWCS

Concerning the social dimension, sustainable UWCS should ensure access to urban water services and these services must effectively satisfy the current users' needs and expectations. Nowadays, urban water services are clearly customer oriented and the priorities, in opposition to what happened in the past, are not simply related to the availability of the service. Furthermore, sustainability should imply the acceptance of the UWCS and its role in the community should be relevant. As far as the environmental dimension is concerned, sustainable UWCS should include the optimisation of the use of water, energy and materials and minimise downstream negative impacts (effluents, emissions and waste). Guaranteeing the UWCS economic sustainability corresponds to the objective of the economic dimension and includes criteria related to the investment required, efficiency, leverage and liquidity. The coverage of the costs assumes a very important role here, but it is not the unique performance metric to make the UWCS sustainable in this view. Concerning the governance dimension of the UWCS sustainability, public participation in the water related activities should be effective, particularly in setting objectives and expectations (or the levels of service). Participation of stakeholders is obligatory at the river basin level according to the EC Water Framework Directive and is needed to a better acceptance and awareness of stakeholders. Transparency is also a key issue. Information and publications should be available in quantity and quality. They should be accurate, useful and accessible. Stakeholders should be more water 'literate'. Furthermore, accountability should also be ensured in the UWCS, as well as clearness and steadiness in the policies followed. The UWCS policies adopted should be measurable over time, coherent, consistent and independent of political cycles. All these issues are essential for the UWCS governance. Transparency and accountability are major principles in public services, irrespectively of being provided by private or public firms. The UWCS are also acknowledged as an integrated part of city planning and have important interfaces in areas such as energy, transportation, leisure and community development. Being such an important part of the cities, they influence their liveability and sustainable development (Binney *et al.*, 2010). Urban water services should be valued both socially and economically and should be supplied with high quality so that customers may accept the value paid. Finally, ensuring the infrastructural dimension supposes that infrastructure performance is improving over time and that the levels of service provided do not decline under any circumstance. Likewise, it is expected that the infrastructure is robust enough to adapt to demand and to face systematic or occasional adversities. Population growth (or decay), stringent regulations, climate variability, technological evolution and stricter customer expectations will demand a better performance and response of infrastructure.

3.3. Criteria

There are criteria associated with each objective of the UWCS sustainability. Those objectives are achieved if the corresponding criteria are fulfilled. For example, to achieve the objective for UWCS sustainability of 'ensuring access to urban water services' the satisfaction of the criteria a1) Physical service accessibility and a2) Economic service accessibility are required either for the objective to 'effectively satisfy the current users' needs and expectations' the criterion b1) quality of service should be guaranteed. Table 4 presents the criteria for the objectives defined for the UWCS sustainability.

3.4. Performance metrics

There will be metrics for each criterion (not only performance indicators but other metrics, such as best practices check lists, results of inquiries,…) which will allow for its assessment. As mentioned, the objective of this report is not to define the metrics for each criterion of each objective of UWCS sustainability, which will be discussed in detail in the WP3.1 of the TRUST project. However, some suggestions are given for the guidelines of MCDA and for a first preliminary assessment of UWCS sustainability. Thus, the following metrics are hypothesis for each criterion (relative to each objective of UWCS sustainability) defined in Table 5. For example, for the physical service accessibility, the performance indicators of water and wastewater services coverage might (should) be considered or for the economic service accessibility relative to the affordability by the customers, the performance indicators might be, for example, the price for the first 12 m^3 household consumption or the average bill.

Table 4: Dimension, objectives and criteria of the UWCS sustainability

Dimension	Objectives	Criteria
Social	a) Access to urban water services	a1) Physical service accessibility a2) Economic service accessibility
	b) Effectively satisfy the current users' needs and expectations	b1) Quality of service b2) Drinking water quality
	c) Acceptance and awareness of UWCS	c1) Willingness to pay c2) Complaining c3) Acceptance of new sources of water
	d) Relevant role in community	d1) Social responsibility d2) Work conditions
Environment	e) Optimise the use of water, energy and materials	e1) Efficient use of water e2) Energy use e3) Material use e4) Final uses of efficiency
	f) Minimise downstream negative impacts	f1) Pollution prevention f2) Pollution control
Economic	g) Ensure economic sustainability of the UWCS	g1) Investment g2) Efficiency g3) Leverage g4) Liquidity
Governance	h) Public participation	h1) Participation initiatives
	i) Transparency	i1) Availability of information and documents i2) Accessible information and written documents i3) Public disclosure
	j) Accountability	j1) Individual mechanisms of accountability j2) Collective mechanisms of accountability
	k) Clearness, steadiness and measurability of the UWCS policies	k1) Clearness of policies defined ex-ante k2) Change of policies k3) Implementation of policies
	l) Existence and alignment of city planning	l1) Corporate planning l2) City planning l3) Water resources planning
Infrastructure	m) Performance	m1) Failures
	n) Robustness	n1) Flexibility n2) Adaptability n3) Reliability

Table 5: Metrics of each criterion of the objectives of UWCS sustainability

Criteria	Metrics
a1) Physical service accessibility	Water coverage; Wastewater coverage
a2) Economic service accessibility	Price of the average household consumption (e.g. 12 m^3); Average bill
b1) Quality of service	Interruptions; Drinking water quality; Flooding of properties; Billing
c1) Willingness to pay	Inquiry on willingness to pay
c2) Complaining	Complaints; suggestions
c3) Acceptance of new sources of water	Acceptance of reclaimed water
d1) Social responsibility	Investment on community
d2) Work conditions	Training; Absenteeism; Work accidents, Employee satisfaction
e1) Efficient use of water	Leakage (real losses); Leakage best practices; Reclaimed water; Use of grey water; Rainwater harvesting; Checklist of best practices
e2) Energy use	Energy efficiency; energy generation; Checklist of best practices
e3) Material use	Checklist of best practices (materials, chemicals and

Criteria	Metrics
	construction)
e4) Final uses of efficiency	Checklist of best practices (water, wastewater, rain water)
f1) Pollution prevention and control	Wastewater treatment coverage; Quality issues (wastewater, sludge, nutrients, treatment failures, ...); Overflow discharges; Greenhouse gas emissions
g1) Investment	Innovation; Maintenance and replacement of assets
g2) Efficiency	Coverage of total costs; Staff productivity
g3) Leverage	Debt equity ratio
g4) Liquidity	Current ratio
h1) Participation initiatives	Check list of best practices
i1) Availability of information and written documents	Check list of best practices
i2) Easiness of access to information and documentation	Check list of best practices
i3) Public disclosure	Check list of best practices
j1) Individual mechanisms of accountability	Check list of best practices
j2) Collective mechanisms of accountability	Check list of best practices
k1) Clearness of policies defined ex-ante	Check list of best practices
k2) Change of policies	Check list of best practices
k3) Implementation of policies	Check list of best practices
l1) Corporate planning	Existence of plans (strategic, tactical, ...)
l2) City planning	Check list of best practices
l3) Water resources planning	Investment on community
m1) Failures	Main failures; Sewer blockages
n1) Flexibility	Checklist of best practices
n2) Adaptability	Checklist of best practices
n3) Reliability	Replacement/rehabilitation; Treatment utilisation; Storage capacity

4. A QUESTIONNAIRE FOR THE BASELINE ASSESSMENT OF UWCS

4.1. Introduction

Water is essential for economic development and for the wellbeing of humans and ecosystems. According to the UN (http://www.un.org/waterforlifedecade), two main challenges related to water are affecting the sustainability of human urban settlements: the lack of access to safe water and sanitation, and increasing water-related disasters such as floods and droughts (see also chapter 2). Furthermore, half of humanity now lives in cities, and within two decades, nearly 60 per cent of the world's people will be urban dwellers. In developed countries more than 80 per cent of the people will live in cities (Figure 9).

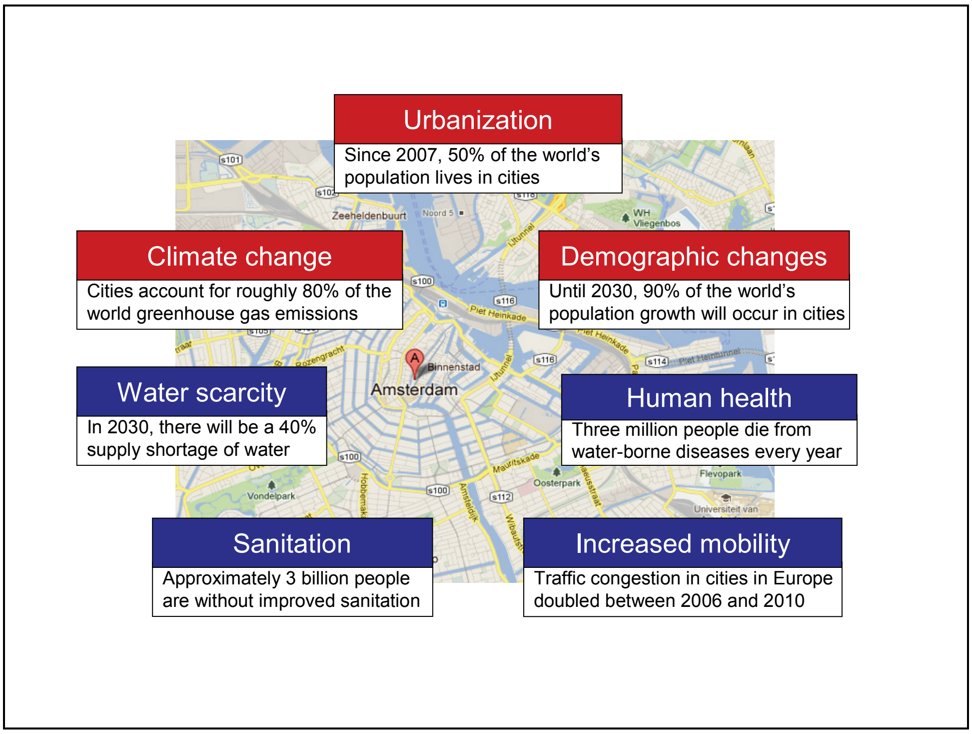

Figure 9: Challenges in cities

Cities cannot be sustainable without ensuring reliable access to safe drinking water and adequate sanitation. According to the European Commission, the balance between water demand and availability has reached a critical level in many areas of Europe (water scarcity) as in the rest of the world. In addition, more and more areas are facing droughts resulting from climate change.

In the context of the TRUST, the decision has been made to analyze the current state and best practices in urban water systems. As part of it, a questionnaire has been developed for a baseline or preliminary assessment to assess the sustainability of the urban water cycle as part of WA 1 (Diagnosis and Vision supervised by Rui Cunha Marques).

4.2. The questionnaire

The questionnaire for the baseline assessment of the sustainability of the UWCS of TRUST cities and regions is based on work by TRUST partners. Valuable input has also been given by Peter Dane (European Bench-mark Co-operation). We have used as much as possible the terminology (and codes) as published by IWA/AWWA (Alegre et al., 2006; Matos et al., 2003). The questionnaire can be seen as a basic SWOT matrix (Strength, Weakness, Opportunities and Threats) framework (figure 10), with a focus on the water and wastewater utilities, but also addressing the external developments (such as urbanization, climate change) and the ambitions and plans to address these in the very near future.

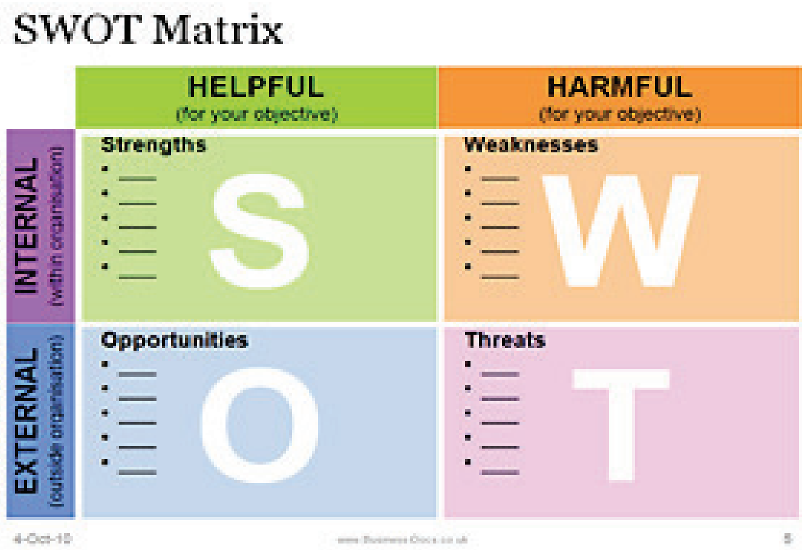

Figure 10: SWOT matrix.

The questionnaire consists of five parts highlighting the TBL aspects as highlighted in the previous chapters of this document (Figures 3 and 8 and Table 4) and consists of 5 parts:

- Part A: General information
- Part B: Drinking water that needs to be provided by the cities involved in TRUST.
- Part C: Wastewater
- Part D: Environmental quality, biodiversity and attractiveness
- Part E: Governance

The final questionnaire for the assessment of the sustainability of TRUST cities and regions has been distributed as an excel file with 5 parts (A-E) and the following categories (question No, Name, Definition, IWA-Code, Unit and a row for the answers). Below you will find the most important parts of this excel sheet (Table 6)

Table 6: Metrics of each criterion of the objectives of UWCS sustainability

No	Name	Definition
A. 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.
C	Household occupancy	Resident population / total number of dwelling units (houses + apartments) Total transmission and distribution ma
D	Supply area (drinking water)	Area that can or is intended to be served by the distribution network
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
F	Annual average rainfall	Annual average rainfall (average for the past 30 years)
G	Daily average air temperature	Average daily air temperature of the year (averages for the past 30 years)
B. 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
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
1c	Natural springs and wetlands sources	Annual abstraction of natural springs and wetlands water / total annual abstraction x 100
1d	Well water sources	Annual abstraction of well water / total annual abstraction x 100
1e	Borehole water sources	Annual abstraction of borehole water / total annual abstraction x 100
1f	Saline and brackish water sources	Annual abstraction of saline and brackish water / total annual abstraction x 100
1g	System input volume	The water volume input of the global system during the assessment period (here: 1 year)
2	Population coverage	Percentage of the resident population that is served by the undertaking.
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.
4	Service connections	Total number of service connections in the supply area, at the reference date
4a	Average household consumption	calculated automatically (A14/C24)
5	Water losses	Water losses per connection and year. This indicator is adequate for urban distribution systems.
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
7	Average water charges for direct consumption	Ratio between the water sales revenue for direct consumption and billed water.
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.
9	Average mains age	Average mains age for the global supply system based on the age of each mains and its length
10	Number of main failures	
10a	Main failures per length	calculated automatically (D28*100/C8)
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
		b) Non controlled groundwater

No	Name	Definition
		c) Reuse of treated waste water
		d) Desalinated water
		e) Other (specify)
		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.
C. 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
		b) Collection and transport
		c) Collection, transport and treatment
		d) Transport
		e) Transport and treatment
		f) Treatment
		g) Other
14	Percentage of population covered by:	a) Waste water collection
		b) Waste water treatment
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
16	Collected sewage (m3/inhabitant)	Collected sewage per inhabitant
17	Sewer system length	a) Length of combined sewers managed by the utility
		b) Length of stormwater sewers managed by the utility
		c) Length of sanitary sewers managed by the utility
18	Wastewater treated	a) Wastewater treated by wastewater treatment plants or by on-site system facilities that are the responsibility of the wastewater utility
		b) Wastewater treated with techniques to generate and recover energy
		c) Wastewater treated with techniques to recover nutrients, especially phosphates
19	Sludge	a) Dry weight of sludge produced in wastewater treatment plants managed by the utility
		b) Dry weight of sludge going to landfill
		c) Dry weight of sludge thermally processed
		d) Dry weight of sludge disposed by other means than energy costs
20	Energy costs	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
21	Average age of the sewer system	Average age of the sewer system based on the distribution of ages and lengths
22	Sewer blockages	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.
D. ENVIRONMENTAL 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).
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

No	Name	Definition
		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).
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)
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).
E. GOVERNANCE		
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
		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
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
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
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
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

No	Name	Definition
		actors, e.g. water companies, cities, provincial or national authorities).Scoring as in No.28
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
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.
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).
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.

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TRANSITIONS TO THE URBAN WATER SERVICES OF TOMORROW

Current State of Sustainability of Urban Water Cycle Services

Part II – Baseline Assessment of the Sustainability of Urban Water Cycle Services

Deliverable 11.1

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Current State of Sustainability of Urban Water Cycle Services

Part II - Baseline Assessment of the Sustainability of Urban Water Cycle Services

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EXECUTIVE SUMMARY

The necessity of Urban Water Cycle Services (UWCS) adapting to future stresses calls for changes that take sustainability into account. Megatrends (e.g. population growth, water scarcity, water pollution and climate change) pose urgent water challenges in cities. This document presents the baseline assessment or quick scan of the sustainability of UWCS for 11 cities, i.e., the TRUST cities (Algarve, Athens, Reggio Emilia, Amsterdam, Hamburg, Oslo, Cities of Scotland and Bucharest), as well as the city of Rotterdam and two African cities in Angola (Kilamba Kiaxi) and Tanzania (Dar es Salaam). Most of the work has been done by the colleagues who completed the TRUST questionnaire for the baseline sustainability assessment of the TRUST cities and regions.

From a methodological point of view, there are options to improve the way the assessments have been made. The scores of the cities are dependent on data availability and quality. 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/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 less biodiverse than national/regional data would suggest.

The baseline assessment showed that the cities vary considerably with regard to the sustainability of the UWCS. We have tried to capture this in the Blue City Index (BCI), the arrhythmic mean of 24 indicators comprising the City Blueprint (van Leeuwen et al., 2012), with a minimum score of 0 and a maximum score of 10. The BCI varied from 3.31 (Kilamba Kiaxi) to 7.72 (Hamburg), but more importantly, it was positively correlated with the Gross Domestic Product (GDP) per person), the ambitions of the local authorities regarding the sustainability of the UWCS, the voluntary participation index (VPI), all governance indicators according to the World Bank, and, last but not least, the happiness of people expressed as happy-life-years, i.e., how long and happy people live.

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. The main challenge is to start the discussion with all stakeholders, to enhance public participation, and to translate the baseline assessments into actions to improve the UWCS of cities in order to address the challenges ahead of us. 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. Cities can learn from each other! Theoretically, if cities would share their best practices, the BCI might reach a value of 9.70, which is close to the theoretical maximum of 10. It 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 is the deliverable D11.1b – Part II. It has the following structure:

Chapter 1 provides the introduction to UWCS.

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 2 in which the information is presented based on the completed TRUST questionnaires and regional/national information provided in public sources. For the introduction of the cities maximum use has been made from the information provided in the TRUST Magazine 02 (2012) about the cities of tomorrow.

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

The report has been presented and discussed at the TRUST Basel Workshop on 4-5 October 2012 and has been modified based on this input.

ACKNOWLEDGEMENTS

I would like to thank the collaborative teams (see table below) involved in the assessment of cities by completing the TRUST questionnaire for the baseline assessment of the sustainability of UWCS. Their feedback on earlier versions of this report is very much appreciated. I would also like to thank Marielle van de Zouwen, Jos Frijns, Theo van de Hoven, Peter Dane, Merijn Schriks, Nicoline Scholman, Rui Cunha Marques, David Schwesig and Sveinung Sægrov for their contributions.

City	Contributions from	Institution
Algarve	Helena Lucas José Gascão Joaquim Freire Maria João Freitas António Jorge Monteiro	Aguas do Algarve LNEC (Laboratório Nacional de Engenharia Civil) LNEC LNEC Instituto Superior Técnico, Portugal
Athens	Christos Makropoulos	National Technical University
Reggio Emilia	Vittorio Di Federico	University of Bologna
Hamburg	Thomas Giese Kim Augustin Niles-Peter Bertram David Schwesig	Hamburg Wasser Hamburg Wasser Hamburg Wasser IWW Water Research Centre
Amsterdam	Ingrid Heemskerk Paulien Hartog Brian Sewbaks	Waternet Waternet Waternet
Oslo	Jadranka Milina Rita Ugarelli	Water and Sewerage Works SINTEF Building and Infrastructure
Scotland	Paul Jeffrey Heather Smith George Ponton Colin O'Neill	Cranfield Water Science Institute Cranfield Water Science Institute Scottish Water Scottish Water
Bucharest	Gabriela Mercore	Apa Nova Bucuresti
Rotterdam	Daniel Goedbloed Kees van Leeuwen	City of Rotterdam KWR Watercycle Research Institute
Kilamba Kiaxi	António Jorge Monteiro	Instituto Superior Técnico, Portugal
Dar es Salaam	Kees van Leeuwen Philipo Chandy	KWR Watercycle Research Institute Ministry of Water, Tanzania

TABLE OF CONTENTS

1. INTRODUCTION

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 Commision, 2012a). 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 (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, 2008; 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).

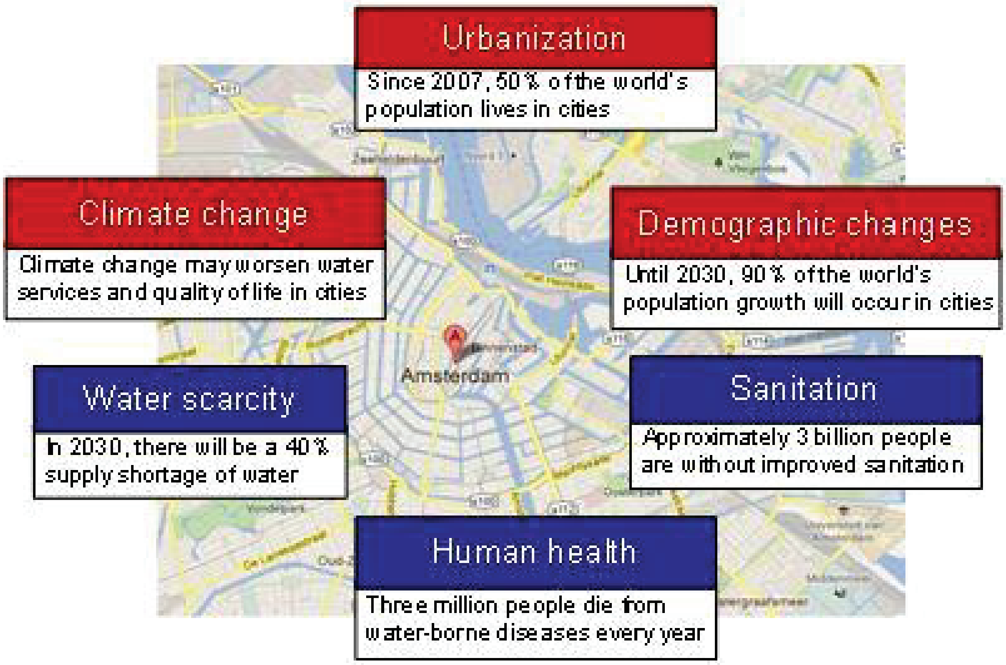

Figure 1. Megatrends pose urgent challenges in cities (Van Leeuwen and Chandy, 2012).

The main objective of TRUST (Transitions to the Urban Water Services of Tomorrow) is to support water authorities and utilities in Europe in formulating and implementing appropriate urban water policies in order to enhance urban water cycle services. TRUST aim is to deliver knowledge to support urban water cycle services (UWCS) towards a sustainable and low-carbon water future without jeopardising service quality. It will do this through research drive 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. Equally, there is currently no consensus on how to assess the sustainability of UWCS.

In the context of the TRUST project it has been decided to obtain data from contact persons in TRUST pilot 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 TRUST pilot 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. Scope of the analysis of cites and regions

Urban water management is complex. It has a wide scope and many stakeholders are involved. Therefore, the baseline assessment of cities and regions in TRUST 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 in TRUST 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 (TRUST, 2012).

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 (TRUST, 2012). 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). The activities in TRUST and the City Blueprint (Marques, 2012; Van Leeuwen et al., 2012; Van Leeuwen and Chandy, 2012) resulted in the development of a questionnaire for the baseline assessment of cities and regions participating in the TRUST project (Annex 1). This TRUST Questionnaire basically covers the aspects shown in Table 1, as well as general information on cities.

The process to gather the data for the baseline assessment and the way the information is presented in this report is given in Figure 2. The assessment criteria as defined within TRUST and presented in Table 1 are also included in Table 2 for each indicator of the City Blueprint.

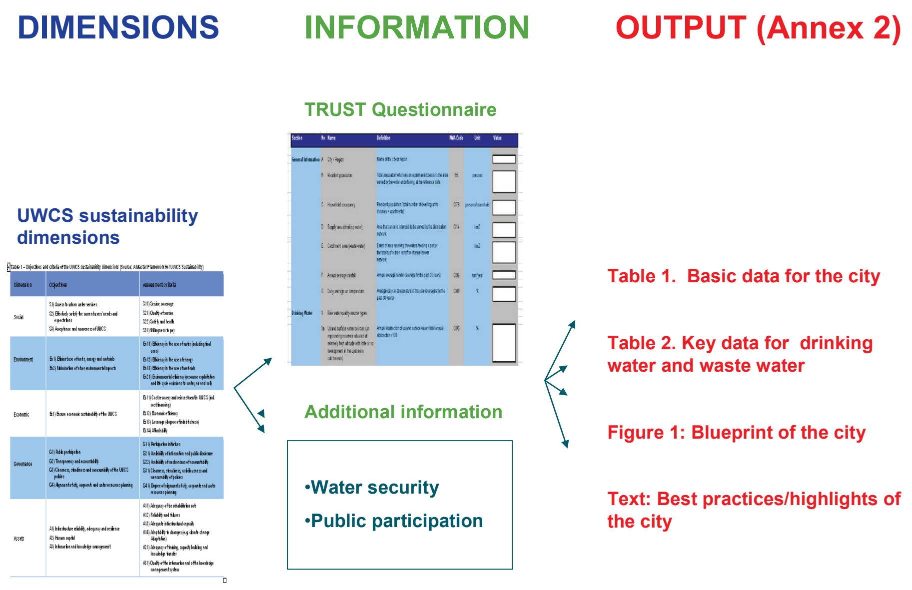

Figure 2. The relation between the UWCS sustainability dimensions (as presented in Table 1 of this report), the TRUST information gathering process (Trust Questionnaire as presented in Annex 1 of this report and the additional data needs) and the output as presented in the reports of 11 cities/regions given in Annex 2 of this report.

Table 2 Indicators of the City Blueprint (Van Leeuwen et al., 20102; Van Leeuwen and Chandy, 2012)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.

2.2. 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.

2.3. Data and calculations

The assessment criteria for the baseline assessment are summarized in Table 1 and 2. Detailed information about the methodology, sources of information and calculations for each of the 24 indicators are provided in Van Leeuwen et al. (2012), Figure 2 and Appendix 1. In this report, slight adaptations were needed compared to our previous work as 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, two indicators were modified. Indicator 12 (Table 2) now focuses on the percentage of total sewage sludge that is recycled (thermally processed or applied in agriculture) and indicator 16 (maintenance) was modified into average age of the infrastructure for wastewater collection and distribution. This was done because the methodology was originally developed for the Netherlands. For instance, the rule of thumb as applied in the Netherlands, that the maximum age of concrete sewer systems embedded in peaty soils should not exceed 40 years, was not longer adequate for the broader range of variations in sewer systems in Europe. In fact, the need for replacement 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 has been renamed by replacing "safety" with climate change adaptation strategies, or in short: "adaptation strategies". All other calculations are identical to the methodology used for the city blueprint calculations of Rotterdam and Dar es Salaam (Van Leeuwen and Chandy, 2012).

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 m3/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 Norway, Dar es Salaam and Angola, as only information was provided for EU countries (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 (URL1; EFILWC, 2006) as described in Van Leeuwen and Chandy (2012).

If, despite the attempts of the partners in the TRUST project and 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.

2.4. 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 in this TRUST study.

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 can not 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.

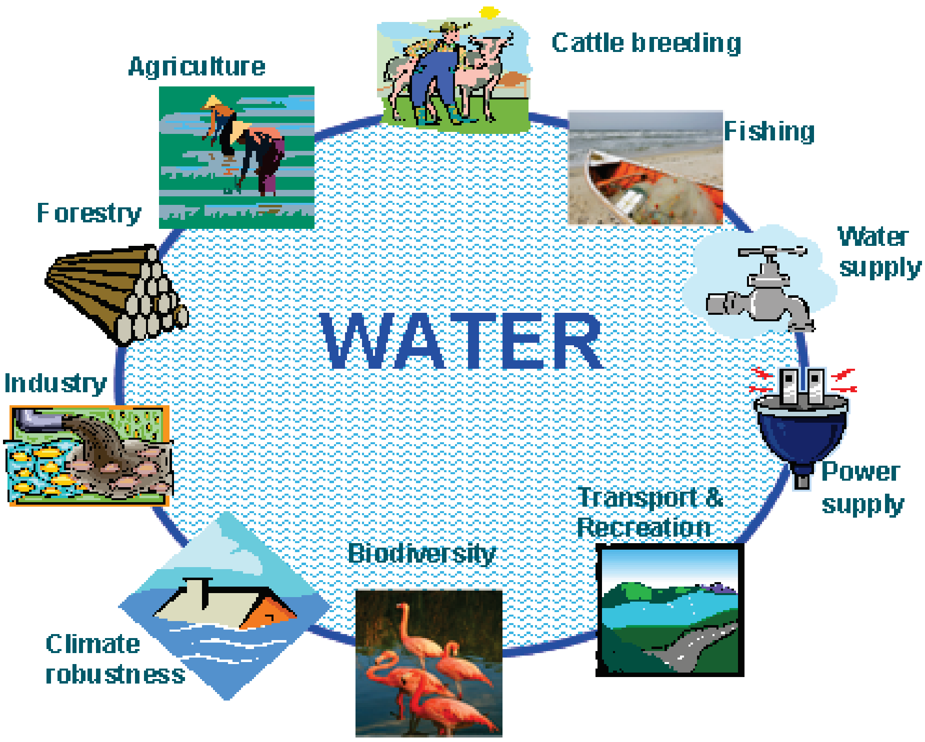

Figure 3. Urban water cycle services demonstrate that competing needs for water lead to trade-offs in practice (Van Leeuwen et al., 2012).

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.

3.1.1. 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.

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:

- The internal water footprint, i.e. the water use inside the country,
- 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 in TRUST we have used both approaches, i.e. the information from WFN (Indicators 1-3 in Table 2) as well as the information from the FAO Aquastat database (see Annex 2).

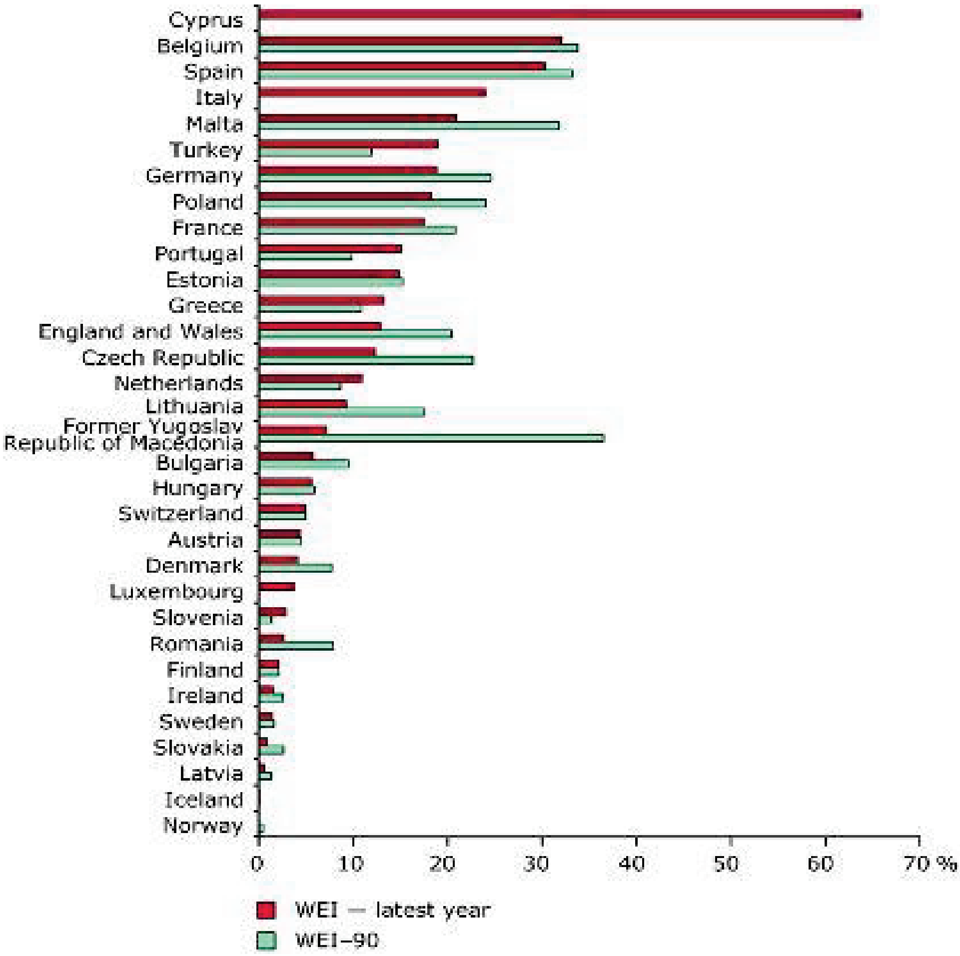

Figure 4. The water exploitation index (WEI) according to the EEA (2011).

3.1.2. 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 data were used as input for the calculation of the scores for surface water quality (indicator 4 in Table 2).

3.1.3. 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 TRUST 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 5). 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; Oslo, Scotland, Reggio, Athens, Bucharest, Madrid obtain a score of 6. Amsterdam and Hamburg obtain a score of 1 and Algarve a score 4. No information was available for Oslo, but an expert judgement estimate of 6 has been given. The scores for Angola and Tanzania have been obtained from the information on effects on ecosystems from the environmental performance index (2010).

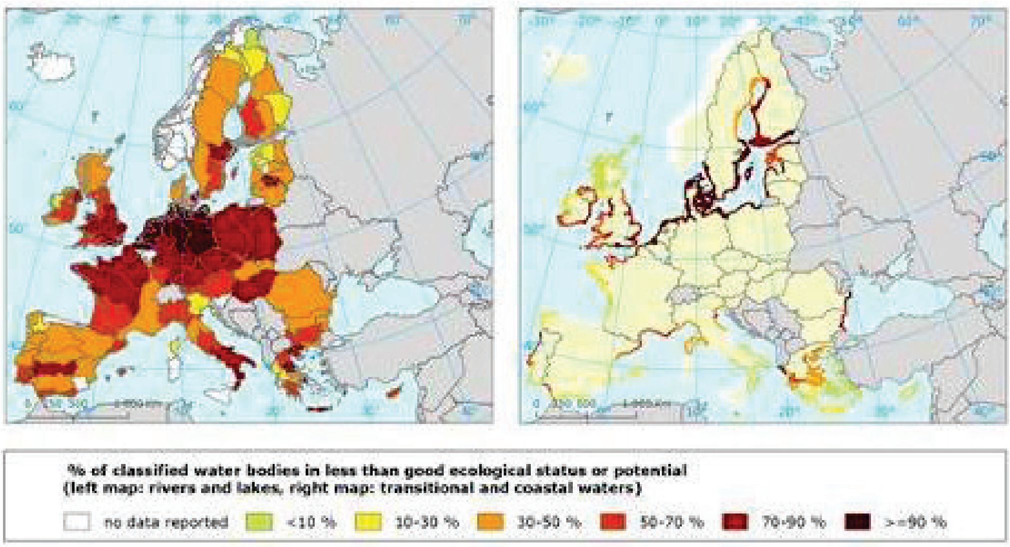

Figure 5. Ecological status of water bodies in Europe according to the EEA.

3.1.4. Groundwater quality

The similar lack of information provided in the responses on the TRUST 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 (URL2). Information for the Netherlands was provided in PBL (2008) and is shown in Figure 6. This led to the scores as presented in Table 3.

Table 3. Groundwater quality

Country	EEA viewer info	Score
Norway	55 of 56 samples for nitrate are good	9.8
Germany	620 out of a total of 987 samples are good	6.4
United Kingdom	533 samples out of 723 samples are good	7.3
Italy	359 samples out of 552 samples are good	6.5
Portugal	No data	Estimate = 5
Greece	No data	Estimate = 5
Spain	431 data out of 638 samples are good	6.7
Romania	123 good out of 142 samples	8.7
Netherlands[a]	Most groundwater bodies are at risk	3

a) Based on specific information for the Netherlands (see text)

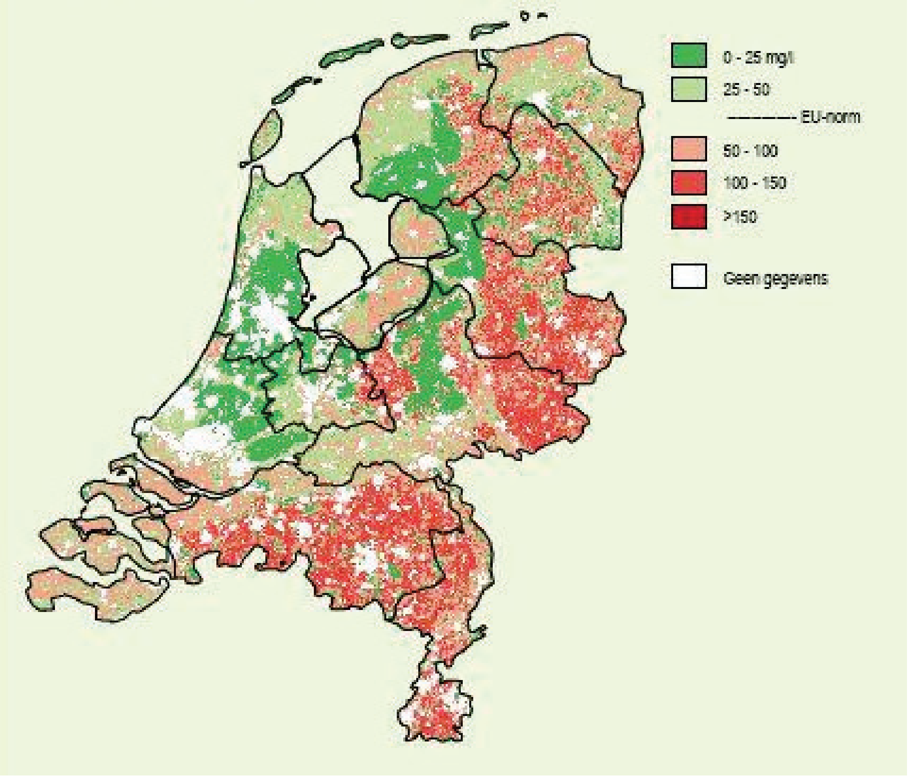

Figure 6. Nitrates in shallow groundwater in the Netherlands.

3.1.5. 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.

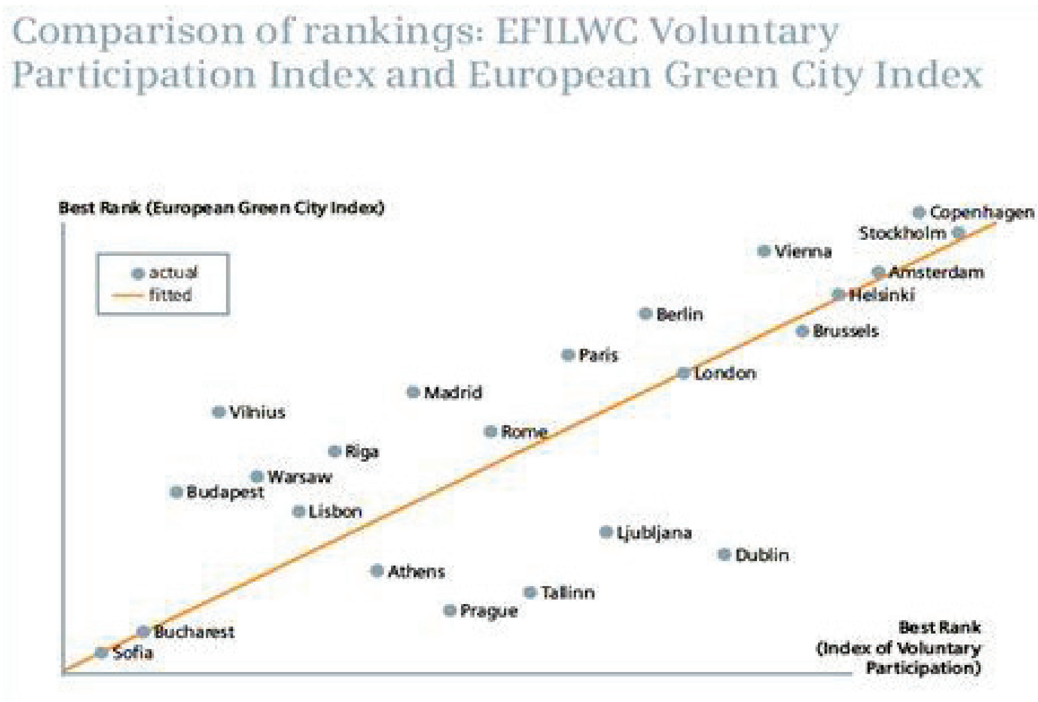

Figure 7. The relation between the index of voluntary participation (VPI) and the ranking according to the European green city index (2009).

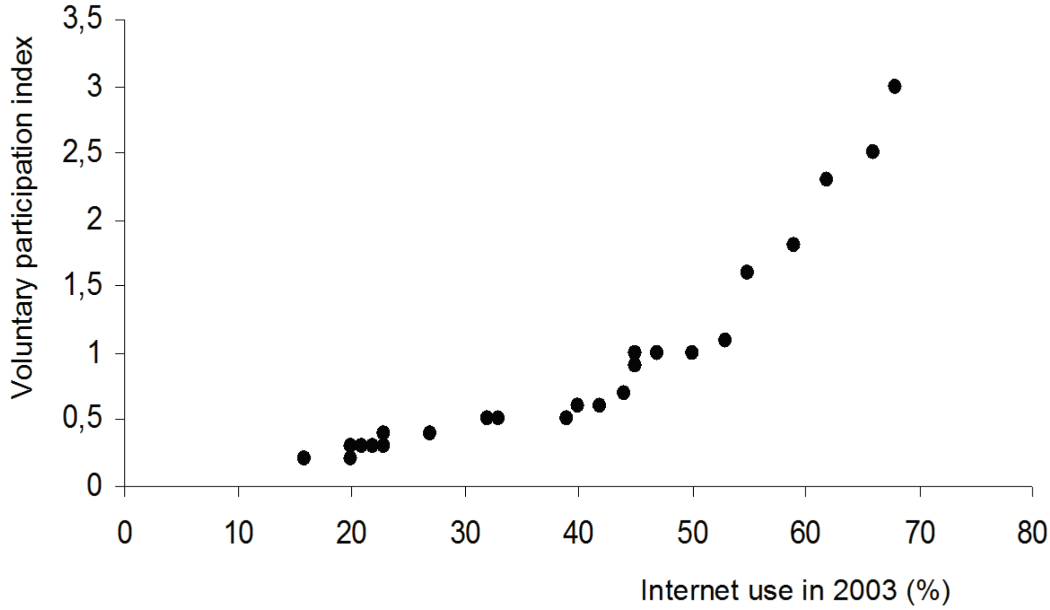

Figure 8. The relation between internet use and the VPI (Van Leeuwen and Chandy, 2012)

3.2. Comparison of UWCS of cities

The information from the TRUST questionnaire (Annex 1) and the additional information gathered for water security, public participation and the regional or national estimates for local environmental quality (surface water, groundwater and biodiversity) have been used to make short reports of the cities and regions of TRUST. These short reports of the TRUST cities, together with information for the cities of Rotterdam, Kilamba Kiaxi (Angola) and Dar es Salaam (Tanzania) are presented in Annex 2.

3.2.1. Drinking water

The information that has been provided via the TRUST questionnaires has been adequate to score most parameters. 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 m3 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 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).

3.2.2. 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 4 and Figure 4. Please note that all these parameters, except drinking water consumption, are based on data for countries and not for cities.

*Table 4. Indicators for water use and water stress for countries and drinking water consumption in cities/regions**

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.

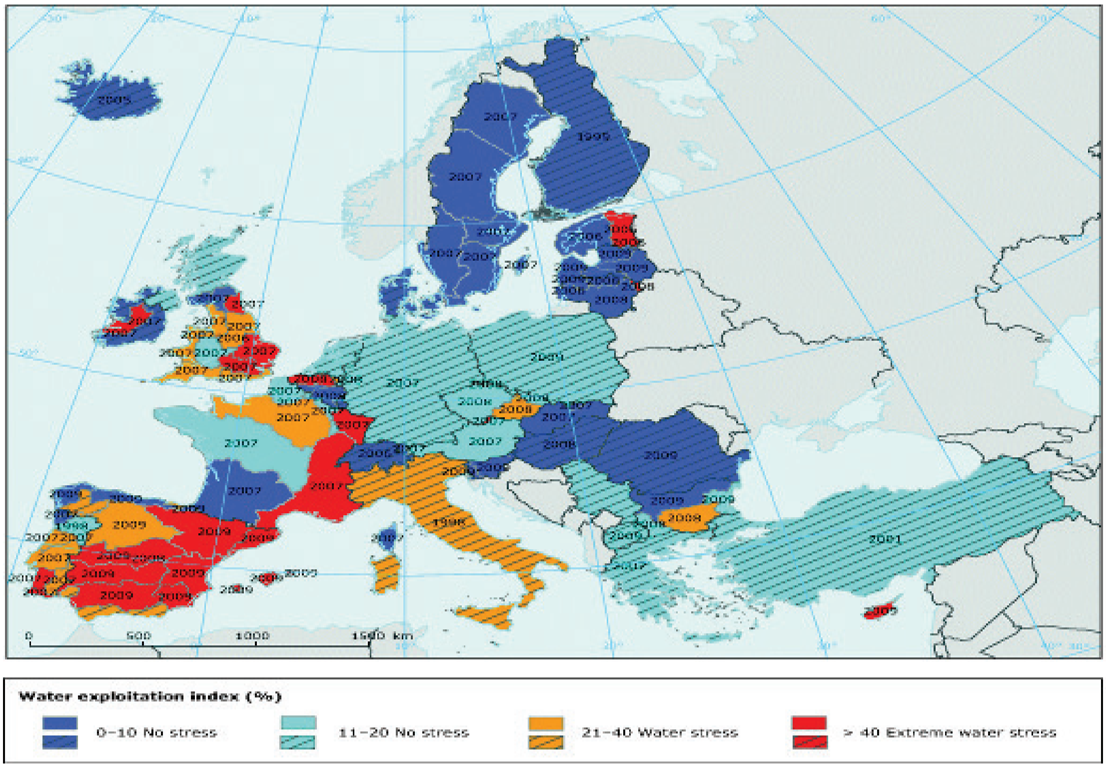

Figure 9. The water exploitation index (%) in Europe (source: EEA)

3.2.3. Waste water

For the waste water services in Europe, the population coverage varied from 90 % (Reggio Emilia) to 99.5 % for Oslo. Most of the systems were collection, transport and treatment systems. Energy recovery takes place in most cities and regions. Nutrient recovery is an exception and only takes place in Hamburg and Reggio Emilia. 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 Scotland, the city of Reggio Emilia and the cities in Algarve, apply their sludge in agriculture. In some places in Scotland and in the Algarve small fractions of the sewage sludge is going into landfill. In Bucharest 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 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 83 % for Amsterdam. The separation was even higher for Athens (97%). Energy recovery from waste water takes place in all European cities except the cities in Algarve. Nutrient recovery from waste water takes place only in Reggio Emilia and Hamburg. Unfortunately, no information is available for Scotland for both energy and nutrient recovery from waste water.

3.2.4. 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). Most of the information of the TRUST questionnaire has been transformed into scores for 24 indicators, comprising the so-called City Blueprint (Van Leeuwen et al., 2012; Table 2). These scores also comprise information on environmental quality and governance as presented in Table 2 and the TRUST questionnaire (Annex 1). The results for all cities and regions of TRUST are presented in Table 5. The scores of Rotterdam and two African cities have been included. For many indicators of the two African cities expert judgement estimates were used as no information was available. The City Blueprints for each individual city or region are presented in Annex 2.

Table 5. Individual scores for the 24 indicators of the City Blueprint as described in Table 2.

Indicator	ALG	ATH	REG	AMS	HAM	OSL	SCO	BUC	ROT	KIL	DAR
1 Total water footprints	3.43	3.98	4.1	6.92	7.05	7.06	7.62	6.17	6.92	6.5	8.40
2 Water scarcity	6.25	1.32	3.08	7.4	2.39	9.83	4.92	8.24	7.4	9.05	6.3
3 Water self-sufficiency	4.01	5.35	3.93	0.54	3.12	3.18	2.48	8.52	0.54	8.57	9.32
4 Surface water quality	7.79	4	8.22	6	7.86	9.51	8.16	8.15	6	5.18	8.5
5 Groundwater quality	5*	5*	6.5	3	6.4	9.8	7.3	8.7	3.0	5*	5*
6 Sufficient to drink	9.7	10	9.38	10	10	10	9.7	8.2	10	0.4	6
7 Water system leakages	6.5	7.8	8.4	9.46	9.56	7.71	6.68	6	9.4	5	7
8 Water efficiency	6	6	10	10	2	5.5	7	6	10	2*	2*
9 Drinking water consumption	5.4	7.3	9.4	9.8	9.7	6.42	7.7	9.4	10	10	8.97
10 Drinking water quality	9.99	9.95	10	10	9.99	9.95	9.99	10	9.9	4**	4
11 Safe sanitation	9.21	9.5	9	9.99	9.9	10	9.32	8.15	9.73	0	5.6

12 Recycling of sewage sludge	9.4	10	10	10	10	10	9.74	0	10	2*	2*
13 Energy efficiency	6	6	8	10	10	5	4	5	7	0*	0*
14 Energy recovery	0	10	8	10	10	8	0*	0	5	0*	0*
15 Nutrient recovery	0	0	9.9	0	10	0	0*	0	0	0*	0*
16 Average age	8.9	8	4.8	7.2	5.4	4.5	5.1	5	6.7	2*	2*
17 Separation of waste water and stormwater	0	9.72	4.06	8.28	7.63	6.4	6.55	0.1	0.5	0*	0*
18 Commitments to climate change	6	5	4	8	10	7.5	7	2	9	2*	2*
19 Climate change adaptation measures	6	5	4	10	10	7.5	5	2	10	2*	2*
20 Climate-robust buildings	6	5	4	7	10	7.5	8	5	9	2*	2*
21 Biodiversity	4	6	6	1	1	6*	6	6	1	6,48***	7.78***
22 Attractiveness	8	9	6	9	10	9.5	8	5	8	5*	5*
23 Management and action plans	6	5	6	7	10	7	6	6	8	2*	2*
24. Public participation	1	1.3	1.7	7.7	3.3	10	3.3	0.7	7.7	0.15	0.3

* NA-expert judgement scores; **expert judgement based on data for Dar es Salaam; ***Based on data from the environmental performance index (2010)

3.2.5. Blue City Index (BCI)

As a simple indicator for the performance of the individual cities regarding the sustainability of their urban water systems, the average of the 24 indicator scores has been calculated. This average is called the Blue City Index (BCI) and is the arithmetic mean of the 24 indicators comprising the city blueprint. These data are given in Table 6 below, together with some other indicators such as the scores for the commitments for SUWM (indicator 23), the VPI (voluntary participation index) according to the EFILWC (2006), and the GDP per capita (in international dollars for 2011) as reported by the IMF (URL3). Comparisons were also made with some governance indicators according to the World Bank (URL4) 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). Finally the BCI has been compared to the HLY (happy life years), i.e., how long and happy people live (URL5). These data are summarized in Table 6.

Table 6. Summary information about the BCI, UWCS management and action plans (indicator 23) for the cities and various national indexes from the IMF (URL3), World Bank (URL4) and the Erasmus University Rotterdam (URL5).

City	BCI	UWCS	VPI	GDP	GE	RQ	RL	HLY
Algarve	5.61	6	1	23363	78.7	73.9	81.7	44.4
Athens	6.26	5	1.3	26258	66.8	69.7	66.7	50.8
Reggio Emilia	6.60	6	1.7	30464	66.4	75.4	63.4	53.8
Amsterdam	7.43	7	7.7	38077	91.9	92.9	91.5	56.3
Hamburg	7.72	10	3.3	42023	96.7	98.1	97.7	59.9
Oslo	7.41	7	10	53396	96.2	91	98.1	62.8
Scotland	6.23	6	3.3	36522	92.4	94.3	92.5	56.4
Bucharest	5.18	6	0.7	12493	47.4	74.9	56.3	41
Rotterdam	7.03	8	7.7	42023	96.7	98.1	97.7	59.9
Kilamba Kiaxi	3.31	2	0.15	5924	11.4	12.3	10.3	17.8
Dar es Salaam	4.01	2	0.3	1610	36.5	35.5	34.3	14.4

Like in the European green city index, there is a positive relation between the performance of the cities/regions regarding their water services (BCI) and the VPI. The Pearson correlation coefficient (r) is 0.727. The BCI also correlates well with the UWCS commitments of the cities/regions (r = 0.904) and the GDP (r = 0.927; Figure 10). The BCI is also positively correlated with all governance indicators of the World Bank, for instance the government effectiveness (Figure 11). The correlation coefficient for the BCI and GE, RQ and RL was 0.927, 0.921 and 0.917, respectively. The highest correlation was found for the relation between the BCI and the HLY: 0.9505. This is partly due to the uneven distribution of the data pairs (Figure 12). Further analysis of other World Bank Indicators has not been performed as all World Bank indicators for the subset in this report (11 cities in 10 countries) intercorrelate strongly. This is shown in Table 7, where also another World Bank indicator has been included, i.e. voice and accountability (VA). 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 intercorrelations are demonstrated for e.g. RL and GE (0.994) and RL and RQ (0.967).

Table 7. Pearson correlation matrix for the indicators for 11 cities in 10 different countries

	BCI	VPI	UWCS	GDP	GE	RQ	VA	RL	HLY
BCI	X	0,727	0,904	0,927	0,927	0,921	0,860	0,917	0,950
VPI	0,727	X	0,571	0,867	0,746	0,670	0,553	0,742	0,711
UWCS	0,904	0,571	X	0,794	0,842	0,887	0,795	0,856	0,858
GDP	0,927	0,867	0,794	X	0,918	0,858	0,821	0,905	0,940
GE	0,927	0,746	0,842	0,918	X	0,951	0,917	0,994	0,919
RQ	0,921	0,670	0,887	0,858	0,951	X	0,891	0,967	0,941
VA	0,860	0,553	0,795	0,821	0,917	0,891	X	0,919	0,858
RL	0,917	0,742	0,856	0,905	0,994	0,967	0,919	X	0,922
HLY	0,950	0,711	0,858	0,940	0,919	0,941	0,858	0,922	X

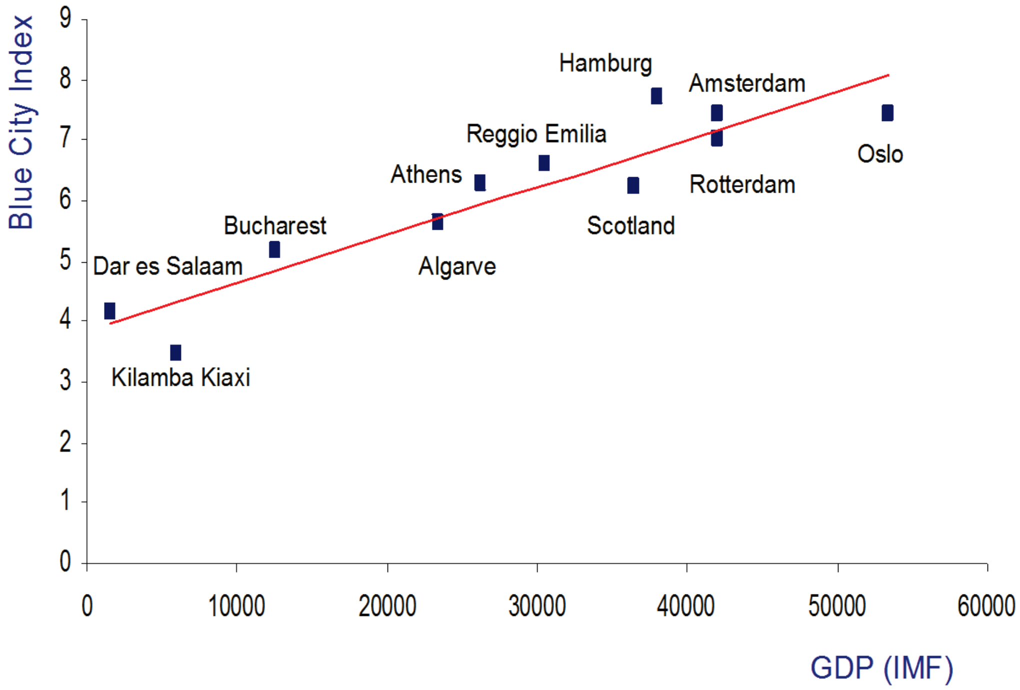

Figure 10. The relation between the BCI (blue city index) and the GDP per capita according to the IMF

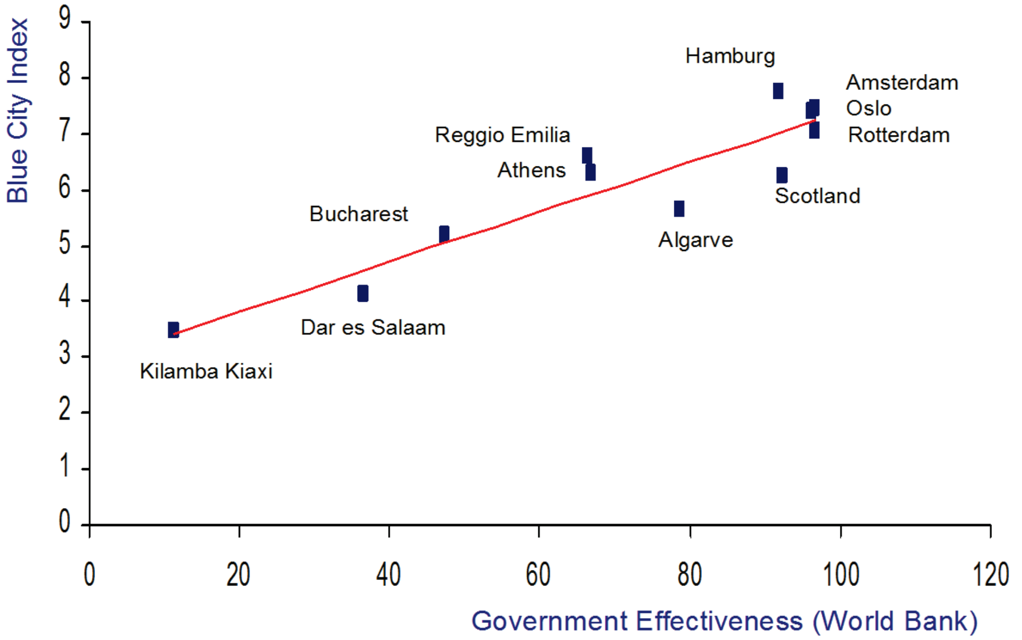

Figure 11. The relation between the BCI (blue city index) and government effectiveness

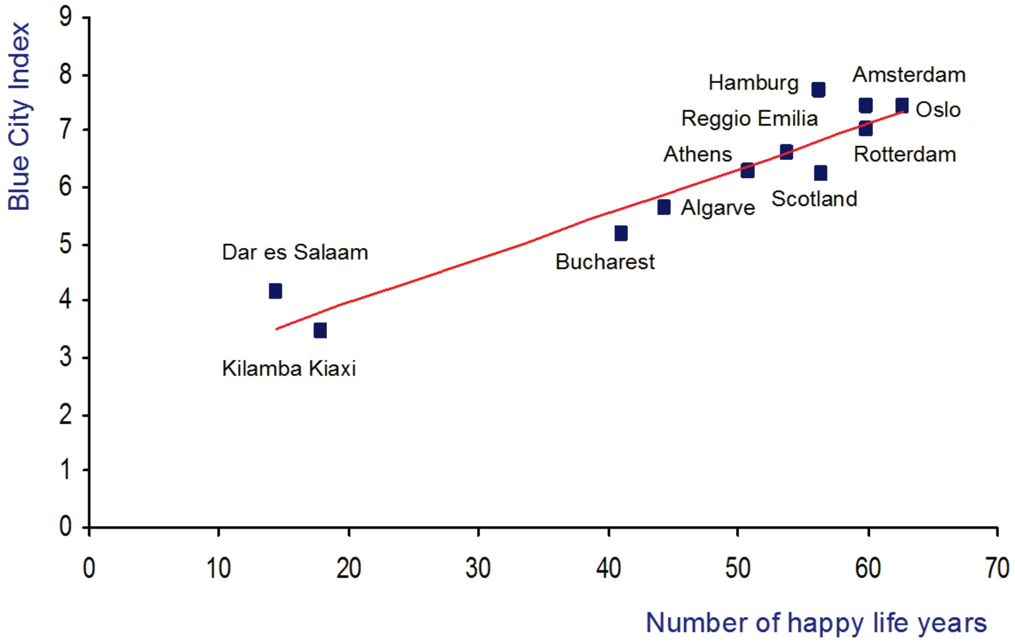

Figure 12. The relation between the BCI (blue city index) and the number of happy life years (URL5)

3.3. Implementation of best practices in cities

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 8. In Table 8 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 8) are given. This is shown in Figure 13. 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 14).

Table 8. Indicators, best performing cities and highest score per indicator for 11 cities.

Indicator	Lowest score	Best score	Best performing cities
1 Total water footprint	3.43	8.4	DAR, SCO, OSL
2 Water scarcity	1.32	9.83	OSL, KIL, BUC
3 Water self-sufficiency	0.54	9.32	DAR, KIL, BUC
4 Surface water quality	4	9.51	OSL, DAR
5 Groundwater quality	3	9.8	OSL, BUC
6 Sufficient to drink	6	10	ATH, AMS, HAM, OSL, ROT,
7 Water system leakages	5	9.56	HAM, AMS, ROT
8 Water efficiency	2	10	REG, AMS, ROT
9 Drinking water consumption	5.4	10	ROT, KIL
10 Drinking water quality	4	10	REG, AMS, BUC
11 Safe sanitation	0	10	OSL, AMS
12 Recycling of sewage sludge	0	10	ATH, REG, AMS, HAM, OSL, ROT
13 Energy efficiency	0	10	AMS, HAM
14 Energy recovery	0	10	ATH, AMS, HAM
15 Nutrient recovery	0	10	REG, HAM

16 Average age	2	8.9	ALG, ATH
17 Separation of waste water and stormwater	0	9.72	ATH, AMS
18 Commitments to climate change	2	10	HAM, ROT
19 Adaptation measures	2	10	AMS, HAM, ROT
20 Climate-robust buildings	2	10	HAM
21 Biodiversity	1	7.78	DAR
22 Attractiveness	5	10	HAM, OSL, AMS
23 Management and action plans	2	10	HAM
24. Public participation	0.15	10	OSL

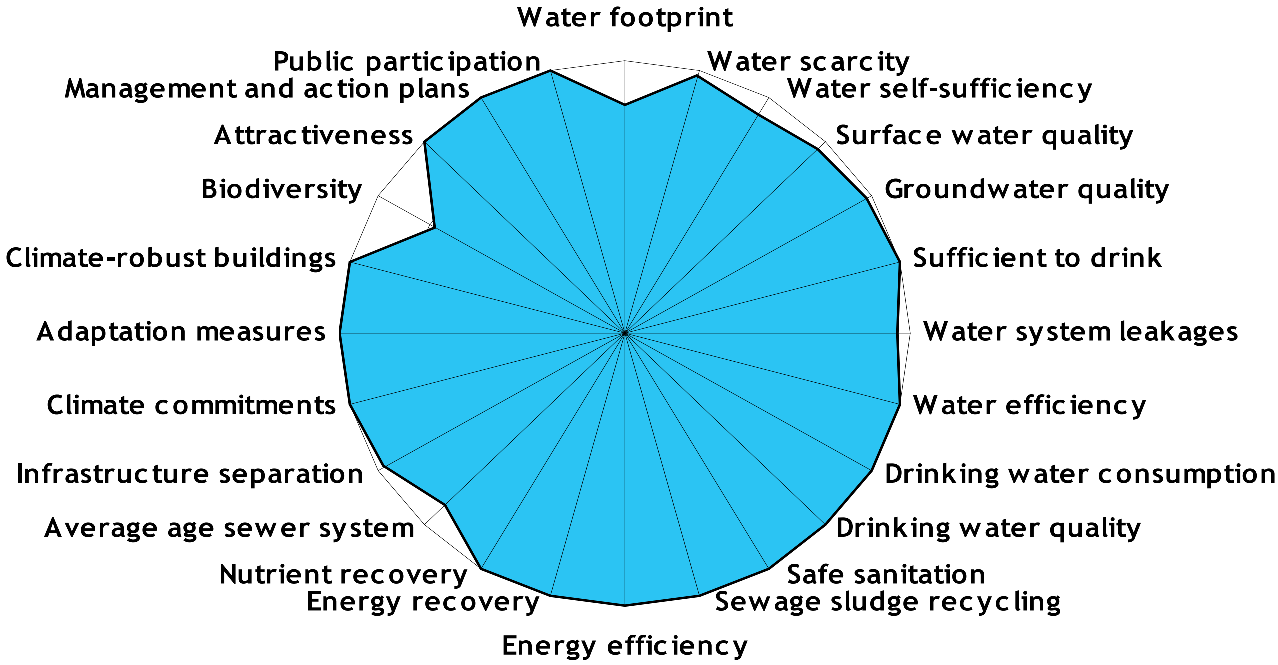

Figure 13. City Blueprint of a theoretical city that has implemented all the best practices (best scores as listed in Table 8) currently available in all cities presented in this report. It shows that cities can learn from each other and that active exchange of "best practices", can significantly improve the sustainability of UWCS of cities

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 (Annex 1) and the city blueprint 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.

Retrospectively, it would have been better to modify the questionnaire. 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.

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 in the case of Rotterdam (van Leeuwen et al., 2012) and Dar es Salaam (Van Leeuwen and Chandy, 2012) leads to much lower scores and are clear examples of this. In other words the scores as provided in the current report on environmental quality are probably too optimistic and are underestimations of the actual environmental quality of the TRUST 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. 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.

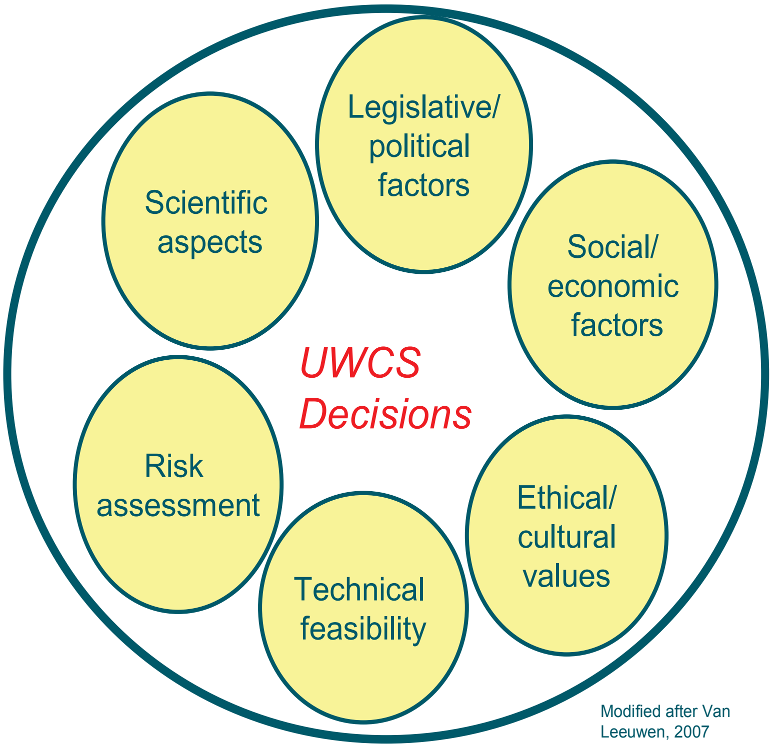

Figure 14. Elements of UWCS decision-making.

While water is generally abundant in much of 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 3.1.1. 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 Table 4 and Figures 3 and 8. 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 TRUST baseline 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 2. Finally, care should be taken to attach absolute value to the results. The City Blueprint and the city reports in Annex 2 can be used as a preliminary decision support tool and information, but other aspects need to be included as well (Figure 14; Van Pelt and Swart, 2011). When these limitations are taken into account, the baseline assessment provides stakeholders in TRUST pilot 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 13). The learning potential would theoretically allow an increase in the range of BCI scores from 3.31 (Kilamba Kiaxi) and 7.72 (Hamburg) to 9.70 (Figure 13). We hope and expect that the results of this baseline survey of UWCS will be used to:

- Refine parts of the assessment, with tailor-made in-depth studies and advanced models, if necessary
- Identify priorities and budgets (planning)
- Raise/improve awareness (particularly in communicating with the public) Translate knowledge and educate
- Enable informed decision-making
- Aid in the evaluation and approval (through decision-making) processes
- Monitor and measure progress
- Compare outcomes
- Stimulate the exchange of best practices for UWCS (Makropoulos et al., 2012; UNEP, 2008).

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), whereas water management options related to climate change have been presented by De Graaf et al. (2007a,b)

5. CONCLUSIONS

The baseline assessment presented in this report showed that the cities vary considerably with regard to the sustainability of the UWCS. We have tried to capture this in Annex 2 of this report and in the Blue City Index (BCI), the arrhythmic mean of 24 indicators comprising the City Blueprint (van Leeuwen et al., 2012). The BCI varied from 3.31 (Kilamba Kiaxi) to 7.72 (Hamburg), but more importantly, it was positively correlated with the GDP (per person), the ambitions of the cities regarding the sustainability of the UWCS, the VPI, all governance indicators according to the World Bank, and, last but not least, the happiness of people expressed as happy-life-years, i.e., how long and happy people live.

The fastest route to failure in the transition towards sustainable cities (Figure 15) would be to sit and wait for e.g. the ultimate technological breakthroughs in water technology. This is not at all necessary. The main challenge is to start the discussion with all stakeholders, to enhance public participation, and to translate the baseline assessments into actions to improve the UWCS of cities in order to address the challenges ahead of us.

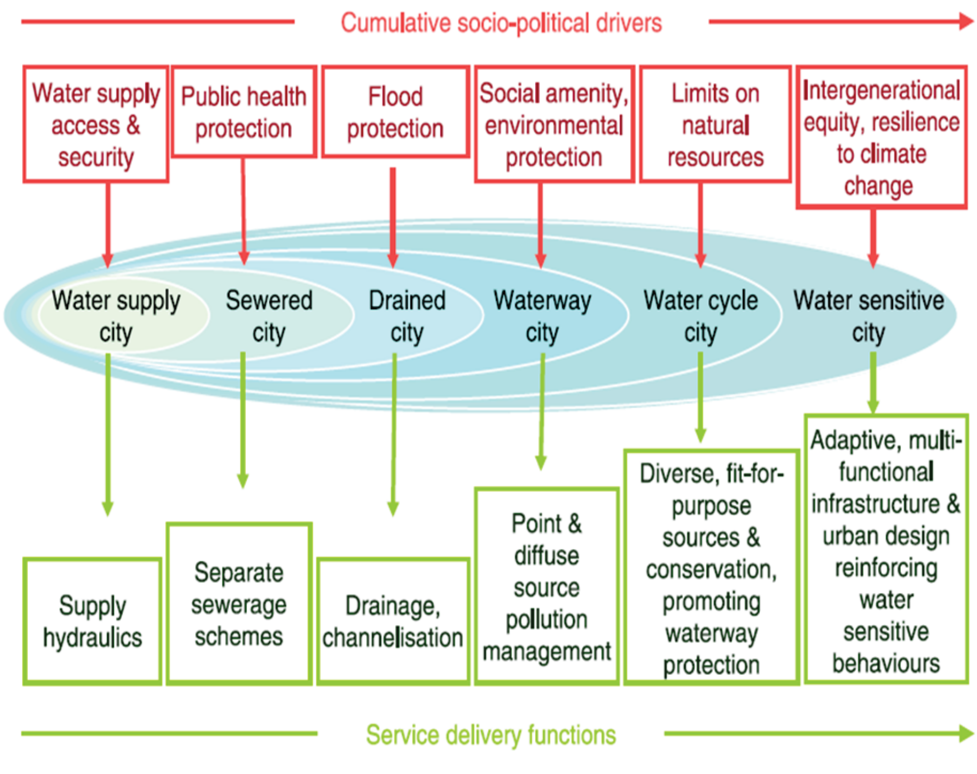

Figure 1 | Urban Water Management Transitions Framework (source: Brown *et al.* 2009).

Figure 15. Transitions of UWCS in cities according to Brown et al. (2009)

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 (Makropoulos et al., 2012; UNEP, 2008). Cities can learn from each other! Theoretically, if cities would share their best practices, the BCI might reach a value of 9.70, which is close to the theoretical maximum of 10. It 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 (Figure 14), and is ultimately the responsibility of the cities themselves.

There assessment of the sustainability of the UWCS of the TRUST cities and regions as presented in this report show that there are differences between the regions and cities. Some preliminary conclusions can be drawn:

- The water scarcity cluster (Algarve, Athens and Reggio Emilia) may need to focus on their total water footprint, water scarcity, water self-sufficiency, UWCS ambitions and public participation. Water consumption in Algarve and Athens is relatively high. Water consumption in Reggio Emilia is much lower
- The green cities (Amsterdam and Hamburg) may need to focus on water self-sufficiency, environmental quality (surface water quality, groundwater quality and biodiversity) and nutrient recovery (Amsterdam). Rotterdam may need to focus more on the separation of waste water and stormwater systems.
- The urban and per urban examples (Oslo and Scotland) may need to focus on water self-sufficiency, energy efficiency, nutrient recovery and ageing infrastructures.

Megatrends (e.g. population growth, pollution, climate change) pose urgent water challenges in cities (Figure 1). Based on the responses provided in the TRUST questionnaire, it can be concluded that the challenges differ among the cities. Referring to Tables 1 (the UWCS sustainability dimensions) and the results presented in Table 5 and the reports of the cities (Annex 2), the main challenge will reside in the integration of these 5 dimensions, and, in particular, in enhancing voluntary participation.

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7. ANNEX 1. 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	

NB! This file is available as separate Excel file!

2	Population coverage	Percentage of the resident population that is served by the undertaking.	QS3	%	
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	
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)	
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).		

8. ANNEX 2. REPORTS OF 11 CITIES/REGIONS

8.1. Algarve

Introduction

Algarve is a tourist region in the south of Portugal with an insulation level higher than 3000 h/year. Algarve's regional capital Faro is the European city with lowest number of days per year with rain (60). The Algarve multi-municipal water supply and sanitation system, which covers all 16 municipalities in the region, supplies around 450,000 inhabitants during the low season and around a million and a half during the high season. Águas do Algarve, is responsible for the bulk water supply system and bulk sanitation system in the Algarve region. The main aim is to supply enough quality drinking water all year round and to equip the Algarve Region with a safe system in terms of public health and promoting environmental quality. A special attention is given to the water quality of Algarve's beaches and rivers, which is an essential factor for the well-being of the population and for developing the region's economy and tourism. Algarve region faces limited water resources (low precipitation of approximately 500 mm per year), a fragile ecosystem and strong building stress on the costal area. One of the heaviest stress factors is tourism pressure, leading to highly seasonal fluctuating water demand, a very wide range of service conditions between low and high season and risks emerging from scarcity of water and energy. Numbers state that there are 15 million night stays per year and 35 golf courses in operation representing a water demand equivalent to 350 thousand inhabitants. The challenge is therefore how to meet that demand in a sustainable way, especially taking into account that Algarve has also an important agricultural activity. In this context, Águas do Algarve developed a regional wastewater reuse plan for irrigation of golf courses, to minimize pressures on aquifers. The plan has already been submitted to regulatory agencies and approved.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of Algarve. No data were provided for indicators 5 (groundwater quality) and 22 (attractiveness). These were given scores of 5 and 8, respectively (Figure 1). Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for Portugal is 68.7 km^3 per year. Most of this water (38 km^3/year is from internal (national) sources, but 30 km^3/year is from external sources leading to a high dependency ratio of 44.7%. The TRWR per capita for

Table 1. Basic data for Algarve and Portugal

Resident population (x 1000)	451
Household occupancy	1.3
Supply area (drinking water) km^2	4996
Catchment area (waste water) km^2	4996
Annual average rainfall (mm)	510
Daily average air temperature (^oC)	17.4
Population density (inhab/km^2)[a]	116
TRWR per capita (m^3/year)[a]	6435
Total freshwater withdrawal as % of TRWR[a]	12.3

a) National data according to FAO Aquastat

Portugal is 6435 m^3 per year. Most of the water withdrawal in Portugal is from agriculture (6.2 km^3), industry (1.6 km^3), followed by municipalities (1.1 km^3). In Portugal, the total withdrawal per capita per year is 812 m^3. The total freshwater withdrawal in Portugal is 12.3 % of TRWR (Table 1). The surface water quality is relatively good. Biodiversity and shallow groundwater quality is about average (Figure 1).

Drinking water

Drinking water is prepared from upland surface water sources (92.7%) and borehole water sources (7.3%). There is 97 % population coverage. The total water consumption in Algarve is 146.2 m^3 per person per year. This relatively high and may be explained by the fact that water consumption as calculated may implicitly include drinking water consumption of tourist. The quality of the supplied water is very good (Table 2 and Figure 1). The mains length is 455 km and the average age is 11 years. The number of mains failures is very low (0.46 per 100 km). The water losses in the Algarve region are considerable (35 %).

Table 2. Key data for drinking water and waste water for Algarve

Drinking water		**Waste water**	
System input volume (million m^3/year)	68.06	Number of properties connected (x 1000)	281
Population coverage	97	Collected sewage (m^3/inhabitant per y))	93.0
Authorised consumption (million m^3/year)	65.9	Length of combined sewers (km)	398
Consumption m^3 per person per year	146.2	Length of stormwater sewers (km)[a]	0
Service connections x 1000	337	Length of sanitary sewers (km)	0
Water losses (m^3) per connection and year	--	Wastewater treated (million m^3)	46.5
Water losses (%)	35	Total sludge produced in STPs (ton DS/y)	4221
Quality of supplied water	99.9	Sludge going to landfill (ton DS/y)	261
Average water charges (€ / m^3)	0.4563	Sludge thermally processed (ton DS/y)	9
Mains length (km)[b]	455	Sludge disposed by other means (ton DS/y)	3960
Average mains age (y)	11	Energy costs (million €)	2.41
Number of main failures[b]	2	Average age of the sewer system (y)	11
Main failures per 100 km	0.46	Sewer blockages	2
Asset turnover ratio	NA	Sewer blockages per 100 km	0.5

a) *This is the price for bulk water systems.*

b) *In bulk water distribution systems*

Waste water

The waste water system of Algarve is a transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 92 %. There is a system of combined sewers only and therefore, the separation is 0%. The average age of the waste water network is 11 years and the number of sewer blockages per 100 km (0.5) is very low (Table 2). The energy costs for the waste water system are 2.8 million € (Table 2). No measures have been taken to recover energy and nutrients from wastewater. Sewage sludge is mainly recycled in agriculture as only a small fraction is going to landfill.

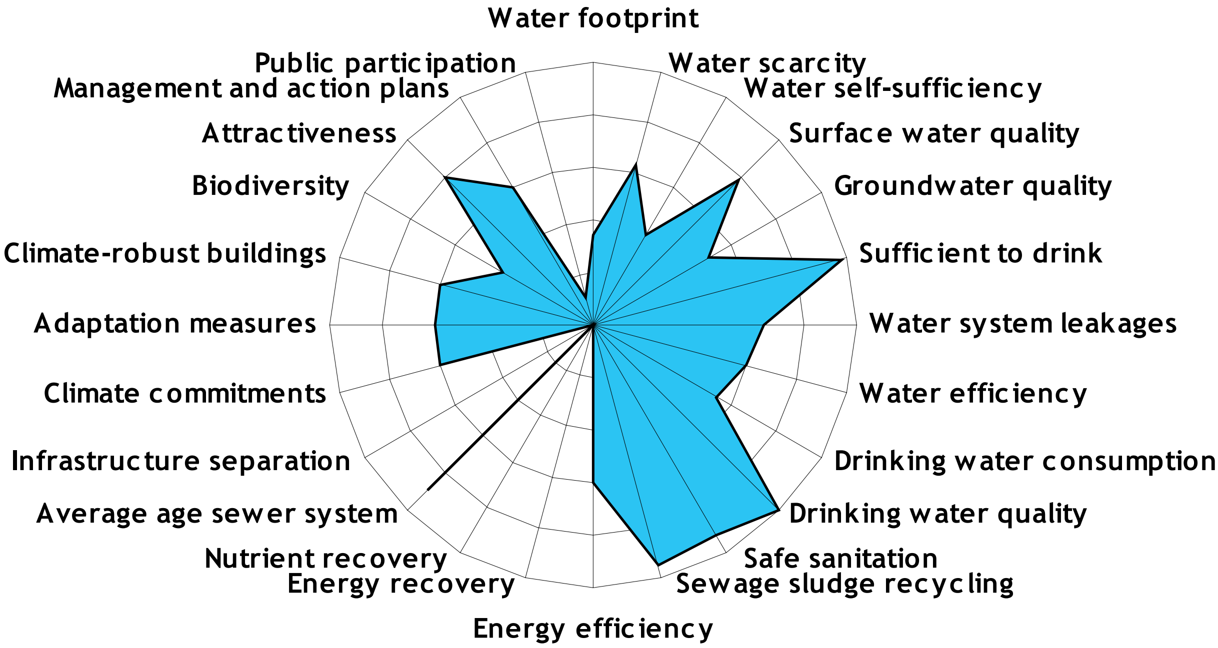


Figure 1. City Blueprint of Algarve

Governance

Algarve shows commitment to sustainable solutions. This is reflected in the governance scores which are all scored with 6. The external collaboration is good (type and level) and both score with a 4.

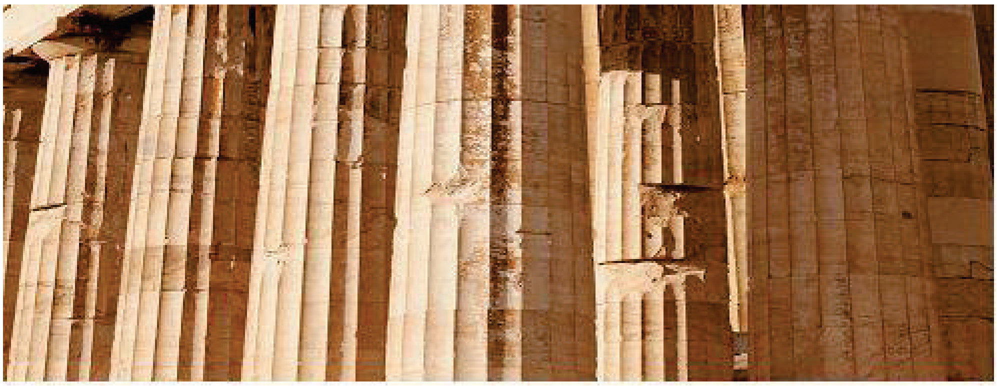
Highlights of Algarve

Highlights of Algarve related to UWCS management are: (1) reuse, (2) energy recovery, (3) water safety plans and contingency plans.

Further steps

Based on the scores for Algarve, the following aspects may need further attention: water system leakages, water consumption and efficiency, energy and nutrient recovery and involvement of the public (public participation).

8.2. Athens



Introduction

Athens, the capital of Greece, is a major population centre of approximately 5,000,000 (and an immigration destination or at least an immigration hub). Athens is in a water scarce area: Western Greece is the wet part of the country while Eastern Greece (where Athens is situated) is much drier with most of the demand for water and almost all the population. This spatial and temporal imbalance led to the development of a very long water conveyance system that presents challenges for both real time control and long term planning – as well as security. To support the operation of this complex system, the Athens water company adopted a model, developed in the National Technical University of Athens (NTUA), which helps to achieve an optimum trade-off between required energy for the operation (pumping) and system reliability. To further improve energy use, the company installed small hydroelectric plants in the water supply system. An extensive leakage detection and repair program has already been undertaken resulting in reduction of leakages by almost 20% over the last 10 years. However, demand has now reached the capacity of the system. To address this, the company is looking for additional measures and options to improve system reliability within a financially difficult period for the country, including centralised reuse schemes at their main wastewater treatment plan.

The water system is run by two companies: EPEYDAP (which owns the supply assets and reservoirs and is a public company) and EYDAP, which owns the system downstream of the treatment plants and is responsible for providing water to the end-users. Demand has risen exponentially over the past 80 years, but appears to have been stabilized at 415hm3 (a value close to the system's capacity) for the past 5 years. The water supply companies aim to implement new technologies of waste water treatment and take advantage of alternative water sources to increase the cost-effectiveness, performance, safety and sustainability of the water system.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of Athens. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for Greece is 74.25 km^3 per year. Most of this water (58 km^3/year is from internal (national) sources leading to very small dependency ratio of 21.9%. The TRWR per capita for Greece is 6537 m^3 per year. Most of the water withdrawal in Greece is from agriculture (8.5 km^3), municipalities (0.85 km^3), followed by industry (0.2 km^3). In Greece, the total withdrawal per capita per year is 841 m^3. The total freshwater withdrawal in Greece is 12.7 % of TRWR (Table 1). The surface water quality, biodiversity and shallow groundwater quality is relatively good (Figure 1).

Table 1. Basic data for Athens and Greece

Resident population (x 1000)	4900
Household occupancy	2.5
Supply area (drinking water) km^2	1400
Catchment area (waste water) km^2	630
Annual average rainfall (mm)	414
Daily average air temperature (^oC)	17.7
Population density (inhab/km^2)[a]	86
TRWR per capita (m^3/year)[a]	6537
Total freshwater withdrawal as % of TRWR[a]	12.7

a) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from upland surface water sources (97.7 %) and borehole water sources (2.2%). There is 100 % population coverage. The total water consumption in Athens is 105.8 m^3 per person per year. The quality of the supplied water is very good (Table 2 and Figure 1). The mains length is 8777 km and the average age is 55 years. Unfortunately, the number of mains failures is not available. The water losses in Athens are about 22 %.

Table 2. Key data for drinking water and waste water for Athens

Drinking water		Waste water	
System input volume (million m^3/year)	420	Number of properties connected (x 1000)	400
Population coverage	100	Collected sewage (m^3/inhabitant per y)	78.9
Authorised consumption (million m^3/year)	328	Length of combined sewers (km)	250
Consumption m^3 per person per year	105.8	Length of stormwater sewers (km)[a]	1200
Service connections x 1000	2036	Length of sanitary sewers (km)	7550
Water losses (m^3) per connection and year	45	Wastewater treated (million m^3)	268
Water losses (%)	22	Total sludge produced in STPs (ton DS/y)	40410
Quality of supplied water	99.5	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m^3)	0.72 (ex VAT)	Sludge thermally processed (ton DS/y)	40410
Mains length (km)	8777	Sludge disposed by other means (ton DS/y)	0
Average mains age (y)	55	Energy costs (million €)	7.845
Number of main failures	NA	Average age of the sewer system (y)	20
Main failures per 100 km	NA	Sewer blockages	NA
Asset turnover ratio	NA	Sewer blockages per 100 km	NA

a) This information has not been provided. However, based on the proceedings of the NATO (2000), the storm sewer protection network of Athens was estimated to be 1200 km long. This figure has been used for the further calculations.

Waste water

The waste water system of Athens is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 90 %. There is a system of combined sewers, sanitary sewers and stormwater sewers. The separation of this infrastructure is 97% (score 9.7 in Figure 1). The average age of the waste water network is 20 years and the number of sewer blockages per 100 km is not available. The energy costs for the waste water system are 7.8 million € (Table 2). Measures have been taken to recover energy from wastewater (100% of the waste water) but there is no nutrient recovery from waste water. Sewage sludge is thermally recycled for 100%.

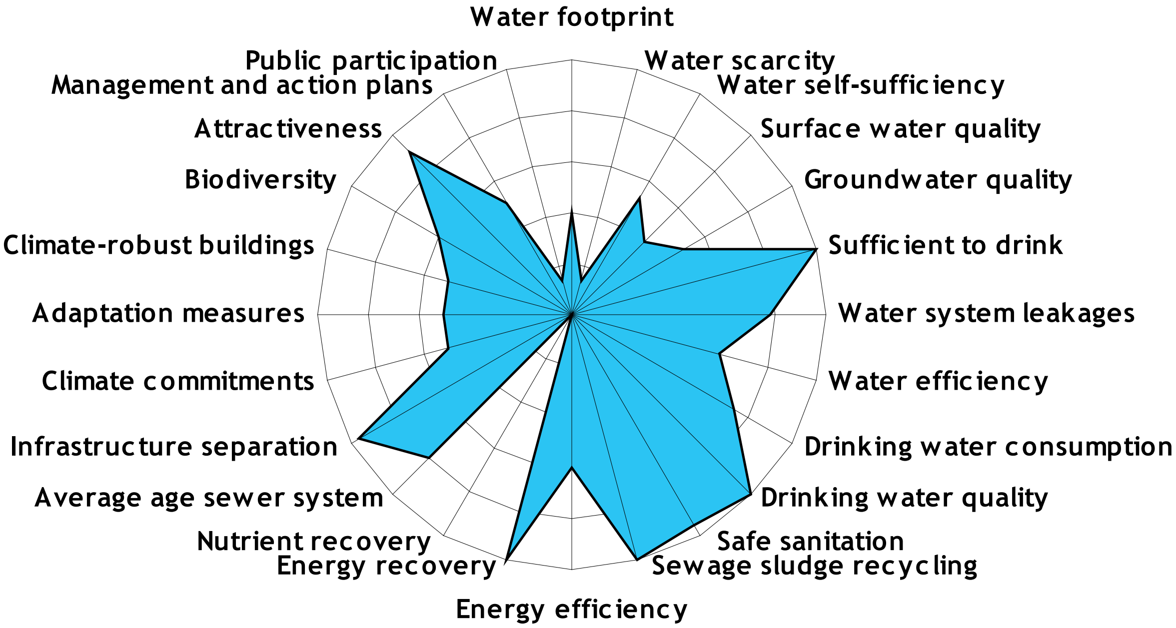


Figure 1. City Blueprint of Athens

Governance

Athens shows commitment to sustainable solutions. This is reflected in the governance scores which vary from 5-6. The external collaboration is modest (type and level) and both score with a 2. In the European green city index (2009) Athens ranked low for buildings, in large part because of the city's lack of energy-efficient building standards or incentives.

Highlights of Athens

Highlights of Athens related to UWCS management have not been provided but discussions have taken place at the TRUST Basel Workshop. The current economic and financial situation in Greece makes long-term planning on UWCS very difficult. This hinders further steps on waste water reuse, further construction activities.

Further steps

Based on the scores for Athens, the following aspects may need further attention: water system leakages, water consumption, nutrient recovery and involvement of the public (public participation). The current economic and financial situation in Greece makes long-term planning on UWCS very difficult. This hinders further steps on waste water reuse, further construction activities. Furthermore, as a result of the current situation, the trend in Athens is that people are leaving the city.

8.3. Reggio Emilia

Introduction

The city of Reggio Emilia lies in the Po plain in Northern Italy, 50 km North-West from Bologna in the Emilia Romagna region. With 170.000 inhabitants, it is the capital city of its Province in the eastern part of the Emilia Romagna region. Its territory has deeply changed in the last decades becoming densely built, with a very high population growth rate due to immigration. It is also home to intensive agricultural practices, livestock farming and a number of small industries, many devoted to food transformation. The area is currently facing important challenges, from both a social and an environmental point of view. From the water cycle perspective, Reggio Emilia represents a system of scarcity with regard to financial resources, water and energy. IREN, managing the water cycle in Reggio and in the nearby Parma and Piacenza, wishes to include these aspects in a new concept for optimized management, including operation, maintenance and renewal

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of Reggio Emilia. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for Italy is 191 km^3 per year. Most of this water (182.5 km^3/year is from internal (national) sources leading to very small dependency ratio of 4.6%. The TRWR per capita for Italy is 3159 m^3 per year. Most of the water withdrawal in Italy is from agriculture (20.1 km^3), industry (16.3 km^3), followed by municipalities (9.1 km^3). In Italy, the total withdrawal per capita per year is 790 m^3. The total freshwater withdrawal in Italy is 23.7 % of TRWR (Table 1). The surface water quality, biodiversity and shallow groundwater quality is relatively good (Figure 1).

Table 1. Basic data for Reggio Emilia and Italy

Resident population (x 1000)	170
Household occupancy	2.2
Supply area (drinking water) km^2	232
Catchment area (waste water) km^2	232
Annual average rainfall (mm)	750
Daily average air temperature (°C)	14
Population density (inhab/km^2)[a]	201
TRWR per capita (m^3/year)[a]	3159
Total freshwater withdrawal as % of TRWR[a]	23.7

a) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from borehole sources (100 %) and there is 93.8 % population coverage. The total water consumption in Reggio Emilia is 58.9 m^3 per person per year) and is relatively low. The quality of the supplied water is excellent (Table 2 and Figure 1). The mains length is 575 km and the average age is 50-60 years. The number of mains failures is very high (117.5 per 100 km) and the water losses are about 16 %.

Table 2. Key data for drinking water and waste water for Reggio Emilia

Drinking water		**Waste water**	
System input volume (million m^3/year)	12.38	Number of properties connected (x 1000)	77.3
Population coverage	93.8	Collected sewage (m^3/inhabitant per y))	83.18
Authorised consumption (million m^3/year)	9.98	Length of combined sewers (km)	427
Consumption m^3 per person per year	58.7	Length of stormwater sewers (km)	163
Service connections x 1000	20.7	Length of sanitary sewers (km)	129
Water losses (m^3) per connection and year	16	Wastewater treated (million m^3)	14.15

Water losses (%)	16	Total sludge produced in STPs (ton DS/y)	2714
Quality of supplied water	100	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m^3)	1.01 ex VAT	Sludge thermally processed (ton DS/y)	0
Mains length (km)	575	Sludge disposed by other means (ton DS/y)	2714
Average mains age	50-60	Energy costs (million €)	1.000
Number of main failures	676	Average age of the sewer system (y)	52 [a)]
Main failures per 100 km	117.5	Sewer blockages	408
Asset turnover ratio	3.375 estimate	Sewer blockages per 100 km	56.7

a) Estimate based on information from Ugarelli et al. (2009).

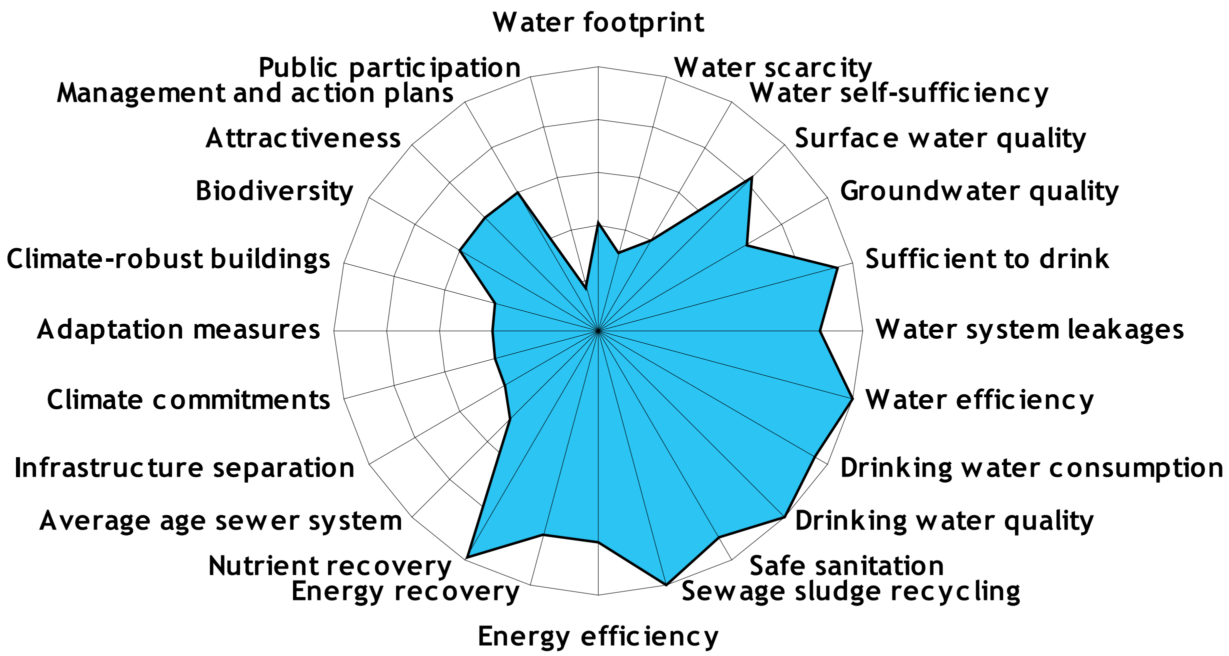


Figure 1. City Blueprint of Reggio Emilia.

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 90 %. There is a system of combined sewers, sanitary sewers and stormwater sewers. The separation of this infrastructure is 40% (score 4 in Figure 1). The average age of the waste water network has not been provided, but a reasonable good estimate is that the average age is about 52 years (Ugarelli et al., 2009). The number of sewer blockages per 100 km is relatively high (56.7). The energy costs for the waste water system are 1 million € (Table 2). Recently (2012) measures have been taken to recover energy from wastewater (80% of the waste water). Nutrient recovery from waste water is 99%. Sewage sludge is applied in agriculture leading to a recycling rate of 100%.

Governance

Reggio Emilia shows commitment to sustainable solutions. This is reflected in the governance scores which vary from 4 (energy recovery, climate change and energy efficiency) -10 (water efficiency). The external collaboration (type and level) both score with a 4.

Highlights of Reggio Emilia

Highlights of Reggio Emilia are: (1) collaboration between utility management and institutions (EU, Universities), (2) the infrastructures and (3) competent staff.

Further steps

Based on the scores for Reggio Emilia, the following aspects may need further attention: infrastructure separation, maintenance of the drainage system, although it has been subject of a specific study (Ugarelli et al., 2009), further commitments to climate change adaptations and public participation.

8.4. Amsterdam

Introduction

Amsterdam is the capital of the Netherlands and home to almost 800.000 people. Amsterdam and water are intimately connected; the name of the city refers to the adjacent Amstel River, which terminates in the well known historical canals that run through the city centre. The city's aim to develop as a competitive and sustainable European metropolis in the face of economic, demographic and climate challenges neatly align with the rationale and objectives of TRUST. Amsterdam has always taken a prominent position in national and international water management. Its water company was the first to deliver piped water in the country (1853) and the first in the world that does not use chlorine in the treatment of its surface water. In 2006 the various urban water-related services were brought under one roof, culminating in the country's first water cycle company called Waternet. The city's unique water cycle approach has proven highly beneficial.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of Amsterdam. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for the Netherlands is 91 km^3 per year. Only 11 km^3/year is from internal (national) sources leading to a dependency ratio of almost 88%! This is also reflected in the low score for water self-sufficiency. The TRWR per capita is 5478 m^3 per year. Most of the water withdrawal in the Netherlands is from industry (9.3 km^3), followed by municipalities (1.25 km^3) and agriculture (0.07 km^3). In the Netherlands, the total withdrawal per capita per year is relatively low, i.e., 639 m^3 which is 11.7 % of TRWR (Table 1). The surface water quality is reasonable, but the shallow groundwater quality and biodiversity of surface waters is poor (Figure 1).

Table 1. Basic data for Amsterdam

Resident population (x 1000)	931
Household occupancy	1.95
Supply area (drinking water) km^2	287
Catchment area (waste water) km^2	269
Annual average rainfall (mm)	847
Daily average air temperature (°C)	10.1
Population density ($inhab/km^2$)[a]	400
TRWR per capita (m^3/year)[a]	5478
Total freshwater withdrawal as % of TRWR[a]	11.7

a) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from lowland surface water sources (88%) and borehole sources (12 %) and there is 100% population coverage. The total water consumption (50 m^3 per person per year) ranks as lowest amongst the TRUST cities. The quality of the supplied water is excellent (Table 2 and Figure 1). The mains length is 3098 km and has an average age of 26 years. The number of main failures is very low (0.839 per 100 km) and so are the water losses (5.4 %).

Table 2. Key data for drinking water and waste water for Amsterdam

Drinking water		Waste water	
System input volume (million m^3/year)	36.14	Number of properties connected (x 1000)	777
Population coverage	100	Collected sewage (m^3/inhabitant per y)	87
Authorised consumption (million m^3/year)	46.6	Length of combined sewers (km)	523
Consumption m^3 per person per year	50	Length of stormwater sewers (km)	1669
Service connections x 1000	409	Length of sanitary sewers (km)	866
Water losses (m^3) per connection and year	5	Wastewater treated (million m^3)	80.97

Water losses (%)	5.4	Total sludge produced in STPs (ton DS/y)	20734
Quality of supplied water	100	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m^3)	1.30 VAT excluded	Sludge thermally processed (ton DS/y)	20.734
Mains length (km)	3098	Sludge disposed by other means (ton DS/y)	0
Average mains age	35.6	Energy costs (million €)	1.136
Number of main failures	26	Average age of the sewer system (y)	28
Main failures per 100 km	0.839	Sewer blockages	573
Asset turnover ratio	0.389	Sewer blockages per 100 km	18.7

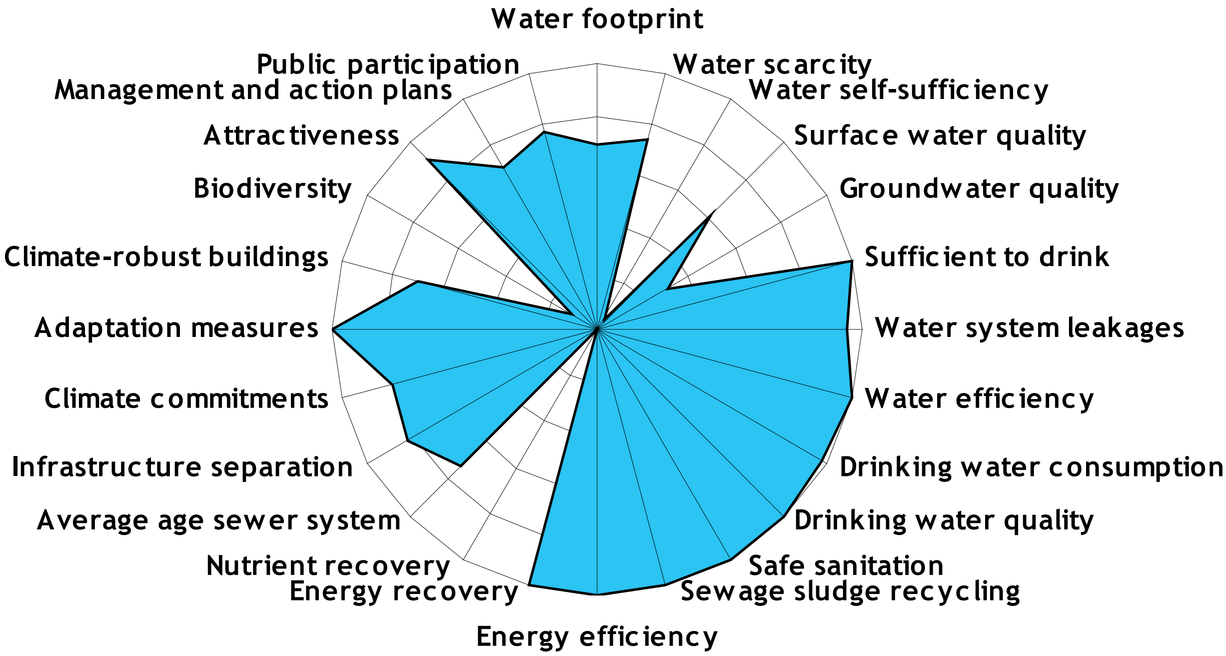


Figure 1. City Blueprint of Amsterdam

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is nearly 100 %. There is a system of combined sewers, sanitary sewers and stormwater sewers. The separation of this infrastructure is 82.8.5 % (score 8.28; Figure 1). The average age of the waste water is 28 year and the number of sewer blockages per 100 km is relatively high (18.7). The energy costs for the waste water system are 1.1 million € (Table 2). Waste water is effectively used to recover energy, but nutrient recovery is 0%. As a result of a national law related to the pollution of sewage sludge by heavy metals and other persistent pollutants, the application of sewage sludge in agriculture is forbidden and all sewage sludge is thermally treated.

Governance

Amsterdam shows an adequate commitment to sustainable solutions. This is reflected in the governance scores which vary from 7-10. The external collaboration (type and level) both score with a 4. These results and aspects of governance are in line with information provided in the European green city index (2009), where Amsterdam scores low in carbon dioxide emissions, good in clean and efficient energy use as most of the heat is produced by the Waste and Energy Company, by converting biomass and biogas derived from waste and sewage into heat and electricity. In the European green city index report, Amsterdam is ranked number one for water.

Highlights of Amsterdam

Highlights of Amsterdam are: (1) the multi level water safety approach (NL demonstration project Amsterdam metropolitan area), (2) energy and resource recovery from the watercycle, and (3) living with water (entanglement between urban quality and water management; e.g. the WATERgraafsmeer programme).

Further steps

Based on the scores for Amsterdam, the following aspects may need further attention: nutrient recovery from waste water and biodiversity. Upstream pollution of surface waters may hinder Amsterdam to further improve biodiversity and surface water quality and probably needs further attention at provincial and (inter)national level. At the TRUST Basel workshop Amsterdam clarified that biodiversity and nutrient recovery were on top of their agenda.

8.5. Hamburg

Introduction

Hamburg, in the north of the country, is Germany's second largest city. The city situated on the banks of the river Elbe is a port city and a major industrial and commercial location. The port of Hamburg is the second largest in Europe, after Rotterdam, and is of key significance for the German economy (German green city index, 2012). The City of Hamburg was awarded the title "European Green Capital 2011" by the EU Commission because of its ambitious targets in sustainability, climate and environmental protection. The HAMBURG WASSER group is deeply involved in supporting activities to achieve these targets. Besides the daily experiences of water supply and waste water management for about 2 million people the company focuses on the growing problem of storm water events, developing concepts for attenuating the consequences of climate change and increased sealing. The HW group also works on the production of renewable energy in urban areas (production and treatment of biogas, feeding in the gas distribution system, wind energy plants, operating a new system for heat production from sewers) and currently develops a semi-centralised waste water system which separates grey and black water and uses black water for energy production.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of the city of Hamburg. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for Germany is 154 km^3 per year. This is equivalent to a TRWR per capita of 1871 m^3 per year. Most of the water withdrawal is by industry (27 km^3) and for municipal purposes (5 km^3). The total withdrawal per capita per year is 391 m^3. This is a considerable amount leading to a total freshwater withdrawal in Germany of 21% of TRWR (Table 1). The environmental quality (surface water quality, groundwater quality) is reasonable but the biodiversity of aquatic ecosystems according to information provided by the European Environment Agency is very low. Most water bodies have a less than good ecological status or potential. This has been scored with a 1 in Figure 1). Despite this, the attractiveness of the city of Hamburg has been scored very high (10; see Figure 1).

Table 1. Basic data for Hamburg/Germany

Resident population (x 1000)	2050
Household occupancy	2.0
Supply area (drinking water) km^2	1200
Catchment area (waste water) km^2	1400
Annual average rainfall (mm)	773
Daily average air temperature (^oC)	9
Population density (inhab/km^2)[a]	230
TRWR per capita (m^3/year)[a]	1871
Total freshwater withdrawal as % of TRWR[a]	21

a) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from borehole sources (100%) and there is 100% population coverage. The total water consumption (52.6 m^3 per person per year) ranks amongst the lowest of the TRUST cities. This has been the result of a long campaign in Hamburg to save water. This is also the explanation for the relatively low score (score = 2) of Hamburg for the indicator 8 (water efficiency). For Hamburg water efficiency is not a high priority anymore as water efficiency has been improved considerably over the last decades. The quality of the supplied water is excellent (Table 2 and Figure 1). The average age of the distribution system is 43 years and the number of main failures is about average. The water losses in the system are extremely low (4.4 %).

Table 2. Key data for drinking water and waste water for the city of Hamburg

Drinking water		**Waste water**	
System input volume (million m^3/year)	118	Number of properties connected (x 1000)	700
Population coverage	100	Collected sewage (m^3/inhabitant per y)	75
Authorised consumption (million m^3/year)	108	Length of combined sewers (km)	1216
Consumption m^3 per person per year	52.6	Length of stormwater sewers (km)	1710
Service connections x 1000	660	Length of sanitary sewers (km)	2224
Water losses (m3) per connection and year	7.2	Wastewater treated (million m^3)	150

Water losses (%)	4.4	Total sludge produced in STPs (ton DS/y)	46900
Quality of supplied water	99.97	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m3)	1,77 excl. VAT	Sludge thermally processed (ton DS/y)	46900
Mains length (km)	5412	Sludge disposed by other means (ton DS/y)	0
Average mains age	43	Energy costs (million €)	7.7
Number of main failures	525	Average age of the sewer system (yr)	46
Main failures per 100 km	9.70	Sewer blockages	144
Asset turnover ratio	0.44	Sewer blockages per 100 km	2.8

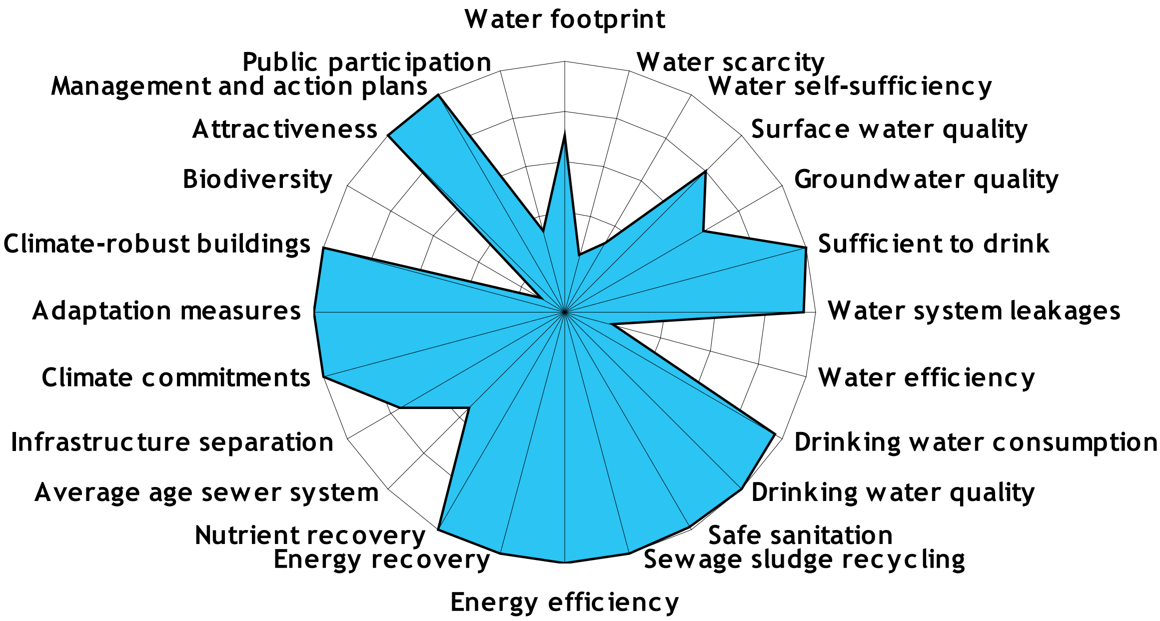


Figure 1. City Blueprint of Hamburg

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 99%. There is a system of combined sewers, sanitary sewers and stormwater sewers and the separation of this infrastructure is 76% (score 7.6; Figure 1). Despite the fact that the average age of the waste water is relatively high (46 years), the number of sewer blockage per 100 km is relatively low. The energy costs for the waste water system are relatively high (Table 2).

Wastewater is effectively treated and energy and nutrients are recovered. All sewage sludge is thermally recycled. This leads to a score of 10 in Figure 1.

Governance

The city of Hamburg shows a very high level of commitment to sustainable solutions. This is reflected in high scores for sustainable urban water management, energy-efficient building (European green city index, 2009) and the way the external collaboration is organized. Hamburg has explored green options and answers to its metropolitan challenges, shared its experiences and practices as the European Green Capital of 2011. Hamburg has set ambitious climate protection goals such as reducing its CO_2 emissions by 40% by 2020 and by 80% by the year 2050.

Highlights of Hamburg

(1) The RISA-Project – Rain InfraStructure Adaption

The project RISA aims at developing adequate responses concerning rainwater management in order to avoid flooding of basements, streets and properties as well as water pollution from combined sewer overflow and urban / street run-off. The goals of the RISA project are:

- Flood protection & inland flood control
- Water body conservation
- Near-natural water balance

The project focuses on the identification of technological requirements and the creation of conditions that enable a forward-looking and sustainable rainwater management. The main objective is to maintain the actual drainage comfort and to guarantee/improve water protection and inland flood protection. Moreover, the project seeks to integrate water management measures into urban and regional planning and to adapt the institutional setting accordingly. Project results will support the development of a „Structural Plan Rainwater", a guidance document for administrations, experts and property owners for new rainwater management in Hamburg. Therewith, the project RISA contributes to the climate protection concept and climate change adaptation strategy of the senate of Hamburg. The measure addresses the fact that rainwater management is a municipal joint task. The project was funded by the State Ministry of Urban Development and Environment of Hamburg (Behörde für Stadtentwicklung und Umwelt) in co-operation with HAMBURG WASSER, the municipal Water Supply and Wastewater Disposal Company in Hamburg in September 2009. Further information: http://www.risa-hamburg.de/index.php/english.html

(2) Unity in Diversity- The Jenfelder Au

"Unity in diversity" is the slogan selected to represent the social and environmental standards incorporated into the Jenfelder Au neighbourhood, located in the eastern part of the city of Hamburg. The Jenfelder Au will be the first neighbourhood in Hamburg where the HAMBURG WATER Cycle will be incorporated into newly constructed buildings. The neighbourhood, which also incorporates other efficient approaches for energy production, comes very close to fully fulfilling the vision of a neighbourhood with a completely self-sufficient energy supply. Additionally, the space-efficient development plan ensures affordable access to townhouses with gardens in Jenfeld. The individuality of the approximate 2,000 future residents is also not sacrificed. The award-wining concept, given to West 8, the city planners from the Netherlands, incorporates a variety of house and apartment styles with individual aspects which harmonize to form one neighbourhood which truly manifests the motto, "unity in diversity". Further information: http://www.hamburgwatercycle.de/index.php/the-jenfelder-au-quarter.html

(3) The HAMBURG WATER Cycle® in the Jenfelder Au

The HAMBURG WATER Cycle will be carried out for the first time in a larger scale in the Jenfelder Au. There, the HWC will be implemented in approximately 630 residential units, making the development of a neighbourhood with climate-neutral residences with sustainable water drainage possible. The project is unique in its size and value as an example to spur future innovation in urban development and planning. For these reasons, the Jenfelder Au is a pilot project of the "National Urban Development Policy" of the Federal Ministry of Building and Urban Development (BMVBS) and the Federal Institute of Building, Urban Affairs and Spatial Development (BBSR). The HAMBURG WATER Cycle can vary on its scale of implementation. The most crucial feature is the separation of wastewater streams and the subsequent energy recovery from the wastewater. In the neighbourhood of Jenfelder Au, a feature is added, rainwater, which extends the creative possibilities of urban- and landscape- planners. In the open space design, rainwater becomes a creative element. The Jenfelder Au stormwater management concept decouples the rainwater flow from the sewer network, allowing the water to flow over the natural landscape back to the local waters. The landscape and urban planning concept is made possible through the use of open channels which allow rain to flow through streams and waterfalls to retention basins which are in the form of attractive ponds and lakes. Thus, the appearance of the residential area is enhanced, and the flood protection is optimized as the retention basins are designed to provide further storage potential in case of heavy downpours. Further information: http://www.hamburgwatercycle.de/index.php/the-hwc-in-the-jenfelder-au.html

Further steps

According to the German Green City Index (2012), Hamburg ranks above average in water. The annual per capita water consumption of 53 cubic meters is well below the European city average of about 93 cubic meters. The water losses (4.4%) in the drinking water distribution system are very low. Biodiversity may be an area where further improvements are needed.

8.6. Oslo

Introduction

The capital of Norway, Oslo, has a population of 600.000 inhabitants. Oslo city's water resources portfolio consists of forty lakes which are scattered in the large forest area surrounding the city, eight major urban watercourses and the Oslo fjord. Rapid population growth in the urban, metropolitan area (population of 1.4 million) and in the entire Oslo fjord region (population of 1.7 million) places significant stress on this unique fresh-marine water environment and poses challenges regarding both ecosystem and water supply and wastewater services. Proximity to the water has shaped Oslo, its history, industry and people. The Akerselva River gave power to numerous mechanical workshops which were established on its banks in the early nineteenth century. Today, an important political goal for the city of Oslo is to sustain Oslo's blue-green infrastructure and to reopen the city's rivers, and bring the sight of running water in a green environment into people's daily lives.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of the city of Oslo.

Table 1. Basic data for Oslo/Norway

Resident population (x 1000)	625
Household occupancy	1.9
Supply area (drinking water) km^2	160
Catchment area (waste water) km^2	160

Annual average rainfall (mm)	814
Daily average air temperature (°C)	6.5
Population density (inhab/km^2)[a]	15
TRWR per capita (m^3/year)[a]	78231
Total freshwater withdrawal as % of TRWR[a]	0.77

a) National data according to FAO Aquastat

Norway has plenty of water. The total renewable water resources (TRWR), according to FAO are 382 km^3 per year and this is 78231 m^3 per person per year, which is the highest volume among the cities and regions in our TRUST project. The environmental quality (surface water quality, groundwater quality and biodiversity) is relatively high and so the attractiveness of Oslo (Figure 1).

Drinking water

Drinking water is made from upland surface water sources, and there is 100% population coverage. The total water consumption (124 m^3 per person per year) is relatively high. The quality of the supplied water is excellent (Table 2 and Fig 1). The average age of the distribution system is 55 years and the number of main failures is about average. The water losses in the system are relatively high (23%).

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is nearly 100%. There is a system of combined sewers, sanitary sewers and stormwater sewers and the separation of this infrastructure is 64% (score 6.4; Figure 1). Despite the fact that the average age of the waste water is high (55 years), the sewer blockage per 100 km are moderate. The energy costs for the waste water system are relatively low. Energy is recovered from waste water, but this is not the case for nutrients (the score for this indicator is 0 in Figure 1). All sludge produced is thermally recycled. This leads to a score of 10 in Figure 1.

Table 2. Key data for drinking water and waste water

Drinking water		**Waste water**	
System input volume (million m^3/year)	95.5	Number of properties connected (x 1000)	325
Population coverage	100	Collected sewage (m^3/inhabitant per y))	195

Authorised consumption (million m³/year)	77.7	Length of combined sewers (km)	753
Consumption m³ per person per year	124.3	Length of stormwater sewers (km)	715
Service connections x 1000	41.5	Length of sanitary sewers (km)	641
Water losses (m3) per connection and year	429	Wastewater treated (million m³)	120.6
Water losses (%)	22.9	Total sludge produced in STPs (ton DS/y)	5875
Quality of supplied water	99.25	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m³)	1.23 incl. VAT	Sludge thermally processed (ton DS/y)	5875
Mains length (km)	1560	Sludge disposed by other means (ton DS/y)	0
Average mains age	55	Energy costs (million €)	0.731
Number of main failures	222	Average age of the sewer system (yr)	55
Main failures per 100 km	14.23	Sewer blockages	179
Asset turnover ratio	0.15	Sewer blockages per 100 km	8.5

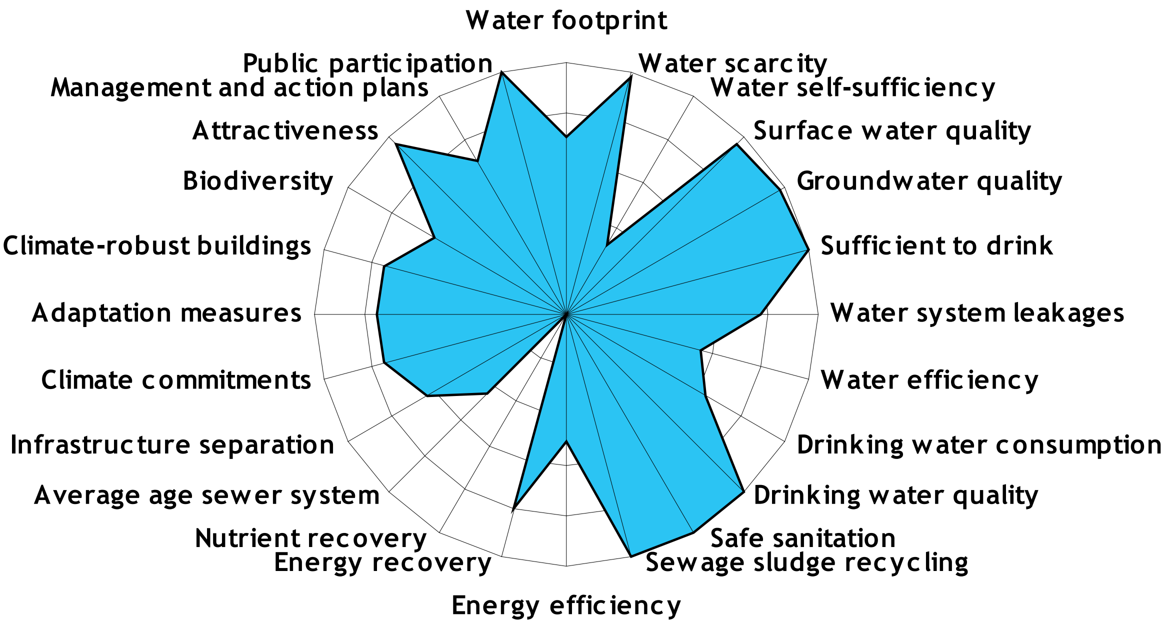


Figure 1. City Blueprint of Oslo.

Governance

Oslo shows a relatively high level of commitment to sustainable solutions. This is reflected in the relatively high scores for sustainable urban water management, energy-efficient building (European green city index, 2009), the way the external collaboration is organized and the (estimated) high level of voluntary participation which is a prerequisite to fulfil these ambitions. This is further supported by the City Government and Oslo Water and Sewerage Works. The City Government has developed an ambitious sustainable strategy and the Oslo Water and Sewerage works has participated in many national research and development projects and has been a major end user or pilot city in many EU projects.

Highlights of Oslo

- The "Fjord City"-project – Renewal of the old wastewater system in downtown Oslo (The "Midgard Serpent"-project)

"Fjord City", the cluster of waterfront developments underway in the Norwegian capital, is a complex project designed to respond to economic and political stimuli and technological change. Renewal of the old wastewater system in downtown Oslo is among the priority sustainability goals for the "Fjord City"-project. The new wastewater system is an extension of the old one from the 1890s with nine of 35 overflows discharging directly into the Akerselva River and the Bjørvika bay more than 25 times per year. The system which conveys sewage to one of two wastewater treatment plants is designed to intercept combine sewer overflows and to increase sewer detention capacity. The main achievements of this strategic investment in Oslo's wastewater infrastructure include meeting recreational water quality objectives under the most likely climate change and population growth scenarios. With only one overflow point left in the system, which will operate every third year at a maximum, a large reduction of the possibility for acute discharge from the sewer mains is obtained. The saving of €12 million over a 40 year period is realized by phasing out five pumping stations. The project triggered the use of innovative technologies and methods, from micro-tunnelling in the subsidence exposed areas and the heritage sites, to new approaches to design, modelling and measurement. Further studies are required to refine the control of interplay between the interceptor and wastewater treatment plant. The wastewater project which has a financial framework of €180 million will be completed during the first half of 2014. Further information: http://www.prosjekt-fjordbyen.oslo.kommune.no/english_pages/ and http://www.vann-og-avlopsetaten.oslo.kommune.no/aktuelt/prosjekter/midgardsormen/article225260-54556.html

- Creating transportation fuel out of wastewater

The sewage from the city is conveyed to two wastewater treatment plants; VEAS located 30 kilometers to the west, and Bekkelaget 3 km to the east. Both WWTPs operate in activated sludge mode with sludge digestion and biogas production. Oslo water company is the owner of the Bekkelaget wastewater treatment plant which is operated by a private contractor, and has shares in the regional wastewater treatment plant VEAS which is run by an inter-municipal company.

The Bekkelaget wastewater treatment plant serves a population of approximately 300,000 and has a daily processing capacity of 120,000 m3. The plant was built in 2001 and included two thermophilic anaerobic digesters for sludge treatment. The process produced an annual yield of 20 GWh equivalent of biogas, with methane content of 60%. Most of the biogas (16.5 Wh) was used onsite to deliver heat for sludge heating (12 GWh) and drying (4.5 GWh), while the rest was flared. In addition, the plant used 11 GWh of electricity for the wastewater treatment process.

The sludge drying unit was closed due to poor air quality, high maintenance costs, and the preference of farmers – who were the main recipient of the treated sludge – for dewatered rather than dried sludge. Several alternatives uses for the biogas were considered, ending in the decision to invest in biomethane upgrade facilities.

To increase the quantity of available biogas which can be upgraded to biomethane, a heat pump and heat exchangers were installed, delivering the heat necessary for sludge heating (13 GWh) while using 2.6 GWh electricity. In addition, a biomethane upgrade unit was installed using pellets as an energy source (2.1 GWh). This made it possible to upgrade all of produced biogas into biomethane rather than using it for other purposes. Annual production of biomethane is estimated at 2.1 million Nm3, sufficient to provide the fuel needs of 80 city busses, in place of diesel.

Benefits

Finance – € 232,000 annual pre-tax profit

Energy – going from a net energy consumer (-7.5 GWh) to a net energy producer (+5.3 GWh)

Environmental:

–– 3,700 tons of CO_2 in annual avoided emissions from transport (70% reduction)

–– 98% reduction in particulate matter and 78% reduction in nitrogen oxide

Further information: http://xynteo.com/uploads/TCS-Xynteo-smart-water-paper.pdf

3) Extraction of the thermal energy from the sewer transport system

In the Skøyen heating central two heat pumps extract energy from the city's sewer system. Further information: http://www.energi.no/en/energiproduksjon/heat-from-sewerage-system-used-for-district-heating

Further steps

a) According to the European green city index (2009), Oslo is ranked a relatively poor 20th place in the water category, reflecting its high water consumption, a fairly high leakage rate and the city's low rate of residential water metering. The TRUST baseline assessment underlines these first two findings.

The key priority areas include:

The Norwegian capital Oslo is a high latitude city with high energy demand and the abundance of water. Its water and wastewater company which has an abundance of inexpensive water resources has a much lower value of water lost than a utility which has a water resource deficit and is having to impose restrictions on customer water use. However, meeting 25-30 year plan horizon needs in form of new water sources which are less reliable than existing ones and more costly to develop, has created political pressure to re-imagine supply and demand balance and its components. In order to reach a sustainable balance, the demand side is to be looked at carefully first. For Oslo water and wastewater as a company, end-use efficiency (efficiency of household water-using devices stock, smart metering, effective pricing, the role of tariff, promoting behavioural changes), technological improvements in leakage detection and economic level of leakage in the long-term planning, and barriers for drinking water use reduction by using rainwater for purposes which do not require potable water (garden watering, street flushing), are the most important issues in a multi-step transition from today's status to the vision 2040.

b) Furthermore the waste water collection and distribution system may need a more in-depth study regarding the maintenance, and nutrient recovery may be another issue for further study.

The key priority areas include:

1) CC: Adaptation to climate changes integrated into land management and development, and operation of infrastructure

- Sustain Oslo's blue-green infrastructure by rainwater harvesting, reopening the city's streams and mapping overland flood routes
- Smart process and asset management

2) Minimize pollution of the fresh and marine waters

- Upgrading of the WWTPs and eliminating the main causes of pollution of the urban streams (UWWTD, WFD)

3) Energy and nutrient recovery from the wastewater system

- Upgrading and extension of WWTPs to increase energy recovery. After upgrading WWTPs will contribute roughly 10% to the city's CO_2 emission reduction goal
- Nutrient recovery will depend on nutrient discharge regulations, the costs to extract these resource components from wastewater, and markets.

8.7. Cities of Scotland

Introduction

Scotland is home to 5.2 million people covering an area of 78782 km^2, resulting in a population density of 65.6/km^2. Scotland has an abundance of fresh water resources. Over 1.9% of land surface in Scotland is covered by freshwater. That is around 70% of the area and 90% of the volume of all the UK's inland surface water. The water contained in Loch Ness alone is nearly twice the amount found in all the standing waters of England and Wales combined. As water rich country Scotland has recently set out a vision to become a responsible Hydro Nation which contributes to the strategy to develop a low carbon economy. Scotland has a dynamic water sector and the abundance of water resources will be harnessed more fully as a Hydro Nation to boost the Scottish economy. Developing as a Hydro Nation is a huge opportunity for Scotland.

Scottish Water is the provider of both water and waste water services for the whole of Scotland. Since its creation over ten years ago Scottish Water has made significant improvements and investments in customer service, water quality, environmental protection, and waste water compliance. Leakage for 2011/12 reduced to 33% and is projected to reach the economic level of leakage by 2012/13. It has the lowest customer charges in the UK, while maintaining a strong customer satisfaction rating of 83%. Significantly improvements have been made in compliance both water and wastewater over the last ten years. The latest carbon footprint shows a reduction of 9,000 tonnes of CO_2 equivalents. Scottish Water has transformed the industry in Scotland in the last ten years of its existence with £5.5billion investment, driving down operational expenditure and ensuring its customers have the lowest possible charges while providing the highest possible customer service. Scottish Water is currently producing 5% of its energy requirements and this is expected to rise to 10% by 2015 with ambitious plans for wind and hydro generation in the future.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system of the cities of Scotland. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for the UK is 147 km^3 per year. This is equivalent to a TRWR per capita of 2361 m3 per year. Most of the water withdrawal in the UK is municipal (7.4 km^3), followed by industry (4.3 km^3) and agriculture (1.3 km^3). In the UK, the total withdrawal per capita per year is relatively low, i.e., 213 m^3 which is 8.8% of TRWR (Table 1). The environmental quality (surface water quality, groundwater quality and biodiversity) is relatively good.

Table 1. Basic data for Scotland

Resident population (x 1000)	5233
Household occupancy	2.1
Supply area (drinking water) km^2	79796
Catchment area (waste water) km^2	1892
Annual average rainfall (mm)	1530
Daily average air temperature (^oC)	7.52
Population density (inhab/km^2)[a]	256
TRWR per capita (m^3/year)[b]	213
Total freshwater withdrawal as % of TRWR[b]	8.82

a) Source: Wikipedia based on data from 2010

b) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from upland surface water sources (88.9%), lowland surface water sources (7.7%), springs (0.2%) and borehole sources (3.2 %) and there is 97% population coverage. The total water consumption (96.6 m^3 per person per year) ranks average amongst the TRUST cities. The quality of the supplied water is excellent (Table 2 and Figure 1). Scottish Water manages the longest mains length of all TRUST cities and regions (47720 km) and has an average age of 45 years. The number of main failures is about average.

Table 2. Key data for drinking water and waste water for Scottish Water

Drinking water		**Waste water**	
System input volume (million m^3/year)	692	Number of properties connected (x 1000)	2460
Population coverage	97	Collected sewage (m^3/inhabitant per y))	228
Authorised consumption (million m^3/year)	481	Length of combined sewers (km)	17467
Consumption m^3 per person per year	96.6	Length of stormwater sewers (km)	8113
Service connections x 1000	2582	Length of sanitary sewers (km)	25078
Water losses (m3) per connection and year	89.21	Wastewater treated (million m^3)	290
Water losses (%)	33.20%	Total sludge produced in STPs (ton DS/y)	20030
Quality of supplied water	99.86	Sludge going to landfill (ton DS/y)	509
Average water charges (€ / m3)	1,22 *	Sludge thermally processed (ton DS/y)	0
Mains length (km)	47720	Sludge disposed by other means (ton DS/y)	19520
Average mains age	45	Energy costs (million €)	18.990
Number of main failures	8757	Average age of the sewer system (yr)	49
Main failures per 100 km	18.28	Sewer blockages	3121
Asset turnover ratio	NA	Sewer blockages per 100 km	6.2

* ex VAT

In Scotland the amount of waste water treated is 145136 tonnes BOD/yr. The value presented in Table 2 is based on the assumption that municipal waste water has an average BOD of 500 mg O_2/L. Figure 1 is a snap shot of indicators for Scotland based on the data supplied with a qualitative interpretation to enable a high level comparison.

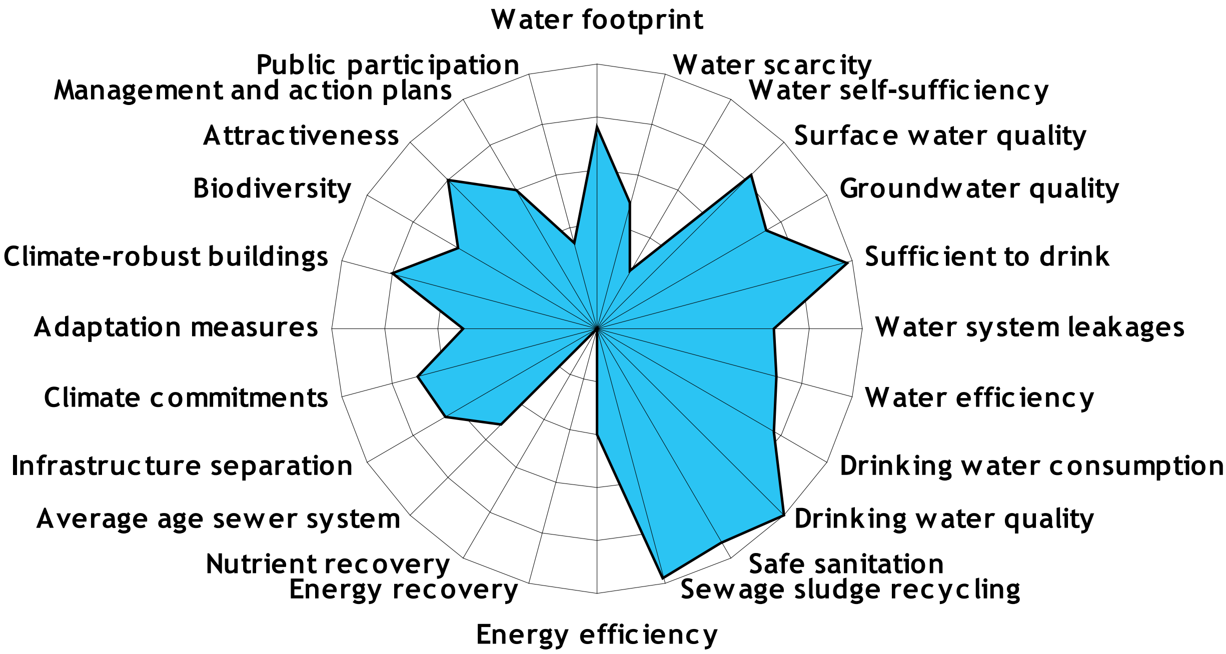


Figure. 1. City Blueprints of Scotland

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 93 %. There is a system of combined sewers, sanitary sewers and stormwater sewers with an impressive total length: 50657 km. The separation of this infrastructure is 65.5 % (score 6.55; Figure 1). Despite the fact that the average age of the waste water is relatively high (46 years), the number of sewer blockages per 100 km is relatively low. The energy costs for the waste water system are 18.99 million € (Table 2). Currently wastewater is not effectively used to recover energy and nutrients.. Most sewage sludge is applied in agriculture. This leads to a score of 9.7 for sewage sludge recycling in Figure 1.

Governance

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". Scottish Water positively engages with its customers through public forms, local and regional customer plans that covered 13 topics. The results of the TRUST questionnaire show that Scotland has ambitions to sustainable solutions for UWCS. This is reflected in the governance scores (questions 28-35) which vary from 4 (waste water efficiency) to 7 (water efficiency and climate commitments). Furthermore, there are a number of very promising initiatives:

(1) Scottish Water has the lowest carbon footprint for drinking water in the UK, mainly due to the high quality of raw water in the environment and the extensive use of gravity systems for distribution rather than having to pump water around.

(2) Investments are made to improve waste water treatment. The small village of Cartland near Lanark is the location of an ambitious plan by Scottish Water to offer a modern waste water treatment process to 16 properties for the first time. This £1.5million project is part of a pilot study to investigate the feasibility of providing low carbon emission treatment works. The project offers a number of interesting benefits for customers in Cartland, as well as a low carbon facility.

(3) The official opening of Scottish Water's new Glencorse Water Treatment Works (WTW). The works has sustainability at its very core. The works is hidden under Scotland's largest 'grass' roof, helping it to blend into the neighbouring Pentland Hills. In a world first a mobile pipeline production plant was installed on the route of the 9 mile pipeline transferring water – by gravity – into the capital. An on-site hydro turbine also provides a third of the facility's energy needs. This initiative received great support from Friends of the Earth Scotland: "Not only will these works supply Edinburgh's citizens with clean drinking water in an energy efficient, gravity-fed way, but the works will also be more than energy sufficient through electricity generated by an on-site hydro electric scheme. These factors, along with the sensitive and eco-friendly design and landscaping of the works, make them a very welcome addition to the city of Edinburgh's infrastructure."The grass roof will also help to harvest rainwater into bio-diverse wetlands surrounding the site. These will provide rich habitats for indigenous plant, animal and insect life.

Also, it is worth noting that Scottish Water has a strong network of research collaborations with universities, other water companies, and national bodies such as UKWIR (UK Water Industry Research). The UKWIR scope of work covers drinking water, sewage, sludge, treatment, and regulation. Scottish Water also collaborates with key stakeholders such as SEPA (Scottish Environmental Protection Agency) and WIC (the Water Industry Commission for Scotland) on long term planning of water services for Scotland.

Highlights of Scotland

Highlights of Scotland related to UWCS are described in detail in the Annual Report and Accounts 2011/12. The next 10 points are taken from this report and summarized below:

1. Customer service. We have improved customer service levels. Our Overall Performance Assessment (OPA) score has more than doubled since 2002.

2. Keeping customer charges low. In 2012/13 the average household charge is the lowest in the UK water industry, £52 lower than the average in England and Wales. This is a transformation from 2002/03 when the average household charge in Scotland was £30 higher than in England and Wales.

3. Investment across Scotland. In the last 10 years we have invested a total of £5.5 billion. This has delivered investment across Scotland to improve drinking water quality and protect the natural environment.

4. Improving drinking water quality. Our compliance with strict water quality standards has improved from 99.44% of all samples meeting the required criteria in 2002 to 99.86% in 2011. Since 2002 we have improved 4,876 miles of water pipes.

5. Waste water treatment. We are helping to protect the natural environment of Scotland. Our waste water treatment works compliance has improved by 87% since 2002.

6. Leakage reduction. Leakage has been reduced from 1,132 million litres of water a day in 2002/03 to 629 million litres a day in 2011/12 – a reduction of over 44%.

7. Improving water pressure. We have reduced the number of households on our low pressure register by 90%, from 14,942 properties in 2002/03 to 1,542 in 2011/12 – and we continue to work to improve pressure for the remaining customer properties on the low pressure register.

8. Reducing risk of flooding. The number of customer properties affected by internal sewer flooding has fallen by 61% since 2002/03 from 710 to 277 in 2011/12. In addition, we have reduced the number of general sewer "flooding incidents, which do not affect customer properties, by 61% from 551 to 213.

9. Resilience to climate change. We have made significant progress in renewable energy provision since 2002 and are now producing over 5% of our own annual energy demand.

10. Keeping costs low. Since 2002 we have reduced our real operating costs by around 40% through using new cost-saving technologies, rationalising our asset base and incorporating more innovative and efficient ways of working.

Further steps

Based on the Annual Report and Accounts of Scottish Water, the following aspects may need further attention: energy and nutrient recovery from waste water, and greater energy efficiency and self generation. Scottish Water is committed to improving the environment both today and in the future and is actively reviewing its long term water and waste strategies to improve its sustainability.

8.8. Bucharest

Introduction

Bucharest is the capital of Romania and home to almost 2 million people. Since 2000 the company Apa Nova Bucuresti (ANB) is in charge with water supply and sanitation for the city. The owners are Veolia Water (74%), the municipality of Bucharest (16%) and the employees of ANB (10%). In 2010, the company had 1900 employees and provided water and sewage utilities for 2 millions inhabitants through three water treatment plants and a pipeline network (water and sewage) of approximately 4000 km. A new wastewater plant that has been constructed by the municipality with the help of ISPA funds (Instrument for Structural Policies Pre-Accession) has recently started operation and is run by ANB. Since 2000 Bucharest meets the European norm regarding drinking water quality. As a water provider in a capital and with water and sewage service in transition, ANB restores and guarantees the continuity of supply and the high drinking water quality since then. Through metering and a non revenue water reduction strategy the global water demand of the city decreased from 585 Mm3 in 2000 to 225 Mm3 in 2011. The electrical consumption was also reduced by more than 75%. The municipality of Bucharest and ANB work together in order to raise the awareness of customers and inhabitants on water resources management and waste water treatment and impact of those services on the environment, by monitoring for instance its carbon foot print. ANB long term vision and strategy is to deliver the best water and sewage services in terms of quality and experience to its customers, to value water and waste water services as potential energy sources and to be a responsible actor of the city's life by decreasing its environmental impact and raising awareness. The activities that were reported include a feasibility study on the completion of the WWTP, the rehabilitation of the main sewerage collectors and the Dambovita collector (a complex underground construction of 45 km, whose current capacity of receiving waste waters is below 50%. It is expected that these plans will improve the overall UWCS in Bucharest. In order to achieve those commitments, innovation and global benchmarking are required on asset management, energy-water nexus and demand management which is the reason why ANB and Veolia Environment Research and Innovation joined the TRUST project.

Results of the baseline assessment

The results of the baseline assessment based on the completed TRUST questionnaire together with some additional information are summarized in Tables 1 and 2 and Figure 1. Table 1 provides the general information whereas Table 2 summarizes the key data for the drinking water and waste water system for Bucharest. Based on the FAO Aquastat database, the total renewable water resources (TRWR) available for Romania is 212 km^3 per year. Most of this water is from external sources (80%). The TRWR per capita is 9862 m^3 per year. Most of the water withdrawal in Romania is industrial (4.2 km^3), followed by municipal (1.5 km^3) and agriculture (1.2 km^3). In Romania, the total withdrawal per capita per year is 320 m^3 which is 3.2 % of TRWR (Table 1). Surface water in Bucharest is managed by a national body, Apele Romane. Like for all cities in this TRUST baseline assessment, the assessment of environmental quality is based on information from regional and/or national databases, mostly summarized by the EEA (see Section 3). Based on this information, it can be concluded that the environmental quality (surface water quality, groundwater quality and biodiversity) in Bulgaria is relatively good, but it is very likely that the environmental quality in the city of Bucharest is lower.

Table 1. Basic data forBucharest

Resident population (x 1000)	2104
Household occupancy	2.39
Supply area (drinking water) km^2	228
Catchment area (waste water) km^2	228
Annual average rainfall (mm)	572
Daily average air temperature (^oC)	10.2
Population density (inhab/km^2)[a]	90
TRWR per capita (m^3/year)[a]	9862
Total freshwater withdrawal as % of TRWR[a]	3.24

a) National data according to FAO Aquastat

Drinking water

Drinking water is prepared from lowland surface water sources (99.9%) and borehole water sources (0.1 %) and there is 82.25 % population coverage. The total water consumption, based on billed volumes to the population in Bucharest was 161 litres per person per day, which is 58.7 m^3 per person per year. The quality of the supplied water is excellent (Table 2 and Figure 1). The mains failures per length are high. The average mains age exceeds 30 years. In 2001, the network efficiency was 54% and it increased to 60 % in 2011. These data show that 40 % of the water is lost (calculated as produced volumes minus billed volumes). The gradual improvement is also shown by another indicator, i.e., the daily losses ratio (distributed volume which is not billed). This value steadily dropped from 327 m^3/km/day in 2001 to 97 m^3/km/day in 2011.

Table 2. Key data for drinking water and waste water for Bucharest

Drinking water		Waste water	
System input volume (million m^3/year)	239	Number of properties connected (x 1000)	112
Population coverage	82	Collected sewage (m^3/inhabitant per y))	84.6
Authorised consumption (million m^3/year)	136	Length of combined sewers (km)	2157
Consumption m^3 per person per year	58.7	Length of stormwater sewers (km)	27
Service connections x 1000	121	Length of sanitary sewers (km)	25078
Water losses (m3) per connection and year	742	Wastewater treated (million m^3)	66
Water losses (%)	40	Total sludge produced in STPs (ton DS/y)	8468
Quality of supplied water	100	Sludge going to landfill (ton DS/y)	100
Average water charges (€ / m^3)	0.63*	Sludge thermally processed (ton DS/y)	0
Mains length (km)	2444	Sludge disposed by other means (ton DS/y)	0
Average mains age	>30	Energy costs (million €)	NA
Number of main failures	3269	Average age of the sewer system (yr)	NA
Main failures per 100 km	134	Sewer blockages	12597
Asset turnover ratio	0.65	Sewer blockages per 100 km	577

*excl. VAT

Waste water

The waste water system is a collection, transport and treatment system. The percentage of the population covered by adequate waste water collection and treatment is 82 %. The length of the system is 2184 km. It is a system of combined sewers and only a very small fraction of the system is for stormwater only. Therefore, the separation of this infrastructure is only 1.2 % (score 0.12; Figure 1). The average age of the waste water system is unknown. For the scoring in Figure 1 the waste water system is assumed to have an average age of 50 years (score = 5). The number of sewer blockages per 100 km is high (577), but this must be seen against the progress that has been made in Bucharest as the total number of sewer blockages was 20502 in 2003 and was reduced to 12597 in 2011. The energy costs for the waste water system are not available and at this point in time it is expected that wastewater is not yet effectively used to recover energy and nutrients. Data that have been provided for the use of sewage sludge show that 100% is going to landfill.

Governance

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". The results of the TRUST questionnaire show that the governance scores (questions 28-35) which vary from 2 (climate change) to 6 (water efficiency), with an average of 5.

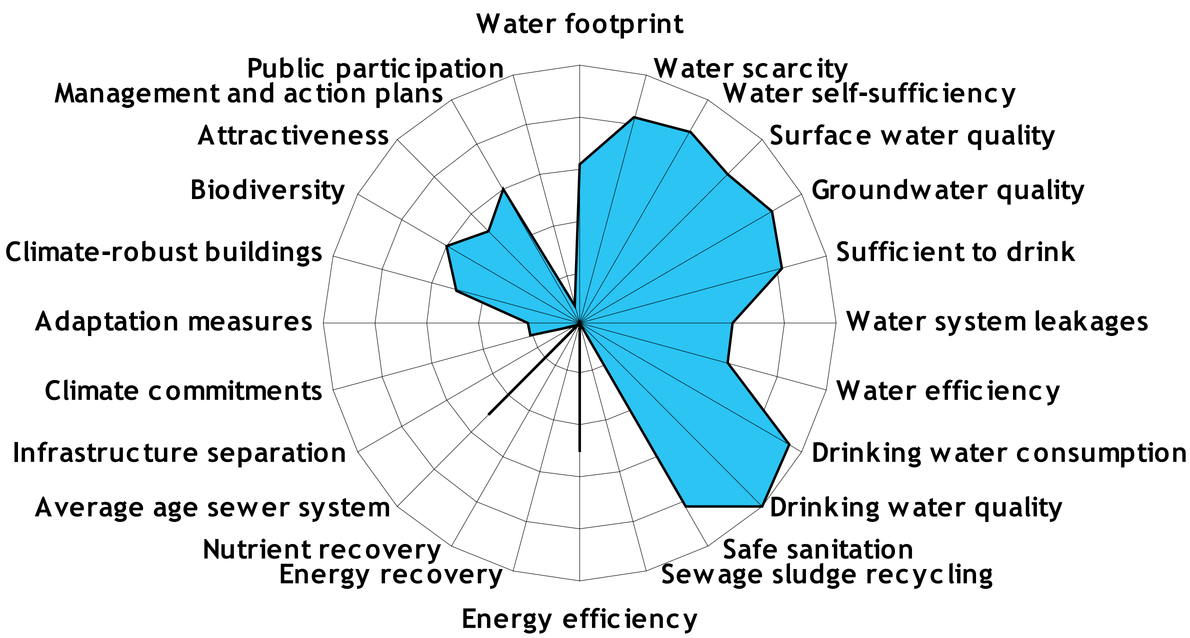


Figure. 1. City Blueprint of Bucharest

Further steps

According to the European green city index (2009), Bucharest ranks low in the water category as a result of a number of factors: household water consumption has continued to increase over the past decade, and water loss in the distribution system is also high (40%). According to this report there are plans to rehabilitate the wastewater treatment plant in Bucharest, with the aim of alleviating pollution levels in the Danube River. This is widely regarded as the most important environmental project in Romania.

The TRUST baseline assessment does not confirm the results of the European green city index report. The household water consumption has not increased over the past decade, but steadily dropped - and significantly - based on billed volumes from 408 (in 2000) to 161 litres per capita per day in 2011.

The questions concerning water governance refer to the involvement of several actors, including local government, local or national bodies and civil society. As discussed at the Basel Workshop, there is currently no clear support from a coherent national strategy on sustainable development. Furthermore, the collaboration with the public bodies is not very easy. This is reflected in the current UWCS governance scores (questions 28-35) which vary from 2 (climate change) to 6 (water efficiency). On the other hand Apa Nova has undertaken several ambitious actions to improve the sustainability of the UWCS in Bucharest:

1. Reduction of water losses in the distribution systems, leading to clear improvements over the last decade.
2. Reduction in the household water consumption, leading to very significant improvements over the last decade.
3. Reduction of energy consumption (rehabilitation of all pumping stations).
4. Analysis on the carbon footprint, using Veolia Water methodology and action plans for reducing the carbon footprint (e.g. renewal of the car fleet, installation of GPS devices on vehicles; buying "green" energy which prevented the emission of 15.600 tonnes of CO_2).
5. Information campaigns for customers on the monitoring of water consumption, on the reduction of leakages (including information on the company's website) as well as on the proper use of the sewerage system.
6. Actions for promoting biodiversity.

In 2011, the BMJ Rating audit on Social and Environmental Responsibility awarded to Veolia Water Romania (Apa Nova Bucuresti and Apa Nova Ploiesti) an AA+ rating (81 points out of 100), thus indicating a high performance level in this field.

As stated above, the results of the TRUST questionnaire show that the governance scores (questions 28-35) varied from 2 (climate change) to 6 (water efficiency), with an average of 5. This reflects the average level of involvement of all actors concerned. In Bucharest, however, the water and sewerage services are not public, but managed by a private operator. This private utility company clearly shows high ambitions towards sustainable solutions (see points 1-6 above), and therefore the overall commitments for the city of Bucharest on sustainable urban water management (Question 34 in the TRUST Questionnaire) received a score 6.

8.9. Rotterdam

Rotterdam has been the first city for which an assessment was made of the sustainability of the urban water cycle (Van Leeuwen et al., 2012). The assessment presented here differs from this first publication. The results presented here are in line with the methodology (and data sources) applied to the other cities of TRUST. This leads to differences with our previous work but improves the comparability with the other cities in this report.

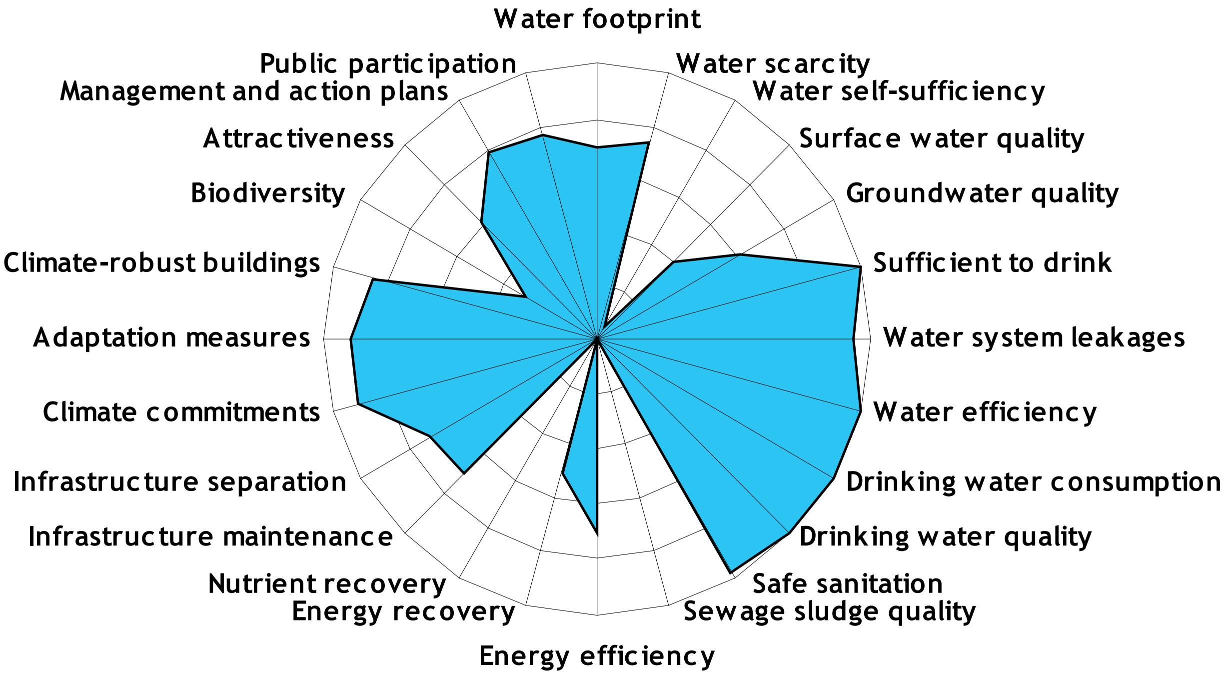


Figure 1. City Blueprint of Rotterdam based on the methodology and data sources used for all other TRUST cities in this report.

8.10. Kilamba Kiaxi (Angola)

A preliminary assessment has been carried out for the city of Kilamba Kiaxi in Angola (Southwest Africa). This new city belongs to the Province of Luanda and lies close to the city of Luanda. Luanda is the capital of Angola, a harbour city, facing the Atlantic Ocean, and has been described in the African green city index (2011). The annual average temperature of Luanda is 18 °C. The city of Kilamba Kiaxi has 1,343,134 inhabitants. The household occupancy is 7 and the supply and catchment area is 131 km^2. The annual average rainfall for Angola is 1010 mm/year (FAO Aquastat). The TRWR is 148 km^3/year and the TRWR per capita is 7756 m^3/year. All the water in Angola is from within the country leading to a dependency ratio of 0%. Total water withdrawal per capita is 43.02 m3. The total freshwater withdrawal as % of the TRWR is 0.4327%. The population density in Angola is low: 15.31 inhabitants per km^2. The authorised water consumption in the city of Kilamba Kiaxi is 1.912.115 m^3/year, with about 7500 service connections. The population coverage is low and only 4%. With an average household consumption of 255 m^3/year and an average household occupancy of 7, the annual consumption for the part of the population that is adequately served for drinking water is 36.43 m^3/person. This has been scored with a 10 in Figure 1. Water losses are considerable: 50%. The average mains age is 40 years. Data gaps were considerable and most of them have been replaced by expert judgement scores of 2. This leads to the following preliminary city blueprint:

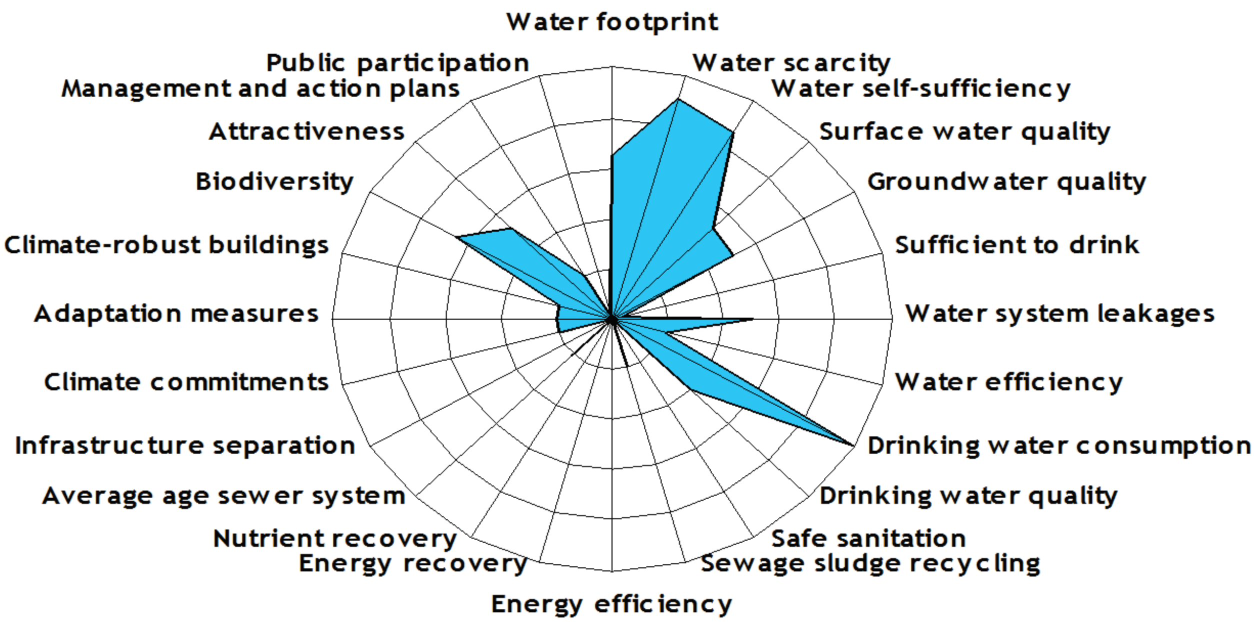


Figure. 1. City Blueprint of Kilamba Kiaxi.

8.11. Dar es Salaam (Tanzania)

Dar es Salaam, more commonly known as Dar, is the largest city of Tanzania in East Africa. It has a population of 3 million, a number expected to double by 2020. It is a big harbour city located at the Indian Ocean. Dar has been the subject of a more in-depth analysis (Van Leeuwen and Chandy, 2012). The annual average temperature of Dar is 26 ^{o}C. The annual average rainfall for Tanzania is 1071 mm/year (FAO Aquastat). The TRWR for Tanzania is 96 km^3/year and the TRWR per capita is 2147 m^3/year. The dependency ratio is 12.75 0%. Total water withdrawal per capita in Tanzania is 144.7 m^3. The total freshwater withdrawal as % of the TRWR is 5.385%. The population density in Tanzania is 47.34 inhabitants per km^2. In order to allow for a better comparison with all the TRUST cities analyzed in this report, we have used similar data sources and calculation methodologies as for the other TRUST cities. Local information on environmental quality has been replaced by data sources used for the other TRST cities. The expert judgement score for groundwater quality has been set at 5 and the score for surface water is based on national information for Tanzania (environmental performance index, 2010), i.e. the water quality index (85.0), leading to a score of 8.5. Biodiversity has been estimated in a similar manner. This values for water quality and biodiversity are actually much better than local water quality of Dar (Van Leeuwen and Chandy, 2012). The City Blueprint for the city of Dar es Salaam is shown in Figure 1.

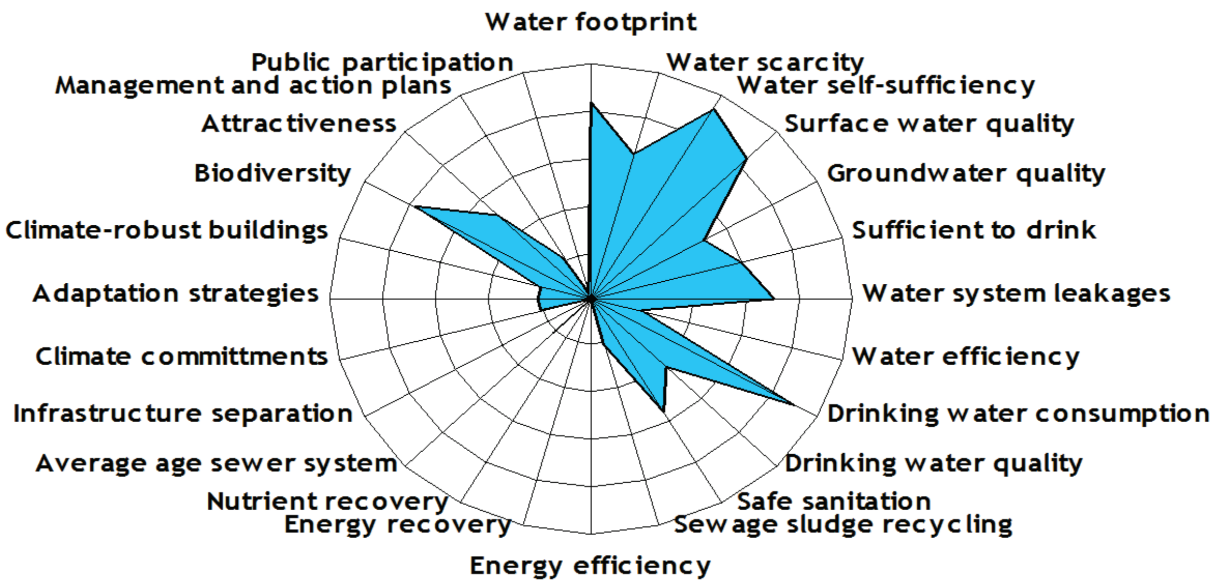


Figure. 1. City Blueprint of Dar es Salaa

Current State of Sustainability of Urban Water Cycle Services

TOWARDS A BASELINE ASSESSMENT OF THE SUSTAINABILITY OF URBAN WATER CYCLE SERVICES. BASELINE ASSESSMENT OF THE SUSTAINABILITY OF URBAN WATER CYCLE SERVICES. **D 11.1**

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