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Water Scarcity Management in the Context of Urban Climate Resilience: Benchmarking the Case Studies of Istanbul and London

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Title

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Degree: Master in Urban Climate & Sustainability

Abstract

In recent years, the exacerbated effects of climate change have brought the concept of "climate resilience" to the agenda in cities and its necessity has been increasingly recognized in order to cope with the gradual effects. Cities, with their complex nature and urban forms, are highly vulnerable to climate change-related impacts, and this is where "climate resilience" constitutes a remarkable solution to overcome or adapt to these challenges.

Water is one of the critical and vital assets triggered in cities and it needs strategic management approaches in order to establish a solid infrastructure and provide uninterrupted service. In this context, climate resilience offers many opportunities, especially in places prone to water scarcity, by contributing in various ways to the city's assets, infrastructure, and utility management. This is where this research takes the stage with a benchmarking between two case studies; London in UK and Istanbul in Turkey, aiming to verify the contribution of urban climate resilience to water scarcity management and reveal its levels of contribution. This study not only provides insights into the benefits of climate resilience and the interrelation between climate resilience and water scarcity management, but also provides recommendations for the identified vulnerable case study based on the strengths observed in the best practice case study. The research conducted a comprehensive literature review on the concept of urban climate resilience, water scarcity, sustainable water management, and the current policies, strategies, and action plans of each case study to gain a broad understanding of each topic and move towards the research aim. To conduct the benchmarking study, the concept of urban resilience was contextualized in a framework with its qualities and dimensions, followed by a set of indicators and a quantitative assessment tool specifically tailored to water scarcity management based on the developed framework.

The quantitative results of the assessment demonstrated the successful contribution of the climate resilience strategy to the management of water scarcity in cities; showing that Istanbul is vulnerable in terms of water scarcity management as it lacks a city-level climate resilience strategy or policy, while London has a stronger management performance with its strategy tailored to the city's needs. In this direction, in the light of the strengths identified in London, actions were proposed for the high risks observed in Istanbul. These actions will not only improve water scarcity management in Istanbul but will also move the city towards the climate resilience. In addition, despite London is the best practice of this research, some recommendations were also presented for the moderate risks identified in London. If the tailor-made action plans developed in this research that address the risks observed in cities are implemented by the relevant authorities, it can bring case cities closer to the concept of climate resilience and sustainability.

Keywords

water scarcity, climate resilience, climate change, urban resilience, water management, sustainability, resilience framework, assessment tool

Originality statement. I hereby declare that this Master's dissertation is my own original work, does not contain other people's work without this being stated, cited and referenced, has not been submitted elsewhere in fulfilment of the requirements of this or any other award.	**Signature**

DEDICATION

I dedicate this dissertation work;
to my parents, Verjin and Murat Iskenderoglu, who raised me to be the person I am today and always supported me with their continuous love, trust and faith in me,
and to my younger sister, Janin Iskenderoglu, who is always there for me.

CONTENT

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Thank you

Nadin Iskenderoglu Atahan

LIST OF FIGURES

LIST OF TABLES

APPENDICES

ABBREVIATIONS

CRI	City Resilience Index
CS	Case Study
ESOP	Environment and Climate Sector Operational Programme
EU	European Union
GI	Green Infrastructure
GLA	Greater London Authority
IBB	Istanbul Metropolitan Municipality
IPCC	Intergovernmental Panel on Climate Change
ISKI	Istanbul Water and Sewerage Administration
KPI	Key Performance Indicator
LCCP	London Climate Change Partnership
LCD	Litres per Capita per Day
M&R	Maintenance and Repair
MEW	Monitoring and Early Warning
MS	Microsoft
NBS	Nature Based Solutions
NCWR	Non-conventional Water Resources
R&D	Research and Development
SuDS	Sustainable Drainage Systems
TURKSTAT	Turkish Statistical Institute
UK	United Kingdom
UN	United Nations

CHAPTER 1

1 INTRODUCTION

1.1 Problem Statement

Climate change and its implications threaten cities to a great extent, by resulting in various failures and disruptions in urban systems. Water-related assets, infrastructures and utilities is one of the critical components of urban developments and it already confronts challenges due to rapid population growth along with its increasing demands. Encountered challenges will be exacerbated by the extreme events of climate change (Bichai & Cabrera Flamini, 2018), as water is highly vulnerable to climate change and its impacts.

The increase in unpredictable climate events in recent years brought the concept of "urban resilience" to the fore and led to its wide adoption in urban strategies/policies as a key to climate adaptation in cities.

“Urban climate resilience” refers to quickly respond and recover from shocks and stresses emerged by climate change. Therefore, building urban resilience in cities is crucial for society and is a need, especially in risk-prone zones (Tumini, et al., 2017). Albeit the growing importance of climate resilience, there are still gaps in integrated frameworks, tools, and methods to comprehensively assess urban resilience in cities (Ribeiro & Gonçalves, 2019).

Returning to the subject of water, scarcity management is critical to build urban resilience, especially in drought prone cities. Therefore, a comprehensive assessment of water scarcity management is vital in these cities to ensure robust water assets and infrastructures and build a resilient city. However, it has been determined that there is a gap in the assessment of the water-related consequences of climate policies (IPCC, 2008) and that a quantitative assessment tool is needed for water problems triggered by climate change.

The aim of this research, that set off from the underlined gaps in the literature, intends to reveal the contribution of urban climate resilience to water management performance in cities by meeting the needs. To reveal this in a straightforward manner, the London and Istanbul case studies were strategically chosen.

These case studies have a great potential to discover the interconnections between climate resilience and water scarcity management, as London offers a best-practice with its urban climate resilience strategy, while Istanbul stands vulnerable due to a lack of city-level resilience policies or strategies.

Accordingly, this research will contribute to the concept of urban climate resilience by developing an integrated framework for urban resilience and it will fill the gaps in the literature by designing a tailor-made quantitative assessment tool to evaluate water scarcity management performances in the context of climate resilience in selected case studies.

1.2 Aim and Objectives

This research seeks to answer the following main question:

> ***"How can the concept of urban climate resilience contribute to managing water scarcity in a city?"***

In this regard, the main aim of this research is to shed light on the link between water scarcity management and climate resilience concept and to reveal whether the climate resilience approach contributes to the management of water scarcity problem sustainably and develops robust water assets, infrastructures, and services.

In order to achieve this aim, the objectives given in Figure 1-1 are developed.

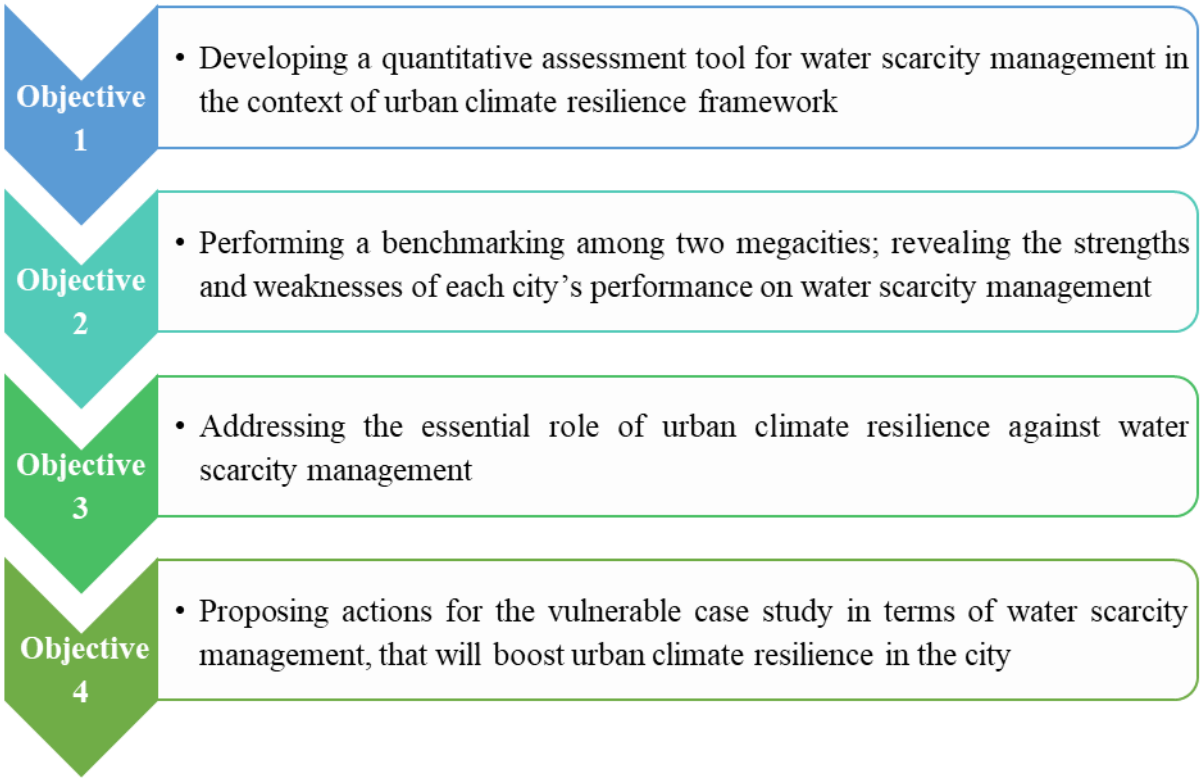

Figure 1-1 Objectives of the Research

The overall objective of this research is to contribute to the concept of urban climate resilience by developing a framework and to design an assessment tool for water scarcity management that will lead to a comprehensive benchmarking analysis among case studies.

The integrated assessment tool will enable to analyse the strengths and weaknesses of each city and ultimately the proposed actions towards water scarcity management will move the vulnerable city closer to the concept of urban climate resilience.

1.3 Key Methods

This research is an inductive piece of work within a pragmatic philosophy, that intends to collect relevant data either qualitative or quantitative. The "mixed method" adopted for the research provides a hybrid structure which that combines qualitative interpretation, statistical evaluation and comparative analysis, giving the subject a multifaceted perspective.

In addition, "case study approach" was embraced as a research strategy, to enable an in-depth exploration on the research subject by means of a real-life setting.

To achieve the main aim, each objective was linked with a method to achieve the milestones step by step. The methods determined to achieve each objective are illustrated in Figure 1-2.

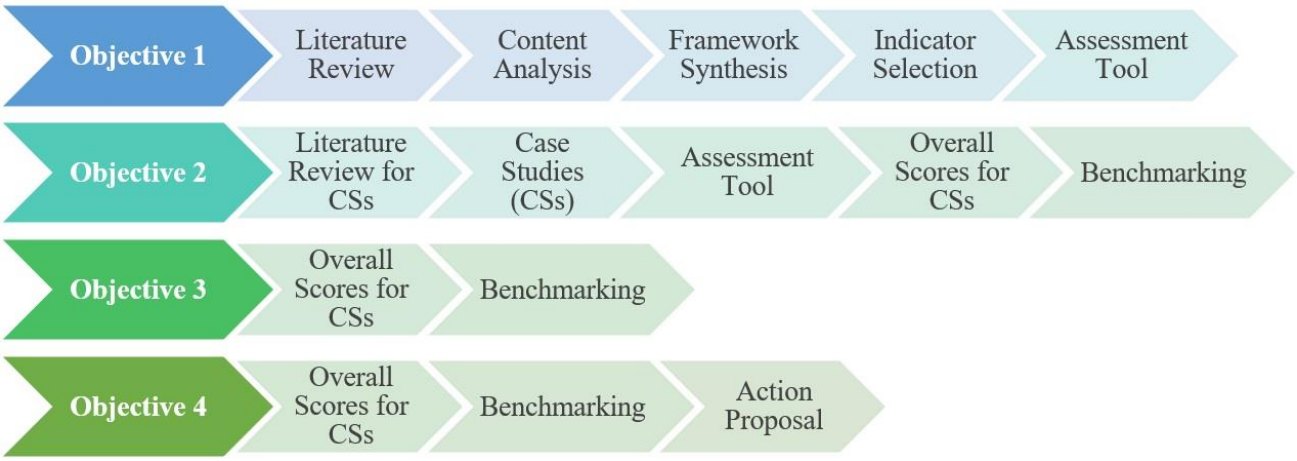

Figure 1-2 Methods Determined for Each Objective

- ✓ The *first objective* will be achieved through; a general literature review on urban climate resilience and water scarcity, content analysis of the collected data, “framework synthesis” for the development of the resilience framework, indicator selection and finally the development of an assessment tool (using MS Excel as an instrument).
- ✓ In order to achieve the *second objective*, first, literature review is conducted for case studies, then case studies are evaluated under the assessment tool developed, overall scores are calculated for each case and benchmarking is performed between the results.
- ✓ The *third objective* is fulfilled by the evaluation and benchmarking analysis of the overall results obtained for the case studies.
- ✓ Finally, the *fourth objective* is achieved by proposing actions for vulnerable case study (refers to the case study scored the lowest) in light of best practice (refers to the case study scored the highest).

1.4 Report Structure

This thesis report consists of six chapters.

- **Chapter 1** gives an outline of this research, presenting the introduction, scope, aim and objectives of the research, and adopted methods.

- **Chapter 2** presents the literature review to establish background information on climate change and its cascading impacts in cities, the emerging risk of water scarcity, the essential role of urban climate resilience and its importance in water scarcity management, respectively. In addition, this chapter conceptualizes urban resilience with its qualities and dimensions, as well as revealing the knowledge gaps observed in the literature and key questions that will be a step forward towards the main aim.

- **Chapter 3** introduces the case studies and clarifies the reasons behind selecting these two case studies, London and Istanbul. It also provides an overview of each case study, enlightening the reader on the risk of water scarcity and climate change and the strategies or policies pursued in each city to deal with them.

- **Chapter 4** explains the methodology adopted in this research to achieve the ultimate aim. This chapter describes the methods applied to conduct the research and details the data analysed and synthesized. It also sets out the research structure and steps followed, from the literature review to the final step, the action proposal.

- **Chapter 5** encompasses the results of the assessment conducted for each case study, sets out their strengths and weaknesses in water scarcity management, and discusses the results of each case study separately, as well as comparing the results.

- **Chapter 6** covers the conclusions answering the research question and provides recommendations for the vulnerabilities identified for each case study, to improve their water scarcity management in the context of urban climate resilience. In addition, the limitations of the research and opportunities for future research are also included in this chapter.

Following these chapters, appendices presenting detailed assessment sheets of case studies are provided at the end of the report.

CHAPTER 2

2 LITERATURE REVIEW

This chapter encompasses the literature review relevant to the problem stated, aim and objectives of this study. The provided background will leverage the understanding of climate change and cascading impacts in cities, emerging water scarcity risk, the pivotal role of urban climate resilience and its importance in water management, respectively. Finally, this chapter will present the knowledge gaps and key questions of this study.

2.1 A Closer Look to Climate Change

Climate change is one of the greatest challenges in the world (Reckien, et al., 2017), with its extreme events, unprecedented scale, and unpredictability. As a result of climate change, abnormal weather and climate events have been encountered since the 1950s (IPCC, 2014). The frequency, intensity, and extent of extreme events such as heavy rainfalls, floods, heatwaves, droughts, water scarcity, wildfires and rise in sea levels are increasing worldwide with the reality of climate change (IPCC, 2014).

Projected climate scenarios of the Intergovernmental Panel on Climate Change (IPCC) highlight the severity and significant impacts on urban developments. The impacts are distributed unevenly around the world, and the type and size vary by regions, continents, and population. Some regions suffer from knock-on events of heatwaves, droughts and associated water scarcity, while others are severely affected by heavy rainfall and floods (UN Water, 2019). These extremes have been experienced more frequently in recent years and influence the urban life and interconnected urban dynamics, infrastructures and systems adversely, along with exacerbating the existing stresses in developments (Gasper, et al. 2011; IPCC, 2014).

2.2 Complex Nature of Cities and the Key Drivers

Cities are complex systems in which various urban infrastructures and assets are intertwined, yet, highly vulnerable to climate change and the associated unpredictable and intense natural events due to their steady nature (Salimi & Al-Ghamdi, 2020).

The literature acknowledges that dense settlements such as large cities and megacities are more vulnerable to climate change-related impacts, hazards, or natural events (Meerow & Stults, 2016), due to their size, high population density, high resource consumption and intensive land use (Borden, et al., 2007; Deppisch & Schaerffer, 2011). While rural-urban migrations (especially in the Middle East), rapid urbanization and overpopulation at the cities already put pressure on critical infrastructures leading to service disruptions and/or capacity shortages, climate change further increases the tension at urban systems and makes cities more fragile.

Critical infrastructures are one of the key elements for proper functioning of cities. Possible disruptions or malfunctions in such essential urban systems threaten human wellbeing (Tyler & Moench, 2012).

The literature review indicates that extreme events intensified by climate change pose a serious threat to cities, especially more severe in megacities and their main components.

2.3 Emerging Crisis: Water Scarcity

Water is the lifeblood of the planet and one of the vital elements of cities. While climate change poses a major threat to water-related assets, the built environment and urban infrastructure, it also jeopardizes the environmental, social and economic pillars of sustainable development (UN Water, 2010).

Extreme weather and climate events have a direct impact on the availability and quality of water in cities (Duran-Encalada, et al., 2017). Temperature increase, changes in runoff and precipitation patterns along with climate anomalies, are likely to cause eutrophication and algal blooms in water bodies. Frequent dry periods, higher temperatures, severe droughts ensued from climate change deteriorates the quality of water through altering its composition and cause a decrease in quantity of water resources whilst increasing the water scarcity risk (Sadoff & Muller, 2009; IPCC,2014).

"Drought" and "water scarcity" are two terms usually mixed and used interchangeably. Although “drought” and "water scarcity" meet on common grounds and generally occur in the same periods, these two notions have concrete differences. Water scarcity is the insufficiency of water resources to meet the long-term demands; while drought is a natural phenomenon emerged as a result of below-normal precipitation levels, adversely affecting the water resources, soil, and interlinked production activities, as well as resulting in serious hydrological instabilities (Republic of Turkey Ministry of Forestry and Water Affairs, 2017).

Water scarcity is on the global agenda today with the tangible evidences in many countries on every continent (Bond, et al., 2019 ; Bigas, et al., 2012) and rings the alarm bells for the future water crisis. Water scarcity is triggered by increasing population trends and climate change and becomes more urgent over time (Purvis & Dinar, 2020). The studies and research in the literature reviewed so far highlight that by 2050, urban growth and climate change alone can cause additional 1.8 billion people living under severe water stress (Schlosser, et al., 2014). On the other hand, the United Nations World Water Development Report estimates that “40% of the world’s population will live under severe water stress” by 2050 (UN Water, 2018).

Today, 3.6 billion people across the world, live in areas suffering from water scarcity for at least a month per year, and this number is expected to reach around 4.8 to 5.7 billion by 2050 (UN Water, 2018). The climate models developed by McDonald et al. (2011) revealed; approximately 150 million people living in cities face a perennial water shortage, in other words a person daily reaching less than 100 litres of water from sources located within their urban

boundaries. Likewise, these future scenarios showed a large increase in numbers by 2050, reaching up to 1 billion (McDonald, et al., 2011).

The strong water-related impacts, especially in the form of perennial water scarcity will be spotted particularly in the Middle East and North Africa (McDonald, et al., 2011). Although intense water stress is common in Africa, climate change has serious implications across the Europe, North America, and Southeast Asia as well (Schlosser, et al., 2014).

2.4 The Concept of Urban Climate Resilience

In recent years, there has been a growing interest in the concept of "urban resilience" both in literature and practice - particularly in policies - with the exacerbating climate change. Current results in academic literature and practice elicit the strong interactions between the "urban resilience" notion and “climate adaptation and mitigation” actions.

The concept has been widely acknowledged by policymakers and researchers to cope with the climate related extremes and maintain the status quo or necessary urban functions in cities. Tumini et. al. (2017) highlights the necessity and crucial role of building resilience in cities for the society, especially at the risk prone zones (Tumini, et al., 2017; Sharifi, 2020).

The term "urban resilience" has various definitions in the literature from different research areas, based on various applications at urban context. Despite different definitions, typically they all assemble under the same roof. The common objective of the resilience concept is to minimize the effects of the confronted extremes, correspondingly, can be expressed as “ability of a system to adapt or overcome the encountered disturbances” (Ribeiro & Gonçalves, 2019). In a similar vein, Leichenko (2011, p.164) defines the “urban resilience” as “the ability of a city or urban system to withstand a wide array of shocks and stresses”.

In the light of the literature, "urban climate resilience" which will be extensively used in this study, will refer to "the ability of cities to give a quick response to extreme climatic events and bounce back from potential hazards".

The concept of "climate resilience" has recently been widely recognized by urban developments and has been adopted in policies to strengthen cities' vital assets, essential infrastructures, and services against the serious consequences of climate change. “100 Resilient Cities” initiative developed by Rockefeller Foundation and the global alliance of “Global Covenant of Mayors for Climate & Energy” aiming resilient and low-emission cities, are of great examples for “climate resilience” turn in the policies.

In addition, the "C40 Cities Climate Leadership Group" is one of the most important international cooperation networks that supports the world's largest cities to cope with the climate change to achieve the goals set in the Paris Agreement. The C40 network promotes sustainable and resilient actions in the 97 member megacities, that accounts for the one twelfth of the total world population.

2.4.1 Understanding the Dimensions and Qualities

With the prominence of the concept of "urban resilience" against climate change, the increasing studies in practice and in academia have brought various dimensions and qualities of resilience as well as different definitions.

To realize an assessment in the context of urban climate resilience, it is important to first understand the concept, its components, dimensions, and qualities.

2.4.1.1 Components and Dimensions

The study conducted by Tyler and Moench, (2012) links resilience with urban climate and describes the “urban climate resilience” term under three key components: systems, agents, and institutions. Accordingly, a resilient system must be *flexible* to be able to cope with shocks without cascading failures and remain functional under these conditions without being fully affected by sudden events. Agents should be *responsive* to the shocks, disruptions and failures quickly in an organizational context, should be *resourceful* to provide the necessary financial resources and assets, and should have the *capacity to learn* from past experiences to improve performance. Institutions interconnect two components: agents and systems; and they provide rights and authorizations for critical urban systems, perform accountable, transparent, and responsive decision-making processes, provide the necessary information to identify the risks and vulnerabilities as well as the required adaptation actions, contribute to application of new knowledges to improve the urban resilience (Tyler & Moench, 2012).

On the other hand, several studies investigating urban resilience and disaster resilience in communities acknowledged five key dimensions: physical, natural, social, economic, and institutional (Ribeiro and Gonçalves, 2019; Patel and Nosal, 2016; Ostadtaghizadeh et al., 2015). However, a systematic review conducted by Assarkhaniki et al., (2020) classified resilience under: **social**, **environmental**, **economic**, **institutional**, and **infrastructural** dimensions. Assarkhaniki et al. (2020), as a recent systematic study, gathers the physical dimension stated in previous studies under the infrastructure dimension and the natural dimension under the environmental dimension, in order to create a comprehensive framework to measure urban resilience.

The dimensions to be used in this study will follow the key dimensions proposed by Assarkhaniki et al. (2020), who gathered previous studies under a single roof and conceived a multi-faceted framework for urban resilience notion. These dimensions will act as a solid basis for the performance indicators and for the assessment tool to be designed in the context of urban climate resilience.

2.4.1.2 Qualities

There are several researches in the literature that defines the resilience concept, the qualities, and conceives a framework to evaluate urban resilience in cities.

One of the pioneering examples of such tools is “City Resilience Index” (CRI) developed by Arup in cooperation with Rockefeller Foundation. The CRI was released to support the Rockefeller Foundation's "100 Resilient Cities” program and the index provides an assessment tool for cities to evaluate their urban resilience performance in an extensive manner, both qualitatively and quantitatively, and underlines seven key qualities of resilience, namely; flexibility, robustness, redundancy, integrated, reflective, resourceful, inclusivity.

In addition to the CRI, various studies in the literature acknowledge different qualities for the same concept. These are; diversity, efficiency, autonomy, independence, collaboration (Godschalk, 2003), modularity, foresighting, stabilizing and buffering (in terms of absorbing shocks) (Kim & Lim , 2016), innovation and variability (Allan, et al., 2013).

A study conducted by Ribeiro & Gonçalves, 2019 unveils the most commonly cited qualities as: “redundancy, diversity, efficiency, robustness, connectivity, adaptation, resources, independence, innovation, inclusion and integration” (Ribeiro & Gonçalves, 2019).

The findings for the qualities of resilient systems acquired from academic literature are summarized in Figure 2-1, to present the bigger picture of the concept.

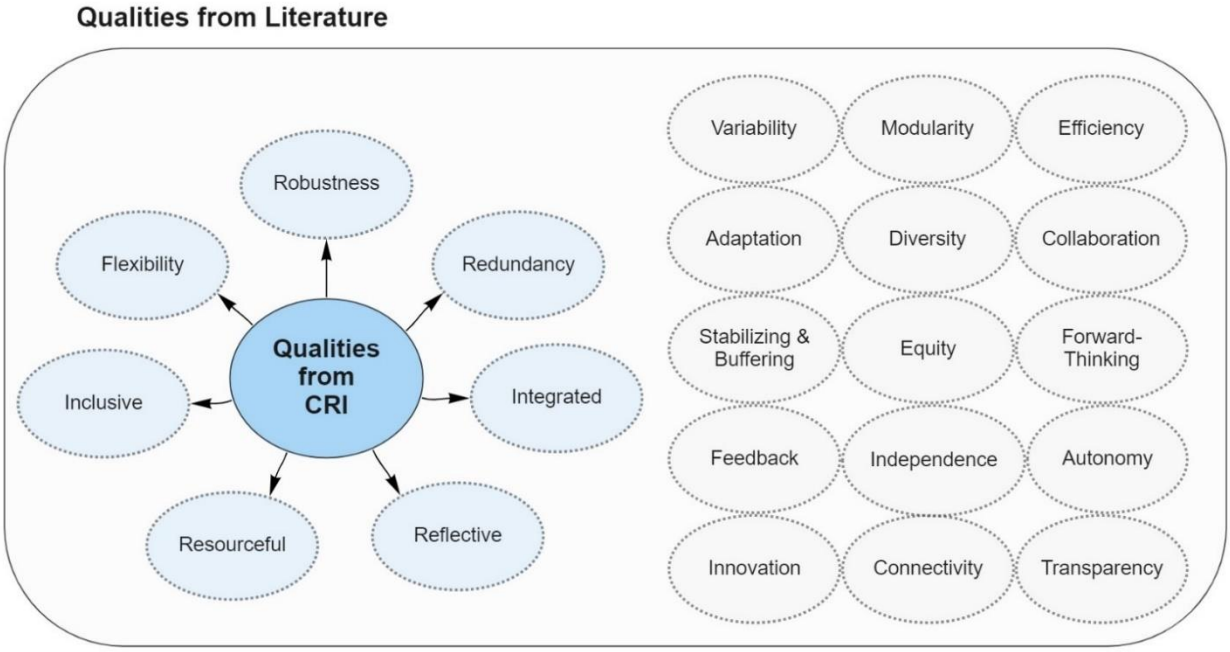

Figure 2-1 Qualities of Resilience in Literature

Source: Own edition according to the literature review (Ribeiro & Gonçalves, 2019; Kim & Lim , 2016; Allan, et al., 2013; Godschalk, 2003; Meerow & Stults, 2016; City Resilience Index, Rockefeller Foundation – ARUP)

As a result of a comprehensive literature review, nine qualities of resilience that will be used to shape the assessment tool in this study is determined as; **flexibility**, **robustness**, **redundancy**, **resourceful**, **reflective**, **independence**, **inclusive**, **integrated** and **innovation**. Relevant information and justification for the qualities and the assessment tool is presented in Chapter 4.3.1.

2.5 An Overview to Urban Climate Resilience against Water Scarcity

Among the vital urban components, "water resources and scarcity management" are of paramount importance in cities, as water is a key element for life and affects almost all aspects of development and society, e.g. agricultural activities and production, food security, health, sanitation etc (UN Water, 2010). By all means, it is more important especially for the risk zones that are currently facing water scarcity issues or are expected to face in the future, as a consequence of climate change.

Apart from climate change and emerging drought problems, large populations also greatly trigger water scarcity and make cities more vulnerable, especially megacities. Overpopulation leads to evolving resource consumptions, causes stress on the water services and infrastructures; ultimately, jeopardizes sustainable resource management through overexploitation.

Undoubtedly, along with urban growth and climate change, the challenges faced in water resources will further aggravate the water crisis and "water scarcity management" will gain more prominence and urgency in the world.

Under current and future water-related challenges, alignment with the "urban resilience" concept in policies or urban development plans has become necessary to ensure sustainable and effective management of water resources. The resilience approach brings great benefits to cities by strengthening the existing water infrastructures, systems, and services, and supporting quick response and recovery from shocks and stresses caused by climate change.

In this context, this research will make a comparative assessment with two case studies and will demonstrate the contribution of urban climate resilience strategies to sustainable water scarcity management in megacities.

2.6 Knowledge Gaps

In the literature, many definitions, principles, and features were revealed for urban resilience. Nevertheless, there are still lack of frameworks and tools to conduct a comprehensive assessment on resilience, which paves the way for further studies on resilience (Ribeiro & Gonçalves, 2019).

As water is a vital component of urban life, various approaches were generated in recent years focusing on water management (Özerol, et al., 2020) and several studies were performed at national and regional level to identify the vulnerabilities of water infrastructures against climate change (Salimi & Al-Ghamdi, 2020). Despite there are wide variety of studies in national, regional, or global scales; the literature review outlines certain impacts of climate change,

particularly water-related drought and the associated risk of water scarcity are neglected at the urban/city level.

The technical paper of the IPCC (2008) on "Climate Change and Water" unveils the requirement of an "improved assessment of the water-related consequences of different climate policies and development plans" and suggests developing indicators to ensure monitoring the climate change impacts on water resources and related systems (IPCC, 2008).

In another major study conducted on water stress, Schlosser, et al. (2014) underlines the growing need for a quantitative assessment tool specifically designed for water-related problems caused by climate change.

In this context, this research will fill the gaps in the literature by developing a framework for urban resilience and an integrated assessment tool tailored specifically for water scarcity management.

Overall, the following key questions will be addressed by this study:

- How does urban climate resilience relate to management of water scarcity? What are the interactions?
- How can an urban resilience strategy or plan help cities to robust the water-related assets, services, and critical infrastructures?
- How to assess the performance of water scarcity management in the context of climate resilience?

CHAPTER 3

3 CASE STUDIES

In order to provide a solid basis for benchmarking, two cities are selected from the C40 Cities Network, both confronting water scarcity risk, having similar populations, megacity profile, and similar scale of connections with surrounding regions.

The City of London in the United Kingdom and the city of Istanbul in Turkey is selected to conduct this benchmarking study. In order to highlight the pivotal role of urban climate resilience policies in water scarcity management, key differences in policies and strategies against climate change were also considered among selected cities. Accordingly, while London has a city-level "urban resilience strategy" against extreme events, and a "drought response framework" tailored to the city's needs; Istanbul is more vulnerable to hazards in terms of not having urban resilience or drought plan other than national policies.

Detailed background information for each case study is provided in this chapter.

3.1 Case Study No 1: City of London

London is the capital city of the United Kingdom, home to a population of 8.9 million in 2019, and is one of the UK's largest, diverse and vibrant urban areas (Greater London Authority, 2021). The Greater London Authority (GLA) estimates that the population will reach 10 million in the 2030s and almost 11.3 million in 2050, indicating that London will join the group of megacities in the world, by reaching a population of 10 million by 2030.

Rapid urban growth in Greater London puts a large pressure on services, infrastructure, the built environment, and the well-being of the inhabitants, especially the water assets/resources with increased demand for water. In addition to urbanization, climate change is one of the factors that significantly affects urban systems in the city and is expected to further exacerbate the strains on urban systems in London.

The main risks identified for the city by the London Climate Change Partnership (LCCP) are flooding, heatwaves and water scarcity. Unless an action plan is provided, London will face a serious risk of water scarcity in the future, with the growing population and increased drought periods due to climate change. Although London is known for its rainy weather throughout the year, it is surprisingly drier than Istanbul in terms of rainfall per capita, which provides a solid basis for comparative assessment with Istanbul in terms of water scarcity management.

The "climate emergency" declaration of the mayor in 2019 helped bring climate actions and programs to the fore and push the concept of urban climate resilience forward. In this regard, there were developed several frameworks and policies to tackle with drought and associated water scarcity in London, for instance, the “Drought Response Framework” conceived by the London Resilience Partnership promotes the reduction in water consumption, increases drought

awareness and strengthens resilience against the impacts, while minimizing negative impacts at both organizational and individual levels (London Resilience Partnership, 2019).

Another strategy developed at city level is the "London Environment Strategy", which promotes resilience to the long-term effects of climate change such as extreme weather events. It acknowledges the pressure on infrastructure, housing, people's well-being, services, and the urban environment due to the growing population in London and recognizes climate change and extreme weather events as a serious threat, that exacerbates the current tensions. With regards to the water-related actions, one of the main objectives has been set to provide an "efficient, secure, resilient and cost-effective water supply"; focusing on leakage reduction, water-metering, public awareness on water consumption, efficient use of water (Greater London Authority, 2018).

In addition, "London City Resilience Strategy 2020" embraced by GLA ensures a long-term resilience by collecting different policy areas under a single roof which is shown in Figure 3-1.

Figure 3-1 London City Resilience Strategy, 2020

Source: Own edition, London City Resilience Strategy 2020 (GLA, 2020)

This resilience strategy provides notable insights into building community resilience, sustainable use of environmental resources, and building robust infrastructures and environments, as well as good governance in terms of policy and strategy in London (Greater London Authority, 2020).

Daily water consumption in the city was recorded as 149 per capita per day (LCD), indicating a high level of consumption (Greater London Authority, 2018). In this regard, to raise awareness about climate change and to create a water-saving culture in the city, the London City Resilience Strategy (2020) specifically explores opportunities for public awareness.

On the other hand, the recent London Plan (2021) highlights the importance of urban greening and nature-based solutions to build resilience to climate change and robust infrastructures in the city. It also supports feasibility studies investigating alternative water sources in the city, emphasizing the non-conventional water resources in the city to create redundancy. Thames

Water currently studies several strategic water resource alternatives to address drought and water scarcity, including several options for London, such as effluent reuse, water transfers, a potential new reservoir, or a groundwater source (Greater London Authority, 2021). Recently, Thames Water and Affinity Water have proposed building an "Abingdon reservoir" by 2037, which will ensure London's future water supply by creating an additional water storage (Cooper, 2019).

All these policies, plans and strategies followed in London describe the well-managed approaches against climate change and its effects on urban forms, and clearly reveals the steps towards climate resilience in the city.

3.2 Case Study No 2: City of Istanbul

Turkey is located in the Mediterranean Basin, one of the most vulnerable regions affected by the impacts of climate change. The IPCC Report shows that the Mediterranean Basin is a highly affected area and future projections demonstrate the precipitation will decrease, leading to higher water scarcity problems in the basin.

The city of Istanbul is one of the provinces located in the northwest of Turkey and it is the major cultural, economic, and historic centre of the country. Istanbul is considered to be the most populous city in the country with a population of 15,519,267 (TURKSTAT, 2021), corresponding to 18.7% of the country's population, and the city is one of the few megacities in the world with its population of 15 million.

Rapidly developing Istanbul witnesses many problems similar to other megacities, such as overpopulation, urbanization, fast growing economy, and these put pressure on urban systems and natural assets of the city.

Migration from rural-to-urban and from eastern to western cities, particularly to Istanbul, causes an uneven population distribution in the country and aggravates water scarcity by creating a great stress in water resources of the western cities as in Istanbul. The most recent statistical data show that the daily average water consumption in Istanbul is high with 189 LCD (TURKSTAT, 2021). Although there are some education campaigns or programs aimed at raising awareness, the biggest underlying reason for high water consumption is that the public is not sufficiently aware of climate change and water scarcity. In addition, not only the lack of awareness, but also social behaviours, culture and ways of doing things directly affect the high consumption levels in the city.

Climate change will cause fragility in the socio-economic aspects of the city by interacting with the urban dynamics. In addition to physical effects to urban infrastructure and services, climate change will strain the capacity of these services.

In recent years, Istanbul has been confronting with drought problems due to climate change. To provide climate resilience, “National Drought Management Strategy Document and Action Plan” at country level and “Istanbul Climate Change Action Plan” at city level have been developed.

On the other hand, great progress has been made in the environmental sector and climate change in Turkey with the EU accession initiatives. The harmonization of EU legislation with national regulations has accelerated the environmental development in the country. Investments in the country were financed and supported by the EU in order to improve environmental quality, promote climate adaptation and ensure sustainable environmental management (Delegation of the European Union to Turkey, 2019), which were undoubtedly important steps for Istanbul as well. As a matter of fact, infrastructure investments in the water sector in Istanbul have been increased, albeit mostly grey infrastructure instead of green infrastructure (GI) projects. Similar to the country's investment approaches, Istanbul tends to adopt predominantly grey infrastructure rather than more sustainable approaches such as NBS.

With respect to the water scarcity problem in the city, Melen Dam which is currently making the greatest contribution in terms of water supply, was one of the non-conventional solution approaches applied by transferring water from adjacent basin after a huge water scarcity encountered in Istanbul. Melen Project was a large and expensive project as it included a 180 km-long water transmission line from Melen watershed. In this way, the water problem of Istanbul was postponed. However, apart from instant solution approaches, no sustainable solution has been found for the water scarcity problem from past to present. The need for a sustainable water supply solution still possesses great importance and urgency, as one of the major impacts of climate change is water scarcity in the Mediterranean Region (Cuceloglu, et al., 2017).

All the points mentioned above give an idea about the approaches and steps taken against climate change and its biggest threat, water scarcity in Istanbul.

CHAPTER 4

4 METHODOLOGICAL APPROACH

This chapter presents the approaches and methods considered in this research in order to answer the main question of the study and fulfil the objectives.

4.1 Research Design

The literature review in Chapter 2 highlights that climate resilience is a complex concept to systematically analyse, measure, and characterize. Due to such constraints, the vast majority of researchers in literature propose a qualitative research method for assessing resilience and embrace this method in their studies.

On the other hand, there are some great examples of quantitative method that evaluate resilience by scoring and ranking under a comparative framework. Some researchers have also created quantitative tools to measure strengths and weaknesses under the indicators determined for the concept (Engle, et al., 2014), to give insights and a statistical perspective on urban resilience.

In addition to the "urban resilience" concept, "urban water management" is another discipline that is the subject of this research, and assessment approaches in the literature involve the examples for both qualitative and quantitative methods. Many researchers espouse the hybrid method in which qualitative and quantitative research methods are interwoven, to give a multi-faceted perspective to the subject. The mixed method enables qualitative interpretation and statistical evaluation as well as comparative analysis through a scoring (Ulian, et al., 2017).

In this context, the pragmatic philosophy internalizing mixed method is adopted for this research. The pragmatic philosophy is a combined way of collecting and analysing data in a variety of ways, giving a broad perspective to research. In fact, integration of the mixed method further enhances the research by allowing the selection of the most suitable method, either qualitative or quantitative.

The inductive approach was followed within a pragmatic philosophy. The inductive approach begins with data collection, forms patterns to analyse the acquired data, and eventually refines a new theory. Therefore, pragmatic philosophy and inductive approach was found to be the most suitable for this research, as it intends to create an assessment tool for water scarcity management in the context of urban climate resilience, and ultimately, to reveal the contribution of resilience concept.

Further to the philosophy and approach, this study embraced a cross-sectional design. The cross-sectional design stands as the most appropriate paradigm, by enabling data collection on urban resilience and water scarcity management from various sources at one specific time, making inferences about the links between concepts and supporting the development of an assessment tool to compare selected case studies.

The research design is summarized in a research onion given in Figure 4-1, to provide an overview to the strategy, methods and approaches.

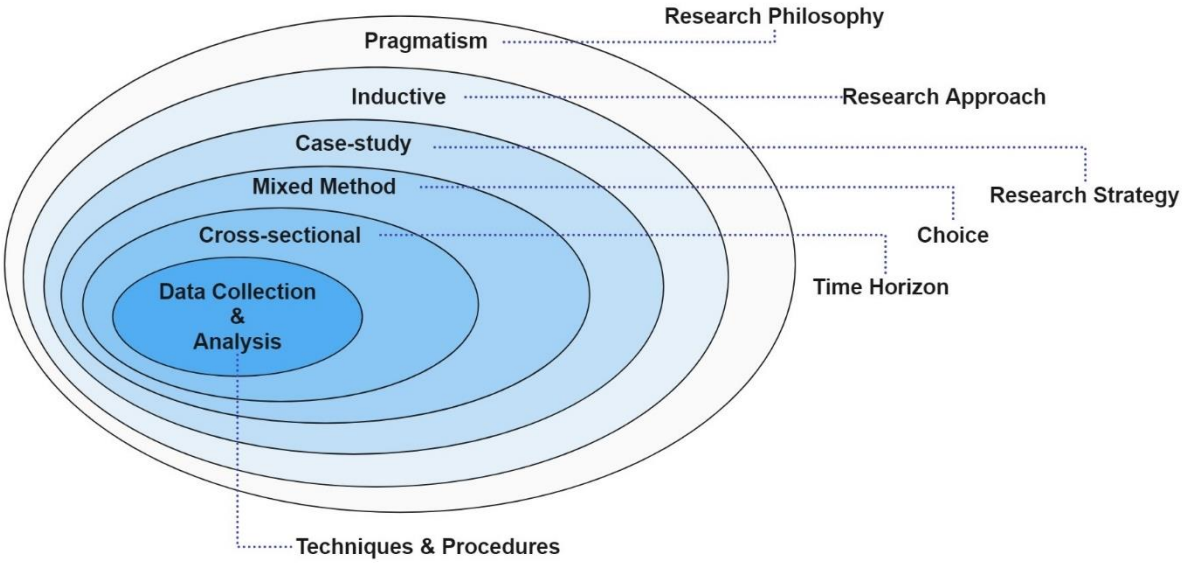

Figure 4-1 Summary of Research Design

Source: Adapted from “Research Onion” of Saunders et al. (2015)

4.2 Research Strategy

In order to make an in-depth exploration on the research subject and acquire a solid understanding on the dynamics, "case study approach" was adopted as a research strategy.

The case study approach enables research to be conducted in a real-life setting and provides a broad understanding of the subject by giving insights into the "what" and "why" questions, findings for the possible actions, and refining a theory (Saunders, et al., 2015).

In addition, practice-oriented research with case studies has an advantage over other research strategies as they are more flexible, entails less pre-structuring and draws the bigger picture of the subject (Verschuren & Doorewaard, 2010). In this regard, two cities were selected from the C40 Network of Cities as described in Chapter 3 based on their common water scarcity risks, large populations, and megacity profile: the city of London in the United Kingdom and the city of Istanbul in Turkey.

It is worth noting that, London refers to “best practise” in this research with its urban level initiatives and strategy on climate resilience, on the contrary to Istanbul that has limited resilience policies at city level.

4.3 Research Phases, Methods and Instruments

This research will not only conduct a benchmarking study, but also provide a framework for urban climate resilience based on dimensions and qualities compiled from the literature, further promoting the development of an assessment tool for benchmarking. Accordingly, the research consists of three phases.

Detailed information for the phases and the methods applied in each phase is given in this chapter.

4.3.1 Phase-A: Understanding Urban Climate Resilience

The first phase of this research focuses on collecting data on urban climate resilience and its definitions, influencing factors, dimensions and qualities, and synthesizing the gathered information. Thus, this phase provides a thorough understanding of the concept and principles of resilience and contributes to the development of the assessment tool in Phase-B by gathering the dimensions and qualities of resilience in a single framework.

4.3.1.1 General Literature Review

As a first step in this phase, a literature review was conducted to unveil the theoretical background of the "urban resilience" approach with all its pros and cons, principles, underlying dimensions and qualities.

The literature review was performed using such variety of secondary and tertiary sources, but not limited to; recent academic papers, technical papers, books, institutional reports, frameworks for urban resilience and indicators compiled, as well as national/urban level strategies, policies, and other documents from websites.

4.3.1.2 Data Analysis

The data collected through the literature review paved the way for the next step: data analysis. In this step, information gathered about the dimensions and qualities of "urban resilience" was analysed by relational content analysis method based on their relevance and close interaction with the research theme: water scarcity management, i.e. water-related assets, services, management, and institutional governance.

- **<u>Determination of Dimensions</u>**

The dimensions of the resilience concept that will contribute to the framework in this study is selected based on a recent academic research conducted by Assarkhaniki et al., (2020). The authors of the research performed a systematic review, conceptualized the resilience dimensions in the view of sustainability, and ultimately concluded five key dimensions for resilience: *social, economic, institutional, infrastructural* and *environmental*. Each dimension is defined in the following Table 4-1 (Assarkhaniki, et al., 2020).

Table 4-1 The Dimensions Determined for Urban Resilience Concept

No	Dimensions	Description
1	Social	Indicates the features related with the population and demographics, community, collective life, and its features.
2	Economic	Refers the financial capacity of people and government.
3	Institutional	Reveals the performance of government and the governance, preparedness to stresses, capacity to response and recovery features as well as measuring the effectivity of mitigation actions.
4	Infrastructural	Consists of the functionality, efficiency, accessibility, emergency response features of urban critical infrastructures and its related services.
5	Environmental	Identifies the impacts on environment, measures the performance of services related with environment/human/ecosystem and their functionality.

These five dimensions referring to sustainable development goals were acknowledged in this study to broaden the viewpoints upon "urban climate resilience" and "water scarcity management". The main advantage of following the findings of Assarkhaniki et al., (2020) is the ability to bring a multi-faceted view to the subject from a sustainability perspective.

- **Determination of Qualities**

As a result of the literature review, nine key qualities closely related to the research subject were identified, those frequently cited in both academic papers and professional reports.

In the selection process, priority was given to the qualities those closely correlated with urban water management and facilitate performance measurement of water-related assets, services and administrative aspects, as part of the relational content analysis method.

The following key qualities are determined to design the assessment tool; *flexibility, robustness, redundancy, resourceful, reflective, independence, inclusive, integrated* and *innovation*. Each quality is described in Table 4-2.

Table 4-2 The Qualities Determined for Urban Resilience Concept

No	Qualities	Description
1	Flexibility	Flexible systems imply to the ability to easily evolve and adapt to changing conditions. Flexibility can be achieved by innovation that brings new technologies and knowledge into practice.
2	Robustness	Robust systems refer to strong, resistant, well-managed and planned assets, developments, services and infrastructure that can cope with external shocks, stresses or hazards.
3	Redundancy	Redundant implies to cost-effective spare capacity designed to support the system in the event of a component failure, so that the system does not fail and maintains its functionality by the replaced spare.
4	Resourceful	Resourceful means having sufficient resources in present to fulfill the needs under shocks or stresses, to be able to respond to any level of disruption quickly.
5	Reflective	Reflective systems enable constant learning from past experiences and inform the future decision-making.
6	Independence	The independent system maintains its operation functionality regardless of external forces and control bodies.
7	Inclusive	Inclusivity promotes involving communities and all groups of people especially vulnerable one's for the consultation process during planning and visioning resilience in cities.
8	Integrated	Integration promotes the interconnection between all urban components that contribute to a common purpose, support each other and ensures collective functioning of systems as well as consistent decision-making in shorter period of time.
9	Innovation	Innovation refers to the ability to find different alternatives and new technologies to fulfil the needs and continue the operation during shocks, stresses or hazards.

4.3.1.3 Data Synthesis

In the last step of Phase-A, "framework synthesis" method was adopted. Refined data on the dimensions and qualities of urban resilience (please see Chapter 4.3.1.2) are gathered under a framework given in Figure 4-2, which forms the backbone of the assessment tool in Phase-B.

The inner five parts of the framework (Figure 4-2) illustrate the dimensions and the outer nine notions present the qualities of urban resilience. The literature asserts that the coexistence of dimensions and qualities, as stated in this framework, is the “key” to building urban resilience in cities.

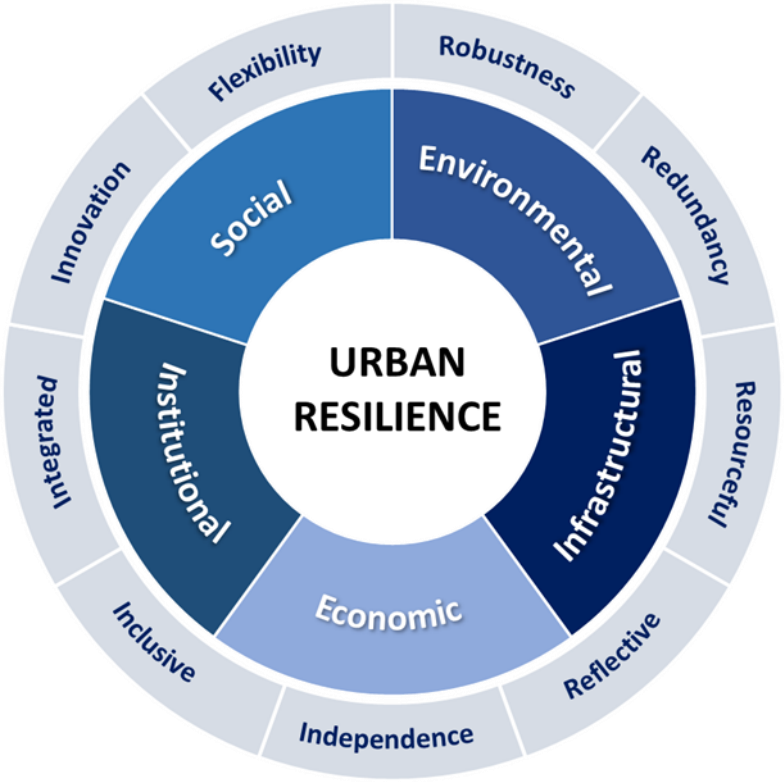

Figure 4-2 Designed Urban Resilience Framework

As previously stated, the five “dimensions” inferred from the study of Assarkhaniki et al. (2020) conceptualize urban resilience under the sustainability pillars. Thus, the adoption of these dimensions in the research will lead to promote sustainability while building resilience in the city.

On the other hand, through the relational content analysis method; the “qualities” those have dynamic interactions with sustainable urban water management strategies and those closely related to water-related services, assets and administrative aspects, were primarily considered.

In this sense, the synergy between dimensions and qualities acknowledged within this framework not only represents a vision for sustainable urban water management, but also contributes to achieve sustainable development.

4.3.2 Phase-B: Developing an Assessment Tool

Following the first phase, an assessment tool is developed in Phase-B.

The resilience qualities presented in the framework act as a pillar for the assessment tool. The qualities are linked to various indicators determined by literature review to create this tool, and ultimately, evaluate the performance of water scarcity management in the context of urban climate resilience. Since the nature of climate resilience and water management present conceptual and numerical features, both qualitative and quantitative indicators were selected according to the framework established in Phase-A.

Subsequently, the determined indicator set is collected under a single roof: the assessment tool, in order to evaluate the water scarcity management performances of the case studies under the principles of climate resilience.

4.3.2.1 Detailed Literature Review

A more detailed literature review was required for this phase to identify indicators with strong links to both resilience principles and water scarcity management. Therefore, in contrast to the literature review conducted in a more general context in the first phase, the review at Phase-B mainly focused on, but not limited to; national/urban resilience strategies and policies, urban water management reports, guidelines, drought response frameworks, climate change action plans and public/private institutional documents and so on.

These multiple secondary sources gave an in-depth understanding on the necessary indicators and formed the basis for the assessment tool.

4.3.2.2 Data Analysis

The indicator set has been the starting point for developing the assessment tool. The indicator set was identified by the analysis of the data collected via literature review.

For each resilience dimension shown in the framework, 10 key performance indicators (KPIs), both qualitative and quantitative, were selected. Thus, 50 KPIs were determined to form the assessment tool.

The relevant selection process and indicators are elaborated below. Each indicator code provided in this chapter will henceforth be used in this study to indicate each KPI.

i. <u>Social Resilience Dimension</u>

To evaluate the case studies, qualitative indicators were selected for the social dimension. The following Table 4-3 presents a selected set of indicators as well as the underlying qualities of each indicator.

Table 4-3 Indicators for Social Resilience Dimension

Resilience Dimension	Underlying Quality	Indicator Code	Indicator
Social	Flexibility	S.1.1	Adaptive capacity in the city and the ability of people to respond quickly to emergencies, extreme events of climate change, especially, to water scarcity
	Inclusive	S.1.2	Level of public awareness on climate change and emerged water scarcity problem
	Inclusive	S.1.3	Stakeholder engagement in decision-making processes of climate adaptation, action and/or resilience plans at the city level
	Inclusive	S.1.4	Equal access to safe water, especially vulnerable groups
	Integrated & Inclusive	S.1.5	Education programs, workshops, training activities on climate change, its emerging impacts, urban climate resilience concept and on the possible actions/measures that can be taken at individual level
	Integrated & Inclusive	S.1.6	Collaboration and co-operation among stakeholders, especially in an extreme event/hazard
	Integrated & Inclusive	S.1.7	Assessment of impacts of water tariffs and/or new regulations on vulnerable groups in the society
	Integrated & Inclusive	S.1.8	Drought management policies and/or drought response frameworks that ensure public awareness, engagement, and preparedness for water scarcity
	Integrated & Inclusive	S.1.9	Water-saving culture
	Robustness	S.1.10	Quality of life and public health & safety associated with water supply and sanitation

The indicators presented in Table 4-3 for the social resilience dimension are mainly focused on a better understanding of the following issues in the case studies.

- ***Adaptive capacity and quick response ability of people against a stress or a shock (S.1.1),*** to determine the residents' preparedness and the flexibility in the city, as well as revealing the current state of the adaptive capacity against short- or long-term interruptions.

- ***Public awareness on climate change and water scarcity problem (S.1.2), and the achieved level of water saving culture (S.1.9);*** to discover whether awareness is widely built in the city and is ultimately reflected in social behaviours - that help to minimize the water footprint and conserve water - in the city.

- ***Stakeholder engagement level especially in decision-making processes of climate related actions, plans and strategies (S.1.3)*;** to enlighten the level of stakeholder involvement, i.e. whether they are informed or they have a voice or influence in decision-making processes, and whether they are actively engaged and work collaboratively with relevant authorities to shape climate-related initiatives together.

- ***Equal access opportunities to safe water (S.1.4)*;** to explore whether vulnerable groups are identified in the city and there are efforts to include all social groups, especially the vulnerable one's, and whether fair and equal access to safe drinking water is provided to all through different programs and initiatives in the city.

- ***Collaboration and cooperation among stakeholders to cope with extreme events (S.1.6).*** This indicator reveals the level of collaboration and cooperation between stakeholders; whether there is a "poor" collaboration and cooperation among stakeholders, indicating low information sharing and slow response to extreme events; or there is "some degree" of collaboration and cooperation among stakeholders, indicating that information sharing is achieved but not efficient in terms of quick response to shocks and building resilience in the city; or there is a multi-agency cooperation structure and an active information sharing among stakeholders that strengthens the quick response mechanism in the city.

- ***Impact assessment for developed water tariffs and new regulations (S.1.7),*** to reveal impacts on society, especially on vulnerable people, and to explore whether the principle of "affordability for all" is the focus of the development of tariffs and regulations.

- ***Developed drought management policies or response frameworks to ensure public awareness, engagement, and preparedness for water scarcity* (S.1.8).** This indicator aims to ascertain whether drought management is widely adopted in the city through developed policies or response frameworks and whether preparedness is achieved among the people and thus in the city.

- ***Quality of life and public health & safety associated with water supply and sanitation services (S.1.10),*** to determine if there is "poor" quality of life and public health and safety indicating a lack of water supply and sanitation services in the city and therefore poor quality water accessed by people; or whether a "high" quality of life and public health has been achieved, meaning well-managed, sustainable water supply and sanitation services that result in good quality drinking water.

In order to analyse the water scarcity management performance in terms of social resilience, all the points mentioned above are covered in detail in the assessment tool within the scope of the developed scoring scheme from score 1 to 5.

ii. Environmental Resilience Dimension

The indicators were specifically selected to explore water scarcity management in case studies from the environmental dimension, while covering the resilience qualities mentioned in the framework.

The selected set of qualitative and quantitative indicators for environmental resilience dimension are presented in Table 4-4.

Table 4-4 Indicators for Environmental Resilience Dimension

Resilience Dimension	Underlying Quality	Indicator Code	Indicator
Environmental	Innovation	EN.1.1	Hydrological modelling, development of scenarios for current/future water demand and availability, and mapping potential impacts
	Innovation & Resourceful	EN.1.2	Adoption of water-efficient technologies
	Innovation & Resourceful	EN.1.3	Continuous monitoring of water quantity and quality in water resources
	Integrated	EN.1.4	Integrated water resources management (IWRM) and performing relevant water assessments
	Resourceful	EN.1.5	Sustainable use of water resources
	Resourceful	EN.1.6	Daily average water consumption per capita
	Robustness	EN.1.7	Identification of opportunities for NBS and implementation
	Robustness & Innovation	EN.1.8	Monitoring and early warning systems for drought
	Robustness & Resourceful	EN.1.9	Preservation, conservation and/or restoration of water resources and ecosystems
	Robustness & Resourceful	EN.1.10	Sound environmental management to ensure quality water supply by controlling pollution

The indicators for the environmental resilience dimension given in Table 4-4, are mainly focused on a better understanding of the following issues in the case studies.

- ***Hydrological modelling, development of scenarios for current/future water demand and availability and mapping potential impacts (EN.1.1);*** *t*o ascertain whether drought-prone zones through innovative technologies are identified and relevant scenarios and action plans are developed to deal with extreme events such as the risk of water scarcity.

- ***Water-efficient technologies (EN.1.2);*** to explore the recognition and extent of adoption of water-saving technologies in the city and to find out if opportunities are created for new fields of application. This indicator ultimately helps define the level of resourcefulness in the city, i.e. whether it has sufficient resources to meet needs under shocks or stress.

- ***Continuous monitoring of water quantity and quality in water resources (EN.1.3);*** to investigate whether water resources are continuously monitored in terms of quality and quantity, or there is only periodic monitoring. Also, another important issue explored with this indicator is whether the data collected is evaluated and modelling is done to identify possible actions.

- ***Integrated water resources management (IWRM) and relevant water assessments performed (EN.1.4);*** to investigate the degree of recognition and adoption in urban policies or strategies of IWRM, which supports sustainable water management in cities and regular water assessments in terms of quality and quantity.

- ***Sustainable use of water resources (EN.1.5);*** to determine whether the pillars of sustainability and sustainable development are acknowledged in urban policies and strategies in the city, and whether the sustainable use of water resources and water conservation are promoted. This indicator also focuses on understanding the existence of actions or initiatives in terms of water minimization.

- ***Daily average water consumption per capita (EN.1.6);*** to reveal the current state of water consumption in the city and to understand the effectiveness of the actions taken or initiatives launched, whether they were sufficient or insufficient to reduce water consumption.

- ***Opportunities for nature-based solutions (NBS) and implementation (EN.1.7);*** to identify whether NBS options are recognized in urban policies and strategies and evaluated as an option in the city for projects to create robust environmental assets, services and infrastructure.

- ***Monitoring and early warning systems for drought (EN.1.8);*** to determine whether a monitoring and early warning system against drought events are developed in the city and preparedness is supported to create a robust city against shocks and stresses.

- ***Preservation, conservation and/or restoration of water resources and ecosystems (EN.1.9);*** this indicator mainly focuses on determining whether water resources and ecosystems are protected and whether emphasis is placed on urban policies and strategies, and on revealing the effectiveness and efficiency of the actions taken.

- ***Sound environmental management to ensure quality water supply by controlling pollution (EN.1.10).*** This indicator mainly aims to determine the effectiveness of environmental management adopted in the city to monitor whether the necessary steps are taken for safe water supply and whether water and environmental pollution is prevented or reduced.

To evaluate water scarcity management performance in terms of environmental resilience, all the above-mentioned aspects are covered in the assessment tool under the developed scoring scheme from 1 to 5.

iii. Infrastructural Resilience Dimension

Qualitative and quantitative indicators were selected for the infrastructural dimension to evaluate the case studies. Table 4-5 below presents the selected set of indicators, as well as the underlying qualities for each indicator.

Table 4-5 Indicators for Infrastructural Resilience Dimension

Resilience Dimension	Underlying Quality	Indicator Code	Indicator
Infrastructural	Innovation	INF.1.1	Smart water leak detection & water metering and continuous monitoring systems for water supply networks and relevant infrastructures
	Integrated	INF.1.2	Rate of population served by water supply network in total municipal population (%)
	Redundancy & Independence	INF.1.3	Spare (back-up) capacity for water infrastructure and services
	Reflective & Integrated	INF.1.4	Data and information sharing in water utilities and feedback system to inform the future from past experiences
	Resourceful & Innovation	INF.1.5	Capacity building for non-conventional water resources (NCWR); such as, water transfers, groundwater use, desalinization, treated wastewater reuse, water harvesting, etc.
	Robustness	INF.1.6	Retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or new GI designs in urban development
	Robustness	INF.1.7	Green buildings, green features and green infrastructures (GI) across the city and integration of GI into urban planning
	Robustness	INF.1.8	Average water leakage rate at water supply network
	Robustness & Innovation	INF.1.9	Maintenance and Repair (M&R) for water-related infrastructures - including water and wastewater services, networks and assets - and adoption of technologies to conduct M&R
	Robustness & Integrated	INF.1.10	Integration of "climate resilience" into water assets, services and all relevant infrastructure design, operation and maintenance activities

The indicators for the infrastructure resilience dimension listed in Table 4-5 are mainly focused on a better understanding of the following aspects of the case studies.

- ***Smart water leak detection & water metering and continuous monitoring systems for water supply networks and relevant infrastructures (INF.1.1);*** to determine whether innovative solutions are integrated into water networks and infrastructures to cope with water losses in the city and whether losses are reduced, or effective countermeasures are taken.

- ***Rate of population served by water supply network in total municipal population (INF.1.2).*** This indicator aims to reveal the development level of water supply network and its capacity to serve the entire population of the city. As a result, it will help to analyse the efficiency of the integrated water network achieved in the city.

- ***Spare capacity for water infrastructure and services (INF.1.3);*** to determine whether back-up capacity for water-related infrastructure and assets is included in policies and whether capacity is being built or steps are being taken to build it in the city.

- ***Data and information sharing in water utilities and feedback system to inform the future from past experiences (INF.1.4).*** This indicator focuses on the information sharing mechanism in water utilities, to reveal if feedback loops are developed for the infrastructure and cascading or persistent failures are minimized. In this sense, "successful" data and information sharing specified in the assessment tool indicates widespread adoption of the feedback system for infrastructures and reduced cascading or persistent failures, while "advanced" data and information sharing refers to improved feedback mechanism and largely avoided failures.

- ***Capacity building for NCWR (INF.1.5);*** to determine the level of knowledge and recognition of NCWR in the city, as well as identify steps taken to realize the NCWR alternatives in practice. "Insufficient" knowledge and capacity for NCWR highlighted in the assessment tool indicates the need to disseminate NCWR throughout the city, both at institutional and individual levels and then identify capacity building options; while "significant" capacity refers to the recognition of NCWR in urban policies or strategies in the city, and actions taken or being taken to increase the amount of water for the supply network by means of NCWR, although there are some gaps in terms of individual and institutional level actions. On the other hand, the "built capacity" discoursed in the assessment tool refers to the wide recognition and adoption of NCWR in the city as an alternative source and ultimately the integration of innovative technologies for additional capacity, and so to achieve resourceful city.

- ***Retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or new GI designs in urban development (INF.1.6);*** to determine whether the essential role of "green" and GI in the city against climate change is recognized, and actions or programs are undertaken to incorporate "green" into the city's critical infrastructure through retrofit and replacement programs. The "effective" retrofit and replacement programs in the assessment tool refer widely adopted and disseminated GI in the city.

- ***Green buildings, green features, and GI across the city and integration of GI into urban planning (INF.1.7).*** This indicator aims to understand the level of knowledge and recognition of "green" in the city and efforts to integrate it into existing infrastructure and urban planning.

- ***Average water leakage rate at water supply network (INF.1.8).*** This indicator aims to shed light on water losses in the network and determine whether the measures taken are effective in reducing water losses, and whether additional measures are needed to establish a robust infrastructure.

- ***Maintenance and Repair (M&R) for water-related infrastructures and adoption of technologies to conduct M&R (INF.1.9);*** to determine whether a regular M&R is conducted for water infrastructures such as water and wastewater networks and related assets, and whether innovative technologies (e.g. SCADA) are adopted to ensure comprehensive control and M&R over the infrastructure. This indicator was selected to determine whether an uninterrupted service and robust water infrastructure is achieved through regular M&R.

- ***Integration of "climate resilience" into water assets, services and all relevant infrastructure design, operation and maintenance activities (INF.1.10).*** This indicator aims to determine whether the concept of "climate resilience" is recognized in the city and, if embraced, its level. The focus is on the concept's level of integration in the city, through initiatives launched or actions taken towards urban climate resilience.

All the points mentioned above are elaborated in the assessment tool under the scoring scheme developed from 1 to 5, to evaluate water scarcity management performance in terms of infrastructural resilience.

iv. Economic Resilience Dimension

In order to evaluate the case studies under economic dimension, qualitative indicators were selected. The selected set of indicators for economic resilience, as well as the underlying qualities for each indicator are presented in Table 4-6.

Table 4-6 Indicators for Economic Resilience Dimension

Resilience Dimension	Underlying Quality	Indicator Code	Indicator
Economic	Inclusive	EC.1.1	Inclusion of awareness-raising campaigns for "water footprint minimization" in financial plans
	Innovative & Flexibility	EC.1.2	Incentive programs to reduce water consumption in the agricultural sector
	Innovative & Flexibility	EC.1.3	R&D investments to seek innovative solutions for sustainable water management
	Integrated	EC.1.4	New funding opportunities by international cooperation & partnerships on climate change
	Redundancy	EC.1.5	Budget allocation to back-up (spare) capacity for water-related infrastructure, assets and services
	Resourceful & Robustness	EC.1.6	Investments in water resources development and management, water reclamation and reuse projects
	Robustness	EC.1.7	Budget allocation to improve climate resilience in urban water systems
	Robustness	EC.1.8	Investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses
	Robustness	EC.1.9	Investments in climate-resilient urban built environment to increase adaptation capacity against climate change
	Robustness	EC.1.10	Water tariff regulations to manage the supply-demand gap

The economic resilience indicators given in Table 4-6 are mainly focused on a better understanding of the following features of the case studies.

- ***Inclusion of awareness-raising campaigns for "water footprint minimization" in financial plans (EC.1.1);*** to reveal if a significant amount of budget is allocated to awareness programs/campaigns to promote water conservation in the city.

- ***Incentive programs to reduce water consumption in the agricultural sector (EC.1.2);*** to determine whether sustainable production and water conservation are promoted in the agricultural sector through incentive programs for new technologies and modernization of production processes. This indicator ultimately aims to explore support for flexibility and innovative solutions in the agricultural sector.

- ***R&D investments to seek innovative solutions for sustainable water management (EC.1.3);*** to specify whether R&D is adopted in the water management sector and ultimately backed by significant investments to improve water security and conservation of water resources.

- ***New funding opportunities by international cooperation & partnerships on climate change (EC.1.4).*** This indicator mainly aims to explore new funding opportunities created in the city through international cooperation and partnerships about climate change. In this sense, "successful" international cooperation & partnerships stated in the assessment tool indicates different opportunities created for funding new technologies, projects, and initiatives to boost water management, while created "some" international cooperation and partnerships refer to insufficient funding opportunities to achieve integrated water management. On the other hand, the "strong" collaborations and partnerships mentioned in the assessment tool point to various financing opportunities that lead to solid steps towards water scarcity management and building climate resilience in the city.

- ***Budget allocation to back-up (spare) capacity for water-related infrastructure, assets and services (EC.1.5);*** to identify the level of budgets allocated to create a redundancy in water-related infrastructure. Thus, this indicator focuses on the financial aspect of spare capacity in cities rather than recognition of the concept or implementation. The "insufficient" budget allocation indicated in the assessment tool indicates that the budget is insufficient to develop redundancy and resilience to climate change in the city, while the "large" budget allocation refers to redundant and climate-resilient water systems.

- ***Investments in water resources development and management, water reclamation and reuse projects (EC.1.6).*** This indicator determines whether there are investments in the city in the development and management of water resources, and whether there are investments in water supply alternatives, such as water reclamation and reuse projects. The mentioned "significant investments" in the assessment tool indicates to a progress made in terms of developing water resources by means of investing reclamation and reuse projects. On the other hand, "some investments" refers to gaps in budget allocation and thus the realized reclamation and reuse alternatives.

- ***Budget allocation to improve climate resilience in urban water systems (EC.1.7);*** to illuminate the amount of budget allocated to promote climate resilience in urban water systems. The "reasonable budget" stated in the assessment tool indicates that there are budgets allocated, albeit insufficient to build resilience, but the concept still needs to be boosted in the city's water systems. On the other hand, "significant budget" refers to a considerable amount of budget is devoted to climate resilience in water systems and partially robustness is achieved in urban water systems, although there are parts of the

system that still need more investment. In addition, mentioned “large budget” in the assessment tool refers to the allocation of sufficient budget to ensure the development of robust water systems against climate change in the city.

- ***Investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses (EC.1.8).*** This indicator was selected to demonstrate whether investments are made, and budget is devoted to water supply maintenance and retrofit programs, to reduce or prevent water losses caused by bust pipes and leaks in water networks. The “significant investments” in the assessment tool indicate that some budget is allocated to maintenance and retrofit programs to reduce and/or prevent water losses, and water loss is significantly reduced, but improvements are still needed in the network

- ***Investments in climate-resilient urban built environment to increase adaptation capacity against climate change (EC.1.9).*** This indicator mainly focuses on the amount of investment made in building adaptive capacity in the city through the adopted climate resilience approach in the urban built environment. The indicator aims to reveal whether the essential role of climate resilient design is recognized and funded to develop adaptive capacity in urban built forms.

- **Water tariff regulations to manage the supply-demand gap (EC.1.10).** This indicator focuses on the effectiveness of the water tariff, i.e. whether vulnerable groups are covered by the tariff and it is socially inclusive in terms of “affordability for all” principle and whether it promotes water savings by managing consumption and the water supply-demand gap through smartly developed tariffs such as step tariffs.

The points listed above are elaborated in the assessment tool under the scoring scheme.

v. Institutional Resilience Dimension

Qualitative indicators were selected to evaluate the case studies under the institutional dimension. Table 4-7 below presents the selected set of indicators and the qualities associated with each indicator.

Table 4-7 Indicators for Institutional Resilience Dimension

Resilience Dimension	Underlying Quality	Indicator Code	Indicator
Institutional	Innovation & Independence	INS.1.1	Capacity building for non-conventional water resources (NCWR)
	Integrated	INS.1.2	Fragmentation of responsibilities among organizations/authorities for water resources management
	Integrated	INS.1.3	Addressing water scarcity and its impacts on water assets and services from a holistic perspective in policymaking
	Redundancy	INS.1.4	Internalization of spare capacity for water-related assets, infrastructure and systems in urban planning
	Reflective & Innovation	INS.1.5	Monitoring and/or assessment tool for climate actions to measure adaptive improvements and identify progress towards urban climate resilience, as well as to determine future actions based on current experience
	Resourceful	INS.1.6	Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments
	Robustness	INS.1.7	Development and adoption of climate resilience policies & strategies at the urban level
	Robustness	INS.1.8	Acknowledging the essential role and vulnerability of "water" in urban policies
	Robustness	INS.1.9	Recognizing the potential of NBS against climate change and integration in urban policies, strategies and action plans
	Robustness	INS.1.10	Targets to reduce water losses and leakages in water supply system

The institutional resilience indicators listed in Table 4-7 are intended to provide insights into the following features of the case studies;

- ***Capacity building for non-conventional water resources (INS.1.1);*** *to* understand the mindset and approaches of the authorities towards NCWR and whether NCWR alternatives such as water reuse, rainwater harvesting, and grey water recycling are being adopted by the relevant authorities and integrated into urban planning and urban development policies in the city. “Some capacity built” highlighted in the assessment tool refers to limited individual practices in the city and lack of

integration into urban planning and development policies; while the stated "amount of capacity built" indicates that NCWR have some best practices in the city, although NCWR requires wider integration into urban planning and development policies. Furthermore, the "significant amount of capacity built" noted in the assessment tool highlights that NCWR is well-integrated into urban planning and development policies and that such alternatives are widely adopted throughout the city.

- ***Fragmentation of responsibilities among organizations/authorities for water resources management (INS.1.2).*** This indicator aims to shed light on the institutional fragmentation and thus the effects of the fragmented responsibility structure on water management and to reveal the city's strategies to cope with this complexity. The "large fragmentation" mentioned in the assessment tool refers to a complex structure in the integrated management of water resources, in which various organizations make different decisions on the same water system and leave the responsibility to one another or are unwilling to consider their mandate relative to other organizations. On the contrary, "minimized fragmentation" specified in the assessment tool indicates that the level of fragmentation reduced to the lowest level, coordination and collaboration among organizations is ensured, and quick decision-making is provided against emerging problems.

- ***Addressing water scarcity and its impacts on water assets and services from a holistic perspective in policy-making (INS.1.3).*** This indicator aims to reveal whether water scarcity and its impacts on water resources and services are comprehensively addressed in policymaking and whether highlight the synergies between people and ecosystems and the dynamics of water supply and demand.

- ***Internalization of spare capacity for water-related assets, infrastructure and systems in urban planning (INS.1.4);*** to determine whether "spare capacity", i.e. additional capacity, is internalized in the city and included in the urban planning of the city by the relevant authorities for the development of redundant water infrastructure and systems that provide rapid relief from shocks and stresses.

- ***Monitoring and/or assessment tool for climate actions (INS.1.5)*** to measure adaptive improvements and identify progress towards urban climate resilience, as well as to determine future actions based on current experience. Accordingly, this indicator mainly focuses on determining whether the authorities developed a monitoring and/or assessment tool to monitor progress in climate resilience and determine future actions.

- ***Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments (INS.1.6);*** to determine whether water efficiency is included in urban plans and policies, especially if water efficient technologies such as rainwater harvesting, water reuse, grey water recycling are promoted for new developments.

- ***Development and adoption of climate resilience policies & strategies at the urban level (INS.1.7).*** This indicator aims to reveal whether city level climate resilience policies and strategies have been developed that support urban resilience against extreme events caused by climate change.

- ***Acknowledging the essential role and vulnerability of "water" in urban policies (INS.1.8).*** This indicator explores whether the vital role of "water" and its vulnerability to climate impacts are acknowledged in urban policies and whether there are strategies to follow to deal with a potential water scarcity issue.

- ***The potential of Nature Based Solutions (NBS) recognized against climate change and integration in urban policies, strategies, and action plans (INS.1.9).*** This indicator aims to reveal whether NBS is considered as an alternative to climate change in the city and integrated into urban policies, strategies, and action plans to create robust urban forms.

- ***Targets to reduce water losses and leakages in water supply system (INS.1.10);*** intends to unveil the targets set against water losses and the level of loss reduction achieved in the city's water network.

The remarked aspects above are explored in detail under the scoring scheme in the assessment tool, to evaluate water scarcity management performance in terms of institutional resilience.

4.3.2.3 Assessment Tool

In order to collect the indicators under a single roof and to create an assessment tool, MS-Excel was used as an instrument.

In the assessment tool, the numerical range from 1 to 5 given in Table 4-8 was used for scoring indicators.

Table 4-8 Scoring Scheme Developed for the Assessment Tool

Scoring Scheme				
Highly Undesirable 1	Undesirable 2	Neutral 3	Desirable 4	Highly Desirable 5

Each score description was individually tailored to each indicator to provide unambiguous statement and accurate scoring. If there was a quantitative data available for the indicator, the description was quantified based on the data.

For the overall scoring, the weight of each indicator was selected equally in order to provide an uncomplicated and straightforward justification.

4.3.3 Phase C: Benchmarking & Proposing Actions

The final phase of this research consists of conducting literature review for each case study, evaluating the indicators, obtaining an overall score for each case and comparing the results. Ultimately, this phase proposes actions towards the vulnerable case study, in the lights of the best practice. The research methods followed at this phase are given below.

4.3.3.1 Focused Literature Review

The literature review in the last phase of the research sought result-oriented information about the selected case studies. This focused review was conducted to collect the necessary data to address each indicator in the assessment tool. Several urban level sources -mainly secondary- were reviewed under this step, but not limited to; city level strategy plans and policies, climate change action plans, climate change risk assessment, vulnerability analysis reports, public/private reports on resilience, drought and water crisis, drought response frameworks, research articles and other documents relative to selected case studies.

4.3.3.2 Case Studies

The case studies were specifically selected from cities that have a megacity profile, vulnerable in terms of their excessive resource demands and both under risk of water scarcity exposed by climate change. Despite the similarities, the case studies differed significantly from each other in the way they address the problems and their approach to water scarcity risk.

The primary reason in choosing these case studies underlies in this major difference; while London embraces city-level integrated urban resilience strategy, Istanbul draws a more vulnerable position with its insufficient policies on urban resilience. This difference forms the basis for benchmarking to successfully manage the risk of water scarcity in cities and reveal the importance of climate resilience.

4.3.3.3 Benchmarking

The benchmarking among the case studies is the final step of this research. In this step, case studies were analysed according to the indicators and scoring was made for each indicator. Thus, the water scarcity management performance of each case study was quantified, and overall scores were calculated. The city with the lowest overall score referred to “vulnerable city”, while the highest referred to “best practice”. The performance level of each city was evaluated in line with a theoretical background, by qualitative interpretation and quantitative analysis methods. The measured results also addressed the strengths and vulnerabilities of each

city in terms of water scarcity management. The strengths observed in best practice set a precedent for the vulnerable city, and actions were proposed for the vulnerable, to manage water scarcity in the city and ultimately boost urban climate resilience. In a broad sense, this benchmarking study not only enabled to discover the correlation between "urban climate resilience" and "water scarcity management" but also contributed to the vulnerable case to advance towards urban climate resilience notion, in a sustainable manner.

4.3.4 General Overview

The general overview of the research design is gathered under a single diagram in Figure 4-3, to illustrate the structure of the research phases, steps, methods, and instruments. Each step is numbered consecutively, and synergies are indicated by arrows to outline the design in a relatively straightforward manner. In addition, links between the phases, related methods and the objectives are visualized under a diagram provided in the following Figure 4-4.

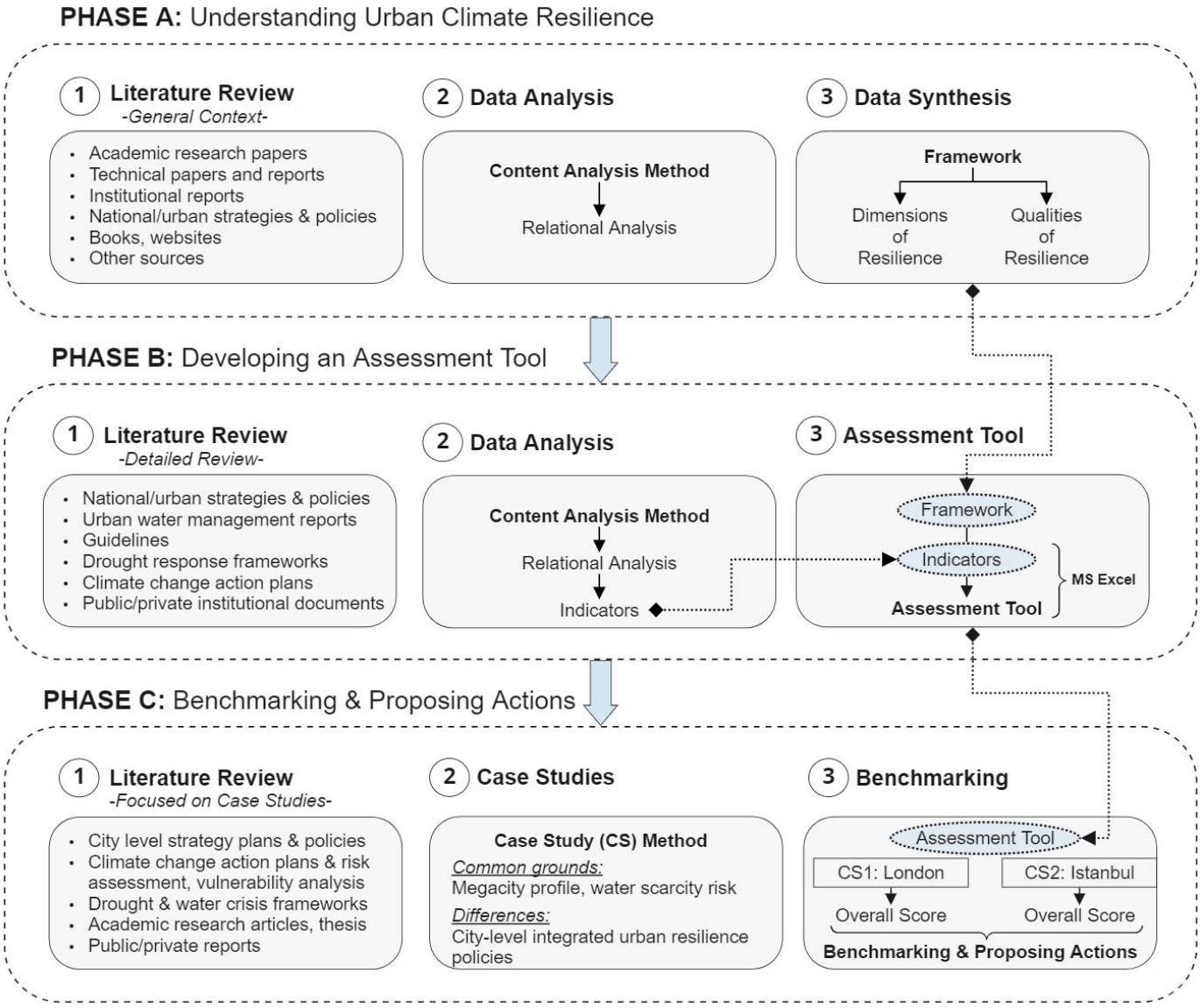

Figure 4-3 General Overview of Research Phases, Methods and Instruments

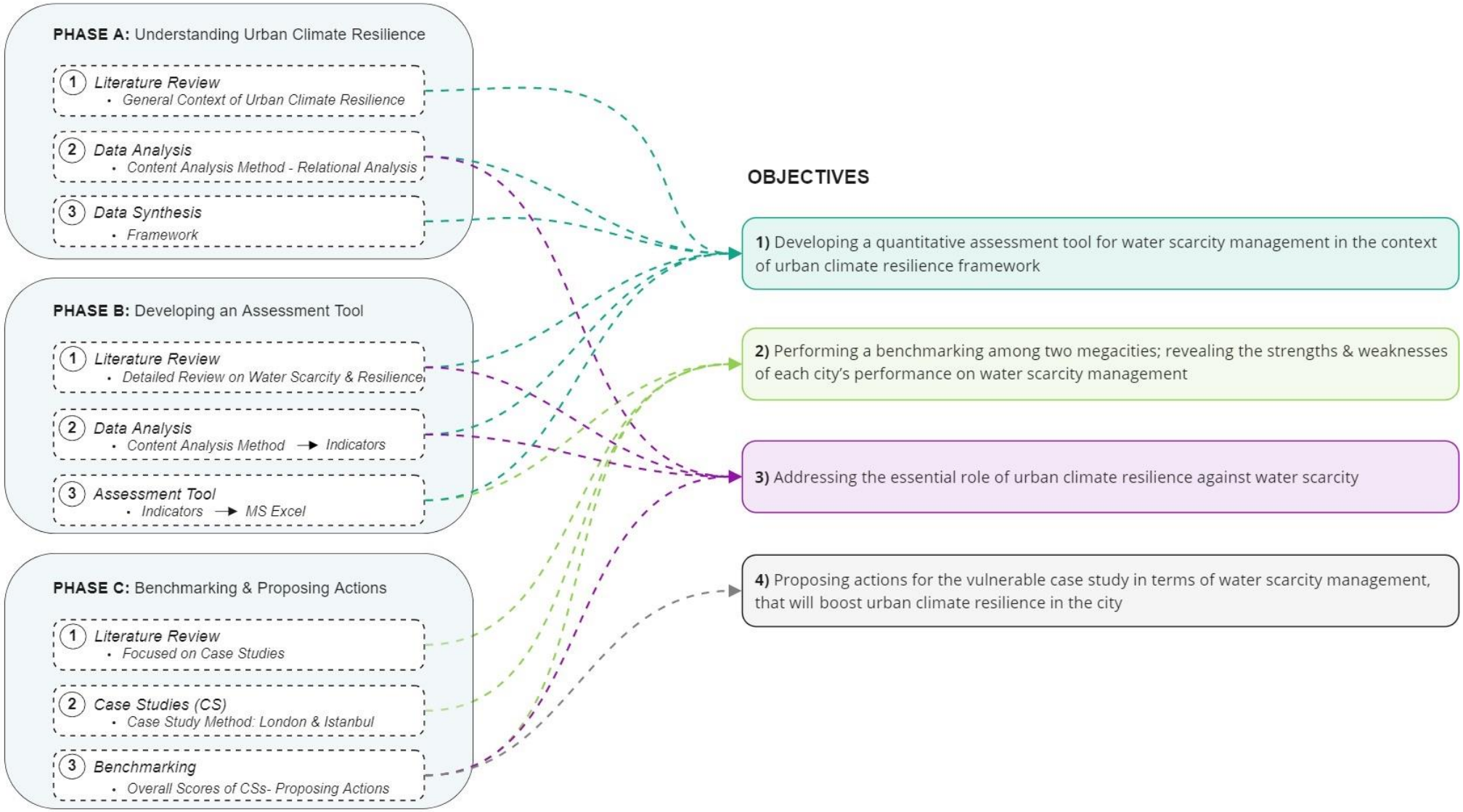

Figure 4-4 Connections between the Phases, Methods and Objectives

CHAPTER 5

5 RESULTS AND DISCUSSION

This chapter presents the results derived from the assessment in line with the methodology provided in Chapter 4 and the discussion of the results.

The chapter answers the main research question by following the objectives of the research, respectively.

The objectives shaping this research and this chapter are as follows:

Objective 1:

Developing a quantitative assessment tool for water scarcity management in the context of urban climate resilience framework

Objective 2:

Performing a benchmarking among two megacities; revealing the strengths & weaknesses of each city's performance on water scarcity management

Objective 3:

Addressing the essential role of urban climate resilience against water scarcity management

Objective 4:

Proposing actions for the vulnerable case study in terms of water scarcity management, that will boost urban climate resilience in the city

With these objectives in mind, the chapter is divided into 3 chapters.

- **Chapter 1:** This chapter first presents the results for the Istanbul case study. The overall results of the assessment of the city's water scarcity management performance, identified weaknesses and strengths are given under separate sub-chapters, respectively. Following the results, a discussion is presented under a separate sub-chapter to discuss the overall results for each resilience dimension and correlate them to the facts observed in the city.
- **Chapter 2:** In this section, the same structure as in chapter 1 is followed. It first presents the results for the London case study. The overall results of the assessment of the city's water scarcity management performance, identified weaknesses and strengths are given under separate sub-chapters, respectively. Following the results, a discussion is given

under a separate sub-chapter to discuss the overall results for each resilience dimension and correlate them to the facts observed in the city.

- **Chapter 3:** This chapter first presents the findings of the benchmarking study of those case study results provided in the first 2 chapters. In the results section, the overall results of the case studies are demonstrated in a single diagram to outline the differences and similarities between the case cities. Next, the discussion sub-chapter follows the results to further clarify the benchmarking findings.

5.1 The Case Study of Istanbul

5.1.1 Results

5.1.1.1 Overall Results of the Assessment

The determined resilience dimensions i.e. social, environmental, infrastructural, economic and institutional were analysed for the case study by means of the KPIs, as described in the methodology. Based on the analysis of the KPIs, assessment scores were calculated for each dimension.

Appendix-1 of this report provides detailed assessment sheets for each resilience dimension of the Istanbul Case Study and gives the scores for each KPI, while this chapter presents the overall scores only. Accordingly, Table 5-1 illustrates the overall scores calculated for each dimension.

Table 5-1 The Overall Scores for the Istanbul Case Study

Dimensions	Average Score
Social	2.80
Environmental	2.80
Infrastructural	**3.20**
Economic	2.90
Institutional	**2.70**
Overall Resilience	**2.88**

As can be seen from the Table 5-1, the highest resilience is calculated for the infrastructural dimension with 3.20 out of 5, and the lowest score is calculated for the institutional dimension with 2.70. Economic resilience follows infrastructure with a score of 2.90, followed by social and environmental resilience with a score of 2.80.

The results of the dimensions contributed equally to the overall resilience calculation as described in the methodology, and the arithmetic mean of the results for Istanbul's urban resilience level in terms of water scarcity management was calculated as 2.88 out of 5.

5.1.1.2 Vulnerabilities

This section presents the vulnerabilities identified in water scarcity management in Istanbul. Since the assessment is conducted with KPIs based on resilience principles, the identified vulnerabilities also inform about the resilience performance in the city.

A numerical range of 1 to 5 was used to score the indicators, as described in the methodology in Chapter 4. In this sense, vulnerabilities for Istanbul were determined as the indicators those gave 1 "highly undesirable" and 2 "undesirable" results in the assessment.

These lowest scores, namely score 1 and 2, can also be described as "high risk" requiring immediate action and "risk" requiring action in the short term, respectively, in terms of water scarcity management.

As a result of the assessment performed for Istanbul, the vulnerabilities given in Table 5-2 were identified. Indicators with a score 1 are shown in dark red, referring to “high risk”, while score 2 are highlighted in red to indicate “risk”.

Table 5-2 Vulnerabilities of Istanbul in terms of Water Scarcity Management

Score	Code for Indicator	Underlying Quality	Identified Vulnerabilities
Social			
2	S.1.1	Flexibility	Adaptation capacity is weak; citizens are unprepared and vulnerable to shocks, stresses, or extreme events
	S.1.5	Integrated & Inclusive	Inadequate educational programs, workshop, or training activities to raise public awareness on climate change and urban climate resilience
	S.1.8	Integrated & Inclusive	No city level drought management policies and/or drought response frameworks, only at the national level
	S.1.9	Integrated & Inclusive	Poor water saving culture
Environmental			
1	EN.1.6	Resourceful	High daily average water consumption per capita
2	EN.1.8	Robustness & Innovation	No monitoring and/or early warning system against drought yet
Infrastructural			
2	INF.1.6	Robustness	City is poor in terms of green infrastructures (GI). Lack of retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or no new GI designs in the city

Score	Code for Indicator	Underlying Quality	Identified Vulnerabilities
2	INF.1.7	Robustness	Lack of integration of green infrastructures (GI) into urban planning and inadequate implementation of green buildings, green features, and GI throughout the city
Economic			
2	EC.1.7	Robustness	Insufficient budget allocation to climate resilience in urban water systems
	EC.1.9	Robustness	Lack of investments in climate resilient urban built environment to create adaptive capacity
Institutional			
2	INS.1.2	Integrated	Fragmentation of responsibilities among organizations/ authorities for water resources management and hence cooperation and coordination problems in taking action
	INS.1.5	Reflective & Innovation	Inadequate monitoring and/or assessment tool for climate actions to measure adaptive improvements and identify progress towards urban climate resilience
	INS.1.6	Resourceful	Gaps in urban plans and policies to reduce water consumption and increase water efficiency in new developments
	INS.1.7	Robustness	No city-level climate resilience policies or strategies
	INS.1.9	Robustness	Inadequate emphasis and integration of Nature Based Solutions (NBS) in urban policies, strategies, and action plans

As can be seen in Table 5-2, the biggest vulnerability in the city was found to be high water consumption per capita.

5.1.1.3 Strengths

This section presents the strengths identified in water scarcity management in Istanbul.

As stated in Chapter 5.1.1.2, numerical range from 1 to 5 was used to score the indicators. In this sense, strengths for Istanbul were determined as the indicators those gave 4 "desirable" and 5 "highly desirable" results in the assessment.

As a result of the assessment performed for Istanbul, the strengths given in Table 5-3 were determined. Indicators with score 4 are shown in green, while those with score 5 are highlighted in darker green to indicate the good performance.

Table 5-3 Strengths of Istanbul in terms of Water Scarcity Management

Score	Code for Indicator	Underlying Quality	Strengths
Social			
4	S.1.7	Integrated & Inclusive	Water tariffs and new regulations considering all social groups within the scope of "affordability for all" principle
	S.1.10	Robustness	Overall high quality of life and public health & safety associated with advanced water supply and sanitation
Environmental			
4	EN.1.3	Innovation & Resourceful	Continuous monitoring of the city's water bodies and water supply sources in terms of quality and quantity
Infrastructural			
4	INF.1.1	Innovation	Continuous monitoring systems, smart water leak detection and water metering in majority of the water supply network and related infrastructures
	INF.1.9	Robustness & Innovation	Regular maintenance and repair for water-related infrastructures
5	INF.1.2	Integrated	Population served by water supply network in the city
Economic			
4	EC.1.10	Robustness	Water tariff regulations based on volumetric consumption to manage the supply-demand gap
Institutional			
4	INS.1.8	Robustness	Recognition of "water vulnerability" in the major urban policies
	INS.1.10	Robustness	Effective targets to reduce water losses and leaks in the water supply system

As can be seen in Table 5-3, the greatest strength in water management is determined to be the ability of the water network to serve the entire municipal population.

5.1.2 Discussion

The findings in Chapter 5.1.1 indicate that despite the efforts of the Istanbul Metropolitan Municipality on climate adaptation, there are large gaps in urban climate resilience in Istanbul.

In this section, the weaknesses (Table 5-2) and strengths (Table 5-3) revealed by the assessment are discussed under the cause-effect relationship, based on the facts identified in the city. Each resilience dimension is explained according to the overall scores given in Table 5-1 with reference to the KPIs.

5.1.2.1 Social Resilience

Istanbul's social resilience level in terms of water scarcity management was calculated 2.80 out of 5, which indicates a “risk” status by remaining below the “neutral” level (i.e. score 3).

This vulnerability can be largely associated with the lack of public awareness in Istanbul on climate change, climate resilience and water scarcity, while this unawareness can be explained by the insufficient number of awareness raising campaigns and educational programs in the city (refers to S.1.5 in Table 5-2).

Contrary to the water efficiency approach in the city, which is a vital element for Istanbul, as being one of the Turkey's megacities with a high population and high demand on natural resources, the lack of awareness in the city causes high water consumption. Social behaviours, habits and culture of the people have direct impact on water management. In this context, the poor water-saving culture associated with an unconscious society has been identified as another obstacle to water scarcity management in Istanbul (refers to S.1.9 in Table 5-2).

In addition, the assessment results were also spotted that adaptive capacity in the city is weak and people are unprepared to extreme events of climate change or emergencies (refers to S.1.1 in Table 5-2). Based on the literature review and assessment results it was also found that city lacks urban level drought management policy, that is tailored with city’s needs (refers to S.1.8 in Table 5-2).

Although the overall score points to a vulnerability in social resilience, there were also spotted a few strong aspects (KPIs with high score) in the city; particularly on the quality of life and public health&safety associated with the safe water served through advanced water supply and sanitation services in the city (refers to S.1.10 in Table 5-3) and on the city’s water tariff considering all social groups (refers to INS.1.7 in Table 5-3).

To sum up, despite there are a few social strengths in the city, insufficient awareness level poses a major obstacle to water-saving culture and complicates water management with unconscious consumption behaviours. Lack of awareness and insufficient public engagement thus hinders social resilience in the city and thereof water scarcity management.

5.1.2.2 Environmental Resilience

Environmental resilience was determined at the same level as social resilience with a score of 2.80, after the calculated lowest score for institutional resilience with 2.70.

In Turkey, from past to present, significant progress has been made in the environmental sector with the initiative to join the EU. The harmonization of EU legislation with national regulations was a major step that triggered environmental development. EU has funded several environmental infrastructure investments to improve the quality of environment, build climate adaptation and support the sustainable environmental management in the country (Delegation of the European Union to Turkey, 2019).

However, it is worth noting that the grey infrastructure investments lead the environmental management approaches in the country, and hence in Istanbul. The country tends to adopt grey infrastructures as a straightforward solution when faced with an environmental problem.

The research results pointed to the lack of a drought monitoring and early warning system (refers to EN.1.8 in Table 5-2), which creates a weakness in environmental resilience.

Moreover, despite the emphasis on "water efficiency" and "water vulnerability" in urban policies, statistical data from the literature showed that daily water consumption in Istanbul is relatively high, around 189 LCD (refers to EN.1.6 in Table 5-2) (TURKSTAT, 2021). This high level of water consumption is strongly associated with a lack of environmental awareness in the city, as previously mentioned in the social dimension.

Finally, as observed from the results, the lack of evaluation and implementation of NBS alternatives (refers to EN.1.7 in Appendix-1) for the urban built environment creates a gap in environmental resilience and causes a "moderate risk" for water management in Istanbul.

5.1.2.3 Infrastructural Resilience

Among the five resilience dimensions evaluated within the scope of this research, the strongest dimension for Istanbul was determined as infrastructural resilience. This determined strength can also be associated with Turkey's EU Accession Programme.

As previously stated, different programs have been funded by the EU. "Environment and Climate Sector Operational Programme" (ESOP) is among these initiatives, and within the scope of this program, the EU provides financial assistance to Turkey in the environment and climate change areas. This program supports various environmental infrastructures, albeit mainly grey infrastructure and increases the resilience of environmental management such as water, wastewater, solid waste management across the country.

Furthermore, the harmonization of EU legislation with national regulations also brought the sustainable development approach to the fore and accelerated environmental infrastructure investments in the country.

As a result of the mentioned accession process, the improvements observed especially in the water network and related infrastructures created strengths for the infrastructure resilience

dimension in this research. Namely, the advanced water supply network serving the entire municipal population in the city (TURKSTAT, 2021) (refers to INF.1.2 in Table 5-3); regular maintenance and repair for water-related infrastructures (refers to INF.1.9 in Table 5-3); continuous monitoring, smart water leak detection and water metering in majority of the water supply network and related infrastructures (refers to INF.1.1 in Table 5-3) are the identified strong aspects.

Besides the strengths, vulnerabilities in the city are mainly linked to the lack of integration of GI in urban planning (refers to INF.1.7 in Table 5-2) and the lack of retrofit programs in terms of transforming grey into green infrastructure (refers to INF.1.6 in Table 5-2).

In conclusion, all the adapted national policies and the environmental infrastructure projects implemented within the scope of EU accession clarify the high overall score calculated for the infrastructural resilience dimension in Istanbul; despite low scores obtained due to the poor integration of GI into urban planning and lack of GI retrofit programs.

5.1.2.4 Economic Resilience

Despite the economic resilience dimension follows infrastructure as the second highest score in the assessment, it remains below the "neutral" level (i.e. score 3), which indicates a risk in terms of water scarcity management and indicates the need for an action.

The economy is the main factor affecting the investments in a country and Turkey is not one of the best examples in terms of strong economy, which is also verified by the results of this research.

Since 2018, Turkey has been experiencing an economic recession. The already unstable economy has recently been exacerbated as a result of the COVID-19 pandemic. Due to the economic difficulties in the country, overall investments were greatly affected, and the allocated budgets were decreased at certain level, or the investments were pushed into the background.

According to the assessment results, the lack of investments in the climate-resilient urban built environment (refers to EC.1.9 in Table 5-2) and the insufficient budget allocated to the climate-resilient water investments (refers to EC.1.7 in Table 5-2) are seen as "risk" factors those can be associated with the specified economic condition.

Yet, there was also obtained a good performance in water scarcity management. One of the strengths of economic resilience is water tariff adjustments based on volumetric consumption to manage the supply-demand gap (EC.1.10 in Table 5-3) that promotes reductions in water consumption.

In conclusion, the fact that the actions to be taken in the climate change pushed into the background due to the stated economic conditions explains the overall score remaining below the "neutral" level, and the "risk" situation for water scarcity management.

5.1.2.5 Institutional Resilience

Although institutional resilience reveals several strengths, particularly ambitious targets for water losses in the water supply system (refers to INS.1.10 in Table 5-3) and the adoption of "water vulnerability" in urban policies (refers to INS.1.10 in Table 5-3), institutional resilience was nevertheless identified as the most vulnerable among the five resilience dimensions assessed in Istanbul.

This vulnerability can be largely attributed to the complex hierarchical structure of water resources management in Turkey. Different central and provincial public authorities are responsible for the management of water resources, and each authority participates in the management within its limits of power.

Uncertain institutional jurisdictions and the inability to determine the main authority at the local level raise important institutional problems. This complexity causes organizational coordination and cooperation problems, fragmented management structure, and fragmented responsibilities that delay decision-making processes (refers to INS.1.2 in Table 5-2).

On the other hand, another major institutional weakness of the city was spotted as the lack of climate resilience strategy at the city-level (refers to INS.1.7). Although Istanbul is part of the C40 cities that helped adopt climate resilience approaches in the city, the literature review showed that the city lacks a tailor-made climate resilience strategy; and this constitutes a weakness in institutional resilience, posing a risk to water scarcity management.

Another risk revealed by the assessment is the lack of adequate emphasis in urban policies and plans on NBS, which is a key asset to build climate resilience in cities (refers to INS.1.9 in Table 5-2). Despite the new recognition of the importance of urban green in combating climate change and its integration into the Istanbul Climate Change Action Plan (2018); green investments, especially NBS, have been disregarded. The gap in the integration of NBS into urban policies and the lack of implementation in the city, represent an institutional weakness for the Istanbul Water and Sewerage Administration (ISKI), the relevant authority in water management in Istanbul.

Not only NBS, but also water efficiency approaches in the city face a similar problem in terms of lack of emphasis in urban policies and regulations. Based on the literature review it was concluded that there is a gap in urban planning in terms of water efficiency. More specifically, urban planning regulations, building codes, relevant urban development frameworks and policies in Turkey were found to be weak in promoting water efficiency. While this lack of regulatory in the city points to an institutional weakness, it also adversely affects the water scarcity management, as can be seen through this assessment results (refers to INS.1.6 in Table 5-2).

In addition, adaptation monitoring for climate action to measure adaptive improvements in Istanbul was also identified as a weakness as a result of this assessment (refers to INS.1.5 Table 5-2). This fact can be attributed to the lack of an existing monitoring system for climate actions; however, Istanbul Climate Change Action Plan 2018 states that a monitoring system is currently

under development and progress in monitoring and evaluation indicators for climate adaptation is currently at the 25-50% stage.

To sum up, all these stated factors hinder the institutional resilience and hence the water scarcity management in Istanbul.

5.2 The Case Study of London

5.2.1 Results

5.2.1.1 Overall Results of the Assessment

Similar to the Istanbul Case Study, the five dimensions for urban resilience were analysed with the assessment tool developed. Based on the analysis of the KPIs, assessment scores were calculated for each dimension. Detailed assessment sheets of the London Case Study are provided in Appendix-2.

Table 5-4 presents the scores calculated for each dimension and the overall resilience score of the city.

Table 5-4 The Overall Scores for the London Case Study

Dimensions	Average Score
Social	**4.00**
Environmental	3.90
Infrastructural	3.90
Economic	**3.70**
Institutional	3.80
Overall Resilience Score	**3.86**

Based on the results presented in Table 5-4, the highest resilience is calculated for the social dimension with 4 out of 5, and the lowest score is calculated for the economic dimension with 3.70. Social resilience is followed by environmental and infrastructural resilience with a score of 3.90, then institutional resilience with a score of 3.80.

The results of the dimensions contributed equally to the overall resilience calculation as described in the methodology, and the arithmetic mean of the results for London's urban resilience level in terms of water scarcity management was calculated as 3.86 out of 5.

5.2.1.2 Vulnerabilities

This section presents the vulnerabilities identified in water scarcity management in London. Since the assessment is made with KPIs that follow the resilience principles, the determined vulnerability indicators also provide information about the resilience performance of the city.

A numerical range from 1 to 5 was used to score the indicators. However, unlike Istanbul, no "high risk" or "risk" status was observed in London's results, i.e. no KPIs resulting in score 1 or 2. Therefore, for the London case study, vulnerabilities were defined as KPIs that resulted in a score 3 "neutral". These identified vulnerabilities can require both short and medium-term actions regarding the water scarcity management, depending on the current state of the indicator and the level of emergency due to climate change in the city.

As a result of the assessment performed for London, the vulnerabilities given in Table 5-5 were identified. Indicators with score 3 are highlighted in yellow colour, referring to "moderate risk".

Table 5-5 Vulnerabilities of London in terms of Water Scarcity Management

Score	Code for Indicator	Underlying Quality	Vulnerabilities
Social			
3	S.1.2	Inclusive	Insufficient public awareness on climate change and the emerging water scarcity problem. However, opportunities are being explored by feasibility of public awareness-raising under the London City Resilience Strategy
Environmental			
3	EN.1.6	Resourceful	Daily average water consumption per capita
Infrastructural			
3	INF.1.3	Redundancy & Independence	Insufficient spare capacity for water infrastructure
	INF.1.8	Robustness	Water losses due to significant leakage rate in the aging water supply network, approximately %24.4 according to London Environment Strategy (2018)
Economic			
3	EC.1.3	Innovative & Flexibility	Deficiencies in R&D investments and implementation of innovative technologies for sustainable water management due to lack of incentives to water companies and regulatory barriers in the sector

Score	Code for Indicator	Underlying Quality	Vulnerabilities
3	EC.1.8	Robustness	Insufficient investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses
	EC.1.9	Robustness	Insufficient investments in climate resilient urban built environment to create adaptive capacity
Institutional			
3	INS.1.2	Integrated	Fragmentation of responsibilities among organizations/ authorities for water resources management
	INS.1.4	Redundancy	Gaps in urban policies and strategies to further highlight or adopt redundancy for water-related assets, infrastructure, and systems

5.2.1.3 Strengths

This section presents the strengths identified in terms of water scarcity management in London. These indicators also indicate the city's resilience performance.

As previously stated, a numerical range from 1 to 5 was used to score the indicators. In this sense, strengths for London were determined as the indicators resulted in 4 "desirable" and 5 "highly desirable" scores in the assessment.

The strengths identified for the London case study are given in Table 5-6. Indicators with score 4 are shown in green, while those with score 5 are highlighted in darker green to indicate good performance.

Table 5-6 Strengths of London in terms of Water Scarcity Management

Score	Code for Indicator	Underlying Quality	Strengths
Social			
4	S.1.1	Flexibility	Considerable adaptation capacity in the city; citizens are prepared to some degree for short-term interruptions and/or shocks, extreme events, or hazards
	S.1.3	Inclusive	Stakeholder involvement and collaborations in the decision-making processes of climate adaptation strategies, action, and resilience plans
	S.1.4	Inclusive	Free and equally accessible safe drinking water. Drinking water fountain programs carried out in the city ensure equal opportunities by providing accessible water to different social groups

Score	Code for Indicator	Underlying Quality	Strengths
4	S.1.5	Integrated & Inclusive	Various educational programs, workshops, training activities on climate change, its emerging impacts, urban climate resilience concept and on the possible actions/measures
	S.1.6	Integrated & Inclusive	Significant collaboration and co-operation among stakeholders
	S.1.8	Integrated & Inclusive	Effective drought management policy and/or response framework at the city level
	S.1.9	Integrated & Inclusive	Wide adoption of water efficient technologies and firm steps towards a water saving culture
	S.1.10	Robustness	Overall high quality of life and public health & safety associated with advanced water supply and sanitation
5	S.1.7	Integrated & Inclusive	Well-managed water tariff and effective regulations considering all social groups within the scope of "affordability for all" principle
Environmental			
4	EN.1.1	Innovation	Actions taken based on hydrological modelling and impact mapping to build resilience and maintain water assets for the future
	EN.1.2	Innovation & Resourceful	Promotion of water efficient technologies and their widespread adoption in most sectors/industries
	EN.1.3	Innovation & Resourceful	Continuous monitoring of the city's water bodies and water supply sources in terms of quality and quantity
	EN.1.4	Integrated	Sustainable water management achieved through an integrative framework and adoption of integrated water resources management (IWRM) in urban policies and strategies to promote resilience.
	EN.1.5	Resourceful	Widespread adoption of sustainability in urban policies and strategies, and various city-wide initiatives/actions for the sustainable use of water resources
	EN.1.7	Robustness	The importance of NBS is well-recognized and incorporated into various urban policies, strategies and action plans. NBS alternatives are considered as an option in most projects.
	EN.1.8	Robustness & Innovation	Monitoring and developed early warning system for drought events
	EN.1.9	Robustness & Resourceful	Sustainable preservation, conservation and/or restoration of water resources
	EN.1.10	Robustness & Resourceful	Sound management against environmental pollution and concrete steps towards safe water

Score	Code for Indicator	Underlying Quality	Strengths
Infrastructural			
4	INF.1.1	Innovation	Continuous monitoring systems, smart water leak detection and water metering in majority of the water supply network and related infrastructures
	INF.1.4	Reflective & Integrated	Successful data and information sharing in water utilities and wide adoption of feedback systems in water-related infrastructure to prevent cascading or persistent failures
	INF.1.5	Resourceful & Innovation	Building significant spare capacity for non-conventional water resources (NCWR) in the city and placing great emphasis on NCWR in urban policies and strategies
	INF.1.6	Robustness	Retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and new GI designs in the city
	INF.1.7	Robustness	Integration of green infrastructures (GI) into urban planning and implementation of green buildings, green features and GI across the city. Solid steps towards replacing grey infrastructure with GI
	INF.1.9	Robustness & Innovation	Regular maintenance and repair for water-related infrastructures
	INF.1.10	Robustness & Integrated	Integration of "Climate resilience" into water-related urban infrastructure, services and assets
5	INF.1.2	Integrated	Population served by water supply network in the city
Economic			
4	EC.1.1	Inclusive	Incorporating awareness campaigns into the financial plan
	EC.1.2	Innovative & Flexibility	Incentive programs to boost sustainable production and water savings in agriculture sector
	EC.1.4	Integrated	Several funding opportunities by means of successful international cooperation and partnerships on climate change
	EC.1.5	Redundancy	Significant budget allocation to build a back-up (spare) capacity for water-related infrastructure, assets & services
	EC.1.6	Resourceful & Robustness	Significant investments in water resources development and management, water reclamation and reuse
	EC.1.7	Robustness	Considerable amount of budget allocation to increase climate resilience in urban water systems
	EC.1.10	Robustness	Water tariff regulations based on volumetric consumption to manage the supply-demand gap

Score	Code for Indicator	Underlying Quality	Strengths
Institutional			
4	INS.1.1	Innovation & Independence	Amount of capacity built in the city for non-conventional water resources (NCWR)
	INS.1.3	Integrated	Water scarcity and its impacts on water assets and services are addressed holistically in policies with reference to synergies between people, ecosystems, and water supply & demand dynamics.
	INS.1.5	Reflective & Innovation	Monitoring and assessment tool to ascertain the progress on climate resilience and identify the future actions
	INS.1.6	Resourceful	Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments
	INS.1.7	Robustness	Development and adoption of city-level climate resilience policies and strategies
	INS.1.8	Robustness	Recognizing the "water vulnerability" in the major urban policies
	INS.1.9	Robustness	Recognizing the importance of Nature Based Solutions (NBS) against climate change and integration of NBS into urban policies, strategies, and action plans
	INS.1.10	Robustness	Effective targets to reduce water losses and leaks in the water supply system

As can be seen in Table 5-6, the strongest aspects in water scarcity management were identified in the “social” and “infrastructure” dimensions. Effective regulations and well-managed water tariffs that take into account all social groups within the scope of the “affordability for all” principle in the city is one of the strongest aspects determined under the social resilience dimension, while the other is determined under the infrastructure dimension as “the water supply network that currently covers the population in London”.

In addition, large number of strengths with high scores were piled up under the "social" dimension which explains the calculated highest score in Table 5-4.

5.2.2 Discussion

The findings in Chapter 5.2.1 reveal that despite the efforts of the Greater London Authority and the dedicated support of the mayor, there are still some gaps in London's adaptive capacity and urban climate resilience.

In this section, the weaknesses (Table 5-5) and strengths (Table 5-6) revealed by the assessment are explained under the cause-effect relationship, based on the facts identified in the city. Each resilience dimension is discussed according to the overall scores given in Table 5-4 with reference to the KPIs.

5.2.2.1 Social Resilience

Among the five dimensions of resilience evaluated within the scope of this research, social resilience was determined as the strongest aspect for London.

In light of the literature review, the public awareness level in London was identified insufficient to provide robust urban climate resilience (refers to S.1.2 in Table 5-5). However, it was also found that opportunities to raise awareness in the city were explored with a feasibility study, under the “sustainable water use” action determined in the London City Resilience Strategy (2020). Based on these efforts, it was concluded that London aims to fill the gaps in its urban climate resilience by promoting stakeholder engagement through awareness. Urban policies and strategies support this argument by pointing to London's educational programs, workshops, and activities on climate change to raise public awareness (refers to S.1.5 in Table 5-6).

In other respects, it was found that stakeholders play an important role in London's actions against climate change. For instance, stakeholder engagement and co-design have been key steps in the London City Resilience Strategy (2020). Various opportunities were created to involve stakeholders during developing a resilience strategy, such as workshops to discuss urban resilience and understand climate challenges in the city, public consultation process via online surveys, co-design solutions, and collaborative strategy development, respectively. These engagement methods have supported the collaborative shaping of resilience strategy and plans in the city (refers to S.1.3 in Table 5-6) (Greater London Authority, 2020).

The most significant strength in London is observed in water tariffs and water supply regulations, that follow the "affordability for all” principle. In London, water tariffs are set taking into account all social groups, especially the vulnerable (refers to S.1.7 in Table 5-6).

According to Table 5-6, other strengths uncovered by the assessment are as follows:

- ✓ Adaptive capacity to shocks, stresses, or extreme event, which is ensured by addressing long-term risks as an action under the London City Resilience Strategy (2020). A better understanding of risks enables these challenges to be managed and prepared for long-term shocks, stresses or extreme events, ultimately building adaptive capacity (refers to S.1.1)

- ✓ Free and equally accessible safe drinking water which is promoted by fountain programs launched in the city to ensure equal opportunities (refers to S.1.4)
- ✓ Collaboration and co-operation achieved among stakeholders (refers to S.1.6) via developed "multi-agency coordination and information sharing" structure under the "Strategic Coordination Protocol"
- ✓ Effective drought response framework at the city level, that reveals risks and possible actions (refers to S.1.8)
- ✓ Wide adoption of water efficient technologies and firm steps towards a water saving culture through “sustainable water use” action determined in the London City Resilience Strategy (2020) (refers to S.1.9)
- ✓ Advanced water supply and sanitation services ensure high quality of life and public health and safety in the city (refers to S.1.10)

All these concrete initiatives and steps explain the high score achieved in the social resilience dimension.

5.2.2.2 Environmental Resilience

Another strength that follows the highest score calculated in the city is the environmental resilience dimension with a score of 3.90.

In line with the strengths given in Table 5-6, the calculated high score for environmental resilience can be attributed to the widespread recognition of sustainability in the city and successful integration of sustainable water use (EN.1.5), sustainable conservation of water resources (EN.1.9), and the integrated water resource management (IWRM) approach (EN.1.4) into urban policies, strategies and action plans.

Another strong aspect that can be pointed through this assessment is the recognition of the importance of NBS in the city (refers to EN.1.7 in Table 5-6). The conducted literature review on the recent London Plan (2021), London City Resilience Strategy (2020), London Environment Strategy (2018) and the London Water Strategy (2011) showed that NBS alternatives have gained an important place in projects, and SuDS, urban greening and GI investments have been accelerated with the full understanding of the importance of green in the city to adapt climate change. Further to the projects, London has created a Green Infrastructure Task Force focusing on the long-term implementation and delivery of GI in the city.

In addition, the mayor’s "climate emergency" declaration in 2019 was helped to push the climate actions and relevant programs forward. In this direction, an ambitious goal "Making London a National Park City" was set to boost urban green and nature in the city, while building climate resilience through NBS and GI (Greater London Authority, 2018).

Another strength derived from the assessment was the monitoring and early warning system developed for drought events (refers to EN.1.8). This strength can be strongly linked to "Drought and Water Scarcity Research Programme" funded by the UK Government, which has made a great progress in terms of interactive monitoring and early warning (MEW) system across the country. The interactive tools map the prone zones and provide insights into drought and water scarcity risks across the country, as well as at the city level.

Other strengths uncovered through the assessment are listed below according to Table 5-6.

- ✓ Planning and taking actions based on hydrological modelling and impact mapping to build resilience and protect water assets for the future (refers to EN.1.1)
- ✓ Promotion of water efficient technologies and their widespread adoption in most sectors, e.g. industrial, agricultural and domestic uses (refers to EN.1.2)
- ✓ Continuous monitoring of the city's water bodies and water supply sources (i.e. abstracted surface water, groundwater and other resources) in terms of quality and quantity and regular assessment of the data to observe the current state and take actions if necessary (refers to EN.1.3)
- ✓ Sound environmental management against pollution and concrete steps towards safe water (refers to EN.1.10)

All the aforementioned facts strongly support the water scarcity management from an environmental resilience perspective.

Nevertheless, a “moderate risk” for water scarcity management was also identified for the environmental resilience dimension. Despite the importance given to water efficiency in urban policies and various public awareness programs in London; literature data shows that average water consumption in the city is still high, with around 149 LCD (Greater London Authority, 2018). High consumption has been a focus in the recent London City Plan (2021), which set actions by appointing 105 LCD water supply design standard for new developments. In addition to that, "Supplementary Planning Guidance on Sustainable Design and Construction" supports developers to aim 80 LCD for new developments (Greater London Authority, 2014).

Overall, these actions of GLA constitute a solid step towards water efficiency and are promising for significant reductions, in contrast to the recent high consumption level. Undoubtedly, reductions in water consumption will help boost the environmental resilience.

5.2.2.3 Infrastructural Resilience

The infrastructural resilience was determined at the same level with environmental resilience with a score of 3.90, after the calculated highest score, namely social resilience with score 4.00.

The assessment results showed that the greatest performance in terms of infrastructure resilience is the connection rates of water supply network (refers to INF.1.2 in Table 5-6). In fact, this strength can be explained by the advanced water network serving almost all households in the city, covering residents within the GLA.

As mentioned earlier, after the climate emergency declaration, investments in climate resilience were soared up (refers to INF.1.10 in Table 5-6), great emphasis was placed to GI and green features in urban policies/strategies, and GI projects were fostered in the city (refers to INF.1.7 in Table 5-6). According to the London Plan (2021) and the London Environment Strategy (2018), "SuDS in London", "Greening the Business Improvement Districts", "Green Roofs and Walls" and "Grey to Green" are some of these programs those were launched in the city.

In addition, through the Green Infrastructure Task Force created, opportunities were sought to integrate GI into both existing and new infrastructures to derive maximum benefit from GI in the city. Accordingly, retrofit programs have been initiated for the existing critical infrastructures and housings, as well as new designs to integrate “green” into the city (refers to INF.1.6 in Table 5-6).

Adopting green features and green designs imitating nature in the built environment is a solid step towards strengthening climate resilience in critical infrastructures, including London's water infrastructure and assets; hence it also boosts the water scarcity management in the city.

On the other hand, initiatives to build spare capacity for non-conventional water resources (NCWR) in the city and the high emphasis on NCWR in urban policies/strategies are another strength pointed by the assessment (refers to INF.1.5 in Table 5-6). The good performance of this indicator strongly correlates with the existing feasibility studies searching for alternative water sources in the city. The London Plan (2021) states that Thames Water currently studies several strategic water resource approaches to address drought and water scarcity, including several options for London, such as effluent reuse, water transfers, a potential new reservoir, or a groundwater source.

Some other strengths observed in terms of infrastructure dimension in water scarcity management are summarized below according to Table 5-6.

- ✓ Innovative technologies for monitoring and leak detection are integrated into the water network. Thus, most of the city's water supply network and related infrastructures provide continuous monitoring systems, smart leak detection and water metering, and if not, various programs are launched to promote such technologies (INF.1.1)

- ✓ Successful data and information sharing in water utilities and wide adoption of feedback mechanisms in water-related infrastructure to prevent cascading or persistent failures in the system (INF.1.4)
- ✓ Regular maintenance and repair programs performed for water-related infrastructures, to prevent or minimize the constant failures due to the aging infrastructure of London (INF.1.9)

The stated key factors help develop robust infrastructures and explain the high score calculated for the infrastructural resilience dimension in the research. However, a few “moderate risks” were also defined for the infrastructural resilience as in the following.

- ✓ The final classification of Environment Agency on water stressed areas demonstrates that the city of London is classified as a "serious water stress" area (Environment Agency, 2021) and the water problem in the city is triggered by both climate change and rapid population growth. Redundancy plays an important role in providing uninterrupted service to people and in this context, London has already recognized the significance of spare capacity for its water infrastructure and embedded the concept of "redundancy" in its urban resilience policies. However, there are still some gaps both in policies and in practice, and there is a lack of spare capacity for water infrastructure (refers to INF.1.3 in Table 5-5), especially in terms of water storage facilities to cope with severe droughts and maintain the supply.
- ✓ According to the vulnerabilities identified, another challenge to resilient infrastructure is water losses due to aging infrastructure in London. Pipe bursts and leaks due to old water supply network pose a major challenge for both GLA and the water companies serving the city. Although various programs have been initiated for the maintenance and reinforcement of the water supply network, the leakage rate is still high (refers to INF.1.8 at Table 5-5) and it can be concluded that the efforts are insufficient.

5.2.2.4 Economic Resilience

The economic resilience was identified as the most fragile element for London in terms of water scarcity management.

Despite pursuing resilience strategies and climate adaptation plans and embedding “green solutions” and “sustainability” into urban policies; research results show that investments in such approaches are still insufficient to develop a resilient city. The literature review indicates that the city still lacks the desired level of adaptive capacity to cope with climate challenges, pointing to insufficient investments and inadequate practices to create a resilient urban built environment (refers to EC.1.9 at Table 5-5).

As mentioned in Chapter 5.2.2.3, the biggest challenge to resilient infrastructure is water losses due to aging infrastructure and assets in the city, and it was revealed that existing initiatives and programs are insufficient to reduce water losses. In this context, it can be concluded that more

investments are needed in maintenance and retrofit programs to reduce water losses (refers to EC.1.8 in Table 5-5).

Another weakness that is pointed by the results is investments in research and development (R&D) in the water sector referring to EC.1.3. According to the literature review, it was observed that R&D in the UK water sector remains in the background and receives less government support than other sectors. There has been a decline in research and innovation for new solutions since the early 90s, as water companies have to finance R&D under their own operational or capital expenditures. Lack of incentives and regulatory barriers of the existing water system are the main barriers to R&D, which may explain the fragility defined in EC.1.3 and be attributed to the low score calculated for economic resilience dimension.

These identified factors explain the lowest overall score calculated and the "moderate risk" status for water scarcity management in the economic dimension.

Nevertheless, some indicators showing good performance in water scarcity management were also observed, as follows (pls. see Table 5-6 in Chapter 5.2.1.3):

- ✓ Importance attached to inclusivity and incorporated awareness-raising campaigns into financial plans (EC.1.1) to develop water saving culture and promote water conservation in the city;
- ✓ Incentive programs to foster sustainable production and water efficiency in agriculture sector (EC.1.2);
- ✓ New financing opportunities created through successful international cooperation and partnerships on climate change that help sustainably improve water management (EC.1.4);
- ✓ Budget allocations to build spare capacities for water-related infrastructure, assets, and services (EC.1.5), and to increase climate resilience in urban water systems (EC.1.7)
- ✓ Investments in water resources development and management, water reclamation and reuse (EC.1.6)
- ✓ Water tariff regulations based on volumetric consumption to manage the supply-demand gap (EC.1.10) to promote reduction in water consumptions.

5.2.2.5 Institutional Resilience

The second most vulnerable dimension for London was determined as institutional resilience with a score of 3.80.

This vulnerability can be largely attributed to the complex management of the water sector and fragmentation of responsibilities among different authorities (refers to INS.1.2 in Table 5-5). The literature underpins this argument by highlighting the privatized water sector since 1989 and the fragmented structure of liability between different water companies and other authorities in the water industry (Lobina, 2001). The institutional structure adopted in the water

sector creates challenges in coordination and cooperation between the relevant water companies and authorities at both the national and urban level.

These managerial issues have been widely recognized in the UK and the Environment Agency has developed a “National Framework for Water Resources” to increase cooperation and collaboration among water companies at the regional level. In fact, this framework will help to overcome existing barriers between water companies, while developing a regional strategic plan for water management in cooperation (Environment Agency, 2020).

In addition, although London has already recognized the importance of spare capacity for its water infrastructure and has embedded the concept of "redundancy" in its urban resilience policies; the assessment concluded that more emphasis should be placed on the “redundancy” of water-related assets, infrastructure and systems (refers to INS.1.4 in Table 5-5). For instance, in the light of the literature, it has been revealed that alternative water supply sources such as extra water storage facilities are needed in the city to cope with severe droughts and to meet the required supply demand in an emergency (Cooper, 2019).

Some institutional strengths were also revealed as a result of the evaluation. According to Table 5-6 in Chapter 5.2.1.3, strengths can be defined as follows:

- ✓ Existing practices and amount of capacity built in the city for non-conventional water resources such as water reuse, rainwater harvesting and grey water recycling (INS.1.1) and recognized water recycling systems as an action in the city’s resilience strategy. In this direction, “Integrated Circular Water Systems” project has been launched to explore rainwater, greywater, and reclaimed wastewater reuse opportunities in the city to increase water reuse in the city.
- ✓ Water scarcity and impacts on water assets and services are comprehensively addressed in urban policies, with reference to the synergy between ecosystems and water supply and demand dynamics (INS.1.3).
- ✓ Regular monitoring and annual reporting structure established in London (INS.1.5), to identify the progress of each action and monitor its contribution to the Paris Agreement.
- ✓ Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments (INS.1.6) by setting ambitious targets. The “London Plan” states that all new developments should provide 105 LCD as a standard design level, while the "Supplementary Planning Guidance on Sustainable Design and Construction" supports developers to have high water efficiency in new houses with 80 LCD.
- ✓ Developed city-level climate resilience strategy (i.e. London City Resilience Strategy, 2020), that reveals the climate risks affecting both the community and the urban infrastructure in the city and possible actions to prevent or minimize them (INS.1.7).

- ✓ The essential role and vulnerability of water is well-recognized in the major urban policies (INS.1.8).
- ✓ Recognition of the potential of NBS against climate change and good integration into urban policies, strategies, and action plans (INS.1.9).
- ✓ Effective targets set to reduce water losses and leakages in the water supply system (INS.1.10).

5.3 Benchmarking Study

5.3.1 Results

This chapter presents the results from the benchmarking of the two case studies, namely London and Istanbul. Table 5-7 summarizes the overall scores calculated for each case study to observe the dynamics of each resilience dimension comparatively.

Table 5-7 Overall Score Comparison of Case Studies

Dimensions	Case Study-I Istanbul	Case Study-II London	Difference
Social	2.80	**4.00**	1.20
Environmental	2.80	3.90	1.10
Infrastructural	**3.20**	3.90	0.70
Economic	2.90	**3.70**	0.80
Institutional	**2.70**	3.80	1.10
Overall Resilience Score	**2.88**	**3.86**	**0.98**

The overall scores presented in Table 5-7 were also gathered under a radar type graph in Figure 5-1 to demonstrate the water scarcity management performances in a straightforward manner and to provide an easy understanding for the comparison. In Figure 5-1, the green line represents the overall scores of Istanbul, the blue line the results of London, and the red line the baseline for benchmarking denoting the “neutral” level.

In this research, while scores below the baseline level indicate undesirable situations, that is, the risk situation; above baseline signify desired levels, i.e. good performances in water scarcity management.

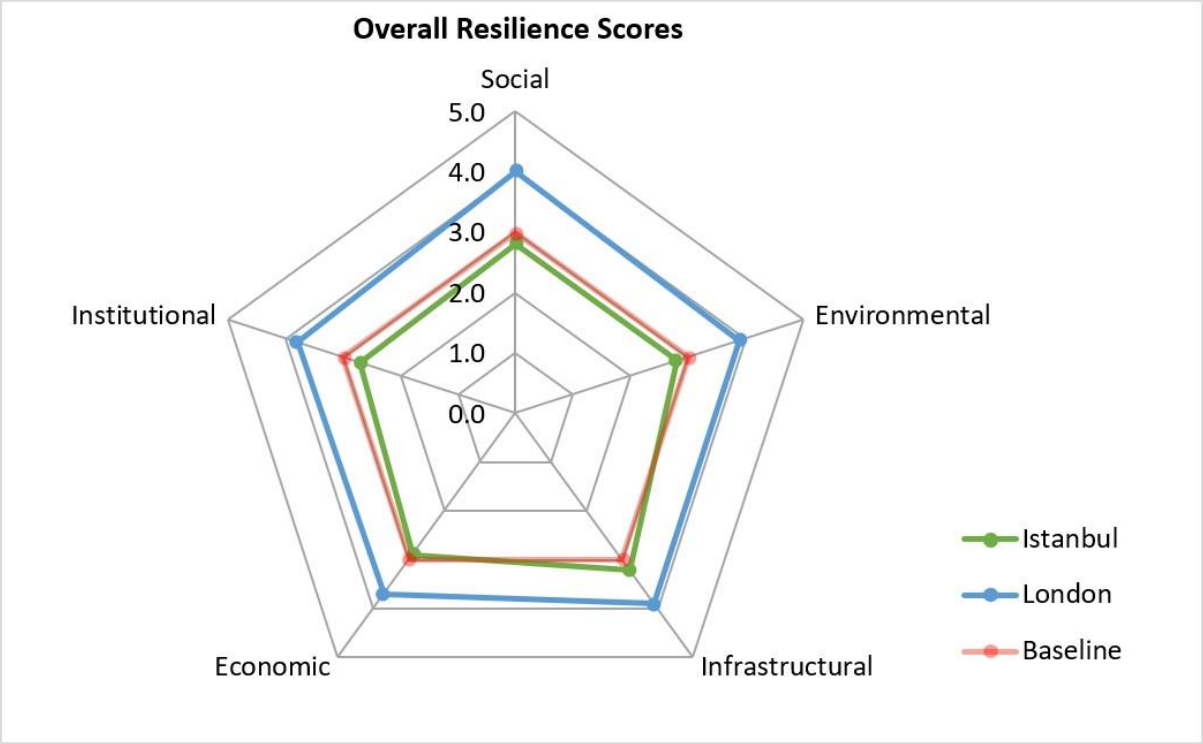

Figure 5-1 Overall Water Scarcity Management Performances of the Case Studies

The graph in Figure 5-1 will be the cornerstone for the 3rd objective "addressing the essential role of urban climate resilience against water scarcity management", which will be further explained in the following discussion chapter.

Overall, this benchmarking was undertaken to provide a better understanding of the performance of the case studies for each resilience dimension and to propose actions for the revealed "vulnerable" case based on the strengths uncovered from the "best practice". Thereby, the benchmarking results will be a step towards achieving the 4th objective of this research by proposing actions in Chapter 6.

5.3.2 Discussion

Considering the overall results of the two case studies in Table 5-7, it was confirmed that Istanbul was the "vulnerable city" of this research with the lowest overall score (refers to 2.88), and London was the "best practice" with the highest score (refers to 3.86). This result provides strong evidence for the research aim, demonstrating the great contribution of the climate resilience approach integrated into urban strategies, as revealed by the results of the London case study, while Istanbul pointed to a vulnerability in managing water scarcity with lack of city-level climate resilience policies and/or strategies. This result also fulfils the 3rd objective of this research by revealing the importance of urban climate resilience in water scarcity management.

Analysing the results in Figure 5-1, it was observed that all five resilience dimensions for London were above the baseline indicating good performance in water scarcity management. On the contrary, for Istanbul, all resilience dimensions except the infrastructural dimension were below the baseline, indicating a vulnerability, that is, a "risk" situation in water scarcity management.

For the results in Table 5-7, the following key conclusions were drawn in line with the literature.

5.3.2.1 Social Resilience

As a result of the benchmarking study, the biggest difference between the case studies was determined in the social resilience dimension. Social resilience is determined as the strongest aspect for London with score 4, while it constitutes one of the lowest scores for Istanbul with score 2.80.

Based on the literature review, the large difference between the dimensions of social resilience can be strongly associated with the lack of public awareness on the concepts of sustainable water use, climate change and urban resilience in Istanbul, due to insufficient programs to raise awareness. On the other hand, the lack of awareness brings another vulnerability in Istanbul; insufficient adaptive capacity and unpreparedness for extreme climatic events.

London differs greatly from Istanbul in terms of social resilience as can be seen in Table 5-7. In contrast to Istanbul, the strongest aspect for London was observed in social resilience with various awareness-raising programs on climate change, climate resilience and water minimization across the city, steps to improve adaptation capacity (Greater London Authority, 2020), and a city-level drought response framework that supports preparedness for extreme events.

In conclusion, London sets a good example for Istanbul with its great performance observed in social resilience dimension.

5.3.2.2 Environmental Resilience

The benchmarking results also disclose the different dynamics of the two case studies regarding environmental resilience dimension. The difference observed between the two cities points to a major deficiency for Istanbul in this dimension.

One of the vulnerabilities observed in Istanbul is the high water consumption per capita with 189 LCD, that can be strongly associated with the lack of environmental awareness in the city. In this sense, London does not set the best example in water consumption with 149 LCD, but the way both cities address the problem, and their management strategies make a significant difference in their overall environmental resilience scores.

In London, various water efficiency and climate change awareness campaigns, a step change in regulations and in city plans to embrace water efficiency in new developments and developed comprehensive national drought monitoring and early warning systems pose the important values for the city in terms of environmental resilience.

These aspects specified for London set a precedent for Istanbul for water scarcity management in terms of environmental resilience.

5.3.2.3 Infrastructural Resilience

The least difference between the two case studies was found in the infrastructural resilience dimension. The infrastructural resilience was the strongest aspect observed in Istanbul, above the baseline with a score of 3.20, while it was resulted as 3.90 for London.

As discussed earlier in Chapter 5.1.2, the driving force behind Istanbul's infrastructural resilience is the EU Accession Programme. However, as aforementioned, the city majorly relies on grey infrastructure and new investments also follow the same mindset. Similar to the other results of Istanbul in the assessment, climate resilience in infrastructure was also found weak relative to London. The poor emphasis on NBS in urban policies and in urban planning, inadequate integration of GI in the city, as well as lack of retrofit programs for the existing infrastructure to switch into GI, were the major barriers found through the assessment.

Contrary to Istanbul, significant progress has been made in climate resilience, with concrete steps taken to integrate and implement GI in London, as detailed in Chapter 5.2.2. The "Green City Fund", "SuDS in London", "Greening the Business Improvement Districts", "Green Roofs and Walls" and "Grey to Green" are some of the programs identified in the London Plan (2021) and the London Environmental Strategy (2018). All these initiatives demonstrate GLA's willingness to implement GI widely in the city and its great efforts in this direction.

In summary, London sets an example for Istanbul with its strategic actions and programs to promote climate resilience in the city and its ambitious goal of "Making London a National Park City" as detailed in Chapter 5.2.2.

5.3.2.4 Economic Resilience

The most striking difference between the case studies on economic resilience is the insufficient budget allocation to climate resilience in Istanbul.

The literature review on Istanbul's financial plans and investment programmes also confirms this by revealing this fact in numbers. In the 2021 Investment & Utility Programme of the IBB (Istanbul Metropolitan Municipality, 2021), it was observed that approximately £323,725k (3,922,514k TL) budget was allocated for the "Environmentally Responsible Istanbul" program, which is divided into 4 main objectives: waste management, renewable energy and energy efficiency, sustainable green spaces, and climate change. However, the municipality's performance program revealed that only £80k (967k TL) was allocated to adaptation and combating climate change (Istanbul Metropolitan Municipality, 2021).

In contrary, London poses a great strength in recognizing the climate resilience and various investments was made to create adaptive capacity in the city against climate change. After "climate emergency" was declared in 2019, the GLA was accelerated its investments in climate resilience to ensure robustness in the city. The "Climate Emergency and Climate Adaptation Delivery" with £799k, "Climate Resilient and Healthy Streets Infrastructure" with £4,000k,

"Climate Resilience through Nature" with £500k and "Street Tree Planting" with £500k are some of these programs, that demonstrate GLA's solid steps towards a climate resilient city.

Considering the large population, urbanization levels and grey infrastructure tendency in Istanbul, the budget allocated to climate adaptation was found inadequate compared to London. In fact, it is worth noting that, other economic conditions and factors of the two cities should be taken into account at this point, since investments are directly associated with the financial powers. However, in this study, in order not to deviate from the main theme of "water scarcity management", the comparison of other economic factors were excluded from the scope and was not examined further.

Overall, in line with the vulnerabilities of economic resilience in Istanbul, and conversely, London's strengths in this regard; it can be concluded that London can set an example for Istanbul in this dimension as well. In this sense, in Chapter 6, actions are proposed for Istanbul in line with the economic resilience strengths seen in London.

5.3.2.5 Institutional Resilience

One of the largest gaps between case studies was observed in institutional resilience. In fact, this can be strongly attributed to Turkey's relatively poor policymaking compared to the UK, particularly in terms of water efficiency, NBS and climate resilience. The importance given to climate change and environmental issues in public authorities in Turkey is insufficient, and as a result, the emphasis placed to these concepts in urban policies remains in the background.

In addition, although institutional fragmentation is a major problem in water management in both countries (as stated in discussion chapters of each case study), the way they handle the problem and their risk management strategies lead to a significant difference in overall institutional resilience score.

The UK widely acknowledges and confronts coordination and cooperation issues in the water sector. In this context, the developed "National Framework for Water Resources" by the Environment Agency makes a step change in strategic and regional cooperation and promotes a better management by connecting water companies under separate regional groups.

Despite the coordination problem in the water management sector in Turkey was mentioned in various reports and in the academic literature, unlike the UK, this issue was not fully internalized by the Turkish authorities and the problem was remained in the background due to different priorities.

In line with the literature, the above-mentioned differences in water management strategies in terms of institutional resilience have been revealed, and it has been concluded that London has several strengths compared to Istanbul and sets a good example.

CHAPTER 6

6 CONCLUSION AND RECOMMENDATIONS

This chapter presents conclusions and recommendations based on the findings from the assessment conducted and proposes actions to vulnerabilities to improve climate resilience in each case study. Further to the action proposal, this chapter also underlines the limitations of the study and opportunities for future studies to enhance the research.

6.1 Conclusion

The main aim of this research is to shed light on the connection between water scarcity management and the concept of climate resilience, and ultimately to reveal the contribution of the climate resilience approach to the sustainable management of water scarcity in cities and the development of robust water-related assets, infrastructures and services.

The research focused on the benchmarking of two case studies, with the aim of revealing the contribution of the climate resilience policies in cities. With a strategic approach, London, that has urban-level resilience initiatives and "London City Resilience Strategy", and Istanbul, where climate resilience is insufficient in practice and does not have a city-level resilience policy or strategy, were selected.

The literature review spotted to a gap in the assessment of water-related consequences of climate policies (IPCC, 2008), and to a growing need in quantitative assessment tool specifically designed for water-related problems triggered by climate change.

In this sense, this research followed a specific methodology by interconnecting these two facts and developed a quantitative assessment tool in the context of climate resilience to assess water scarcity management in two selected case studies. In this way, it not only helped address the main research question, but also filled the gap identified in the literature.

As a result of the assessment, it was clearly demonstrated that the climate resilience approaches adopted in cities and the policies followed in this direction contribute positively to the management of water scarcity, as evidenced by the high overall resilience score in London, in contrast to the low score in Istanbul.

This research clearly showed that the climate resilience concept embraced in urban planning and the built environment supports sustainable water scarcity management through different dimensions such as social, environmental, infrastructural, economic and institutional.

The results of London underpinned the argument specified in research aim and demonstrated the essential role of climate resilience in a city, revealing several strengths associated with water assets, infrastructures and services across each resilience dimension assessed. The London case study also answered the main research question by revealing the contribution levels of the adopted climate resilience strategy to water scarcity management.

Based on the research results, the contributions of climate resilience to water scarcity management are determined as follows for each dimension:

- ***In social dimension:***

  Stakeholder engagement and collaborations in the decision-making process; major efforts to raise awareness on water minimization and climate change; firm steps towards water saving culture; providing equally accessible water; built adaptive capacity in the city to shocks, stresses or extreme events; city level drought response frameworks that promote preparedness; high quality of life and public health and safety achieved through an advanced supply network; socially strong water tariff taking into account all social groups, namely the vulnerable.

- ***In environmental dimension:***

  Hydrological modelling and impact mapping leading to build robust water assets; widespread adoption of water efficient technologies; continuous monitoring of water resources; sustainable water management and resource conservation; attaching importance to sustainability in urban policies; integrated water resources management (IWRM) adopted in policies; drought monitoring and early warning systems; sound environmental management that ensures safe water.

- ***In infrastructural dimension:***

  Continuous monitoring systems, smart water leak detection and water metering in the water supply infrastructure; widespread adoption of feedback systems in infrastructure to prevent cascading or persistent failures; spare capacity for non-conventional water resources (NCWR) and great emphasis placed on NCWR in urban policies; integration of GI into urban planning and its wide adoption across the city; solid steps to replace grey infrastructure with GI, e.g. retrofit programs; regular maintenance and repair for water-related infrastructure; integration of "climate resilience" into water-related infrastructure, services and assets; advanced water supply network.

- ***In economic dimension:***

  Incorporating awareness campaigns into financial plans; incentive programs for agriculture sector to boost sustainable production and water savings; funding opportunities by successful international cooperation and partnerships on climate change; budgets allocated to build spare capacity for water-related infrastructure, assets and services; investments in water resources management, water reclamation and reuse; significant budgets allocated to improve climate resilience in the urban water systems; effective water tariffs to manage the supply-demand gap.

- ***In institutional dimension:***

  Capacity building programs for non-conventional water resources (NCWR); wide recognition of water scarcity in policies; monitoring and assessment to ascertain progress on climate resilience; urban plans and policymaking on water efficiency for new developments; city-level climate resilience policies and strategies; "water vulnerability" recognized in urban policies; integration of NBS into urban policies; effective targets for reducing water losses and leaks.

In conclusion, climate resilience strategies followed in cities provide multiple benefits to cities, as listed above, especially in terms of sustainable management of water scarcity.

As can be seen from the research results, since water scarcity management and urban climate resilience are interrelated, vulnerabilities of the resilience dimensions identified in Chapter 5 must first be addressed to achieve good performance in water scarcity management. In this context, a set of actions tailored to the city's risks has been identified for each case study in the following Chapter 6.2.

6.2 Recommendations

This research not only focused on revealing benefits of the climate resilience concept in cities, but also aimed to boost the water scarcity management performances in both case studies. In this regard, this chapter presents an action plan for each case study based on the identified vulnerabilities in Chapter 5.

6.2.1 Actions Proposed for Istanbul Case Study

Quantitative research results confirmed that Istanbul was “vulnerable” in water scarcity management compared to London, which is referred to “best practice” in this study. In this context, London set a good example for Istanbul in this research and an action plan for Istanbul is proposed in Table 6-1, in line with the strengths observed in London.

The proposed actions will not only improve Istanbul's water scarcity management, but also ensure its progress towards a climate resilient city, if implemented by Istanbul Water and Sewerage Administration.

6.2.2 Actions Proposed for London Case Study

Despite London set a good example to Istanbul in this study, some “medium risks” (i.e. neutral scores) were also observed regarding water scarcity management in London. To improve those vulnerabilities and strengthen management performance, this research also proposed risk-related actions for London in the context of urban climate resilience in Table 6-2.

Table 6-1 Actions Proposed for Istanbul Case Study

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
Social			
S.1.1	Adaptation capacity is weak; citizens are unprepared and vulnerable to shocks, stresses or extreme events	Addressing long-term risks is one of the key actions in London that enables to manage risks and improve preparedness for long-term shocks, stresses or extreme events, ultimately building adaptive capacity (London City Resilience Strategy, 2020).	Adaptive planning approach and principles should be adopted in the city. Istanbul may follow a similar path as London towards climate resilience. Emergency frameworks, planning and risk management should be improved by conducting a “long-term risk assessment” to ensure society is prepared for the shocks, stresses and risks emerged by climate change.
S.1.5	Inadequate educational programs, workshop or training activities to raise public awareness on climate change and urban climate resilience	Various educational programmes, workshops, training activities on climate change, its emerging impacts, on the concept of urban climate resilience and possible actions/measures are offered to raise public awareness and increase public participation.	The number of educational programs, workshops and training activities on climate change, its emerging impacts, on the concept of urban climate resilience and possible joint or individual actions/measures should be increased throughout the city. Such educational activities will increase public participation, as people will realize that all individual actions are valuable in achieving "urban climate resilience".
S.1.8	No city level drought management policies and/or drought response frameworks, only at the national level	Effective drought response framework at the city level. It ensures preparedness in the city by revealing the risks and possible measures or actions.	An effective drought management policy and/or response framework should be developed at the city level. Relevant policies or frameworks ensure preparedness in the city by informing the people on potential risks and possible measures or actions.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
S.1.9	Poor water saving culture	Sustainable water use is one of the key actions towards climate resilience in London (London City Resilience Strategy, 2020) and sets a good example for Istanbul. The launched project according to this action, explores the main barriers to water-saving measures to take actions, promote efficient solutions and improve savings in the city.	The main barriers against water-savings should be explored. Water efficiency should be a principle for all urban activities in the city. Changes in water consumption behaviours at both the urban and individual levels should be supported. Water efficient technologies and sustainable use of water should be widely promoted throughout the city.
Environmental			
EN.1.6	High daily average water consumption per capita	While London is not the best example with a water consumption of 149 LCD (London Environment Strategy, 2018), it can still set a good example for Istanbul with the current ambitious water reduction targets and initiatives. The London Plan defines actions for improving water efficiency in existing buildings under the retrofit programs and ensures water efficiency in new developments by setting a 105 LCD design standard. On the other hand, Mayor's "Supplementary Planning Guidance on Sustainable Design and Construction" promotes to aim 80 LCD for new developments. In addition to urban development targets, the mayor works with London's water companies to ensure; leakage reduction, water metering, water efficient solutions and devices are promoted to customers and public awareness is being raised for the financial benefits of saving water.	Since Istanbul's buildings are mostly old and not designed to be water efficient, retrofit programs that focus on or integrate water efficiency in existing buildings should be initiated. Setting ambitious targets in building codes and specifications for new developments can help reduce water consumption in the city. In Istanbul water supply design is being performed based on 250 LCD average water demand which may also be reduced by creating public awareness on water minimization. In 2018, 189 LCD consumption has been recorded in Istanbul (TURKSTAT, 2021). Istanbul Water and Sewerage Administration (ISKI) should promote water metering and water efficient solutions or devices to customers across the city and raise public awareness in various ways.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
EN.1.8	No monitoring and/or early warning system against drought yet	The UK Government has funded a "Drought and Water Scarcity Research Programme" which has made great progress in terms of an interactive monitoring and early warning (MEW) system. The program launched a dynamic monitoring tool, the "UK Drought Portal", that maps drought severity across the country. "UK Water Resources Portal" has been another step which reveals hydrometeorological data along with river and groundwater flows and other indicators. Both interactive tools map the prone zones and give insights about drought and water scarcity risks. These portals are followed by a number of other monitoring tools to promote preparedness in the country. Yet, the MEW system has been developed through several workshops with multiple stakeholders that provide a broad understanding of the different impacts and their levels and the necessary priorities in design. Thus, a robust and appealing system has been obtained.	Since Turkey is one of the climate sensitive countries under the Mediterranean climate, there are various strategies and plans that recognize the need for monitoring and early warning (MEW) system to boost preparedness in the country against extreme climate events and especially drought. The developed "National Drought Management Strategic Document and Action Plan" is one of these, emphasizing the need for an early warning system in the country. However, Turkey still lacks a MEW system and efforts are underway to implement. As in the UK case, the government needs to support MEW systems and accelerate development phase by initiating a program in the country. In addition, the participation of stakeholders in the design phase can also ensure that the MEW system appeals everyone.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
Infrastructural			
INF.1.6	City is poor in terms of green infrastructures (GI). Lack of retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or no new GI designs in the city	London has created a Green Infrastructure Task Force focused on the long-term implementation and delivery of GI in the city. The purpose of this task force is to explore opportunities to integrate GI into both existing and new infrastructure to derive maximum benefit from GI in the city. In addition, the Mayor of London strongly supports urban greening with various investments and initiatives. The London Plan (2021) and the London Environment Strategy (2018) set different policies such as: "SuDS in London", "Greening the Business Improvement Districts", "Green Roofs and Walls" and "Grey to Green". On the other hand, the GLA budget for 2021-2022 highlights the "Retrofit Programmes for Workplaces and Homes for Energy Efficiency" which is funded with approximately £4,245k and £496k in capital. All these initiatives entail retrofit programs for existing infrastructure in the city and they also include new GI designs to meet the ambitious goals.	Although the importance of green buildings and green built environment has been recognized in city plans (e.g. Istanbul Climate Change Action Plan, Istanbul Strategy Plan 2020-2024) and policies for climate adaptation, unfortunately GI is not yet widespread in practice. The city's infrastructure currently relies on grey infrastructure and new projects are mostly dominated by grey. GI investments should be increased in the city and retrofit, and replacement programs should be initiated throughout the city to embed green features into existing structures. Not only retrofit programs, but also new projects based on GI should be developed and invested to realize the actions identified in current urban policies.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
INF.1.7	Lack of integration of green infrastructures (GI) into urban planning and inadequate implementation of green buildings, green features and GI throughout the city	The Mayor of London lends considerable support to urban greening with various investments and initiatives. "Making London a National Park City" is one of these goals, and a "Green City Fund" (In 2021-2022 GLA budget, this fund is stated to be replaced by new investment programs) was launched in 2017 that funded more than 80 projects to take action towards the world's first National Park City. On the other hand, the London Plan (2021) and the London Environment Strategy (2018) set different policies such as: "SuDS in London", "Greening the Business Improvement Districts", "Green Roofs and Walls" and "Grey to Green" to strongly promote green features and infrastructures in the city.	There are some action plans at national and urban level. The "National Smart Cities Strategy and Action Plan" at the national level and the "Strategy Plan for 2019-2023" of the Republic of Turkey Ministry of Environment and Urbanization promote the green building and development practices in urban transformations and developing the "Green Building Certification System". On the other hand, the "Istanbul Climate Change Action Plan" and "Istanbul Strategic Plan for 2020-2024", which were created at the urban level, emphasize the importance of preserving the green cover, and increasing green buildings and green built environment. Although GI has been emphasized in the policies, unfortunately it has not yet received the necessary attention in investment plans. In this context, London poses a good example as the City Assembly strongly supports the investments and creates funds to achieve the targets. Istanbul Metropolitan Municipality should focus on GI rather than grey as a solution and accelerate and develop GI investments by creating funds/financial resources.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
Economic			
EC.1.7	Insufficient budget allocation to climate resilience in urban water systems	Climate resilience investments soared in London after the Mayor has declared a climate emergency in 2019. In the 2021-2022 GLA Budgets, a significant amount of budget is allocated to climate resilience programs and GI programs are financed in significant amounts to cope with climate change, in other words, to build resilience. "Sustainable Urban Drainage (SuDS) and Water Reuse" sub-program under "A New Green Deal Fund" having £20,000k total budget, "Water Fountains Program" with £1,558k and "Climate Resilience through Nature" with £500k programs are some of these budgets allocated for urban water-related systems to build climate resilience. Thus, a total of approximately £22,000k has been provided by GLA to environmental projects to build citywide climate resilience through these programs alone. In addition, Thames Water, which serves London, has allocated £2.1 billion under AMP7 to increase the resilience of water infrastructure and utilities.	Climate resilience concept has been newly recognized, and some attempts are being undertaken recently. Istanbul Water and Sewerage Administration (ISKI) has allocated £159,389k (1,939,987k TL) for wastewater investments and £121,262k (1,477,966k TL) for drinking water investments in their 2021 budget plan. However, while there are some projects that increase climate resilience, most of the investments rely on grey infrastructures. In this context, ISKI's policy should focus from grey to green infrastructure that integrates with nature, the concept of climate resilience should be prioritized, and both programs and budgets should be reviewed to promote resilient urban water systems.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
EC.1.9	Lack of investments in climate resilient urban built environment to create adaptive capacity	The Mayor of London made a "climate emergency declaration" in 2019, and many programs were launched in line with this declaration, and climate resilience investments were accelerated in the city to develop adaptive capacity. The GLA budgets for 2021-2022 state that the "Green City Fund" will be replaced by new infrastructure programs focused more on climate resilience, greening and recovery. Some of these programs that demonstrate GLA's solid steps towards a climate resilient city are: o "Climate Emergency and Climate Adaptation Delivery" with £799k, o "Climate Resilient and Healthy Streets Infrastructure" with £4,000k, o "Climate Resilience through Nature" with £500k, o "Street Tree Planting" with £500k.	The concept of climate resilience in the city came to the fore and its importance was understood by the developed "Istanbul Climate Adaptation Action Plan" in 2018. In the 2021 Investment & Utility Programme of the IBB (Istanbul Metropolitan Municipality, 2021), approximately £323,725k (3,922,514k TL) budget has been allocated to the "Environmentally Responsible Istanbul" program, which divides into 4 main objectives: waste management, renewable energy and energy efficiency, sustainable green spaces, and climate change. According to the IBB Performance Program (2021) only £80k (967k TL) of this total budget has been allocated for adaptation and combating climate change (Istanbul Metropolitan Municipality, 2021) which is rather low when compared to London, considering the population and urbanization levels and grey infrastructure tendency in Istanbul. In this context, the Municipality's investment plan should be reviewed, and more emphasis should be placed on the concept of climate resilience, thus more budget should be allocated, and climate change programs and projects should be increased.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
Institutional			
INS.1.2	Fragmentation of responsibilities among organizations/authorities for water resources management and hence cooperation and coordination problems in taking action	Although the UK is not the best example for Turkey in terms of inter-institutional coordination and cooperation, it sets an example with the steps taken and initiatives developed. The UK privatized the water sector in 1989 and since then water management stakeholders have been these water companies, other regulatory and national authorities. This fragmented liability structure in the water industry poses a problem in emergencies. There are also coordination and cooperation problems in the UK's water management due to the fragmentation of responsibilities between water companies and other authorities. In order to create a step change in strategic & regional cooperation and ultimately better management, the Environment Agency has developed a "National Framework for Water Resources". Under this framework, regional groups of key water companies have been formed and as a next step they will work closely, address existing cooperation barriers and collaboratively develop regional plans for water management.	There is a complex hierarchical structure in water resources management in Turkey. Many central and provincial public institutions are involved in the management of the water resources and each institution participates in the management within its power. The major problems in management are the unclear institutional jurisdictions and the inability to determine the main authority at the local level. Inter-institutional coordination and cooperation are lacking, and this situation causes a fragmented management and slows down the operations. In this context, the UK can set a good example with its sector-wide collaboration under the "National Framework for Water Resources", which develops regional water resources plans to focus on the needs of the whole nation rather than just local communities. Since the water sector in Turkey is predominantly managed by public institutions, regional cooperation opportunities between "Water and Sewerage Administration"s can be explored. A feasibility study can be conducted to explore collaborative water management opportunities and possible structural changes in public institutions in Turkey.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
INS.1.5	Inadequate monitoring and/or assessment tool for climate actions to measure adaptive improvements and identify progress towards urban climate resilience	A regular monitoring and annual reporting structure have been established in London to identify the progress of each action and monitor its contribution to the Paris Agreement. Accordingly, the London Environment Strategy Implementation Plan provides detailed monitoring for each action and is updated annually to show the progress. As a C40 member, London reports its climate data annually through the online CDP portal. In addition, other monitoring and reporting is carried out at the project level on a regular or adhoc basis. On the other hand, the progress of some specific KPIs is reported annually in the Mayor's Annual Report.	The adaptation monitoring system is currently under development. Istanbul Climate Change Action Plan 2018 states that the progress in monitoring and evaluation indicators for climate adaptation is currently at the %25-50 stage. Although it is a good start in terms of action monitoring and evaluating the effectiveness of actions, the development of the system should be accelerated as climate change intensifies its effects in Istanbul over time.
INS.1.6	Gaps in urban plans and policies to reduce water consumption and increase water efficiency in new developments	"Water efficiency" is included in most urban planning policies, both at the national and urban level. National urban policy in the UK states that social housing should be built with 105 LCD and new private housing with 125 LCD. On the other hand, the London Plan states that all new developments should provide 105 LCD as a standard design level, while the mayor's "Supplementary Planning Guidance on Sustainable Design and Construction" supports developers to have high water efficiency in new houses with 80 LCD. The London Water Strategy also defines some actions for the mayor to monitor water consumption in new	Building codes for urban planning in Turkey do not emphasize the concept of water efficiency to reduce water consumption in new developments and do not include any water efficiency targets. Urban planning regulations and development frameworks and policies in Turkey are weak in promoting water efficiency. In this context, UK sets a good example for Turkey in both national and urban level policies. The water efficiency approach and standard water consumption design limits in Turkey should first be included in national level regulations and building codes. Following this, water efficiency targets for new developments should be adopted by urban-level initiatives. These actions will be a step forward to ensure water resilience in new developments in Turkey.

Indicator Code	Identified Vulnerabilities in Istanbul	Strengths Observed in London	Current Condition in Istanbul & Proposed Actions
		homes to ensure that actual water efficiency levels match projected efficiency targets. These ambitious targets for new developments in urban plans and policies represent solid steps towards water efficiency in London's urban planning.	
INS.1.7	No city-level climate resilience policies and/or strategies	The "London City Resilience Strategy" has been developed, which reveals the climate risks affecting both the community and the urban infrastructure in the city and possible actions to prevent or minimize them, and ultimately accelerate investments for a "climate resilient city".	As a member of the C40 Cities, Istanbul has accelerated its climate adaptation actions and has started to adopt certain level of resilience approaches in the city's infrastructure. However, the city still lacks an urban climate resilience policy or strategy. Following best practices in C40 cities and particularly the London case study addressed in this research, Istanbul should primarily develop a tailor-made urban climate resilience strategy rather than following a national strategy. A city level strategy will inform about city-specific vulnerabilities and provide a local course of action.
INS.1.9	Inadequate emphasis and integration of NBS in urban policies, strategies and action plans	NBS has gained importance in the city and recognized in majority of urban policies/strategies/plans. The London Plan (2021) and the London Environment Strategy (2018) are some of these policies that emphasize the importance of urban greening and the need for GI's, to build robust infrastructures and resilience in the city.	The vital importance of urban green has newly been recognized in the city with the increasing effects of climate change. Although preserving the urban green area and increasing the green per capita in the city are acknowledged and included in the policies, no special emphasis is placed on NBS or GI to build resilience. In this context, London can be a good example for Istanbul. Istanbul can accelerate green investments by adopting NBS and urban greening as a key component in its policies.

Table 6-2 Actions Proposed for London Case Study

Indicator Code	Identified Vulnerabilities in London	Current Condition in London & Proposed Actions
Social		
S.1.2	Insufficient public awareness on climate change and the emerging water scarcity problem. However, opportunities are being explored by feasibility of public awareness-raising under the London City Resilience Strategy	Feasibility studies should focus on creating new opportunities as well as exploring gaps in awareness-raising to address deficiencies.
Environmental		
EN.1.6	Daily average water consumption per capita	Although London has made various initiatives on water efficiency, put the necessary emphasis on water efficiency in urban policies, set water supply design standards for new developments and initiated various public awareness programs in the city, the data obtained for average water consumption shows that consumption is still high with 149 LCD (London Environment Strategy, 2018). This shows that the actions at the individual level have not reached the desired level and reveals that individual actions in the society should be encouraged more and a step change should be made in the behaviours. Accordingly, London should continue its public awareness efforts and keep investing in awareness-raising campaigns, workshops, and other programmes. Environmental awareness, water scarcity and climate change impacts can also be incorporated into education system (i.e. primary, secondary school), and awareness can be raised in the city from an early age, which can help disseminate knowledge in every home.

Indicator Code	Identified Vulnerabilities in London	Current Condition in London & Proposed Actions
INF.1.3	Insufficient spare capacity for water infrastructure	The city of London has been classified as a "serious water stress" area by the UK Environment Agency. The water problem in the city is triggered by both climate change and rapid population growth. Redundancy plays an important role in providing uninterrupted service to people. London has already recognized the importance of spare capacity for its water infrastructure and has embedded the concept of "redundancy" in its urban resilience policies. However, there are still gaps both in policies and in practice and there is a lack of spare capacity, especially in terms of water storage facilities to cope with severe droughts and maintain supply. Recently, Thames Water and Affinity Water have proposed to build the "Abingdon reservoir" by 2037, but this project needs to be accelerated and implemented as soon as possible given the current climatic conditions. On the other hand, alternative solutions to the Abingdon reservoir are largely unsustainable and rely mainly on the abstraction from rivers. In this sense, GLA should develop and increase the feasibility studies on London's water supply resources and possible alternatives, to build spare capacity to maintain its continuous services and meet the needs under an extreme event such as drought, water scarcity etc.

Indicator Code	Identified Vulnerabilities in London	Current Condition in London & Proposed Actions
INF.1.8	Water losses due to significant leakage rates in the water supply network	One of the most important problems observed in London's water system is aging infrastructure. Large amounts of water are lost due to frequent bursts and leaks in old pipes. The Mayor's Water Strategy (2011) states that almost half of the water pipes are over 100 years old and the "Appendix-4: Resilience" document of Thames Water states that %67 of the leaks are below the City of London, which pose a challenge in terms of cost and accessibility. Despite these challenges, Thames Water has recently implemented a program to replace the old Victorian mains and has also set a 5-year target to reduce leakage rates. They aim to reach 4.1% in 2020/21, 10.2% in 2021/22 and ultimately 20% in 2024/25. However, GLA should continue to support and make major investments in all water companies of London, to promote ambitious targets and smart metering across the city. Although water leakage rates are widely recognized by the GLA, Thames Water and in urban policies, current leakage rates & water losses are still high and reveal that actions are insufficient. Under the reality of water scarcity, water resilience projects aimed at reducing water loss should be the main focus in London and should be developed throughout the city.
Economic		
EC.1.3	Deficiencies in R&D investments and implementation of innovative technologies for sustainable water management	Unfortunately, research and innovation in the UK water sector has remained in the background as it receives less government support compared to other sectors. Water companies are required to finance R&D under operational or capital expenditures. Records show that operational spending on R&D at water companies fell by £27,000k from the early 90s to 2009. It is possible to attribute the decreasing level of R&D in water companies to the lack of incentives and regulatory barriers in the current system. In this context, the government, water companies, regulatory authorities, namely Ofwat, Environment Agency should work in cooperation towards R&D strategies in the medium and long term. The government should focus on incentive programs in R&D together with regulatory authorities and the incentives to water companies should be increased to promote R&D and sustainable water management at the local level.

Indicator Code	Identified Vulnerabilities in London	Current Condition in London & Proposed Actions
		Regulatory authorities (e.g. Ofwat) can provide annual performance assessments for water companies based on the innovative solutions they have implemented.
EC.1.8	Insufficient investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses	As mentioned earlier, London has an old water infrastructure (more than 100 years old) and bursts and leaks in pipes cause large amounts of water loss. Therefore, GLA strongly emphasizes this issue and shows its support financially. On the other hand, Ofwat has been promoting water companies to be prepared to the population growth and climate change, which has shaped the new AMP7 period. Covering the period 2020-2025, AMP7 can be characterized as a milestone in both climate resilience and sustainable water management. Nevertheless, considering the current water losses, it can be said that the actions are insufficient and concrete actions are needed in terms of maintenance and strengthening of the existing infrastructure. Under the reality of water scarcity, water resilience investments in London should focus heavily on water supply maintenance and retrofit programs.
EC.1.9	Insufficient investments in climate resilient urban built environment to create adaptive capacity	The fundamental role of climate resilience in the urban built environment is recognized in the city through the policies and plans followed. Enhancing green spaces in the city, including green belts and green corridors, promoting GI and urban greening, ensuring net biodiversity gain in the city, are key components of the London Plan (2021) and the London Environment Strategy (2018) to build a sustainable and resilient built environment. While these sound plans and strategies have been adopted, there are still opportunities to increase investments in the urban built environment and increase adaptive capacity. In this sense, financial support should be increased so that the policies and actions determined in the plans and strategies can be implemented widely.

Indicator Code	Identified Vulnerabilities in London	Current Condition in London & Proposed Actions
Institutional		
INS.1.2	Fragmentation of responsibilities among organizations/ authorities for water resources management	The UK has had a privatized water sector since 1989, resulting in a fragmented liability structure in the water industry, which in turn creates difficulties in emergencies. There are coordination and cooperation problems in the UK's water management due to the fragmentation of responsibilities between different water companies and other authorities. These problems were largely recognized in the UK and in order to create a step change in strategic & regional cooperation and collaboration, the Environment Agency has developed a "National Framework for Water Resources". Under this framework, regional groups of key water companies have been formed and as a next step the water companies will work closely, address existing cooperation barriers, and collaboratively develop regional plans for water management. Thus, regional planning managed by the national framework will lead to the selection of the best strategic solutions to challenges in cooperation. However, there are still gaps in this fragmented structure that need to be filled and more opportunities for cooperation should be created in this regard.
INS.1.4	Gaps in urban policies and strategies to further highlight or adopt redundancy for water-related assets, infrastructure and systems	The importance of spare capacity for building a resilient system is recognized by the GLA, and "redundancy" is emphasized in some urban policies and strategies. However, there are still gaps in both policy and practice, and there is a lack of spare capacity, particularly in water-related assets such as extra water storage facilities to cope with severe droughts and maintain the necessary supply. To strengthen such critical elements and build resilience, redundancy should be a key component of urban policymaking and widely adopted at both the national and urban levels.

6.3 Opportunities for Future Studies

This research contributed to some of the gaps noted in Chapter 2.6, but there are still some opportunities for future work. These can be listed as follows:

- ✓ Only one case study referred to “best practice” has shaped the research based on its strong aspects on the subject. In a similar vein, the recommendations for Istanbul and conclusion of the research were limited to the strengths observed in a single case study, i.e. London. In this context, a broader study with multiple case studies is recommended. Evaluation of various case studies with the assessment tool created is an opportunity for future studies and will provide a wider perspective on the subject. Thus, a more comprehensive and versatile research can be achieved by evaluating multiple cases and recommendations can be made based on different evidence obtained from different cases without repeating a single case study (Gustafsson, 2017).
- ✓ In economic resilience dimension, both cities are compared in terms of budgets allocated to specific programs. In fact, in order to make an accurate determination in terms of economic resilience, it is necessary to consider the micro-, medium- and macro-economic levels (Rose & Krausmann, 2013). In this research, in order not to deviate from the main aim of "revealing the contribution of urban climate resilience to water scarcity management", the comparison of micro-, meso- and macro-economic levels of the case studies were excluded from the scope and was not examined further. In this sense, the underlined gap presents an opportunity for future studies and the economic resilience dimension can be explored in depth by considering all economic levels.
- ✓ Another future opportunity for this research is in terms of indicators determined for the assessment tool. In this research, mainly 10 indicators were selected for each resilience dimension, which gives 50 KPIs in total. In future work, these KPIs can be further developed, both in number and in the qualities of resilience covered.

6.4 Limitations

In the research, qualitative and quantitative data were mainly collected through the secondary sources, such as online academic publications and articles, technical reports of institutions, and especially national and urban policies, action plans, strategies and frameworks. Therefore, the developed resilience framework and the determined indicators for the assessment tool are limited to subjective judgements of the collected secondary data.

Besides, the indicators selected for the assessment tool are limited to the common grounds found for the two cities. As the two cities have different policies and strategies that focus on different aspects, the most challenging part of the research was the identification of the indicators, due to seeking solid grounds for benchmarking.

Finally, due to the benchmarking strategy between the two case study followed in this research, the results, conclusions and recommendations for the vulnerable city are limited by the strengths observed in best practice.

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APPENDIX-1

ASSESSMENT SHEETS OF ISTANBUL CASE STUDY

SOCIAL DIMENSION								
Underlying Quality	**Code for Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Flexibility	S.1.1	Adaptive capacity in the city and the ability of people to respond quickly to emergencies, extreme events of climate change, especially, to water scarcity	No adaptive capacity in the city. Citizens are completely unprepared and vulnerable to shocks, stresses or extreme events.	Adaptation capacity is weak in the city, but there are initiatives to build/improve the capacity. Citizens are unprepared and vulnerable to shocks, stresses or extreme events.	Adaptive capacity is built in the city but there are rooms for further improvements. While a portion of the population is prepared and can respond the shocks and extreme events, the rest of the population is vulnerable.	There is a considerable amount of adaptation capacity in the city, and it is still being developed. Citizens are prepared to some extent for short-term interruptions and/or shocks, extreme events or hazards; however, the capacity should be further increased throughout the city.	High adaptive capacity in the city. Citizens are fully prepared to short or long-term disruptions and capable of reacting quickly to shocks, extreme events, or hazards.	2
Inclusive	S.1.2	Level of public awareness on climate change and emerged water scarcity problem	The public is completely unaware of climate change and the emerging water scarcity problem in the city.	The public has little awareness of climate change and the emerging water scarcity in the city. There are no individual level mitigation measures/actions.	A certain segment of society has awareness. Some people voluntarily change their water consumption habits. However, these attempts are insufficient, and awareness should be expanded in the city.	The majority of people are aware of the climate emergency. Collaborative initiatives for adaptation have been launched and steps are being taken towards preparedness for extreme events.	Widespread awareness and preparedness have been achieved at the city level against climate change and the emerging water scarcity problem.	3
Inclusive	S.1.3	Stakeholder engagement in decision-making processes of climate adaptation, action and/or resilience plans at the city level	No contact is made with stakeholders, they are ignored and unaware of ongoing decision-making processes. They are not included in any stage.	Stakeholders are informed but they only have a basic knowledge about plans and progresses. They are not involved in the decision-making process.	Stakeholders are partially aware of the ongoing plans. Opportunities are rarely created to ask their opinions/concerns. However, it does not have much influence on decision making.	Stakeholders are aware of ongoing plans and decision-making processes. They are engaged and collaborations are supported to shape strategies and plans together.	Actively engaged citizens & other key stakeholders to boost climate resilience across the city. They are empowered, have a direct influence and drive the decision-making.	3
Inclusive	S.1.4	Equal access to safe water, especially vulnerable groups (e.g. Homeless people, people with disabilities, refugees, low-income population etc.)	No equal access to safe, well-managed drinking water. Vulnerable groups suffer more from a lack of access to safe water.	There are initiatives to ensure equal access to safe water. However, vulnerable groups are still suffering, and there are no concrete actions for such groups.	Equal access to safe drinking water. Vulnerable groups are identified in the city. Although there are some efforts to provide equal opportunities for vulnerable one's, they should be improved. Better inclusion is being explored.	Equal access to safe drinking water. Vulnerable groups are identified in the city and better inclusion programs are launched for such groups.	Fair and equal access to safe drinking water. Vulnerable groups are identified in the city and especially prioritized and included in services.	3

SOCIAL DIMENSION								
Underlying Quality	**Code for Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Integrated & Inclusive	S.1.5	Education programs, workshops, training activities on climate change, its emerging impacts, urban climate resilience concept and on the possible actions/ measures that can be taken at individual level	No education programs in the city. People are completely unaware of climate change, its emerging issues, and actions that can be taken individually.	Some educational programs are launched in the city, but they are insufficient. A proportion of the population is aware of climate change, while the rest is completely unconscious. Education programs should be increased and accelerated throughout the city.	Reasonable number of training programs. A significant portion of the population is aware of climate change and takes some actions voluntarily, while the rest are unconscious. Educational programs should be increased to promote public participation.	Citizens are provided with various educational activities. Most people are aware of the actions to be taken and individual and/or joint steps are taken in this context. However, there are also those who are unconscious and/or do not participate in the actions. Public participation should be further enhanced.	Wide range of educational programs for citizens. All people know how to respond to extreme events of climate change and aware that all individual actions are valuable to achieve "urban climate resilience".	2
Integrated & Inclusive	S.1.6	Collaboration and co-operation among stakeholders, especially in an extreme event/hazard, i.e. Government, customers, companies, industries, policy-makers, other water-related public/private agencies and authorities	No collaboration or co-operation between stakeholders. Poor resilience / vulnerable development to an emergency or hazard.	Poor and/or inadequate collaboration and co-operation among stakeholders to cope with an extreme or emergency event.	There is some degree of collaboration and co-operation among stakeholders to deal with an emergency / hazard. However, more collaboration is required to build resilience.	A "multi-agency coordination and information sharing" structure is created against an emergency or major event in the city, that increases collaboration and cooperation among stakeholders. However, collaborations are still being strengthened to create more integrated and resilient services.	Quick response mechanism by strong collaboration and co-operation between stakeholders. Resilient development is ensured.	3
Integrated & Inclusive	S.1.7	Assessment of impacts of water tariffs and/or new regulations on vulnerable groups in the society	Vulnerable groups are not taken into account in water tariffs and regulations. No relevant impact assessment is made for vulnerable groups.	The importance of including vulnerable groups is slowly being understood. However, water tariffs and regulations continue to be developed as usual without including these groups. No impact assessment is conducted.	Water tariffs and regulations are developed as usual, but on some items special attention is paid to vulnerable groups. Although analysis is conducted to ensure affordability for all, no comprehensive impact assessment is done.	Water tariffs and new regulations are determined by considering all social groups. Importance is attached to the concept of "affordability for all" and/or impact assessments are conducted to determine the state.	Water tariffs and regulations are well-managed by paying particular attention to vulnerable groups. Impact assessments are made to determine the effectiveness of the tariff in ensuring affordability for all.	4
Integrated & Inclusive	S.1.8	Drought management policies and/or drought response frameworks that ensure public awareness, engagement and preparedness for water scarcity	No drought-related management policies, frameworks or preparedness, neither at the city level nor at the national level. No public engagement.	No drought management policies or response frameworks at the city level. There are national policies and frameworks. The preparedness is obtained indirectly via national measures and climate change action plans. Weak public awareness and there are attempts to strengthen the engagement.	There is a drought management policy and/or response framework at the city level. Amount of preparedness is achieved with the public engagement, but there are still some deficiencies. Drought policies and frameworks should be improved, and engagement should be strengthened.	Effective drought management policy and/or response framework at the city level. A certain level of preparedness is achieved with the public engagement, but progress is still being made in building a solid consensus.	High public awareness by the strong drought management policy and response framework at the city level. Successful preparedness is achieved through high public engagement and consensus.	2

SOCIAL DIMENSION								
Underlying Quality	**Code for Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Integrated & Inclusive	S.1.9	Water-saving culture	No water conservation. High water consumption across the city.	The importance of water saving is recognized in the city and it is increasing day by day. Opportunities are sought to adopt and/or develop water efficient technologies.	Water-efficient technologies are newly becoming widespread. The importance of water conservation and efficient use is recognized at the urban and individual level.	Water efficient technologies are widely applied or tried to be applied in the first place. It is aimed to boost water saving through behavioral changes at urban and individual level. Firm steps are being taken towards a water saving culture.	Efficient use of water, reduced water footprint and large amount of water savings by the water-saving culture embraced across the city.	2
Robustness	S.1.10	Quality of life and public health & safety associated with water supply and sanitation	Public health is in danger and quality of life is poor due to the lack of water supply and sanitation services in the city.	Poor quality of life and inadequate public health & safety, as water supply and sanitation services are newly being developed.	Water supply and sanitation services exist but outdated, which results moderate quality of life and average public health and safety.	Advanced water supply and sanitation services, although there may be some disruptions / failures in the water system. Overall, high quality of life and public health and safety are ensured in terms of water supply & sanitation.	High quality of life and public health & safety are ensured through well-managed, sustainable water supply and sanitation services.	4
							Overall Score:	**28**
							Overall Average:	**2.8**

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation	EN.1.1	Hydrological modelling, development of scenarios for current/future water demand and availability, and mapping potential impacts	No hydrological modelling or scenarios for the city. There is no impact mapping to better define and detect the prone zones.	Concrete steps are taken towards hydrological modelling for the city. In current condition, there is no scenario or impact mapping developed.	Hydrological modelling gives a good breath of current and future water assets, water demand and availability of the city. Impact mapping is prepared to identify prone zones, but no concrete action has yet been taken to build resilience.	Hydrological modelling provides a holistic view of current and future water assets, demand and supply balance in the city. The drought prone zones are determined by impact mapping. Some steps were taken to build resilience in these areas, but more solid actions are required.	Various modelling tools are used and different scenarios are developed for the city in terms of water resources, demand and availability. Possible impacts of scarcity are well addressed and mapped, and strong actions are taken against drought prone zones.	3
Innovation & Resourceful	EN.1.2	Adoption of water-efficient technologies	No technology is adopted to ensure water efficiency in the city and there are no steps in this sense. Water consumption levels continue to increase at the same rate.	Water-efficient technologies are being researched and application opportunities are newly being explored and developed.	The application of water-efficient technologies is growing day by day, not only based on environmental awareness, but also to make economic savings. They are adopted in the city, but there are still a significant number of new opportunities, sectors to explore and implement.	Water efficient technologies are promoted in the city and are widely adopted in most sectors such as industrial, agricultural, and domestic uses. However, there are still some opportunities for new implementation or replacement / enhancement.	Water-efficient technologies are adopted for all uses, namely industrial, agricultural, and domestic uses, in order to reduce the overall water consumption in the city.	3
Innovation & Resourceful	EN.1.3	Continuous monitoring of water quantity and quality in water resources (i.e. surface water, groundwater and other sources)	No monitoring is conducted to track or measure water quality or quantity.	Periodic monitoring is carried out to detect water levels in the city's major water resources. The monitoring is insufficient. It is based on quantity rather than quality, or vice versa.	Continuous monitoring is conducted to monitor number of water bodies and water supply sources; this includes both water quality and quantity. Collected data are evaluated regularly. However, automatic monitoring systems are still lacking for some resources.	Continuous monitoring is carried out by automatic systems to monitor most water bodies and water supply sources of the city, for both water quality and quantity. Collected data are regularly evaluated and/or modelling is performed. However, in some locations, monitoring systems require maintenance and inspection work.	Continuous monitoring is conducted by automatic systems to monitor the quality and quantity of water bodies and/or each water supply source of the city. Monitoring system is refurbished and fault-free. To provide safe water, collected quantitative & qualitative data are regularly evaluated and actions are taken when necessary.	4
Integrated	EN.1.4	Integrated water resources management (IWRM) and performing relevant water assessments	Unacquainted with IWRM. Neither IWRM nor water assessments are conducted in the city.	Especially in the face of climate change, the importance of IWRM is increasingly recognized. There are new initiatives to employ IWRM at water governance but has a long way to go towards sustainable water management. No water assessments have been conducted yet.	The essential role of IWRM is recognized and adopted in most of the urban policies and strategies. However, there is still a gap and need for improvement in terms of wider adoption and implementation. In this direction, the application areas are tried to be expanded and opportunities are sought.	IWRM is adopted in urban policies and strategies in the city to foster resilience. Sustainable water management is being achieved through an integrative framework and water is consumed safely. Regular water assessments are conducted to improve water-efficiency, as well as water quality.	IWRM is embraced in all urban policies, frameworks & strategies and water assets are well-managed and water is consumed safely & sustainably. Regular water assessments are conducted to identify the need for improvement or actions required in assets, services, infrastructures. Water resilience is built.	3

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Resourceful	EN.1.5	Sustainable use of water resources	Unfamiliar with sustainability concept or sustainable use of water.	Familiar with sustainability and there are initiatives to embed the concept in urban policies to ensure water conservation in both quantity and quality, under the reality of climate change and emerging water scarcity risk.	Sustainable development is gaining more importance every day. Sustainability is mainstreamed in urban policies and strategies and attempts to implement this concept in various sectors in the city are increasing, especially in water resources to cope with water scarcity.	Sustainability and sustainable development are widely accepted in the city and incorporated into urban policies and strategies. Sustainable use of water resources is enhanced through various initiatives and actions across the city, both at the individual and institutional level.	Broad public awareness on sustainability and climate change. Effective measures are taken against the emerging water scarcity risk at both individual and population levels throughout the city. Water is consumed efficiently and sustainably.	3
Resourceful	EN.1.6	Daily average water consumption per capita (L/capita.day)	>180	160 < - ≤ 180	140 < - ≤ 160	120 < - ≤ 140	100 < - ≤ 120	1
Robustness	EN.1.7	Identification of opportunities for nature-based solutions (NBS) and implementation	No awareness or knowledge about NBS in the city. No implementation.	NBS is gradually being recognized in the city and knowledge on such alternatives is increasing. There are no practices yet, but there are some initiatives in terms of policymaking.	NBS alternatives are discussed and applied in cases where the needs can be met effectively and successfully with these alternatives. NBS is gaining importance in building climate resilience and more opportunities are sought in practice.	NBS alternatives are considered and evaluated as an option in most projects. The vital importance of NBS is well-understood in the city and reflected on several urban policies, strategies & action plans. However, there are still some gaps in implementation and there is a need to extend NBS.	NBS is widely used in the city. With sound knowledge of climate resilience and sustainability, the city's most water assets and services rely on NBS to conserve water bodies in a sustainable manner and ultimately build resilience.	3
Robustness & Innovation	EN.1.8	Monitoring and early warning systems for drought	There is no monitoring or early warning system developed for drought events. The urban & environmental assets i.e. water resources, urban ecosystems and people are extremely vulnerable and unprepared for drought.	Acquainted with the monitoring and early warning systems but no implementation yet. "Early warning" is emphasized in urban plans and/or policies. There are new projects and/or initiatives to conduct monitoring and develop early warning system.	Monitoring and early warning system is gradually being developed for drought events. But requires significant improvements.	Monitoring and early warning system for drought events has been developed, but there is still room for some improvements.	Monitoring and early warning system is developed to raise awareness and foster preparedness for upcoming drought events and to ensure protection of environmental assets, resources, ecosystems and people.	2
Robustness & Resourceful	EN.1.9	Preservation, conservation and/or restoration of water resources and ecosystems	No knowledge about preservation, conservation and restoration of water resources and ecosystems and therefore there is no practice in the city.	With the emerging risk of water scarcity, preservation, conservation and restoration works gained importance in the city. There are initiatives in terms of policy-making and strategy development. Although, there is still lack of knowledge and practice.	Major water resources and ecosystems are sustainably preserved, conserved and restored. These actions are increasingly included in urban strategies and policies, but they need to be further expanded and mainstreamed.	Most water resources and ecosystems are sustainably preserved, conserved and restored. They gained a firm place in strategies and plans. However, there are still some minor implementation gaps and conservation actions need to be expanded in practice to cover all water bodies and ecosystems of the city.	Water resources and ecosystems are well-preserved, conserved and restored to build sustainable and resilient urban environment. These actions are recognized and adopted in almost all urban policies, strategies and plans.	3

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness & Resourceful	EN.1.10	Sound environmental management to ensure quality water supply by controlling pollution	No environmental management to control pollution. Water pollution and hence the quality of water supply is a huge problem in the city.	There are efforts to strengthen environmental management and some important steps are taken, but not sufficient. The quality of water supply is affected both directly and indirectly by various pollution problems, such as solid waste, wastewater, surface water and runoff.	Environmental management is of great importance in urban policies, strategies and plans. Concrete actions and measures are taken to protect water supply resources. Safe water is provided by advanced drinking water treatment plants throughout the city. However, environmental management in some parts of the city is weak and is being improved/developed.	Sound management against environmental pollution. Environmental management is widely accepted and plays an important role in urban policies, strategies and plans. There are concrete environmental steps towards safe water. However, environmental management is still being improved / strengthened in some parts of the city, especially due to runoff and drainage problems.	A robust environmental management mechanism throughout the city, namely effective and sustainable water / wastewater management, solid waste management and effective surface water drainage, runoff control; provides quality water supply.	3
							Overall Score:	**28**
							Overall Average:	**2.8**

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation	INF.1.1	Smart water leak detection & water metering and continuous monitoring systems for water supply networks and relevant infrastructures	No monitoring, smart water leak detection and/or water metering for water supply networks and water-related infrastructures.	Periodic monitoring is conducted to measure water flowrates and detect water leakages at the water supply network. However, there is no continuous monitoring system. No effective measures to reduce water losses.	Continuous monitoring systems, smart water leak detection and water metering are provided in most of the water supply network and related infrastructures in the city. However, actions are insufficient and water loss cannot be reduced effectively. The network needs improvement and regular maintenance & repair.	Continuous monitoring systems, smart water leak detection and water metering are provided in majority of the water supply network and related infrastructures in the city. Water loss is significantly reduced, but parts of the network still need improvement.	Continuous monitoring systems, smart water leak detection and water metering are provided in all water supply network and related infrastructures in the city. Water loss is almost completely eliminated.	4
Integrated	INF.1.2	Rate of population served by water supply network in total municipal population (%)	<40%	40 ≤ - ≤ 60%	60 < - ≤ 80%	80 < - ≤ 90%	>90%	5
Redundancy & Independence	INF.1.3	Spare (back-up) capacity for water infrastructure and services	No spare capacity is built for any infrastructure or service. No knowledge about the importance of back-up against climate change in the city.	The importance of spare capacity against shocks/stresses is gradually recognized. There are some initiatives to build spare capacity for water infrastructure and especially in policy making. The supply of spare parts/equipment and storage tanks are started to be emphasized.	Spare capacity is built to water infrastructure and services in the city. However, there are still some gaps in the capacity provided for water infrastructure. Significant improvements and actions are required to continue operating independently against shocks, stresses or extreme events.	Sufficient spare capacity is built for water infrastructure and services in the city; storage tanks, spare parts/equipment are provided. However, some further actions are required to build a robust & independent infrastructure.	A large spare capacity is built for water infrastructure and services through allocated funds, sound back-up plans, storage tanks, spare parts and equipment, in order to continue operating independently, by responding extreme events and shocks quickly.	3
Reflective & Integrated	INF.1.4	Data and information sharing in water utilities and feedback system to inform the future from past experiences	No information sharing and feedback mechanism in water utilities	There are new initiatives to improve data and information sharing. The feedback mechanism is currently weak, but some concrete steps are being taken to increase its effectiveness.	There is a data and information sharing mechanism in water utilities. Although feedback loops are adopted in some infrastructures to prevent cascading or persistent failures, some still do not have and/or need improvement.	Successful data and information sharing in water utilities. Feedback loops are widely adopted to prevent cascading or persistent failures. However, some improvements and/or R&D are needed in this mechanism.	Enhanced data and information sharing in water utilities. Advanced feedback loops inform the future from past experiences to avoid cascading or persistent failures.	3
Resourceful & Innovation	INF.1.5	Capacity building for non-conventional water resources (NCWR); such as, water transfers, groundwater use, desalinization, treated wastewater reuse, water harvesting, etc.	No knowledge about NCWR and no additional capacity is built for such alternatives. The city is highly vulnerable in terms of water supply in the event of an emergency, shock or stress.	Insufficient knowledge on NCWR. There are some efforts to increase the amount of water, but they change the amount slightly. NCWR knowledge should be enhanced and promoted across the city at both institutional and individual levels. Capacity	NCWR are recognized in the city and adopted to cope with urgent events. Although there are some examples of NCWR in the city, the approach in these applications is to provide instant solutions to the problem. The mindset should be changed, and long-term	Significant capacity is built or being built for NCWR to increase the amount of water supply. NCWR and capacity building are gaining importance and increasingly emphasized in urban strategies. However, some firm steps need to be taken at both the institutional	Capacity is built for NCWR. With such alternative sources and technologies, the amount of water supply is increased significantly, and the city becomes highly water resilient. Capacity building is of great importance and widely featured in urban strategies,	3

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
				building for such alternatives should then be considered.	capacity building programs should be launched for NCWR, and their emphasis should be increased in urban strategies.	and individual level to boost water resilience.	especially to cope with climate change.	
Robustness	INF.1.6	Retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or new GI designs in urban development	The municipality is not familiar with GI. Therefore, there are no GI practices in the city and/or programs to retrofit or replace existing infrastructure with GI.	GI knowledge in the city is poor but increasing. There is no significant retrofit or replacement programs for the existing infrastructure and/or no significant new GI designs in the city. Urban development relies on grey infrastructure.	GI is gradually recognized in the city. The essential role of "green" against climate change is acknowledged and emphasized in strategies/policies. Although there are some practices in GI, city's infrastructure mainly relies on grey infrastructure.	GI is recognized in the city. Retrofit and replacement programs are in progress at some parts of the city, and there are new designs with the GI. However, the number of practices & launched programs can be increased to ensure a resilient city.	Effective retrofitting and replacement programs are being conducted across the city and the GI is implemented comprehensively. The development of GI is underpinned in urban policies as the best alternative especially to achieve climate resilience, and the concept is widely adopted for new designs.	2
Robustness	INF.1.7	Green buildings, green features and green infrastructures (GI) across the city and integration of GI into urban planning	Unacquainted with green features, green buildings or GI. No practices for such elements in the city.	The level of knowledge on green buildings, GI and green features is increasing and gaining importance against climate change. However, there is no significant step in implementation yet.	Green features, green buildings and GI recently gained a prominence in the city and in the urban policies and strategies, to build climate resilience. New initiatives have been launched to slowly integrate GI to the existing grey infrastructure and promote green features.	Green features, green buildings and GI are recognized in the city. In addition to integrating GI into urban planning, strategy plans and policies, there are also solid steps towards replacing grey infrastructure with GI to achieve climate resilience.	Green features, green buildings and GI are promoted and widely adopted across the city. GI is well-integrated into urban planning and widely developed to boost efficient and sustainable use of resources and enhance water availability & quality in the city.	2
Robustness	INF.1.8	Average water leakage rate at water supply network	>40%	30< - ≤40%	20< - ≤30%	10< - ≤20%	5< - ≤10%	3
Robustness & Innovation	INF.1.9	Maintenance and Repair (M&R) for water-related infrastructures - including water and wastewater services, networks and assets - and adoption of technologies to conduct M&R	Water-related infrastructures and assets are not maintained and/or no information is available on the (M&R) of the related infrastructures. No technologies are used.	Maintenance and repair of the infrastructures are performed occasionally. On-point M&R is performed, in case of malfunctions. There is no regular and comprehensive M&R. Unfamiliar with technologies, conventional methods are adopted.	Regular inspections and M&R are carried out covering most of the infrastructure. The adoption of technologies for comprehensive control services is a new mindset for the municipality and it becomes increasingly common.	M&R is performed regularly and technologies (e.g. SCADA) are adopted for control. Sufficient number of qualified personnel for M&R and technicians for the technologies are assigned. Although customers are constantly served with services, some parts of the infrastructure still require particular attention and improvements.	Regular control and M&R is conducted for all water & wastewater infrastructures by means of technologies, e.g. supervisory control and data acquisition (SCADA) system. Sustainable and resilient water & wastewater management and continuous service provision is provided across the city.	4

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness & Integrated	INF.1.10	Integration of "climate resilience" into water assets, services and all relevant infrastructure design, operation and maintenance activities	The city is far from the "climate resilience" concept and there is no integration.	"Climate resilience" is newly being recognized in the city. In this context, some initiatives are launched in terms of policymaking, to enable its integration into urban systems.	"Climate resilience" is newly recognized and being integrated into water-related urban infrastructure, services and assets. Integration is increasing across the city, but there is a long way to go towards climate resilience.	"Climate resilience" is mostly integrated into water-related urban infrastructure, services and assets; yet there is still some lacking. Therefore, resilience projects/works are still ongoing within the city.	"Climate resilience" is a vital element of the city and it is embraced in all water-related assets, services, infrastructures and all operation and maintenance activities to boost robustness.	3
							Overall Score:	**32**
							Overall Average:	**3.2**

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Inclusive	EC.1.1	Inclusion of awareness-raising campaigns for "water footprint minimization" in financial plans	Awareness-raising campaigns are not included in financial plans and/or no budget is allocated.	Awareness-raising campaigns for water minimization in the city are gradually gaining importance and newly being adopted in the financial plan.	Awareness campaigns to promote water savings are included as a sub-item in the financial plan and small amounts are allocated. Budget allocation should be improved and campaigns should be increased.	Awareness raising campaigns to promote water conservation are included in the financial plan. However, it should be more prominent in the plan and the amount of budget allocation should be reviewed.	Awareness raising campaigns are an important element of the financial plans. A large budget is allocated to awareness raising, to minimize water footprints, promote water conservation and change in consumption behaviours.	3
Innovative & Flexibility	EC.1.2	Incentive programs to reduce water consumption in the agricultural sector	No incentive programs to reduce water withdrawal / consumption in agriculture sector.	Incentive programs are newly developed in the city to promote water conservation in the agricultural activities. The number of incentives allocated and the number of programs should be increased.	There are some incentive programs to increase water savings by new technologies and modernization in the agriculture sector. However, the number of the programs and scope should be further expanded.	There are incentive programs to boost sustainable production and water savings in agriculture sector. However, programs need to be further expanded to cover all agricultural activities within the city.	Advanced incentive programs for sustainable production and water conservation in the agriculture sector. Incentives to reduce water withdrawal & consumption by promoting change in production patterns and irrigation technologies.	3
Innovative & Flexibility	EC.1.3	R&D investments to seek innovative solutions for sustainable water management	No investments for R&D to seek innovative solutions.	The importance of R&D in sustainable water management has recently been recognized and R&D investments have recently come to the fore in the city.	There are some R&D investments to find innovative solutions for sustainable water management. However, there are still gaps in the implementation of innovative technologies and R&D investments need to be increased significantly.	R&D investments are made in innovative technologies to provide sustainable water management and to seek alternative solutions to strengthen water security. However, investments must be increased to develop effective flexibility.	There are large R&D investments in innovative technologies to ensure sustainable water management, conserve water resources and strengthen water security.	3
Integrated	EC.1.4	New funding opportunities by international cooperation & partnerships on climate change	There is no international cooperation and partnerships on climate change. Therefore, there are no new funding opportunities.	International cooperation and partnerships on climate change are newly explored and developed, and new funding opportunities are sought to build resilience and support water management.	There are some international cooperation and partnerships, and new funding opportunities are created accordingly. However, these opportunities are insufficient. Further collaborations and partnerships should be sought.	Successful international cooperation & partnerships lead to different funding opportunities for innovation, new technologies, projects and initiatives to boost water management. However, there are still some minor gaps in collaborations, partnerships and funding. These can be developed further.	Strong international cooperation and partnerships in climate change create range of funding opportunities; leading to build climate resilience in the city and take firm steps towards water scarcity management.	3

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Redundancy	EC.1.5	Budget allocation to back-up (spare) capacity for water-related infrastructure, assets and services	No budget is allocated to create back-up capacity.	The importance of back-up capacity against climate change has newly been recognized, and there are some efforts to create changes in the design phases through new policies established. Financial plans are being reviewed to allocate a budget for creating back-ups.	A budget is allocated for back-up capacity in water-related infrastructure, assets & services. However, it is insufficient to develop redundancy and resilience against climate change in urban water systems. Therefore, the allocation should be increased significantly.	A budget is allocated to build a back-up capacity for water-related infrastructure, assets & services. However, some infrastructure, services and assets still need to improve capacity and allocations should be reviewed and increased accordingly.	Large amount of budget is allocated to back-up capacity for water-related infrastructure, assets & services. Redundancy and so redundant water systems is acknowledged as an important component to build climate resilience in the city.	3
Resourceful & Robustness	EC.1.6	Investments in water resources development and management, water reclamation and reuse projects	There are no investments in water resources development and management, water reclamation and reuse projects.	With the adverse impacts on water resources exacerbated by climate change, the development and management of water resources, water reclamation and reuse have recently come to the fore and investment opportunities are being sought.	Some investments are made. However, there are still many gaps and investment opportunities in the city. In particular, reclamation and reuse alternatives should be widely adopted not only in agricultural or industrial uses, but also in domestic uses, and infrastructure should be retrofitted accordingly.	There are significant investments in water resources development and management, water reclamation and reuse. However, there are still some deficiencies and areas for improvement in water resources management. Reclamation and reuse opportunities in the city should be further explored.	There are large investments in water resources development and management, water reclamation and reuse projects to increase water conservation and sustainable use of water in the city.	3
Robustness	EC.1.7	Budget allocation to improve climate resilience in urban water systems	No budget allocation to improve climate resilience in urban water systems.	Climate resilience is gaining importance and the budgets allocated to resilience in water systems are increasing. However, solid steps should be taken and investments should be increased significantly to ensure climate resilience in urban water systems.	There is a reasonable amount of budget allocation to increase climate resilience in urban water systems. However, improvements are required to boost resilience, so investments need to be increased significantly.	A considerable amount of budget allocation to increase climate resilience in urban water systems. However, some parts of the water systems require more investment.	Large budget allocation to initiatives and/or projects to improve climate resilience in urban water systems.	2
Robustness	EC.1.8	Investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses (e.g. bursting pipes, leakages in water supply networks)	No investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses.	Investments in water supply maintenance and retrofit programs are increasing. Action plans have been developed to reduce the overall water loss in the city, but concrete steps have not yet been taken yet to reduce and/or prevent water losses.	Investments are made in maintenance and retrofit programs to reduce and/or prevent water losses. However, investments should be increased and programs should be further expanded throughout the city to prevent bursting of pipes and leakages.	Significant investments are made in maintenance and retrofit programs to reduce and/or prevent water losses due to leakages and bursting pipes in the network. Water loss is significantly reduced, but improvements are still required in the network.	Large investments are made in maintenance and retrofit programs to reduce and/or prevent water losses due to leakages, bursting pipe problems in the network. Water losses are almost completely prevented.	3

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness	EC.1.9	Investments in climate-resilient urban built environment to increase adaptation capacity against climate change	There are no investments for climate-resilient designs or associated urban built forms.	The concept of climate resilience is newly being recognized. No significant investments made in the city, but there are some initiatives promoting climate-resilient designs in urban developments and built environment, albeit insufficient.	The essential role of climate resilient design is recognized in the city. There are some investments to boost adaptive capacity by means of climate-resilient designs in urban built environment. However, investments should be enhanced.	The essential role of climate resilient design is widely recognized in the city. There are significant investments for climate-resilient urban built forms to improve the adaptive capacity. However, there are also some opportunities to further increase investments.	Large investments to climate-resilient designs and built forms in the urban environment. Sufficient adaptive capacity is built against climate change.	2
Robustness	EC.1.10	Water tariff regulations to manage the supply-demand gap	There are no water tariff regulations to manage the supply-demand gap in the city.	The efficiency of the water tariff is newly evaluated in terms of supply and demand. There are no regulations yet to manage and/or fill the supply-demand gap.	Water tariff adjustments are made to manage the supply-demand gap. However, the tariff should be improved according to water scarcity and special attention should be paid to the inclusion of vulnerable groups during the regulation of the water tariff.	Water tariff regulations are made to manage the supply-demand gap. Water pricing is set depending on the volume consumed i.e. step tariff to promote reduction in water consumptions. Different social groups are taken into account under different categories in these adjustments.	Scarcity-driven (e.g. aridity indexed tariff) water pricing strategies are followed and effective regulations are made in the water tariff to manage the supply-demand gap, taking into account all social groups and especially vulnerable ones.	4
							Overall Score:	**29**
							Overall Average:	**2.9**

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation & Independence	INS.1.1	Capacity building for non-conventional water resources (e.g. water reuse, rainwater harvesting and grey water recycling) and integration into urban planning/development policies	Lack of knowledge in non-conventional water resources in the city. No capacity is built and they are not integrated in urban policies.	Insufficient knowledge in non-conventional water resources, but the awareness on the importance of water reuse, rainwater harvesting or grey water recycling is raising. However, no capacity is built or not integrated into urban planning yet.	Some capacity is built and/or still being built for non-conventional water resources in the city. There are individual practices within the city in some developments. However, it is not integrated into urban planning/development policies.	Amount of capacity is built in the city for non-conventional water resources. Non-conventional resources have best practices in some developments in the city. However, practices should be increased across the city and more widely included in urban planning/development policies.	Significant amount of capacity is built for non-conventional water resources. Such non-conventional resource alternatives are well integrated into urban planning/development policies. They are widely being adopted in most of the new developments.	3
Integrated	INS.1.2	Fragmentation of responsibilities among organizations/authorities for water resources management (larger fragmentation complicates the integrated management of water resources; various organizations make different decisions on the same water system or leave the responsibility to one another, unwilling to consider their mandate relative to other organizations.)	There is a large fragmentation of responsibilities between institutions/authorities. This results in leaving the responsibility to one another and/or inability to make quick decisions in the face of emerging problems.	There is a fragmentation. This slows the decision-making processes or causes institutions & authorities to leave the responsibility to others or remain unresponsive to a certain extent depending on their limits. However, the need for institutional adjustments is recognized in policies and there are some initiatives for change.	There is a fragmentation, but organizations/authorities do not remain unresponsive and take actions. The need of institutional arrangements and structural redesigns are recognized and/or addressed in various policies. Steps towards change are taken gradually to reduce fragmentation.	Although fragmentation cannot be prevented, it is reduced. Organizations/authorities work in cooperation and coordination, but there is still a need for institutional arrangements and structural redesigns that can further improve the integrated management.	Although fragmentation cannot be prevented, it is minimized to the lowest level. Organizations/authorities work in collaboration and coordination, and quick decisions are taken against emerging problems. A successful integrated management structure is developed.	2
Integrated	INS.1.3	Addressing water scarcity and its impacts on water assets and services from a holistic perspective in policy-making	Water scarcity and its negative impacts on water assets and services are not addressed in policy-making.	Water scarcity and its negative impacts on water assets and services are identified in the city. However, they have not been addressed in urban policies/strategies yet. There are new steps to incorporate such risks in policy-making.	Water scarcity and its impacts on water assets and services are addressed in urban policies, but policy-making should be improved. Larger emphasis should be placed on the synergy between people and ecosystems, and the water supply /demand dynamics.	Water scarcity and its impacts on water assets and services are addressed in policies, referencing the synergy between people and ecosystems, and water supply & demand dynamics. However, there are opportunities to enhance the references in policies.	Water scarcity and its impacts on water assets and services are addressed holistically in policy-making and so in urban policies, focusing on the synergy between people and ecosystems, and water supply /demand dynamics.	3
Redundancy	INS.1.4	Internalization of spare capacity for water-related assets, infrastructure and systems in urban planning	Spare capacity for water-related critical infrastructure and systems is not internalized and emphasized in urban planning.	The importance of spare capacity has recently been recognized. There are new efforts to integrate it into urban planning.	The importance of "spare capacity" to build a robust system is recognized in the city and redundancy is emphasized in urban planning. However, there are some gaps in policies/strategies to further highlight or adopt the redundancy.	Spare capacity has been embedded in urban planning. However, there are still some opportunities to put more emphasis on back-up in policies or strategies.	Spare capacity for water-related critical infrastructure and systems are successfully adopted in urban planning and emphasized in all urban policies and strategies, to ensure bounce back from shocks and hazards.	3

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Reflective & Innovation	INS.1.5	Monitoring and/or assessment tool for climate actions to measure adaptive improvements and identify progress towards urban climate resilience, as well as to determine future actions based on current experience	There is no monitoring and/or assessment tool to identify the progress on climate resilience.	Monitoring and/or assessment tool is newly being developed or has recently been developed.	A monitoring and/or assessment tool has been developed to identify progress on climate resilience and future actions. However, the monitoring and/or assessment tool needs major improvements.	There is a monitoring and/or assessment tool to ascertain the progress on climate resilience and identify the future actions. But there are still opportunities to further improve the monitoring and/or assessment tool.	There is an advanced monitoring and an assessment tool to measure the performance of climate actions, and ultimately reveal the progress on climate resilience achieved in the city, as well as informing the future through experiences.	2
Resourceful	INS.1.6	Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments	Urban plans and policies do not promote and/or include any targets to increase water efficiency or reduce water consumption in new developments.	The use of water-efficient technologies for new developments (e.g. rainwater harvesting, water reuse, grey water recycling) has recently been promoted in urban plans & policies and made mandatory for some large-scale new developments. However, urban plans & policies require large improvements.	There are some urban plans and policies, that promote reducing water consumption and increasing water efficiency in new developments. However, policies / plans are not very effective and improvement is required.	For new developments; water efficient technologies are promoted (e.g. water reuse & grey water recycling) and/or limitations are set in urban plans to further reduce the amount of water consumed. However, there are still improvement opportunities in urban plans & policies to boost water efficiency.	Providing water-efficient new developments with low water consumption is one of the main focuses of city plans and policies and is successfully promoted. Significant water reduction is achieved in the city.	2
Robustness	INS.1.7	Development and adoption of climate resilience policies & strategies at the urban level	There is no city-level resilience policy and/or strategy. Climate change risks are neglected in the urban governance.	No city level resilience policies and/or strategies other than climate change action plan or adaptation & mitigation focused plans.	Resilience policies and/or strategies are newly being developed at the urban level.	Resilience policies and/or strategies have been developed and adopted in the city. City residents are informed about necessary actions with the provided information via policies/strategies. However, efforts and actions need to be further stepped up and developed to strengthen climate resilience across the city.	Strong resilience policies and/or strategies have been developed and successfully adopted across the city. City residents are informed about necessary actions with the provided comprehensive and consistent information via policies/strategies.	2
Robustness	INS.1.8	Acknowledging the essential role and vulnerability of "water" in urban policies	The essential role and vulnerability of "water" is not acknowledged in urban policies.	The vital importance of "water" and its role in urban life is well understood, and there are policy adjustments and initiatives in policy-making processes to highlight the key role and vulnerability of water in urban systems.	The role and vulnerability of water is recognized and acknowledged in some urban policies. However, there are large gaps to further emphasize and embed the key role of water in urban policies.	The essential role and vulnerability of water is well-addressed in the major urban policies. However, there are still opportunities to further emphasize the vulnerability of water in policies.	The vital importance of "water" and its vulnerability is successfully acknowledged in all urban policies to protect and preserve water resources.	4

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**Istanbul Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness	INS.1.9	Recognizing the potential of Nature Based Solutions (NBS) against climate change and integration in urban policies, strategies and action plans	Administrative authorities in the city are unfamiliar with the NBS. Therefore, NBS is not integrated into any policy, strategy or plan at the urban level.	NBS is newly recognized or already recognized by the city's administrative authorities. NBS is not extensively included in urban policies, strategies and action plans; and there are new attempts to integrate such solutions.	The potential of NBS is recognized against climate change and it is integrated into some of the urban policies, strategies and plans developed. However, there are large gaps, in other words opportunities to further integrate the key role of NBS.	NBS has come to the forefront and gained importance in the city with the exacerbating climate change. It is integrated into the urban policies, strategies and plans developed. However, there are still opportunities to further highlight NBS in some policies, strategies and plans.	The potential of NBS is well recognized to tackle climate change issues such as water scarcity, desertification and drought. NBS is integrated into all urban policies, strategies and action plans.	2
Robustness	INS.1.10	Targets to reduce water losses and leakages in water supply system	No targets set to reduce water losses and leakages.	The importance of the targets has recently been recognized and some targets have been set accordingly to reduce water losses and leakages in the urban water supply system.	There are targets to reduce water losses and leaks in the water supply system, but city-wide reductions are minimal and/or invisible. Therefore, targets should be reviewed and higher goals should be set.	Effective targets have been set to reduce water losses and leaks in the water supply system. However, there are opportunities to set more ambitious targets to achieve further water reductions.	There are ambitious targets to reduce supply system water losses and leakages. Significant reductions were achieved.	4
							Overall Score:	**27**
							Overall Average:	**2.7**

APPENDIX-2

ASSESSMENT SHEETS OF LONDON CASE STUDY

SOCIAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Flexibility	S.1.1	Adaptive capacity in the city and the ability of people to respond quickly to emergencies, extreme events of climate change, especially, to water scarcity	No adaptive capacity in the city. Citizens are completely unprepared and vulnerable to shocks, stresses or extreme events.	Adaptation capacity is weak in the city, but there are initiatives to build/improve the capacity. Citizens are unprepared and vulnerable to shocks, stresses or extreme events.	Adaptive capacity is built in the city but there are rooms for further improvements. While a portion of the population is prepared and can respond the shocks and extreme events, the rest of the population is vulnerable.	There is a considerable amount of adaptation capacity in the city and it is still being developed. Citizens are prepared to some extent for short-term interruptions and/or shocks, extreme events or hazards; however, the capacity should be further increased throughout the city.	High adaptive capacity in the city. Citizens are fully prepared to short or long-term disruptions and capable of reacting quickly to shocks, extreme events or hazards.	4
Inclusive	S.1.2	Level of public awareness on climate change and emerged water scarcity problem	The public is completely unaware of climate change and the emerging water scarcity problem in the city.	The public has little awareness of climate change and the emerging water scarcity in the city. There are no individual level mitigation measures/actions.	A certain segment of society has awareness. Some people voluntarily change their water consumption habits. However, these attempts are insufficient and awareness should be expanded in the city.	The majority of people are aware of the climate emergency. Collaborative initiatives for adaptation have been launched and steps are being taken towards preparedness for extreme events.	Widespread awareness and preparedness has been achieved at the city level against climate change and the emerging water scarcity problem.	3
Inclusive	S.1.3	Stakeholder engagement in decision-making processes of climate adaptation, action and/or resilience plans at the city level	No contact is made with stakeholders, they are ignored and unaware of ongoing decision-making processes. They are not included in any stage.	Stakeholders are informed but they only have a basic knowledge about plans and progresses. They are not involved in the decision-making process.	Stakeholders are partially aware of the ongoing plans. Opportunities are rarely created to ask their opinions/concerns. However, it does not have much influence on decision making.	Stakeholders are aware of ongoing plans and decision-making processes. They are engaged and collaborations are supported to shape strategies and plans together.	Actively engaged citizens & other key stakeholders to boost climate resilience across the city. They are empowered, have a direct influence and drive the decision-making.	4
Inclusive	S.1.4	Equal access to safe water, especially vulnerable groups (e.g. Homeless people, people with disabilities, refugees, low-income population etc.)	No equal access to safe, well-managed drinking water. Vulnerable groups suffer more from a lack of access to safe water.	There are initiatives to ensure equal access to safe water. However, vulnerable groups are still suffering, and there are no concrete actions for such groups.	Equal access to safe drinking water. Vulnerable groups are identified in the city. Although there are some efforts to provide equal opportunities for vulnerable one's, they should be improved. Better inclusion is being explored.	Equal access to safe drinking water. Vulnerable groups are identified in the city and better inclusion programs are launched for such groups.	Fair and equal access to safe drinking water. Vulnerable groups are identified in the city and especially prioritized and included in services.	4

SOCIAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Integrated & Inclusive	S.1.5	Education programs, workshops, training activities on climate change, its emerging impacts, urban climate resilience concept and on the possible actions/measures that can be taken at individual level	No education programs in the city. People are completely unaware of climate change, its emerging issues, and actions that can be taken individually.	Some educational programs are launched in the city, but they are insufficient. A proportion of the population is aware of climate change, while the rest is completely unconscious. Education programs should be increased and accelerated throughout the city.	Reasonable number of training programs. A significant portion of the population is aware of climate change and takes some actions voluntarily, while the rest are unconscious. Educational programs should be increased to promote public participation.	Citizens are provided with various educational activities. Most people are aware of the actions to be taken and individual and/or joint steps are taken in this context. However, there are also those who are unconscious and/or do not participate in the actions. Public participation should be further enhanced.	Wide range of educational programs for citizens. All people know how to respond to extreme events of climate change and aware that all individual actions are valuable to achieve "urban climate resilience".	4
Integrated & Inclusive	S.1.6	Collaboration and co-operation among stakeholders, especially in an extreme event/hazard, i.e. Government, customers, companies, industries, policy-makers, other water-related public/private agencies and authorities	No collaboration or co-operation between stakeholders. Poor resilience / vulnerable development to an emergency or hazard.	Poor and/or inadequate collaboration and co-operation among stakeholders to cope with an extreme or emergency event.	There is some degree of collaboration and co-operation among stakeholders to deal with an emergency / hazard. However, more collaboration is required to build resilience.	A "multi-agency coordination and information sharing" structure is created against an emergency or major event in the city, that increases collaboration and cooperation among stakeholders. However, collaborations are still being strengthened to create more integrated and resilient services.	Quick response mechanism by strong collaboration and co-operation between stakeholders. Resilient development is ensured.	4
Integrated & Inclusive	S.1.7	Assessment of impacts of water tariffs and/or new regulations on vulnerable groups in the society	Vulnerable groups are not taken into account in water tariffs and regulations. No relevant impact assessment is made for vulnerable groups.	The importance of including vulnerable groups is slowly being understood. However, water tariffs and regulations continue to be developed as usual without including these groups. No impact assessment is conducted.	Water tariffs and regulations are developed as usual, but on some items special attention is paid to vulnerable groups. Although analysis is conducted to ensure affordability for all, no comprehensive impact assessment is done.	Water tariffs and new regulations are determined by considering all social groups. Importance is attached to the concept of "affordability for all" and/or impact assessments are conducted to determine the state.	Water tariffs and regulations are well-managed by paying particular attention to vulnerable groups. Impact assessments are made to determine the effectiveness of the tariff in ensuring affordability for all.	5
Integrated & Inclusive	S.1.8	Drought management policies and/or drought response frameworks that ensure public awareness, engagement and preparedness for water scarcity	No drought-related management policies, frameworks or preparedness, neither at the city level nor at the national level. No public engagement.	No drought management policies or response frameworks at the city level. There are national policies and frameworks. The preparedness is obtained indirectly via national measures and climate change action plans. Weak public awareness and there are attempts to strengthen the engagement.	There is a drought management policy and/or response framework at the city level. Amount of preparedness is achieved with the public engagement, but there are still some deficiencies. Drought policies and frameworks should be improved and engagement should be strengthened.	Effective drought management policy and/or response framework at the city level. A certain level of preparedness is achieved with the public engagement, but progress is still being made in building a solid consensus.	High public awareness by the strong drought management policy and response framework at the city level. Successful preparedness is achieved through high public engagement and consensus.	4

SOCIAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Integrated & Inclusive	S.1.9	Water-saving culture	No water conservation. High water consumption across the city.	The importance of water saving is recognized in the city and it is increasing day by day. Opportunities are sought to adopt and/or develop water efficient technologies.	Water-efficient technologies are newly becoming widespread. The importance of water conservation and efficient use is recognized at the urban and individual level.	Water efficient technologies are widely applied or tried to be applied in the first place. It is aimed to boost water saving through behavioural changes at urban and individual level. Firm steps are being taken towards a water saving culture.	Efficient use of water, reduced water footprint and large amount of water savings by the water-saving culture embraced across the city.	4
Robustness	S.1.10	Quality of life and public health & safety associated with water supply and sanitation	Public health is in danger and quality of life is poor due to the lack of water supply and sanitation services in the city.	Poor quality of life and inadequate public health & safety, as water supply and sanitation services are newly being developed.	Water supply and sanitation services exist but outdated, which results moderate quality of life and average public health and safety.	Advanced water supply and sanitation services, although there may be some disruptions / failures in the water system. Overall, high quality of life and public health and safety are ensured in terms of water supply & sanitation.	High quality of life and public health & safety are ensured through well-managed, sustainable water supply and sanitation services.	4
							Overall Score:	**40**
							Overall Average:	**4**

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation	EN.1.1	Hydrological modelling, development of scenarios for current/future water demand and availability, and mapping potential impacts	No hydrological modelling or scenarios for the city. There is no impact mapping to better define and detect the prone zones.	Concrete steps are taken towards hydrological modelling for the city. In current condition, there is no scenario or impact mapping developed.	Hydrological modelling gives a good breath of current and future water assets, water demand and availability of the city. Impact mapping is prepared to identify prone zones, but no concrete action has yet been taken to build resilience.	Hydrological modelling provides a holistic view of current and future water assets, demand, and supply balance in the city. The drought prone zones are determined by impact mapping. Some steps were taken to build resilience in these areas, but more solid actions are required.	Various modelling tools are used and different scenarios are developed for the city in terms of water resources, demand and availability. Possible impacts of scarcity are well addressed and mapped, and strong actions are taken against drought prone zones.	4
Innovation & Resourceful	EN.1.2	Adoption of water-efficient technologies	No technology is adopted to ensure water efficiency in the city and there are no steps in this sense. Water consumption levels continue to increase at the same rate.	Water-efficient technologies are being researched and application opportunities are newly being explored and developed.	The application of water-efficient technologies is growing day by day, not only based on environmental awareness, but also to make economic savings. They are adopted in the city, but there are still a significant number of new opportunities, sectors to explore and implement.	Water efficient technologies are promoted in the city and are widely adopted in most sectors such as industrial, agricultural, and domestic uses. However, there are still some opportunities for new implementation or replacement / enhancement.	Water-efficient technologies are adopted for all uses, namely industrial, agricultural and domestic uses, in order to reduce the overall water consumption in the city.	4
Innovation & Resourceful	EN.1.3	Continuous monitoring of water quantity and quality in water resources (i.e. surface water, groundwater and other sources)	No monitoring is conducted to track or measure water quality or quantity.	Periodic monitoring is carried out to detect water levels in the city's major water resources. The monitoring is insufficient. It is based on quantity rather than quality, or vice versa.	Continuous monitoring is conducted to monitor number of water bodies and water supply sources; this includes both water quality and quantity. Collected data are evaluated regularly. However, automatic monitoring systems are still lacking for some resources.	Continuous monitoring is carried out by automatic systems to monitor most water bodies and water supply sources of the city, for both water quality and quantity. Collected data are regularly evaluated and/or modelling is performed. However, in some locations, monitoring systems require maintenance and inspection work.	Continuous monitoring is conducted by automatic systems to monitor the quality and quantity of water bodies and/or each water supply source of the city. Monitoring system is refurbished and fault-free. To provide safe water, collected quantitative & qualitative data are regularly evaluated and actions are taken when necessary.	4
Integrated	EN.1.4	Integrated water resources management (IWRM) and performing relevant water assessments	Unacquainted with IWRM. Neither IWRM nor water assessments are conducted in the city.	Especially in the face of climate change, the importance of IWRM is increasingly recognized. There are new initiatives to employ IWRM at water governance but has a long way to go towards sustainable water management. No water assessments have been conducted yet.	The essential role of IWRM is recognized and adopted in most of the urban policies and strategies. However, there is still a gap and need for improvement in terms of wider adoption and implementation. In this direction, the application areas are tried to be expanded and opportunities are sought.	IWRM is adopted in urban policies and strategies in the city to foster resilience. Sustainable water management is being achieved through an integrative framework and water is consumed safely. Regular water assessments are conducted to improve water-efficiency, as well as water quality.	IWRM is embraced in all urban policies, frameworks & strategies and water assets are well-managed and water is consumed safely & sustainably. Regular water assessments are conducted to identify the need for improvement or actions required in assets, services, infrastructures. Water resilience is built.	4

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Resourceful	EN.1.5	Sustainable use of water resources	Unfamiliar with sustainability concept or sustainable use of water.	Familiar with sustainability and there are initiatives to embed the concept in urban policies to ensure water conservation in both quantity and quality, under the reality of climate change and emerging water scarcity risk.	Sustainable development is gaining more importance every day. Sustainability is mainstreamed in urban policies and strategies and attempts to implement this concept in various sectors in the city are increasing, especially in water resources to cope with water scarcity.	Sustainability and sustainable development are widely accepted in the city and incorporated into urban policies and strategies. Sustainable use of water resources is enhanced through various initiatives and actions across the city, both at the individual and institutional level.	Broad public awareness on sustainability and climate change. Effective measures are taken against the emerging water scarcity risk at both individual and population levels throughout the city. Water is consumed efficiently and sustainably.	4
Resourceful	EN.1.6	Daily average water consumption per capita (L/capita.day)	>180	160 < - ≤ 180	140 < - ≤ 160	120 < - ≤ 140	100 < - ≤ 120	3
Robustness	EN.1.7	Identification of opportunities for nature-based solutions (NBS) and implementation	No awareness or knowledge about NBS in the city. No implementation.	NBS is gradually being recognized in the city and knowledge on such alternatives is increasing. There are no practices yet, but there are some initiatives in terms of policymaking.	NBS alternatives are discussed and applied in cases where the needs can be met effectively and successfully with these alternatives. NBS is gaining importance in building climate resilience and more opportunities are sought in practice.	NBS alternatives are considered and evaluated as an option in most projects. The vital importance of NBS is well-understood in the city and reflected on several urban policies, strategies & action plans. However, there are still some gaps in implementation and there is a need to extend NBS.	NBS is widely used in the city. With sound knowledge of climate resilience and sustainability, the city's most water assets and services rely on NBS to conserve water bodies in a sustainable manner and ultimately build resilience.	4
Robustness & Innovation	EN.1.8	Monitoring and early warning systems for drought	There is no monitoring or early warning system developed for drought events. The urban & environmental assets i.e. water resources, urban ecosystems and people are extremely vulnerable and unprepared for drought.	Acquainted with the monitoring and early warning systems but no implementation yet. "Early warning" is emphasized in urban plans and/or policies. There are new projects and/or initiatives to conduct monitoring and develop early warning system.	Monitoring and early warning system is gradually being developed for drought events. But requires significant improvements.	Monitoring and early warning system for drought events has been developed, but there is still room for some improvements.	Monitoring and early warning system is developed to raise awareness and foster preparedness for upcoming drought events and to ensure protection of environmental assets, resources, ecosystems and people.	4
Robustness & Resourceful	EN.1.9	Preservation, conservation and/or restoration of water resources and ecosystems	No knowledge about preservation, conservation and restoration of water resources and ecosystems and therefore there is no practice in the city.	With the emerging risk of water scarcity, preservation, conservation and restoration works gained importance in the city. There are initiatives in terms of policymaking and strategy development. Although, there is still lack of knowledge and practice.	Major water resources and ecosystems are sustainably preserved, conserved and restored. These actions are increasingly included in urban strategies and policies, but they need to be further expanded and mainstreamed.	Most water resources and ecosystems are sustainably preserved, conserved and restored. They gained a firm place in strategies and plans. However, there are still some minor implementation gaps and conservation actions need to be expanded in practice to cover all water bodies and ecosystems of the city.	Water resources and ecosystems are well-preserved, conserved and restored to build sustainable and resilient urban environment. These actions are recognized and adopted in almost all urban policies, strategies and plans.	4

ENVIRONMENTAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness & Resourceful	EN.1.10	Sound environmental management to ensure quality water supply by controlling pollution	No environmental management to control pollution. Water pollution and hence the quality of water supply is a huge problem in the city.	There are efforts to strengthen environmental management and some important steps are taken, but not sufficient. The quality of water supply is affected both directly and indirectly by various pollution problems, such as solid waste, wastewater, surface water and runoff.	Environmental management is of great importance in urban policies, strategies and plans. Concrete actions and measures are taken to protect water supply resources. Safe water is provided by advanced drinking water treatment plants throughout the city. However, environmental management in some parts of the city is weak and is being improved/developed.	Sound management against environmental pollution. Environmental management is widely accepted and plays an important role in urban policies, strategies and plans. There are concrete environmental steps towards safe water. However, environmental management is still being improved / strengthened in some parts of the city, especially due to runoff and drainage problems.	A robust environmental management mechanism throughout the city, namely effective and sustainable water / wastewater management, solid waste management and effective surface water drainage, runoff control; provides quality water supply.	4
							Overall Score:	**39**
							Overall Average:	**3.9**

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation	INF.1.1	Smart water leak detection & water metering and continuous monitoring systems for water supply networks and relevant infrastructures	No monitoring, smart water leak detection and/or water metering for water supply networks and water-related infrastructures.	Periodic monitoring is conducted to measure water flowrates and detect water leakages at the water supply network. However, there is no continuous monitoring system. No effective measures to reduce water losses.	Continuous monitoring systems, smart water leak detection and water metering are provided in most of the water supply network and related infrastructures in the city. However, actions are insufficient and water loss cannot be reduced effectively. The network needs improvement and regular maintenance & repair.	Continuous monitoring systems, smart water leak detection and water metering are provided in majority of the water supply network and related infrastructures in the city. Water loss is significantly reduced, but parts of the network still need improvement.	Continuous monitoring systems, smart water leak detection and water metering are provided in all water supply network and related infrastructures in the city. Water loss is almost completely eliminated.	4
Integrated	INF.1.2	Rate of population served by water supply network in total municipal population (%)	<40%	40 ≤ - ≤ 60%	60 < - ≤ 80%	80 < - ≤ 90%	>90%	5
Redundancy & Independence	INF.1.3	Spare (back-up) capacity for water infrastructure and services	No spare capacity is built for any infrastructure or service. No knowledge about the importance of back-up against climate change in the city.	The importance of spare capacity against shocks/stresses is gradually recognized. There are some initiatives to build spare capacity for water infrastructure and especially in policy making. The supply of spare parts/equipment and storage tanks are started to be emphasized.	Spare capacity is built to water infrastructure and services in the city. However, there are still some gaps in the capacity provided for water infrastructure. Significant improvements and actions are required to continue operating independently against shocks, stresses or extreme events.	Sufficient spare capacity is built for water infrastructure and services in the city; storage tanks, spare parts/equipment are provided. However, some further actions are required to build a robust & independent infrastructure.	A large spare capacity is built for water infrastructure and services through allocated funds, sound back-up plans, storage tanks, spare parts and equipment, in order to continue operating independently, by responding extreme events and shocks quickly.	3
Reflective & Integrated	INF.1.4	Data and information sharing in water utilities and feedback system to inform the future from past experiences	No information sharing and feedback mechanism in water utilities	There are new initiatives to improve data and information sharing. The feedback mechanism is currently weak, but some concrete steps are being taken to increase its effectiveness.	There is a data and information sharing mechanism in water utilities. Although feedback loops are adopted in some infrastructures to prevent cascading or persistent failures, some still do not have and/or need improvement.	Successful data and information sharing in water utilities. Feedback loops are widely adopted to prevent cascading or persistent failures. However, some improvements and/or R&D are needed in this mechanism.	Enhanced data and information sharing in water utilities. Advanced feedback loops inform the future from past experiences to avoid cascading or persistent failures.	4
Resourceful & Innovation	INF.1.5	Capacity building for non-conventional water resources (NCWR); such as, water transfers, groundwater use, desalinization, treated wastewater reuse, water harvesting, etc.	No knowledge about NCWR and no additional capacity is built for such alternatives. The city is highly vulnerable in terms of water supply in the event of an emergency, shock or stress.	Insufficient knowledge on NCWR. There are some efforts to increase the amount of water, but they change the amount slightly. NCWR knowledge should be enhanced and promoted across the city at both institutional and individual levels. Capacity	NCWR are recognized in the city and adopted to cope with urgent events. Although there are some examples of NCWR in the city, the approach in these applications is to provide instant solutions to the problem. The mindset should be changed and long-term	Significant capacity is built or being built for NCWR to increase the amount of water supply. NCWR and capacity building are gaining importance and increasingly emphasized in urban strategies. However, some firm steps need to be taken at both the institutional	Capacity is built for NCWR. With such alternative sources and technologies, the amount of water supply is increased significantly, and the city becomes highly water resilient. Capacity building is of great importance and widely featured in urban strategies,	4

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
				building for such alternatives should then be considered.	capacity building programs should be launched for NCWR, and their emphasis should be increased in urban strategies.	and individual level to boost water resilience.	especially to cope with climate change.	
Robustness	INF.1.6	Retrofit or replacement programs for existing infrastructures with green infrastructure (GI) and/or new GI designs in urban development	The municipality is not familiar with GI. Therefore, there are no GI practices in the city and/or programs to retrofit or replace existing infrastructure with GI.	GI knowledge in the city is poor but increasing. There is no significant retrofit or replacement programs for the existing infrastructure and/or no significant new GI designs in the city. Urban development relies on grey infrastructure.	GI is gradually recognized in the city. The essential role of "green" against climate change is acknowledged and emphasized in strategies/policies. Although there are some practices in GI, city's infrastructure mainly relies on grey infrastructure.	GI is recognized in the city. Retrofit and replacement programs are in progress at some parts of the city, and there are new designs with the GI. However, the number of practices & launched programs can be increased to ensure a resilient city.	Effective retrofitting and replacement programs are being conducted across the city and the GI is implemented comprehensively. The development of GI is underpinned in urban policies as the best alternative especially to achieve climate resilience, and the concept is widely adopted for new designs.	4
Robustness	INF.1.7	Green buildings, green features and green infrastructures (GI) across the city and integration of GI into urban planning	Unacquainted with green features, green buildings or GI. No practices for such elements in the city.	The level of knowledge on green buildings, GI and green features is increasing and gaining importance against climate change. However, there is no significant step in implementation yet.	Green features, green buildings and GI recently gained a prominence in the city and in the urban policies and strategies, to build climate resilience. New initiatives have been launched to slowly integrate GI to the existing grey infrastructure and promote green features.	Green features, green buildings and GI are recognized in the city. In addition to integrating GI into urban planning, strategy plans and policies, there are also solid steps towards replacing grey infrastructure with GI to achieve climate resilience.	Green features, green buildings and GI are promoted and widely adopted across the city. GI is well-integrated into urban planning and widely developed to boost efficient and sustainable use of resources and enhance water availability & quality in the city.	4
Robustness	INF.1.8	Average water leakage rate at water supply network	>40%	30< - ≤40%	20< - ≤30%	10< - ≤20%	5< - ≤10%	3
Robustness & Innovation	INF.1.9	Maintenance and Repair (M&R) for water-related infrastructures - including water and wastewater services, networks and assets - and adoption of technologies to conduct M&R	Water-related infrastructures and assets are not maintained and/or no information is available on the (M&R) of the related infrastructures. No technologies are used.	Maintenance and repair of the infrastructures are performed occasionally. On-point M&R is performed, in case of malfunctions. There is no regular and comprehensive M&R. Unfamiliar with technologies, conventional methods are adopted.	Regular inspections and M&R are carried out covering most of the infrastructure. The adoption of technologies for comprehensive control services is a new mindset for the municipality and it becomes increasingly common.	M&R is performed regularly and technologies (e.g. SCADA) are adopted for control. Sufficient number of qualified personnel for M&R and technicians for the technologies are assigned. Although customers are constantly served with services, some parts of the infrastructure still require particular attention and improvements.	Regular control and M&R is conducted for all water & wastewater infrastructures by means of technologies, e.g. supervisory control and data acquisition (SCADA) system. Sustainable and resilient water & wastewater management and continuous service provision is provided across the city.	4

INFRASTRUCTURAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness & Integrated	INF.1.10	Integration of "climate resilience" into water assets, services and all relevant infrastructure design, operation and maintenance activities	The city is far from the "climate resilience" concept and there is no integration.	"Climate resilience" is newly being recognized in the city. In this context, some initiatives are launched in terms of policymaking, to enable its integration into urban systems.	"Climate resilience" is newly recognized and being integrated into water-related urban infrastructure, services and assets. Integration is increasing across the city, but there is a long way to go towards climate resilience.	"Climate resilience" is mostly integrated into water-related urban infrastructure, services and assets; yet there is still some lacking. Therefore, resilience projects/works are still ongoing within the city.	"Climate resilience" is a vital element of the city and it is embraced in all water-related assets, services, infrastructures and all operation and maintenance activities to boost robustness.	4
							Overall Score:	**39**
							Overall Average:	**3.9**

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Inclusive	EC.1.1	Inclusion of awareness-raising campaigns for "water footprint minimization" in financial plans	Awareness-raising campaigns are not included in financial plans and/or no budget is allocated.	Awareness-raising campaigns for water minimization in the city are gradually gaining importance and newly being adopted in the financial plan.	Awareness campaigns to promote water savings are included as a sub-item in the financial plan and small amounts are allocated. Budget allocation should be improved and campaigns should be increased.	Awareness raising campaigns to promote water conservation are included in the financial plan. However, it should be more prominent in the plan and the amount of budget allocation should be reviewed.	Awareness raising campaigns are an important element of the financial plans. A large budget is allocated to awareness raising, to minimize water footprints, promote water conservation and change in consumption behaviours.	4
Innovative & Flexibility	EC.1.2	Incentive programs to reduce water consumption in the agricultural sector	No incentive programs to reduce water withdrawal / consumption in agriculture sector.	Incentive programs are newly developed in the city to promote water conservation in the agricultural activities. The number of incentives allocated and the number of programs should be increased.	There are some incentive programs to increase water savings by new technologies and modernization in the agriculture sector. However, the number of the programs and scope should be further expanded.	There are incentive programs to boost sustainable production and water savings in agriculture sector. However, programs need to be further expanded to cover all agricultural activities within the city.	Advanced incentive programs for sustainable production and water conservation in the agriculture sector. Incentives to reduce water withdrawal & consumption by promoting change in production patterns and irrigation technologies.	4
Innovative & Flexibility	EC.1.3	R&D investments to seek innovative solutions for sustainable water management	No investments for R&D to seek innovative solutions.	The importance of R&D in sustainable water management has recently been recognized and R&D investments have recently come to the fore in the city.	There are some R&D investments to find innovative solutions for sustainable water management. However, there are still gaps in the implementation of innovative technologies and R&D investments need to be increased significantly.	R&D investments are made in innovative technologies to provide sustainable water management and to seek alternative solutions to strengthen water security. However, investments must be increased to develop effective flexibility.	There are large R&D investments in innovative technologies to ensure sustainable water management, conserve water resources and strengthen water security.	3
Integrated	EC.1.4	New funding opportunities by international cooperation & partnerships on climate change	There is no international cooperation and partnerships on climate change. Therefore, there are no new funding opportunities.	International cooperation and partnerships on climate change are newly explored and developed, and new funding opportunities are sought to build resilience and support water management.	There are some international cooperation and partnerships, and new funding opportunities are created accordingly. However, these opportunities are insufficient. Further collaborations and partnerships should be sought.	Successful international cooperation & partnerships lead to different funding opportunities for innovation, new technologies, projects and initiatives to boost water management. However, there are still some minor gaps in collaborations, partnerships and funding. These can be developed further.	Strong international cooperation and partnerships in climate change create range of funding opportunities; leading to build climate resilience in the city and take firm steps towards water scarcity management.	4

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Redundancy	EC.1.5	Budget allocation to back-up (spare) capacity for water-related infrastructure, assets and services	No budget is allocated to create back-up capacity.	The importance of back-up capacity against climate change has newly been recognized, and there are some efforts to create changes in the design phases through new policies established. Financial plans are being reviewed to allocate a budget for creating back-ups.	A budget is allocated for back-up capacity in water-related infrastructure, assets & services. However, it is insufficient to develop redundancy and resilience against climate change in urban water systems. Therefore, the allocation should be increased significantly.	A budget is allocated to build a back-up capacity for water-related infrastructure, assets & services. However, some infrastructure, services and assets still need to improve capacity and allocations should be reviewed and increased accordingly.	Large amount of budget is allocated to back-up capacity for water-related infrastructure, assets & services. Redundancy and so redundant water systems is acknowledged as an important component to build climate resilience in the city.	4
Resourceful & Robustness	EC.1.6	Investments in water resources development and management, water reclamation and reuse projects	There are no investments in water resources development and management, water reclamation and reuse projects.	With the adverse impacts on water resources exacerbated by climate change, the development and management of water resources, water reclamation and reuse have recently come to the fore and investment opportunities are being sought.	Some investments are made. However, there are still many gaps and investment opportunities in the city. In particular, reclamation and reuse alternatives should be widely adopted not only in agricultural or industrial uses, but also in domestic uses, and infrastructure should be retrofitted accordingly.	There are significant investments in water resources development and management, water reclamation and reuse. However, there are still some deficiencies and areas for improvement in water resources management. Reclamation and reuse opportunities in the city should be further explored.	There are large investments in water resources development and management, water reclamation and reuse projects to increase water conservation and sustainable use of water in the city.	4
Robustness	EC.1.7	Budget allocation to improve climate resilience in urban water systems	No budget allocation to improve climate resilience in urban water systems.	Climate resilience is gaining importance and the budgets allocated to resilience in water systems are increasing. However, solid steps should be taken and investments should be increased significantly to ensure climate resilience in urban water systems.	There is a reasonable amount of budget allocation to increase climate resilience in urban water systems. However, improvements are required to boost resilience, so investments need to be increased significantly.	A considerable amount of budget allocation to increase climate resilience in urban water systems. However, some parts of the water systems require more investment.	Large budget allocation to initiatives and/or projects to improve climate resilience in urban water systems.	4
Robustness	EC.1.8	Investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses (e.g. bursting pipes, leakages in water supply networks)	No investments in water supply maintenance and retrofit programs to reduce and/or prevent water losses.	Investments in water supply maintenance and retrofit programs are increasing. Action plans have been developed to reduce the overall water loss in the city, but concrete steps have not yet been taken yet to reduce and/or prevent water losses.	Investments are made in maintenance and retrofit programs to reduce and/or prevent water losses. However, investments should be increased and programs should be further expanded throughout the city to prevent bursting of pipes and leakages.	Significant investments are made in maintenance and retrofit programs to reduce and/or prevent water losses due to leakages and bursting pipes in the network. Water loss is significantly reduced, but improvements are still required in the network.	Large investments are made in maintenance and retrofit programs to reduce and/or prevent water losses due to leakages, bursting pipe problems in the network. Water losses are almost completely prevented.	3

ECONOMIC DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness	EC.1.9	Investments in climate-resilient designs and urban built environment to increase adaptation capacity against climate change	There are no investments for climate-resilient designs or associated urban built forms.	The concept of climate resilience is newly being recognized. No significant investments made in the city, but there are some initiatives promoting climate-resilient design in urban developments and built environment, albeit insufficient.	The essential role of climate resilient design is recognized in the city. There are some investments to boost adaptive capacity by means of climate-resilient designs in urban built environment. However, investments should be enhanced.	The essential role of climate resilient design is widely recognized in the city. There are significant investments for climate-resilient urban built forms to improve the adaptive capacity. However, there are also some opportunities to further increase investments.	Large investments to climate-resilient designs and built forms in the urban environment. Sufficient adaptive capacity is built against climate change.	3
Robustness	EC.1.10	Water tariff regulations to manage the supply-demand gap	There are no water tariff regulations to manage the supply-demand gap in the city.	The efficiency of the water tariff is newly evaluated in terms of supply and demand. There are no regulations yet to manage and/or fill the supply-demand gap.	Water tariff adjustments are made to manage the supply-demand gap. However, the tariff should be improved according to water scarcity and special attention should be paid to the inclusion of vulnerable groups during the regulation of the water tariff.	Water tariff regulations are made to manage the supply-demand gap. Water pricing is set depending on the volume consumed i.e. step tariff to promote reduction in water consumptions. Different social groups are taken into account under different categories in these adjustments.	Scarcity-driven (e.g. aridity indexed tariff) water pricing strategies are followed and effective regulations are made in the water tariff to manage the supply-demand gap, taking into account all social groups and especially vulnerable ones.	4
							Overall Score:	**37**
							Overall Average:	**3.7**

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Innovation & Independence	INS.1.1	Capacity building for non-conventional water resources (e.g. water reuse, rainwater harvesting and grey water recycling) and integration into urban planning/development policies	Lack of knowledge in non-conventional water resources in the city. No capacity is built and they are not integrated in urban policies.	Insufficient knowledge in non-conventional water resources, but the awareness on the importance of water reuse, rainwater harvesting or grey water recycling is raising. However, no capacity is built or not integrated into urban planning yet.	Some capacity is built and/or still being built for non-conventional water resources in the city. There are individual practices within the city in some developments. However, it is not integrated into urban planning/development policies.	Amount of capacity is built in the city for non-conventional water resources. Non-conventional resources have best practices in some developments in the city. However, practices should be increased across the city and more widely included in urban planning/development policies.	Significant amount of capacity is built for non-conventional water resources. Such non-conventional resource alternatives are well integrated into urban planning/development policies. They are widely being adopted in most of the new developments.	4
Integrated	INS.1.2	Fragmentation of responsibilities among organizations/authorities for water resources management (larger fragmentation complicates the integrated management of water resources; various organizations make different decisions on the same water system or leave the responsibility to one another, unwilling to consider their mandate relative to other organizations.)	There is a large fragmentation of responsibilities between institutions/authorities. This results in leaving the responsibility to one another and/or inability to make quick decisions in the face of emerging problems.	There is a fragmentation. This slows the decision-making processes or causes institutions & authorities to leave the responsibility to others or remain unresponsive to a certain extent depending on their limits. However, the need for institutional adjustments is recognized in policies and there are some initiatives for change.	There is a fragmentation, but organizations/authorities do not remain unresponsive and take actions. The need of institutional arrangements and structural redesigns are recognized and/or addressed in various policies. Steps towards change are taken gradually to reduce fragmentation.	Although fragmentation cannot be prevented, it is reduced. Organizations/authorities work in cooperation and coordination, but there is still a need for institutional arrangements and structural redesigns that can further improve the integrated management.	Although fragmentation cannot be prevented, it is minimized to the lowest level. Organizations/authorities work in collaboration and coordination, and quick decisions are taken against emerging problems. A successful integrated management structure is developed.	3
Integrated	INS.1.3	Addressing water scarcity and its impacts on water assets and services from a holistic perspective in policy-making	Water scarcity and its negative impacts on water assets and services are not addressed in policy-making.	Water scarcity and its negative impacts on water assets and services are identified in the city. However, they have not been addressed in urban policies/strategies yet. There are new steps to incorporate such risks in policy-making.	Water scarcity and its impacts on water assets and services are addressed in urban policies, but policy-making should be improved. Larger emphasis should be placed on the synergy between people and ecosystems, and the water supply /demand dynamics.	Water scarcity and its impacts on water assets and services are addressed in policies, referencing the synergy between people and ecosystems, and water supply & demand dynamics. However, there are opportunities to enhance the references in policies.	Water scarcity and its impacts on water assets and services are addressed holistically in policy-making and so in urban policies, focusing on the synergy between people and ecosystems, and water supply /demand dynamics.	4
Redundancy	INS.1.4	Internalization of spare capacity for water-related assets, infrastructure and systems in urban planning	Spare capacity for water-related critical infrastructure and systems is not internalized and emphasized in urban planning.	The importance of spare capacity has recently been recognized. There are new efforts to integrate it into urban planning.	The importance of "spare capacity" to build a robust system is recognized in the city and redundancy is emphasized in urban planning. However, there are some gaps in policies/strategies to further highlight or adopt the redundancy.	Spare capacity has been embedded in urban planning. However, there are still some opportunities to put more emphasis on back-up in policies or strategies.	Spare capacity for water-related critical infrastructure and systems are successfully adopted in urban planning and emphasized in all urban policies and strategies, to ensure bounce back from shocks and hazards.	3

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Reflective & Innovation	INS.1.5	Monitoring and/or assessment tool for climate actions to measure adaptive improvements and identify progress towards urban climate resilience, as well as to determine future actions based on current experience	There is no monitoring and/or assessment tool to identify the progress on climate resilience.	Monitoring and/or assessment tool is newly being developed or has recently been developed.	A monitoring and/or assessment tool has been developed to identify progress on climate resilience and future actions. However, the monitoring and/or assessment tool needs major improvements.	There is a monitoring and/or assessment tool to ascertain the progress on climate resilience and identify the future actions. But there are still opportunities to further improve the monitoring and/or assessment tool.	There is an advanced monitoring and an assessment tool to measure the performance of climate actions, and ultimately reveal the progress on climate resilience achieved in the city, as well as informing the future through experiences.	4
Resourceful	INS.1.6	Urban plans and policies promote reducing water consumption and increasing water efficiency in new developments	Urban plans and policies do not promote and/or include any targets to increase water efficiency or reduce water consumption in new developments.	The use of water-efficient technologies for new developments (e.g. rainwater harvesting, water reuse, grey water recycling) has recently been promoted in urban plans & policies and made mandatory for some large-scale new developments. However, urban plans & policies require large improvements.	There are some urban plans and policies, that promote reducing water consumption and increasing water efficiency in new developments. However, policies / plans are not very effective and improvement is required.	For new developments; water efficient technologies are promoted (e.g. water reuse & grey water recycling) and/or limitations are set in urban plans to further reduce the amount of water consumed. However, there are still improvement opportunities in urban plans & policies to boost water efficiency.	Providing water-efficient new developments with low water consumption is one of the main focuses of city plans and policies and is successfully promoted. Significant water reduction is achieved in the city.	4
Robustness	INS.1.7	Development and adoption of climate resilience policies & strategies at the urban level	There is no city-level resilience policy and/or strategy. Climate change risks are neglected in the urban governance.	No city level resilience policies and/or strategies other than climate change action plan or adaptation & mitigation focused plans.	Resilience policies and/or strategies are newly being developed at the urban level.	Resilience policies and/or strategies have been developed and adopted in the city. City residents are informed about necessary actions with the provided information via policies/strategies. However, efforts and actions need to be further stepped up and developed to strengthen climate resilience across the city.	Strong resilience policies and/or strategies have been developed and successfully adopted across the city. City residents are informed about necessary actions with the provided comprehensive and consistent information via policies/strategies.	4
Robustness	INS.1.8	Acknowledging the essential role and vulnerability of "water" in urban policies	The essential role and vulnerability of "water" is not acknowledged in urban policies.	The vital importance of "water" and its role in urban life is well understood, and there are policy adjustments and initiatives in policy-making processes to highlight the key role and vulnerability of water in urban systems.	The role and vulnerability of water is recognized and acknowledged in some urban policies. However, there are large gaps to further emphasize and embed the key role of water in urban policies.	The essential role and vulnerability of water is well-addressed in the major urban policies. However, there are still opportunities to further emphasize the vulnerability of water in policies.	The vital importance of "water" and its vulnerability is successfully acknowledged in all urban policies to protect and preserve water resources.	4

INSTITUTIONAL DIMENSION								
Underlying Quality	**Code for the Indicator**	**Indicator**	**London Case Study Scoring Scheme**					**Score**
			Highly Undesirable 1	**Undesirable 2**	**Neutral 3**	**Desirable 4**	**Highly Desirable 5**	
Robustness	INS.1.9	Recognizing the potential of Nature Based Solutions (NBS) against climate change and integration in urban policies, strategies and action plans	Administrative authorities in the city are unfamiliar with the NBS. Therefore, NBS is not integrated into any policy, strategy or plan at the urban level.	NBS is newly recognized or already recognized by the city's administrative authorities. NBS is not extensively included in urban policies, strategies and action plans; and there are new attempts to integrate such solutions.	The potential of NBS is recognized against climate change and it is integrated into some of the urban policies, strategies and plans developed. However, there are large gaps, in other words opportunities to further integrate the key role of NBS.	NBS has come to the forefront and gained importance in the city with the exacerbating climate change. It is integrated into the urban policies, strategies and plans developed. However, there are still opportunities to further highlight NBS in some policies, strategies and plans.	The potential of NBS is well recognized to tackle climate change issues such as water scarcity, desertification and drought. NBS is integrated into all urban policies, strategies and action plans.	4
Robustness	INS.1.10	Targets to reduce water losses and leakages in water supply system	No targets set to reduce water losses and leakages.	The importance of the targets has recently been recognized and some targets have been set accordingly to reduce water losses and leakages in the urban water supply system.	There are targets to reduce water losses and leaks in the water supply system, but city-wide reductions are minimal and/or invisible. Therefore, targets should be reviewed and higher goals should be set.	Effective targets have been set to reduce water losses and leaks in the water supply system. However, there are opportunities to set more ambitious targets to achieve further water reductions.	There are ambitious targets to reduce supply system water losses and leakages. Significant reductions were achieved.	4
							Overall Score:	**38**
							Overall Average:	**3.8**