Identifying transferrable lessons of Urban Water Management and Governance in the USA and beyond

Facilitating Integrated Water Resources Management through the Application of the City Blueprint Framework and Governance Capacity Framework

Master's Thesis

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1. Abstract

Cities in the U.S. face increasing pressures on their water resources from urbanization and climate change resulting in depletion, pollution, and increased flood and heat risk. These challenges are complex while the specific impacts of climate change are uncertain. Integrated water resources management (IWRM) and adaptive management (AM) are the keys for cities to address the complexity and uncertainty they face. The research determines the trends and pressures that may affect a city's water resources management and assesses the IWRM performances of Los Angeles, New York City, Boston, Milwaukee, Portland and Phoenix in order to identify strengths and areas for improvement of IWRM. Enhancing governance capacity on the city level facilitates the improvement of IWRM practices. The governance capacity of New York City was assessed in order to identify governance conditions that can be strengthened in New York City and other cities in the U.S. The results show that cities in the U.S. face pressure from urbanization and heat risk while tertiary wastewater treatment, solid waste recycling, nutrient recovery from wastewater treatment, stormwater separation, and green space can be improved to enhance the overall IWRM performance of U.S. cities. There is room for improvement for all governance conditions with special focus on improving continuous learning through increased monitoring, evaluation and cross-stakeholder learning.

2. Introduction

2.1 Societal Background

From the beginning of civilization cities have served as havens for the exchange of ideas and the trade of goods and services. Today cities continue to serve this function as centers of transport, communication, energy, water and sanitation services. This concentration of efficient infrastructure and services attracts talent and skilled labor, which facilitates the exchange of ideas, development of knowledge and skills and the promotion of creativity (United Nations, 2011). As a result, cities have become exceedingly attractive to a greater number of people and urban populations have skyrocketed from 746 million in 1950 to 3.9 billion in 2014 with an additional 2.5 billion people projected to reside in urban areas by 2050 (*figure1*) (United Nations, 2014).

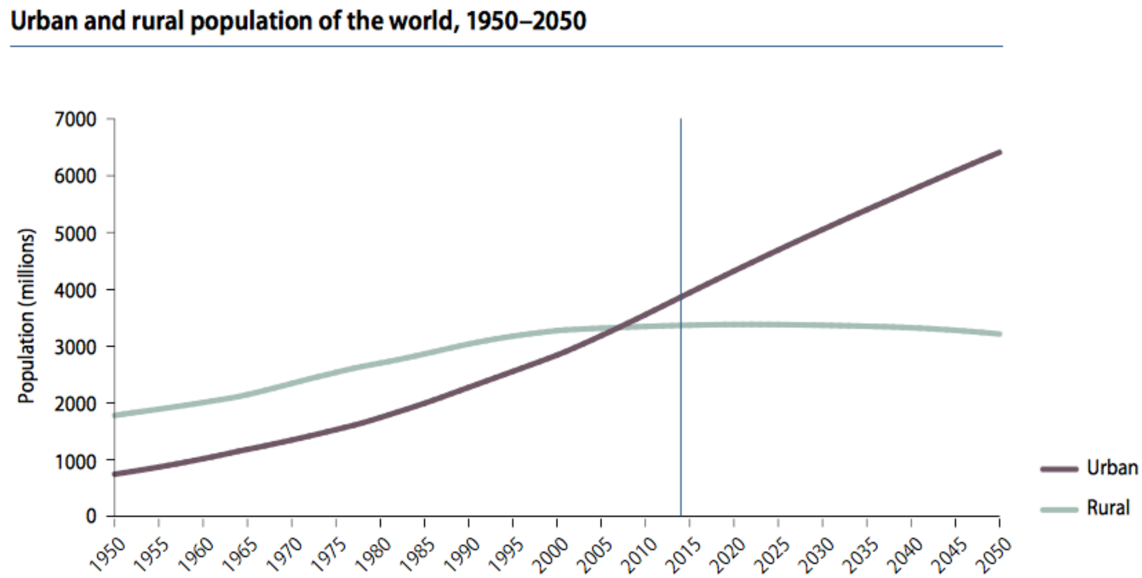

Figure 1 Global urban population growth. Projected to increase by 2.5 billion people by 2050 (UNDP, 2014).

Population growth coupled with expected economic growth in urban areas will lead to increased pressure on global water resources, which are already increasingly threatened by groundwater depletion, saltwater intrusion, and pollution due to poor resource management (Hausmann, 2014; Bates et al., 2008; Vörösmarty et al., 2000). Currently, urban areas are the main drivers of global environmental change, constituting 75% of all global resource consumption (Yeh & Huang, 2012). Due to this enormous influence and impact, urban areas can act as both the cause and the solution to global environmental challenges and are instrumental for achieving sustainable development (Yeh & Huang, 2012).

This pressure on water resources will be amplified by climate change, which will place even greater stress on both the urban environment and global water resources. The IPCC reports that heavy precipitation events are projected to become more frequent, which along with sea level rise will lead to increased flood risk, while the area affected by drought is likely to increase and water quality is likely to decrease (Bates et al., 2008). Furthermore, changes in seasonality as a result of earlier and decreased spring snowmelt will alter the timing of available water supplies and effect water infrastructure and industries that rely on established flows (Vaux, 2015). These changes in climatic drivers of water systems coupled with the non-climatic trends and pressures related to rapid urbanization and population growth will place an increasingly greater strain on the water resources and water infrastructure of cities in the future.

Moreover, water infrastructure in developed countries is aging and there is inadequate investment to upgrade these systems while in the developing world, inadequate investment and rapid urbanization have left many people without access to safe water and sanitation sources (Moe & Rheingans, 2006). Currently, 1.1 billion people do not have access to safe drinking water and more than 2 billion people are affected by water shortages each year while 2 million tons of untreated human waste flows into waterways daily (Cap-Net, 2009). The political will needed to make changes to the urban water infrastructure that would properly address these challenges is lacking while the longer they are ignored the more ecologically, socially and monetarily costly these challenges become (Bates et al., 2008).

2.2 Water Challenges in the USA

The research focuses on six cities in six different regions of the U.S. These cities are New York, NY (Mid-Atlantic), Boston, MA (New England), Milwaukee, WI (Great Lakes), Portland, OR (Pacific Northwest), Los Angeles, CA (Far West), and Phoenix, AZ (Southwest). These regions vary drastically in their geography, climates and cultures. The characteristics of each city are displayed in *Table 1* below. Due to the large contribution of cities to water resource challenges as a result of large populations and consumption patterns, the focus on cities, which coincide with administrative boundaries, will facilitate decision-making by increasing the relevance of risks and benefits to local public and private actors (Hunt and Watkiss, 2011).

Table 1 Characteristics of 6 U.S. Cities. New York is the most densely populated city in the U.S. while Phoenix receives the least rain and is the hottest of the 6 cities studied. Source: U.S. Census Bureau (2016); NOAA, (2016).

City	Avg. Annual Rainfall (mm)	Avg. Temperature (C°)	Population Density (People/km^2)	GDP per Capita ($)	Population Change (2010-2015) (%)
New York	1086.36	12.5	10429.34	32,459	4.6
Boston	1111.76	10.83	4938.99	34,770	8.0
Milwaukee	882.90	8.83	2389.3	19,636	.9
Portland	914.4	12.5	1689.26	32,438	8.3
Los	379.22	18.56	3124.44	28,320	4.7

Angeles					
Phoenix	203.96	23.94	1080.23	24,057	8.0

Cities are the driving force of the American economy, culture and politics. Boston is the birthplace of the American Revolution, Thomas Jefferson penned the famed words "All men are created equal" in Philadelphia and New York City was the site of George Washington's inauguration and the nation's first capital. Los Angeles is the capital of the motion picture industry and New York City is the birthplace of Jazz, Hip Hop, Punk and Salsa music. In 2013 metropolitan areas accounted for 90% of the nation's GDP (IHS Global Insight, 2013). Six out of the twenty-five most economically powerful cities in the world are in the U.S., while American metropolitan areas account for 36 of the 100 largest economies in the world (Kearney, 2016; IHS Global Insight, 2013).

The U.S. is a highly urbanized country with 80.7 percent of the American population residing in urban areas (U.S. Census Bureau, 2012). Overall, cities in the U.S. are growing at a faster rate than the U.S. population, between 2000 and 2013 the population in U.S. cities grew by 24.1 million, or 13.9 percent, while the total U.S. population grew 12.3 percent (Cohen et al., 2015). This population growth is expected to continue and by 2060, the U.S. population is projected to increase to 417 million people with 87 percent of the population living in urban areas (Colby & Ortman, 2015).

The U.S. is home to abundant water resources with the third largest amount of total renewable water resources per capita in the world at 9,538 m^3 per year (FAO Aquastat, 2016). Annually, the country withdraws 13.64% of its total renewable water resources (FAO Aquastat, 2016). However, blue water scarcity, defined as the ratio between consumptive water use and blue water availability, measured by natural runoff minus environmental flow requirements, occurs throughout the majority of the country between 2 to 12 months a year (*figure 2*) (Hoekstra et al., 2012). Additionally, water consumption by urban areas is increasing as urban populations continue to grow. As of 2005 urban water use made up 21.1% of all consumptive water use withdrawals in comparison to 9.7% of withdrawals in 1950 (Lopardo & Bernex, 2015).

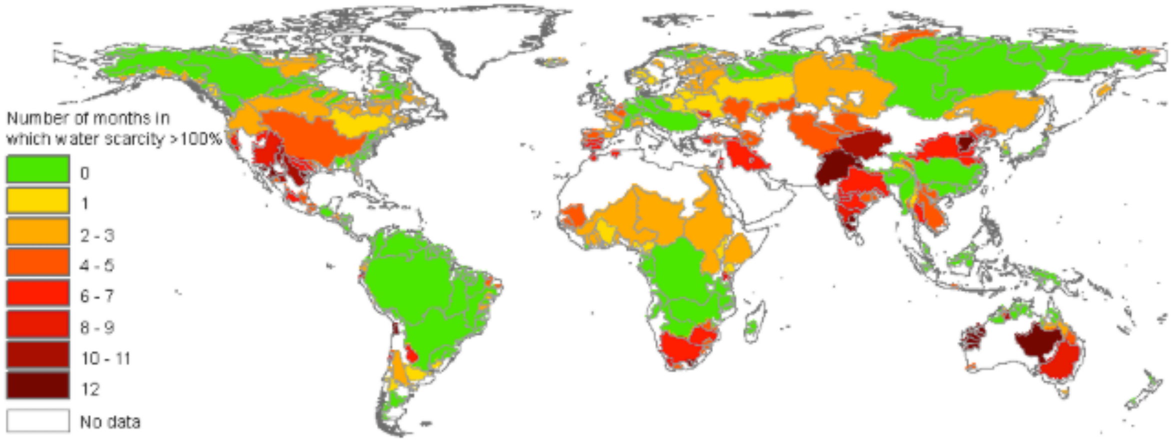

Figure 2 Number of months during the year in which water scarcity exceeds 100% for the world's major river basins. Period 1996-2005 (Hoekstra et al., 2012)

While the majority of urban areas have access to abundant high quality water supplies, there are areas, particularly in the West, that face increasing scarcity. The West is the region with the most urbanized and fastest growing population in the U.S. (seen below in *figure 3*), which results in increased pressure on already scarce water resources (Cohen et al., 2015). The population of the Phoenix Metropolitan area, located in the Sonoran desert, is projected to grow 72% from 4,482,900 in 2015 to 7,733,900 by 2050 (ADOA-EPS, 2016). While the population of Los Angeles County is projected to increase from 10,200,000 to 11,346,360 by 2040 (California Department of Transportation, 2014). The Colorado River is a major source of water for both Phoenix and Los Angeles and supplies water to 33 million people in the West (EPA, 2016). Currently, the Colorado River Basin experiences severe water scarcity 5 months of the year (*figure 4*) (Hoekstra et al., 2012). Moreover, recently the water supplies of the river have been reduced due to drought, decreased snowpack, and hotter, drier springs and climate change is expected to result in irregular storage levels in Colorado River fed reservoirs, decreased discharge and decreased hydropower production (EPA, 2016).

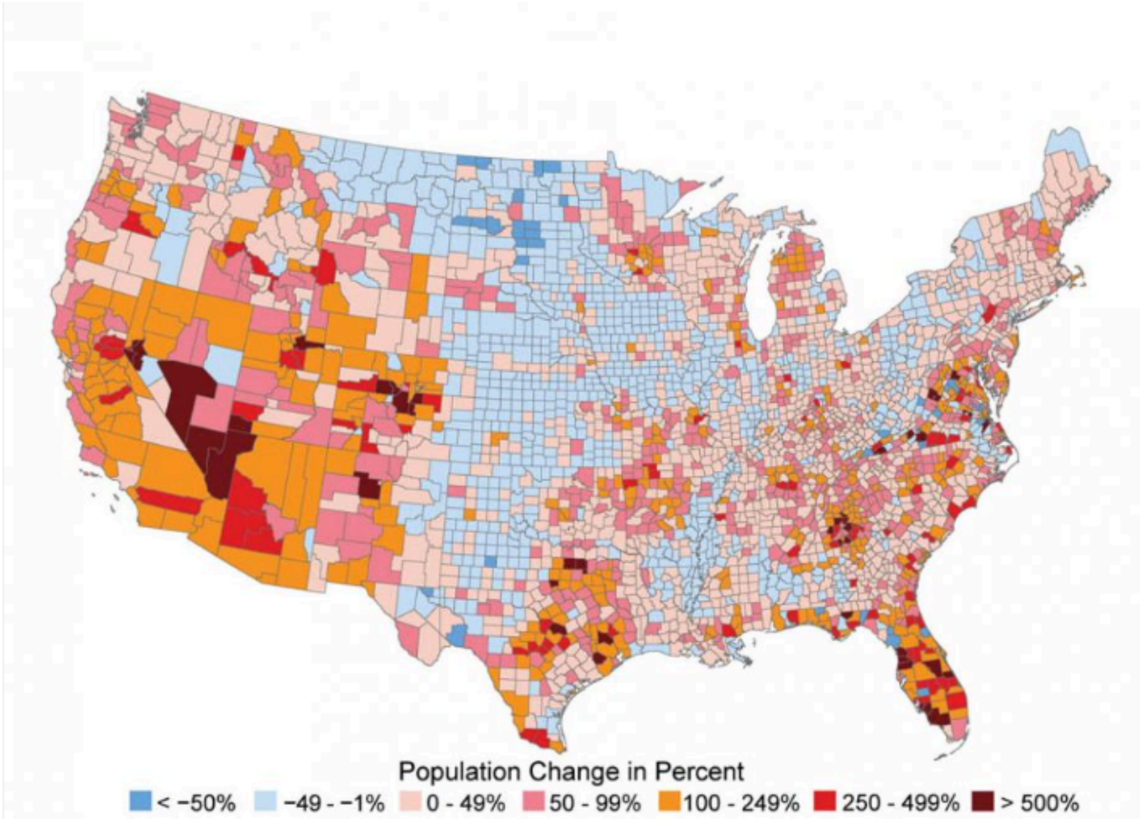

Figure 3 Percentage change in population from 1970 - 2008. The majority of the population growth is in the West. Source: USGCRP (2016).

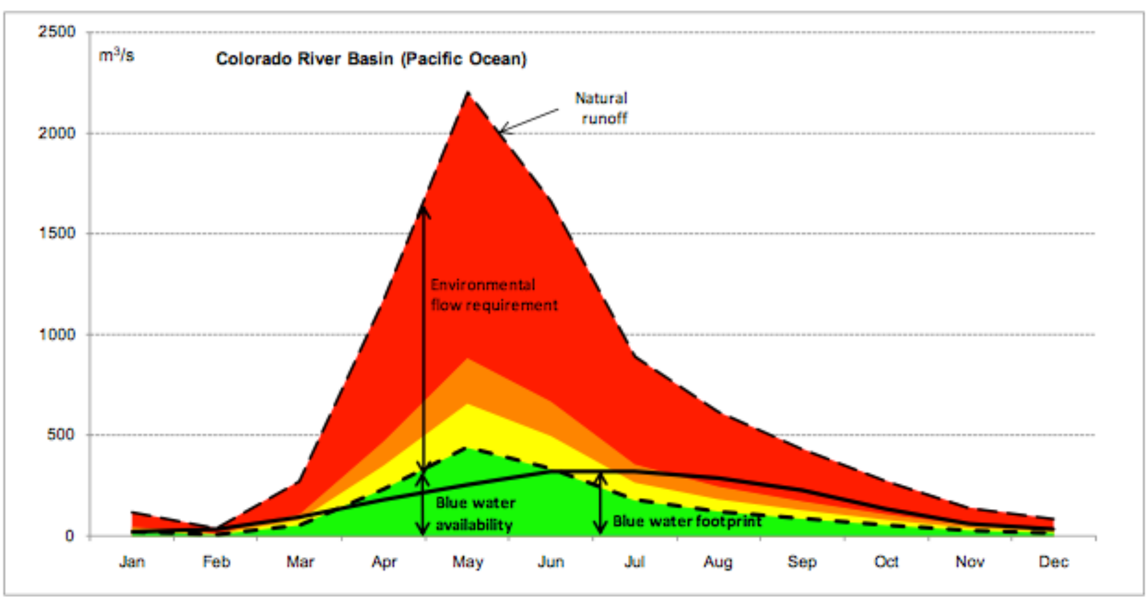

Figure 4 The blue water footprint compared to the blue water availability in the Colorado River Basin. Period 1996-2005. Blue water availability (natural runoff minus environmental flow requirement) is shown in green. When the blue water footprint moves into the yellow, orange and red colors, water scarcity is moderate, significant and severe, respectively. (Hoekstra et al., 2012).

In addition, it is predicted that other regions will experience increases in rainfall and sea level rise leading to pollution and saltwater intrusion of water supplies (Backlund et al., 2008). From 1900 to 2005 New York City has experienced an annual average temperature increase of 1.06°C, an average annual precipitation increase of 10% or 106.7 mm and sea level rise of approximately .3 meters (NYC Department of Environmental Protection Climate Change Program, 2008). By 2080 average annual temperature is projected to increase between 4.17°C to 4.44°C, average annual precipitation will increase another 7.5% to 10% and sea level will rise between .399 meters and .45 meters (NYC Department of Environmental Protection Climate Change Program, 2008). In addition, it is expected that New York City will experience more frequent extreme weather events. In 2012, Hurricane Sandy exposed the vulnerability of the city to extreme weather events, causing $19 billion in damages and lost economic activities while claiming the lives of 44 New Yorkers (Goldstein, Peterson & Zarrilli, 2014).

Boston is located 346 km to the northeast of New York City and faces similar climate change impacts. It is projected that by 2100 Boston will experience between .74 m to 2.26 m of relative sea level rise, increased extreme precipitation and urban flooding and increased urban temperatures (The Boston Research Advisory Group, 2016). In addition, it is projected that the city will face more intense storms as a results of a northward shift in the track of tropical storms (The Boston Research Advisory Group, 2016).

Milwaukee is located in the Great Lakes region. The Great Lakes contain 21% of the world's fresh surface water and provides drinking water for 45 million people (Gregg, Feifel, Kershner & Hitt, 2012; Kahl & Stirratt, n.d.). The region is projected to experience an average temperature increase of 1.5-7°C and longer and more frequent heat waves (Gregg, Feifel, Kershner & Hitt, 2012). In addition, there has been an observed 71% reduction in ice coverage on Lake Michigan in winter between 1973 and 2010, which is expected to continue into the future (Gregg, Feifel, Kershner & Hitt, 2012). Precipitation is projected to increase 20% for the region by the end of the 21st century and extreme rain events will become more frequent (Gregg, Feifel, Kershner & Hitt, 2012; Kahl & Stirratt, n.d.). This increased precipitation along with an observed .305 m increase in relative water level rise due to glacial rebound of the land will increase the likelihood of urban flooding and sewer overflows, which may degrade water quality and endanger the drinking water supply of Milwaukee (Gregg, Feifel, Kershner & Hitt, 2012; Kahl & Stirratt, n.d.).

Lastly, Portland is expected to experience an increase of 3°C in average annual temperature, increased precipitation and earlier peak snowpack leading to decreased water availability in summer (Oregon State University, 2004). This decreased summer water availability will coincide with an increase in summer water demand due to increased temperatures and a fast growing population and may lead to conflict between hydropower production, which generates 43% of Oregon's electricity, and drinking water supply (Oregon Department of Energy, 2013; Oregon State University, 2004).

Overall, climate change will increase pressure on urban water resources that are already under pressure from urbanization. During the 20th century in the U.S. water storage capacity increased to meet the growing demand for water through the construction of large-scale infrastructure projects. Today, new large-scale water storage projects are less feasible due to fewer suitable storage sites within proximity of the demand and less available public financing for large-scale projects (Vaux, 2015).

In addition, the U.S. is facing an aging water infrastructure, a lack of government commitment, and insufficient financial support (Vaux, 2015). The American Society of Civil Engineers reports that the water infrastructure of the U.S. is aging and degraded while funding for proper maintenance and replacement is lacking. Without increased funding there will be enormous impacts on public health and the economy (ASCE, 2016). At present, it is estimated that there are 240,000 water main breaks and 75,000 sewer overflows that discharge 3 to 10 billion gallons of untreated wastewater every year across the nation. (Mehan, 2002). The Environmental Protection Agency (EPA) has identified a potential $500 billion gap in funding for the nation's drinking and wastewater infrastructure by 2020 (Mehan, 2002). The costs of treating and delivering drinking water exceed the available funds needed to sustain the systems (Vaux, 2015). However, elected politicians are unwilling to allocate funds to replace and maintain the water infrastructure and consumer costs for water supply and wastewater treatment, on average .3% of disposable income, only offset a small part of the required expenses (Vaux, 2015). Additionally, the lack of funding puts the quality of the water supply at risk as the list of potential drinking water contaminants is growing faster than the capacity of the EPA to evaluate them (Vaux, 2015). To make matters worse numerous studies show that the costs to citizens and the economy continue to increase the longer climate change adaptation and mitigation are postponed (EEA, 2007; Stern, 2007; PLB, 2014).

U.S. cities need to develop the governance capacity to address the social, financial, and environmental challenges they face while simultaneously adapting to uncertainty caused by climate change (Varis et al., 2006; Pahl-Wostl, 2007). These challenges require a new water resources management paradigm that integrates institutional, social, economic and environmental perspectives on water, land and energy in order to decrease consumption in cities, control pollutants and adapt to climate change (Le Vo, 2007; Vaux, 2015) Integrated Water Resources Management (IWRM) and Adaptive Management (AM) form the foundation for this new water resources management paradigm, which enables cities to better manage the complexity and uncertainty of the risks they face (Cap-Net, 2009; Medema et al., 2008). IWRM builds resilience by pursuing a holistic approach to environmental sustainability, economic efficiency and social equity while incorporating participatory decision making and ensuring the application of optimal practices (Muller, 2007). The AM approach improves management through continuous learning and experimentation in order to increase understanding of social-ecological systems and adapt to complexity and uncertainty (Medema et al., 2008). While there is a substantial amount of literature produced on the concepts of these management frameworks there is a need to facilitate the practical application of this knowledge to the city level (Medema et al., 2008; Koop & van Leeuwen, 2015; Rahaman & Varis, 2005; UN-Water & GWP, 2007).

Cities have a major impact on the environment as they emit 30% to 40% of the global anthropogenic greenhouse gases from within their borders and alter land use, ecosystems and hydrological systems (Krause, 2011; Grimm et al, 2008; Yeh & Huang, 2012). However, cities also hold the key for solving global environmental problems as they have the authority over policy on transportation, land-use, building codes, electricity production and transmission, and waste management (Yeh & Huang, 2015; Krause, 2011). In the absence of federal initiative on climate change, city governments have become the leaders of U.S. climate protection efforts (Krause, 2011). Similarly, federal support for water infrastructure is lacking and funding for water infrastructure has decreased in real purchase power since the mid-1980's and state and city governments now account for 96% of all spending on water and wastewater infrastructure (Eskaf, 2016). As a result, U.S. cities have the responsibility and opportunity to manage their water resources sustainably.

2.3 Objective:

To provide empirical based insight into the most essential water management and water governance conditions that are necessary in order to develop the capacity to tackle water challenges in cities in the USA and beyond.

2.4 Research Question:

Main question:
What are the IWRM performances of cities in the USA in relation to other cities facing similar water and climate adaptation challenges and which governance conditions are most essential to develop the governance capacity to deal with the challenges of urban heat islands, water scarcity, flood risk, wastewater treatment and solid waste treatment?

SQ1: What are the main social, environmental and financial trends and pressures that may hamper the IWRM performances of Los Angeles, Portland, Phoenix, Milwaukee, Boston and New York City?

SQ2: What are the IWRM performances of Los Angeles, Portland, Phoenix, Milwaukee, Boston and New York City and how do they relate to cities that face similar water challenges?

SQ3: What are the most essential governance conditions that determine the governance capacity needed to address urban heat islands, water scarcity, flood risk, wastewater treatment and solid waste treatment in New York City in particular and cities in the USA in general?

3. Theoretical Framework

As stated previously, cities should encourage IWRM and AM to deal with the growing complexity and uncertainty in the water sector (Cap-Net, 2009; Medema et al., 2008). IWRM and AM are management approaches. Management involves the activities of analyzing, monitoring, developing and implementing measures to maintain the state of a water resource within desirable bounds (Pahl-Wostl et al., 2012). Governance capacity needs to be developed in order to realize the full potential of these approaches and improve management of water resources (Tropp, 2007; Liedel, Niemann & Hagemann, 2012). The concept of governance capacity to address natural resource management is derived from the theory on governance. Governance concerns the different actors and networks that facilitate the formulation and implementation of water policy. Governance establishes the rules under which management operates (Pahl-Wostl et al., 2012).

There has been a shift in traditional governance mechanisms in recent years as a response to environmental challenges and the reorganization of public, private and social sectors (Stoker, 1998; Lockwood et al., 2010; Kersbergen & Waarden, 2004). These environmental challenges can be classified as “wicked problems”, which are characterized by their complexity due to contested and multiple problem sources, perspectives, and solutions as well as fragmented institutional settings (Lockwood et al., 2010). In order to address these problems there is a need for novel policy and institutional responses through good water governance (Lockwood et al., 2010; U.N. Water & GWP, 2007).

The U.N. recognizes the need for good water governance in contributing to the achievement of the Sustainable Development Goals (SDGs) (U.N. Water & GWP, 2007; U.N. Water, 2015). Good governance refers to the interaction between government and non-government actors and stresses the need to find new processes to address the multi-actor character of society and lead to an outcome that is decided upon among multiple actors (Slinger et al., 2011). Good water governance takes into account the principles of legitimacy, transparency, accountability, human rights, rule of law and inclusiveness and refers to how power and authority are exercised and distributed in society, how decisions are made and the extent of public participation in decision-making processes regarding water (OECD, 2015; Slinger et al., 2011).

Governance is the biggest obstacle for the sustainable management of water resources and "water crises are primarily governance crises" (Pahl-Wostl, 2009; Pahl-Wostl et al., 2012; OECD, 2015). The implementation of IWRM and AM in water resources management represents a major paradigm shift away from the application of generalized solutions for water challenges (Gupta, 2011; Pahl-Wostl et al., 2012). Instead, it is now believed that in order for management to be sustainable and effective countries need to manage their own financial, technological and institutional capability and knowledge on solutions should be deeply embedded in the local context (Gupta, 2011, Pahl-Wostl et al., 2012; Leidel et al., 2012; U.N. Water, 2015). The OECD acknowledges the importance of cities for national and global sustainability and IWRM and states that "capacity is often the Achilles heel of sub-national governments," (OECD, 2016). The shift in approach to water management promoted by the concepts of IWRM and AM has left many local communities without the governance capacity to sustainably and effectively manage their water resources (Liedel et al., 2012).

The concept of governance capacity is grounded in literature on environmental governance, climate adaptation, adaptive management, water governance and capacity development. Leidel et al., define capacity as, "the ability of a society to identify, understand and address problems, to learn from experience and to accumulate knowledge for future issues" (2012). Satijn & ten Brinke identified five types of governance capacity for adaptive water management, which enable the integration of several interests into one solution that benefits society as a whole (2011). They identified organizational, financial, legal, institutional and social capacities. Organizational capacity seeks to manage strategies across organizations in order to achieve joint solutions while financial capacity should increase efficiency to invest slightly more in a solution to serve multiple interests (Satijn & ten Brinke, 2011). In addition, legal capacities should ensure that laws and regulations do not conflict one another while institutional capacity should ensure that arrangements are made in order to increase knowledge sharing and goal formation between different sectors (Satijn & ten Brinke, 2011). Social capacity is built through stakeholder engagement and communication with the public in order to create support (Satijn & ten Brinke, 2011). The research focuses on governance capacity as the key set of governance conditions that should be present or developed in order to enable change that will be effective in finding dynamic solutions to complex challenges.

Numerous studies have identified the governance gaps and barriers that hinder policy design, regulation and implementation of integrated water resources management (U.N. Water, 2015, OECD, 2015; OECD, 2011). Addressing these gaps will require the development of governance capacity in order to integrate legal, managerial, financial, institutional, and social elements to enable effective change (Satijn & ten Brinke, 2011). However, there is a void in scientific work concerning a comprehensive framework for governance capacity on the city level. Previous studies from the OECD support the development of indicators for water governance. The OECD developed 12 principles for good water governance and recognized the need for indicators based on the 12 principles identified in order to improve the water policy cycle (Akhmouch & Romano, 2015). Additionally, the OECD in *Water Governance in Cities* acknowledges the immense role of cities in water resource management and examines the governance structure that promotes the greatest resilience and adaptation in cities and identifies best practices as well as existing multi-level governance gaps (2016). The focus of this research on governance capacity, instead of governance gaps, constructively emphasizes the areas where cities are succeeding as well as the areas that need improvement.

The literature on IWRM and governance processes is primarily theoretical in nature, which results in difficulty translating to practical decision-making (Lenton & Muller, 2012). This research aims to bridge the gap between scientific knowledge and local authorities, which will allow for the transformation of theory into practice. Additionally, best practices are currently employed in a few cities illustrating that the scientific and technological knowledge exists to tackle urban IWRM challenges.

4. Methodology

The research evaluated the social, economic and environmental trends and pressures through the Trends and Pressures Framework (TPF) and the IWRM performances through the City Blueprint Performance Framework (CBF) of Boston, New York, Milwaukee, Portland, Phoenix and Los Angeles. Additionally, the governance capacity of New York City was assessed through the Governance Capacity Framework (GCF). These 3 frameworks (TPF, CBF, GCF) make up The City Blueprint Approach (Koop & van Leeuwen, 2015).

The City Blueprint Approach is a diagnostic tool that provides cities with a snapshot of the social, environmental, and financial challenges they face (TPF), their water resources management performance (CBF), and their water governance capacity (GCF). The City Blueprint Approach is intended to be the first internationally standardized indicator framework for IWRM on the city level and represents a shift of focus in IWRM to the city level. Currently, 45 cities have undergone an assessment through the TPF and CBF. 36 of the 45 cities assessed are located in Europe. The GCF is a recent expansion of the City Blueprint Approach and has been applied to Amsterdam, Melbourne and Quito. The research compares the IWRM performances of 6 cities in the USA with cities in Europe and beyond in order to find transferable lessons and opportunities in water management and governance approaches.

4.1 Trends and Pressures Framework

The City Blueprint trends and pressures framework (TPF) assesses the main social, environmental and financial trends and pressures that may influence or affect local water management (van Leeuwen et al., 2012; Koop & van Leeuwen, 2015). The TPF is used to make the distinction between the trends and pressures a city faces and the city's actual IWRM performance. The trends and pressures are exogenous characteristics that may affect water management. For example, a city may suffer from water stress due to their location in an arid climate and not because of overconsumption or poor management practices. There are 18 indicators including sub-indicators *(Table 2)* that are standardized to a scale of 0-4 and ranked by degree of concern *(Table 3).* Data on these indicators was collected from U.N., World Bank and U.S. government sources (*Appendix 1*).

Table 2 Indicators of the Trends and Pressures Framework separated into 3 categories.

Categories	Indicators	Sub-indicators
Social Pressures	Urbanization Rate	
	Burden of Disease	
	Education Rate	
	Political Instability	
Environmental Pressures	Flooding	Urban Drainage Flood
		River Peak Discharges
		Sea Level Rise
		Land Subsidence
	Water Scarcity	Freshwater Scarcity
		Groundwater Scarcity

		Saltwater Intrusion
	Water Quality	Surface Water Quality
		Biodiversity
	Heat Risk	Heat Island Effect
Financial Pressures	Economic Pressure	
	Unemployment Rate	
	Poverty Rate	
	Inflation Rate	

Table 3 Scale and level of concern of T&P Framework

TPF Indicator Score	Degree of Concern
0 - 0.5	No concern
0.5 - 1.5	Little concern
1.5 - 2.5	Medium concern
2.5 - 3.5	Concern
3.5 - 4.0	High Concern

4.2 City Blueprint Framework

The City Blueprint Framework (CBF) assesses the sustainability of water resources management based on 25 indicators in seven categories that cover the entire urban water cycle, i.e., water quality, solid waste treatment, basic water services, wastewater treatment, infrastructure, climate adaptation and governance *(Table 4).* The CBF indicators are scored on a scale of 0 – 10 in which 10 implies a superb score while 0 is a poor score. Data on these indicators was collected from online public sources from the U.N., World Bank and national, state and city governmental websites as well as from water management companies, universities, and nonprofits (*Appendix 2*). The data was collected and calculated into an indicator score using the min-max method. The data was then used to construct spider diagrams for each city and the Blue City Index (BCI) score as well as the TPF scores were presented to sustainability officers in each city to obtain feedback on the results and improve reliability and validity. The BCI score can then be compared to other cities that have undergone a CBF assessment. The BCI scores allow for the categorization of cities based on their different levels of sustainable IWRM *(Table 5)* (Koop and van Leeuwen, 2015). The cities were compared by selecting 7 key indicators that were determined to be insufficient based on their categorization as *water efficient* cities and compared to the top 6 cities categorized as *resource efficient and adaptive* cities in order to make recommendations on improvements. These key indicators were tertiary wastewater treatment, solid waste recycling, nutrient recovery, operation cost recovery, stormwater separation, green space, and climate adaptation. The top 6 cities in the *resource efficient and adaptive* cities category were Amsterdam, Heisingborg, Malmo, Kristianstad, Stockholm, and Berlin.

Table 4 CBF Indicators of IWRM

Categories	Indicators
Water Quality	Secondary WWT
	Tertiary WWT
	Groundwater Quality
Solid Waste Treatment	Solid Waste Collected
	Solid Waste Recycled
	Solid Waste Energy Recovered
Basic Water Services	Access to Drinking Water
	Access to Sanitation
	Drinking Water Quality
Wastewater Treatment	Nutrient Recovery
	Energy Recovery
	Sewage Sludge Recycling
	WWT Energy Efficiency
Infrastructure	Stormwater Separation
	Average Age Sewer
	Water System Leakages
	Operation Cost Recovery
Climate Robustness	Green Space
	Climate Adaptation
	Drinking Water Consumption
	Climate Robust Buildings
Governance	Management and Action Plans
	Public Participation
	Water Efficiency Measures
	Attractiveness

Table 5 Categorization of IWRM in Cities (Koop & van Leeuwen, 2015).

BCI Score	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 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 reduces. 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** There is no 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 behavior. Cities are largely water self-sufficient, attractive, innovative and circular by applying multiple (de)centralized solutions.

4.3 Governance Capacity Framework

The Governance Capacity Framework (GCF) assesses the governance of cities when addressing the five major urban water challenges of water scarcity, flood risk, wastewater treatment, solid waste treatment and urban heat island. These major urban water challenges are "wicked problems" characterized by complexity and uncertainty. There are nine governance conditions and 27 indicators of governance capacity *(Table 6)*. The 27 indicators are scored based on a Likert-type scoring system with scores ranging from (++) very encouraging for overall governance capacity to (--) very limiting for overall governance capacity. The scoring provides the city with an understanding of the gradual levels of governance capacity and what steps can be taken to improve capacity.

New York City was selected because it is a frontrunner in climate adaptation strategies (OneNYC) and is the highest performing city in the governance category of the CBF (Koop & van Leeuwen, 2015). The city is a member of the C40 Cities Climate Leadership Group, a member of and one of the leading cities on climate change in the 100 Resilient Cities Network, as well as a signatory of the U.S. Conference of Mayors' Climate Protection Agreement. A governance capacity assessment of the city provides valuable insight into which governance conditions are most needed for developing the necessary governance capacity to implement a comprehensive climate adaptation strategy and address water challenges in cities in the U.S.

The data for each indicator was obtained through a triangular method. First, policy documents and reports were analyzed to provide a preliminary score and background. Second, 15 interviews were performed by selecting 3 stakeholders involved in the governance network for each water challenge. The most relevant stakeholders were identified from the New York City government and key Non-governmental organizations (NGOs). NGOs were included in order to obtain multiple viewpoints from different stakeholders as it was determined that solutions to complex environmental problems need to include stakeholder participation in decision making (Backstrand, 2003; Bingham et al., 2005). A preliminary stakeholder analysis was performed in order to identify relevant stakeholders (*Appendix 3*). The relevant stakeholders were identified and a number of stakeholders were interviewed based on availability and willingness to participate. Subsequently, the snowball method was employed in order to facilitate efficient navigation of the New York City water governance network and identify other available relevant stakeholders in the network. The interviewees were asked 27 open, non-technical predefined questions. After the interviews, the participants received an online questionnaire with questions related to the interviews questions in order to confirm the results of the interviews and increase the reliability of the responses. Lastly, the participants received the preliminary results and indicator scores for their interviews and were asked to provide constructive feedback and additional information for the production of the final scoring.

Table 6 Indicators of Governance Capacity

Dimensions	Condition	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. Policy Ambition	5.1 Ambitious and Realistic Goals 5.2 Discourse Embedding 5.3 Policy 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 Maneuver 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

5. Results

5.1 Trends and Pressures

The trends and pressures that are a concern for the 6 cities are 1. *Urbanization rate* and 8. *Heat risk (table 7).* . Urbanization is a high concern for Los Angeles and a concern for Phoenix and Portland. Heat risk is a high concern for Los Angeles and Phoenix and a concern for Milwaukee and New York City.

Table 7 Trends and Pressures of the 6 selected cities in the USA. 1. Urbanization rate and 8. Heat risk are concerns.

		Phoenix	Portland	Milwaukee	Los Angeles	New York City	Boston
Social	1.Urbanization Rate	3 (Concern)	3 (Concern)	1	4 (High Concern)	1	1
	2.Burden of Disease	1	1	1	1	1	1
	3.Education Rate	2.5	2.5	2.5	2.5	2.5	2.5
	4. Political Instability	1.5	1.5	1.5	1.5	1.5	1.5
Environmental	5.Water Scarcity	2	1	1	2	2	1
	6.Flood Risk	2	2	1	1	2	2
	7.Water Quality	2	2	2	2	1	1
	8.Heat Risk	4 (High Concern)	2	3 (Concern)	4 (High Concern)	3 (Concern)	2
Financial	9.Economic Pressure	1	1	1	1	0	0
	10.Unemployment Rate	1	1	1.5	2	2	1
	11.Poverty Rate	0	0	0	0	0	0
	12.Inflation Rate	0	0	0	0	0	0

Urbanization increases pressure on city governments and available resources, which in turn may hamper the governance capacity of a city to implement IWRM and AM approaches and address urban water challenges.

In addition, heat risk is a high concern for Phoenix and Los Angeles and a concern for Milwaukee and New York City. Heat risk is calculated by taking into account the share of green and blue area in a city and the number of tropical nights >20°C and hot days <35°C between 2070-2100. Increases in heat can place added pressure on a city's energy and water infrastructure and place greater strain on a city's public health services. As stated in the introduction, Phoenix is located in the Sonoran desert and averages 203.96 mm of rainfall a year while Los Angeles experiences a semi-arid climate and averages 379.22 mm of rainfall a year. It is projected that Phoenix will experience 146 days of temperatures of 40°C or above by 2050. In addition, it is projected that Los Angeles will experience 60 – 80 additional days of temperatures of 40°C or above by 2100. In addition, Los Angeles, Phoenix, Milwaukee and New York City have relatively low percentages of green and blue area meaning that they have large amounts of soil that are covered by dark, impermeable material, which aggravates urban heat island. Milwaukee is projected to experience 25 hot days by 2050 and New York City will experience between 39 and 52 hot days by 2050.

The main social, financial and environmental trends and pressures that may hamper the IWRM performances are urbanization in Los Angeles, Phoenix and Portland and heat risk in Los Angeles, Phoenix and Milwaukee, and New York City.

5.2 IWRM Performances

The CBF assessment results show that Los Angeles is the highest scoring out of the 6 cities assessed with a BCI score of 4.9 (*figure 5*), followed by New York City with a BCI score of 4.8 (figure 6) and Boston with a BCI score of 4.6 (figure 7), Portland with a BCI score of 4.6 (figure 8), Milwaukee with a BCI score of 4.5 (figure 9) and Phoenix with a BCI score of 4.4(figure 10). It should be noted that data for groundwater quality and wastewater treatment efficiency could not be found for the city of Boston.

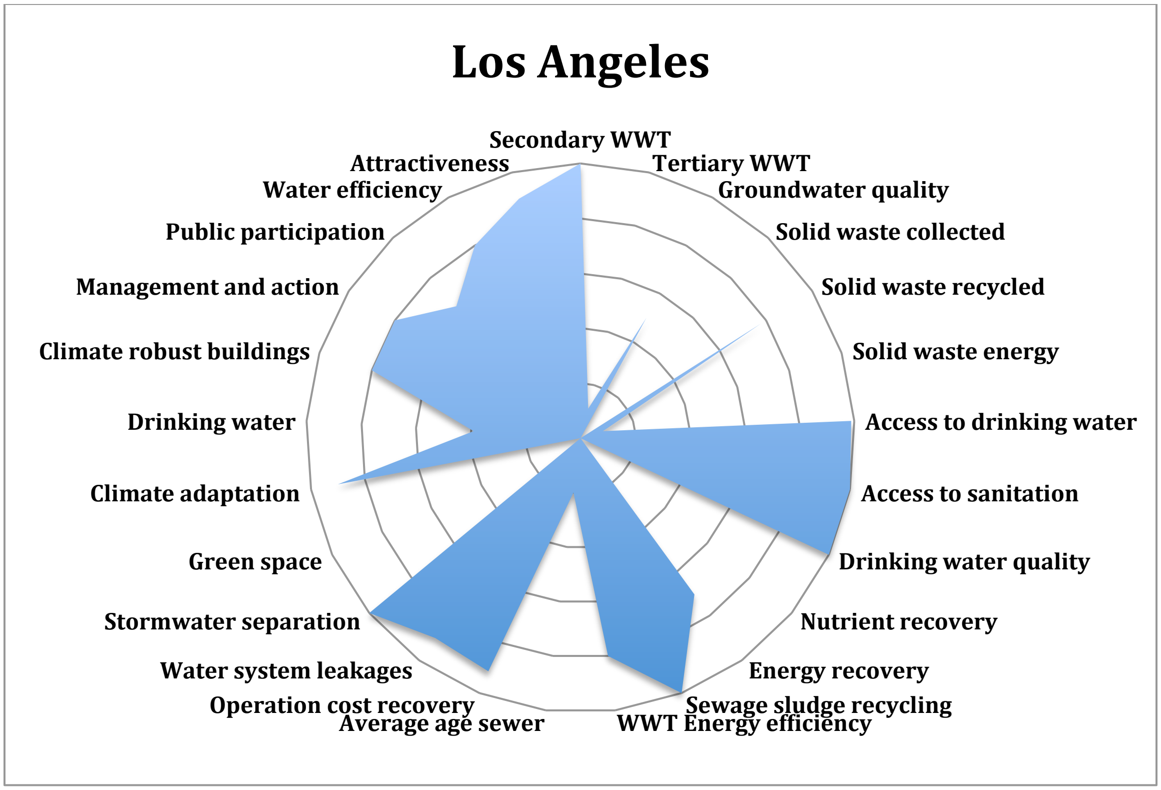

Figure 5 Blue City Index Score of Los Angeles = 4.9 Water Efficient City

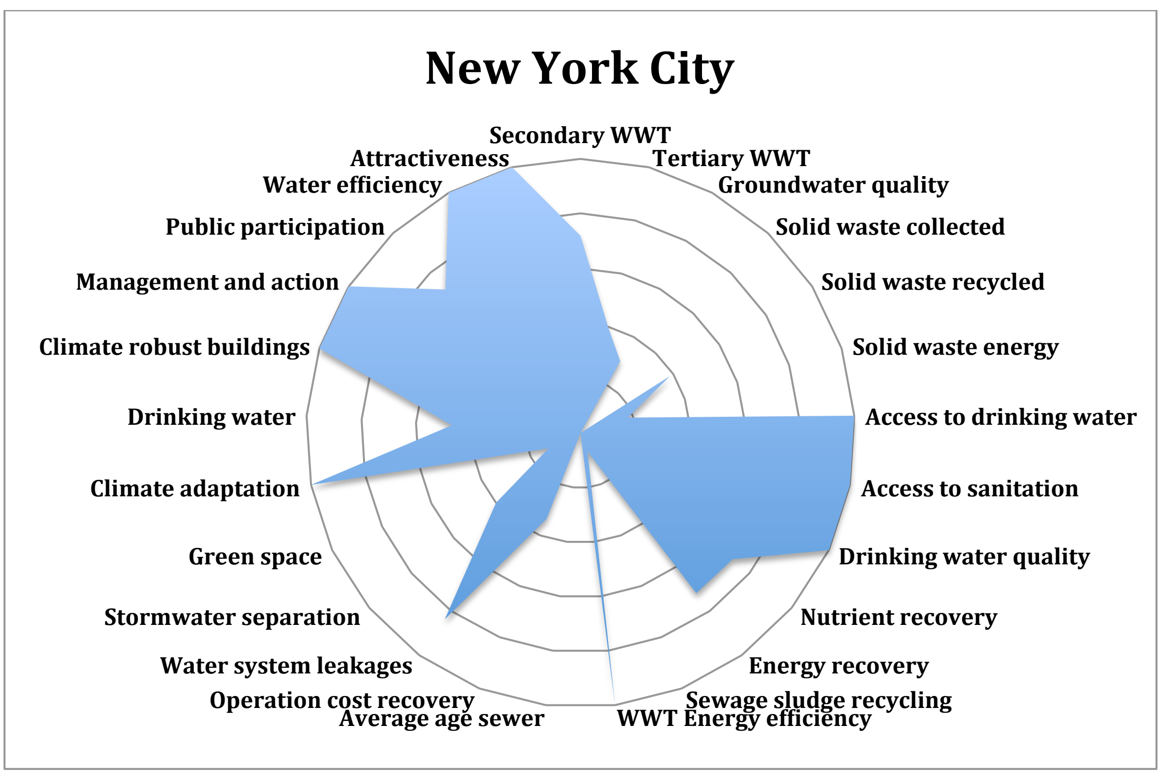

Figure 6 Blue City Index Score of New York City = 4.8 Water Efficient City

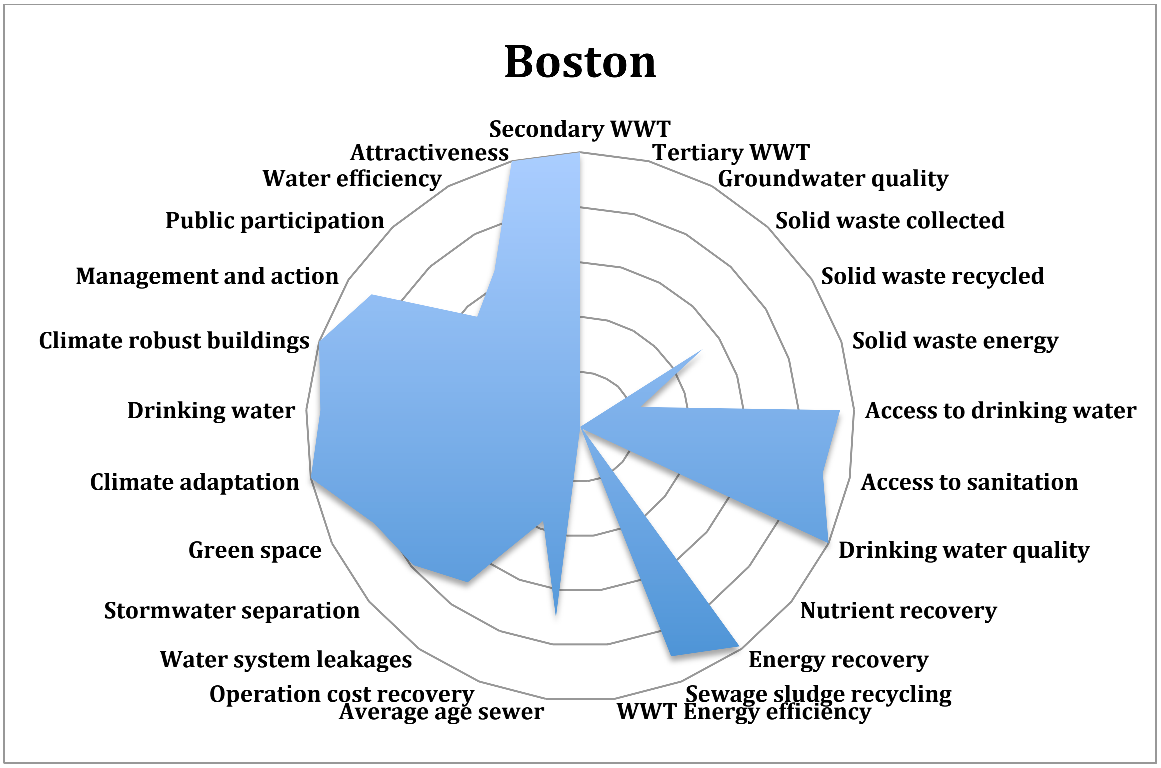

Figure 7 Blue City Index Score of Boston= 4.6 Water Efficient City

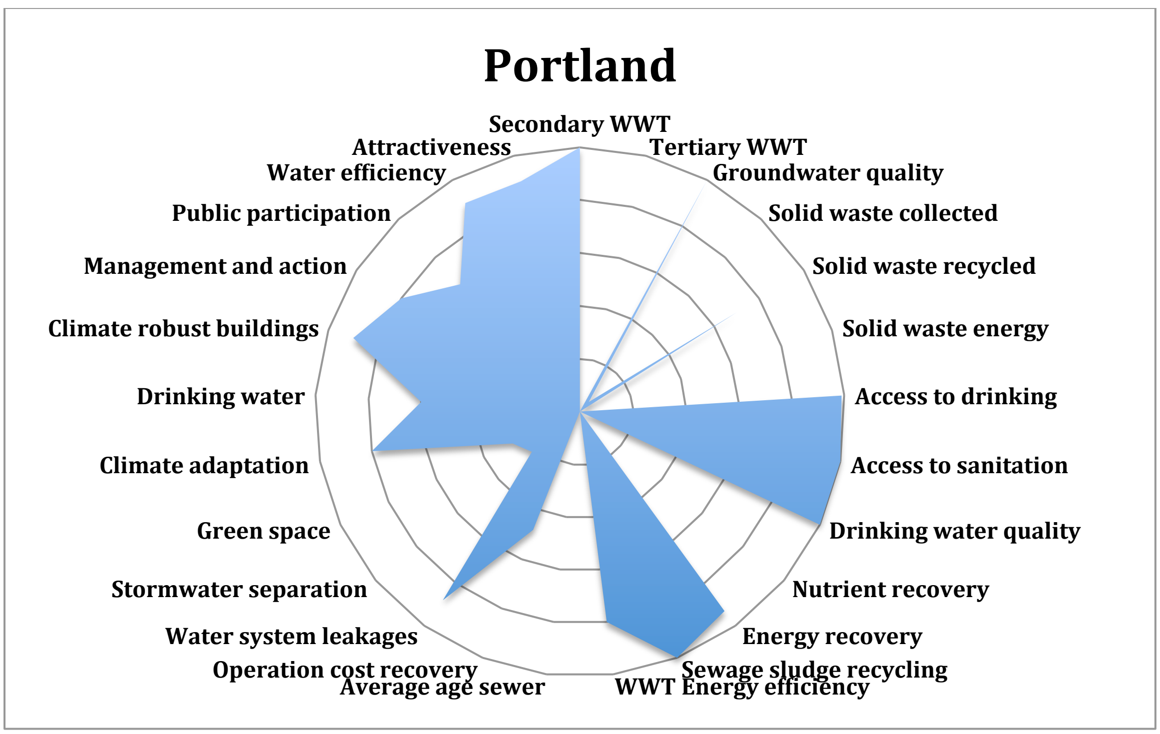

Figure 8 Blue City Index Score of Portland = 4.6 Water Efficient City

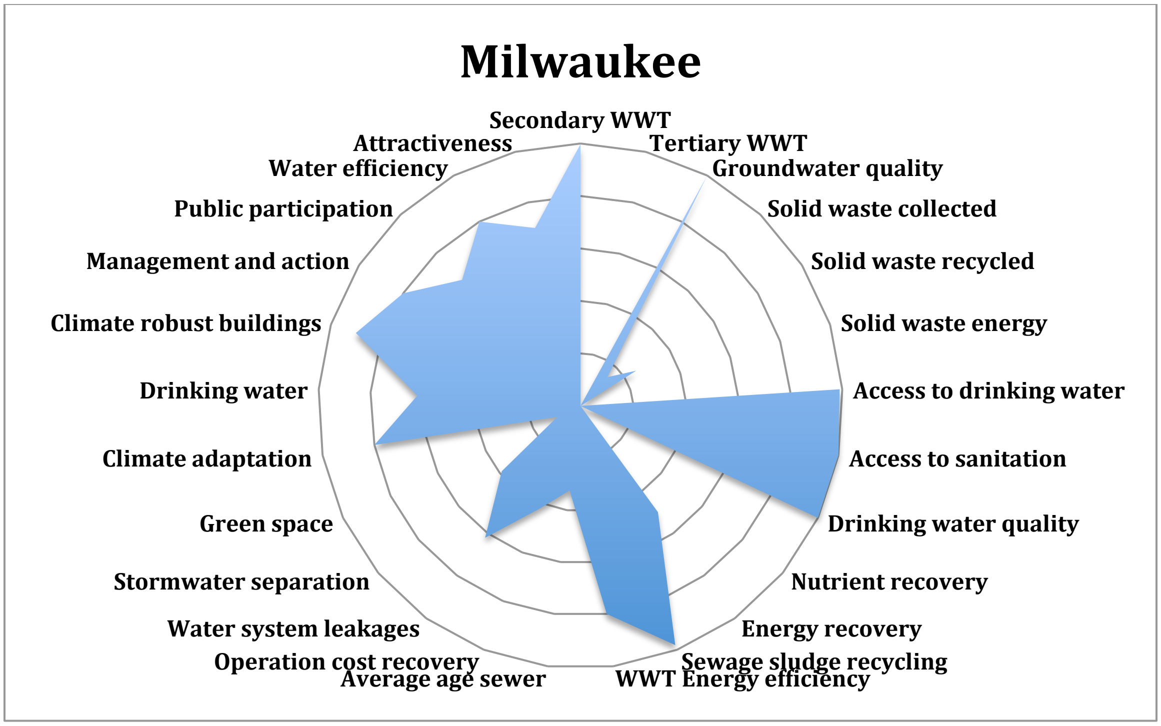

Figure 9 Blue City Index Score of Milwaukee = 4.5 Water Efficient City

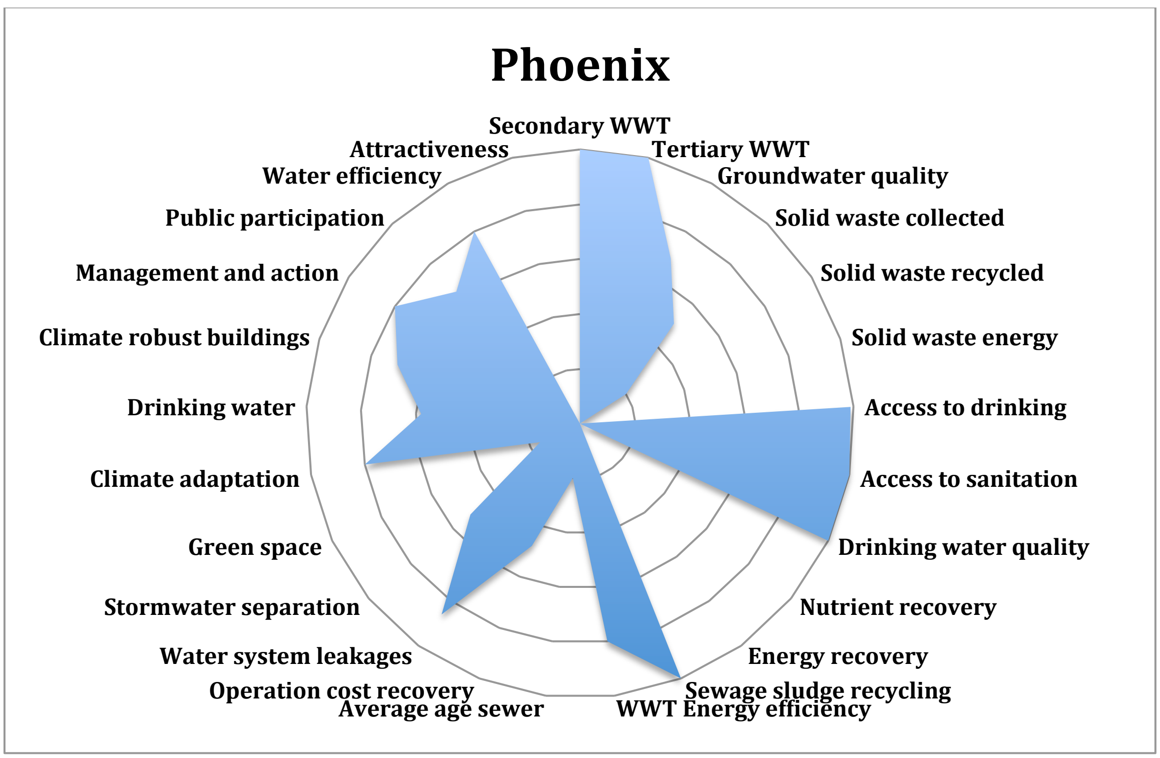

Figure 10 Blue City Index Score of Phoenix = 4.4 Water Efficient City

The CBF provides a snapshot of each city's IWRM performances. The cities were categorized based on the BCI scores assigned to each. As can be seen above, all 6 cities are categorized as *water efficient* cities. *Water efficient* cities are characterized by high implementation of secondary wastewater treatment and increasing tertiary treatment, the use of centralized, technological solutions to increase water efficiency and control pollution, partially applied efficient technologies, high energy recovery from wastewater treatment and limited nutrient recovery. These cities are vulnerable to climate change due to limited stormwater separation, poor adaptation strategies, and low green area ratios. Governance and community involvement are improving (Koop & van Leeuwen, 2015). As is characteristic of *water efficient* cities all 6 cities score high in basic water services and secondary wastewater treatment while Phoenix is the only U.S. city to score high on tertiary wastewater treatment. All 6 cities score high on climate adaptation due to the implementation of publicly available local climate adaptation plan but low on green space and stormwater separation, which increases vulnerability to climate change. When compared to other cities that have been assessed using the CBF, cities in the U.S. receive very low scores in the solid waste treatment category, mainly due to the large amount of waste produced by American households and the low percentage of solid waste that is recycled in comparison to other countries. In addition, the cities score low on nutrient recovery with only 2 cities (New York and Boston) employing any nutrient recovery. Operation cost recovery is a concern when compared to the highest and lowest 10% of cities that have been assessed by the CBF approach. These are the indicators that can be improved in order to enhance the overall IWRM performances of the 6 selected cities.

The IWRM performances of the cities in the U.S. were compared to the top 6 cities categorized as *resource efficient and adaptive* cities by the CBF in order to gain an understanding of practices that can be improved (*figure 5*). *Resource efficient and adaptive* cities often apply nutrient and energy recovery to wastewater treatment while recycling and recovering energy from solid waste. These cities apply water efficient techniques and have reduced water consumption while incorporating climate adaptation into urban planning (Koop and van Leeuwen, 2015). All of the cities that have been categorized as resource efficient and adaptive cities are in Northwestern Europe (Koop and van Leeuwen, 2015). The areas for improvement are tertiary wastewater treatment, solid waste recycling, nutrient recovery from wastewater treatment, stormwater separation, and green space. However, U.S. cities score higher than the top 6 *resource efficient and adaptive* cities in operation cost recovery and climate adaptation.

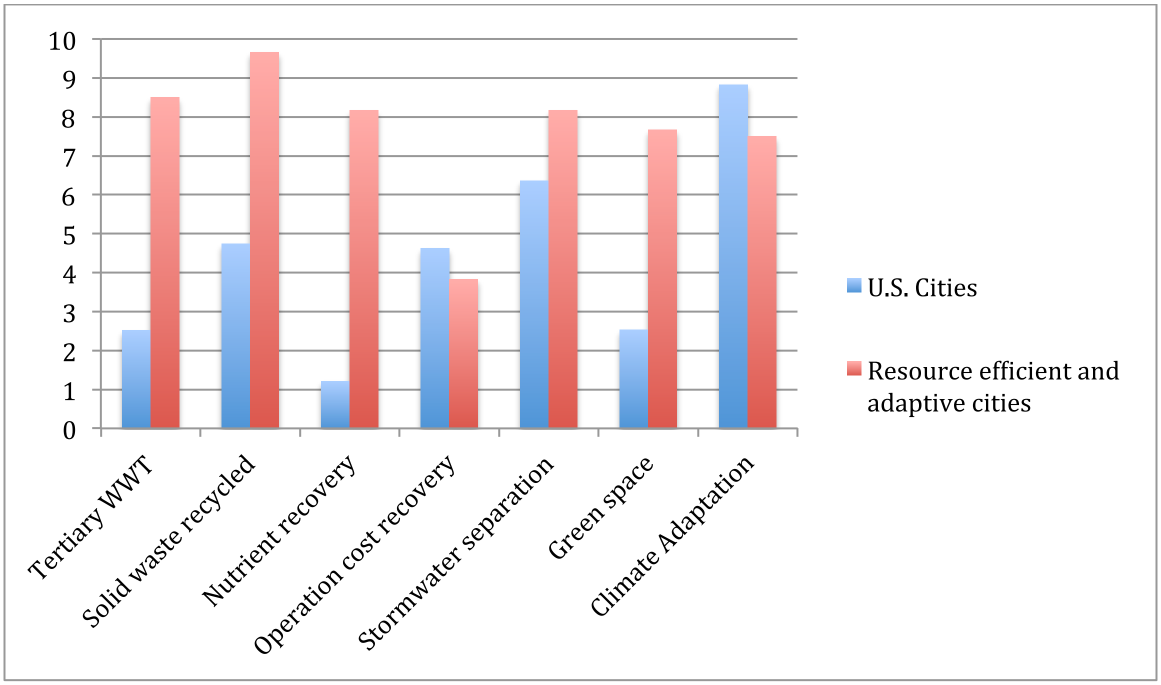

Figure 10 A comparison of the 6 U.S. cities with the top 6 resource efficient and adaptive cities based on average scores for 7 key indicators. U.S. cities have room for improvement in 5 out of the key indicators, with the exception of operation cost recovery and climate adaptation.

5.3 Governance Capacity of New York City

Overall Results

Overall, table 8 shows the results of the governance capacity assessment for the 27 indicators for the 5 urban water challenges. Flood risk scores the highest with a score of 2.6 while wastewater treatment and solid waste treatment both score 2.4 followed by water scarcity with a score of 2.33 and lastly urban heat island with a score of 2.07.

	Water Scarcity	Flood Risk	Wastewater Treatment	Solid Waste Treatment	Urban Heat Island
1.1 Community knowledge	0	0	0	0	0
1.2 Local sense of urgency	-	0	0	+	0
1.3 Behavioral internalization	+	+	0	+	0
2.1 Information availability	0	0	+	0	0
2.2 Information transparency	0	0	0	0	+
2.3 Knowledge cohesion	+	+	0	0	+

3.1 Smart monitoring	++	0	+	0	--
3.2 Evaluation	0	0	0	0	--
3.3 Cross-stakeholder learning	-	0	+	0	-
4.1 Stakeholder inclusiveness	0	+	+	0	-
4.2 Protection of core values	0	0	0	0	-
4.3 Progress and variety of options	0	+	0	0	0
5.1 Ambitious and realistic goals	++	+	0	+	+
5.2 Discourse embedding	0	+	+	0	+
5.3 Policy cohesion	+	+	0	+	+
6.1 Entrepreneurial agents	0	+	+	+	+
6.2 Collaborative agents	-	0	0	0	0
6.3 Visionary agents	0	++	0	++	0
7.1 Room to maneuver	0	+	0	-	-
7.2 Clear division of responsibilities	0	+	+	0	0
7.3 Authority	++	+	++	+	+
8.1 Affordability	+	+	+	+	+
8.2 Consumer willingness-to-pay	0	+	0	0	0
8.3 Financial continuation	+	+	+	+	0
9.1 Policy instruments	0	+	0	0	+
9.2 Statutory compliance	0	+	0	+	+
9.3 Preparedness	+	+	0	+	0

Table 8 Governance indicator scores for each urban water challenge

Figure 11 shows the aggregated scores of the for the 9 governance conditions for New York City when addressing the 5 urban water challenges. 8 out of the 9 governance conditions are indifferent while 3. Continuous learning is limiting to the governance capacity. 5. *Policy ambition* is the highest scoring governance condition although it still scores indifferent. However, this can be seen as encouraging for the future of New York City when addressing the five urban water challenges, as generally policies are ambitious. Overall, there is room for improvement with all of the conditions.

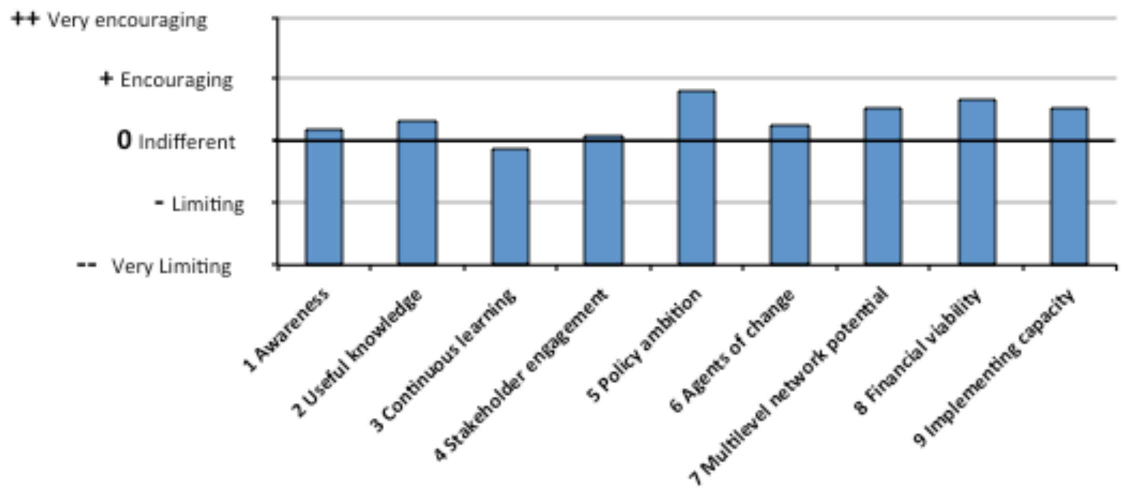

Figure 11 The overview of the governance conditions for NYC for the 5 urban water challenges. 3. Continuous learning is the lowest scoring condition while 5. Policy ambition is the highest scoring.

The averaged results for the 5 urban water challenges for the 27 governance indicators are sorted from the worst scoring indicators to best scoring indicators (*figure 12*). The highest scoring indicators are authority, affordability and ambitious and realistic goals. The lowest scoring indicators are 3.2 *evaluation*, 3.3 *cross-stakeholder learning*, 4.2 *protection of core values* and 7.1 *room to maneuver*.

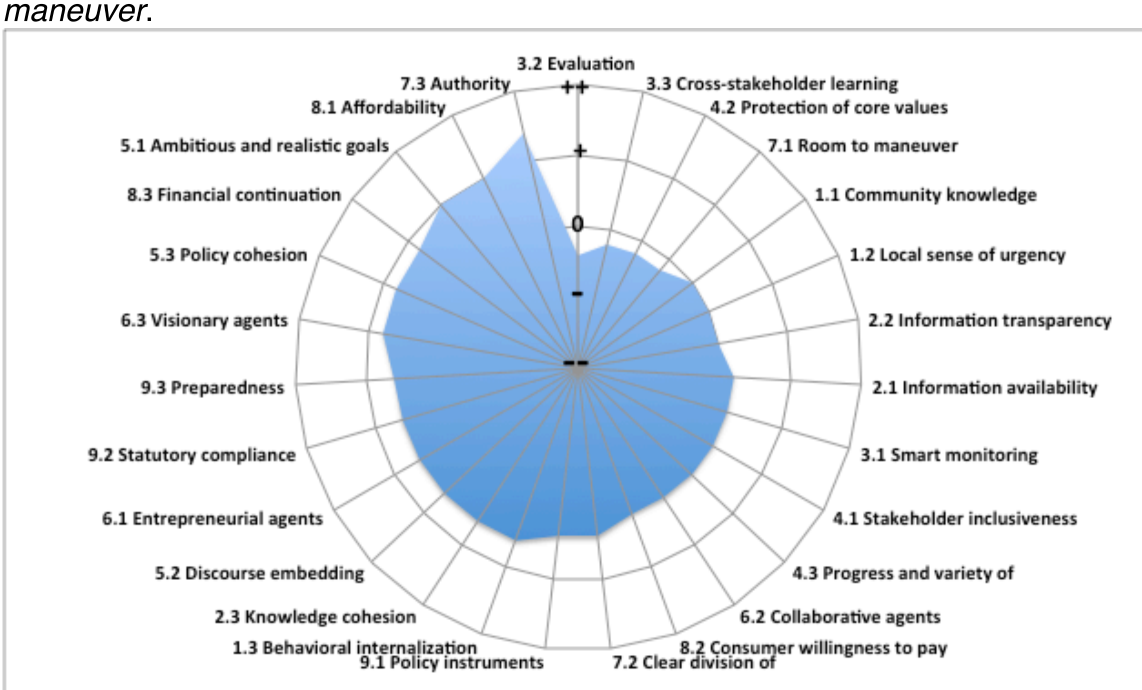

Figure 12 The overview of the governance indicators for NYC for the 5 urban water challenges. 7.3 Authority, 8.1 Affordability and 5.1 Ambitious and realistic goals are encouraging while 3.2 evaluation, 3.3 cross-stakeholder learning, 4.2 protection of core values and 7.1 room to maneuver are limiting.

The indicators that score the highest for the overall governance capacity of New York City are 7.3 *authority*, 8.1 *affordability*, and 5.1 *ambitious and realistic goals (figure 11)*. Authority is very encouraging for both water scarcity and wastewater treatment and encouraging for urban heat island, flood risk and solid waste treatment. In the case of water scarcity and wastewater treatment, the NYC DEP is seen as a legitimate form of authority. In addition, the Mayor's Office of Recovery and Resiliency is a legitimate form of authority for the urban heat island and flood risk challenges and the DSNY is seen as a legitimate form of authority for solid waste treatment challenge.

The affordability of water and climate adaptation services is encouraging for all of the urban water challenges as drinking water and wastewater treatment are covered under one water rate charged by the NYC DEP and the rate, "*is somewhere in the middle compared to other national water rates. Considering that NYC is one of the costliest cities in the US when it comes to other utilities and the standard of living overall, this is a good thing"* (WS3). In addition, solid waste treatment was found to be affordable as it is part of the real estate tax and there is no separate fee for waste management services (SW1; SW2; SW3).

Generally, it was found that the goals to address the 5 urban water challenges were ambitious and realistic. As mentioned previously, the goals set by the NYC DEP for the water scarcity challenge are a result of the construction of the New York Bypass and the shutdown of the Delaware aqueduct. Additionally, the goals for flood risk, urban heat island and general climate change mitigation laid out in the ONENYC plan under the Mayor's Office of Recovery and Resiliency are ambitious and realistic. However, it should be noted that these goals and the general increased capacity were seen as a reaction to Hurricane Sandy (UHI3; FR1).

As can be seen in figure 11 New York City can improve continuous learning approaches in order to enable effective policy change to increase the city's governance capacity. Evaluation and cross-stakeholder learning can be improved. There are some questions on the evaluation practices employed by the city. One interviewee, speaking on flood risk, stated, "*There is a fair amount of evaluation. There is a comprehensive plan. However it is more focused on inputs rather than outcomes (whether or not project was completed not the actual effects of the project)."* While another interviewee, speaking on the evaluation of solid waste management, noted, "*the city council occasionally holds an oversight hearing. I am not sure how honest the evaluation is if it is performed internally*." In addition, as stated previously there is no monitoring or evaluation of urban heat island policy. Through the research it was found that cross-stakeholder learning could be improved. As one interviewee stated on flood risk, cross stakeholder learning is "*very potent here. Possibly too much. Especially post*

Sandy recovery there is a real emphasis on hearing from stakeholders. Maybe too many meetings, oftentimes the meetings are redundant. NYC has a very strong civic participation culture." This sentiment that there is an emphasis on stakeholder meetings in New York City was observed in many interviews. However, one interviewee speaking on water scarcity noted that the, "*knowledge from other stakeholders is hardly used due to limited public concern over the challenge."* As a result, there is stakeholder engagement and interaction but learning is limited due to the informative approach taken by the management authority.

4.2 *protection of core values* is limiting for the governance capacity needed to address the 5 urban water challenges. During the stakeholder engagement process there are stakeholder interests that are not represented such as the environmental justice community (UHI02; WWT02). In addition, not at all interests are accounted for in the end result (UHI01; UHI02; UHI03; FR0; WWT02, SW01).

Lastly, 7.1 *room to maneuver* is limiting as there are limited opportunities to develop alternatives and form unconventional partnerships. The multi-level network potential is affected by the limiting room to maneuver. Alternatives are limited due to the large-scale infrastructure projects that dominate these challenges and the high risk involved in implementing an alternative that fails (SW01; WS01; WWT02; UHI01).

In conclusion, the indicators 3.2 *evaluation*, 3.3 *cross-stakeholder learning*, 4.2 *protection of core values* and 7.1 *room to maneuver* are the most essential governance indicators for determining and improving the overall governance capacity of New York City. 3.*Continuous learning* is the most essential governance condition for determining the overall governance capacity of New York City.

Water Scarcity

Water scarcity is not a perceived as a major challenge in New York City. Condition 5 *policy ambition* is the highest performing condition and is found to be encouraging for developing governance capacity to address water scarcity, while condition 6 *agents of change* is limiting for the governance capacity to address water scarcity (*figure 11*). The remaining 7 conditions of *awareness, useful knowledge, continuous learning, stakeholder engagement process, multi-level network potential, financial viability* and *implementing capacity* are indifferent for the governance capacity to address water scarcity.

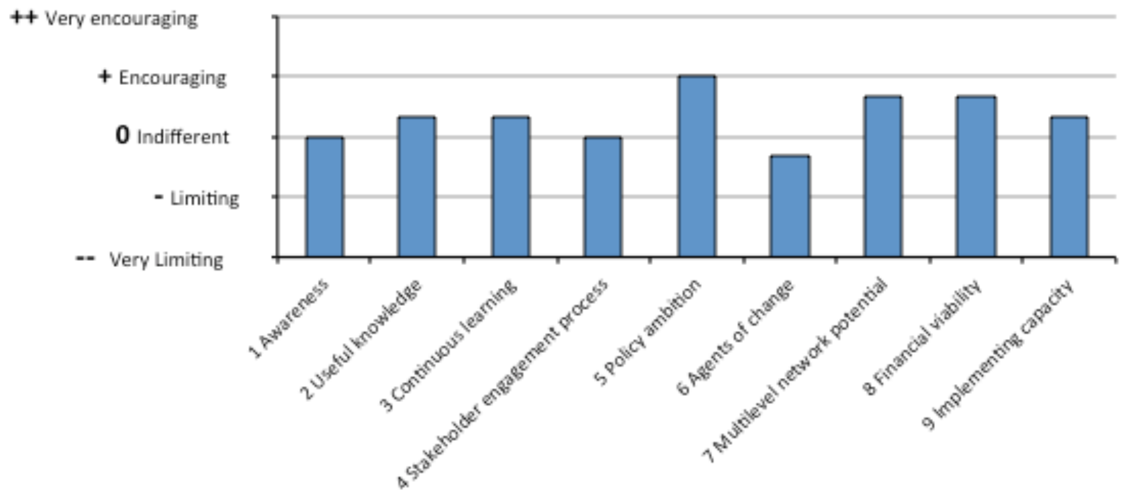

Figure 11 Governance condition performances for the water scarcity challenge. 5. Policy Ambition is the highest performing while 8. agents of change performs the lowest

The lowest scoring and the most essential governance indicators for improving the governance capacity of New York City when addressing water scarcity are indicator 1.2 *local sense of urgency*, indicator 3.3 *cross-stakeholder learning*, and indicator 6.2 *collaborative agents* (*figure 12).* The governance indicators of 7.3 *authority*, 5.1 *ambitious and realistic goals* and 3.1 *smart monitoring* score the highest in the GCF assessment.

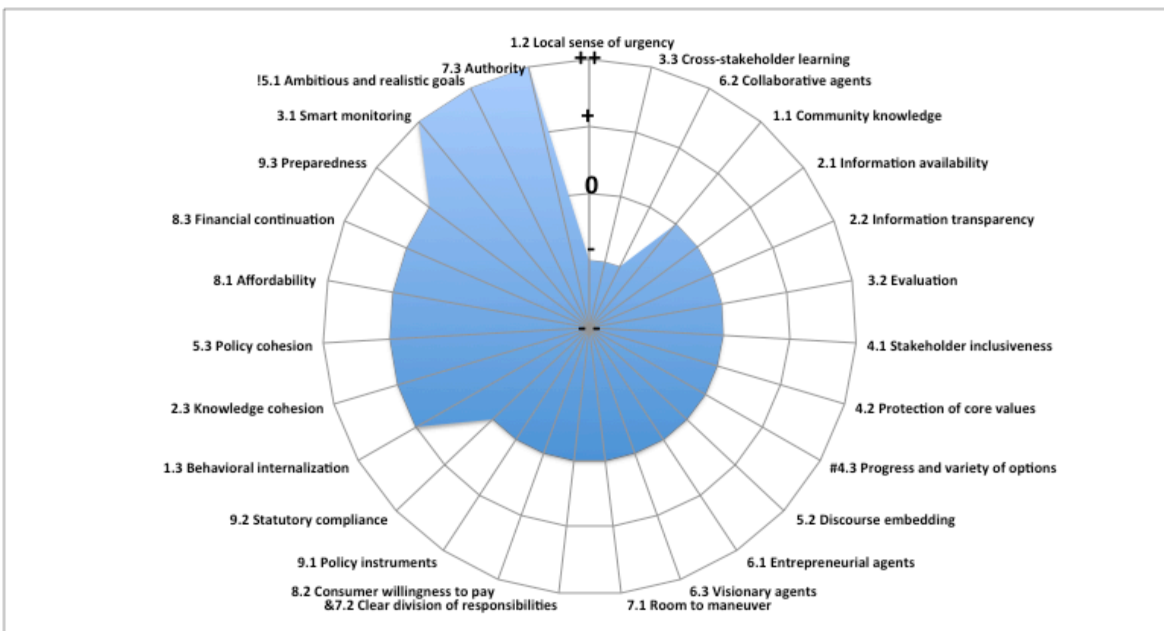

Figure 12 Governance capacity of NYC when addressing water scarcity. 1.2 Local sense of urgency, 3.3 Cross-stakeholder learning and 6.2 Collaborative agents are limiting for the governance capacity to address water scarcity.

Through the interviews it became clear that the New York City Department of Environmental Protection (NYC DEP) had clear authority over the city's drinking and wastewater management (WS1; WS2). NYC DEP sets clear and ambitious goals for water conservation that were stimulated by the New York Bypass project, which is being constructed to address two major leaks in the Delaware Aqueduct (WS1; WS3). This ambition was explained by one interviewee who stated, "*we feel that we have a very comprehensive water conservation program with short term goals and a very broad set of stakeholders. This is leading up to the shutdown of the Delaware Aqueduct in 2022"* (WS3). However, due to the relative abundance of high quality drinking water in New York City there is a lack of a local sense of urgency, as one interviewee stated, "*Water scarcity is not a big issue on the publics mind in New York City."* (WS1). In addition, due to the strong authority of the NYC DEP there is little collaboration between different sectors of society and little cross-stakeholder learning. The challenge is mainly addressed by a small coalition of stakeholders with shared interests and as one interviewee explained, "*knowledge from other stakeholders is hardly used due to limited public concern over the challenge. There is not much engagement on this challenge*" (WS1).

Flood Risk

The governance capacity for addressing flood risk is the highest performing of the 5 urban water challenges in New York City. There are 4 governance conditions that are encouraging for the governance capacity to address flood risk (*figure 13*). The encouraging conditions are *policy ambition* (condition 5), *multi-level network potential* (condition 7), *financial viability* (condition 8) and *implementing* capacity (condition 9).

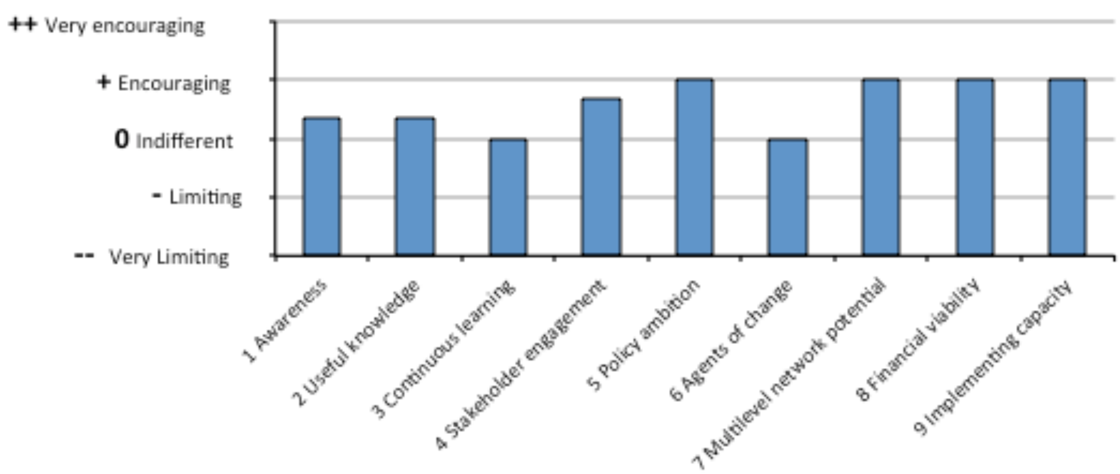

Figure 13 Governance condition performances for the flood risk challenge. The highest performing conditions are 5. Policy ambition, 7. Multi-level network potential, 8. Financial viability, and 9. Implementing capacity. The lowest performing conditions are 3. Continuous learning and 6. Agents of change.

There are no indicators that were found to be limiting or very limiting for the governance capacity when addressing flood risk (*figure 14*). However, through the interviews it became apparent that 1.1 *community knowledge* and 2.2 *information transparency* should continue to be improved. 6.3 *Visionary agents* is very encouraging for the governance capacity to address flood risk.

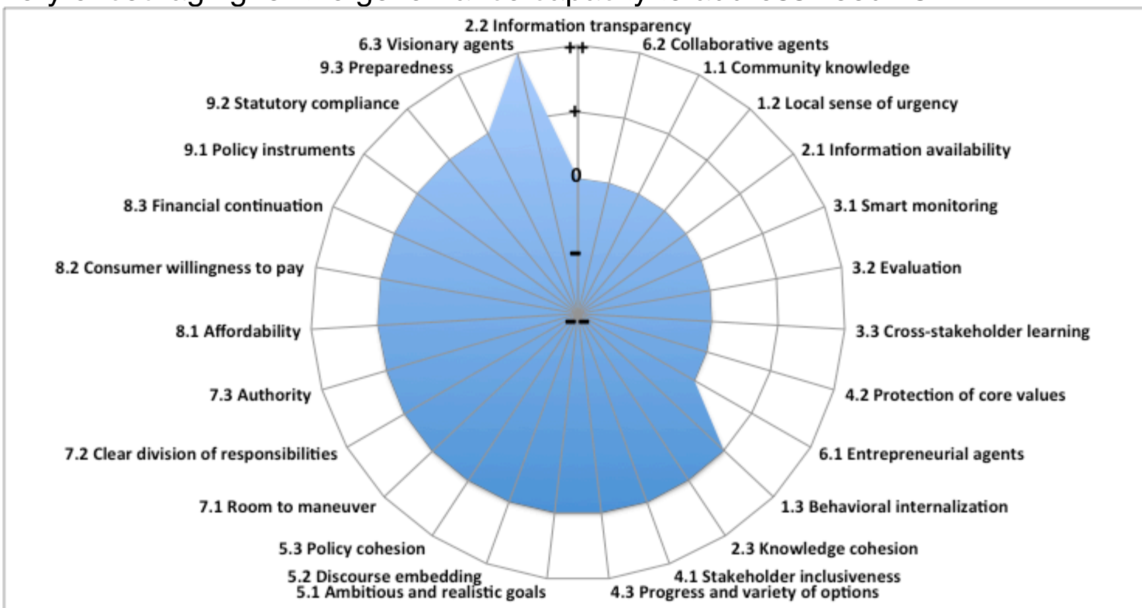

Figure 14 Governance capacity of NYC when addressing flood risk. 6.3 visionary agents is very encouraging for the governance capacity to address flood risk.

The governance capacity score for flood risk is the most encouraging out of all of the challenges. This may be a result of Hurricane Sandy in 2012 which as one interviewee explained, "*increased public awareness and political will and funding from federal, state and city to push policy forward*" (FR2). However, the score for 1.1 *community knowledge* shows that there is now an underestimation of the flood risk challenge as one interviewee explained that, "*people have slipped back to business as usual"* (FR3). In addition, 2.2 *information transparency* could be improved as knowledge on the challenge is available online in flood maps but the information is complex and difficult to understand (FR2, FR3). The city scores highest in the 6.3 *visionary agents* indicator as after Hurricane Sandy the city established the Mayor's Office of Recovery and Resiliency, which is led by a visionary director, who, as one interviewee stated, "*asks the right questions and knows how to change the course to stay on track or get back on the right track" (FR2).*

Wastewater Treatment

Developing governance capacity to address the wastewater treatment challenge in New York City is important as 60 percent of the city's sewers are combined

(NYC DEP, 2010). The governance condition of multi-level network potential is the highest scoring for the wastewater treatment challenge. The remaining 8 governance conditions of 1. *Awareness*, 2. *Useful knowledge*, 3. *Continuous learning*, 4. *Stakeholder engagement*, 5. *Policy ambition*, 6. *Agents of change*, 8. *Financial viability* and 9. *Implementing capacity* score indifferent for the governance capacity to address the wastewater treatment challenge.

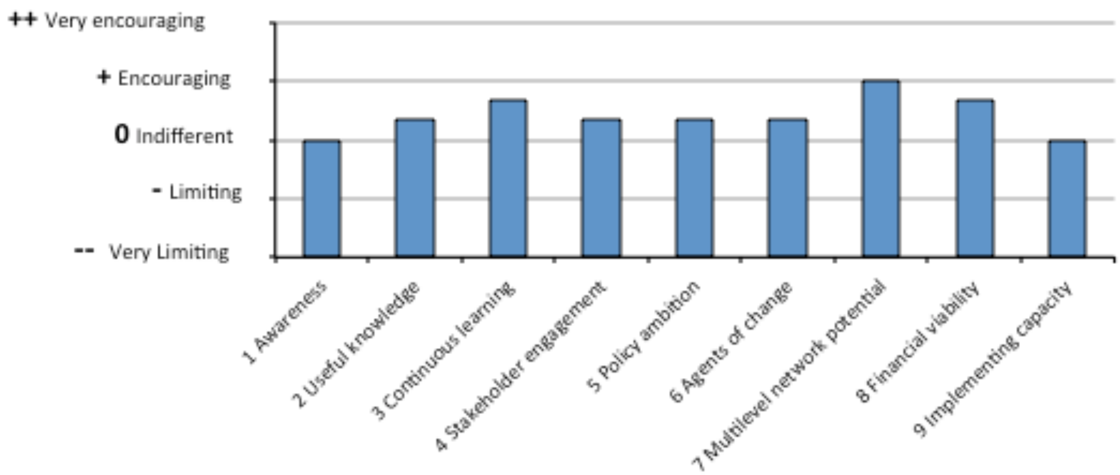

Figure 15 Governance condition performances for the wastewater treatment challenge. The highest performing condition is 7. Multi-level network potential. The lowest performing conditions are 1. Awareness and 9. Implementing capacity.

The most essential governance indicators for determining the governance capacity of New York City when addressing wastewater treatment are 1.1 *community knowledge*, 1.2 *local sense of urgency*, 1.3 *behavioral internalization*, 9.1 *policy instruments*, 9.2 *statutory compliance* and 9.3 *preparedness (figure 16).* Authority is very encouraging for the governance capacity to address the wastewater treatment challenge.

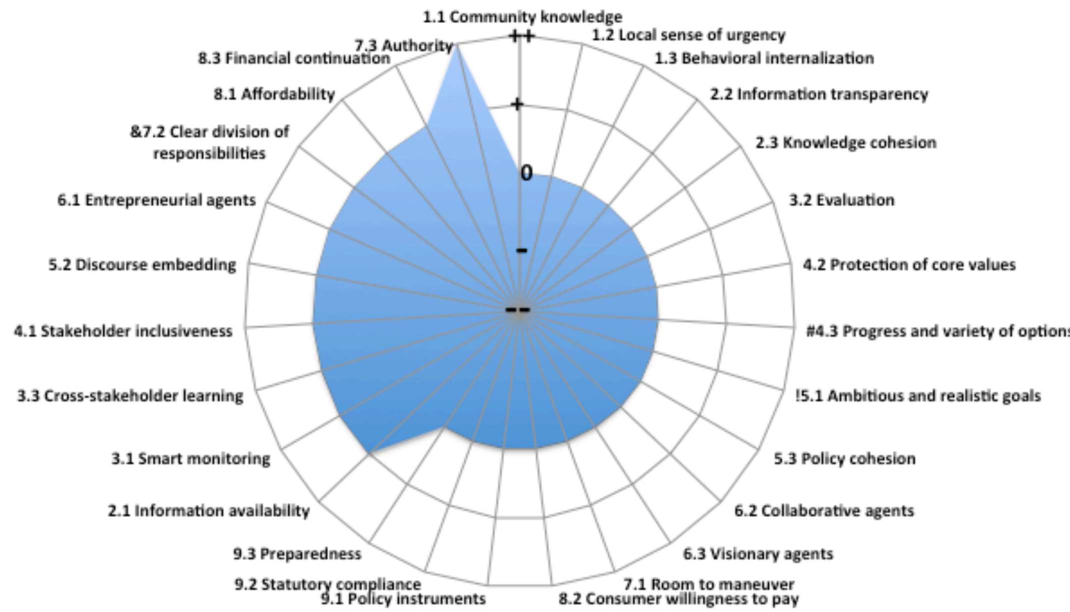

Figure 17 Governance capacity indicators of NYC when addressing wastewater treatment. The highest performing indicator is 7.3 authority.

Wastewater treatment is the responsibility of the NYC DEP and as with the water scarcity challenge the city scores high for the indicator of authority. In addition, similar to water scarcity, public awareness is identified as indifferent. As one interviewee explained it, "*There is very little public awareness of wastewater treatment. Most people that are not in the environmental realm do not think about it. Most people don't know about CSOs (Combined Sewer Overflows) and most people don't care because it is waste. On the other hand, as people become more engaged with waterways they are becoming more aware. There is growing awareness*" (WWT2). Additionally, the wastewater treatment challenge scores low for implementing capacity, which is made up of the indicators 9.1 *policy instruments*, 9.2 *statutory compliance* and 9.3 *preparedness*. According to one interviewee the state of New York and the City of New York have yet to comply with the Environmental Protection Agency's (EPA) requirement that all states use Enterococcus as an indicator bacteria instead of fecal coliform by November 2015 (WWT3). Overall, there is a low awareness of preparation strategies and although the city is performing an analysis of the effects of sea level rise on wastewater treatment infrastructure, one interviewee described the city as, "*far behind*," on preparation to withstand storms, infrastructure failures and emergencies without sacrificing waterways (WWT3).

Solid waste treatment

The most essential governance conditions for determining the governance capacity of New York City when addressing the solid waste challenge are 2. *Useful knowledge,* 3. *Continuous learning*, 4. *Stakeholder engagement* and 7. *Multi-level network potential*. In addition, 1. *Awareness*, 5. *Policy ambition*, 8. *Financial viability* and 9. *Implementing capacity* score indifferent. The highest scoring condition for the governance capacity when addressing solid waste is 6. *Agents of change*.

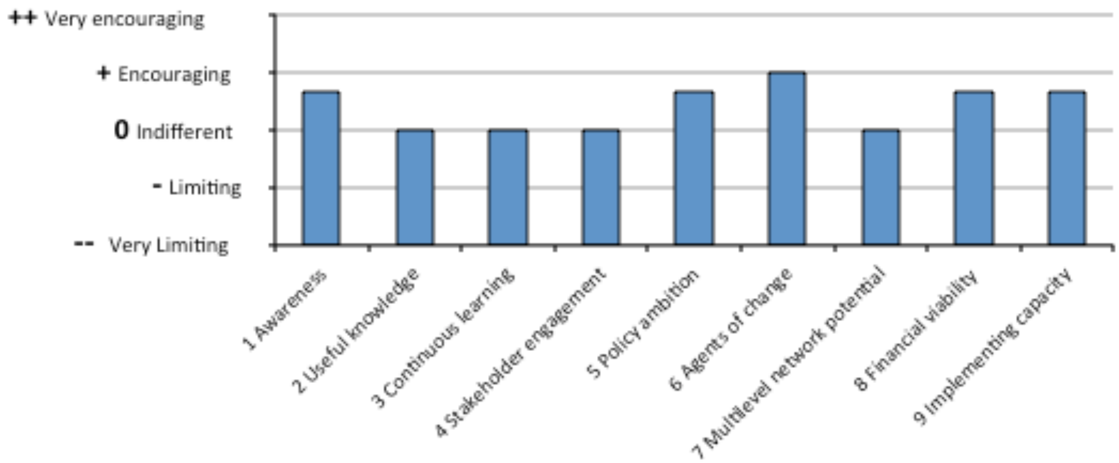

Figure 18 The governance condition performances for the solid waste treatment challenge. 6. Agents of change is encouraging for the governance capacity.

The most essential governance indicator for improving the governance capacity of New York City when addressing solid waste treatment is 7.1 *room to maneuver (figure 19).* Indicator 6.3 *visionary agents* is very encouraging for the governance capacity to address the solid waste treatment challenge.

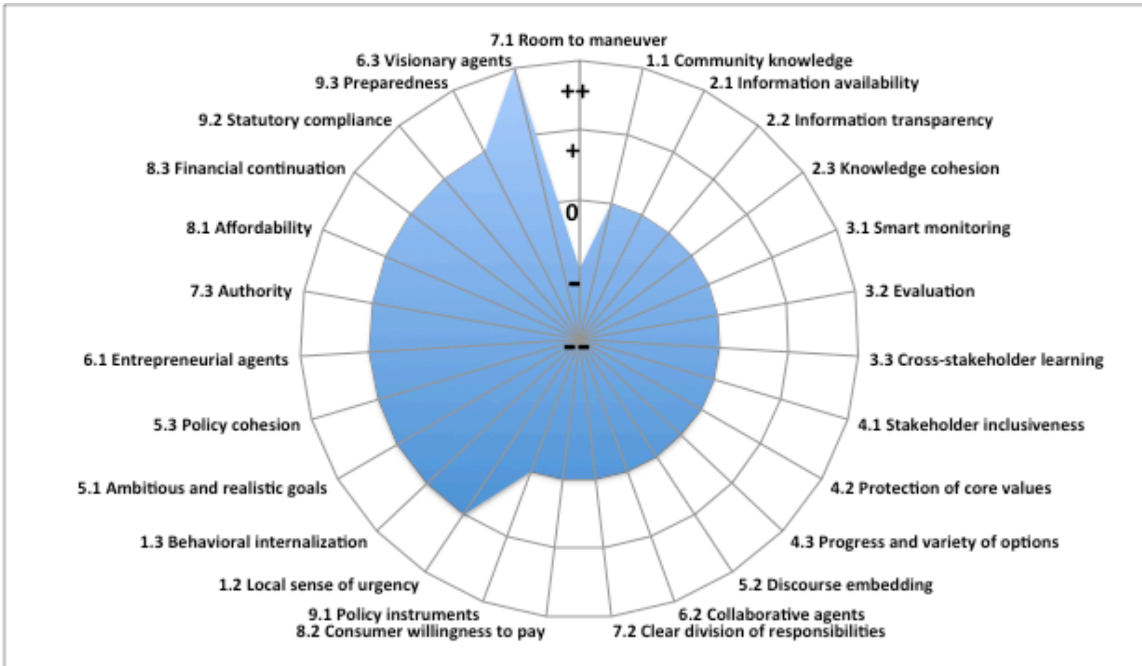

Figure 18 Governance capacity indicators of NYC when addressing solid waste treatment. The highest scoring indicator is 6.3 visionary agents. The lowest scoring indicator is 7.1 room to maneuver.

Solid waste from residences and public municipal buildings is collected and managed by the New York City Department of Sanitation (DSNY). Public awareness seen through the indicator scores of 1.2 *local sense of urgency* and 1.3 *behavioral internalization* are encouraging as there has been a major effort to increase recycling and a shift in focus to managing waste sustainably throughout its lifecycle while also maximizing its use (SW1; SW3). A large part of this change in focus is due to the presence of 6.3 *visionary agents* as the commissioner of the DSNY is seen as visionary in creating a plan to reduce waste to landfills by 90% by 2030 (SW1; SW3). However, the indicator score for 7.1 *room to maneuver* is limiting due to the "*conservative approach the city takes toward contracting private carters*," and because "*New York City is not a hotbed of experimentation due to size and risks. The political risks are too high if your policy fails*" (SW3; SW1). As a result, the opportunities to form partnerships with unconventional actors and develop alternatives are limited (SW1, SW3).

Urban Heat Island

The governance capacity of New York City when addressing urban heat island was the poorest performing of the 5 urban water challenges. The governance conditions that are most essential for determining the governance capacity when addressing urban heat island are 3. *Continuous learning* and 4. *Stakeholder engagement process.* 3. *Continuous learning* is very limiting and 4. *Stakeholder engagement process* is limiting for the governance capacity. However, 5. *Policy* *ambition* is encouraging for the governance capacity to address urban heat island

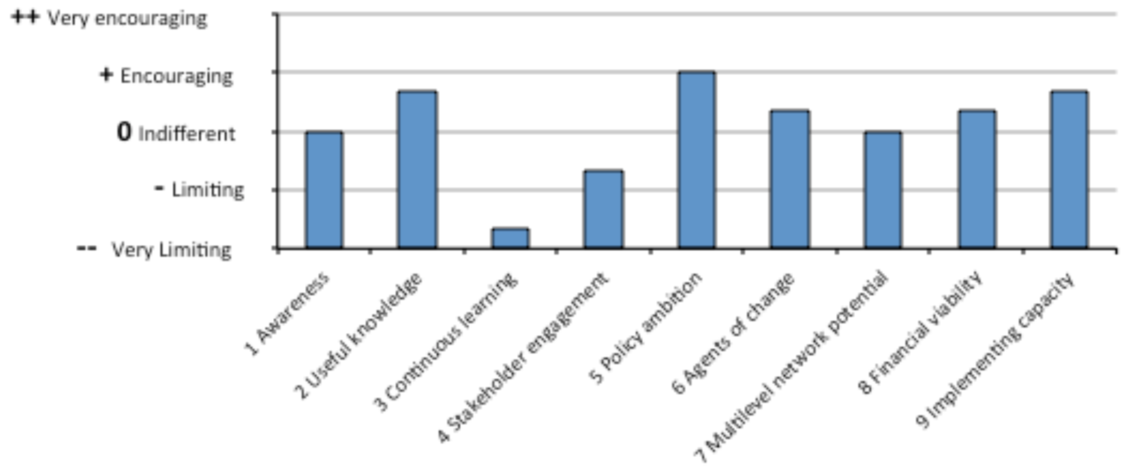

Figure 19 The governance condition performances for the urban heat island challenge. 3. Continuous learning and 4. Stakeholder engagement process are the lowest scoring conditions while 5. Policy ambition is encouraging for the governance capacity.

The most essential governance indicators for improving the governance capacity of New York City when addressing urban heat island are 3.1 *smart monitoring*, 3.2 *evaluation*, 3.3 *cross-stakeholder learning*, 4.1 *stakeholder inclusiveness*, 4.2 *protection of core values* and 7.1 *room to maneuver* (*figure 20).*

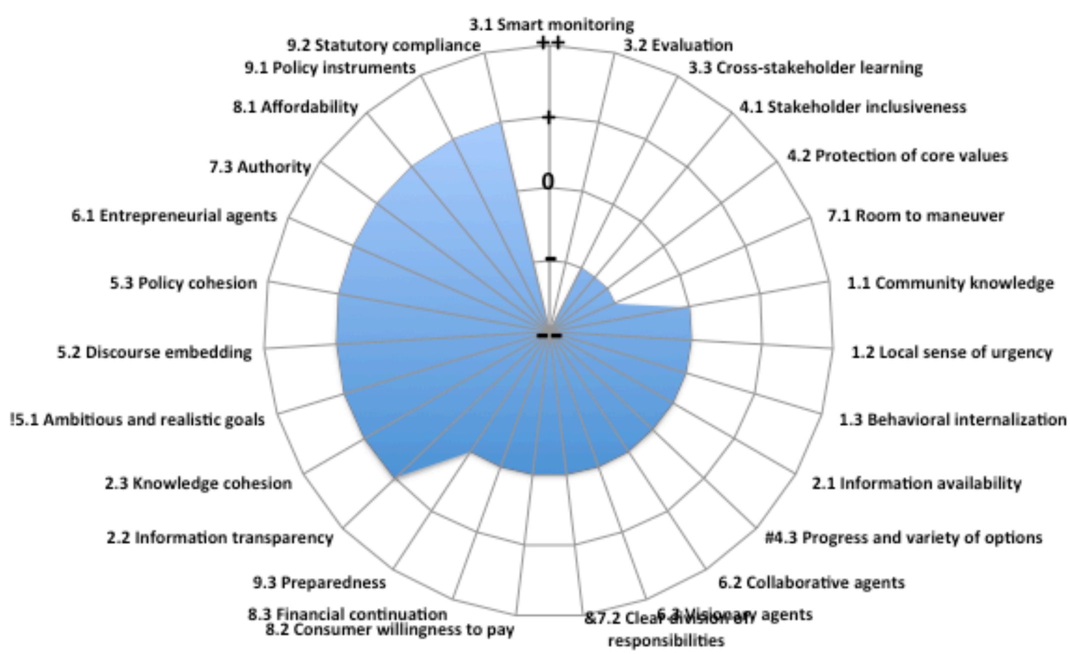

Figure 20 Governance capacity of NYC when addressing urban heat island. The lowest scoring indicators are 3.1 smart monitoring , 3.2 evaluation, and 3.3 cross-stakeholder learning, and 4.1 stakeholder inclusiveness.

The governance capacity for addressing urban heat island is the most limiting of the 5 urban water challenges. It was found that urban heat island is either addressed as a health risk or incorporated into larger climate mitigation efforts (UHI02; UHI03). However, this is changing as New York City has recently launched the Urban Heat Island Mitigation Working Group in the Mayor's Office of Recovery and Resiliency as response to Hurricane Sandy and the larger question of emergency preparedness (UHI02). Currently, there is no monitoring or evaluation of urban heat island policies and as one interviewee noted this creates, *"a problem to propose policies that are not measured. There might be proposals to monitor but whether or not there is the funding is another thing*" (UHI03). In addition, as one interviewee stated, "*The city budget does not include a lot of money for UHI, however there are hundreds of millions of dollars being spent on climate mitigation efforts, including some green infrastructure, which are focused on protecting against flooding but will have some co-benefits in terms of urban heat island. Carbon reduction strategies have the same impacts*"(UHI02). In addition, 3.3 cross-stakeholder learning is limiting as urban heat island, *"remains an issue for policy makers, urban designers and health professionals"* (UHI3). Similarly, 4.1 *stakeholder inclusiveness* is limiting due to the limited amount of stakeholders involved in the challenge.

6. Discussion

As discussed in the introduction, cities in the U.S. are facing increasingly complex and uncertain challenges that require an IWRM and AM approach. Improving governance capacity facilitates IWRM and AM approaches, which enables effective change to find dynamic solutions to these complex challenges.

One of the challenges that U.S. cities face is an aging and deteriorating infrastructure and a lack of funding and political will to repair or replace it (Mehan, 2002; Vaux, 2015; ASCE, 2016). Through the governance capacity assessment of New York City it was found that there is a level of concern for the financial continuation of water services in the city (WS03, WWT02). As one interviewee speaking on wastewater treatment stated, "*there are concerns within the utility that future services, particularly on the wastewater and stormwater services, will be harder and harder to meet the level of service with existing rates. One of the biggest concerns is maintaining a state of good repair in existing facilities*" (WWT3). This is due to a lack of willingness to pay for water services while consumer costs for water services in the U.S. comprise on average .3% of disposable income, which is much less than residents of most other developed nations (Vaux, 2015; Duffy, 2011;WS01; WWT01; WWT02). Another interviewee explained that while there is, "*political support to allocate financial resources,* *there is a lack of public willingness to pay for increased prices*" (WS01). These findings are consistent with the literature on the state of water infrastructure in the U.S. (Vaux, 2015; Mehan, 2002; ASCE, 2016; OECD, 2005). In addition, these findings are consistent with the CBF assessments of the 6 cities in the U.S. *(table 9)*.

	Boston	New York	Milwaukee	Portland	Phoenix	Los Angeles
Operating Cost Recovery Score	1	3.4	4.2	4.8	5.2	9.1

Table 9 Operating recovery costs from the CBF of the 6 selected cities in the U.S.

With the exception of Los Angeles, all of the cities have low scores on operating cost recovery when compared to the highest and lowest 10% of cities that have been assessed with the CBF. Additionally, the water distribution system in the City of Los Angeles is over 100 years old and that the estimated costs of repair are in excess of USD$1.0 billion, while there is no transparent planning to address this problem and the source of the funding for restoration is unclear (Vaux, 2015). As the purpose of the CBF is to provide a snapshot of the IWRM performance of cities the assessment fails to identify this potential future funding crisis. Similarly, in New York City the debt obligation of the NYC DEP for drinking water and wastewater infrastructure has increased from $11.2 billion in 2002 to $29.3 billion in 2010 (Forman, 2014). As one interviewee stated, "*the long term funding exists however there are always competing interests*" (WWT01). This statement highlights that there is a certain amount of uncertainty involved in gaining long-term funding because as one interviewee stated, "*the amount of resources needed and the scope of the problem is too big. The goals are pushed farther and farther away and the process takes too long*" (WWT 03). As a result, this may lead to solutions that are not always optimal solutions but are the most economical, as one interviewee stated about the NYC DEP proposal to treat CSOs through a disinfection process without addressing the solid waste pollution that is discharged to waterways (WWT02). In order to increase the necessary capital investment the privatization of water service utilities and raising the water service rate is recommended (OECD, 2005).

In addition, U.S. cities are facing increasing environmental pressures from pollution, diminishing water supplies, urban flooding due to sea level rise and increases in extreme storm events, and urban heat. Through the TPF urban heat island was identified as a high concern or concern for 4 out of the 6 cities studied (Los Angeles, Phoenix, Milwaukee and New York City). In the governance capacity assessment of New York City the urban heat island challenge was found to be the most limiting challenge of the five identified urban water challenges. New York City experiences an average urban heat island of 4°C in summer and autumn and 3°C in winter and spring (Gedzelman et al., 2003). Heat risk is especially high for Phoenix and Los Angeles due to their locations in the arid west and is projected to become more severe with climate change. The indicators that scored the lowest in the governance capacity assessment of New York City when addressing urban heat island were monitoring, evaluation, cross-stakeholder learning and stakeholder inclusiveness. Through the assessment it was discovered that New York City did not specifically address urban heat island. However, urban heat island mitigation was included in greater climate change mitigation efforts, which are expected to have co-benefits for urban heat island mitigation. In addition, proposing urban heat island specific policy is difficult due to the lack of monitoring and evaluation. An example of this is the Cool Roofs program, which was implemented in order to reduce carbon emissions, reduce urban heat island, reduce internal building temperatures and improve air quality (The City of New York, 2016). There was no effort to monitor the effect of the cool roofs on urban heat island even though the reduction of urban heat island is listed as a co-benefit of the program. However, recently New York City has formed an Urban Heat Island Mitigation Working Group to begin to identify urban heat island specific policies and investments and recommend monitoring (ONE NYC, 2016). This is a step in the right direction according to the assessment of the governance capacity to address urban heat island. Los Angeles and Phoenix address urban heat island extensively in their sustainability plans, while Milwaukee has a comprehensive green infrastructure plan, which does not explicitly address urban heat island but is expected to have co-benefits (Los Angeles Sustainable City Plan, 2015; City of Phoenix Tree and Shade Master Plan, 2010; Refresh Milwaukee, 2013). As a result of the assessment of New York City it can be concluded that developing specific urban heat island policies by engaging and learning from stakeholders to improve the end result and monitoring and evaluating the policies are important for these cities to effectively tackle this challenge.

Water scarcity is occurring in the West and effecting Phoenix and Los Angeles. The governance indicators that were limiting for the governance capacity of New York City when addressing water scarcity were 1.2 *local sense of urgency*, indicator 3.3 *cross-stakeholder learning*, and indicator 6.2 *collaborative agents.* However, water scarcity is not a pressing issue for New York City while it is a tremendous challenge for Phoenix and Los Angeles. Public education is important for addressing water scarcity as water use declines when users know the source of their water and how much they consume (Vaux, 2015). In addition, water management in the West is managed by a maze of water agencies with unclear and conflicting goals (Lyon, 2009). Wastewater recycling and the use of tertiary wastewater treatment is high in Phoenix but can continue to be increased in Los Angeles while rationing and the inclusion of a scarcity value in the price of water encourages conservation (Vaux, 2015).

6.2 Limitations

The research gathered publicly available data from the U.N., World Bank and national, state and city governmental websites as well as from water management companies, universities, and nonprofits to calculate the trends and pressures and city blueprints. The research attempted to gather the most up-to-date data available however due to the volume of data used for this research some sources are from different years. In addition, the TPF, CBF and GCF provide a snapshot of city's IWRM and water governance but it should be noted that the IWRM and governance of a city are always changing and evolving. As mentioned previously, at the time of the study the NYC Urban Heat Island Mitigation Group was still forming under the Mayor's Office of Recovery and Resiliency and only now urban heat island is starting to be specifically addressed in public policy.

Additionally, the TPF and CBF results were presented to sustainability officers in each city to improve the validity and reliability of the results, however responses were only received from the city of Milwaukee, while all cities were alerted that no response is interpreted as agreement with the results.

Furthermore, the construction of the water scarcity indicator for the TPF, which is made up of the sub-indicators freshwater scarcity, groundwater scarcity, and seawater intrusion resulted in a lower score for the cities of Phoenix and Los Angeles. While the pressure of groundwater and freshwater scarcity is high for Phoenix there is no seawater intrusion. When the three sub-indicators were averaged to create the overall indicator score for water scarcity the result was a score of 2 or medium concern. However, this does not reflect the actual situation in Phoenix as described in the introduction. Similarly, groundwater and freshwater scarcity data for Los Angeles was used from the national level, which resulted in a lower water scarcity score then may actually be the case.

7. Conclusion

As cities throughout the world continue to grow and face ever increasing and complex water challenges as well as the uncertain consequences of climate change IWRM and AM approaches should be embraced. In order to facilitate the adoption of these approaches governance capacity must be strengthened. This research facilitates the practical application of IWRM and AM to the city level by identifying the trends and pressures facing a city, the current IWRM performances of a city and the governance capacity of a city when addressing flood risk, water scarcity, urban heat island, wastewater treatment and solid waste treatment.

The major trends and pressures for the 6 cities are urbanization and heat risk. The cities in the U.S. are categorized as *resource efficient* cities. Tertiary wastewater treatment, solid waste recycling, nutrient recovery from wastewater treatment, stormwater separation, and green space can be improved to enhance the overall IWRM performance of these cities. Developing governance capacity to improve IWRM performances and address urban water challenges is important. While there is room for improvement in all 9 governance conditions, continuous learning is the most essential governance condition to determine and improve governance capacity to address urban water challenges in New York City. Additionally, capital investment to improve tertiary wastewater treatment, solid waste recycling, nutrient recovery from wastewater treatment, stormwater separation, and green space in U.S. cities can be enhanced through the privatization of water service utilities and increases in water service rates. While the urban heat island challenge should be specifically addressed in policy and monitoring, evaluation and cross-stakeholder learning should be improved. Education, wastewater recycling, tertiary wastewater treatment and the inclusion of a scarcity value in the price of water are excellent places to start when addressing water scarcity.

The research contributes to the practical application of IWRM and AM approaches on the city level while also contributing to the development of the governance capacity framework (GCF), which is intended to improve city level decision making. In addition, the research expands the number of cities that have undergone a TPF and CBF assessment by assessing 6 cities in the U.S. This is the first application of the GCF to a city in the U.S. and an interesting opportunity for further research can take place through the application of the GCF to a city facing water scarcity such as Los Angeles or Phoenix and a comparison with the results of this research.

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Appendices

Appendix 1: Trends and Pressures

<u>Los Angeles</u>

1. Urbanization Rate
   3.6%
   Score: -0.114 3.6^2 + 1.3275*3.6+ 0.1611 = **3.46266**
   Source: http://www.census.gov/quickfacts/table/PST045215/06037

2. Burden of Disease
   Disability Adjusted Life Years (DALYS) = 22,775
   Score: **1**
   Source:
   http://gamapserver.who.int/gho/interactive_charts/mbd/as_daly_rates/atlas.html

3. Education Rate
   Primary school net enrollment rate = 95.7
   Score: -10^-5 *95.7^3 + 0.0012*95.7^2 – 0.0426*95.7+ 4.3057 = **2.45439307**
   Source: http://www.unicef.org/infobycountry/usa_statistics.html

4. Political Instability
   Political stability worldbank score 2014 = .62
   Score: 4 – (.62 - -2.5 / 2.5 - -2.5) x 4 = **1.504**
   Source: http://info.worldbank.org/governance/wgi/index.aspx#reports

5. Water Scarcity

5.1. Surface Water Scarcity
Water withdrawal as a percentage of total actual freshwater resources = 13.64
Score: **2**
Source: http://www.fao.org/nr/water/aquastat/data/query/results.html

5.2. Groundwater scarcity
The abstracted groundwater as a percentage of the annual groundwater recharge = 2-20%
Score: **1**
Source:
http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/temp/wwap_pdf/Groundwater_development_stress_GDS.pdf

5.3. Seawater Intrusion
Score: **3** (Seawater intrusion reported, significant part of groundwater supply at risk)
Source: http://pubs.usgs.gov/fs/2002/fs030-02/

6. Flood Risk

6.1. Urban Drainage Flood
Soiling sealing = 45%
Score: 45- 31.7 / 69.6 -31.7 * 5 = **1.75**
Source:
http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

6.2. Sea level rise
Percentage of city that would flood with 1 meter of sea level rise = 874 acres out of 321,920 = .27%

Score: **0**
Source: http://ssrf.climatecentral.org.s3-website-us-east-1.amazonaws.com/Buffer2/states/CA/downloads/pdf_reports/Town/CA_Los_Angeles-report.pdf

6.3. River Peak Discharges
Percentage of city that would flood with 1 meter of river level rise = 88,166 out of 2,597,120 acres in L.A. County = .33%
Score: **0**
Source:
https://dpw.lacounty.gov/WMD/NFIP/FMP/documents/ComprehensiveFloodplainManagementPlanDraft.pdf

6.4. Flood Risk due to Land Subsidence
Score: **1** subsidence experience due to oil/groundwater extraction in some areas, uplift from recharge and tectonics.
Source: http://pubs.usgs.gov/fs/fs06903/
http://waterfoundation.net/wp-content/uploads/PDF/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf

7. Water Quality

7.1. Surface Water Quality
WQI = 77.5
Score: 100-77.5 / 25 = **.9**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

7.2. Biodiversity
Water (impact on ecosystems) = 31.6
Score: 100 -31.6/25 = **2.736**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

8. Heat Risk
Number of hot days from 2071-2100: Under RCP8.5 60-80 additional extremely hot days by end of the century.
Percentage of Green/Blue area: 7.9% parks
Score: **4**

Source: http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00197.1
http://cloud.tpl.org/pubs/ccpe_Acreage_and_Employees_Data_2010.pdf

9. Economic Pressure
GDP per capita per day of Los Angeles = 77.6
Score: -.783ln(77.6) +4.115 = **.71**
Source:
http://www.census.gov/quickfacts/table/LFE305214/0644000,06037

10. Unemployment Rate
Rate of 6.3%
Score: .0002*6.3^3-.0173*6.3^2+.5077*6.3-.8356 = **1.73**
Source:
http://www.bls.gov/regions/west/summary/blssummary_losangeles.pdf

11. Poverty Rate
Score: **0**
Source:
http://data.worldbank.org/indicator/SI.POV.GAP2/countries/1W?display=default

12. Inflation Rate
Score: .0025(.119)^3 - .0744(.119)^2 + .8662(.119)+.0389 = .**14**
Source: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?view=map

Milwaukee

1. Urbanization Rate
   3.6%
   Score: -0.114 *.9^2 + 1.3275*.9+ 0.1611 = **1.26**
   Source: http://www.census.gov/quickfacts/table/PST045215/5553000

2. Burden of Disease
   Disability Adjusted Life Years (DALYS) = 22,775
   Score: **1**
   Source:
   http://gamapserver.who.int/gho/interactive_charts/mbd/as_daly_rates/atlas.html

3. Education Rate
   Primary school net enrollment rate = 95.7

Score: -10^-5 *95.7^3 + 0.0012*95.7^2 – 0.0426*95.7+ 4.3057 = **2.45439307**
Source: http://www.unicef.org/infobycountry/usa_statistics.html

4. Political Instability
   Political stability worldbank score 2014 = .62
   Score: 4 – (.62 - -2.5 / 2.5 - -2.5) x 4 = **1.504**
   Source: http://info.worldbank.org/governance/wgi/index.aspx#reports

5. Water Scarcity

5.1. Surface Water Scarcity
Water withdrawal as a percentage of total actual freshwater resources = 13.64
Score: **2**
Source: http://www.fao.org/nr/water/aquastat/data/query/results.html

5.2. Groundwater scarcity
The abstracted groundwater as a percentage of the annual groundwater recharge = 2-20%
Score: **1**
Source: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/temp/wwap_pdf/Groundwater_development_stress_GDS.pdf

5.3. Seawater Intrusion
Score: **0** City located on Lake Michigan. No risk of seawater intrusion
Source:

6. Flood Risk

6.1. Urban Drainage Flood
Soiling sealing = 45.5%
Score: 45.5- 31.7 / 69.6 -31.7 * 5 = **1.82**
Source: http://city.milwaukee.gov/ImageLibrary/Groups/cityGreenTeam/Stormwater/GIBIFINALREPORT.pdf

6.2. Sea level rise
Percentage of city that would flood with 1 meter of sea level rise =
Score: **0**
Source: Not located near the ocean.

6.3. River Peak Discharges

90 residential structures in special flood hazard area. Floodplains cover 6% of neighboring Ozaukee county.
Score: **0**
Source: http://www.co.ozaukee.wi.us/749/Major-Watersheds-Floodplains

6.4. Flood Risk due to Land Subsidence
Score: **0** Significant groundwater withdrawal but no observed subsidence
Source: http://pubs.usgs.gov/circ/circ1186/html/gw_storage.html

7. Water Quality

7.1. Surface Water Quality
WQI = 77.5
Score: 100-77.5 / 25 = **.9**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

7.2. Biodiversity
Water (impact on ecosystems) = 31.6
Score: 100 -31.6/25 = **2.736**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

8. Heat Risk
Number of hot days from 2071-2100: Now 12 days over 33 degrees and by 2055 25 days.
Percentage of Green/Blue area: 11.78% parks
25 hot days and a small percentage of park area.
Score: **3**
Source: http://www.wicci.wisc.edu/report/WICCI-Chapter-1.pdf
http://cloud.tpl.org/pubs/ccpe_Acreage_and_Employees_Data_2010.pdf

9. Economic Pressure
GDP per capita per day of Milwaukee = $53.8
Score: -.783ln(53.8) +4.115 = **.99**
Source:
http://www.census.gov/quickfacts/table/PST045215/5553000

10. Unemployment Rate
Rate of 5.5%
Score: .0002*5.5^3-.0173*5.5^2+.5077*5.5-.8356 = **1.46**

Source: http://www.bls.gov/eag/eag.wi_milwaukee_msa.htm

11. Poverty Rate
Score: **0**
Source:
http://data.worldbank.org/indicator/SI.POV.GAP2/countries/1W?display=default

12. Inflation Rate
Score: .0025(.119)^3 - .0744(.119)^2 + .8662(.119)+.0389 = **.14**
Source: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?view=map

Phoenix

1. Urbanization Rate

   8.3% population growth
   Score: -.114(8)^2 + 1.3275(8) + .1611 = **3.32**
   Source: http://www.census.gov/quickfacts/table/PST045215/0455000

2. Burden of Disease
   Disability Adjusted Life Years (DALYS) = 22,775
   Score: **1**
   Source:
   http://gamapserver.who.int/gho/interactive_charts/mbd/as_daly_rates/atlas.html

3. Education Rate
   Primary school net enrollment rate = 95.7
   Score: -10^-5 *95.7^3 + 0.0012*95.7^2 – 0.0426*95.7+ 4.3057 =
   2.45439307
   Source: http://www.unicef.org/infobycountry/usa_statistics.html

4. Political Instability
   Political stability worldbank score 2014 = .62
   Score: 4 – (.62 - -2.5 / 2.5 - -2.5) x 4 = **1.504**
   Source: http://info.worldbank.org/governance/wgi/index.aspx#reports

5. Water Scarcity

   5.1. Surface Water Scarcity
   Water withdrawal as a percentage of total actual freshwater resources =
   The Colorado river provides 59.1% of water to Arizona.
   Score: **3**

Source: Barnett, T. P., & Pierce, D. W. (2008). When will Lake Mead go dry?. *Water Resources Research*, *44*(3).
http://www.azleg.gov/briefs/senate//arizona's%20water%20supplies.pdf

5.2. Groundwater scarcity
The abstracted groundwater as a percentage of the annual groundwater recharge = water level declines of 300-500 feet
Score: **3**
Source: http://water.usgs.gov/edu/gwdepletion.html
http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/ActiveManagementAreas/Groundwater/PhoenixAMA.htm

5.3. Seawater Intrusion
Score: **0** (Phoenix is not prone to seawater intrusion)
Source:

6. Flood Risk

6.1. Urban Drainage Flood
Soiling sealing = 51-60%
Score: 55- 31.7 / 69.6 -31.7 * 5 = **3.07**
Source: http://azdhs.gov/documents/preparedness/epidemiology-disease-control/extreme-weather/heat/heat-map22.pdf

6.2. Sea level rise
Percentage of city that would flood with 1 meter of sea level rise = Not a coastal city
Score: **0**
Source:

6.3. River Peak Discharges

71,778 acres in designated floodplain out of 327,729 acres. 22%
Score: **3**
Source:
https://www.phoenix.gov/streetssite/Documents/City%20of%20Phoenix%20FMP%20Update%20Phase%201%20Secured%20Reduced%20(1).pdf

6.4. Flood Risk due to Land Subsidence

18 ft. of subsidence in some areas.
Score: **3**
Source:
http://geochange.er.usgs.gov/sw/changes/anthropogenic/subside/

7. Water Quality

7.1. Surface Water Quality
WQI = 77.5
Score: 100-77.5 / 25 = **.9**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

7.2. Biodiversity
Water (impact on ecosystems) = 31.6
Score: 100 -31.6/25 = **2.736**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

8. Heat Risk
146 days over 104 degrees Fahrenheit by 2050
Score: **4**
Source: http://www.climatecentral.org/news/sizzling-summers-20515

9. Economic Pressure
GDP per capita per day of Portland = $65.9
Score: -.783ln(65.9) +4.115 = **.85**
Source: http://www.census.gov/quickfacts/table/PST045215/0455000

10. Unemployment Rate
Rate of 5%
Score: .0002*5^3 -.0173*5^2+.5077*5 -.8356 = **1.3**
Source: http://www.bls.gov/eag/eag.az_phoenix_msa.htm

11. Poverty Rate
Score: **0**
Source:
http://data.worldbank.org/indicator/SI.POV.GAP2/countries/1W?display=default

12. Inflation Rate
Score: .0025(.119)^3 - .0744(.119)^2 + .8662(.119)+.0389 = **.14**
Source: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?view=map

Portland

1. Urbanization Rate

   8.3% population growth
   Score: -.114(8.3)^2 + 1.3275(8.3) + .1611 = **3.32**
   Source: http://www.census.gov/quickfacts/table/PST045215/4159000

2. Burden of Disease
   Disability Adjusted Life Years (DALYS) = 22,775
   Score: **1**
   Source:
   http://gamapserver.who.int/gho/interactive_charts/mbd/as_daly_rates/atlas.html

3. Education Rate
   Primary school net enrollment rate = 95.7
   Score: -10^-5 *95.7^3 + 0.0012*95.7^2 – 0.0426*95.7+ 4.3057 = **2.45439307**
   Source: http://www.unicef.org/infobycountry/usa_statistics.html

4. Political Instability
   Political stability worldbank score 2014 = .62
   Score: 4 – (.62 - -2.5 / 2.5 - -2.5) x 4 = **1.504**
   Source: http://info.worldbank.org/governance/wgi/index.aspx#reports

5. Water Scarcity

   5.1. Surface Water Scarcity
   Water withdrawal as a percentage of total actual freshwater resources = 13.64
   Score: **2**
   Source: http://www.fao.org/nr/water/aquastat/data/query/results.html

   5.2. Groundwater scarcity
   The abstracted groundwater as a percentage of the annual groundwater recharge = 2-20%
   Score: **1**
   Source:
   http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/temp/wwap_pdf/Groundwater_development_stress_GDS.pdf

   5.3. Seawater Intrusion
   Score: **0**

Source:
http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1041&context=geology_fac

6. Flood Risk

6.1. Urban Drainage Flood
Soiling sealing = 65%
Score: 65- 31.7 / 69.6 -31.7 * 5 = **4**
Source:
https://www.nrdc.org/sites/default/files/RooftopstoRivers_Portland.pdf

6.2. Sea level rise
Percentage of city that would flood with 1 meter of sea level rise =
Score: **0**
Source:
http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1041&context=geology_fac

6.3. River Peak Discharges

7,104 acres vulnerable to 100 year flood. 7.7%
Score: **1**
Source: https://www.portlandoregon.gov/pbem/article/329465

6.4. Flood Risk due to Land Subsidence

North American plate uplifting over Juan de Fuca plate currently
Score: **0**
Source: http://nas-sites.org/americasclimatechoices/videos-multimedia/sea-level-rise-for-the-coasts-of-california-oregon-and-washington/

7. Water Quality

7.1. Surface Water Quality
WQI = 77.5
Score: 100-77.5 / 25 = **.9**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

7.2. Biodiversity
Water (impact on ecosystems) = 31.6

Score: 100 -31.6/25 = **2.736**
Source:
http://www.ciesin.columbia.edu/repository/epi/data/2010EPI_country_profiles.pdf

8. Heat Risk
Number of hot days from 2071-2100: ~11
Percentage of Green/Blue area: 19.7%
Score: **2.19**
Source:
https://public.health.oregon.gov/HealthyEnvironments/climatechange/Documents/oregon-climate-and-health-profile-report.pdf
http://parkscore.tpl.org/city.php?city=Portland

9. Economic Pressure
GDP per capita per day of Portland = $88.9
Score: -.783ln(88.9) +4.115 = **.6**
Source: http://www.census.gov/quickfacts/table/PST045215/4159000

10. Unemployment Rate
Rate of 5.4%
Score: .0002*5.4^3-.0173*5.4^2+.5077*5.4-.8356 = **1.43**
Source: http://www.bls.gov/regions/west/or_portland_msa.htm

11. Poverty Rate
Score: **0**
Source:
http://data.worldbank.org/indicator/SI.POV.GAP2/countries/1W?display=default

12. Inflation Rate
Score: .0025(.119)^3 - .0744(.119)^2 + .8662(.119)+.0389 = **.14**
Source: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?view=map

Appendix 2: City Blueprints

Los Angeles

1. Water quality

1. **Secondary WWT**:
   Measure of the urban population connected to secondary waste water treatment plants. The focus on secondary treatment is chosen because

primary treatment is considered rather insufficient for BOD and nutrient removal.

Score: 10
Source: Wastewater System Fact Sheet
https://www.lacitysan.org/cs/groups/public/documents/document/mhfh/mdax/~edisp/qa001435.pdf

2. **Tertiary WWT**

   Score: 1.1
   Source: Wastewater System Fact Sheet
   https://www.lacitysan.org/cs/groups/public/documents/document/mhfh/mdax/~edisp/qa001435.pdf

3. **Groundwater quality:**
   It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater, and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical composition, and to reverse any anthropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact.

   Half of 115 groundwater production wells are unusable due to contamination
   Score: 5
   Source: Groundwater System Fact Sheet
   https://www.lacitysan.org/cs/groups/public/documents/document/mhfh/mdax/~edisp/qa001441.pdf
   https://pubs.usgs.gov/fs/2012/3096/pdf/fs20123096.pdf

2\. <u>Solid waste treatment</u>

4. **Solid waste collected:**
   Represents waste collected from households, small commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that threat or dispose of waste at the same used for municipally collected waste (OECD, 2013).

   Score: 0
   Source:
   https://dpw.lacounty.gov/epd/swims/ShowDoc.aspx?id=3473&hp=yes&type=PDF

5. **Solid waste recycled:**

This indicator represents the percentage of the total collected municipal waste that is recycled or composted. However, when solid waste is used for incineration with energy recovery, it is not possible to also use it for recycling while both practices are sustainable. Therefore the % solid waste that is incinerated is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be recycled (in numerator). Thus this indicator is calculated as shown below.

76.4 % diversion rate in 2011
Score: 7.8
Source:
http://www.forester.net/pdfs/City_of_LA_Zero_Waste_Progress_Report.pdf

6. **Solid waste energy recovered:**
   This indicator represents the percentage of the total collected municipal waste that incinerated with energy recovery (techniques). However, when solid waste is recycled or composted , it is not possible to also use it for incineration with energy recovery, while both practices are sustainable. Therefore the % solid waste that is recycled or composted is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be incinerated with energy recovery (in numerator). Thus this indicator is calculated as shown below.

   20160 tons from Commerce refuse to energy facility
   45760 tons from Southeast resource recovery facility
   Total= 59801618.0608 kg or
   65920 tons out of 3606690 tons
   Score: 2/100-76.4 X 10 = **.847**
   Source:
   http://www.forester.net/pdfs/City_of_LA_Zero_Waste_Progress_Report.pdf

3. <u>Basic water services</u>

7. **Access to drinking water:**
   The proportion of the population with access to affordable safe drinking water. A lower Indicator score is given where the percentage is lower

   Score: 9.9
   Source:
   http://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files

8. **Access to sanitation:**
   A measure of the percentage of the population covered by wastewater collection and treatment. A lower Indicator score is given where the percentage is lower.

Score: 10
Source: http://www.unicef.org/infobycountry/usa_statistics.html#115

9. **Drinking water quality:**
A measure of the level of compliance with local drinking water regulations. A lower Indicator score is given where compliance is lower.

Score: 10
Source: http://terrabellawater.com/wp-content/uploads/2014/08/LADWP-2013-Drinking-Water-Quality-Report.pdf

4. Wastewater treatment

10. **Nutrient recovery:**
Measure of the level of nutrient recovery from the wastewater system.

Score: 0
Source: https://www.lacitysan.org/san/faces/home/portal/s-lsh-wwd/s-lsh-wwd-cw/s-lsh-wwd-cw-p/s-lsh-wwd-cw-p-tp?_adf.ctrl-state=11spfxpcpx_4&_afrLoop=27562851912646113#!
https://www.lacitysan.org/san/sandocview?docname=cnt008623

11. **Energy recovery:**
Measure of energy recovery from the wastewater system.

average 275,000,000 gallons of wastewater enters Hyperion water reclamation plant on dry day.
http://www.ascelasection.org/media/centennial/WWTP_article_for_ASCE_LA_Section_Newsletter_w-photos.pdf

-4 wastewater treatment plants
-Donald Tillman = 80 million gallons a day
-Hyperion = 275 million gallons a day
-Terminal Island = 15 million
-Los Angeles-Glendale = 20 million gallons a day
275,000,000/390,000,000 X10
Score: 7.05
Source: https://www.lacitysan.org/san/faces/home/portal/s-lsh-sp/s-lsh-sp-dgup?_adf.ctrl-state=11spfxpcpx_192&_afrLoop=27563023591899839#!
https://www.lacitysan.org/san/faces/home/portal/s-lsh-es/s-lsh-es-owla?_afrLoop=27563222901644306&_afrWindowMode=0&_afrWindowId=null#!%40%40%3F_afrWindowId%3Dnull%26_afrLoop%3D27563222901644306%26_afrWindowMode%3D0%26_adf.ctrl-state%3D11spfxpcpx_315
http://www.ascelasection.org/media/centennial/WWTP_article_for_ASCE_LA_Section_Newsletter_w-photos.pdf

12. **Sewage sludge recycling:**
    A measure of the proportion of sewage sludge recycled or re-used. For example, it may be thermally processed and/or applied in agriculture.

    3 applications of biosolids in L.A. –Composting, land application and Deep well injection.
    Sludge from Tillman is processed at hyperion
    Sludge from Los Angeles- Glendale processed at Hyperion
    Hyperion=635 wet tons per day of biosolids
    Terminal Island= 35 wet tons per day of biosolids

    Score: 10
    Source: (http://suihoen.thejapanesegarden.com/new/?page_id=42)
    (http://your.kingcounty.gov/dnrp/library/wastewater/wtd/pubs/9912 Benchmarking/om-appx-d.pdf)
    https://www.lacitysan.org/san/sandocview?docname=cnt009595
    https://www.lacitysan.org/san/sandocview?docname=cnt009569

11. **Energy efficiency WWT:**
    This measure is unlikely to already have a value applied. Instead, apply a self- assessment based on the plans, measures and their implementation to improve the efficiency of wastewater treatment. Self-assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

    Biogas provides 80% of energy in Hyperion plant
    Score: 8 (plans are implemented and clearly communicated to the public plus subsidies are made available to implement the plans)
    Source: http://www.nrel.gov/docs/legosti/old/7974.pdf
    http://bpw.lacity.org/BPW_WEB_BOSYAAG_2012-2013.pdf
    The Terminal Island Renewable Energy (TIRE) Project
    https://www.lacitysan.org/san/sandocview?docname=qa001262

5. Infrastructure

14. **Stormwater separation**

1. Total length of combined sewers managed by the utility (km) A
2. Total length of stormwater sewers managed by the utility (km) B
3. Total length of sanitary sewers managed by the utility (km) C

Stormwater separate from Sewer
10782.6 km sanitary sewers
2414.016 km of stormwater sewers

Score: 10

Source: http://www.lastormwater.org/about-us/program-description/ https://www.lacitysan.org/san/faces/home/portal/s-lsh-wwd/s-lsh-wwd-cw/s-lsh-wwd-cw-s?_adf.ctrl-state=q3x2gl1i_3539&_afrLoop=27630627535281156#!

15. **Average age sewer:**
    The average age of the infrastructure is an indication of the commitment to regular system maintenance and replacement. The method compares the average age of the system to an arbitrarily maximum age of 60 years. Moreover, it is assumed that an age of <10 years receives a maximum score since younger systems generally well maintained.

Approx. 50% of pipes are more than 50 years old

Score: 2

Source: (https://www.lacitysan.org/san/faces/home/portal/s-lsh-sp/s-lsh-splawins?_afrLoop=27631447203596010&_afrWindowMode=0&_afrWindowId=null#!%40%40%3F_afrWindowId%3Dnull%26_afrLoop%3D27631447203596010%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dq3x2gl1i_3985) (http://clkrep.lacity.org/onlinedocs/2015/15-0887-S1_misc_10-6-15.pdf)

16. **Water System Leakages:**
    A measure of the percentage of water lost in the distribution system due to leaks (typically arising from poor maintenance and/or system age).

    5.2% water loss

    Score: 8.96

    Source: http://www.usbr.gov/lc/socal/reports/LADWPwaterlossaudit.pdf

17. **Operation cost recovery:**
    Measure of revenue and cost balance of operating costs of water services. A higher ratio means that there is more money available to invest in water services, e.g. infrastructure maintenance or infrastructure separation.

    Score: 9.15

    Sources: (https://controllerdata.lacity.org/dwp)

(https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-financesandreports/a-fr-reports?_adf.ctrl-state=erf7qrx3x_266&_afrLoop=66836220500170&_afrWindowMode=0&_afrWindowId=null#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D66836220500170%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dm6i4z7sa2_17)
(http://cao.lacity.org/debt/LADWP%20Credit%20Presentation%20FINAL.pdf)

6. Climate robustness

18. Green space:
Represents the share of green and blue area, which is essential to combat the heat island effect in urban areas (area defined as built-up area lying less than 200 meters apart).

13.6% park
Score: 1.2
Source: http://parkscore.tpl.org/city.php?city=Los%20Angeles

19. Climate adaptation:
This measure is unlikely to already have a value applied. Instead, apply a self-assessment of the measures and their implementation to protect citizens against flooding and water scarcity related to climate change (e.g. green roofs, rainwater harvesting, safety plans etc.). Self-assessment based on information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

Score: 9 (Annual progress reports)
Sources: (http://www.laregionalcollaborative.com/policy-plans-climate-change/)
(http://www.lamayor.org/sites/g/files/wph446/f/landing_pages/files/pLAn%20Climate%20Action-final-highres.pdf)
(http://environmentla.org/pdf/greenla_cap_2007.pdf)
(http://www.lamayor.org/plan)

20. Drinking water consumption:
Measure of the average annual consumption of water per capita. A lower Indicator score is given where the volume per person is greater.

180.999 m^3/person/year
Score: 3.9
Source: https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-water/a-w-factandfigures?_adf.ctrl-state=16jyr7zmkp_4&_afrLoop=70332954708517

21. Climate robust buildings:

A measure of whether there is a clear policy for buildings to be robust regarding their contribution to climate change concerns (principally energy use). A lower Indicator score is given where policies are weaker.

Score: 8 (progress report on national and state levels, stricter efficiency standards for county than California.)
Sources: (http://energy.gov/eere/better-buildings-neighborhood-program/los-angeles-county-california)
(http://database.aceee.org/city/los-angeles-ca)
(http://green.lacounty.gov/wps/portal/green)

7. Governance

22. Management and action plans:
A measure of the application of the concept of Integrated Water Resources Management (IWRM) in the city. A lower Indicator score is given where plans and actions are limited.

Score: 8 (plans are clearly implemented, funded and communicated to the public)
Sources:
(http://www.ladpw.org/wmd/irwmp/index.cfm?fuseaction=update2013)
(Regional plan for IWRM)
(http://www.lamayor.org/sites/g/files/wph446/f/landing_pages/files/Plan-annual%20update-online.pdf)
Mayor's sustainability plan

23. Public participation:
From worldbank rule of law indicator

Score: 6.6
Source: http://data.worldbank.org/data-catalog/worldwide-governance-indicators

24. Water efficiency measures

Score: 8 (clear city plan and funding. No progress reports yet. LA County plans too)
Source:
http://www.lamayor.org/sites/g/files/wph446/f/landing_pages/files/Plan-annual%20update-online.pdf

25. Attractiveness:

A measure of how surface water features are contributing to the attractiveness of the city and wellbeing of its inhabitants. A lower Indicator score is given where 'attractiveness' is less.

Score: 9 (extremely high property values on the ocean)

Milwaukee

1. Water quality

4. **Secondary WWT**: Measure of the urban population connected to secondary waste water treatment plants. The focus on secondary treatment is chosen because primary treatment is considered rather insufficient for BOD and nutrient removal.
   Score: 99.59/10 = **9.959**
   Source: http://www.mmsd.com/wastewatertreatment/treatment-process
   http://www.mmsd.com/weather/weather-center/volume-treated-data

5. **Tertiary WWT**
   Chlorination but no tertiary treatment
   Score: 0/10 = **0**
   Source: http://www.mmsd.com/wastewatertreatment/treatment-process

6. **Groundwater quality**
   It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater, and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical composition, and to reverse any anthropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact.
   100% of sampled wells met health standard
   Score: 10
   Source: http://wi.water.usgs.gov/gwcomp/find/milwaukee/

2. Solid waste treatment

7. **Solid waste collected** Represents waste collected from households, small commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that threat or dispose of waste at the same used for municipally collected waste (OECD, 2013).

Municipal solid waste produced per person per year in Wisconsin = 738.4 kg
Score: 738.4-136.4/ 842.4-136.4 = **1.5**
Source: http://dnr.wi.gov/files/PDF/pubs/wa/WA418.pdf

8. **Solid waste recycled** This indicator represents the percentage of the total collected municipal waste that is recycled or composted. However, when solid waste is used for incineration with energy recovery, it is not possible to also use it for recycling while both practices are sustainable. Therefore the % solid waste that is incinerated is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be recycled (in numerator). Thus this indicator is calculated as shown below.

   Diversion rate: 24.9% in 2014
   Score: 24.9/100 * 10 = **2.49**
   Source:
   http://city.milwaukee.gov/ImageLibrary/MilwaukeeRecycles/PDFs/Media-Room/2014AnnualReport.pdf

9. **Solid waste energy recovered** This indicator represents the percentage of the total collected municipal waste that incinerated with energy recovery (techniques). However, when solid waste is recycled or composted , it is not possible to also use it for incineration with energy recovery, while both practices are sustainable. Therefore the % solid waste that is recycled or composted is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be incinerated with energy recovery (in numerator). Thus this indicator is calculated as shown below.
   No solid waste incineration in Milwaukee
   Score: 0
   Source: http://energyrecoverycouncil.org/wp-content/uploads/2016/01/ERC_2014_Directory.pdf

3. <u>Basic water services</u>

10. **Access to drinking water** The proportion of the population with access to affordable safe drinking water. A lower Indicator score is given where the percentage is lower
    Based on UNICEF statistics access to improved drinking water sources
    USA urban areas= 99.8
    Score: 98.8/10 = **9.98**
    Source: http://www.unicef.org/infobycountry/usa_statistics.html#115

11. **Access to sanitation** A measure of the percentage of the population covered by wastewater collection and treatment. A lower Indicator score is given where the percentage is lower.
    Based on UNICEF statistics use of improved sanitation facilities

USA urban areas= 99.8
Score: 99.8/10 = **9.98**
Source: http://www.unicef.org/infobycountry/usa_statistics.html#115

12. **Drinking water quality** A measure of the level of compliance with local drinking water regulations. A lower Indicator score is given where compliance is lower.

    Score: 10
    Source:
    http://www.milwaukee.gov/ImageLibrary/Groups/healthAuthors/DCP/PDFs/MWWWaterQltyRpt07.pdf

7. Wastewater treatment
   http://www.mmsd.com/weather/weather-center
http://legis.wisconsin.gov/lab/reports/02-12full.pdf

13. **Nutrient recovery** Measure of the level of nutrient recovery from the wastewater system.
    No evidence of nutrient recovery
    Score: 0

14. **Energy recovery**
    http://www.wrrfdata.org/biogas/biogasdata.php
    Energy recovery at South Shore Reclamation Facility provides 65% of energy needed for facility. (http://www.mmsd.com/mmsd-news/may-be-time-for-mmsd-to-unplug-from-we-energies)
    Score: 4.97
    Source: http://www.mmsd.com/about/facilities

15. **Sewage sludge recycling** A measure of the proportion of sewage sludge recycled or re-used. For example, it may be thermally processed and/or applied in agriculture.

    98% of all biosolids produced used to make Milorganite fertilizer.
    Score= 26,375,720,00/26,914,000,000 * 99.59/100 * 10 = **9.8**

    Source:
    http://www.the-netherlands.org/binaries/content/assets/postenweb/v/verenigde_staten_van_amerika/the-royal-netherlands-embassy-in-washington-dc/import/news/wetskills-2015-presentations/new-biosolids.pdf
    http://www.mmsd.com/weather/weather-center/volume-treated-data

16. **Energy efficiency WWT**
This measure is unlikely to already have a value applied. Instead, apply a self-assessment based on the plans, measures and their implementation to improve the efficiency of wastewater treatment. Self-assessment based on

information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).
Score: 8 Plans are being implementing and funding is available. MMSD 2035 vision meet 100% of energy needs with renewable sources.
Source: http://www.mmsd.com/-/media/MMSD/Documents/Sustainability/MMSD%202035%20Vision.pdf

5. <u>Infrastructure</u>

14. **Stormwater separation**

4. Total length of combined sewers managed by the utility (km) A
5. Total length of stormwater sewers managed by the utility (km) B
6. Total length of sanitary sewers managed by the utility (km) C

MMSD operates 300 miles of sewer, combined sewers 5% of total service area. City of Milwaukee operates 2,446 miles of sewer of which 965.9 is stormwater sewer. (http://www.fwwa.org/wp-content/uploads/2016/03/City-of-Milwaukee-EPA-Audit-Experience.pdf)
(http://city.milwaukee.gov/commoncouncil/District10/Stormwater-and-Sewer-Capacity.htm#.V9vzvztB_ww)
(http://city.milwaukee.gov/mpw/general/About.htm#.V9v95ztB_wx)

City of Milwaukee 1480 miles of combined sewers connect to MMSD regional sewer.
Score: 965.9/ 965.9 + 1480 * 10 = **3.9**

18. **Average age sewer**

Age of laterals: http://www.mmsd.com/-/media/MMSD/Documents/Rules%20and%20Regs/Private%20Property%20I%20and%20I/La%20Follette%20Study.pdf

Score: 60 - 43.77/ 60 – 10 x 10 = **3.25**
Source:
http://www.caee.utexas.edu/prof/maidment/giswr2012/TermPaper/Boersma.pdf

16. Water System Leakages

A measure of the percentage of water lost in the distribution system due to leaks

Score: 50-17/50-0 x 10 = **6.2**
Source:
http://psc.wi.gov/utilityInfo/water/document/waterLoss/pilotTrainingReport.pdf

17. Operation cost recovery

Measure of revenue and cost balance of operating costs of water services. A higher ratio means that there is more money available to invest in water services, e.g. infrastructure maintenance or infrastructure separation.

Operating cost recovery = 1.18
Score: 1.18-.33/2.34-.33 x 10 = **4.23**
Sources: MMSD operating costs (http://www.mmsd.com/-/media/MMSD/Documents/Financial/budgets/2014BudgetFINAL.pdf)
Milwaukee water works operating costs (http://milwaukee.gov/ImageLibrary/Groups/WaterWorks/files/MilwaukeeWaterWorks-FinancialS.pdf)

7. <u>Climate robustness</u>

18. Green space

Land area= 59,126 acres Park area = 5,143 acres = 8.7%
Score: 8.7-8.7/48-8.7 x 10 = **0**
City Park Facts Source: http://parkscore.tpl.org/city.php?city=Milwaukee

19. Climate adaptation

This measure is unlikely to already have a value applied. Instead, apply a self-assessment of the measures and their implementation to protect citizens against flooding and water scarcity related to climate change (e.g. green roofs, rainwater harvesting, safety plans etc.). Self-assessment based on information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

MMSD funding for green seams green infrastructure. Sustainable water reclamation plan
Score: 8
Source:
http://www.mmsd.com/-/media/MMSD/Documents/Sustainability/Sustainability%20Plan.pdf
http://city.milwaukee.gov/ImageLibrary/Groups/WaterWorks/files/EnvironmentalStewardship

20. Drinking water consumption

Measure of the average annual consumption of water per capita. A lower Indicator score is given where the volume per person is greater.
93 gallons per person/per day = 0.352043296 m^3/day x 365 days = 128.5 m^3/person/year
Score: (1-83.3/220.8) x 10 = **6.23**
Source:
http://city.milwaukee.gov/ImageLibrary/Groups/WaterWorks/files/EnvironmentalStewardship

21. Climate robust buildings

A measure of whether there is a clear policy for buildings to be robust regarding their contribution to climate change concerns (principally energy use). A lower Indicator score is given where policies are weaker.

Milwaukee energy efficiency program. Annual reports produced.
Score: 9
Source: http://city.milwaukee.gov/ImageLibrary/Groups/cityGreenTeam/documents/ReFresh2014AnnualReport.pdf

7. Governance

22. Management and action plans

A measure of the application of the concept of Integrated Water Resources Management (IWRM) in the city. A lower Indicator score is given where plans and actions are limited.

IWRM plans are implemented.
Score: 8
Source: http://www.mmsd.com/-/media/MMSD/Documents/Sustainability/MMSD%202035%20Vision.pdf

23. Public participation

From worldbank rule of law indicator
Score: 36.8-5/53-5 x 10 = **6.6**
Source: http://data.worldbank.org/data-catalog/worldwide-governance-indicators

24. Water efficiency measures

Refresh MKE program. Promoting water efficiency.
Score: 8
Source: http://www.refreshmke.com/water_strategies.html

25. Attractiveness

Milwaukee Riverwalk and Lake Michigan are main features of the urban area. Named the 15th most walkable city in the U.S. by Walk Score.
Score: 7
Water is a major feature of the city. Higher property values along lakefront.

Phoenix

1. Water quality

8. Secondary WWT:

Measure of the urban population connected to secondary waste water treatment plants. The focus on secondary treatment is chosen because primary treatment is considered rather insufficient for BOD and nutrient removal.

Score: 10
Source:
https://www.phoenix.gov/waterservicessite/Documents/d_046894.pdf

9. **Tertiary WWT**
82% of treated wastewater is reused.
Score: 10
Source:
https://www.phoenix.gov/waterservicessite/Documents/d_046894.pdf
https://www.phoenix.gov/waterservicessite/Documents/2014%20IPP%20Annual%20Report.pdf#search=91st%20ave%2E%20wastewater%20treatment%20plant
https://www3.epa.gov/region9/water/npdes/pdf/az/phoenix/91st-Ave-fact-sheet.pdf

10. **Groundwater quality:**
It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater, and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical composition, and to reverse any anthropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact.

Groundwater comprises 43% of Arizona's annual water use
Score: 1018/(1018+459) x 10 = **6.89**
Source:
https://legacy.azdeq.gov/environ/water/assessment/download/1104ofr.pdf

2. <u>Solid waste treatment</u>

10. **Solid waste collected:**
Represents waste collected from households, small commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that threat or dispose of waste at the same used for municipally collected waste (OECD, 2013).
483.53 kg/person/year
Score: (1-483.5-136.4/842.4-136.4) x 10 **=5.1**
Source:
https://www.azmag.gov/Documents/pdf/cms.resource/SWPlan26455.pdf

11. **Solid waste recycled:**
This indicator represents the percentage of the total collected municipal waste that is recycled or composted. However, when solid waste is used for incineration with energy recovery, it is not possible to also use it for recycling while both practices are sustainable. Therefore the % solid waste that is incinerated is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be recycled (in numerator). Thus this indicator is calculated as shown below.

20% diversion rate
Score: 2
Source:
https://legacy.azdeq.gov/environ/waste/solid/download/2014_municipal_recycling.pdf
http://www.azcentral.com/story/news/local/phoenix/2015/09/18/phoenix-arizona-recycling-behind-nation-average/72408854/

12. **Solid waste energy recovered:**
This indicator represents the percentage of the total collected municipal waste that incinerated with energy recovery (techniques). However, when solid waste is recycled or composted , it is not possible to also use it for incineration with energy recovery, while both practices are sustainable. Therefore the % solid waste that is recycled or composted is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be incinerated with energy recovery (in numerator). Thus this indicator is calculated as shown below.

No waste combustion is planned
Score: 0
Source:
https://www.azmag.gov/Documents/pdf/cms.resource/SWPlan26455.pdf

3. Basic water services

13. **Access to drinking water:**
The proportion of the population with access to affordable safe drinking water. A lower Indicator score is given where the percentage is lower

Score: 9.9
Source:
http://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files

14. **Access to sanitation:**
A measure of the percentage of the population covered by wastewater collection and treatment. A lower Indicator score is given where the percentage is lower.

Score: **10**
Source: http://www.unicef.org/infobycountry/usa_statistics.html#115

15. Drinking water quality:
A measure of the level of compliance with local drinking water regulations. A lower Indicator score is given where compliance is lower.

Score: 10
Source:
https://www.phoenix.gov/waterservicessite/Documents/wsdprimarywqr.pdf

4. Wastewater treatment

16. Nutrient recovery:
Measure of the level of nutrient recovery from the wastewater system.

No nutrient recovery
Score: 0
Source:
https://www.phoenix.gov/waterservicessite/Documents/2014%20IPP%20Annual%20Report.pdf#search=91st%20ave%2E%20wastewater%20treatment%20plant

17. Energy recovery:
Measure of energy recovery from the wastewater system.
Biogas energy recovery is still in development. 91st ave. renewable biogas project.
Score: 0
Source: https://www.phoenix.gov/waterservicessite/Documents/d_046894.pdf

18. Sewage sludge recycling:
A measure of the proportion of sewage sludge recycled or re-used. For example, it may be thermally processed and/or applied in agriculture.

23rd ave. WWTP = 8692 dry tons, 91st ave. WWTP = 41025 dry tons
Score: 10
Source: http://legacy.azdeq.gov/environ/water/permits/download/bioprog.pdf

19. Energy efficiency WWT
This measure is unlikely to already have a value applied. Instead, apply a self-assessment based on the plans, measures and their implementation to improve the efficiency of wastewater treatment. Self-assessment based on information from public sources (national/regional/local policy document, reports and

websites of actors (e.g. water companies, cities, provincial or national authorities).

Use of solar energy for sludge dewatering. 22% of reclaimed wastewater produced by 91st ave. WWTP used in cooling towers of Palo Verde Nuclear Generating Station, which serves 4 million people.

Score: 8

Source:
https://www.phoenix.gov/waterservicessite/Documents/d_046894.pdf
https://s3-us-west-2.amazonaws.com/gios-web-img-docs/docs/dcdc/website/documents/DCDC_WaterReuse_Final.pdf
https://www.phoenix.gov/oepsite/Documents/d_026991.pdf

5. Infrastructure

14. **Stormwater separation:**

7. Total length of combined sewers managed by the utility (km) A
8. Total length of stormwater sewers managed by the utility (km) B
9. Total length of sanitary sewers managed by the utility (km) C

Separate storm water and sanitary sewers. 4,980 miles of sanitary sewer.

Score: 10

Source:
Source: https://www.phoenix.gov/waterservicessite/Documents/d_046894.pdf
https://www.phoenix.gov/waterservices/envservices/stormwater-program

19. **Average age sewer:**

The average age of the infrastructure is an indication of the commitment to regular system maintenance and replacement. The method compares the average age of the system to an arbitrarily maximum age of 60 years. Moreover, it is assumed that an age of <10 years receives a maximum score since younger systems generally well maintained.

"Many of the largest sewers in the metropolitan Phoenix and Tucson areas were constructed in the 1950s, 60s and 70s. Although these lines might otherwise have been expected to last as long as 100 years, due to the challenging conditions in our climate these pipes cannot be expected to last more than 50 years."

Score: 60-50/60-10 **= 2** (Based on average construction date)
Source: http://www.infrastructurereportcard.org/wp-content/uploads/2015/05/AZ-Report-Card-5.13.15-FINALWEB2.pdf

20. **Water System Leakages:**

A measure of the percentage of water lost in the distribution system due to leaks
(typically arising from poor maintenance and/or system age).

6.8% real loss
Score: 50-6.8/50-0 * 10 = **8.64**
Source:
http://www.azwater.gov/AzDWR/WaterManagement/AMAs/documents/AndyTerrey.pdf

21. **Operation cost recovery:**
Measure of revenue and cost balance of operating costs of water services. A higher ratio means that there is more money available to invest in water services, e.g. infrastructure maintenance or infrastructure separation.

Operating cost recovery ratio = 841,368,000/615,504,000 = **1.37**
Score: 5.17
Source:
https://www.phoenix.gov/budgetsite/Budget%20Books/Summary%20Budget%202015-16.pdf

8. <u>Climate robustness</u>
18. Green space:
Represents the share of green and blue area, which is essential to combat the heat island effect in urban areas (area defined as built-up area lying less than 200 meters apart).

Park space = 15%
Score: 1(15 – 8.7 /48 – 8.7) x 10 = **1.6**
Source:
http://parkscore.tpl.org/city.php?city=Phoenix

19. Climate adaptation:
This measure is unlikely to already have a value applied. Instead, apply a self-assessment of the measures and their implementation to protect citizens against flooding and water scarcity related to climate change (e.g. green roofs, rainwater harvesting, safety plans etc.). Self-assessment based on information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

Tree and Shade Master Plan, Green Infrastructure Plan,

Score: 8 (plans are implemented and funds are available)
Source: https://www.phoenix.gov/Documents/107504.pdf
https://www.phoenix.gov/parkssite/Documents/071957.pdf
https://www.phoenix.gov/oepsite/Documents/d_026991.pdf

20. Drinking water consumption
Measure of the average annual consumption of water per capita. A lower Indicator score is given where the volume per person is greater.

138.17 cubic meters person/year
Score: (1- 138.17 – 45.2/ 266 – 45.2) x 10 = **5.8**
Source:
http://www.azwater.gov/AzDWR/StatewidePlanning/Conservation2/Residential/Residential_Home2.htm

21. Climate robust buildings:
A measure of whether there is a clear policy for buildings to be robust regarding their contribution to climate change concerns (principally energy use). A lower Indicator score is given where policies are weaker.

Climate action plan. Energy efficiency measures, encouragement of renewables and less energy consumption. Yearly progress reports.

Phoenix green building program
Score: 7 (Plans are implemented and clearly communicated to the public)
Source: https://www.phoenix.gov/sustainability/energy

7. <u>Governance</u>

22. Management and action plans
A measure of the application of the concept of Integrated Water Resources Management (IWRM) in the city. A lower Indicator score is given where plans and actions are limited.

Score: 8 (The city takes an integrated approach (wastewater reclamation, Tres Rios wetlands)
Source: https://www.phoenix.gov/sustainability/water

23. Public participation:
From worldbank rule of law indicator

Score: 36.8-5/53-5 x 10 = **6.6**
Source: http://data.worldbank.org/data-catalog/worldwide-governance-indicators

24. Water efficiency measures:
Water management and conservation plan and 5 year progress report.
Score: 8
Source:
https://www.phoenix.gov/waterservicessite/Documents/wsd2011wrp.pdf
https://www.phoenix.gov/waterservicessite/Documents/wsd2011wrp.pdf

25. Attractiveness:
A measure of how surface water features are contributing to the attractiveness of the city and wellbeing of its inhabitants. A lower Indicator score is given where 'attractiveness' is less.

There is very little surface water in the City of Phoenix unless you are taking into account swimming pools.
Score: 0
Source:

Portland

1. Water quality

11. Secondary WWT:
Measure of the urban population connected to secondary waste water treatment plants. The focus on secondary treatment is chosen because primary treatment is considered rather insufficient for BOD and nutrient removal.

Columbia Boulevard service population = 587,865
Tryon Creek service population = 70,000
100% of population connected to secondary wastewater treatment.
Score: 10
Source: http://www.deq.state.or.us/wqpr/787_2009121100003CS01.PDF
https://www.portlandoregon.gov/bes/article/477066

12. Tertiary WWT

No tertiary WWT.
Score: 0
Source: http://www.deq.state.or.us/wqpr/787_2009121100003CS01.PDF
https://www.portlandoregon.gov/bes/article/477066

13. Groundwater quality:
It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater, and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical

composition, and to reverse any anthropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact.

Score: 10
Source: http://www.portlandoregon.gov/water/article/344756
https://www.portlandoregon.gov/water/article/546510

2. Solid waste treatment

13. **Solid waste collected:**
Represents waste collected from households, small commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that threat or dispose of waste at the same used for municipally collected waste (OECD, 2013).

1,079,500 tons collected in 2015. Population of 632,000 as of 2015.
1,549.64 kg/ person/year
Score: 0
Source: https://www.portlandoregon.gov/bps/article/496027

14. **Solid waste recycled:**
This indicator represents the percentage of the total collected municipal waste that is recycled or composted. However, when solid waste is used for incineration with energy recovery, it is not possible to also use it for recycling while both practices are sustainable. Therefore the % solid waste that is incinerated is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be recycled (in numerator). Thus this indicator is calculated as shown below.
70% recycling rate in Portland.
Score: 70/100 = 7
Source: https://www.portlandoregon.gov/bps/article/496027

15. **Solid waste energy recovered:**
This indicator represents the percentage of the total collected municipal waste that incinerated with energy recovery (techniques). However, when solid waste is recycled or composted , it is not possible to also use it for incineration with energy recovery, while both practices are sustainable. Therefore the % solid waste that is recycled or composted is subtracted from the total (100%) of collected municipal waste to obtain the potential percentage of solid waste that can be incinerated with energy recovery (in numerator). Thus this indicator is calculated as shown below.
There is 0% solid waste incineration in Portland. However, incineration is being considered as an option
Score: 0
Source: http://www.oregonmetro.gov/news/powering-homes-garbage

3. Basic water services

17. Access to drinking water:

The proportion of the population with access to affordable safe drinking water. A lower Indicator score is given where the percentage is lower

Score: 9.9

Source: http://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files

18. Access to sanitation:

A measure of the percentage of the population covered by wastewater collection and treatment. A lower Indicator score is given where the percentage is lower.

Score: 10

Source: http://www.unicef.org/infobycountry/usa_statistics.html#115

19. Drinking water quality:

A measure of the level of compliance with local drinking water regulations. A lower Indicator score is given where compliance is lower.

Score: 10

Source: http://www.portlandoregon.gov/water/article/244813

4. Wastewater treatment

20. Nutrient recovery:

Measure of the level of nutrient recovery from the wastewater system.
No nutrient recovery from WWT.

Score: 0

Source: https://www.portlandoregon.gov/bes/article/40669

20. Energy recovery:

Measure of energy recovery from the wastewater system.

Biogas production at the Columbia Boulevard Wastewater Treatment Plant. Supplies 40% of plants electricity needs. Another 20% is sold for industrial use.

Score: 9.3

Source: https://www.portlandoregon.gov/bes/article/344953

21. Sewage sludge recycling:

A measure of the proportion of sewage sludge recycled or re-used. For example, it may be thermally processed and/or applied in agriculture.

Portland no longer landfills sludge.
Score: 10
Source: https://www.portlandoregon.gov/bes/article/41872
https://www.clackamas.edu/uploadedFiles/Departments/Water_and_Environmental_Technology/Water_Environment_School/Content/BIOSOLIDS%20101%20ROADMAP%20OF%20OREGONS%20BIOSOLIDS%20PROGRAM.pdf

22. **Energy efficiency WWT:**
This measure is unlikely to already have a value applied. Instead, apply a self- assessment based on the plans, measures and their implementation to improve the efficiency of wastewater treatment. Self-assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

City of Portland Energy Challenge Plan. Plan to cut energy use in city operations. 10 year report. Columbia Boulevard WWT 40% biogas.
Score: 8
Source: https://www.portlandoregon.gov/bps/article/431300
https://www.portlandoregon.gov/bps/article/437757

5. <u>Infrastructure</u>

14. Stormwater separation

10. Total length of combined sewers managed by the utility (km) A
11. Total length of stormwater sewers managed by the utility (km) B
12. Total length of sanitary sewers managed by the utility (km) C

2,500 miles of sewer. Much of Portland is combined sewers.
22,000 acres of Portland served by separate storm sewer system out of total of 92,800 acres.
Score: 22,000/92,800 = **2.37**
Source: http://www.portlandonline.com/portlandplan/?a=298496&
https://www.portlandoregon.gov/bes/article/41962
(http://www.deq.state.or.us/wq/wqpermit/docs/individual/npdes/ph1ms4/portland/PortlandGroupPermitEvalReport20110131.pdf)

22. **Average age sewer:**
The average age of the infrastructure is an indication of the commitment to regular system maintenance and replacement. The method compares the average age of the system to an arbitrarily maximum age of 60 years.

Moreover, it is assumed that an age of <10 years receives a maximum score since younger systems generally well maintained.

Score:
Source: https://www.portlandoregon.gov/bes/34598
Over 1/3 of 2,500 miles of sewer pipes are more than 80 years old
https://www.portlandoregon.gov/bes/article/487721
https://www.portlandoregon.gov/bes/article/506931

23. **Water System Leakages**
    A measure of the percentage of water lost in the distribution system due to leaks (typically arising from poor maintenance and/or system age).

    6%
    Score: 8.8
    Source: https://www.portlandoregon.gov/water/article/179529

24. **Operation cost recovery**
    Measure of revenue and cost balance of operating costs of water services. A higher ratio means that there is more money available to invest in water services, e.g. infrastructure maintenance or infrastructure separation.

    Operating cost recovery ratio = 1.29
    Score: 4.8
    Source: https://www.portlandoregon.gov/brfs/article/555505

9. Climate robustness

18. Green space:
Represents the share of green and blue area, which is essential to combat the heat island effect in urban areas (area defined as built-up area lying less than 200 meters apart).

17.8% Park area + Williamette river area (~1664 acres) = 19.7% blue/green area
Score: 1(19.7 – 8.7 /48 – 8.7) x 10 = **2.8**
Source:
https://www.portlandoregon.gov/cbo/article/394819
http://parkscore.tpl.org/city.php?city=Portland
https://www.portlandoregon.gov/parks/article/422533

19. Climate adaptation:
This measure is unlikely to already have a value applied. Instead, apply a self-assessment of the measures and their implementation to protect citizens against flooding and water scarcity related to climate change (e.g. green roofs, rainwater harvesting, safety plans etc.). Self-assessment based on

information from public sources (national / regional / local policy document, reports and websites of actors (e.g. water companies, cities, provincial or national authorities).

Green infrastructure plan, EcoRoofs, Portland Climate Action Plan.
Score: 8
Source: https://www.portlandoregon.gov/bps/article/531984

20. Drinking water consumption:
Measure of the average annual consumption of water per capita. A lower Indicator score is given where the volume per person is greater.

132.5 cubic meters person/year
Score: 6
Source: https://www.portlandoregon.gov/water/article/554344

21. Climate robust buildings :
A measure of whether there is a clear policy for buildings to be robust regarding their contribution to climate change concerns (principally energy use). A lower Indicator score is given where policies are weaker.

Climate action plan. Energy efficiency measures, encouragement of renewables and less energy consumption. Yearly progress reports.
Score: 9
Source: https://www.portlandoregon.gov/bps/article/531984

7. Governance

22. Management and action plans:
A measure of the application of the concept of Integrated Water Resources Management (IWRM) in the city. A lower Indicator score is given where plans and actions are limited.

IWRM plans on the state level are being implemented. City of Portland has a watershed management plan.
Score: 8
Source:
https://www.oregon.gov/owrd/LAW/docs/IWRS_Executive_Summary_Final.pdf
https://www.portlandoregon.gov/bes/article/107808

23. Public participation:
From worldbank rule of law indicator

Score: 36.8-5/53-5 x 10 = **6.6**

Source: http://data.worldbank.org/data-catalog/worldwide-governance-indicators

24. Water efficiency measures:
Measure of the application of water efficiency measures by the range of water users across the city. A lower Indicator score is given where efficiency measures are more limited.

Water management and conservation plan and 5 year progress report.
Score: 9
Source: http://www.portlandoregon.gov/water/article/179529
http://www.portlandoregon.gov/water/article/532131

25. Attractiveness
A measure of how surface water features are contributing to the attractiveness of the city and wellbeing of its inhabitants. A lower Indicator score is given where 'attractiveness' is less.

Score: 9
Source: http://www.pdc.us/our-work/urban-renewal-areas/downtown-waterfront/overview.aspx

Appendix 3: Stakeholder Analyses of the Five Urban Water Challenges

Flood Risk			
Stakeholders	**Role**	**Influence**	**Interest**
Formal Actors			
USACE (National)	Main regulatory agency - regulating its navigable waterways, implementing local public works projects, and protecting against flood risks, all as authorized by Congress	High	High
FEMA (National)	Insurance	High	High
NYSDEC (State)	Flood Plain Mangement Plans	High	High

NYC Dept. of City Planning	*Resilient Neighborhoods, Retrofitting Buildings for Flood Risk Design Manual,* Zoning	High	High
City Planning Commission	Enacts zoning, reviews land use, and is the local administrator of the Waterfront Revitalization Program, a State program required under the Coastal Zone Management	High	High
NYC Dept. of Small Business Services	Oversees waterfront construction activity through its dockmaster and waterfront permit units	High	High
NYC Mayor's Office of Recovery and Resiliency	PlaNYC	High	High
NYC Dept. of Buildings	Floodplain Administrator and is tasked with enforcing Appendix G of the NYC Building Code, which prescribes standards for flood-resistant construction in accordance with federal mandates	High	High
NYC Dept. of Environmental Protection	Stormwater mgmt./Wastewater Resiliency Plan	High	High
Assisting Actors			
NYS Department of Health	Community preparedness	Low	High
Alliance for Downtown New York	nonprofit organization representing business and property owners in Lower Manhattan	Medium	High
Rockefeller Foundation	Knowledge & Funding	Medium	High
Nature Conservancy	Knowledge	Medium	High
Metropolitan Waterfront Alliance	Knowledge	Medium	High
NYC environmental justice alliance	Advocacy	Medium	High
The Earth Institute	Knowledge	Medium	High
Interest Groups			
Underprivileged Coastal Communities	Directly affected by flooding	Low	High

The Elderly	Directly affected by flooding	Low	High

Urban Heat Island			
Stakeholders	**Role**	**Influence**	**Interest**
Formal Actors			
Mayor's Office of Recovery and Resiliency	PlaNYC	High	High
NYC Dept. of City Planning	Zoning, Planning	High	High
NYC Dept. of Transportation	Permeable Pavements	High	High
NYC Dept. of Buildings	Cool Roofs	High	High
NYC Dept. of Environmental Protection	Green Infrastructure Program - to reduce runoff also reduces UHI	High	High
NYC Dept. of Parks and Recreation	MillionTrees NYC, Planning	High	High
Assisting Actors			
NYC Office of Emergency Management	Education "Beat the Heat"	Low	High
NYC Dept. of Health and Mental Hygiene	Education	Low	High
EPA	Knowledge	High	Low
Energy Companies (Con Edison/PSEG)	Financing	High	High
Earth Institute	Knowledge	Medium	High
Institute for Social and Economic Research	Cool City Project	Medium	High

Cool Roofs Corporate Sponsors	Financing	High	High
Interest Groups			
Elderly People	Disproportionately affected by heat	Low	High
Underprivileged Communities	Disproportionately affected by heat	Low	High

Water Scarcity			
Stakeholders	**Role**	**Influence**	**Interest**
Formal Actors			
NYSDEC (State)	water withdrawal permits/water conservation requirements)	High	High
NYC Dept. of Environmental Protection	manages water supply, Water Demand Management Plan	High	High
NYC Dept. of Plumbing	Plumbing Code	High	High
New York City Municipal Water Finance Authority	Financing	High	High
Assisting Actors			
Con Edison	WaterSense Program, promote efficiency	Medium	High
EPA	WaterSense Program	Medium	High
RiverKeeper	Advocacy	Medium	High
Interest Groups			

Underprivileged Communities	Less access to water	Low	High
Debilitated Individuals	More susceptible to dehydration/ chronic respiratory illness	Low	High

Waste Water Treatment			
Stakeholders	**Role**	**Influence**	**Interest**
Formal Actors			
EPA (National)	Clean Water Act	High	High
NYSDEC (State)	Responsible for the regulatory aspects of the program and approval of renewal training courses	High	High
New York Water Environment Association (State)	Administers operator certification and certificate renewal	High	High
New York State Environmental Facilities Corporation (State)	Financing for new water and wastewater infrastructure	High	High
NYC Dept. of Environmental Protection	Operates Waste Water Treatment System, Financing	High	High
New York City Municipal Water Finance Authority	Financing	High	High
Mayor's Office of Recovery and Resiliency	PlanNYC (NYC Green Infrastructure Plan)	High	High
Assisting Actors			
RiverKeeper	Education, Reporting	Medium	High
The Bronx River Alliance	Education, Green Infrastructure Plan	Medium	High
Hudson River Foundation	Education, funding for restoration, research to inform policy	Medium	High
Interest Groups			

Recreational users of NYC waterways	Want clean water for recreation	Low	High
Fishermen	Depend on water for livelihood	Low	High
Underprivileged Individuals	Rely on fish for sustenance	Low	High

Solid Waste Management			
Stakeholders	**Role**	**Influence**	**Interest**
Formal Actors			
EPA (National)	Resource Conservation and Recovery Act	High	High
NYSDEC	State Solid Waste Management Plan	High	High
New York City Department of Sanitation	Collects residential and institutional waste. Local Solid Waste Management Plan	High	High
Business Integrity Commission	Licenses Private Waste Companies	High	High
Mayor's Office of Recovery and Resiliency	PlanNYC Solid Waste	High	High
Assisting Actors			
GrowNYC	Recycling education/outreach	Medium	High
Interest Groups			
Marginalized communities	Live closer to waste disposal	Low	High
Park users	Want clean living environment	Low	High
Debilitated Individuals	Pollution from trucks increases chronic respiratory illness	Low	High