Political and sOcial awareness on Water EnviRonmental challenges GA N.687809

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Main Authors:	Stef Koop and Kees van Leeuwen (KWR)
Other Authors:	
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Abstract

In the context of increasingly large challenges of water, waste and climate change in cities, ICT facilitated tools, such as the Digital Social Platforms (DSPs) that are developed and demonstrated in the POWER project, may form an important contribution in the efforts of cities to become sufficiently water-wise and be able to face these increasing water-related challenges. In order to do so, a profound understanding of the key challenges is essential to focus DSPs efforts. For this reason the City Blueprint performance Framework and the Trends and Pressures Framework are applied to 75 cities. The Trends and Pressures Framework provides an indication of the main social, environmental and financial challenges that may affect local water management. The City Blueprint performance Framework assesses the integrated water management performance of a city. Based on these assessments a definition of water-wise management could be formulated that can help cities envision their key objectives. In total, five cross-cutting water-related challenges have been identified that may form a key focus for application of DSPs or other ICT facilitated interactions between politicians, professionals and citizens. These include:

- The critical triangle: Drinking water, sanitation and wastewater treatment
- The untapped potential of urban wastewater
- Improving solid waste treatment: a criticality of sustainable urban growth
- Water use inefficiencies
- Water and climate adaptation in cities

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v.01	10/07/2017	Stef Koop	Milestone first draft circulated
v.02	12/08/2018	Stef Koop & Kees van Leeuwen	First version current deliverable
v.03	23/04/2019	Stef Koop	Draft ready for feedback for internal quality review within KWR Watercycle Research Institute
v.04	15/05/2019	Kees van Leeuwen	Draft with modification to ensure KWR quality standards
v.05	06/06/2019	Stef Koop	Draft that includes feedback of the all partners in the POWER project consortium

Table of Contents

Executive summary

Cities often rely on the surrounding region for their freshwater resources that are crucial for drinking water supply, industry, energy production, recreation, transport and ecology. Cities are particularly vulnerable to social, environmental and financial trends and pressures that affect a broad range of vital city functions, infrastructure and services and can trigger a knock-on effect. For example, extreme events such as floods or droughts can cause an energy break or cut off the water supply which, in turn, hinders economic development in the city and beyond. A rising sea level, urban expansion in high-risk areas, and changing weather patterns such as heat, drought and intensive rainfall, all exacerbate the vulnerabilities of Europe's cities and hinterland. Many urban centres are located in the vicinity of rivers and seas. As such, annual flood losses in Europe are estimated to increase from €4.9 billion in the period 2000-2012 to about €23.5 billion by 2050. Moreover, the world will experience an estimated 40 % freshwater shortage already by 2030. Climate change will cause increased droughts, limit freshwater availability, limit groundwater recharge and will amplify the spread of water-borne diseases and may induce migration. All these water challenges emphasize the necessity of good or 'water-wise' management. In the context of increasingly large challenges of water, waste and climate change in cities, ICT facilitated tools, such as the Digital Social Platforms (DSPs) that are developed and demonstrated in the POWER project, may form an important contribution in the efforts of cities to become sufficiently water-wise and be able to face these increasing water-related challenges. In order to do so, a profound understanding of the key challenges is essential to focus DSPs efforts. Accordingly, the aim of this report is to identify key water-related challenges that can form the focus of DSPs or other ICT facilitated interaction between citizens, professionals and politicians. In this way, cities are supported in their efforts to become 'water-wise'. In order for water-wise cities to be an effective tangible ambition, different levels towards water-wisdom are empirically defined.

In order to fulfil these aims we consistently apply the City Blueprint performance Framework and the Trends and Pressures Framework in the four Key Demonstration Cities (KDCs): Jerusalem (Israel), Leicester (United Kingdom), Milton Keynes (United Kingdom) and Sabadell (Spain). Next, both frameworks are applied to 75 European and non-European cities. The Trends and Pressures Framework consists of 12 descriptive indicators divided over social, environmental and financial categories. The assessment provides an indication of the key challenges that may affect local water management in addressing water-related challenges within their jurisdiction. In turn, the City Blueprint performance Framework assesses the integrated water management performance. This framework consists of 25 indicators that cover the entire urban water cycle and includes categories for water quality, solid waste, basic water services, wastewater treatment, infrastructure, climate adaptation and governance. The geometric average of the 25 indicators is the Blue City Index which is like the indicators scored from 0 (low performance) to 10 (high performance).

The Blue City Indices of the POWER KDCs have similar performances scores to most Western European cities. The key focus of their Digital Social Platform resembles the results of the Trend and Pressures framework results since water scarcity is an issue for Jerusalem and Sabadell. Flood risk, in particular risk of flooding from surface water, is identified as an issue of concern for Leicester. Only Milton Keynes was not scored as being particularly prone to water stress in an international context. However, water scarcity in Milton Keynes was substantially higher than most European cities. Based on the assessment of 75 cities, an empirically-founded definition of water-wise management could be formulated. Water-wise management is a state in which all 25 City Blueprint performance indicators score high. Accordingly, water-wise management may be described as: Cities that apply full resource and energy recovery in their Waste Water treatment (WWT) and solid waste treatment, fully integrate water into urban planning, have multi-functional and adaptive infrastructures, and local communities that promote sustainable integrated decision-making and behaviour. Cities can be largely water self-sufficient, attractive, and innovative and circular by applying multiple (de)centralized solutions (Koop and Van Leeuwen 2015b). None of the 75 cities assessed so far could be classified as being water-wise.

However, if all the best indicator scores of all the assessed cities are combined, we get an imaginary city that has an optimal water management performance. Such a clear mental image of what a water-wise city may look like is considered indispensable for cities to take action. This mental image does not represent an ideal scenario but rather a necessity for cities to be able to address the increasingly pressing challenges of water, waste and climate change. However, it also shows that these challenges can be addressed by the existing experience, knowledge and know-how that already exists in cities across Europe and beyond. If cities exchange their knowledge, experiences and best practices, water-wise management becomes more attainable. The POWER Best Practice Repository can be an important contribution for such an effort. Overall, we can conclude that, first of all, the empirical results show a positive correlation between, on the one hand, governance capacity and in particular a process of continuous learning, and, on the other hand, high water management performance. Such cross-stakeholder evaluation and learning may be enhanced through the use of ICT facilitated tools such as DSPs. Second, the City Blueprint assessments provide a strong framing that may encourage practitioners to improve their management practice and become 'water-wise'. In particular, it shows the huge potential of city-to-city exchange of knowledge, experiences and best practice. The POWER Best Practice Repository may provide an important contribution towards seizing these large opportunities. Third, a key factor for improving water management through ICT facilitated interactions is by identifying water-related challenges that have a high improvement potential that can be seized by engaging citizens with water professionals and politicians. The key challenges that resulted from 75 city assessments can be summarised into five key water-related challenges:

- The critical triangle: Drinking water, sanitation and wastewater treatment
- The untapped potential of urban wastewater
- Improving solid waste treatment: a criticality of sustainable urban growth
- Water use inefficiencies
- Water and climate adaptation in cities

Interestingly, each of these five key water-related challenges can be addressed by an ICT facilitated interaction between citizens, professionals and politicians. In particular because citizens have a key role in each of these key water-related challenges. Hence, DSPs or other ICT tools may form an important contribution in addressing these challenges.

1. Introduction

1.1 Europe's water challenges in cities

Cities are important centres for innovation, economic growth and employment. Worldwide, more than 80 % of the gross world product is generated in cities (Dobbs et al. 2012; Koop and Van Leeuwen 2017). In Europe, cities have an important role because they provide 62 % of Europe's employment and generate 68 % of GDP (EC 2016). Cities are growing rapidly. The United Nations (UN) estimates that 54 % of all people live in cities, and by 2050, this will increase to 66 % (UN 2015). Also European cities continue to grow from housing about 73 % of the population to an estimated more than 80 % in 2050 (EC 2011). Whereas many European cities are already working on climate change mitigation by decreasing energy use and greenhouse gas emissions, the adaptation to climate risks is for most cities a novel challenge (EEA 2016). Cities are particularly vulnerable to social, environmental and financial trends and pressures that affect a broad range of vital city functions, infrastructure and services and can trigger a knock-on effect. For example, extreme events such as floods or droughts can cause an energy break or cuts of the water supply which, in turn, hinders economic development in the city and beyond. A rising sea level, urban expansion in high-risk areas, and changing weather patterns such as heat, drought and intensive rainfall, all enlarge the vulnerabilities of Europe's cities and hinterland.

Many urban centres are located in the vicinity of rivers and seas. Sea level rise and the increase in extreme river discharges pose a projected 15% of the global population at risk of flooding. This is mainly in urban areas including almost all the worlds' mega-cities (Ligtvoet et al. 2014). The flooding of large ports in low-lying deltas might have impacts on the national economy and areas beyond the country. Overall, Jongman et al. (2014) estimate that the annual flood losses in Europe will increase from €4.9 billion in the period 2000-2012 to about €23.5 billion by 2050. Moreover, the frequency of larger events is estimated to increase from once in 16 years to once in 10 years. Extreme rainfall will become more severe due to global warming and its impact is exacerbated by urban expansion in flood prone areas. Urban soils are often largely sealed by buildings and paved infrastructure. Hence, rainwater cannot infiltrate, resulting in increased risk of urban drainage flooding (Shuster et al. 2005). This affects many cities including unexpected places such as the city of Copenhagen (EEA 2012c).

By 2030, the world will experience an estimated 40% freshwater shortage WRS 2009). Freshwater withdrawals are estimated to increase by 50% in 2025 in developing countries, and by 18% in developed countries (WWDR 2006). Climate change will cause increased droughts, limit freshwater availability, limit groundwater recharge and will amplify the spread of water-borne diseases and may induce migration (IPCC 2013). Cities often rely on the surrounding region for their freshwater resources. These freshwater resources are crucial for drinking supply, industry (production processes and cooling), energy production, recreation, transport and ecology. Agriculture is by far the biggest consumer of freshwater whereas domestic and industrial water consumption account for less than 10% globally (Richter et al. 2013; Hoekstra et al. 2012). In particular in southern Europe, the annual water demand is a large share of the freshwater availability. Increasing summer temperatures, longer growing seasons and tourism increase the demand peaks for fresh water. In particular, the drought of 2003 affected a large area extending from Portugal and Spain to the Czech Republic, Romania and Bulgaria (EEA 2010). These droughts will likely be exacerbated and increase in frequency in many parts of Europe as a result of climate change. Cities have to compete with agriculture, energy generation and other sectors for fresh water. Decreasing water consumption by behavioural change, reducing infrastructure leakages, applying alternative water sources such as rainwater or treated wastewater all provide solutions to address local urban freshwater scarcity. These variables for water conservation require smart solutions and need to be integrated in urban water cycle services and urban infrastructure.

Climate change, urbanisation and demographic changes pose serious urban challenges. At the same time, cities form the key to ensure long-term and resilient solutions. There is a trend in which national governments increasingly delegate responsibilities to local municipalities and regions. Larger cities and metropolitan regions are connected to a network of smaller and medium-sized cities. Each city faces different conditions for tackling water-related challenges and has different resources available.

1.2 A water cycle assessment to identify priorities for ICT facilitated interaction

Water issues and climate adaptation are systemic challenges which do not happen in isolation but are intertwined with other environmental and socio-economic factors (EEA 2016). Social and financial structures are among the root causes of water issues and its impacts largely determine a city's vulnerability to challenges of water and climate change. Trends such as the expansion of cities into low-lying, risk-prone areas increase sensitivity to flood risk, and the economy influences the ability of cities to invest in research and design, water infrastructure and other adaptation measures. Social trends or pressures such as the availability of skilled labour force are crucial for running water utilities, improve urban planning and achieve adequate flood risk management. Other social trends such as urban growth can put strong pressure on the city in providing the necessary Urban Water Cycle Services (UWCS) for a continuously increasing population. The social, financial and environmental setting of every city is unique. This context may result in different priorities and influences the ability of cities to attain sustainable UWCS (Koop and Van Leeuwen 2015a).

Despite high levels of pressures and underlying trends that some cities have to deal with, the extent to which these cities adapt and anticipate various water-related challenges can be low (Koop and Van Leeuwen 2015b). Conventional urban water management has often been fragmented across different disciplines acting more or less in silo according to traditional, technical and linear management approaches (Brown and Farrelly 2009; OECD 2011, 2015). At present, cities are starting to transform towards more resilient water management by anticipating for long-term trends such as the impacts of climate change and by flexibly adapting for expected and unexpected changes (EEA 2016; Segrave et al. 2016). Importantly, cities need to know where they are on the path of becoming resilient, adaptive and anticipatory. It is therefore essential that they have a strategic understanding of the various parts and sectors within their urban water cycle in order to find efficient measures by combining multiple objectives from different sectors and stakeholders. Moreover, cities need to understand their priorities with respect to their entire urban water cycle. This can only be obtained by an integrated assessment. Finally, cities can learn from each other by sharing knowledge, experiences and best practices. However, an intelligible and useful city-to-city learning can only be facilitated by a common frame of understanding that needs to be: 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 (Van Leeuwen et al. 2012). The City Blueprint® (Van Leeuwen et al. 2012) aims to be the first assessment that fulfils this role by providing an overview of the main trends and pressures as well as the city's performances of the integrated urban water cycle. Hence, the City Blueprint® forms the basis for identifying city's trends, pressures and performances that enables the POWER DSPs to facilitate constructive discussion between citizens, professionals and politicians within cities and enhance effective exchange of knowledge, experiences and best practices between cities. DSPs can play an important role in local decision-making and awareness raising while, at the same time, be a means of city-to-city exchange of knowledge, experience and best practices centred on major water-related challenges. The aim of this report is to identify the most suitable and relevant water-related challenges that can form the focus of DSPs or other ICT facilitated engagement and interaction between citizens, professionals and politicians. In this way, cities are supported in their efforts to become 'water-wise'.

1.3 Outline of the report

Section 3 first assesses the POWER project four KDCs according to the City Blueprint performance Framework and the Trends and Pressures Framework (conceptual and methodological approach explained in Section 2). In Section 4, both assessment frameworks are applied to 75 cities both within Europe and beyond. The assessment results form the basis for identifying key water-related challenges that are both relevant and suitable for DSPs or other ICT supported engagement and interaction between citizens, professionals and politicians. In Section 5 a discussion of the results is provided both in terms of the key governance conditions that cities require to improve their City Blueprint water cycle assessment performance (relating to Deliverables 4.7 and 4.8) and an interpretation of the key challenges that may be most suitable and relevant for effectively applying DSPs. We end with the conclusions in Section 6.

2. Conceptual and methodological approach

2.1 Introduction

In order to identify the most suitable and relevant water-related challenges that can form the focus of DSPs or other ICT facilitated interaction, it is necessary to have an integrated understanding of the key water-related challenges that a city faces. The key challenges may form the basis for the most meaningful ICT facilitated interaction. In order to determine the challenges it is important to make a clear distinction between key social, environmental and financial pressures that form the context in which a city has to operate (Section 2.2), and water management performances (Section 2.3). Together they form an integrated assessment frame that facilitates cities in determining key priorities for ICT facilitated interaction between politicians, professionals and citizens.

2.2 The City Blueprint® Trends and Pressures Framework

The City Blueprint® Trends and Pressures Framework (TPF) provides a wider context social, environmental and financial components that can either limit or pose windows of opportunity to improve UWCS. The TPF consists of twelve descriptive indicators that are distributed in three categories according to the triple bottom line approach (Koop and Van Leeuwen 2015a; Elkington 1998; Mori and Yamashita 2015). Table 1 provides an overview of the TPF.

A score scaled from 0 to 4 points has been developed for each indicator, where a higher score represents a higher urban pressure or concern. The following ordinal classes, expressed as 'degree of concern', have been used: 0-0.5 points (no concern), 0.5-1.5 (little concern), 1.5-2.5 (medium concern), 2.5-3.5 (concern), and 3.5-4 (great concern). For a detailed description of the data sources and scoring methods we refer to Annex 1 or EIP Water (2017a) website.

For example, a city situated in an arid area may not necessarily experience water stress due to overconsumption, but simply due to the low natural availability of fresh water. In this case, water consumption or the use of water saving techniques are performance indicators (contributing to the City Blueprint assessment), whereas the natural availability of fresh water is a descriptive indicator belonging to the TPF. A more performance-oriented set of indicators (CBF) is more adequate in showing the potential for improvements and sharing of knowledge, experiences and best practices between cities. Therefore, a distinction is made between 'trends and pressures' and the cities "urban water cycle performances".

Table 1 Overview of the Trends and Pressures Framework (TPF; Koop and Van Leeuwen 2015a)

Goal	Baseline performance assessment of the sustainability of urban IWRM	
Framework	Social pressures	1. Urbanization rate 2. Burden of disease 3. Education rate 4. Political instability
	Environmental pressures	5. Flooding 6. Water scarcity 7. Water quality 8. Heat risk
	Financial pressuress	9. Economic pressure 10. Unemployment rate 11. Poverty rate 12. Inflation rate
Data	Public data or data provided by the (waste)water utilities based on a questionnaire (EIP Water 2017a; Annex 1)	
Scores	0: no concern, 1: little concern, 2: medium concern, 3: concern and 4: great concern	
Overall score	Trends and Pressures Index (TPI), the arithmetic mean of 12 indicators. Indicators scoring a concern or great concern (3 or 4 points) are marked and communicated to the stakeholders.	

2.3 The City Blueprint® performance Framework

Table 2 provides an overview of the City Blueprint performance Framework (CBF). The CBF consists of twenty-five performance indicators consisting of seven broad categories that cover various components of urban water cycle. The indicator scores range between 0 points (bad performance) to 10 (excellent performance). The scoring is done by an interactive approach together with local stakeholders such as water utilities, city council, research organizations etc. The final scores are subjected to a quality assurance in order to ensure a reproducible and reliable analysis. The geometric average of all twenty-five indicators results in the Blue City Index (BCI). The BCI provides a first indication of where the city is compared to other cities on their paths to becoming resilient.

Table 2 Overview of the City Blueprint® Framework (CBF; Koop and Van Leeuwen 2015a)

Goal	Twenty-five indicators divided over seven broad categories:	
Framework	**I Water quality**	1. Secondary WWT 2. Tertiary WWT 3. Groundwater quality
	II Solid waste treatment	4. Solid waste collected 5. Solid waste recycled 6. Solid waste energy recovered
	III Basic water services	7. Access to drinking water 8. Access to sanitation 9. Drinking water quality
	IV Wastewater treatment	10. Nutrient recovery 11. Energy recovery 12. Sewage sludge recycling 13. WWT energy efficiency
	V Infrastructure	14. Stormwater separation 15. Average age sewer 16. Water system leakages 17. Operation cost recovery
	VI Climate robustness	18. Green space 19. Climate adaptation 20. Drinking water consumption 21. Climate-robust buildings
	VII Governance	22. Management and action plans 23. Public participation 24. Water efficiency measures 25. Attractiveness
Data	Public data or data provided by the (waste)water utilities and cities based on a questionnaire (EIP Water 2017b; Annex 2)	
Scores	0 (bad performance) to 10 (excellent performance)	
Overall score	Blue City Index® (BCI), the geometric mean of 25 indicators varying from 0 to 10	

Both the Trends and Pressures Framework (Section 2.2) and the City Blueprint performance Framework (Section 2.3) are applied with respect the four POWER KDCs in Section 3 and to 75 cities in Section 4. Key aim is to understand the key water-related challenges that may form the focus of DSPs or other ICT facilitated engagement and interaction between citizens, professionals and politicians.

3. Water cycle trends, pressures and performances in Key Demonstration Cities

In order to determine the key water-related challenges that can form the focus of a DSP, it is important to understand the key social, environmental and financial pressures that form the context in which a city has to operate. This is done through the Trends and Pressures Framework. This section provides the trends and pressures analyses results for each of the KDCs.

3.1 Water cycle trends and pressures in Jerusalem, Leicester, Milton Keynes & Sabadell

Jerusalem

The city of Jerusalem has some key pressures that have implications on its ability to manage water issues. Jerusalem is situated in a dry climate and experiences water scarcity (WRI 2013). The region is famous for its water use efficiency in agricultural practices, and desalinization is commonly applied for the supply of drinking water (Teschner et al. 2012). Moreover, reducing non-revenue water is a key priority for service delivery. All these water management foci are basically necessitated given the water scarce conditions of the region. Heat stress is another important pressure. Obviously the climate has warm seasons. However, the city is densely populated and most areas are covered with buildings, paved streets, parking lots and other heat absorbing materials. There is very limited coverage of vegetated areas and water ponds or streams that have a cooling effect. Moreover, heat from cars or air conditioning amplify street temperatures. Consequently, average temperatures during warm periods are much higher (typically 5 to 10 degrees) than the city's surrounding (Baccini et al. 2008; EEA 2012c). This phenomenon is known as the urban heat island (EEA 2012b, 2016). The urban heat island effect can have adverse impact on health conditions and work productivity, in particular for vulnerable groups such as elderly, young children or asthmatics. Finally, Jerusalem is relatively rich (per capita GDP of US$42,140) and has a strong innovative capacity that is beneficial for water management (IMF 2017). However, at the same time, the city also hosts poorer neighbourhoods that complicate the management environment to deliver water services. Overall, given Jerusalem's considerable pressures related to water scarcity and heat, the current focus of the DSP on water conservation through, amongst others, community gardens is effective. Vegetated areas, such as the community gardens, provide cooling and are effective in mitigating urban heat islands (Baccini et al. 2008).

Table 3 City Blueprint Trends and Pressures (TPF) of the city of Jerusalem, Israel

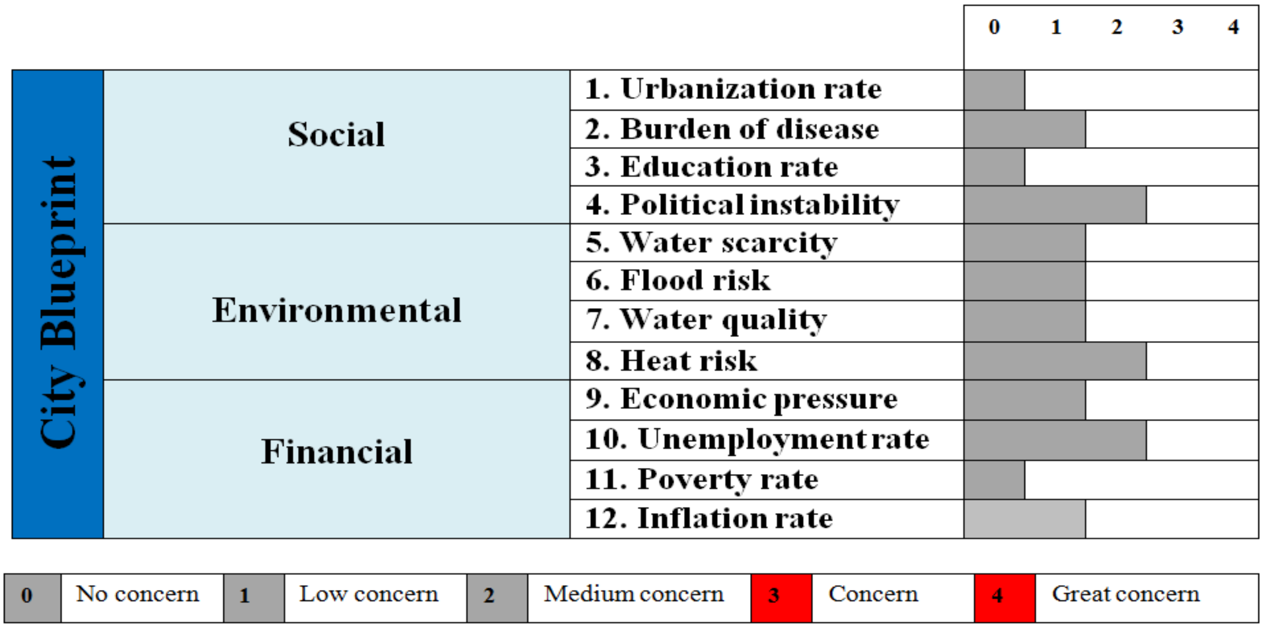
City Blueprint	Social	1. Urbanization rate
		2. Burden of disease
		3. Education rate
		4. Political instability
	Environmental	5. Water scarcity
		6. Flood risk
		7. Water quality
		8. Heat risk
	Financial	9. Economic pressure
		10. Unemployment rate
		11. Poverty rate
		12. Inflation rate

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great concern

Leicester

Leicester does not have many water challenges of concern or great concern compared to other (West-European) cities. Accordingly, the low Trends and Pressure Index relatively low (0.97 points; Strzelecka et al. 2017). Nevertheless, Leicester's riverine flooding is assessed to be a concern because 20.7% of the city centre would be flooded if flood defences failed to protect against a one meter river level increase (EEA 2012a). In addition, the green/blue space coverage is 22.5% which is relatively low meaning that rainwater infiltration is limited and overland flow is enhanced (EEA 2012b). Accordingly, soil sealing is high with almost half (49.6%) of the urban surface being impermeable (EEA 2012c). As such, Leicester is also vulnerable to the Urban Heat Island effect due to its low share of green (and blue) area. In general urban temperatures are often about 4 degrees higher than the surrounding area during heat waves. The municipality of Leicester has suffered from flooding incidents, however the most major flood events in the city have been many years ago (such as the flood event in 1968) and more recent flooding has affected relatively small geographical areas of the city. With respect to social and financial pressures, Leicester has no major concerns when compared to other cities around the globe (Table 4). However, according to UK standards, a substantial part of the city's population has to deal with unsatisfactory level of education, unemployment and economic difficulty. Given Leicester's sensitivity to flood risk, the current focus of the DSP does make a lot of sense. In particular a focus on Sustainable Drainage Systems incorporating green infrastructure would also reduce pressures such as heat stress.

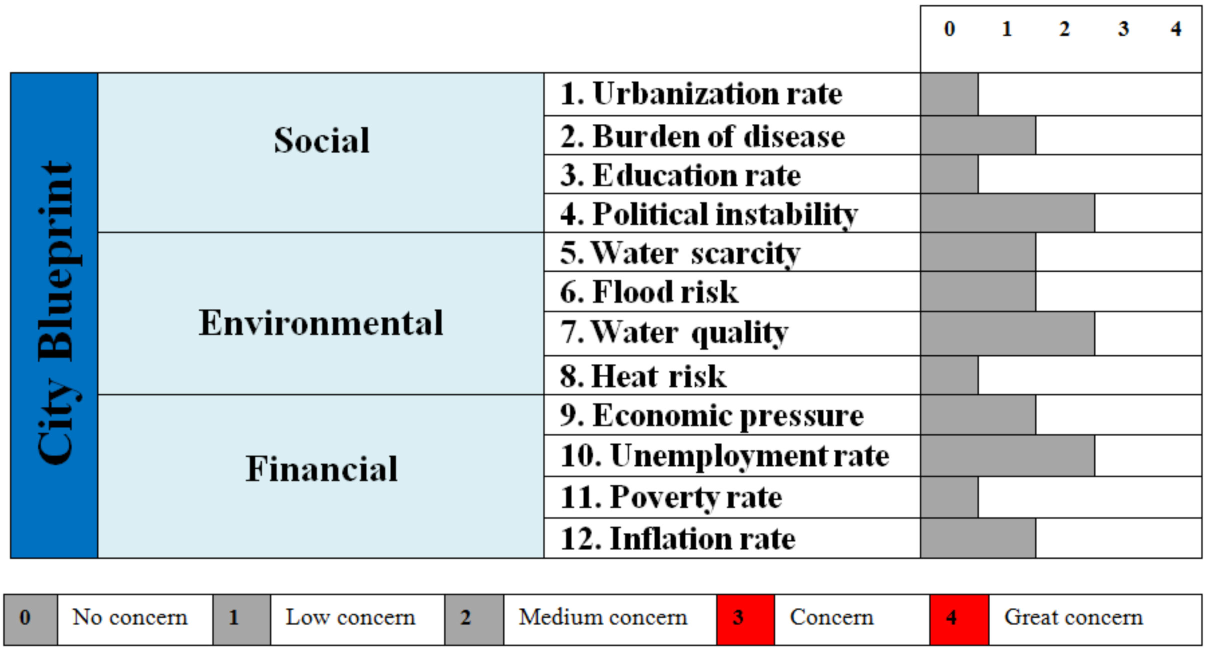
Table 4 City Blueprint Trends and Pressures (TPF) of the city of Leicester, United Kingdom (Strzelecka et al. 2017)



Milton Keynes

Milton Keynes is recognised as a city that is highly designed. The city is a national frontrunner in sustainability and innovation. The city has 261,800 inhabitants and is situated approximately 80 kilometres north-west of London in the United Kingdom. The city is also expected to grow considerably (Milton Keynes Council 2016). Due to its large share of vegetated areas that are intertwined in the urban infrastructure of roads and buildings, issues related to urban heating are largely mitigated. Accordingly, only 29.2% of the city is sealed which forms a sustainable urban drainage system that reduces the impact of flooding including flooding downstream. The region of East Anglia (including Milton Keynes) is one of the driest regions in the United Kingdom and receives on average less than 700 millimetres a year (Met Office 2016). In particular, drought extremes form an issue for local water managers. Hence the region experiences water scarcity issues. Hence, the current focus of the DSP on reduction of drinking water consumption does address an important pressure exerted on the city and wider region. The city is not subjected to pressures of concern. Pressures of medium concern include political instability, water quality and unemployment. Unemployment rates amounts to 4.4% but is likely to increase due to political instability that the United Kingdom is experiencing related to Brexit. Such national pressures can form an important impact on local water management. For example austerity measures may limited overall investments in water infrastructure, flood protection and water quality control.

Table 5 City Blueprint Trends and Pressures (TPF) of the city of Milton Keynes, United Kingdom



Sabadell

The city of Sabadell has 208,000 inhabitants and is situated on the basin of the Ripoll River and the Riusec River, about 22 kilometre north of Barcelona. The city is a highly commercial and industrial city that acts as a driving force for economic and urban development of Spain. However, financial aspects such as the economic pressure and unemployment rate rank as a great concern, with a relatively low national per capita GDP of 25,684 USD per year and high unemployment rate of 18.4% (Eurostat 2017; IMF 2017). Such a context may inhibit large infrastructural investments. Within the municipality demands for a larger scale dual networks that separately distribute drinking water and non-potable water (regenerated water or groundwater) for secondary purposes such as watering parks, gardens or industrial processes do require large capital investments (Steflova et al. 2018). Water scarcity is one of the main concerns in the region. Over 33% of all renewable freshwater resources are abstracted and groundwater salinization is abundant (Aquastat 2015). Both water scarcity and salinization are major challenges to the region and, as such, also push practises of reusing regenerated water. The current DSP is focussed on water reuse and the issue of water scarcity. Since this can be considered the largest water-related pressure, the current focus is effective. The city's vulnerability to urban heat island is expected to be high and flood risk as well as water quality are also found to be of medium concern.

Table 6 City Blueprint Trends and Pressures (TPF) of the city of Sabadell, Spain

Trends and pressures		Indicator	Score (0–4)
	Social	1. Urbanization rate	0
		2. Burden of disease	0
		3. Education rate	2
		4. Political instability	0
	Environmental	5. Water scarcity	3
		6. Flood risk	2
		7. Water quality	2
		8. Heat risk	4
	Financial	9. Economic pressure	4
		10. Unemployment rate	2
		11. Poverty rate	2
		12. Inflation rate	2

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great concern

3.2 Water cycle performances in Jerusalem, Leicester, Milton Keynes & Sabadell

In order to determine the key water-related challenges that can form the focus of a DSP, it is important to have an integrated understanding of the water management performances of a city. This is done through the City Blueprint performance Framework. This section provides City Blueprint performance Framework results for each of the KDCs.

Jerusalem

The Blue City Index for the city of Jerusalem has been assessed to be 6.0 points. Interestingly, the city has a somewhat exceptional profile compared to European cities or cities in the United States (Figure 1; Koop and Van Leeuwen 2015b; Feingold et al. 2018). This has to do with the city's high score for indicators related to climate change adaptation, water infrastructure and wastewater treatment, whereas solid waste treatment, green space coverage and the coverage scores of tertiary wastewater treatment score poorly. Typically, cities that score high on the recovery of energy and nutrients from wastewater also score high on tertiary wastewater treatment coverage. Moreover, cities that score high on climate adaptation plans, also score high on green space coverage. Both deviations are related to the fact that Jerusalem is an old city with little space for vegetated areas and there are significant differences between neighbourhoods in terms of water infrastructure and wastewater treatment. Moreover, complete stormwater separation is relatively unique for developed cities (with the important exception for Australian cities). Besides, the city's water efficiency measures and relatively low consumption of drinking water reflect the water management efforts related to mitigating water scarcity (e.g. Teschner et al. 2012). An important point for improvement is the city's treatment of solid waste. The per capita waste production is relatively high, the recycling of this waste is low and there is no energy recovery from the collected solid waste. Hence, the issue of solid waste (i.e., refuse) forms a key point for improvement for the city of Jerusalem that can also be addressed by a DSP.

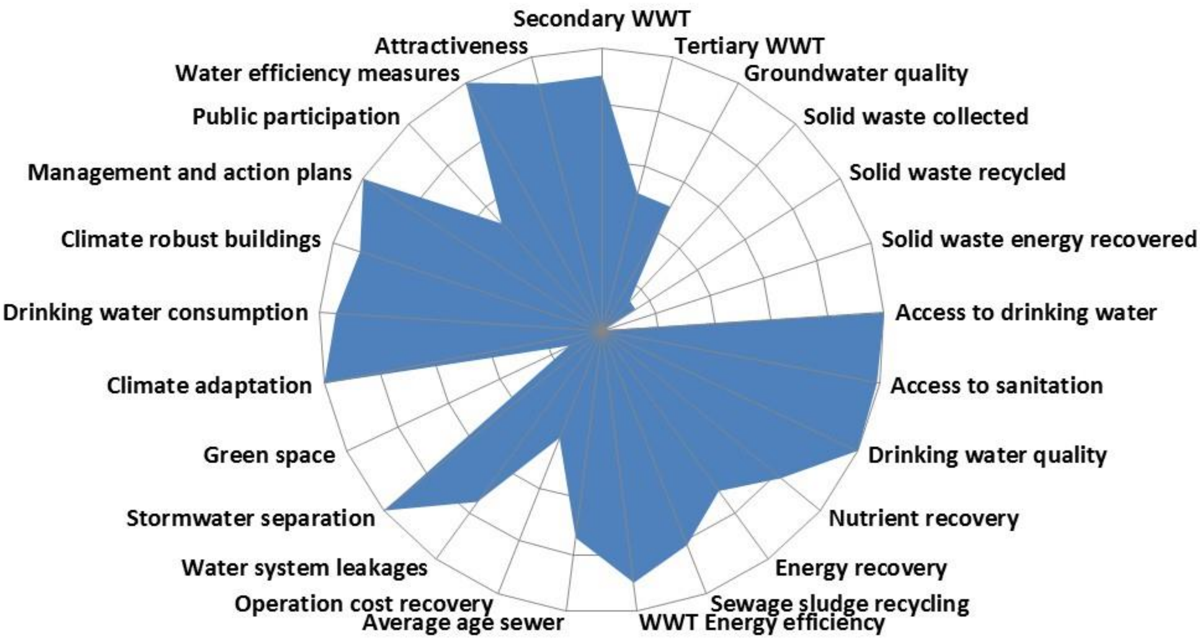


Figure 1 City Blueprint performance Framework results for the city of Jerusalem, Israel

Leicester

The Blue City Index of Leicester is assessed to be 5.3 points, which is below average, compared to other West-European cities. The low scores for performance indicators for "*average age sewer*" and "*storm water separation*" show the potential to reduce this vulnerability. The city is aware of its climate vulnerability and has developed action plans and implements a plethora of measures (Figure 2; LCC 2012a,b, 2013, 2015). There are many opportunities to improve water management within the city with respect to the water infrastructure, increase of green/blue areas, and energy recovery and nutrient recovery in both their solid waste and waste water treatment (Strzelecka et al. 2017). Leicester City Council has developed a Local Flood Risk Management Strategy (LCC 2015a). This strategy document explains the Council's duties and responsibilities, together with those of other risk management authorities such as the Environment Agency and Water Company (i.e., Severn Trent Water). The document also sets out objectives and an action plan covering the short term (1-2 years), the medium term (2-5 years) and long term (5 or more years). The extensive mapping of flood incidents and outcome of the detailed flood risk modelling provided the required evidence for cost-benefit analysis and justification for national investment (Koop et al. 2016). Nutrient recovery from wastewater is only partially done. It would be a good practice to recover nutrients from wastewater since nutrients such as phosphate are on the EU list of critical raw materials (EC 2014). These nutrients are a valuable resource that is becoming increasingly scarce. Also for solid waste treatment, the potential to recover renewable energy is not fully exploited because a third of the solid waste is neither recycled nor used for energy recovery (LCC & LCC). These issues might be considered a priority for Leicester to improve its water management. As the average age of the sewer system is relatively high (STW 2015), the required refurbishment poses opportunities to make a separate stormwater network which would make the city more flood resilient. Severn Trent Water aims to reduce its share of combined sewer overflows and sewer flooding by more frequent cleansing and maintenance on the short-term (2015-2020; STW 2015), where combined sewer replacement by a separated system is the ambition for the long term (i.e. 2010-2035; STW 2007). Finally, the city of Leicester is actively increasing their green and blue area in order to combat flooding, droughts and heat stress (e.g. LCC 2015b). Increasing awareness of Sustainable Drainage Systems forms part of the focus of the Leicester DSP and water community which aims at increasing awareness of flood risk, what people can do to be more prepared, what projects have been going on in the city to reduce flood risk and showcasing activities at the local level such as eco-schools workshops and flood memories campaigns. Such a focus is in addressing flood risk is underlined by the City Blueprint results.

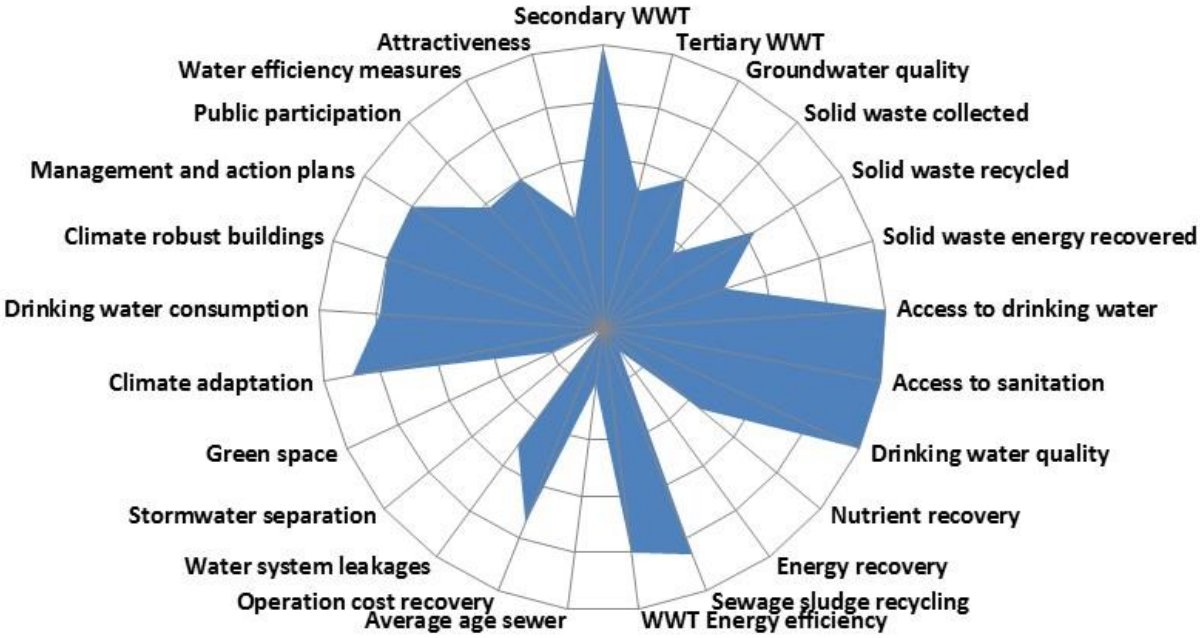


Figure 2 City Blueprint performance Framework results for the city of Leicester, United Kingdom

Milton Keynes

The Blue City Index of Milton Keynes is assessed to be 6.5 points which is amongst the higher scoring cities in West-Europe (Figure 3). Milton Keynes is a designed city with much space for vegetated areas that alleviate the surface runoff due to downpours and mitigates the impact of urban heat islands. The city's drinking water consumption is low. Leakage rates are account to 11% which is substantial. The sewer system is relatively old and requires refurbishments. Unlike many English cities, the stormwater decoupling is rather high since about 50% of total sewer system collects rainwater and sewerage separately. In the refurbishments of the sewer system, this decoupling could be continued in order to be more prepared for the expected increase in intensity and frequency of storm events (EEA 2012). Like many other West European cities, Milton Keynes has a high production of solid waste amounting to 530 kg/person/year (OECD 2013). In addition, the recycling rate of this solid waste is also limited to about 40% of the total amount collected. Although Milton Keynes is one of the higher performing cities of the 75 cities assessed to this date, the recovery of nutrients and energy from its wastewater is still lacking leading to a score of 0 points for both indicators. If techniques for the recovery of nutrients and energy would be included the overall Blue City Index would increase substantially to amount to 8.0 points. It shows that Milton Keynes has the potential to be amongst the highest scoring cities such as Singapore, Seoul and Amsterdam (Kim et al. 2018). In order to further improve, a DSP may also want to target the production and collection of solid waste since these indicators do not score as high as the others. Solid waste forms an issue that can be addressed by improved DSP facilitated interaction between politicians, professionals and citizens. Wastewater treatment can also be further improved. However, this is mainly an issue of investments of local authorities in more advanced treatment technologies. This is something that can be the result of the DSP discussion but is mainly the responsibility of the wastewater treatment company and not so much something that can be improved by more interaction per see.

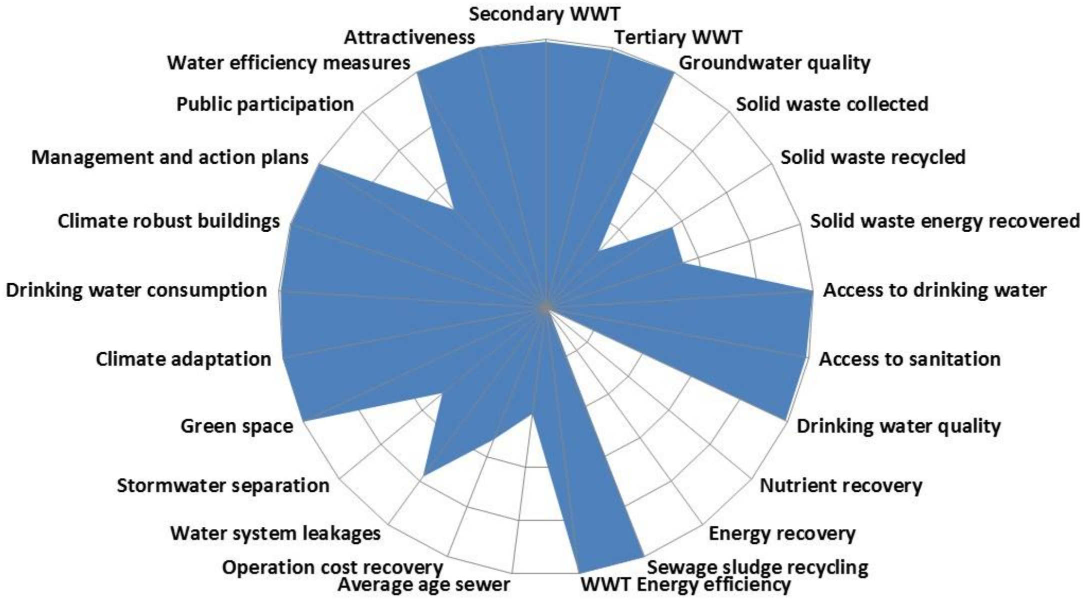


Figure 3 City Blueprint performance Framework results for the city of Milton Keynes, United Kingdom

Sabadell

The Blue City Index for the city of Sabadell is assessed to be 3.7 points which is below average compared to other West-European Cities. However, the city has some strong points related to water stress mitigation, and also much potential to improve its score by relatively feasible measures such as better recover resources and energy from its solid waste and wastewater treatment processes (Figure 4). The city's experiences with water stress episodes has resulted in efforts to reuse treated wastewater for secondary purposes such as watering the city's public parks and for industrial purposes. Partly because such applications replace the use of drinking water, and because of substantial water conservation efforts, the city has a low drinking water consumption of 97 litres/person/day that covers both industrial as well as domestic (Aigues Sabadell 2016). On the other hand, there is room to improve the non-registered water rates of 19.4% (which includes leakage rates and measurement deviations; Aigues Sabadell 2016). Coverage of secondary and tertiary wastewater treatment is rather high which improves the water quality of the receiving waters in the area. This is also important because most water bodies in the regions almost entirely consist of treated wastewater during drier months. However, nutrient recovery from wastewater is not applied and energy recovery from sewage sludge is not totally applied yet. Hence, opportunities are missed for a reliable renewable energy source and sparse nutrients such as phosphate are being lost. The sewer system is rather old and rainwater is not separated from the sewer. Such rainwater may form an important additional source of water for varying applications. Furthermore, combined sewer overflows might occur during storm events. Solid waste production is rather high with 525 kg/person/year (Steflova et al. 2017). At the same time only 33% of the waste is composted and 10% is incinerated in order to recover energy (EEA 2013; OECD 2015). Therefore the recycling of solid waste is rather limited. This also affects water quality. In particular uncollected solid waste, but also poorly maintained landfills, lead to water pollution of rivers, lakes and oceans as has become evident is large concentration of plastics in these waters (Sigler 2014).

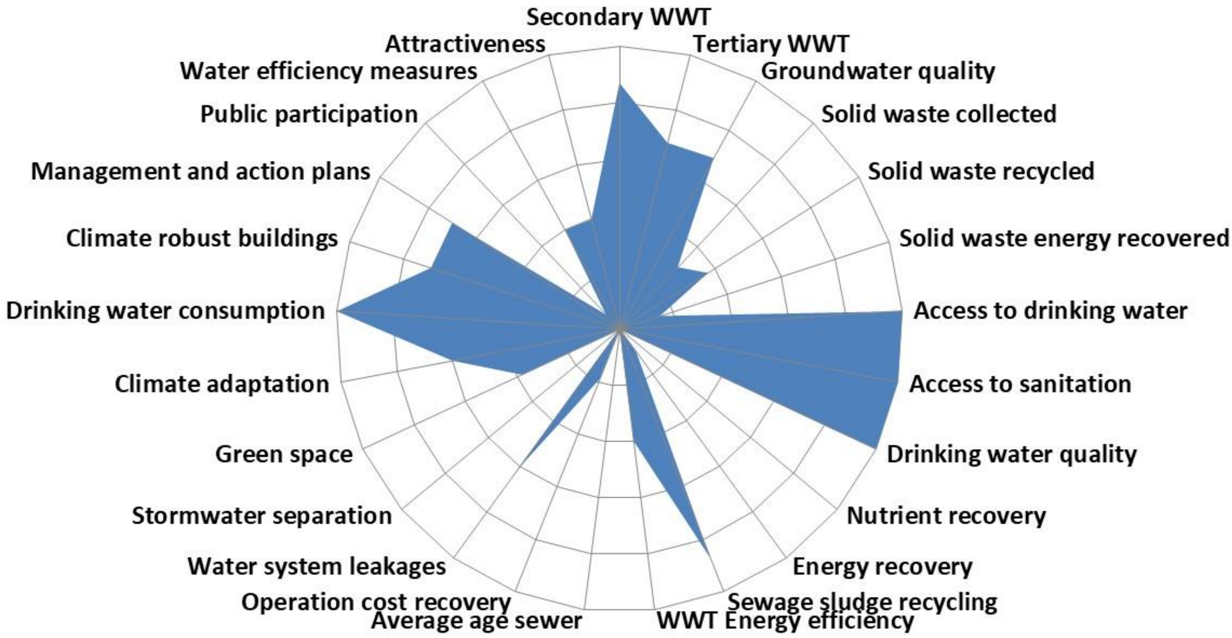


Figure 4 City Blueprint performance Framework results for the city of Sabadell, Spain

4. Water cycle trends, pressures and performances in European cities and beyond

4.1 Introduction

First, this section provides a summary of the key results of the 75 City Blueprint and trends and pressures analyses into five key challenges. Note that the 75 assessments are included in Appendix 1 and that City Blueprint results have been published in 17 peer-reviewed scientific papers. Second, based on the empirical results of 75 city assessments, we provide a heuristic frame for cities to help them envision key goals in improving their water management and ultimately become 'water-wise' (Figure 9). Such an approach provides citizens, professionals and politicians with a better mental image of what is possible and how important the water-related challenge is in their city.

4.2 City Blueprint results of 75 cities

An overview of 75 cities (Figure 5) that have been assessed according to the Trends and Pressures Framework (Figure 7) and the City Blueprint performance Framework (Figure 8) are provided. A very clear relation (Figure 6) could be observed between the city's water management performance (as measured by the City Blueprint performance Framework) and the amount of pressures that cities are subjected to (as measured by the Trends and Pressures Framework). Hence, the need to transform the water management of these cities is both urgent and challenging.

Figure 5 Overview of the 75 cities that have been assessed by the City Blueprint Framework and the Trends and Pressures framework. The selected cities has a global coverage with a European focus.

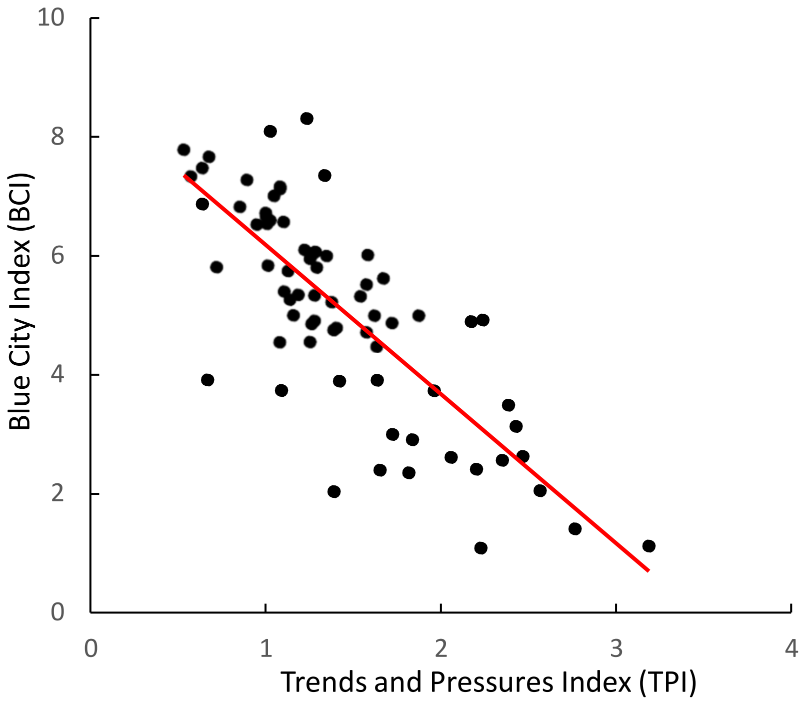


Figure 6 Correlation (r = 0.78; n=75) between water management performance (i.e. the Blue City Index) and key social, environmental and financial pressures (i.e. the Trends and Pressures Index)

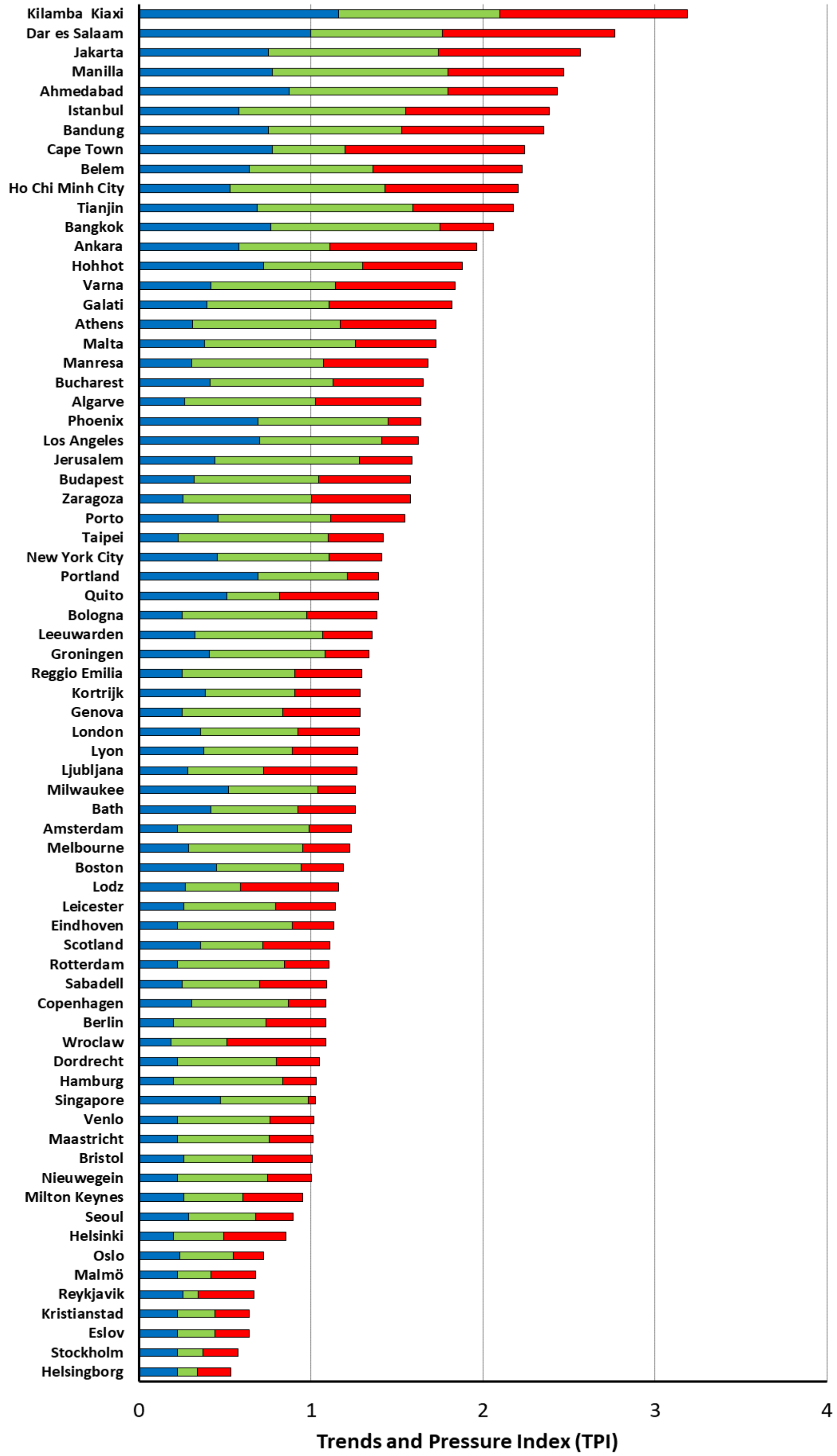


Figure 7 City Blueprint Trends and Pressures (TPF) of the 75 municipalities and regions in 35 countries across the world but predominantly in Europe. *Blue, green* and *red* represent the share of the social, environmental and financial indicators, respectively, to the overall Trends and Pressures Index (TPI)

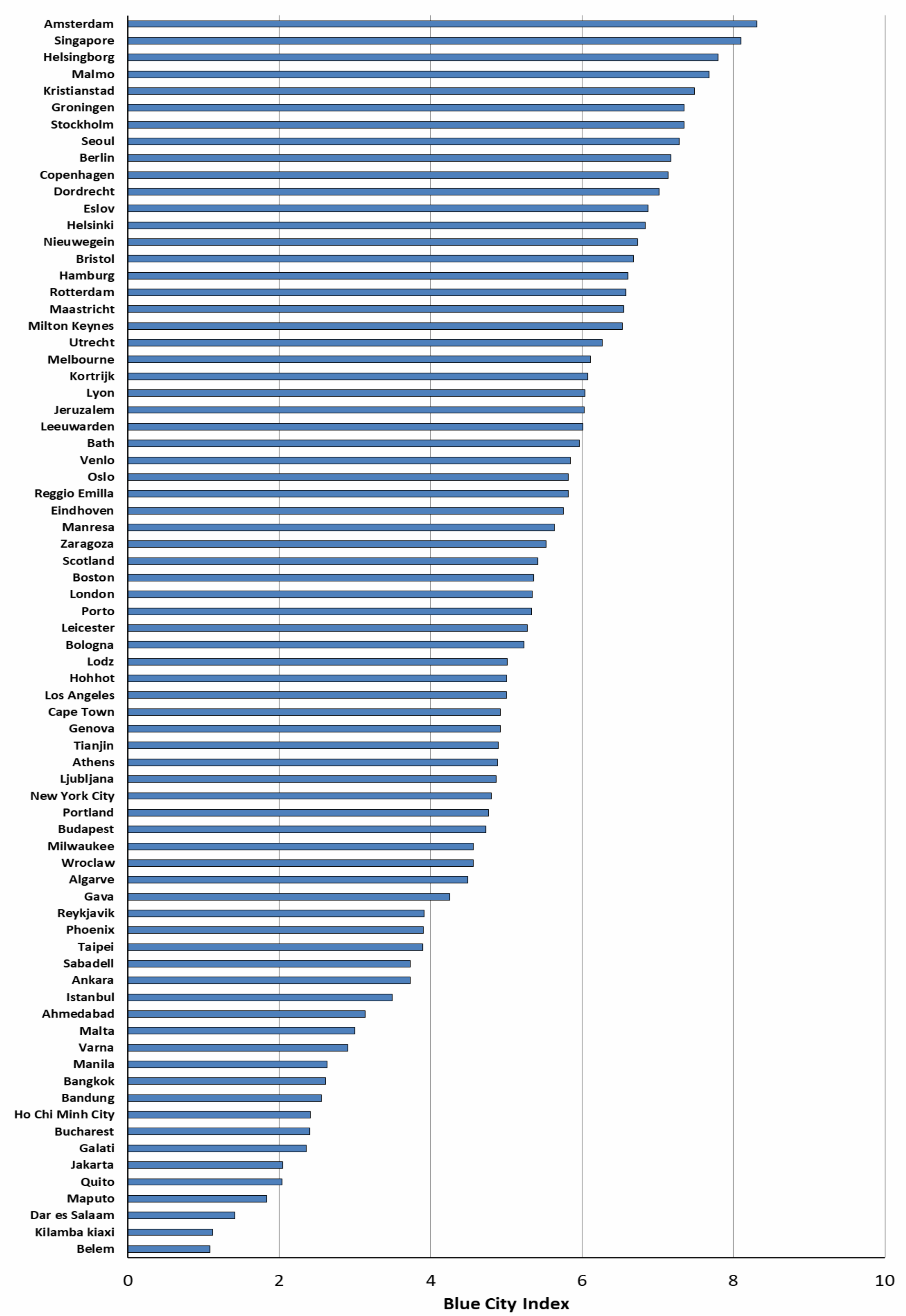


Figure 8 The overall score of the 25 City Blueprint performance Framework (CBF), named the Blue City Index (BCI), of the 75 municipalities and regions in 35 countries across the world but predominantly in Europe. Scores range between 0 points (low performance) to 10 points (high performance)

The critical triangle: Drinking water, sanitation and wastewater treatment

The cities of Ahmedabad (India), Bandung (Indonesia), Belem (Brazil), Bucharest (Romania), Dar es Salaam (Tanzania), Ho Chi Minh City (Viet Nam), Jakarta (Indonesia) and Maputo (Mozambique) still have large communities that lack access to basic water services such as the access to sanitation and high quality drinking water. A lack of drinking water services enhances uncontrolled groundwater withdrawal by private wells. In many cities this leads to substantial ground subsidence and salt water intrusion (e.g. Rahmasary et al. 2019; Aartsen et al. 2018). Next, a total 18 cities do have almost full coverage of drinking water and sanitation services that enable higher water consumptions and therewith higher amount of wastewater. In particular, water pollution becomes issue of concern since only 42% of this collected wastewater gets secondary treatment. Untreated sewer discharge will increasingly lead to large scale water pollution. As observed from the City Blueprint assessments, such pollution predominates in Eastern Europe but particularly in rapidly developing cities at Europe's borders: Africa and Asia. Their rising populations and economic growth lead to rapidly increasing large scale water pollution due to untreated wastewater. In fact, the nutrient emissions in Asia and Africa are projected to double or triple within 40 years leading to eutrophication, biodiversity loss, threatening drinking water, fisheries, aquaculture and tourism (Ligtvoet et al. 2014). Such pollution threatens freshwater resources that need to provide water for the rapidly growing populations and industrial activities. Urbanisation and industrialisation in combination with inefficiencies in water use are becoming a serious barrier for future economic growth, development and can lead directly or indirectly to large scale human migration (Wrathall et al. 2018). Hence, access to potable drinking water, sanitation and wastewater treatment are key to enhance local economies and reduce social unrest and large scale migration. In many cases wastewater treatment is somewhat neglected. However, in order to protect freshwater resources, reduce water-borne diseases and save valuable ecosystem services such as fisheries and tourism, wastewater treatment in cities is indispensable for sustainable growth and of key relevance for Europe to improve living conditions at its borders.

The untapped potential of urban wastewater

Beyond basic necessities of drinking water, sanitation and wastewater treatment, other empirical observations are made as well that relate to climate change adaptation and water in the circular economy. As much as 22 cities do not apply any form of energy recovery techniques at the wastewater treatment plants. In addition, more than half (i.e. 51.5 %) of wastewater is not treated by any form of energy recovering techniques. For Europe, on average 41 % of the potential renewable energy in wastewater is simply wasted. For nutrient recovery 66 % of Europe's wastewater is not treated by any form of nutrient recovery. The average percentage of wastewater that does not receive any form of nutrient recovery is even larger when we include the non-European cities, namely 75 %. These are staggering numbers since raw materials such as phosphate is on the EU list of critical raw materials (EC 2014). Also note these percentages of nutrient and energy recovery are much higher due to the overrepresentation in the City Blueprint assessments of Dutch cities that generally have these recovering techniques installed in their wastewater treatment plants. The potential of recovering energy from wastewater can be considered as big opportunity to enable a societal transition to renewable energy. Unlike many renewable energy sources such as wind or the sun, wastewater can be considered as a reliable and predictable source that does not require large energy storage capacities. It therefore forms an important component of the renewable energy mixture to meet the historical and ambitious Paris agreement to limit global warming to 2.7°C above pre-industrial levels by 2100 (UNFCCC 2015). These numbers show that wastewater is largely an untapped resource for many raw materials, energy and freshwater (UNESCO 2017).

Improving solid waste treatment: a criticality of sustainable urban growth

Besides wastewater, solid waste can also be considered as a large untapped resource since it contains many raw materials and energy (Koop and Van Leeuwen 2017). However, 52 cities (i.e. 70 %) use less than 50 % of their potential to apply energy recovery from their solid waste. For example, German cities burn 21 % of their total solid waste but not seize the opportunity to recover energy out of this carefully collected and separated waste stream (OECD 2013). More than half of the solid waste ends up in landfills where it produces substantial amounts of greenhouse gasses and may lead to water pollution, especially when the site management is insufficient (Rosik-Dulewska et al. 2007; Lazarevic et al. 2010). On average, less than half (47%) of the solid waste is recycled by composting or the recovery of materials such as glass, paper or metals. Plastics enter rivers and oceans. It is estimated that for example 275 million metric tons of plastic waste was generated in 192 coastal countries in 2010 (Jambeck et al. 2015). Approximately 1.7–4.6 % of this plastic ends up in oceans (Jambeck et al. 2015). Because plastic waste does not readily biodegrade, it degrades into smaller pieces which have a large impact on marine ecosystems by ways of ingestion by marine animals (Zarfl et al. 2011; McFedries 2012; Derraik 2002). These plastics form 'soups' in five major ocean gyres: two in the Pacific, one in the Indian and two in the Atlantic. These issues appear in their most severe form in Asia. However, also in many other parts of the world plastic pollution severely impacts aquatic ecosystems. For example, a recent detailed study was made for the river Rhine. Microplastics were found in all samples (892,777 particles per km^2 on average). These microplastics concentrations differed across the river, reflecting various sources such as wastewater treatment plants, tributaries and weirs (Mani et al. 2015). Notably, cities that recycle less than half of their solid waste do produce a low amount of waste. However, their average waste production still amounts to 4.01 kg/person/year, which amounts to large numbers of uncollected and in a substantial number of cases also poorly treated solid waste. These numbers emphasize cities as large contributors to the plastic soup. Recycling leads to substantial reductions in Green House Gas (GHG) emissions. Open dump land-filling emit about 1000 kg CO2-eq. $tonne^{-1}$ of solid waste, whereas this can be reduced to 300 kg CO2-eq. $tonne^{-1}$ if this waste is stored in conventional landfilling. However, solid waste can in fact be a net sink of carbon when most material is recycled or the energy is recovered (Manfredi et al. 2009). The potential to improve urban solid waste management appear to be large both the European and non-European cities that have been assessed.

The reduction of GHG emission and alleviation of environmental pollution may be achieved by applying following principles: reduce, reuse and recover resources from waste. First of all, the root causes, namely the amount of solid waste and that is produced, has to be addressed by increasing water use efficiency and reducing the production of solid waste through policies such as restrictions for packaging materials. Second, the use of products that can be reused can be stimulated. For wastewater, greywater systems in domestic and industrial sites can reduce water consumption (e.g. UNESCO 2017; Steflova et al. 2018). Third, with well-tested treatment techniques, it is possible to recover resources such as sparse materials, phosphate or freshwater. Such a strategy provides opportunities to achieve cost-effectiveness in the long term with only moderate additional investments in new treatment facilities. In particular, the reuse of treated wastewater poses a largely untapped resource for non-potable applications in water stressed regions. Such recovery requires higher investments which are typically recovered in about 5 to 10 years (e.g. Van der Hoek et al. 2015).

Water use inefficiencies

Our results show that, on average, one fifth of the drinking water is lost in the distribution system (i.e., 19 %) and 15 cities have leakage rates that exceeded 30 %. Such leakages are large spills of water, energy and money but also characteristic for old obsolete infrastructure. In order to reduce leakages, substantial infrastructure investments are required. Such investments in many cases is easily recovered over the lifespan of build or refurbished infrastructure. However, the investment costs are also high which forms a limitation. In addition, since most of the water distribution pipes are under the ground and not visible for people. It generally forgotten (e.g. AWWA 2001). Cities in developing regions typically have large leakage rates but it is certainly not limited to these cities. Increasingly Western cities have increasingly obsolete infrastructure and most cities and countries face a water infrastructure investment gap. The average measured drinking water consumption of both industry and domestic consumption is 627 litres/person/day. Industry is the largest consumer of this drinking water. Yet the average domestic water consumption in litres per person per day is 575 in the USA, 490 in Australia, 360 in Mexico, 322 in Japan, 131 in China and 200 – 300 for most European countries (UNDP 2006). Hence, domestic water consumption is high when considering the World Health Organisation estimates that about 50 litres a day is sufficient as a threshold (WHO 2013).

Water and climate adaptation in cities

Stormwater separation is applied in half (i.e. 49 %) of the water infrastructures in the cities assessed. It is remarkable that Copenhagen and almost all Dutch cities have high overall water management performance but low separation rates (less than 12 %). As a consequence, combined sewage overflows, urban drainage flooding, both exacerbated by climate change, may seriously affect water quality and biodiversity (Koop and van Leeuwen 2015b). Hence, combined sewer overflows exacerbate damages from extreme weather events that are projected to increase significantly (Jongman et al. 2014). Moreover, green space coverages (%) differed largely. In Europe, cities green space coverages ranged from 40 % or more for most Scandinavian cities and on the other hand less than 15 % for Athens, Bucharest and all developing cities. A low share of green area increases the vulnerability to urban drainage floods and exacerbated the impact of heat waves (EEA 2012). Increasing green space in cities is important and may result in multiple co-benefits for health, the economy, society and the environment (EC 2015b). Furthermore, the future damage as a result of inaction is often more costly than the necessary investments (Deliverable 4.6; EEA 2012; Klein Tank and Lenderink 2009).

4.3 Levels towards becoming water-wise cities

Based a hierarchical clustering analysis of the City Blueprint assessments various clusters of cities with similar indicator scoring profiles have been identified (Koop 2019). Based on the identified clusters and considering the indicator scores and their meaning, five levels of water management performances could be conceptualized. The levels are well-aligned with the overall score of the City Blueprint assessment: the Blue City Index (BCI). The BCI ranges from 0 (low performance) to 10 (high performance). The identified levels are: I cities lacking basic water services (BCI: 0 – 2), II wasteful cities (BCI: 2 – 4), III water efficient cities (BCI: 4 – 6), IV resource efficient and adaptive cities (BCI: 6 – 8), and V water-wise cities (BCI: 8 – 10). The different levels of water-wisdom are far from optimal and reveal a process of problem-shifting. This problem-shifting refers to a process where one management solution results in the creation of a new problem. The underlying cause of this problem-shifting seems to be that management solutions are too restricted in both time and scope. Based on the City Blueprint water cycle assessments, overarching patterns of problem-shifting can be observed. First problem shift refers to the observation that cities who improve their access to basic water services often experience strong increases in pollution, since sufficient treatment of the resulting increase in wastewater is unaccounted for.

Second, cities that invest in pollution control tend to become path-dependent into a waste(water) treatment approach that does not account for the emerging scarcity of raw materials and need for renewable energy sources.

Third, many cities achieve full access to basic water services and improve their pollution control, but by largely disregarding the key role that water has in the spatial climate change adaptation to challenges such as water scarcity, heat waves and water quality.

Table 7 Identified levels of water-wise management in cities based on the City Blueprint assessments (Koop 2019 and Van Leeuwen 2015b; Koop 2019)

BCI	Categorization of IWRM in cities
0 - 2	**Cities lacking basic water services** Access to potable drinking water of sufficient quality and access to sanitation facilities are insufficient. Typically, water pollution is high due to a lack of WWT. Solid waste production is relatively low but is only partially collected and, if collected, almost exclusively put in landfills. Water consumption is low but water system leakages are high due to serious infrastructure investment deficits. Basic water services cannot be expanded or improved due to rapid urbanization. Improvements are hindered due to governance capacity and funding gaps.
2 – 4	**Wasteful cities** Basic water services are largely met but flood risk can be high and WWT is poorly covered. Often, only primary and a small portion of secondary WWT is applied, leading to large scale pollution. Water consumption and infrastructure leakages are high due to the lack of environmental awareness and infrastructure maintenance. Solid waste production is high and waste is almost completely dumped in landfills. Governance is reactive and community involvement is low.
4 - 6	**Water efficient cities** Cities implementing centralized, well-known, technological solutions to increase water efficiency and to control pollution. Secondary WWT coverage is high and the share of tertiary WWT is rising. Water efficient technologies are partially applied, infrastructure leakages are substantially reduced but water consumption is still high. Energy recovery from WWT is relatively high while nutrient recovery is limited. Both solid waste recycling and energy recovery are partially applied. These cities are often vulnerable to climate change, e.g. urban heat islands and drainage flooding, due to poor adaptation strategies, limited stormwater separation and low green surface ratios. Governance and community involvement has improved.
6 - 8	**Resource efficient and adaptive cities** WWT techniques to recover energy and nutrients are often applied. Solid waste recycling and energy recovery are largely covered whereas solid waste production has not yet been reduced. Water efficient techniques are widely applied and water consumption has been reduced. Climate adaptation in urban planning is applied e.g. incorporation of green infrastructures and stormwater separation. Integrative, centralized and decentralized as well as long-term planning, community involvement, and sustainability initiatives are established to cope with limited resources and climate change.
8 - 10	**Water wise cities** As yet, no city has reached a BCI-score that is within this category so far. These cities apply full resource and energy recovery in their WWT and solid waste treatment, fully integrate water into urban planning, have multi-functional and adaptive infrastructures, and local communities promote sustainable integrated decision- making and behaviour. Cities are largely water self-sufficient, attractive, innovative and circular by applying multiple (de)centralized solutions.

Through the City Blueprint indicator assessment results, a clear mental image of what a water-wise city may look like is developed (Figure 89). Such a mental image is considered indispensable for cities to take action (Koop 2019). Water-wise management is a state in which all 25 City Blueprint performance indicators score high. Accordingly, water-wise management may be described as: Cities that apply full resource and energy recovery in their WWT and solid waste treatment, fully integrate water into urban planning, have multi-functional and adaptive infrastructures, and local communities that promote sustainable integrated decision-making and behaviour. Cities are largely water self-sufficient, attractive, and innovative and circular by applying multiple (de)centralized solutions (Koop and Van Leeuwen 2015b).

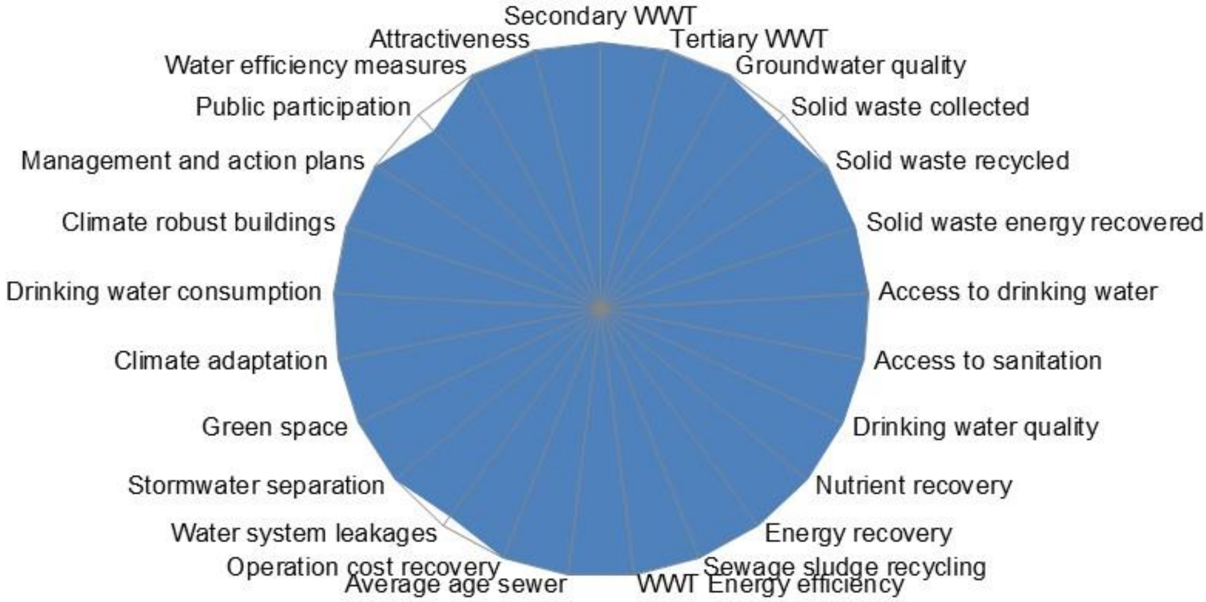


Figure 9 Conceptualisation of water-wisdom by combining the highest City Blueprint indicator scores of the urban water cycle in 75 cities in 35 countries (see appendix 1). No individual city is already water-wise

Figure 9 provides a powerful message for city planners. Although none of the 75 assessed cities scored high on all the indicators. If the highest indicator scores of all these cities are selected, a water-wise city illustrated by an entirely blue spider web is possible. In fact, no new innovations or technologies are required. It is even more feasible since the solutions are already applied and city practitioners do have the knowledge, experiences and know-how. There is a huge potential for water management improvements, if these practitioners would share this knowledge with each other. Note, that a high score of all these indicators is not a luxury but rather a necessity to effectively deal with existing and emerging challenges related to water, waste and climate change. The POWER best practices repository may form an important contribution to stimulate a city-to-city learning process.

5. Discussion

This section provides a discussion of the results of the previous sections. In particular, the role of governance (Deliverable 4.7 and Deliverable 4.8) for achieving water-wise management is discussed (Section 5.1) as well as the potential role of DSPs in achieving this objective (section 5.2).

5.1 Governance conditions for water-wise management

In Deliverable 4.7 and Deliverable 4.8, a comprehensive framework has been proposed to assess the overall capacity of cities to govern water challenges. This Governance Capacity Framework (GCF) distinguishes nine key conditions, with each three indicators that are scored on a range of very encouraging (++) to very limiting the overall governance capacity (Table 8).

Table 8 The water Governance Capacity Framework (GCF) consisting of nine conditions, each defined by three indicators. For each indicator, a Likert scoring scale has been developed ranging from very encouraging (++) to very limiting (--) the capacity (Koop et al. 2017; Deliverable 4.7; Deliverable 4.8)

Dimensions	Conditions	Indicators
Knowing	**1 Awareness**	1.1 Community knowledge 1.2 Local sense of urgency 1.3 Behavioral internalization
	2 Useful knowledge	2.1 Information availability 2.2 Information transparency 2.3 Knowledge cohesion
	3 Continuous learning	3.1 Smart monitoring 3.2 Evaluation 3.3 Cross-stakeholder learning
Wanting	**4 Stakeholder engagement process**	4.1 Stakeholder inclusiveness 4.2 Protection of core values 4.3 Progress and variety of options
	5 Management ambition	5.1 Ambitious and realistic management 5.2 Discourse embedding 5.3 Management cohesion
	6 Agents of change	6.1 Entrepreneurial agents 6.2 Collaborative agents 6.3 Visionary agents
Enabling	**7 Multi-level network potential**	7.1 Room to manoeuvre 7.2 Clear division of responsibilities 7.3 Authority
	8 Financial viability	8.1 Affordability 8.2 Consumer willingness to pay 8.3 Financial continuation
	9 Implementing capacity	9.1 Policy instruments 9.2 Statutory compliance 9.3 Preparedness

The framework has been applied in each of the four Key Demonstration Cities (KDCs). In Sabadell the capacity to govern the reuse of treated wastewater has been assessed (Steflova et al. 2018; Deliverable 4.8). In Leicester the capacity to govern flood risk challenges has been assessed (Koop et al. 2018; Deliverable 4.8). For Milton Keynes, the capacity to govern challenges related to the reduction of drinking water consumption was assessed (Deliverable 4.8). Finally, Jerusalem's capacity to govern the challenge of water conservation was assessed (Deliverable 4.8). In addition, beyond the four KDCs, 11 other cities have been assessed across the globe and with respect to different water-related challenges in order to validate the method and extend the application of DSPs in Europe and beyond. These 11 cities include Ahmedabad in India (Aartsen et al. 2018), Amsterdam in the Netherlands (Koop et al. 2017), Bandung in Indonesia (Rahmasary et al. 2019), Cape Town in South Africa (Madonsela et al. 2018), Melbourne in Australia, New York City in the USA (Feingold et al. 2018), Quito in Ecuador (Schreurs et al. 2017), Rotterdam in the Netherlands (Koop et al. 2018), Seoul in South Korea (Kim et al. 2018), Taipei in Taiwan (Rahmasary et al. 2019), Utrecht in the Netherlands (Brockhoff et al. 2019). In these cities often multiple separate governance capacity analyses have been performed with respect to different water challenges. For example, the capacity to govern flood risk may be very different than the capacity to govern water scarcity. Hence, the governance capacity analysis is specific for a water challenge and the capacity is analysed for each individual water challenge accordingly. A total of 41 separate governance capacity analyses have been performed. For all the cities, also a City Blueprint and Trends and Pressures analyses was performed. Therefore, water management performances (i.e. City Blueprint assessments) could be correlated to various governance conditions as measured by the governance capacity analyses. In this way an empirically-founded indication of how cities can improve their water management performances can be provided. In other words, we can identify the key governance conditions that perform high for cities that also score high with respect to their water management performance as measured by the City Blueprint performance Framework.

This in-depth insight into the capacity profiles of each city and how these profiles compare to one another, provided valuable insights regarding the barriers and enablers for improved water management. However, the extend of empirical data also allowed to identify overarching patterns. In particular, the ability to apply continuous learning as well as the implementing capacity corresponded very well with water management performances, with a correlation coefficient of respectively 0.89 and 0.93 (Koop 2019). Hence, the interaction between implementing capacity (condition 9) and the ability of local authorities to continuously monitor, evaluate and learn (condition 3) seems to be essential to achieve and maintain high water management performance. Cities with high water management performance are observed to be well-prepared (indicator 9.3 preparedness) through policies and plans that have a clear allocation of resources and responsibilities. Such policies and plans may enable a high statutory compliance (indicator 9.2 statutory compliance). Moreover, smart monitoring (indicator 3.1 smart monitoring) seems to ensure that gaps in compliances can be better identified and consequently addressed through a process of continuous evaluation (indicator 3.2 evaluation) and optimization of the use of various policy instruments (indicator 9.1 policy instruments). The role of individuals who provide a long-term vision, promote initiatives, bring actors together, and mobilize the required local resources, seems to be important to achieve higher management performances (indicator 6.1 entrepreneurial agents; r=0.81). It was also observed that cities with higher water management performances seem to have a stakeholder engagement that was more embedded in the decision-making process. The overall geometric average of the 27 governance capacity indicators, the Governance Capacity Index (GCI) correlated well (r=0.83) with water management performances as expressed by the Blue City Index (Figure 10). This correlation is not necessarily a cause-effect relation but seem to be a good indication that management performance can substantially be attributed to a higher governance capacity.

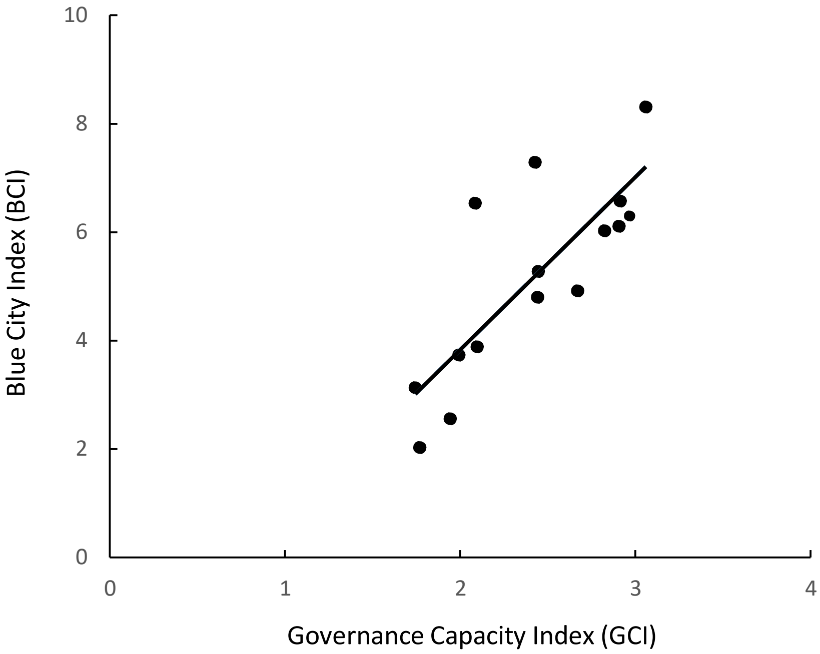


Figure 10 The positive correlation (r=0.81) between the Blue City Index (BCI) and the geometric average of the 27 governance capacity indicators with respect to flood risk, water scarcity and wastewater treatment in 15 cities (Koop 2019)

DSPs have the potential to strengthen key governance conditions, most notably condition 1, 2, 3 and 4: awareness, useful knowledge, continuous learning, and stakeholder engagement process. We have observed that in particular, continuous learning and stakeholder engagement process correlate well with water management performance (as measured by the City Blueprint performance Framework). The two governance conditions are in fact key processes that a DSP can strengthen. The condition continuous learning consists of three indicators, i.e., smart monitoring, evaluation and cross-stakeholder learning. Smart monitoring requires continuous improvements in order to cover new processes, systems or risks that are most effectively identified through an optimized interaction between citizens, professionals representing different organisation, departments and sectors, as well as politicians. In this context, DSPs may also provide an excellent means to apply and integrate citizen science activities into policy implementation and evaluation. Citizen science in known as collaborative research conducted by non-professional citizens, scientists/professionals and potentially other stakeholders. Beyond seizing opportunities of obtaining more data through citizen participation in such research projects, an additional advantage is that citizens are more engaged in solving local water challenges. Hence, it may stimulate cross-stakeholder learning (indicator 3.3; Table 8). Stakeholder engagement process is also observed to be more elaborate in cities with high scores for the City Blueprint performance Framework. Besides continuous learning, DSPs can also contribute to more advanced and in-depth stakeholder engagement processes. For example, ongoing online discussions and feedback, through agenda setting or through selecting the citizen representatives that can in turn be involved in long-term policy implementation and evaluation (referred to as ConCensus; Deliverable 4.4; Elelman an Feldman 2017). The provision of useful knowledge could be considered the ‘raison d'être’ for DSPs. Importantly, through feedback and online as well as offline discussion, information provision can be improved and may originate from different sources apart from the local authorities. For example, the population of best practices in the Best Practice Repository can be from different organisation such as universities, environmental organisations/institutions, companies, citizens etc.. Finally, awareness is somewhat of a paradox since cities that have high water management performances are observed to have low levels of community knowledge and sense of urgency about the water challenges (indicators 1.1 and 1.2).

An explanation may be that if water management performance is low, communities are more exposed to the consequences of water challenges such as floods, heat stress or water pollution, which can possibly affect their daily routines. By contrast, high performing cities anticipate and adapt the challenges resulting in the communities that are not exposed to these challenges and therefore take water services for granted (e.g. OECD 2014). For these cities, DSPs may have a particular challenge in raising awareness and support for water management measures. However, the capacity-building potential of Digital Social Platforms is not limited to these four conditions. For example, with respect to stimulating individuals provide a long-term vision, promote initiatives, bring actors together, and mobilize the required local resources can be a key contribution of DSPs (indicator 6.1 entrepreneurial agents; r=0.81).

5.2 Digital Social Platforms contribution towards water-wise European cities

The results of the City Blueprint and Trends and Pressures assessment of 75 cities, five key water-related challenges have been identified in section 4.1:

- The critical triangle: Drinking water, sanitation and wastewater treatment
- The untapped potential of urban wastewater
- Improving solid waste treatment: a criticality of sustainable urban growth
- Water use inefficiencies
- Water and climate adaptation in cities

Interestingly, each of these five key water-related challenges can be improved by an ICT facilitated interaction between citizens, professionals and politicians. In particular because citizens have a key role in each of these key water-related challenge.

The critical triangle of drinking water, sanitation and wastewater treatment mainly refers to non-European cities. In particular in cities with rapid and sometimes uncontrolled urbanization, informal settlements and insufficient coverage of water and sanitation services through centralised infrastructure is common. A recent estimate states that 32.7 % of the world's population in developing regions is living in slums (UN-HABITAT 2011). Many of these communities rely on unsewered communal toilets, use open spaces or dispose of faeces in polythene bags (Rahmasary et al. 2019). In these cases, community-oriented initiatives replace the lack of centralised water services. In particular, community-based programmes to provide access to sanitation and adequate collection and treatment of wastewater is key. For such programmes, engagement of local communities is essential and ICT facilitated interaction between citizens, professionals and politicians can be effective. In particular, to inform people about the health risk of unsafe sanitation and adverse impact of untreated wastewater. However, DSPs can also be important in operational management or organisational processes.

Likewise, the reuse of treated wastewater is a key solution to mitigate climate change in water stressed regions across the globe (Sanz and Gawlik 2014). The reuse of treated wastewater can trigger different types of public responses based on socio-psychological factors as well as influences related to trust, risk perceptions and affective (emotional) reactions (Smith et al. 2018). The POWER project KDC of Sabadell provides an important case study where a DSP is applied to inform and engage citizens and local stakeholders in this process of reusing treated wastewater. Such communication about water quality aspects as well as advantages and disadvantages of reusing treated wastewater and how people have to use this water for different application is key for the success of such water management systems (Steflova et al. 2018).

The City Blueprint results of 75 cities show that the issue of solid waste production and treatment is particularly low performing which has a particularly thorough impact on water quality, greenhouse gas emission and recovery of resources. In order to reduce waste a strategy of reduce, reuse, recycle, energy recovery and only if the previous options are maximally exploited, controlled landfilling is an option. As such, reducing packaging materials for consumer goods is an important aspect, as well as reusable products. Both strategies require involvement of producers in response to a societal demand for environmental slow waste consumer goods. The consumers or citizens have an important role to play and their awareness and proactive actions are key. Next, for recycling and resource recovery of waste products, citizens awareness and behaviour is again important. The separate collection of amongst others glass, paper and organic material requires behavioural internalization of citizens/consumers. A DSP may be a strong instrument to further stimulate these activities and initiatives. The City Blueprint shows the relevance of such approaches and therefore underlines the potential role of Digital Social Platforms in facilitating them.

Water efficiency is another important challenge that can be enhanced through DSPs. Interestingly, many different digital tools exist for domestic water conservation or for industrial water conservation (e.g. Novak et al. 2018; Perren et al. 2016). However, there are not that many tools that combine the two on a municipal level. This might provide very interesting dynamics to can increase overall water use efficiency. For example through circular solutions where wastewater from one industrial process can be used for other applications in the city. In addition, it might reveal to most cost-effective or viable water saving solutions.

Finally, the City Blueprint assessment show that a significant number of cities do not sufficiently take climate change adaptation into account. More precisely, adaptation and mitigation to more extremes in temperature, downpours and drought periods through amongst others increasing vegetated areas, water bodies or in the urban infrastructure is key (e.g. building design, building insulation requirements etc.). Such initiatives can be integrated in broader initiatives to make the city more attractive, increase biodiversity or create social cohesion (e.g. through community gardens in Jerusalem). Also for addressing such often spatial measures, DSPs may provide good incentives that can contribute to urban climate adaptation efforts.

6. Conclusion

The City Blueprint methodology provides a comprehensive assessment method to assess the management of UWCS in cities around the world. The report presents the results of the City Blueprint that has been carried out in 75 cities with a focusing on the performance in the POWER KDCs. Through the analysis the most suitable and relevant topics that can be addressed using DSPs are identified. These topics may also form the focus of other ICT facilitated engagement and interaction between citizens, professionals and politicians. In this way, this are supported in their efforts to become 'water-wise'. The assessment of 75 cities provided essential clues for enabling cities to improve their water management through the application of DSPs or other ICT facilitated interactions between citizens, professionals and politicians. First of all, the empirical results show a positive correlation between, on the one hand, governance capacity and in particular a process of continuous learning, and, on the other hand, high water management performance. Such cross-stakeholder evaluation and learning may be enhanced through the use of ICT facilitated tools such as DSPs. Second, the City Blueprint assessments provide a strong framing that may encourage practitioners to improve their management practise and become 'water-wise'. In particular, it shows the huge potential of city-to-city exchange of knowledge, experiences and best practice. The POWER Best Practice Repository may provide an important contribution towards seizing these large opportunities. Third, a key factor for improving water management through ICT facilitated interactions is by identifying water-related challenges that have a high improvement potential that can be seized engaging citizens with water professionals and politicians. The observed water management performances and pressures that may constrain local water managers provide five key water-related challenges that may form the focus areas for DSP applications beyond the four Key Demonstration Cities. Interestingly, citizens have a key role in each of these key water-related challenges. Overall, by considering both the potential impact as well as the importance of interaction between citizens, professionals and politicians in addressing the challenges, DSPs might be most effective in addressing the following water-related challenges:

- The untapped potential of urban wastewater
- Improving solid waste treatment: a criticality of sustainable urban growth
- Water use inefficiencies
- Water and climate adaptation in cities

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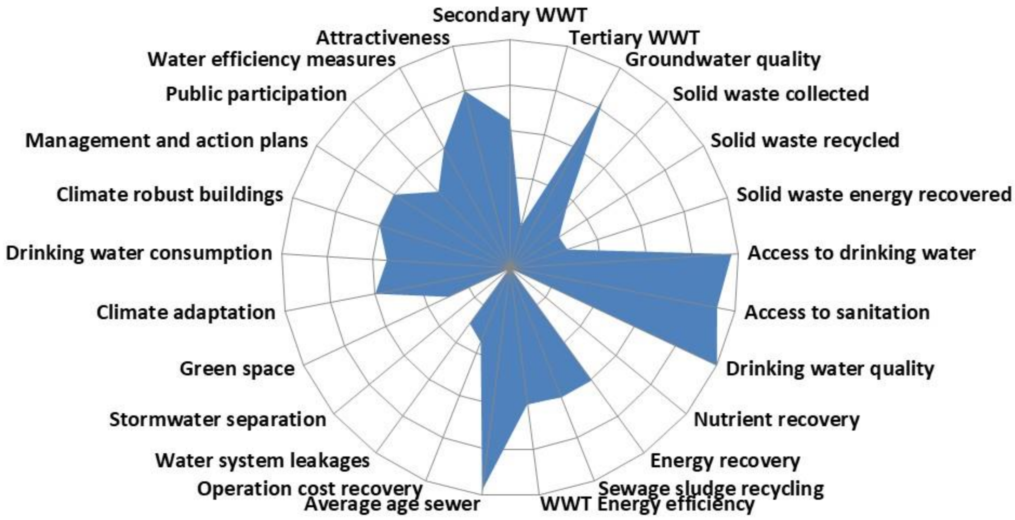
Annex 1 City Blueprint assessments in 75 cities

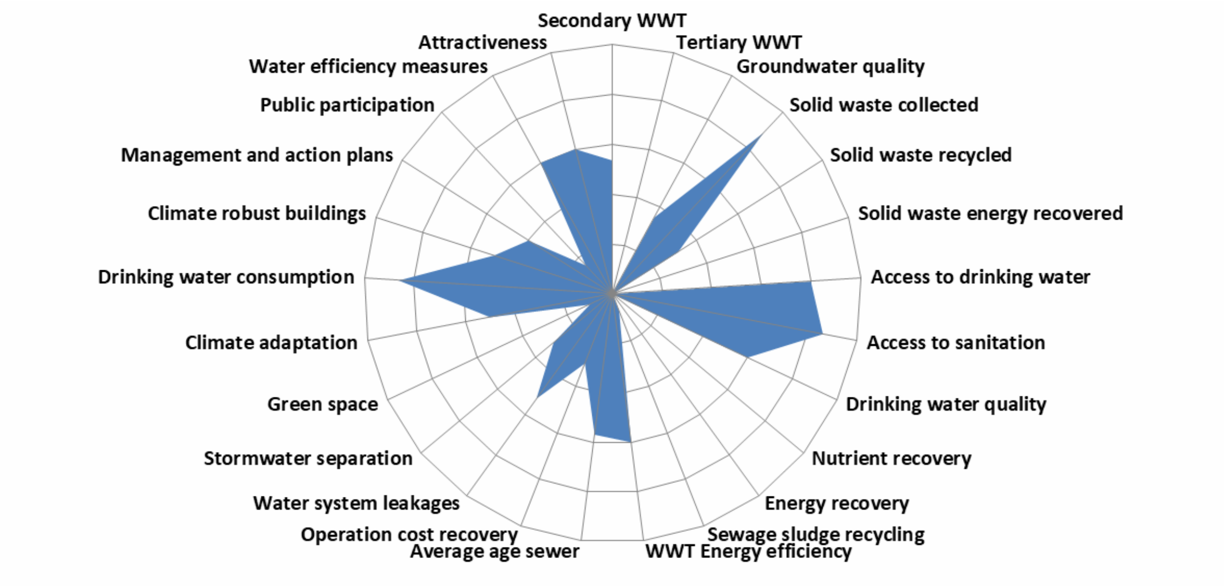
This appendix includes the City Blueprint assessment results of 75 municipalities and regions in 35 different countries. The cities are presented in alphabetic order. The indicator scoring system and key data sources are publicly available on the European Innovation Platform on Water: https://www.eip-water.eu/City_Blueprints

Trends and Pressures scoring system: https://www.eip-water.eu/sites/default/files/Indicators%20of%20the%20Trends%20and%20Pressures%20Framework%20%28Sept%202017%29.pdf

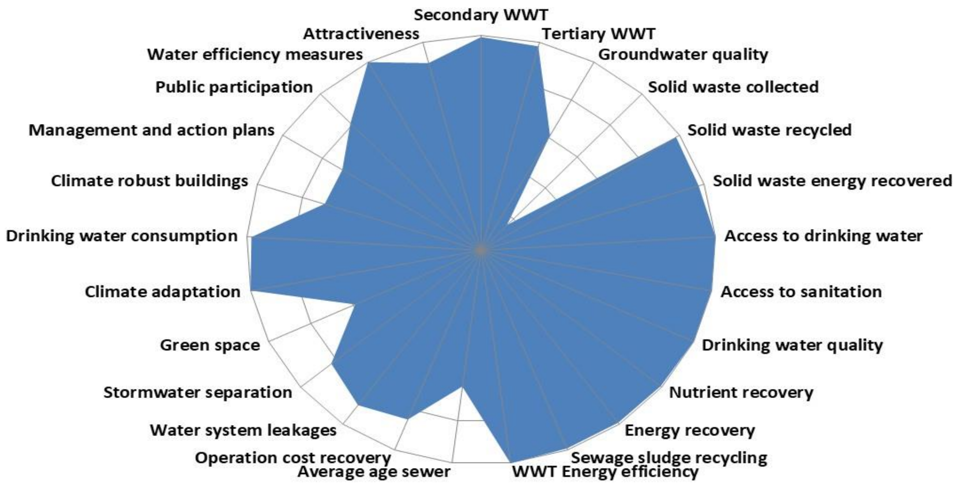
City Blueprint performance Framework scoring system: https://www.eip-water.eu/sites/default/files/Indicators%20of%20the%20City%20Blueprint%20Framework_0.pdf



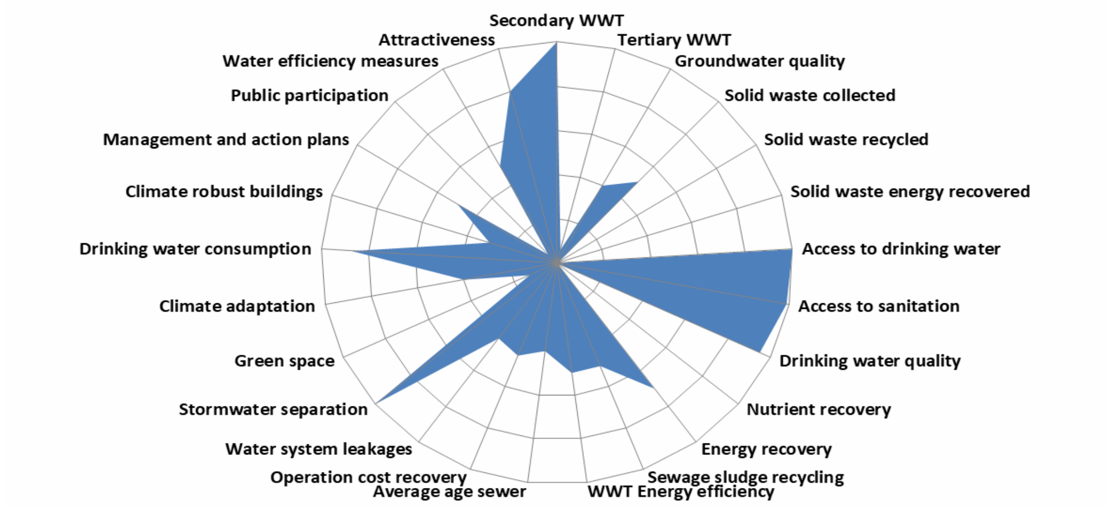
Annex figure A) Blue City Index of **Algarve** is 4.5 points. Water scarcity, heat risk, economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.



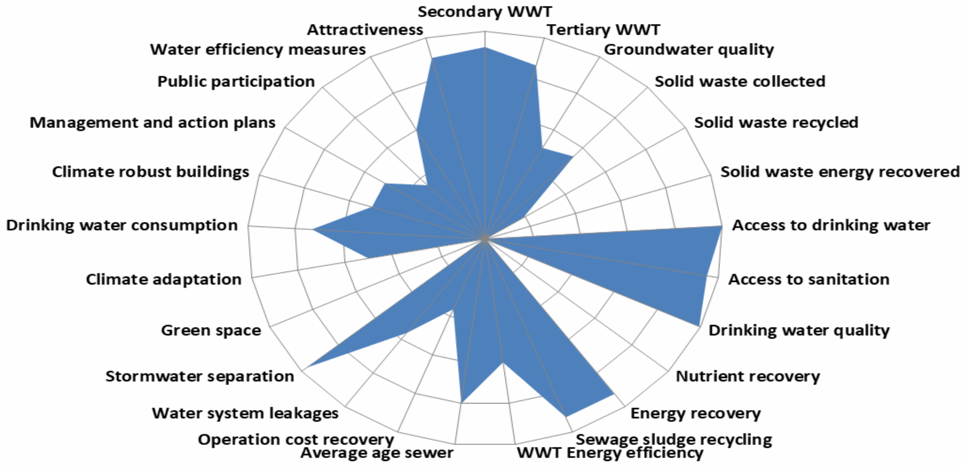
Annex figure B) Blue City Index of **Ahmedabad** is 3.1 points. Urbanization rate, political instability, water scarcity, heat risk, economic pressure and inflation rate have been identified as key pressures that may form constrains for local water managers.



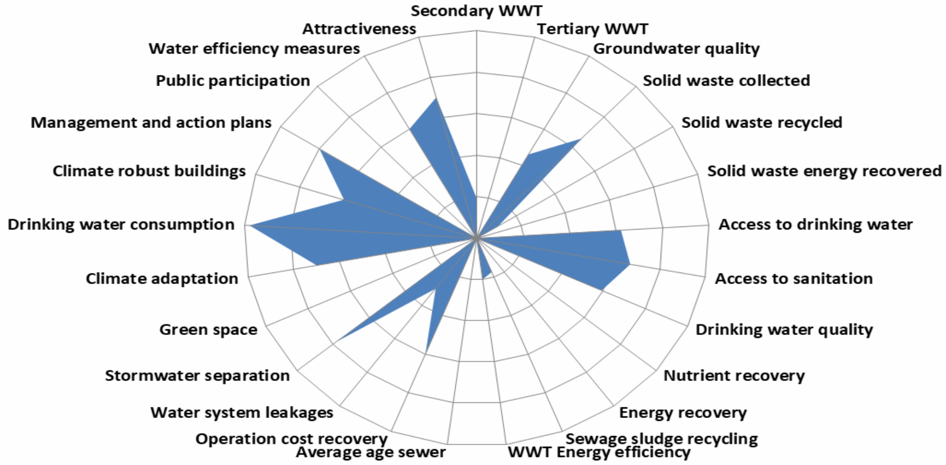
Annex figure C) Blue City Index of **Amsterdam** is 8.3 points. Flood risk and water quality have been identified as key pressures that may form constrains for local water managers.



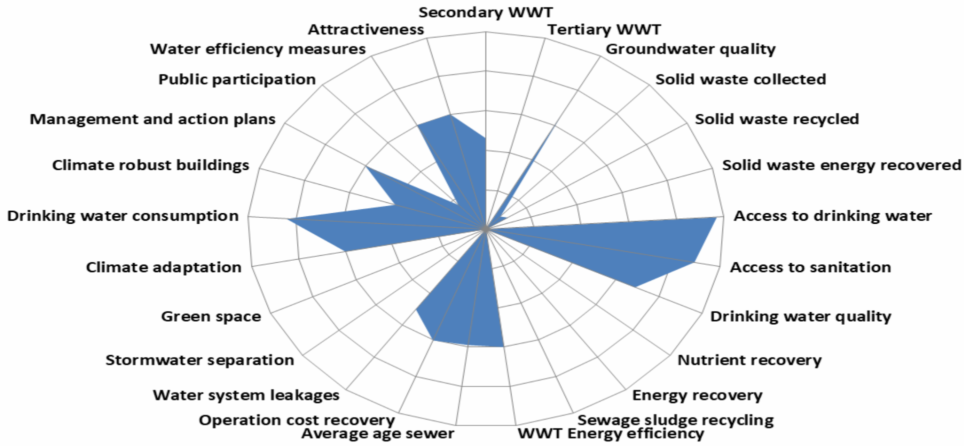
Annex figure D) Blue City Index of **Ankara** is 3.7 points. Political instability, heat risk, economic pressure, unemployment rate and inflation rate have been identified as key pressures that may form constrains for local water managers.



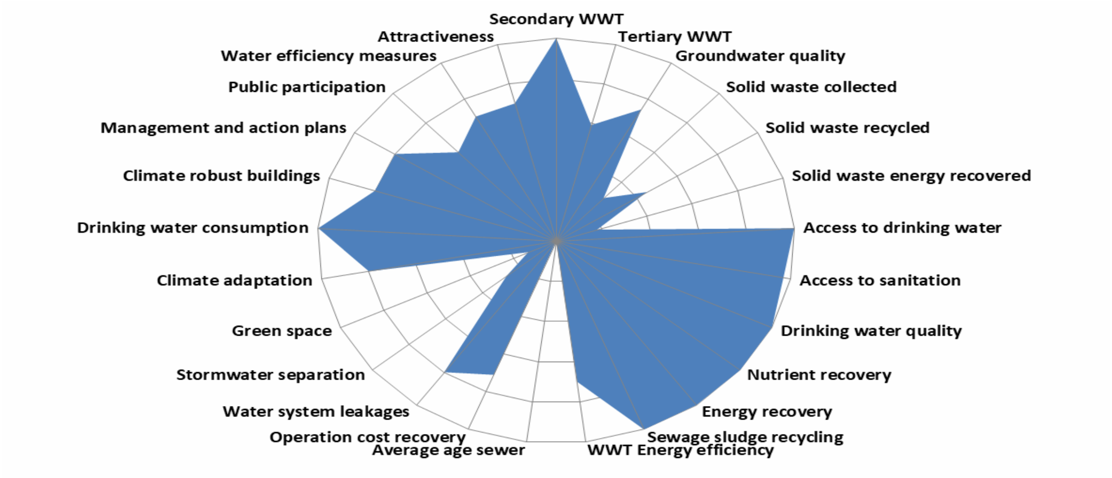
Annex figure E) Blue City Index of **Athens** is 4.9 points. Flood risk, heat risk, economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.



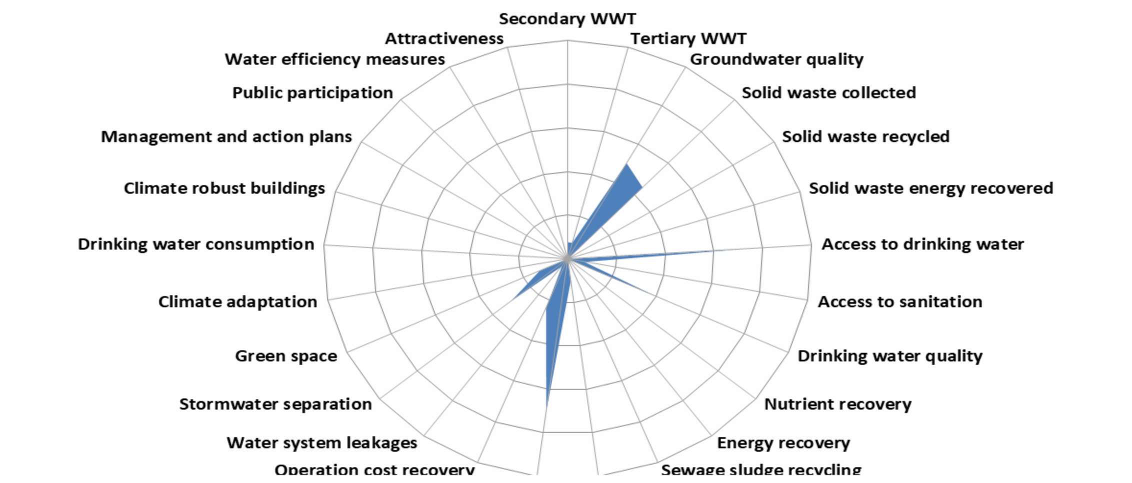
Annex figure F) Blue City Index of **Bandung** is 2.6 points. Urbanization rate, education rate, flood risk, heat risk, economic pressure and inflation rate have been identified as key pressures that may form constrains for local water managers.



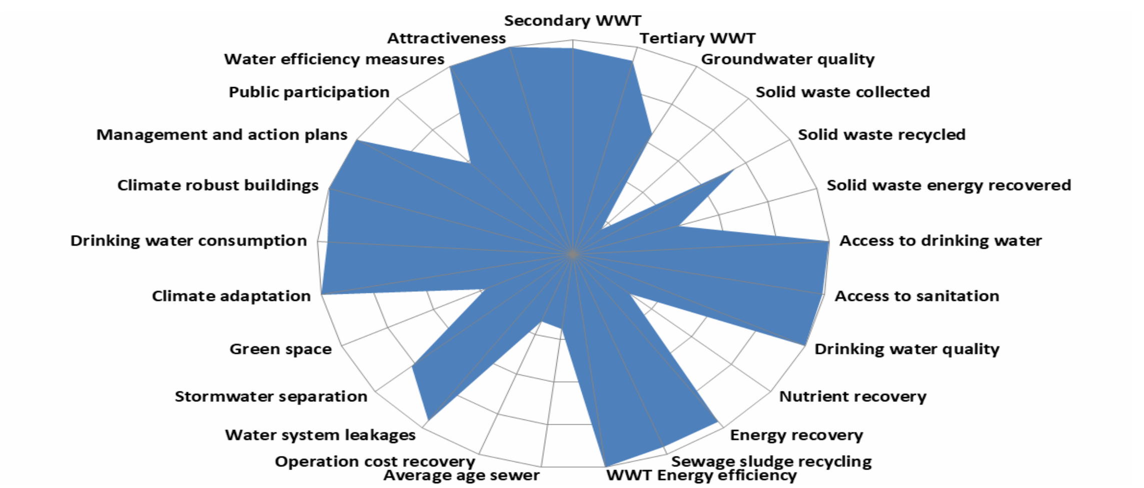
An Annex figure G) Blue City Index of **Bangkok** is 2.6 points. Urbanization rate, political instability, water scarcity, flood risk, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



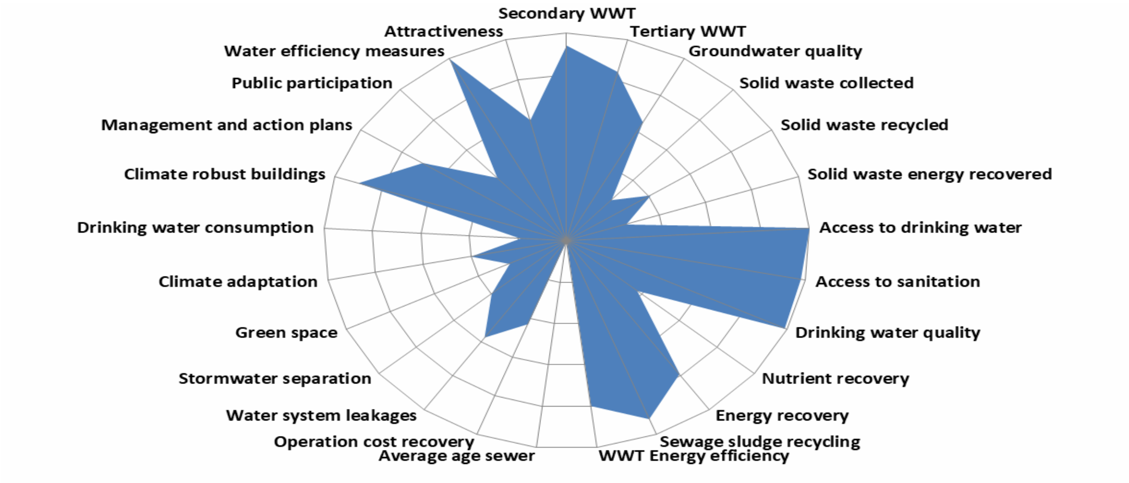
Annex figure H) Blue City Index of **Bath** is 6.0 points. No key pressures have been identified that may form substantially constrains for local water managers.



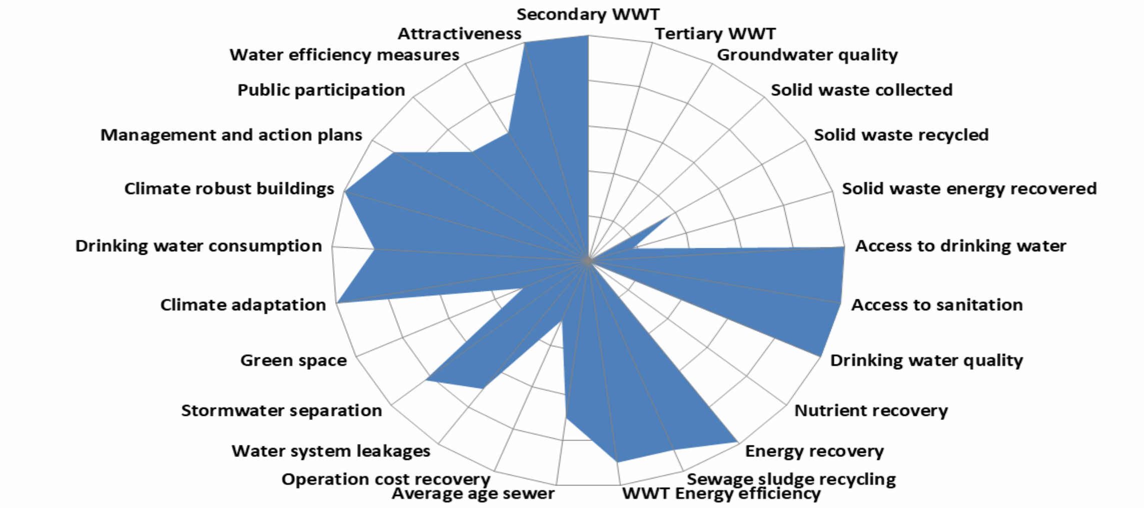
Annex figure I) Blue City Index of **Belém** is 1.1 points. Education rate, flood risk, heat risk, economic pressure and inflation rate have been identified as key pressures that may form constrains for local water managers.



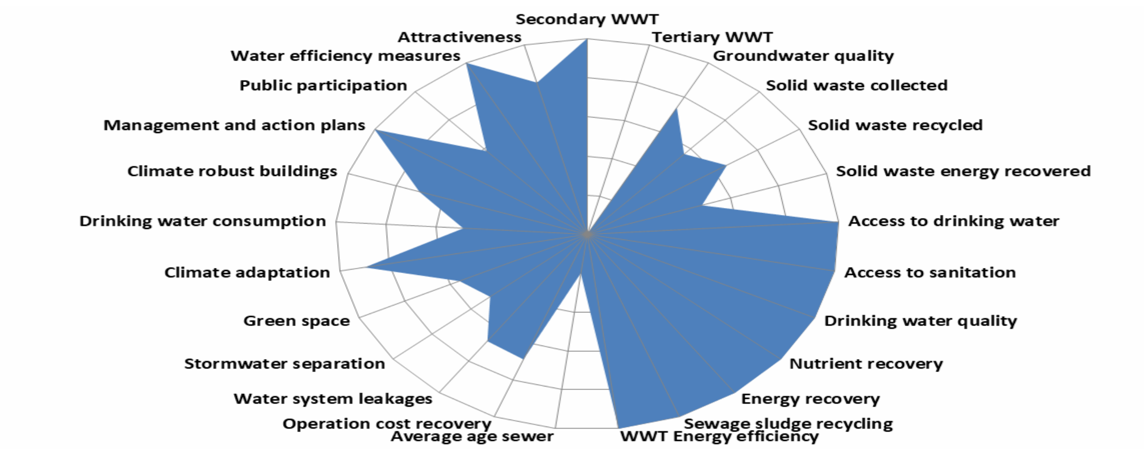
Annex figure J) Blue City Index of **Berlin** is 7.2 points. No key pressures have been identified that may form substantially constrains for local water managers.



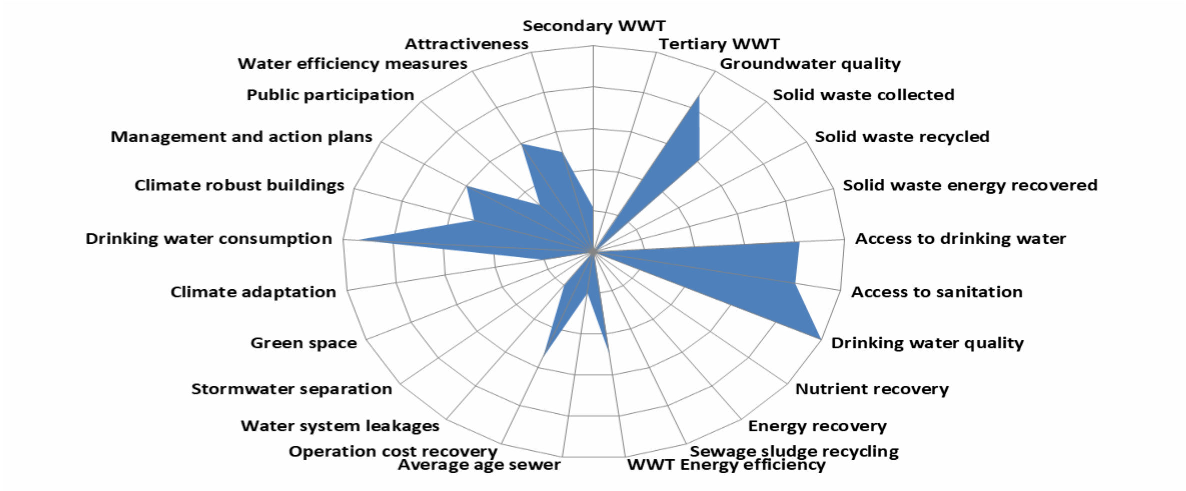
An Annex figure K) Blue City Index of **Bologna** is 5.2 points. Heat risk and unemployment rate have been identified as key pressures that may form constrains for local water managers.



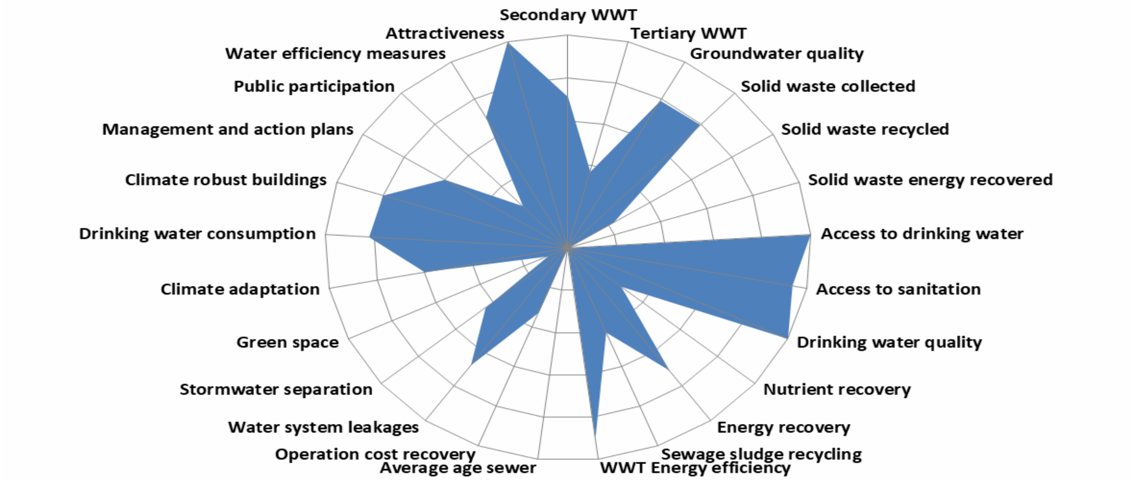
Annex figure L) Blue City Index of **Boston** is 5.4 points. Heat risk and unemployment rate have been identified as key pressures that may form constrains for local water managers.



Annex figure M) Blue City Index of **Bristol** is 6.7 points. No key pressures have been identified that may form substantially constrains for local water managers.



Annex figure N) Blue City Index of **Bucharest** is 2.4 points. Flood risk, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



Annex figure O) Blue City Index of **Budapest** is 4.7 points. Heat risk, economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.

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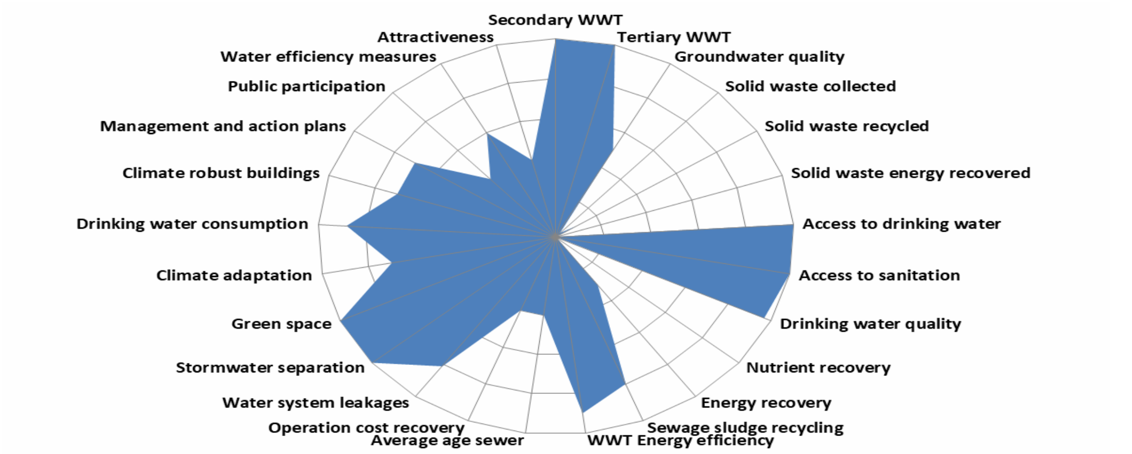
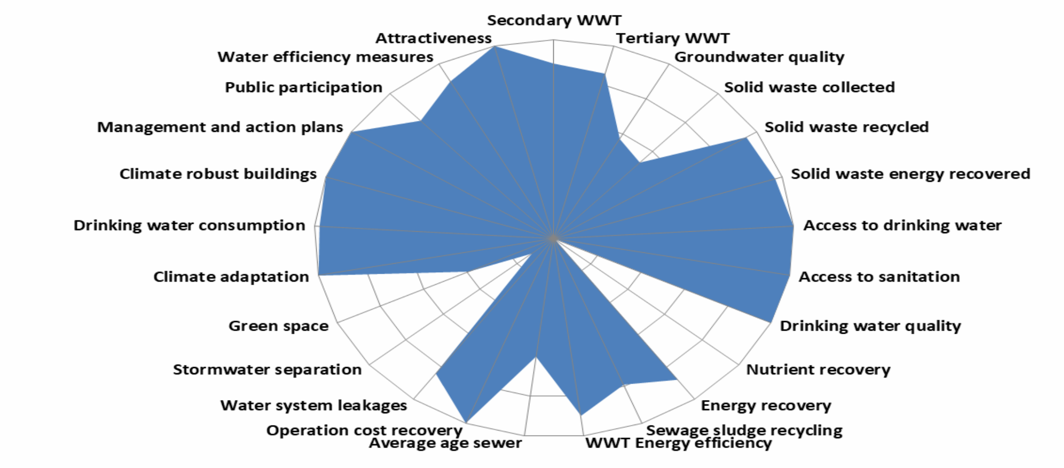
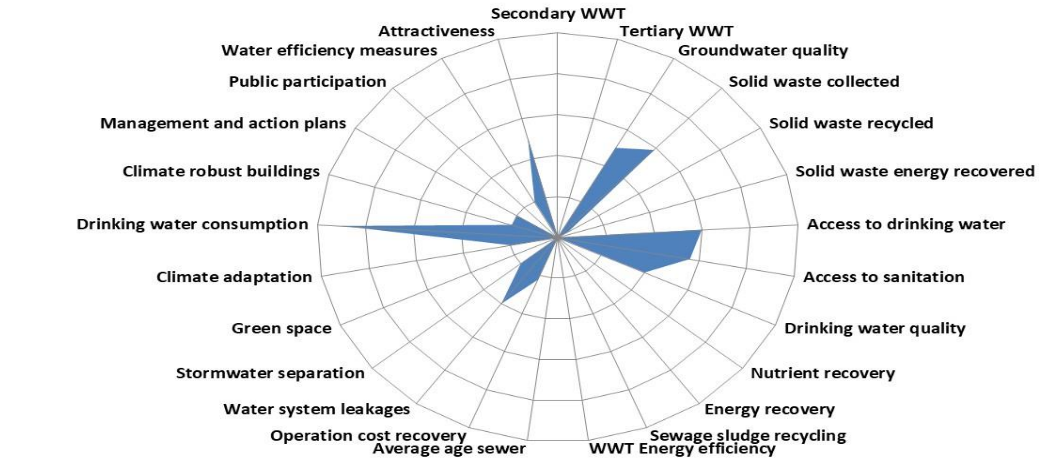


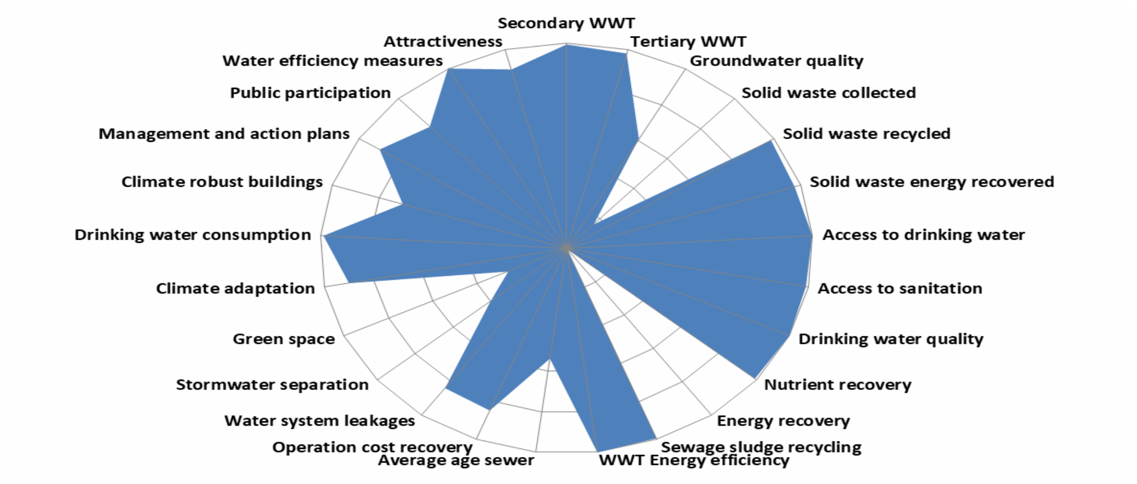
Annex figure P) Blue City Index of **Cape Town** is 4.9 points. Burden of disease, economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.



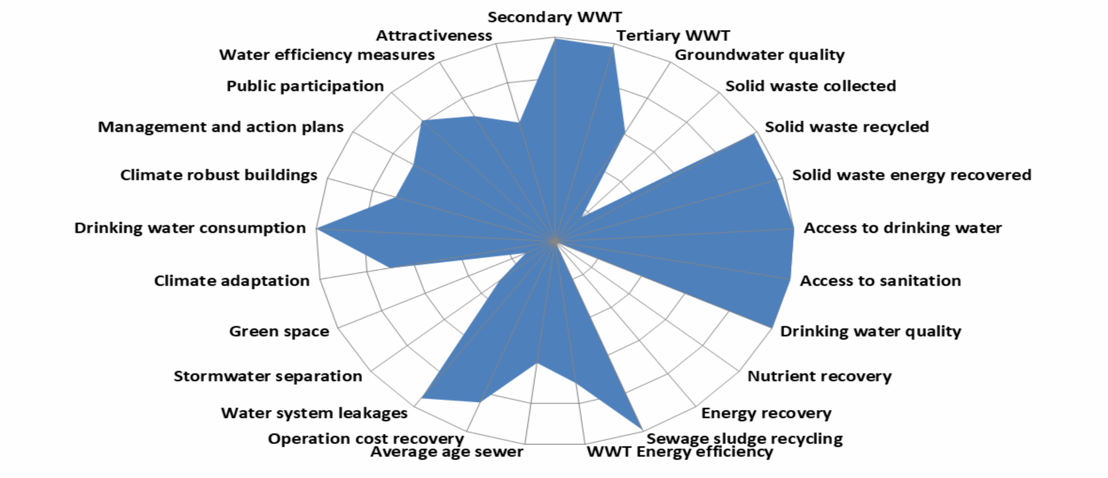
Annex figure Q) Blue City Index of **Copenhagen** is 7.1 points. No key pressures have been identified that may form substantially constrains for local water managers.



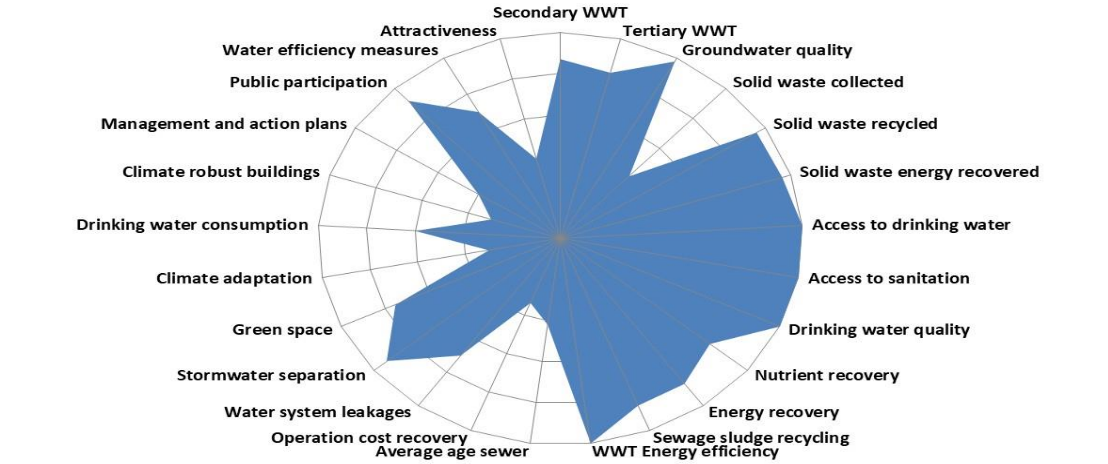
Annex figure R) Blue City Index of **Dar es Salaam** is .1.4 points. Urbanization rate, burden of disease, education rate, flood risk, heat risk, economic pressure, poverty rate and inflation rate have been identified as key pressures that may form constrains for local water managers.



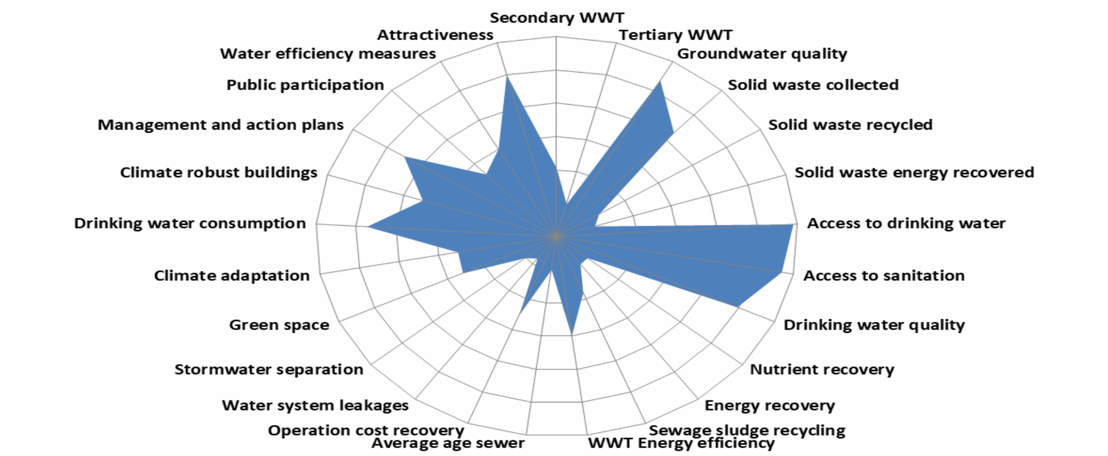
Annex figure S) Blue City Index of **Dordrecht** is 7.0 points. Flood risk and water quality have been identified as key pressures that may form constrains for local water managers.



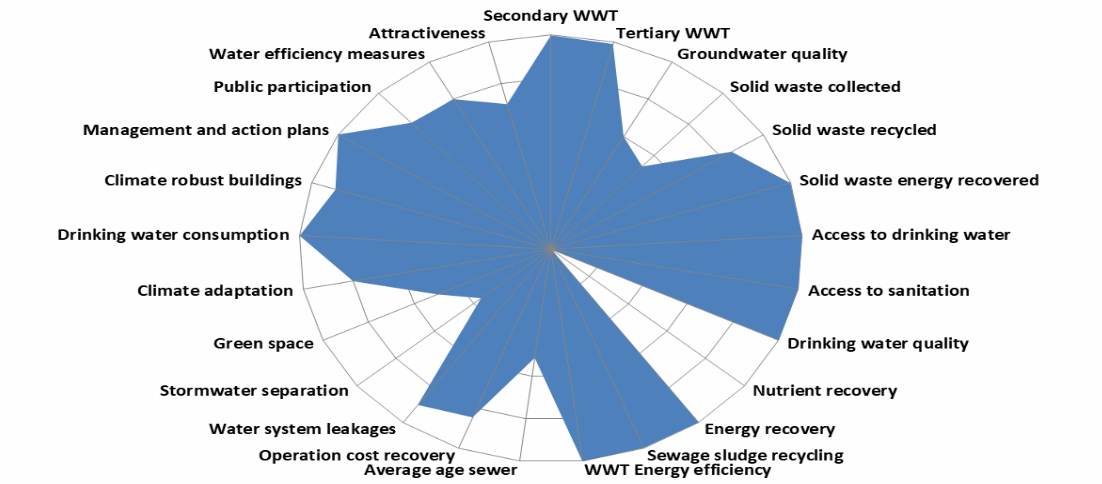
Annex figure T) Blue City Index of **Eindhoven** is 5.8 points. Flood risk has been identified as key pressures that may form constrains for local water managers.



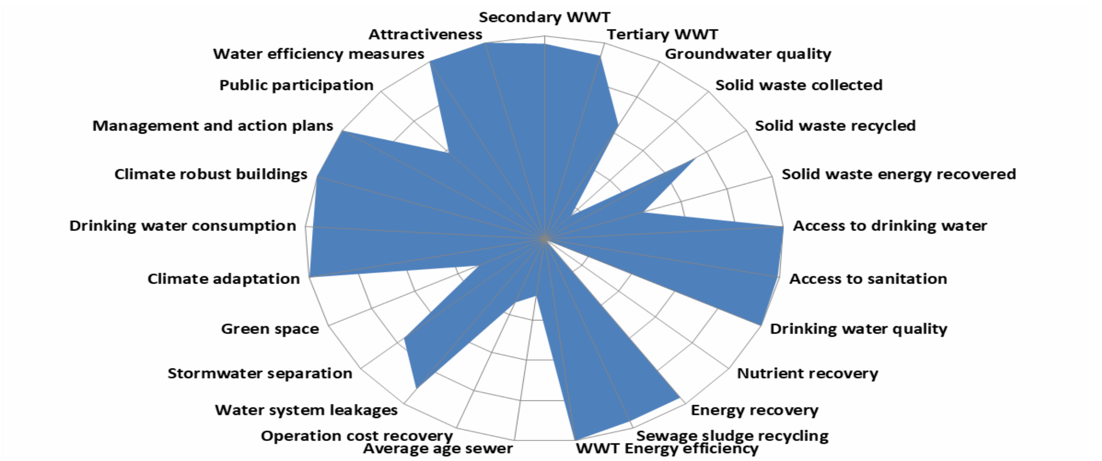
Annex figure U) Blue City Index of **Eslov** is 6.9 points. No key pressures have been identified that may form substantially constrains for local water managers.



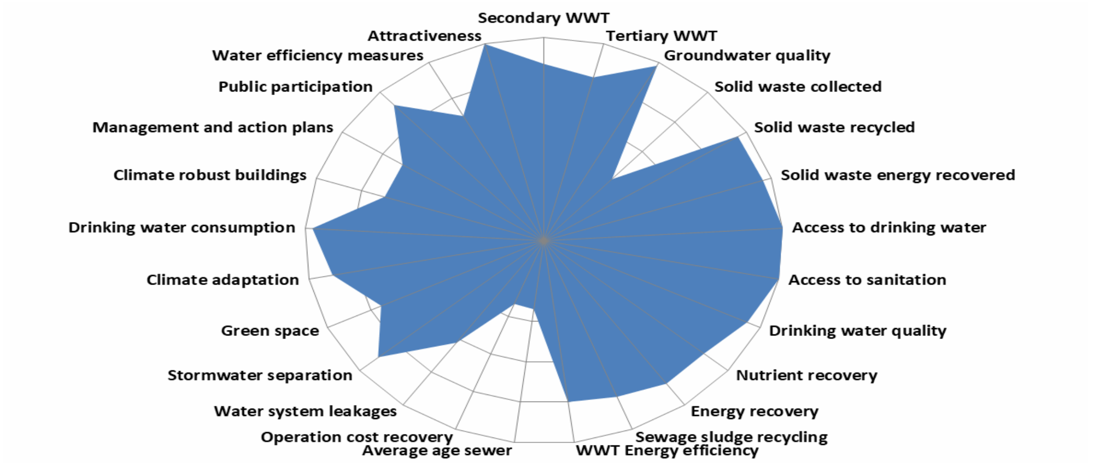
Annex figure V) Blue City Index of **Galati** is 2.4 points. heat risk and economic have been identified as key pressures that may form constrains for local water managers.



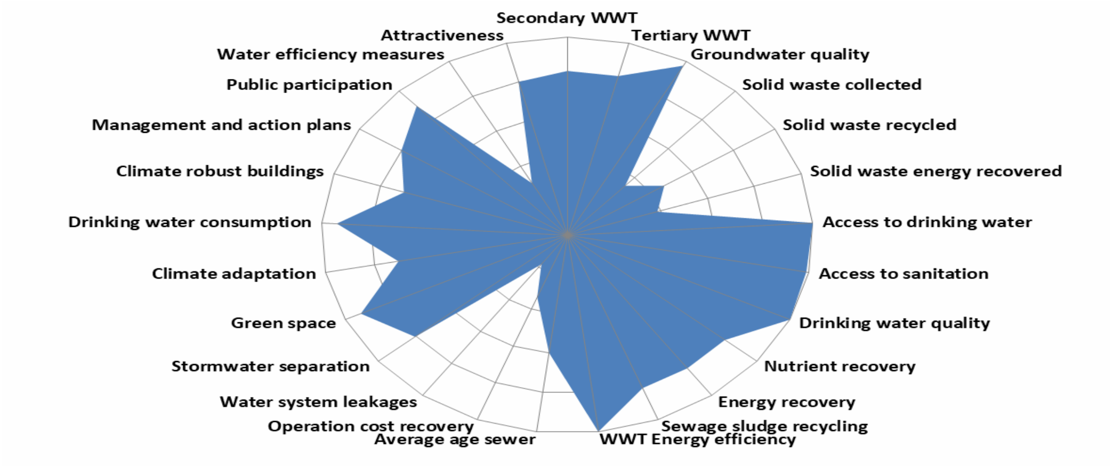
Annex figure W) Blue City Index of **Groningen** is 7.4 points. Flood risk and water quality have been identified as key pressures that may form constrains for local water managers.



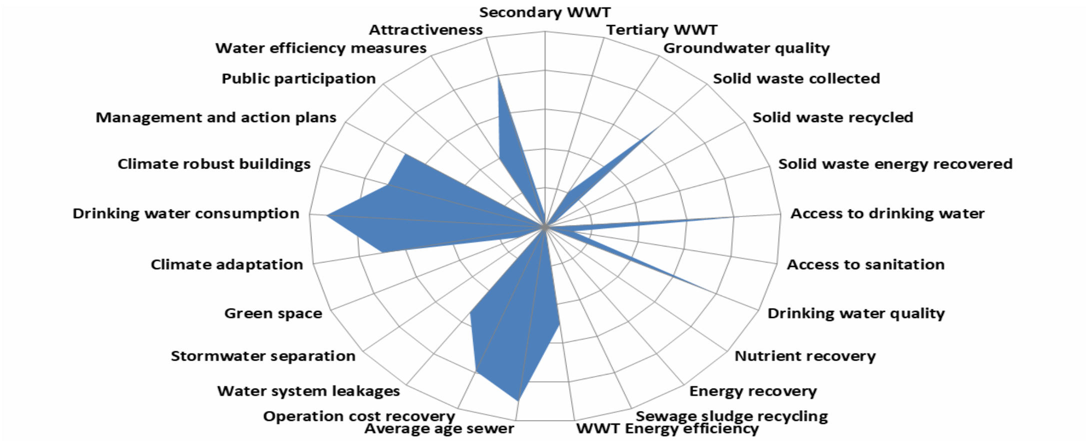
Annex figure X) Blue City Index of **Hamburg** is 6.6 points. Flood risk has been identified as key pressures that may form constrains for local water managers.



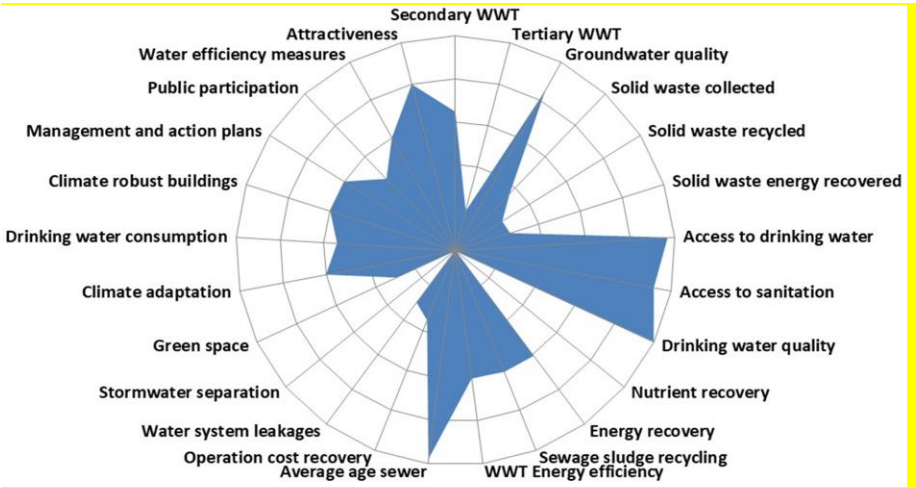
Annex figure Y) Blue City Index of **Helsingborgh** is 7.8 points. No key pressures have been identified that may form substantially constrains for local water managers.



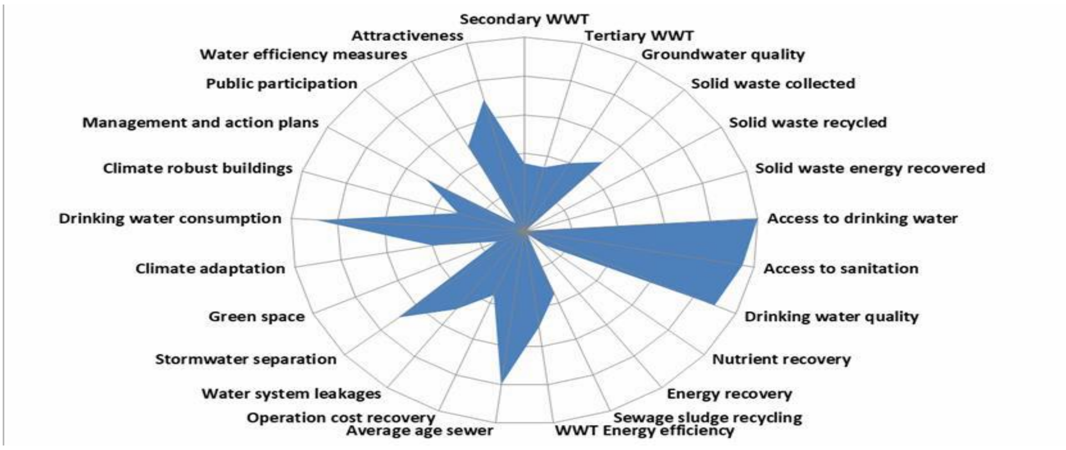
Annex figure Z) Blue City Index of **Helsinki** is 6.8 points. No key pressures have been identified that may form substantially constrains for local water managers.



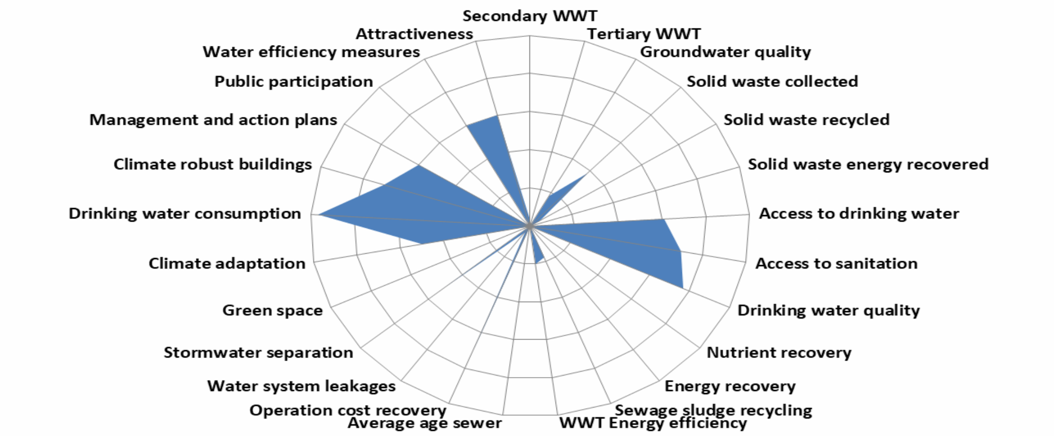
Annex figure AA) Blue City Index of **Ho Chi Minh** is 2.4 points. Urbanization rate, flood risk, heat risk, economic pressure and poverty rate have been identified as key pressures that may form constrains for local water managers.



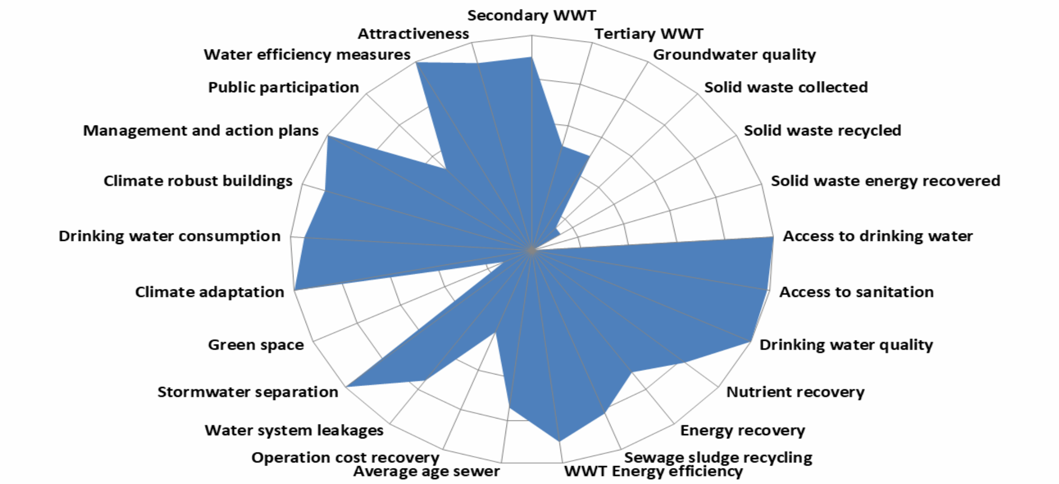
Annex figure AB) Blue City Index of **Hohhot** is 5.0 points. Urbanization, education rate, water scarcity and economic pressure have been identified as key pressures that may form constrains for local water managers.



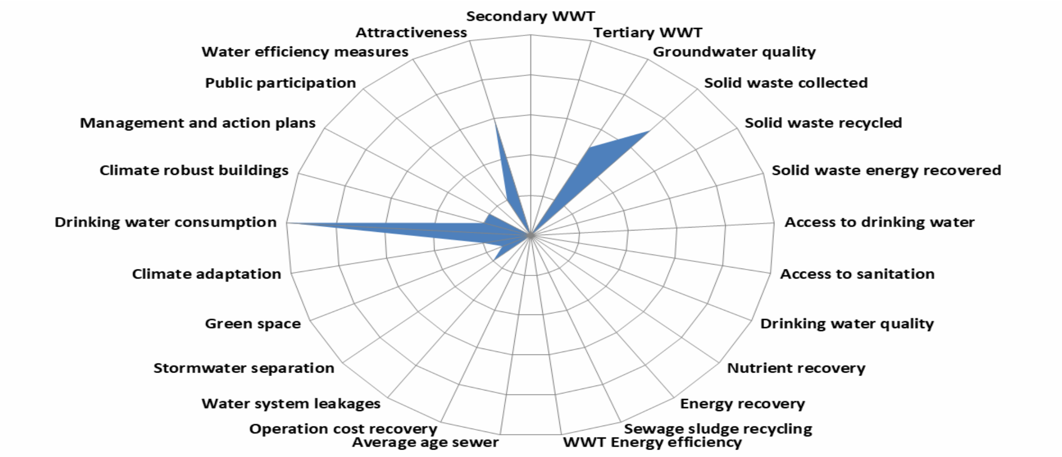
Annex figure AC) Blue City Index of **Istanbul** is 3.5 points. Political instability, flood risk, heat risk, economic pressure, unemployment rate and inflation rate have been identified as key pressures that may form constrains for local water managers.



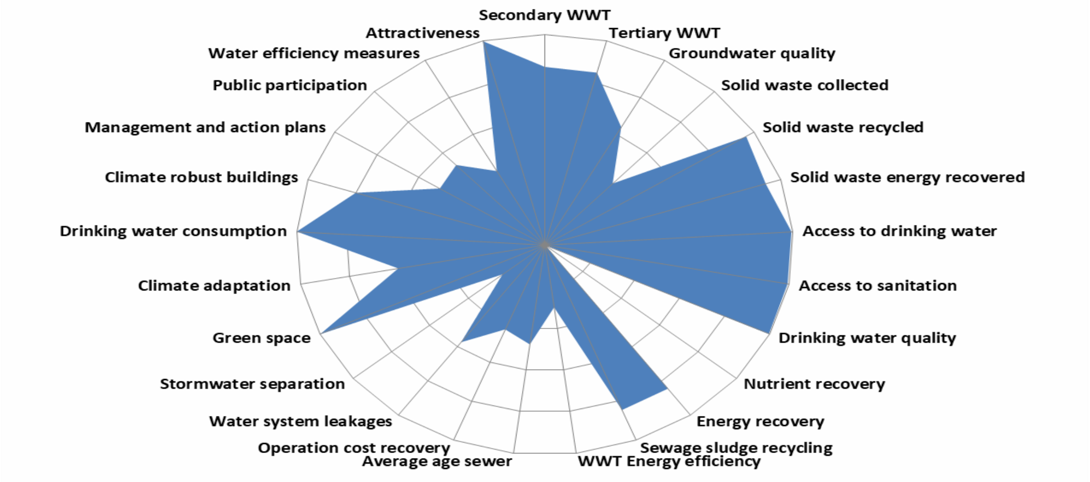
Annex figure AD) Blue City Index of **Jakarta** is 2.0 points. Urbanization rate, education rate, flood risk, heat risk, economic pressure and inflation rate have been identified as key pressures that may form constrains for local water managers.



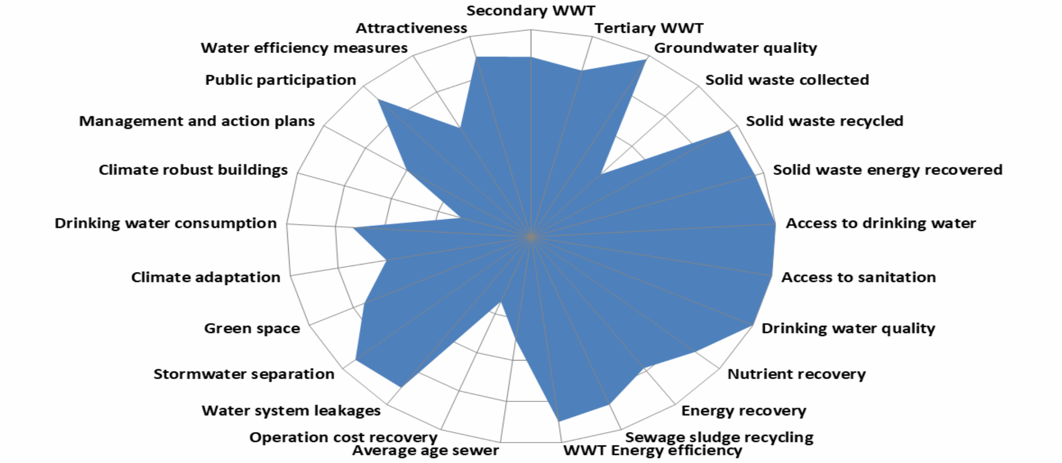
Annex figure AE) Blue City Index of **Jerusalem** is 6.0 points. Political instability, water scarcity and heat risk have been identified as key pressures that may form constrains for local water managers.



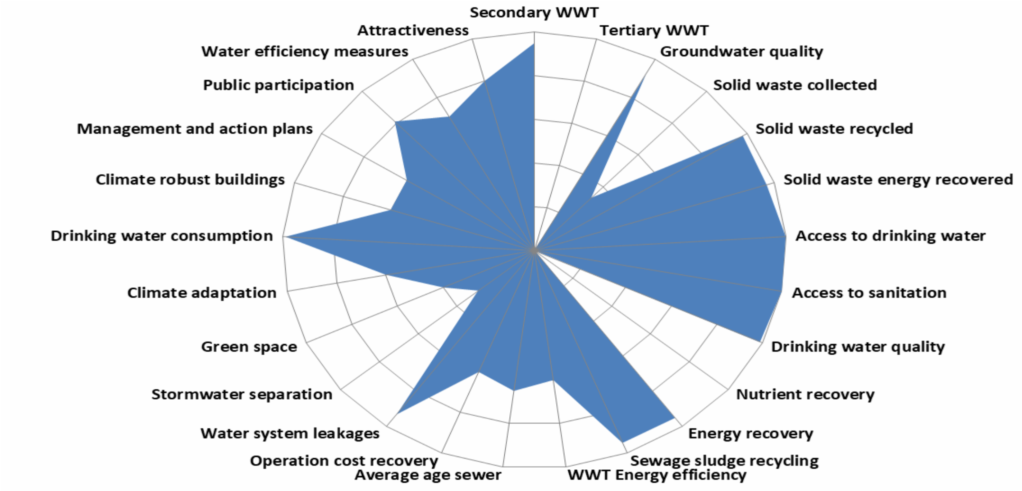
Annex figure AF) Blue City Index of **Kilamba Kiaxi** is 1.1 points. Education rate, burden of disease, education rate, flood risk, heat risk, economic pressure, poverty rate and inflation rate have been identified as key pressures that may form constrains for local water managers.



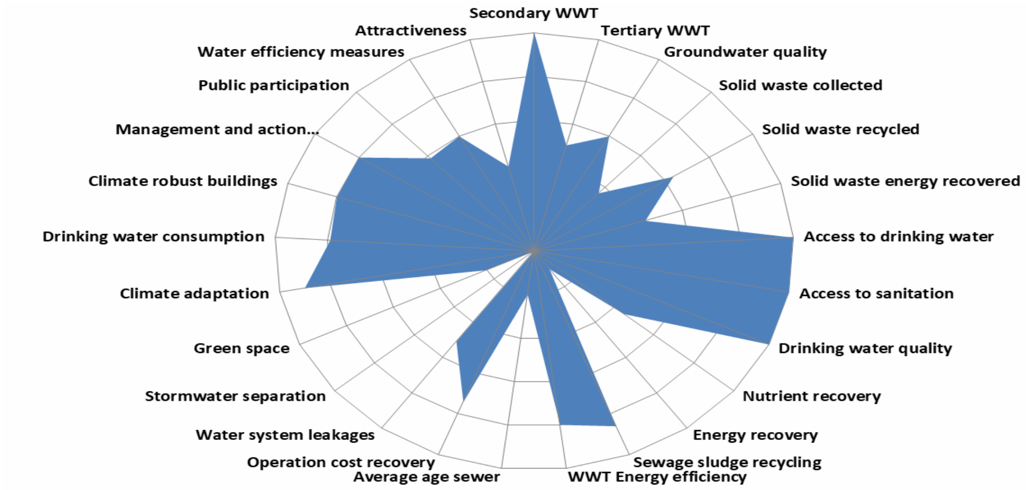
Annex figure AG) Blue City Index of **Kortrijk** is 6.1 points. No key pressures have been identified that may form substantially constrains for local water managers.



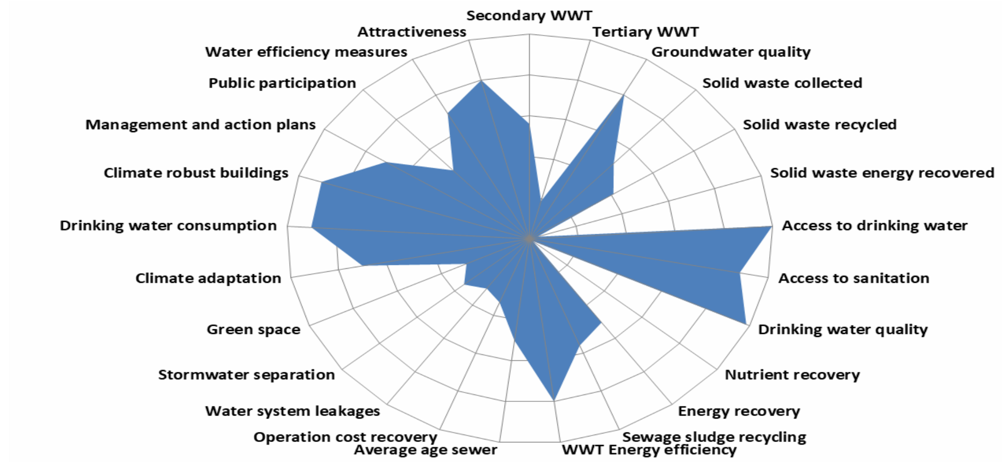
Annex figure AH) Blue City Index of **Kristianstad** is 7.5 points. No key pressures have been identified that may form substantially constrains for local water managers.



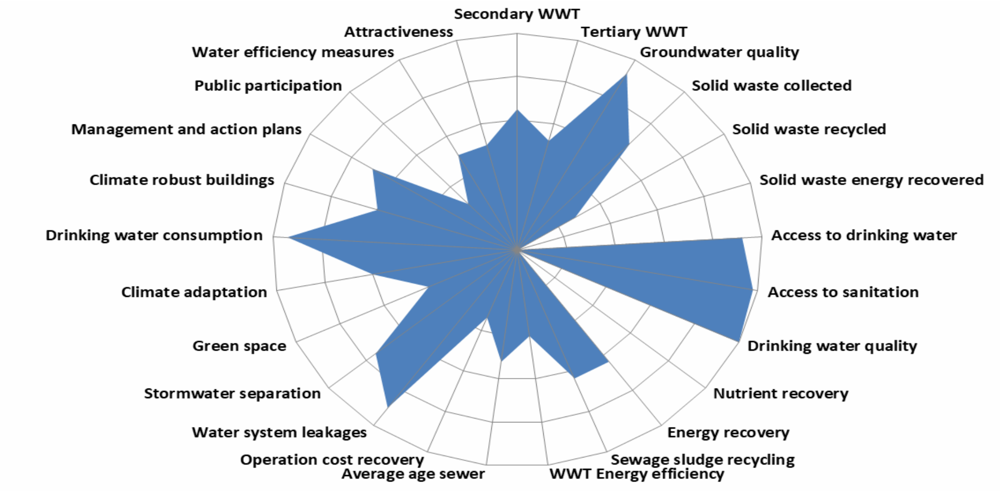
Annex figure AI) Blue City Index of **Leeuwarden** is 6.0 points. Water quality has een identified as key pressures that may form constrains for local water managers.



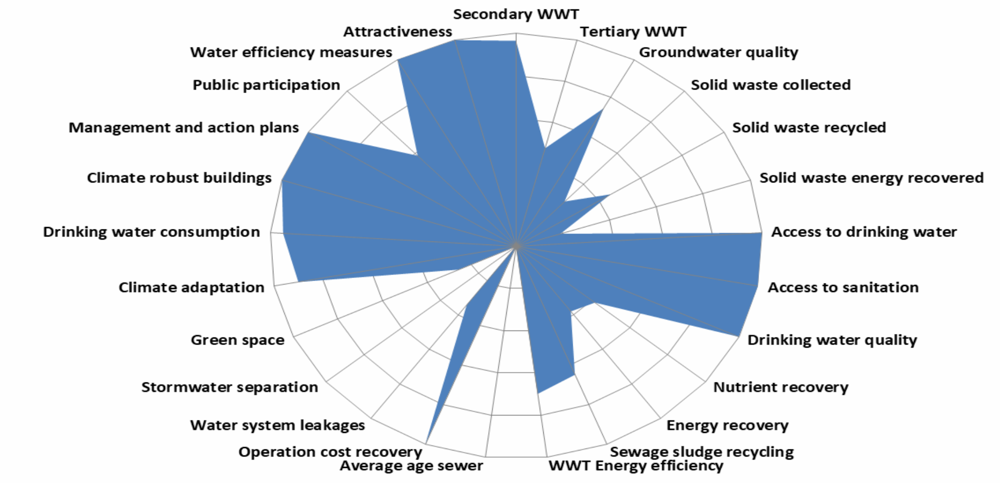
Annex figure AJ) Blue City Index of **Leicester** is 5.3 points. No key pressures have been identified that may form substantially constrains for local water managers.



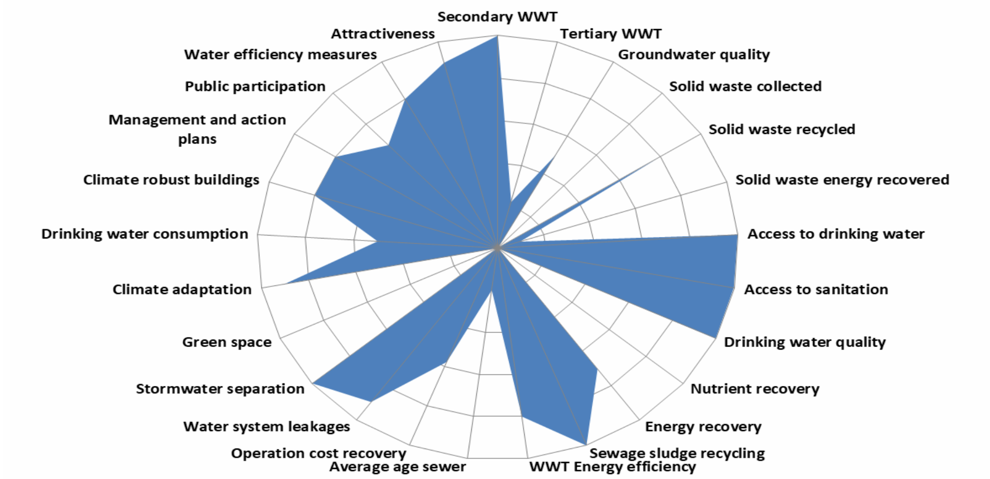
Annex figure AK) Blue City Index of **Ljubljana** is 4.9 points. Unemployment rate has been identified as key pressures that may form constrains for local water managers.



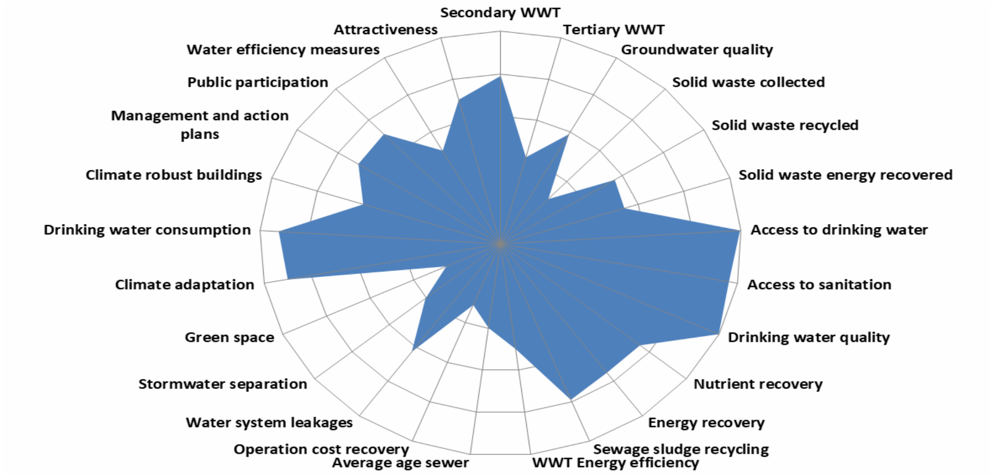
Annex figure AL) Blue City Index of **Lodz** is 5.0 points. Economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.



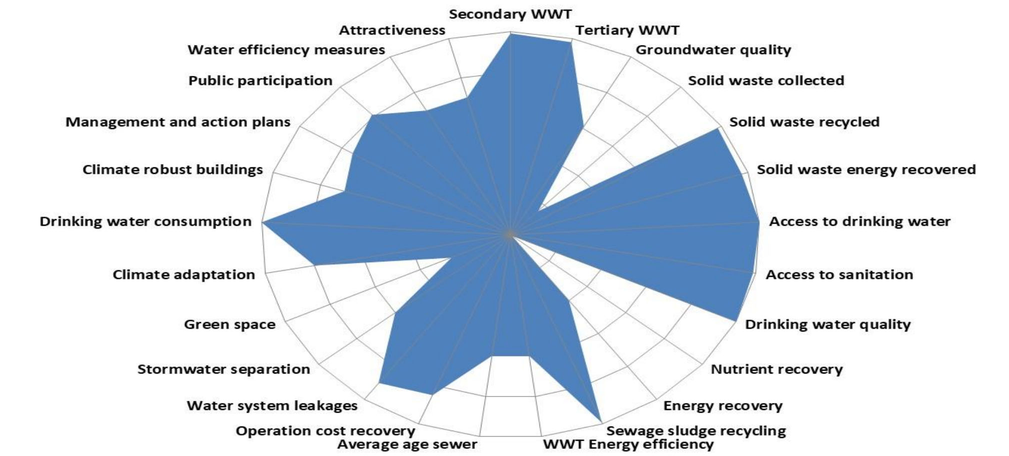
Annex figure AM) Blue City Index of **London** is 5.3 points. No key pressures have been identified that may form substantially constrains for local water managers.



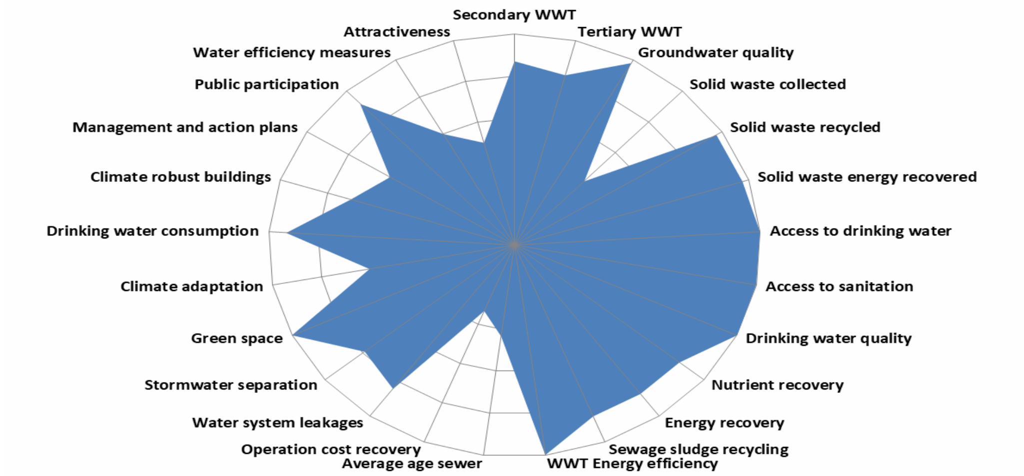
Annex figure AN) Blue City Index of **Los Angeles** is 5.0 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



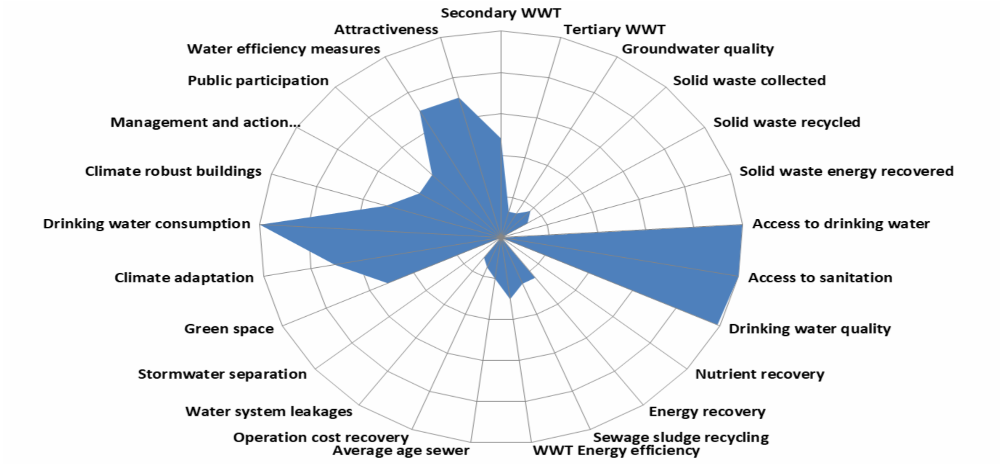
Annex figure AO) Blue City Index of **Lyon** is 6.0 points. No key pressures have been identified that may form substantially constrains for local water managers.



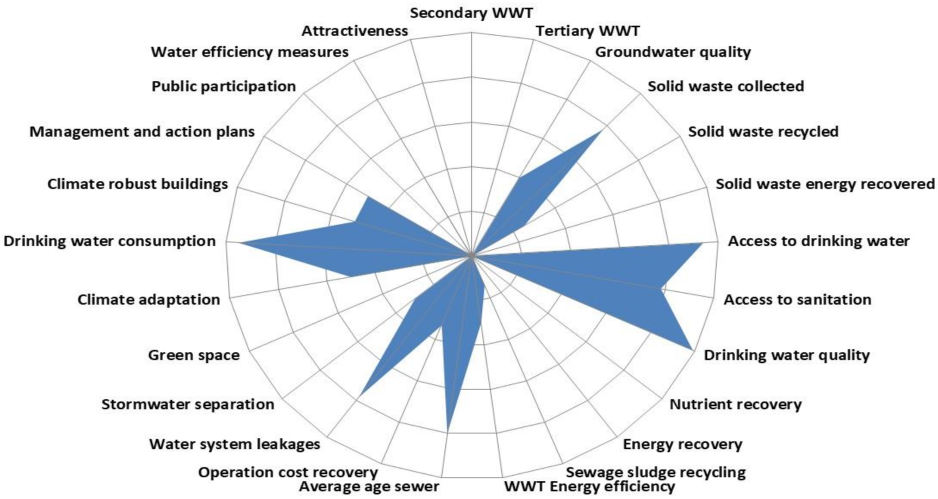
Annex figure AP) Blue City Index of **Maastricht** is 6.6 points. No key pressures have been identified that may form substantially constrains for local water managers.



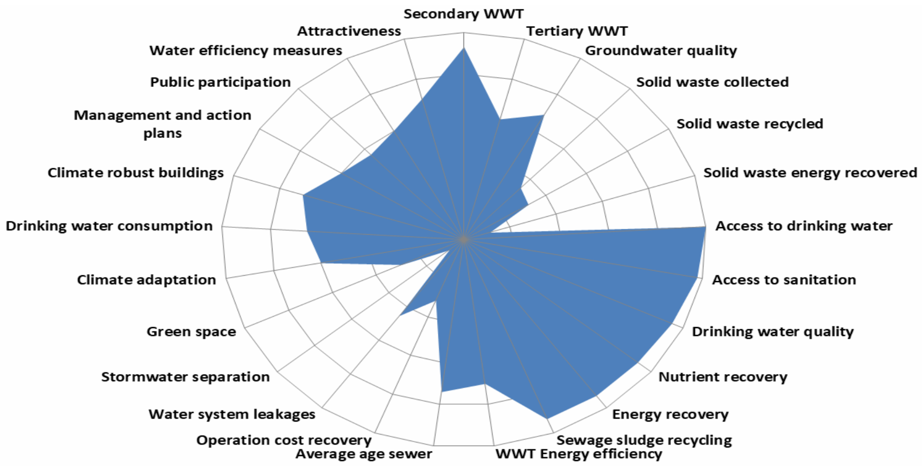
Annex figure AQ) Blue City Index of **Malmö** is 7.7 points. No key pressures have been identified that may form substantially constrains for local water managers.



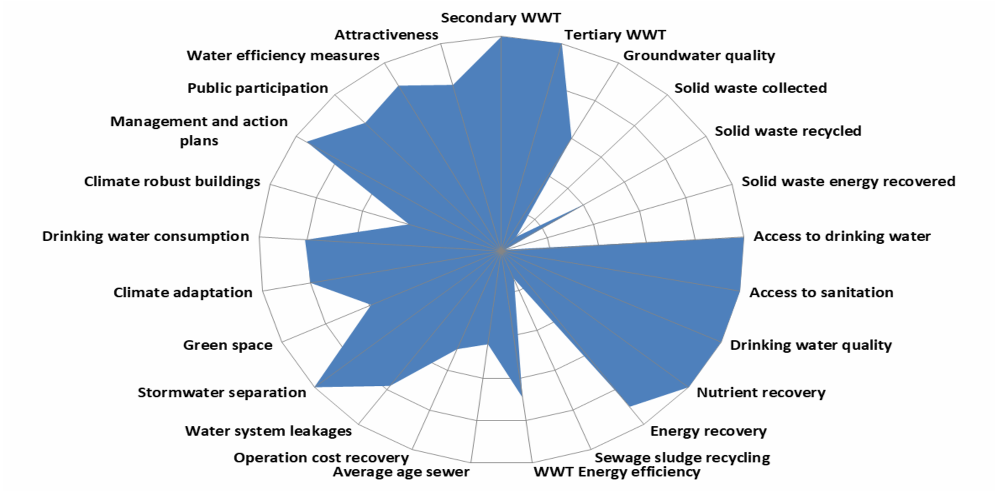
Annex figure AR) Blue City Index of **Malta** is 3.0 points. Education rate, water scarcity, water quality, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



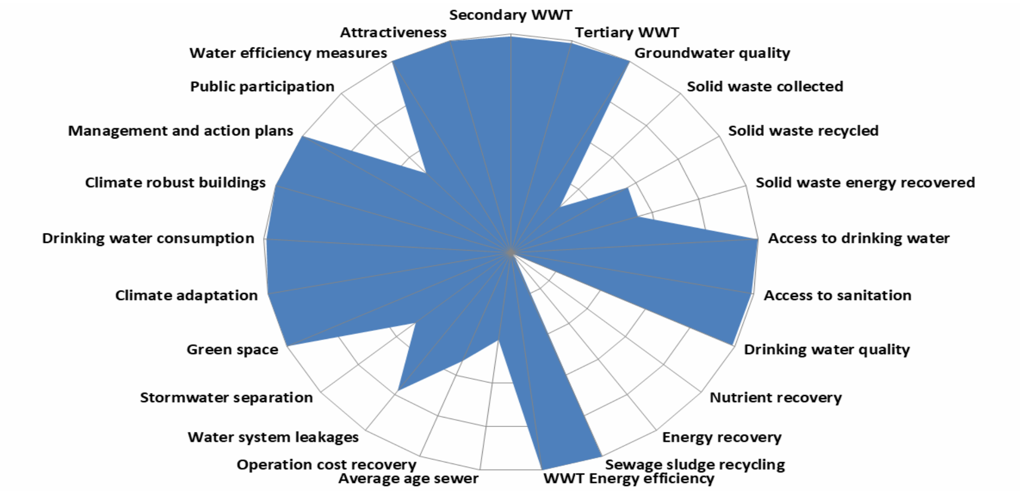
Annex figure AS) Blue City Index of **Manilla** is 2.6 points. Education rate, political instability, water scarcity, flood risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



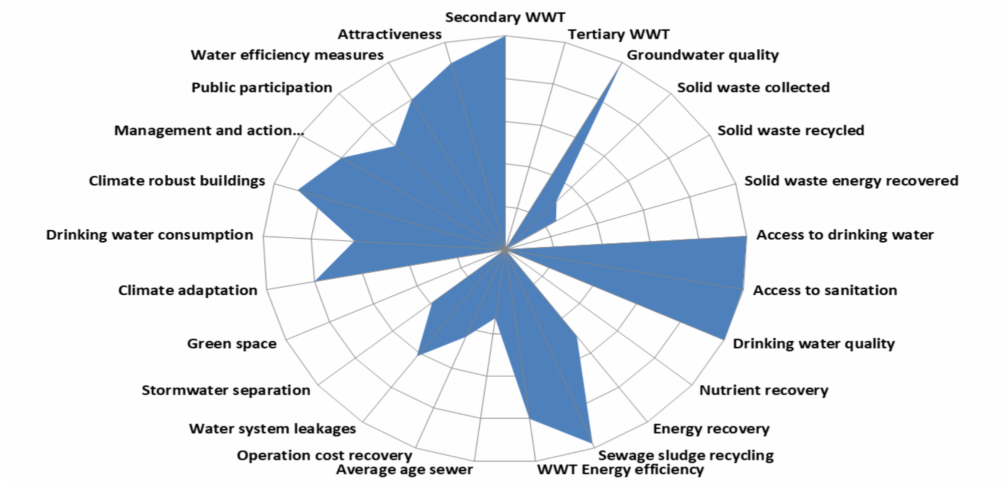
Annex figure AT) Blue City Index of **Manresa** is 5.6 points. Water scarcity and unemployment rate have been identified as key pressures that may form constrains for local water managers.



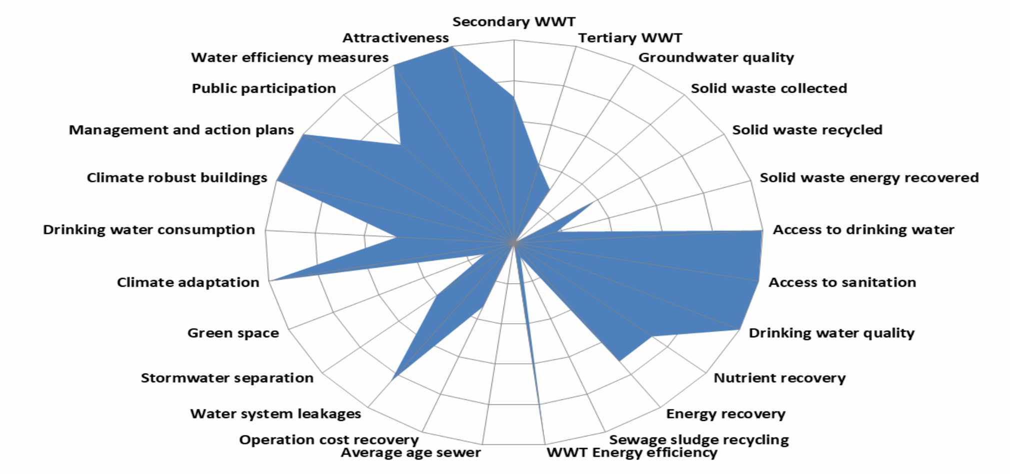
Annex figure AU) Blue City Index of **Melbourne** is 6.1 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



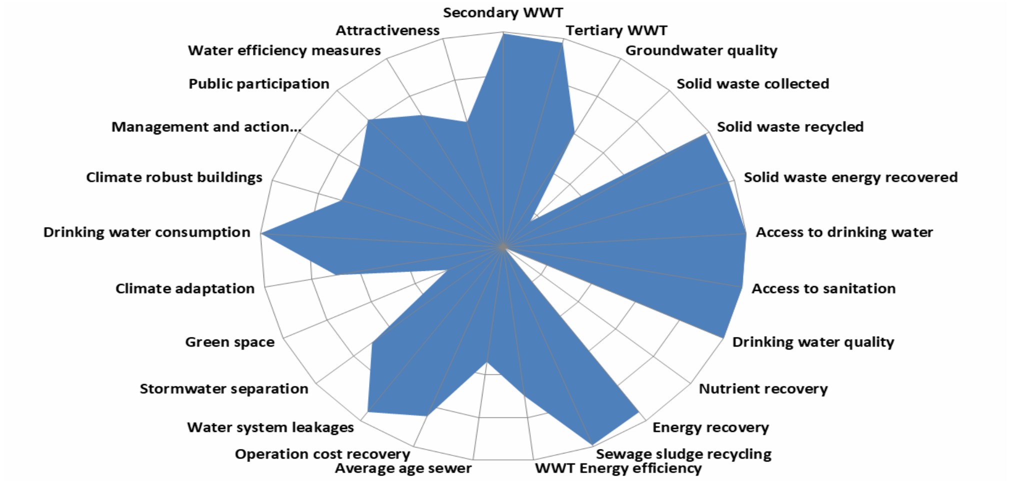
Annex figure AV) Blue City Index of **Milton Keynes** is 6.5 points. No key pressures have been identified that may form substantially constrains for local water managers.



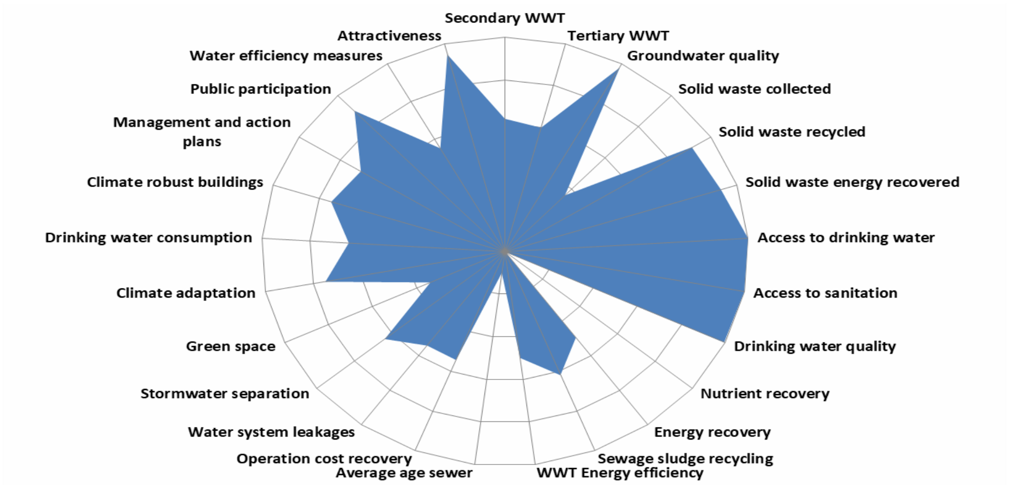
Annex figure AW) Blue City Index of **Milwaukee** is 4.6 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



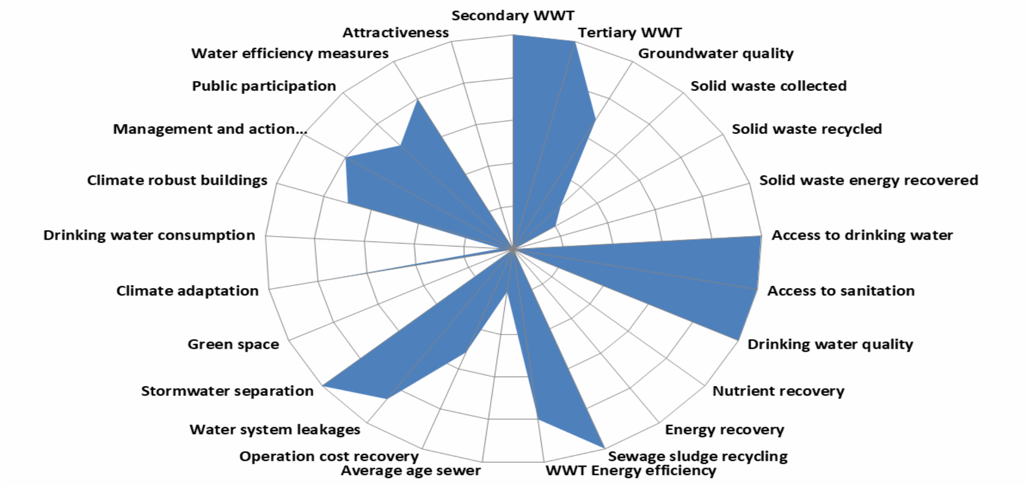
Annex figure AX) Blue City Index of **New York City** is 4.8 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



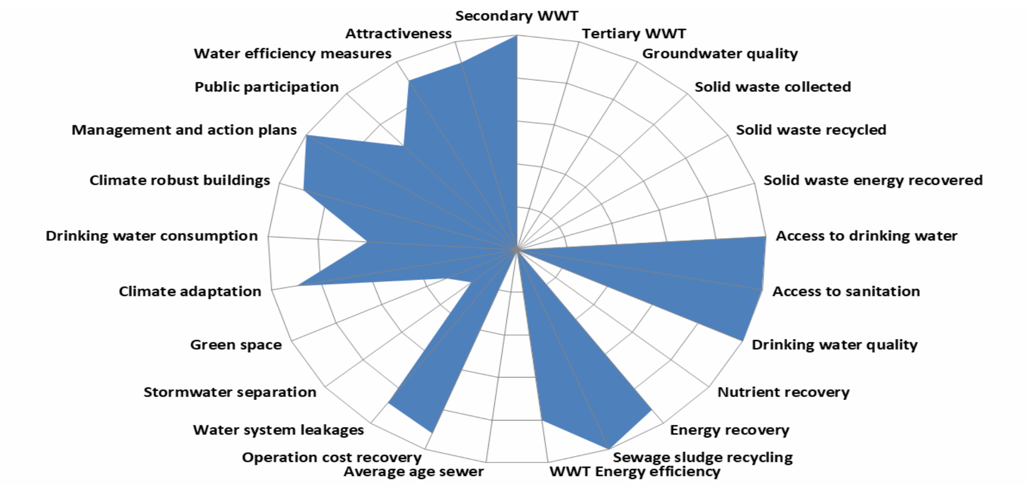
Annex figure AY) Blue City Index of **Nieuwegein** is 6.7 points. No key pressures have been identified that may form substantially constrains for local water managers.



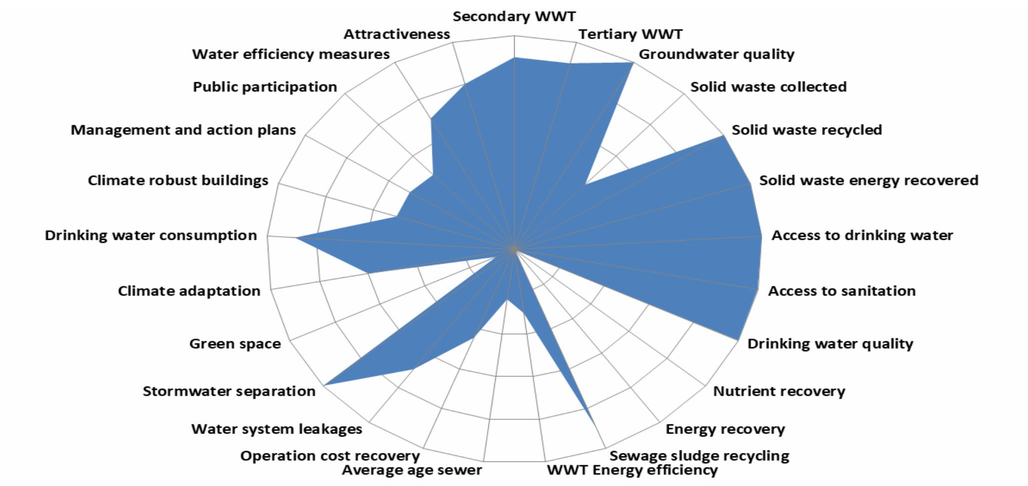
Annex figure AZ) Blue City Index of **Oslo** is 5.8 points. No key pressures have been identified that may form substantially constrains for local water managers.



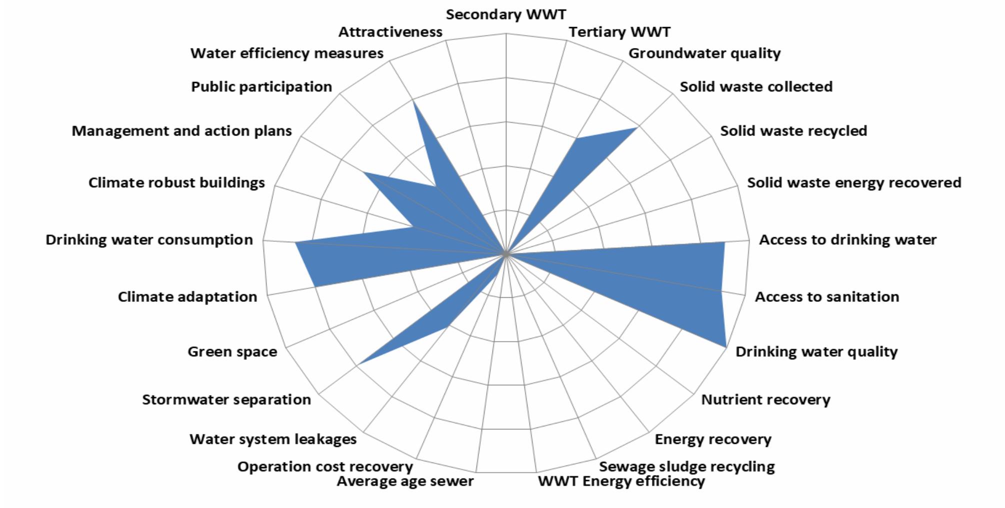
Annex figure BA) Blue City Index of **Phoenix** is 3.9 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



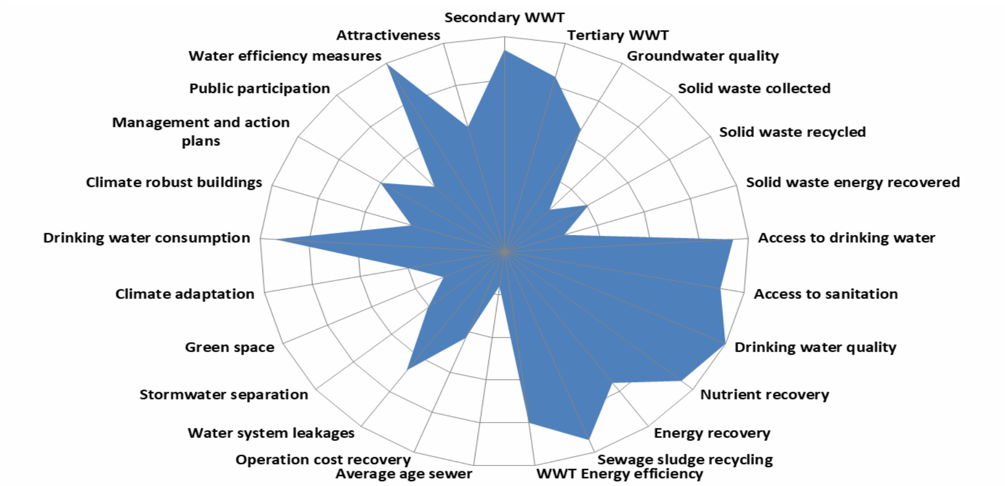
Annex figure BB) Blue City Index of **Portland** is 4.8 points. No key pressures have been identified that may form substantially constrains for local water managers.



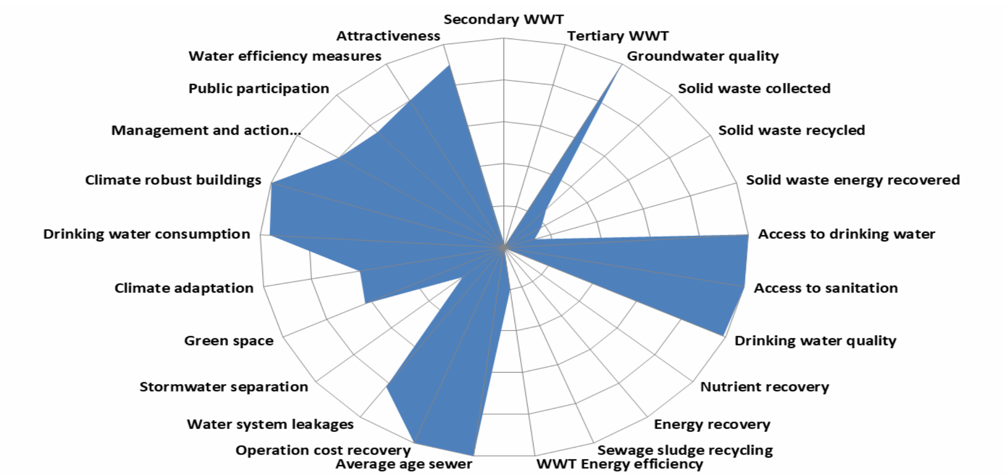
Annex figure BC) Blue City Index of **Porto** is 5.3 points. Water quality, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



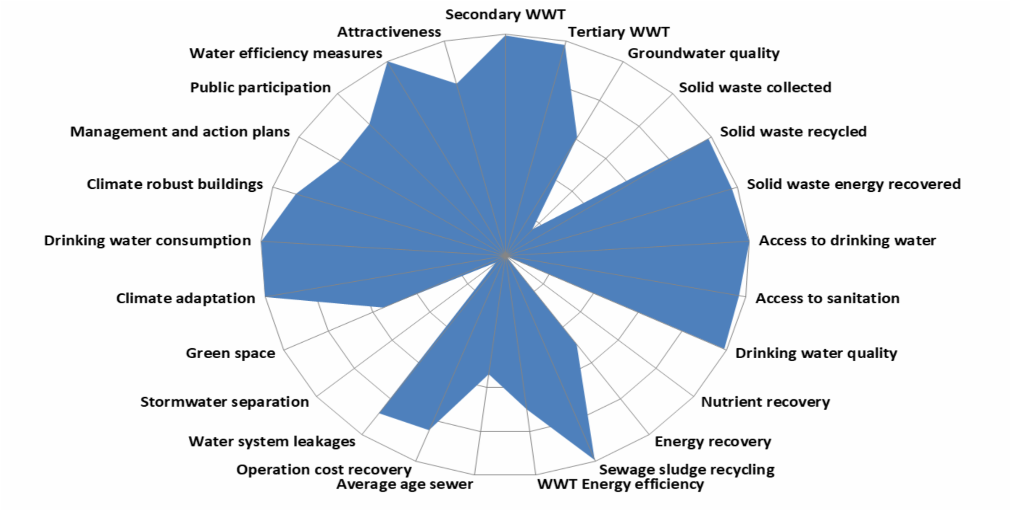
Annex figure BD) Blue City Index of **Quito** is 2.0 points. No key pressures have been identified that may form substantially constrains for local water managers.



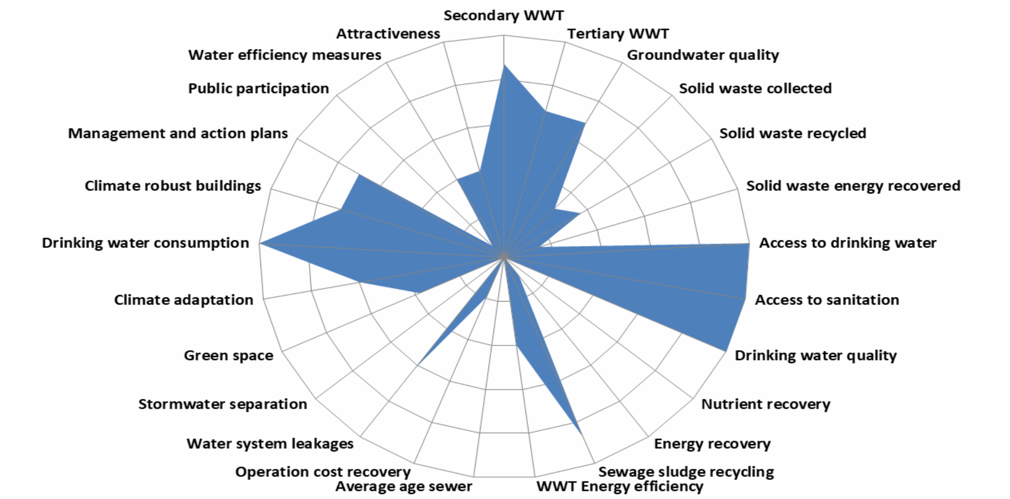
Annex figure BE) Blue City Index of **Reggio Emilla** is 5.8 points. Heat risk and unemployment rate have been identified as key pressures that may form constrains for local water managers.



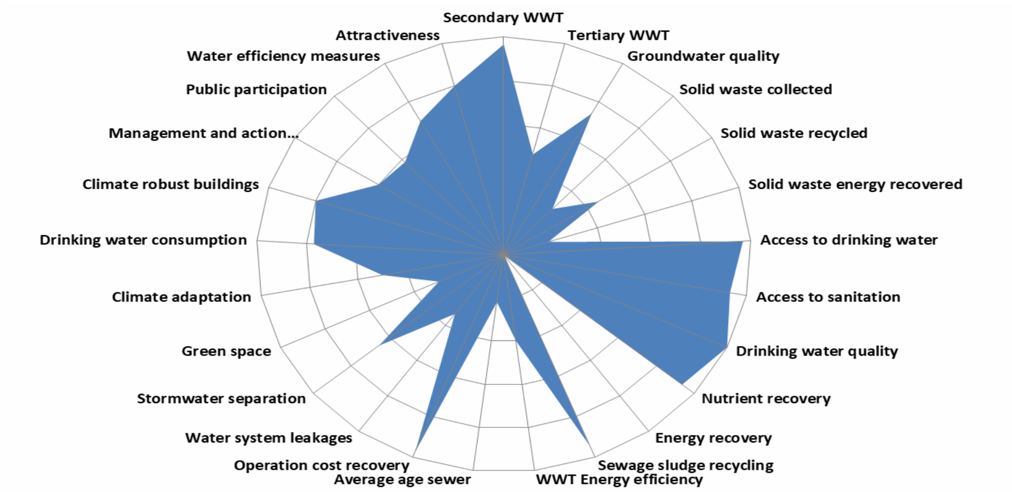
Annex figure BF) Blue City Index of **Reykjavik** is 3.9 points. No key pressures have been identified that may form substantially constrains for local water managers.



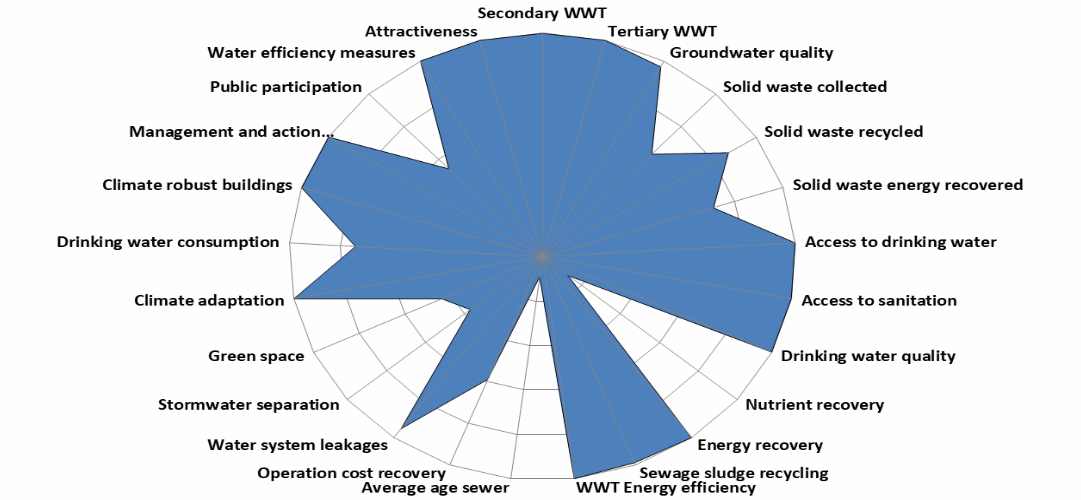
Annex figure BG) Blue City Index of **Rotterdam** is 6.6 points. Flood risk and water quality have been identified as key pressures that may form constrains for local water managers.



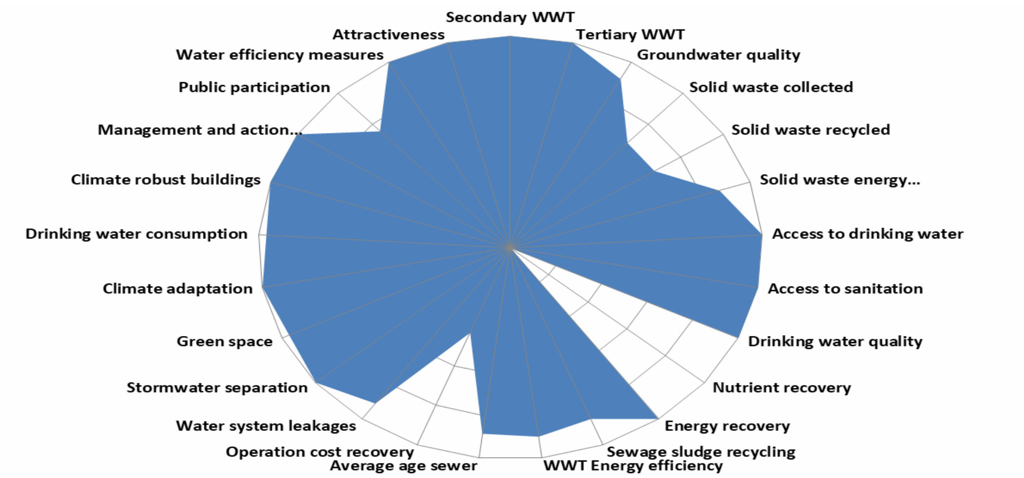
Annex figure BH) Blue City Index of **Sabadell** is 3.7 points. Water scarcity, heat risk and unemployment rate have been identified as key pressures that may form constrains for local water managers.



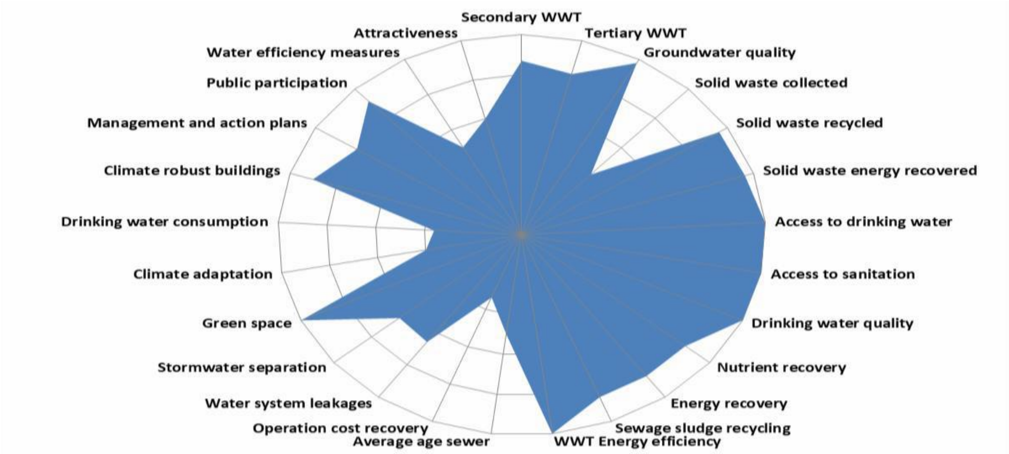
Annex figure BI) Blue City Index of **Scotland** is 5.4 points. No key pressures have been identified that may form substantially constrains for local water managers.



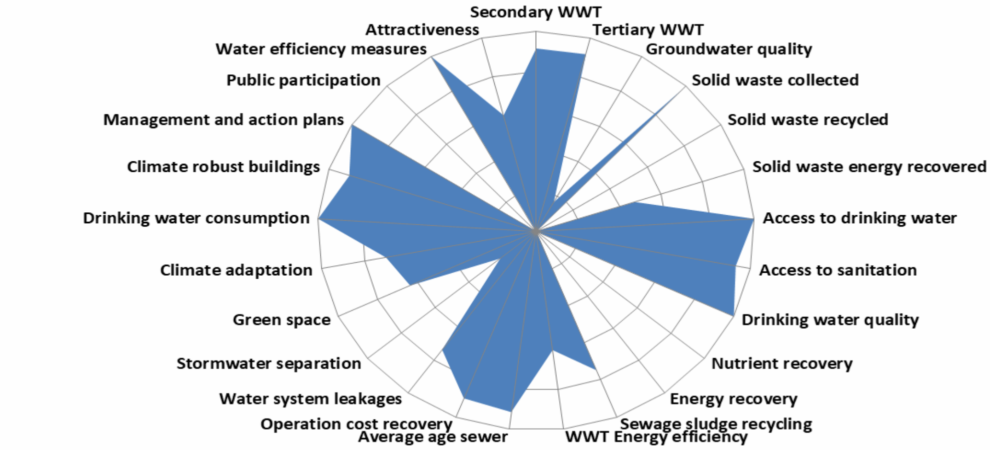
Annex figure BJ) Blue City Index of **Seoul** is 7.3 points. Heat risk has been identified as key pressures that may form constrains for local water managers.



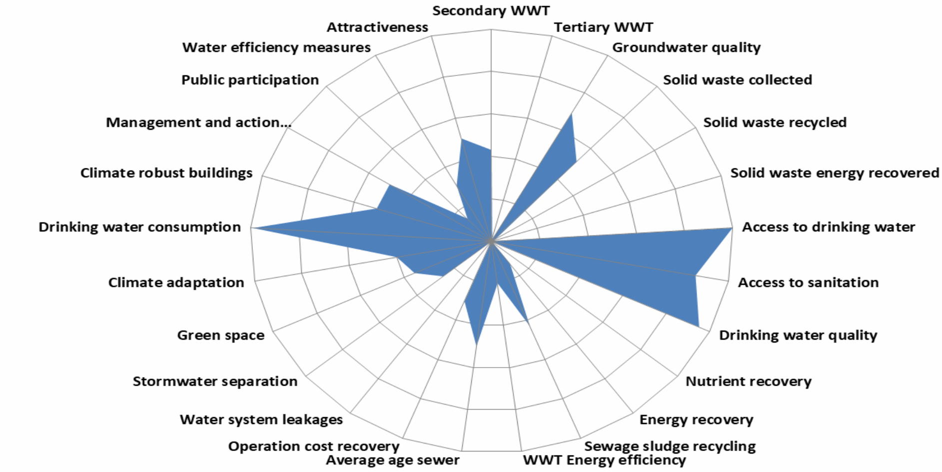
Annex figure BK) Blue City Index of **Singapore** is 8.1 points. No key pressures have been identified that may form substantially constrains for local water managers.



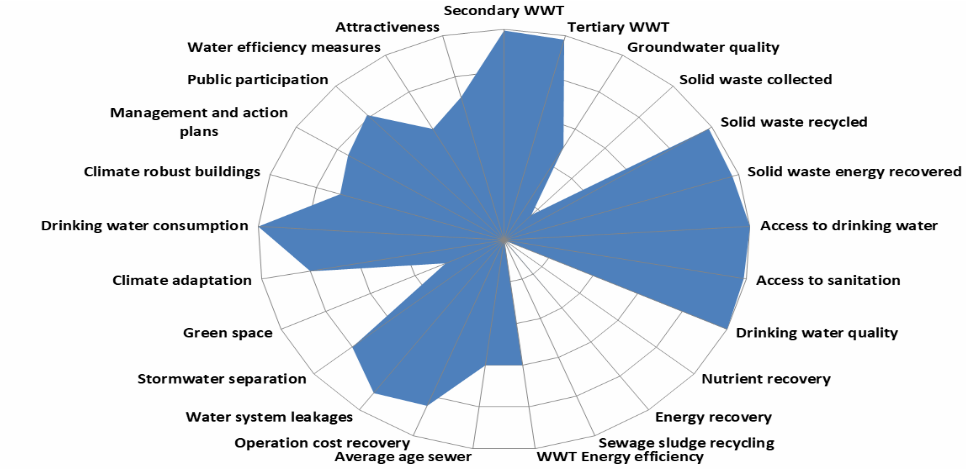
Annex figure BL) Blue City Index of **Stockholm** is 7.3 points. No key pressures have been identified that may form substantially constrains for local water managers.



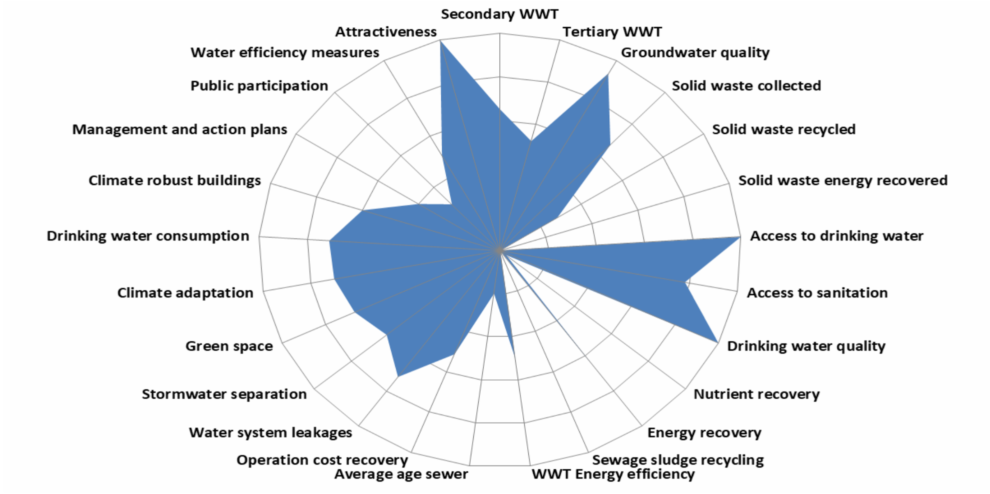
Annex figure BM) Blue City Index of **Tianjin** is 4.9 points. Education rate, water scarcity, flood risk, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



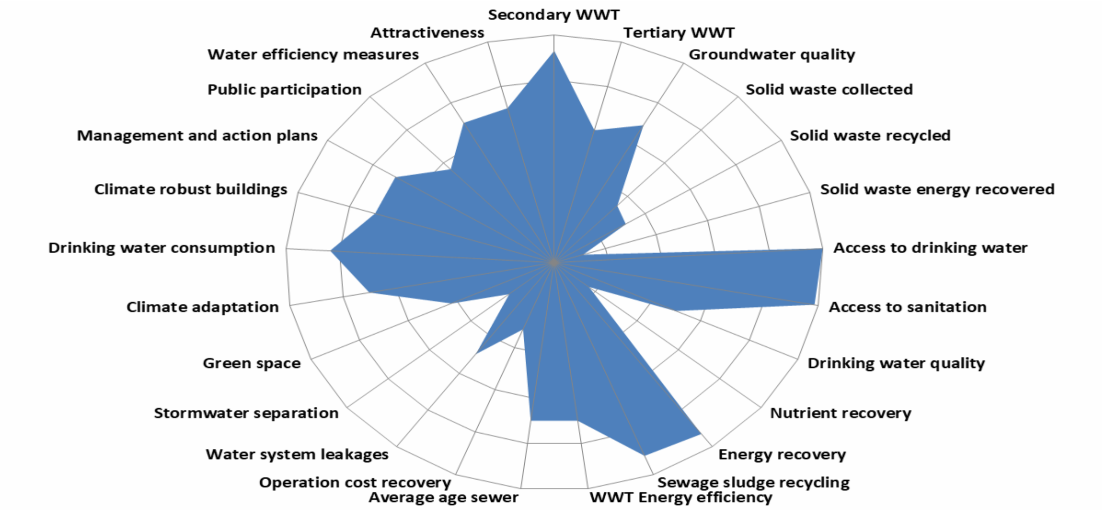
Annex figure BN) Blue City Index of **Varna** is 2.9 points. Flood risk, heat risk and economic pressure have been identified as key pressures that may form constrains for local water managers.



Annex figure BO) Blue City Index of **Venlo** is 2.9 points. No key pressures have been identified that may form substantially constrains for local water managers.



Annex figure BP) Blue City Index of **Wroclaw** is 4.6 points. Economic pressure and unemployment rate have been identified as key pressures that may form constrains for local water managers.



Annex figure BQ) Blue City Index of **Zaragoza** is 5.5 points. Water quality and unemployment rate have been identified as key pressures that may form constrains for local water managers.