POLITECNICO DI MILANO

School of Civil, Environmental and Land Management Engineering

Master of Science in Civil Engineering for Risk Mitigation

Circular Water Management: co-design process towards the development of Action Plans

Supervisor: Dr. Francesco Ballio
Co-Supervisor: Dr. Simona Muratori

Thesis of:
Carlotta Ferraro
Matr. 898909

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English Abstract

The management of water resources in urban contexts is a challenging issue that arises from the high complexity inherent in the water sector. This complexity is due to the intrinsic organisation of the system which is characterised by inter- and intra-sectoral dependencies, multi-stakeholders, multi-scale and multi-level governance. This, coupled with nowadays global change trends, such as population growth, urbanization increase, climate change, etc. directly affect the availability of water resources in different ways causing people dealing with an high variety of problems related to too much, to low or too polluted water. It is difficult to comply with quality and quantity standards to satisfy everyone's needs therefore a careful planning and management is needed.

For this reason, the need to manage water resources in a more sustainable and circular way has emerged and is becoming increasingly felt. In this context, the Interreg Central Europe project City Water Circles fits, in fact its final aim is to enhance water efficiency and reuse in Central European functional urban areas with an integrated circular economy approach by acting on water governance, water efficiency and water loss reduction, rain water management and grey water recycling.

In order to achieve this goal, a new approach to water management needs to be developed, trying to overcome the intrinsic complexities of the urban water system and to solve the obstacles in the water management. This thesis work aims to propose tools and methods conceived to deal with the complexity and problems related to the water system and management of water resources in urban context following an approach based on stakeholder involvement and participation. In fact, a participative learning process is designed and proposed with the final aim to bring to the development of the key elements and strategies of an action plan, which reflects also the social acceptability and circularity principles.

The complete learning process is composed of three parts, of which the first two are the input tools for the development of the third one, the AP (Action Plan) Methodology. They are organised as follows:

- Status Quo self-assessment: analysis to highlight criticalities in the water system;
- Public perception survey: analysis to detect possible social feasibility of intervention, education and population's priorities;
- AP methodology: participative support for developing the key and essential elements of an action plan.

In this way, the cooperation between stakeholders is fostered and solutions are co-designed with them in order to identify the essential elements on which to base the action plan in line with the principles of circular water management identified by the City Water Circles project.

Italian Abstract

La gestione delle risorse idriche nei territori urbani costituisce una questione critica che deriva dall'elevata complessità insita nel settore idrico. Questa complessità è causata dall'organizzazione intrinseca del sistema, che è caratterizzato da dipendenze intersettoriali e intra settoriali, presenza di molti stakeholder, di molte autorità e di governance su più livelli, oltre al fatto che coinvolge diverse scale spaziali. In aggiunta, le attuali tendenze del cambiamento globale, quali la crescita della popolazione, l'aumento dell'urbanizzazione e il cambiamento climatico hanno un impatto diretto sulla disponibilità delle risorse idriche, causando problematiche di diversa natura per le popolazioni, che si trovano ad affrontare problemi legati all'eccedenza, alla scarsità o al troppo inquinamento delle acque. È quindi difficile soddisfare gli standard di qualità e quantità per adempiere alle esigenze di tutti, pertanto è necessaria un'attenta pianificazione e gestione.

Per questo motivo è emersa la necessità di gestire le risorse idriche in un modo più sostenibile e circolare. In questo contesto si inserisce il progetto Interreg Central Europe "City Water Circles" che ha come scopo finale quello di migliorare l'efficienza idrica e il riutilizzo delle acque nelle aree urbane dell'Europa centrale, con un approccio di economia circolare integrata, agendo sulle seguenti aree di intervento: governance delle risorse idriche, efficienza e riduzione delle perdite, utilizzo delle acque piovane e recupero delle acque grigie.

Per raggiungere questo obiettivo, è necessario sviluppare un nuovo approccio alla gestione delle risorse idriche, cercando di superare le complessità intrinseche del sistema e di risolverne gli ostacoli. Questa tesi intende proporre strumenti e metodi concepiti per far fronte ai problemi relativi al sistema idrico e alla gestione delle risorse in contesto urbano, seguendo un approccio basato sul coinvolgimento e progettazione con gli stakeholder. Viene a tale scopo progettato un processo di apprendimento partecipato con l'obiettivo finale di portare all'individuazione degli elementi essenziali e delle strategie su cui si deve fondare un piano d'azione che rifletta anche l'accettabilità sociale ma soprattutto i principi di circolarità.

Il processo completo è composto da tre parti, di cui le prime due sono gli strumenti di input per lo sviluppo della terza che è la metodologia AP (Piano d'Azione). Sono organizzati come segue:

- Autovalutazione dello Status Quo: analisi per evidenziare le criticità nel sistema idrico;
- Sondaggio sulla percezione pubblica: analisi per rilevare l'eventuale fattibilità sociale dell'intervento, l'istruzione e le priorità della popolazione;

- Metodologia AP: processo partecipato per l'identificazione degli elementi chiave su cui si deve basare il piano d'azione.

In questo modo, viene favorita la cooperazione e le soluzioni vengono co-progettate con gli stakeholder al fine di identificare gli elementi essenziali su cui basare il piano d'azione che deve essere conforme ai principi della gestione circolare dell'acqua identificati dal progetto City Water Circles.

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List of abbreviations:

AF: Application Form

AP: Action Plan

CWC: City Water Circles

EASW: European Awareness Scenario Workshop

EEA: European Environmental Agency

EU: European Union

FAO: Food and Agriculture Organisation

FUA: Functional Urban Area

IPCC: Intergovernmental Panel on Climate Change

MT: Master Training

NGOs: Non-governmental organizations

OECD: Organisation for Economic Co-operation and Development

PP: Project Partner

RBD: River Basin District

RBMP: River basin management plans

SG: Stakeholder Group

SME: Small and Medium Enterprise

SOAR: Strengths, Opportunities, Aspirations and Results

UWC: Urban Water Cycle

WBCSD: World Business Council for Sustainable Development

WEI+: Water Exploitation Index plus

WFD: Water Framework Directive

1. Introduction

1.1 Context:

1.1.1 My internship

This thesis work is based on my six months internship at Poliedra in Milan, in particular with reference to the Interreg Central Europe project City Water Circles (CWC).

Poliedra is a consortium of the Politecnico of Milan and the main topics covered are environmental sustainability, mobility, participation, decision support systems, smart cities and communities.

Specifically, considering the CWC project, Poliedra is responsible for:

- stakeholder engagement coordination,
- capacity building process organization,
- smart governance tools identification, and
- definition of assessment methodologies regarding water management for the project urban areas.

During my internship I strongly collaborated with the technical team assigned to the project, composed by other two people, for the success of the activities related to the CWC project.

1.1.2 "City Water Circles" Project

"City Water Circles: Urban Cooperation Models for enhancing water efficiency and reuse in Central European functional urban areas with an integrated circular economy approach" is an Interreg Central Europe project that lasts 3 years (04/2019 – 03/2022)[1].

The partnership is composed by 11 partners from 6 different European countries, the agreement is made between:

- City of Budapest, District 14 Zugló Municipality (lead partner) - Hungary,
- Budapest Sewage Works Plt. Ltd. - Hungary,
- Turin municipality - Italy,
- Poliedra – Service and consultancy centre at Politecnico di Milano on environmental and territorial planning - Italy,

[1] See: https://www.interreg-central.eu/Content.Node/CWC.html

- Maribor Water Supply Company - Slovenia,
- E-Institute - Slovenia,
- City of Bydgoszcz - Poland,
- Institute for Sustainable Development Foundation - Poland,
- Public institution RERA SD for Coordination and development of Split-Dalmatia Country - Croatia,
- Split water and sewerage company Ltd. - Croatia,
- German Association for Rainwater Harvesting and Water Utilisation – Germany.

Their priority is cooperating on water resources for sustainable growth in Central Europe in order to improve water management of functional urban areas to make them more liveable places. The five Functional Urban Areas (FUAs) involved in the project are:

- Budapest (Hungary);
- Turin (Italy);
- Split (Croatia);
- Maribor (Slovenia);
- Bydgoszcz (Poland).

Figure 1.1 The five CWC pilot FUAs and their Countries

1.1.1.2 Project Summary

Climate change is making Central European (CE) cities increasingly vulnerable against urban floods. As urban storm water networks in many CE countries, included Hungary, Poland or part of Slovenia, are in quite a poor condition, heavy rains often lead to damaging urban floods and consequent water pollution in the region. At the same time water scarcity problems are arising in the Mediterranean parts of Central Europe, such as in Croatia or Italy. This coupled with growing drinking water consumption and consequently increasing amount of wastewater to be treated, threatens the safety of future water supplies.

Shared challenges call for adopting and promoting water saving and reuse measures to a much greater extent, both in the public sector and by individuals. Renewing outdated urban water infrastructure systems via applying the novel approach of circular economy offers significant economic and environmental benefits.

Recognizing this emerging potential, municipalities and public (waste) water companies from 5 Functional Urban Areas and thematic expert organisations decided to launch CWC project. Not guided by European Union regulations, CWC partners from 6 countries aim to enable cities making this circular change happen. Goals can be achieved by promoting water saving culture, including use of non-conventional water resources and taking the lead by adopting urban rainwater harvesting and utilisation, greywater recovery measures on city-level, and Nature-Based solutions for water management.

The major barriers that Project Partners (PPs) try to overcome are the absence of EU and national level regulations, the lack of financial support and incentives because of the low price of drinking water, the low awareness of potential benefits among public authorities, relevant stakeholders and the general public, and the limited public institutional capacities to formulate and institutionalise reuse measures.

In this context, in lack of EU-level legal guidance, CWC follows a bottom-up approach. Partners (municipalities, public water companies and thematic expert organizations) join forces to create a knowledge base for urban circular water management and co-develop with local stakeholders a set of innovative methods and tools usable all around Central Europe. The partners demonstrate these solutions in five pilot actions tailored to local needs, develop local strategies and action plans, and elaborate related policy recommendations for national decision-makers. In particular, they formulate and disseminate innovative solutions in the field of urban water efficiency, rainwater harvesting and greywater reuse with the goal to facilitate cities to become driving forces of circular urban water use; applying participatory, cross-sectoral and multi-level approaches.

Each partner will actively participate according to their competences and experiences in co-developing and verifying all project outcomes. Transnational exchange of knowledge, good practices and creative ideas will be continuously ensured via smartly designed cross-learning activities, most importantly in the piloting phase in order to stimulate the cross-regional transfer of innovative solutions tested on the ground.

1.2 Aim of the thesis

Placed in the context previously explained, this thesis work aims to propose tools and methods conceived to deal with the complexity and problems related to the water system and management of water resources in urban context. In fact, the water system is characterized by intrinsic complexities due to the multi-scale, multi-level governance and multi-stakeholders characterising the water system, coupled with the external problems not linked with the organisation of the system but related to the management and to the availability of resources, such as dealing with too much, too little or too polluted water.

This learning process is composed by different components, each one with a specific purpose and conceived for overcoming and solving different problems, because often these are analysed separately and in watertight compartments when instead they influence each other. Furthermore, there is the necessity to find an agreement between the interested parties and make them cooperate for the final objective because they often think only of their own interests neglecting environmental issues. Therefore the methodology here proposed is conceived to deal with the issues previously described jointly. The learning process will be described in detail in the following, allowing a deeper and comprehensive understanding.

In conclusion, the methodology is designed to create cooperation between stakeholders in order to co-design action plans that allow to achieve the circular urban water management within the FUAs and it instructs on how to manage complexities and create agreement between the stakeholders.

1.3 Structure of the thesis

This thesis is organized in six chapters, as follows:

Chapter 1 – Introduction

Here, the context in which this work has been developed is introduced.

Chapter 2 - State of the art: EU water situation and Pressures on water resources.

In this chapter, I provide an overview of the state of the art at European level about the water situation, collecting literature relevant studies aiming to convey a better understanding of the background conditions linked to the CWC project. In particular, the water availability and the related pressures on water resources that can cause water stress, the effects of climate change and the impacts on water systems are described.

Chapter 3 – State of the art: Circular Water Resources Management in urban context

In chapter 3, after introducing the elements composing the urban water cycle, I provide an overview on the challenges related to water management in cities. I analyse first issues related to multi-scale, multi-level governance and multi-stakeholders in the water system. Second I examine the wide diversity of problems related to different components of the water cycle in urban contexts. And finally, I propose, in the optic of CWC project, a possible way to deal with the complexity and problems related to the management of water resources in urban context, that is stakeholder engagement and cooperation coupled with the implementation of circular urban water management.

Chapter 4 - AP Methodology: a model to develop action plans for circular water management

This is the core chapter of the thesis, where the methodology designed is presented. The methodology consists of a learning process for the stakeholder group of each functional urban area of the CWC project, to be implemented during a local competence building workshop. The goal is to develop the first draft of an action plan aimed at implementing circular urban water management with the cooperation of the stakeholders.

The complete learning process is composed of three parts, of which the first two are the input tools for the development of the AP Methodology. They are organised as follows:

- FUA-level Status Quo self-assessment: analysis to highlight criticalities in the water system;
- FUA-level public perception survey: analysis to detect possible social feasibility of intervention, education and population's priorities;
- AP methodology: participative support for developing the key and essential elements of an action plan. This process is called "AP methodology" where AP stands for action plan.

Chapter 5 - Application of the methodology: the case of Turin and the core Master Training

In chapter 5, I present some examples of the results obtained from the application of the process. In particular, there is the real results of the FUA-level Status Quo self-assessment and of the public perception survey for the FUA of Turin. Furthermore, there is the application of the AP Methodology to the core Master Training of the project, held in Milan, were the validity and effectiveness of the learning process were tested. The presentation of all the results is accompanied by comments and discussions.

Chapter 6 – Conclusions

In this final chapter, I present the conclusions and final discussions about the methodology.

This thesis work, as said, has been developed during my internship and the complete process proposed has been designed tailored to the CWC project. For this reason, many references will be made to the project Deliverables during the thesis. The project reports mentioned can be of three different kinds:

- Project Deliverables produced by Poliedra in which I did not participate to the research part and writing of the report;
- Project Deliverables produced by Poliedra in which I collaborated and I also participated in the writing of the report; and
- Project Deliverables produced by other Project Partners and the information provided are taken and here reported.

In any case, in the following, the specific quotation is present in the parts related to the project report and all the mentioned reports are presented in the bibliography.

2. State of the art: water situation and pressures on water resources in Europe

The present chapter will present in brief the current European situation regarding water availability, pressures on water resources and challenges. This is an introductory chapter to present the background conditions in which the CWC project has been developed. The focus will be on freshwater resources such as rivers, lakes, groundwater and artificial reservoir. The assessment of the conditions of marine waters are out of the topic of the CWC project and of this thesis so it will not be discussed here.

Water plays a crucial role and clean water is an essential resource for human health, human activities such as agriculture, energy production, transport and for nature and ecosystems. But it is also under multiple pressures. Currently, only 40% of Europe's surface water bodies achieve good ecological status and in many territories resources are over exploited. In addition, even though European countries have managed to reduce selected pressures, the status of water bodies remains critical both quantitatively and qualitatively; and more efforts are needed to achieve Europe's freshwater environmental standards.

Europe is thought to have adequate amount of water resources. Europeans use billions of cubic metres of water every year not only for drinking, but also for use in farming, manufacturing, heating and cooling, tourism and other service sectors. With thousands of freshwater lakes, rivers and underground water sources available, the supply of water in Europe may seem limitless. However, water scarcity and drought is no longer uncommon. In Europe, water scarcity can arise both as a consequence of the water demand for human activities and as a consequence of reduced meteorological inputs. Water scarcity is becoming increasingly frequent and widespread in Europe, and it is expected to get worse as changing seasonality precipitation decreases and temperatures increase in response to a changing climate (European Environmental Agency [EEA], 2019). This will also make the environmental pressures of water abstraction worse, and the demand to better understand and manage the climate-water-ecosystem-agriculture nexus is likely to increase in the future (EEA, 2018). This is mainly due to many factors, such as population growth, urbanisation, pollution and the effects of climate change, such as droughts, are putting a huge strain on Europe's water supplies and on its quality, these are the pressures on water resources.

Managing water quality and quantity requires detailed knowledge of water abstraction, water use and other pressures. In the following the European water situation and pressures will be present in more detail.

2.1 Water availability, distribution and abstraction

Distribution and availability of fresh water resources across Europe is not homogeneous, there are some areas were water scarcity is becoming increasingly pronounced, like in the Mediterranean part of central Europe. Water scarcity, as previously mentioned, occurs when the demand for water exceeds the amount of available freshwater resources during a certain period. Therefore, it is not only driven by climate conditions, which control the availability of renewable freshwater resources and the seasonality of water supply, but also by water demand, which is largely affected by population trends, socio-economic developments and human activities.

2.1.1 Water abstraction and use by sector

The demand affects both water abstraction and the storage, they constitute considerable pressure on the environment and on freshwater resources and modify the natural hydrological cycle.

Water demand across Europe has steadily increased over the past 50 years, partly due to population growth (EEA, 2019). More people moving to cities and towns has also impacted the demand, especially in densely populated areas. In addition, urban development is projected to increase, thus exacerbating the situation regarding the overexploitation. Therefore, apart from climate patterns variation, population changes are also becoming a significant driver for higher or lower pressures on renewable freshwater resources. For example, in Western Europe, the volume of annual renewable freshwater resources increased by 4% between 1990 and 2017. However, the regional population also increased by 11% over the same period, causing net deficit. Differently, Eastern Europe was the only region where an increase in renewable freshwater resource per inhabitant was observed. The main reason behind this increase was the significant reduction (-6%) in the regional population (EEA, 2019).

In order to understand what could be the causes and the decisive factors, the data about water use by sector and the abstraction by source are now presented.

Overall Europe's water abstraction is about 243.000 million cubic metres per year, they can be split among four main sectors (Data referred to 2015):

1. Household water use (14 %);
2. Industry and mining (18 %);
3. Cooling water for electricity production (28 %); and
4. Agriculture (40 %) (Figure 2.1).

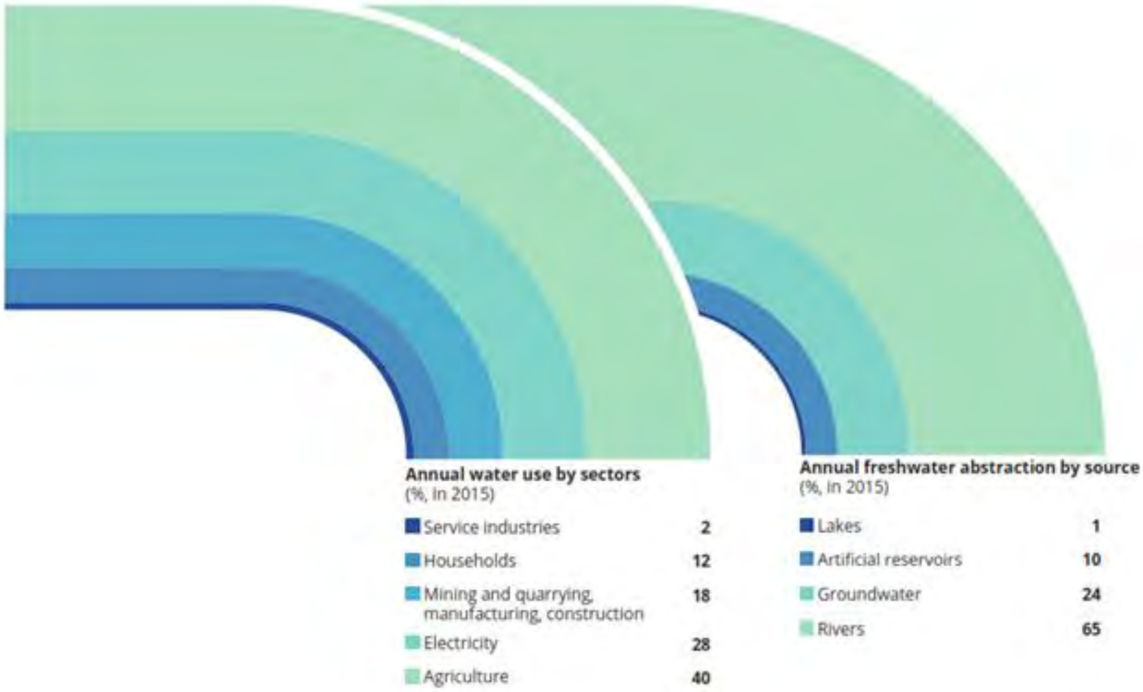


Figure 2.1 Water use in Europe by economic sector and by source. (Source: EEA, 2019)

The most important consumer in Europe is the agricultural sector, followed by the electrical and industrial sector. Household water use constitutes the smallest share, considering the whole territory, but if we focus on urban level, it acquires much more relevance.

However, the data previously mentioned are not distributed equally across Europe, there are geographically differences in the sectors using more water. For instance, in Western Europe public water supply, cooling water and mining are responsible for the majority of water abstraction, whereas in southern Europe and in Turkey agriculture uses the largest share (EEA, 2019). The manufacturing industry is the largest user in northern Europe. Water is abstracted both from surface and from groundwater resources (76% vs 24%), about 89% of Europe's freshwater use (drinking and other uses) comes from rivers and groundwater, while the rest comes from reservoirs (10%) and lakes (1%), which makes these sources extremely vulnerable to threats posed by over-exploitation, pollution and climate change. Freshwater resources are renewable, considering the timing of regeneration, they fluctuate greatly over the years and seasons, creating high pressure when a minor amount of renewable water resources are available for a given season. The level of pressure also fluctuates per type of economic activity throughout the year. Agriculture and public water supplies put high pressure on groundwater resources during spring and summer periods, while the use of water for cooling in energy generation puts high pressure on rivers during autumn and winter periods.

Overall, water abstraction has decreased by 19% in the past 15 years (considering 1990-2015 time frame). However, in 19% of Europe's area water abstraction currently exceeds 20% of the renewable freshwater resource (EEA, 2019). The water abstracted is returned to the environment after being used, but it has often been polluted in the process, causing additional pressures on environment. Therefore, Europe is not on track to meet the objective of achieving good quantitative status of all groundwater bodies by 2020 (EEA, 2019), many steps have to be taken, both in politics and in civil society.

These numbers mask large geographical variations. Water resources and their uses are unevenly distributed, as said, leading to large differences in water stress, therefore it is very difficult to make a general speech and statements valid for all the parts of Europe and identify the general causes of over exploitation because they are multiple and depends on the territory considered. The fact is that, where freshwater resources are under pressure, this causes deterioration in terms of quantity and quality, this phenomena must be contained as much as possible with strategies and measures that should be adopted depending on the context that should be faced, after a care analysis and evaluation.

2.1.2 Water stressed countries

The EEA (2018) estimates that around one third of the EU territory is exposed to water stress conditions, either permanently or temporarily. Countries such as Greece, Portugal and Spain have already seen severe droughts during the summer months, but water scarcity is also becoming an issue in northern regions, including parts of the United Kingdom and Germany.

Water stress can be expressed in multiple ways, one of this is the water exploitation index plus (WEI+), a modified and advanced version from the original WEI that takes into consideration the level of pressure that human activity exerts on the natural water resources of a territory. This indicator quantifies, for an assigned time interval and a specific territory, the total water use as a percentage of the renewable freshwater resources. It estimates how much water is abstracted monthly or seasonally and how much water is returned after use to the environment, in relationship to its availability. The difference between water abstraction and return (withdrawals - refunds) is regarded as water use. It is computed as follows:

$$WEI+ = \frac{water\ use}{renewable\ water\ resources} = \frac{withdrawals\ -\ refunds}{renewable\ water\ resources} \times 100\ [\%]$$

This helps to identify those areas prone to problems related to water stress. In this way, it is also possible to identify, in the medium to long term, where the use of the resource is less sustainable, which leads to a higher frequency of water scarcity situation.

Regarding WEI+ thresholds, no formally agreed limits are available for assessing water stress conditions across Europe; in this thesis, the thresholds used by the European Environmental Agency are considered. Values above 20% indicate that water resources are under water stress, and values above 40% indicate severe water scarcity and that the use of freshwater resources is clearly unsustainable.

In the figure below (Fig. 2.2), the seasonal variation of the WEI+ for river basins districts, referred to the year 2015, is represented. In the summer period water scarcity increases in many European river basins, according to the Fig. 2.2, however, during winter periods there are some river basins exposed to water scarcity (WEI>20%) also in central Europe. In the map below, Cyprus data are missing though it is the most water stressed country in Europe with peak to 80% in 2015.

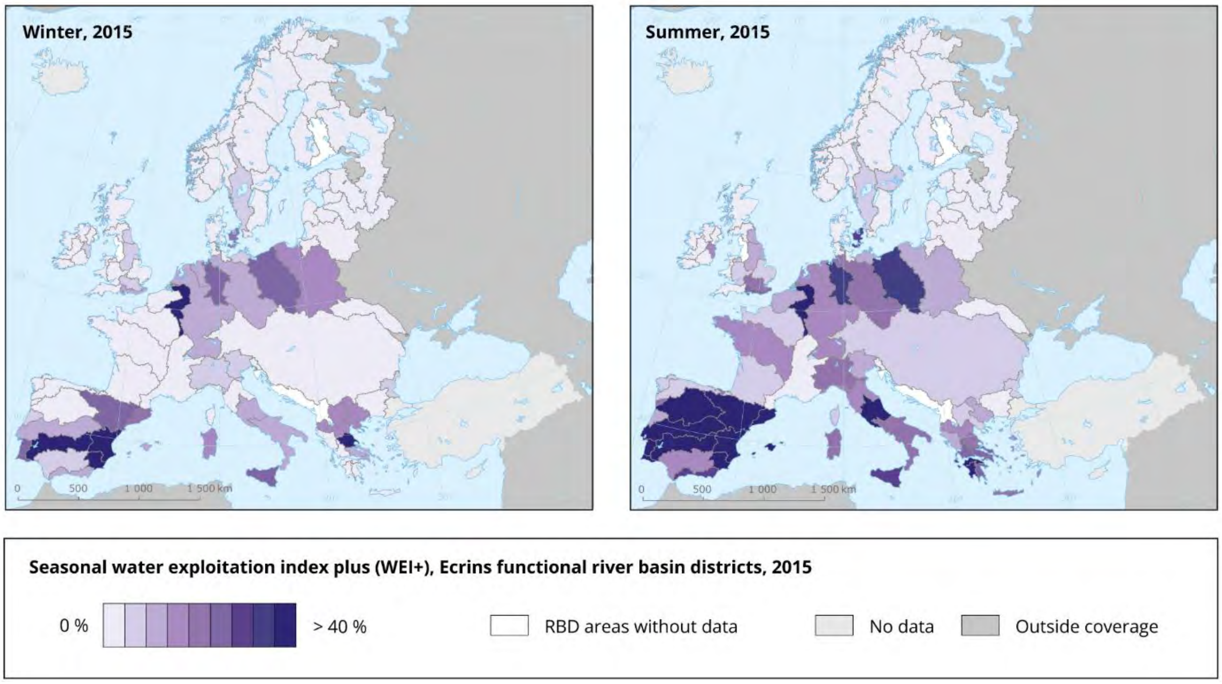


Figure 2.2 Seasonal WEI+ for river basin districts (RBD) in 2015 (Source: EEA, 2019) Available online at: https://www.eea.europa.eu/data-and-maps/figures/seasonal-water-exploitation-index-plus

Every year, there is a degree of variability in the areas experiencing significant water stress conditions, either seasonally or throughout the entire year. As a result, water scarcity affects Europe at different spatial extents, with annual mean range (disregarding Cyprus) of the total European territory between 15% and 25% (EEA, 2019).

The underlying causes of water scarcity, expressed by the water exploitation index, differ. In general, water scarcity is more frequently experienced in southern Europe where more than half of the population lives incessantly under water scarcity conditions. This is particularly experienced during summer, because of higher abstractions from agriculture, public water supply and tourism. In the most affected countries, with limited freshwater resources, such as Cyprus, Malta, and Spain, freshwater is mostly supplied by desalinating seawater.

Nevertheless, water scarcity is not only limited to southern Europe, but extends further to western, eastern and northern areas. This is usually a result of significant urbanisation, combined with high abstractions from the energy and industrial sectors for cooling purposes and from the public water supply sector.

2.2 Climate change:

During the Earth's history climate has changed many times. The current warming trend since the 1950s is unequivocal (Intergovernmental Panel on Climate Change [IPCC], 2014). Climate change has mostly influenced natural systems causing globally temperature raising, warming of oceans, shrinking of the ice sheets, glacial retreat, decreasing in snow cover, rising in sea level, declining artic sea ice, extreme events and ocean acidification, producing widespread impacts on human and natural systems (IPCC, 2014). In particular, surface temperature is projected to continue to rise over the 21st century under all assessed emission scenarios. It is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions (IPCC, 2014).

In addition to the natural variability of the climate, one of the most relevant trigger causes of the climate change is the anthropogenic greenhouse gas emissions. Emissions have continued to increase since the pre-industrial era, driven largely by economics and population growth. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century (IPCC, 2014).

What has been said until now represents the global trend, now we are going to investigate what are the repercussions and the situation in Europe, focusing the attention on everything related to water system. To what extent climate change in Europe has influenced water availability and resources? And, in which measure it affects the hydrological cycle? In the following, there is the attempt to give a reasonable reply to these questions.

The estimation of both the climate change impacts and its amount are a matter of prediction, therefore they are affected by uncertainties but there are different numerical models to create scenarios of future situation that allow to estimate what is needed.

In the context of this thesis and for this research, the documents and reports considered are the ones coming from the official source that is the Intergovernmental Panel on Climate Change (IPCC) because on this topic it is possible to find fake and not scientifically based information. This Body have been created in order to guarantee to policymakers, technicians and scientists objectivity, transparency and to build a common state of knowledge on climate change, which is agreed by the scientific community. In their assessment, in most cases, they also specify for the statements a qualitative level of confidence (from very low to very high) to stress which is the degree of reliability of the analysis (when it was mentioned in their documents it has been reported here).

The situation in Europe presents high variability. In general, observed climate trends and future climate projections show regionally changes in temperature and rainfall in Europe (high confidence), with projected increases in temperature throughout Europe and increasing precipitation in Northern Europe and decreasing precipitation in Southern Europe (IPCC, 2014). Climate projections show a marked increase in high temperature extremes (high confidence), meteorological droughts (medium confidence), and heavy precipitation events (high confidence), with variations across Europe (IPCC, 2014).

The majority of published assessments are based on climate projections in the range 1°C to 4°C global mean temperature per century. Limited evidence exists regarding the potential impacts in Europe under high rates of warming (>4°C global mean temperature per century) (IPCC, 2014), therefore ranges between 1-4°C are also considered for Europe to produce possible scenarios.

Sea level rise and increases in extreme rainfall are projected to further increase coastal and river flood risk in Europe and, without adaptive measures, will substantially increase flood damages (people affected and economic losses) (high confidence) (IPCC, 2014). Flood frequencies could change in response to altered precipitation patterns, in the following the relationship between floods and climate change is discussed in more detail because it is not enough to identify climate change as responsible of increase in frequency of flood events.

The IPCC (2014) clustered the European region into five homogeneous sub-regions (see Fig. 2.3): Atlantic, Alpine, Southern, Northern, and Continental, with similar climate pattern. This classification is used in the next section to highlight the different impacts climate change has in these areas.

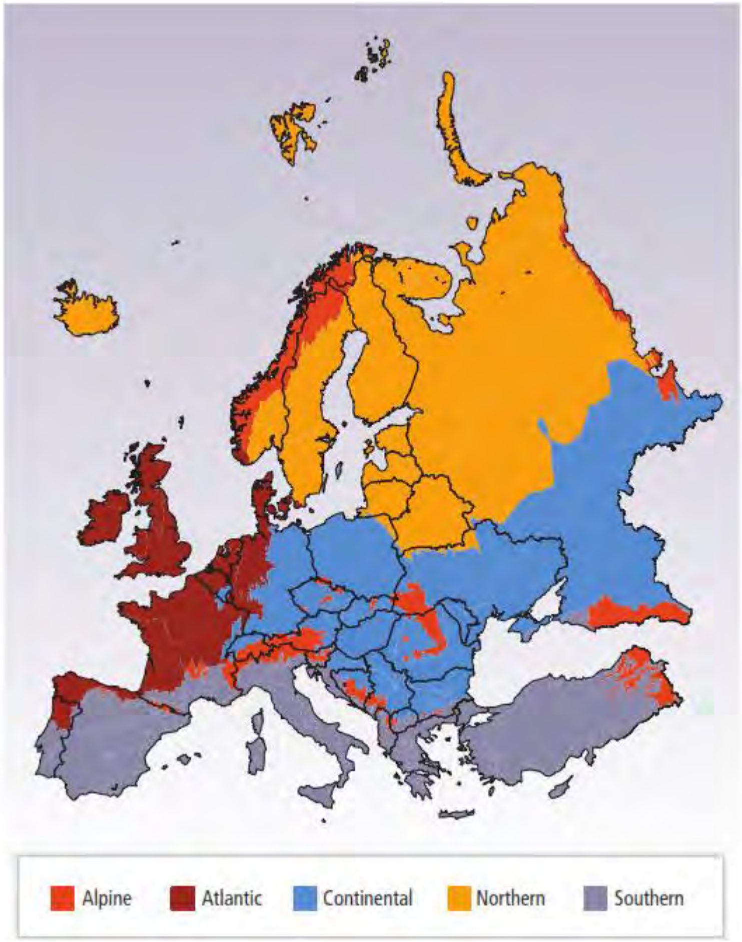


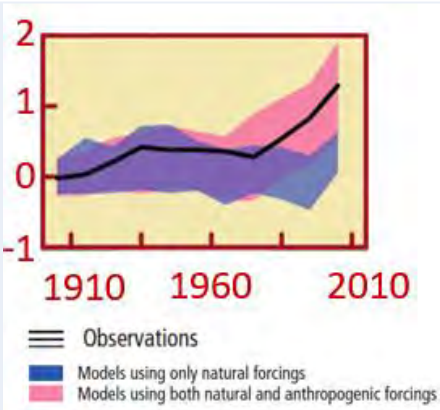
Figure 2.3 Sub-regional classification on the IPCC Europe region. (Source: IPCC, 2014)

2.2.1 Observed and projected changes in the climate system

In the following tables, a brief assessment for observed and projected climate changes in the climate system in Europe are summarized and compared in order to better illustrate the evolution of the European situation. The information is taken from two sources of the Intergovernmental Panel on Climate Change that are:

- Climate Change 2014: Synthesis Report
- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects – Europe.

Table 2.1 Observed and projected changes in temperature, precipitation, drought and desertification and water discharges across Europe. (Source: IPCC, 2014)

TEMPERATURE	
Observed changes	Projected changes
-Increases in warm days and warm nights and decreases in cold days and cold nights since 1950 (high confidence). -Since 1950, high-temperature extremes (hot days, tropical nights, and heat waves) have become more frequent, while low-temperature extremes (cold spells, frost days) have become less frequent. -The average temperature in Europe has continued to increase, with regionally and seasonally different rates of warming being greatest in high latitudes in Northern Europe. Since the 1980s, warming has been strongest over Scandinavia, especially in winter, whereas the Iberian Peninsula warmed mostly in summer.	-There is a general high confidence concerning changes in temperature extremes (toward increased number of warm days, warm nights, and heat waves). -It is very likely that heat waves will occur more often and last longer. - Strongest warming projected in Southern Europe in summer, and in Northern Europe in winter (significant agreement). - Climate change is very likely to increase the frequency and intensity of heat waves, particularly in Southern Europe (high confidence).
 *Figure 2.4 Comparison of observed and simulated changes in land surface temperatures in Europe (Source: IPCC, 2014)*	

PRECIPITATION

Observed changes	Projected changes
-Extreme precipitation increased in part of the continent, mainly in winter over Western-Central Europe and European Russia (medium confidence). -Since 1950, annual precipitation has increased in Northern Europe (up to +70 mm per decade), and decreased in parts of Southern Europe.	-Extreme precipitation events will become more intense and frequent in many regions (very likely). -Precipitation vary regionally and seasonally. Trends are less clear in Continental Europe, with agreement in increase in Northern Europe and decrease in Southern Europe (medium confidence). Precipitation is projected to decrease in the summer months up to southern Sweden and increase in winter, with more rain than snow in mountainous regions. In Northern Europe, a decrease of long-term mean snowpack (although snow-rich winters will remain) toward the end of the 21st century is projected. - Changes in extreme precipitation depend on the region, with a high confidence of increased extreme precipitation in Northern Europe (all seasons) and Continental Europe (except summer). Future projections are regionally and seasonally different in Southern Europe.

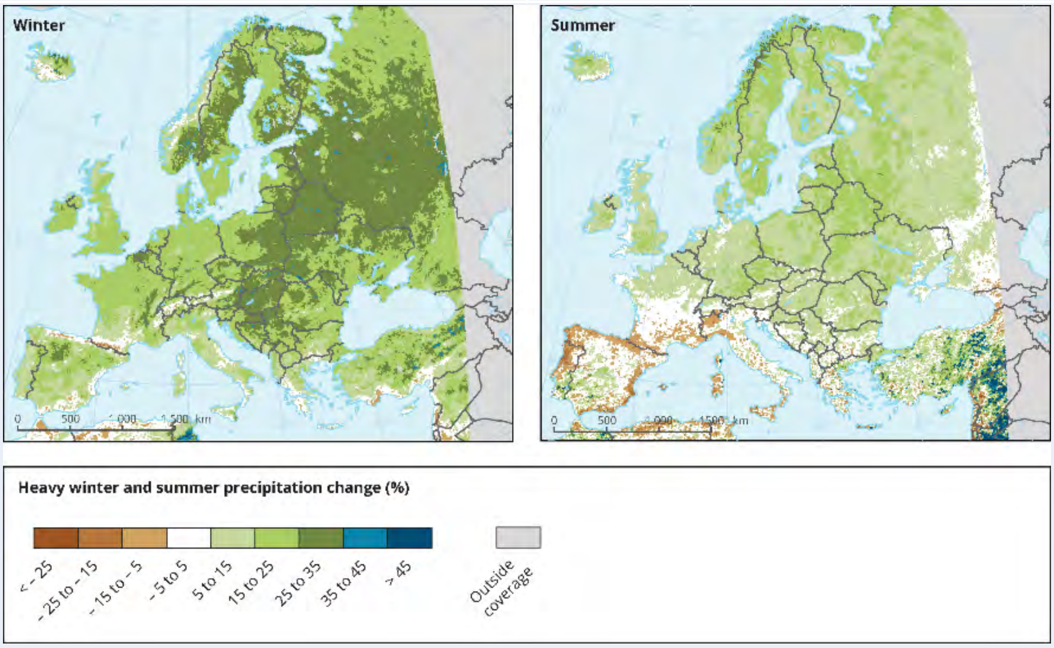


Figure 2.5 Projected changes in heavy precipitation (in %) in winter and summer from 1971-2000 to 2071–2100 for the RCP8.5 scenario. (source EEA, 2017)
Available online at: https://www.eea.europa.eu/data-and-maps/figures/projected-changes-in-20-year-2

DROUGTH and DESERTIFICATION	
Observed changes	Projected changes
-Soil degradation is already intense in parts of the Mediterranean and Central-Eastern Europe and, together with prolonged drought periods and fires, is already contributing to an increased risk of desertification.	-Projected risks for future desertification are the highest in these areas (parts of the Mediterranean and Central-Eastern Europe). -The analysis of trends in droughts is made complex by the different categories or definitions of drought (meteorological, agricultural, and hydrological) and the lack of long-term observational data. Southern Europe shows trends toward more intense and longer meteorological droughts, but they are still inconsistent. -Drought trends in all other sub-regions are not statistically significant. Regional and global climate simulations project (medium confidence) an increase in duration and intensity of droughts in Central and Southern Europe and the Mediterranean up until the UK for different definitions of drought. Even in regions where summer precipitation is expected to increase, soil moisture and hydrological droughts may become more severe as a result of increasing evapotranspiration.

WATER DISCHARGES	
Observed changes	Projected changes
-Streamflow have decreased in the South and East of Europe and increased in Northern Europe. -Dryness has increased mainly in Southern Europe (medium confidence).	-The occurrence of current 100-year return period discharges is projected to increase in Continental Europe, but decrease in some parts of Northern and Southern Europe by 2100. In contrast, studies for individual catchments indicate increases in extreme discharges, to varying degrees, in Finland, Denmark, Ireland, the Rhine basin, Meuse basin, the Danube basin, and France. Although snowmelt floods may decrease, increased autumn and winter rainfall could lead to higher peak discharges in Northern Europe. Declines in low flows are projected for the UK, Turkey, France, and rivers fed by Alpine glaciers. - In the Mediterranean area projected declines in total runoff and groundwater resources

2.2.2 Impacts

Climate change, with the increased occurrence of extreme weather events (in particular heat waves, droughts and heavy precipitations), is projected to have significant impacts in Europe in multiple economic sectors, on society and on the environment. It will increase the likelihood of systemic failures across European countries affecting multiple sectors (medium confidence) (IPCC,2014), with mostly adverse implications for health, agriculture, forestry, energy production and use, transport, tourism, labour productivity, and the built environment. It is also projected to affect the hydrology of river basins. Many climate-related hazards are projected to increase in frequency and intensity, not with general trends and in a homogeneous way, but with significant variations within the regions.

It is not possible to have a clear picture of what the impacts will be but some studies and estimations have been done. In the following some possible impacts due to climate change are reported, remember that they are affected by uncertainty and what is said suggests possible consequences and changes in the European scenario, as we know it now.

Future projected trends confirm the widening of water resource differences between Northern and Southern Europe (IPCC, 2014). In addition, in a number of catchments water resources are already over abstracted and their reliability is threatened by climate change, which induced decline in groundwater recharge and to a lesser extent by the increase in potential demand for irrigation mainly in Southern Europe, as a result of reduced water runoff due to the increased evaporative demand.

In the southern regions, a decrease in the availability of water is expected, soil water content will decay, saturation conditions and drainage will be increasingly rare and restricted to periods in winter and spring (IPCC, 2014), and snow accumulation and melting will change, especially in mountain areas. Groundwater recharge and/or water table level would be significantly reduced by the end of the 21st century for river basins located in southern Italy, Spain, northern France, and Belgium. However, nonsignificant impacts were found for aquifers in Switzerland and in England (IPCC, 2014).

In contrast, across Northern and Continental Europe, an increase in flood hazards in projected, with causes on damages to crops and plant growth, complicate soil workability.

The increase in polarization of extreme events, such as less precipitation in summer and higher rainfall during winter could increase the negative impacts on water quality.

Climate change will increase irrigation needs (high confidence) but future irrigation will be constrained by reduced runoff, demand from other sectors, and by economic costs. By the

2050s, irrigation will not be sufficient to prevent damage from heat waves to crops in some sub-regions (medium confidence). Integrated management of water, also across countries' boundaries, is needed to address future competing demands among agriculture, energy, conservation, and human settlements because it explicitly includes the consideration of environmental and social impacts. Climate change has already been incorporated into water resources planning in some countries, such as England and Wales and in the Netherlands. Some adaptation is possible through uptake of more water-efficient technologies and water-saving strategies.

The capacity to adapt in Europe is high compared to other world regions, but there are important differences in impacts and in the capacity to respond between and within the European sub-regions. In Europe, adaptation policy has been developed at international (European Union), national, and local government levels, including the prioritization of adaptation options. There is limited systematic information on current implementation or effectiveness of adaptation measures or policies. More robust water management, pricing, and recycling policies to secure adequate future water supply and prevent tensions among users could be required in Southern Europe.

Adaptation measures and plans should be developed to face this kind of changes and to prevent projected damages in order to be more resilient, many challenges in adaptation are encountered mainly because climate change affects multiple sectors.

Below, the impact of climate change on flood occurrence and on water quality are analysed in more detail, because some specifications and discussions to this regard need to be pointed out.

2.2.2.1 Flood events

Observed trends in mean annual river flood discharge in medium and large catchments in Europe over the period 1960–2010 shows that there is both increased and decreased river floods in Europe (see Fig. 2.6). Specifically, river floods increased in north western and parts of central Europe, decreased in southern Europe and decreased in north-eastern Europe. The European Environmental Agency (2019) identifies climate change as the main cause (in north western and parts of central Europe, caused by increasing autumn and winter rainfall; in southern Europe, caused by decreasing precipitation and increasing evaporation; and in north eastern Europe, caused by decreasing snow cover and snowmelt). The EEA also argues that these trends will continue to increase with the projected climate change scenarios (see Fig. 2.7).

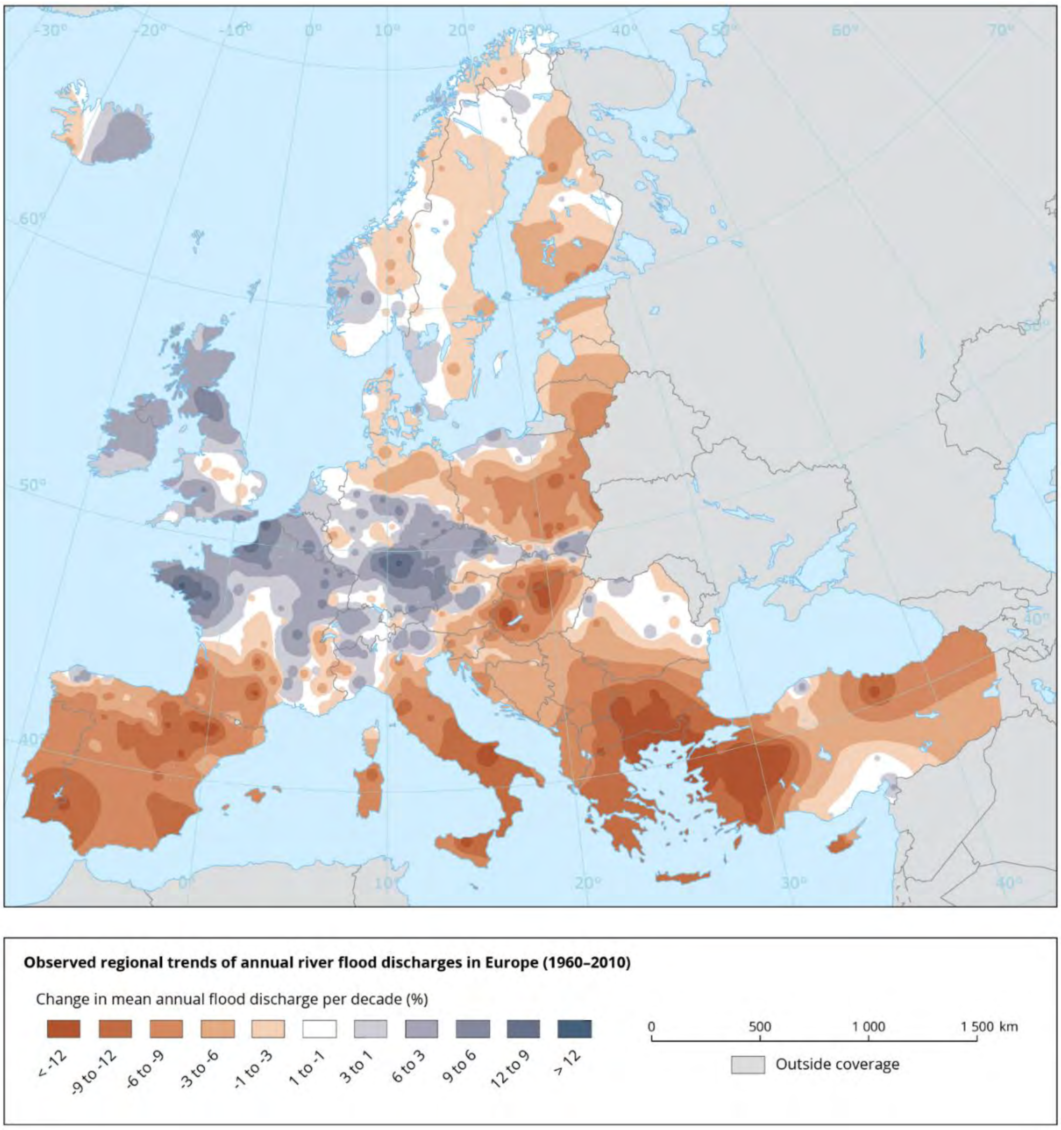


Figure 2.6 Linear trend in the annual maximum of daily river discharge over the period 1960-2010. Blue indicates increasing flood discharges and red denotes decreasing flood discharges (in per cent change of the mean annual flood discharge per decade) (Source: EEA, 2019)
Available online at: https://www.eea.europa.eu/data-and-maps/indicators/river-floods-3/assessment

Figure 2.7 Projected change in maximum 100-year river discharge for two global warming levels (Source: EEA, 2019) Available online at: https://www.eea.europa.eu/data-and-maps/indicators/river-floods-3/assessment

I am not totally in agreement with what is reported by the EEA. The observed increase in river flood events and damages in Europe is well documented, this is true, however it is not only mainly attributable to climate change, but this increase is due also to anthropogenic forcing. According to me, the main cause is the increased exposure of persons and property in flood risk areas, and the contribution of observed climate change is unclear (also supported by the IPCC with high confidence).

In general, I think that few changes in flood trends can be attributed to climate change, partly because European mean and peak discharges are highly variable and partly because they happened with high variability across Europe. For instance, in France, upward trends in low flows were observed over 1948–1988 and downward trends over 1968–2008, therefore identifying a general evolution is very challenging, it highly depends on annual variability.

It is true that climate change modifies the pattern of temperature and precipitation, as reported by the IPCC: Alpine glacier retreat during the last 2 decades caused a 13% increase in glacier contribution to August runoff of the four main rivers originating in the Alps, compared to the long-term average. Increases in extreme river discharge (peak flows) over the past 30 to 50 years have been observed in parts of Germany, the Meuse River basin, parts of Central Europe and North-eastern France. Decreases in extreme river discharge have been observed in the Czech Republic, and no change observed in Switzerland, Germany, and the Nordic countries.

However, I think that it is not possible to identify as primary cause the climate change, but the increasing trend in flood events is due to a competition of causes. Some regions may see increasing risks, but others may see decreases or little to no change.

2.3 Water quality

Water quality is a central topic when speaking about water availability and resources because it is necessary to guarantee good status of water bodies to be usable for drinking, agricultural and industrial purposes.

The spillage into water bodies of toxic substances and pollutants are, in different measures, strictly restricted because they cause degradation of water quality. In fact, polluted water has negative consequences on human health and aquatic ecosystems. Faecal contamination from sewage is both unsafe and unpleasant, excess nutrients lead to eutrophication, which causes major disturbance of aquatic ecosystems, and chemicals that are harmful can, when limit values are exceeded, be a serious threat to both human and ecosystem health (EEA, 2018).

Over the past 30 years substantial progress has been made by EU Member States to improve the quality of Europe's freshwater bodies, thanks to EU rules, in particular the EU's Water Framework Directive, the Urban Waste Water Directive and the Drinking Water Directive (EEA, 2018). These key legislative texts underpin the EU's commitment to improve the state of Europe's water. The goal of EU policies is to significantly reduce the negative impacts of pollution, over-abstraction and other pressures put on water and to ensure that a sufficient quantity of good-quality water is available for both human use and the environment.

One of the major successes for water quality has been the reduction of nutrient, certain hazardous substance and microbial pollution in rivers, lakes, and transitional and coastal waters following the implementation of urban waste water treatment, industrial emission controls and restrictions of chemicals.

Diffuse pollution remains however a problem in Europe. It is mostly due to excessive emissions of chemicals and pollutants. In the second river basin management plans, Member States identified that diffuse pollution is a significant pressure, affecting 38 % of surface water bodies and 35 % of the area of groundwater bodies (EEA, 2018).

Today, despite the progress achieved, the overall environmental health of Europe's many water bodies remains precarious (EEA, 2018), both due to human activities but also climate change has some repercussions.

Climate change may also affect water quality in several ways, with implications for food production and forestry, ecosystem functioning, human and animal health, and compliance with environmental quality standards, including those of the Water Framework Directive. The IPCC (2014) argues that: shallower waters will witness a more rapid temperature increase than deeper waters, since heat is absorbed mainly in the upper water layers and turbulent mixing is truncated by shallow depth. In parallel, a decrease in saturating oxygen concentrations occurs. A reduction in rainfall may lead to low flows that increase concentrations of biological and chemical contaminants. Variability in changes in rainfall and runoff, as well as water temperature increases, will lead to differences in water quality impacts by sub-region. Climate change is projected to increase nutrient loadings: in Northern Europe this is caused by increased surface runoff, and in Southern Europe by increased evapotranspiration and increased concentrations due to reduced volumes of receiving lakes. Increased nutrient loads are foreseen in Danish watersheds, and in France and the UK. In larger rivers, such as the Meuse, increased summer temperature and drought can lead to more favourable conditions for algal blooms and reduced dilution capacity of effluent from industry and sewage works (IPCC, 2014).

In conclusion, water use by most economic sectors has decreased in Europe since the 1990s, thanks to many measures taken to improve efficiency, such as better water pricing or technological improvements in appliances and machines (EEA, 2018). But, still, water will continue to be exploited by sectors such as agriculture and energy, as well as by consumers at home, to meet demand, which is expected to continue to rise. Climate change will continue to put additional pressure on water resources, and it is expected that there will be an increased risk of droughts in many southern regions. Demographic trends will also play a role. At the same time, more people are moving to urban areas, which will also put more stress on urban water supplies. For these reasons, many challenges are posed to the management of water resources, which needs for a smart and very well planned approach that considers all these aspects.

In this context, specific for the CWC project, the negative effects of climate change on the water cycle and sector, as well as of urban sprawl generate a common challenge for Central Europe related to improving water efficiency and storm water management. CWC Project Partners decided to take joint action to flesh out a common framework as a basis for introducing circular approach in urban water management and bring benefits both economically and environmentally.

3. State of the art: Circular Water Resources Management in urban context

Historically, cities have always had to face problems related to the management of water resources; nowadays, this kind of problems are exacerbated by global change trends, such as population growth, urbanization increase, climate change, etc. that directly affect the water resources. This, coupled with the increasing complexity and inter sectoral dependencies of the water system, makes today's management of water resources in urban context a challenging issue. For this reason, the need to manage water resources in a more sustainable and circular way has emerged and has spread. In order to achieve this goal, a new approach to water management needs to be developed that tries to overcome the intrinsic complexities of the urban water system. This approach is based on stakeholder involvement, participation and on the cross-sectoral and multi-level integration of water resources management.

3.1 Elements of urban water cycle

In urban areas, the presence of human beings has modified the original water cycle with the construction of water supply, drainage and sewage infrastructures, and also systems for the collection and storage of rainwater (typical of the driest areas), which regimented water courses and modified the natural flow path of water in order to meet the needs of urbanisation development.

Before proceeding with the description of the main components of the water cycle within the urban context, it is important to explain the difference between the natural water cycle and the urban one. The first one, also referred to as the hydrologic cycle, is defined as the conceptual model describing the storage and circulation of water between the biosphere, atmosphere, lithosphere, and the hydrosphere. Water can be stored in the atmosphere, oceans, lakes, rivers, streams, soils, glaciers, snowfields, and groundwater aquifers. Circulation of water amongst these storage compartments is caused by such processes as evapotranspiration, condensation, precipitation, infiltration, percolation, snowmelt and runoff, which are also referred to as the water cycle components (Marsalek *et al.*, 2006). During the cycle, water is constantly changing between its liquid, vapour and solid states. These processes occurring over millions of years comprise the cycle, but their role within it depends on the spatial-temporal scale chosen for the study. This mechanism ensures the continuous regeneration of water resources, thus maintaining the cycle of life and the biogeochemical cycles of nutrients on the planet[2].

The image below in Fig. 3.1 shows the summary of the natural water cycle without human intervention.

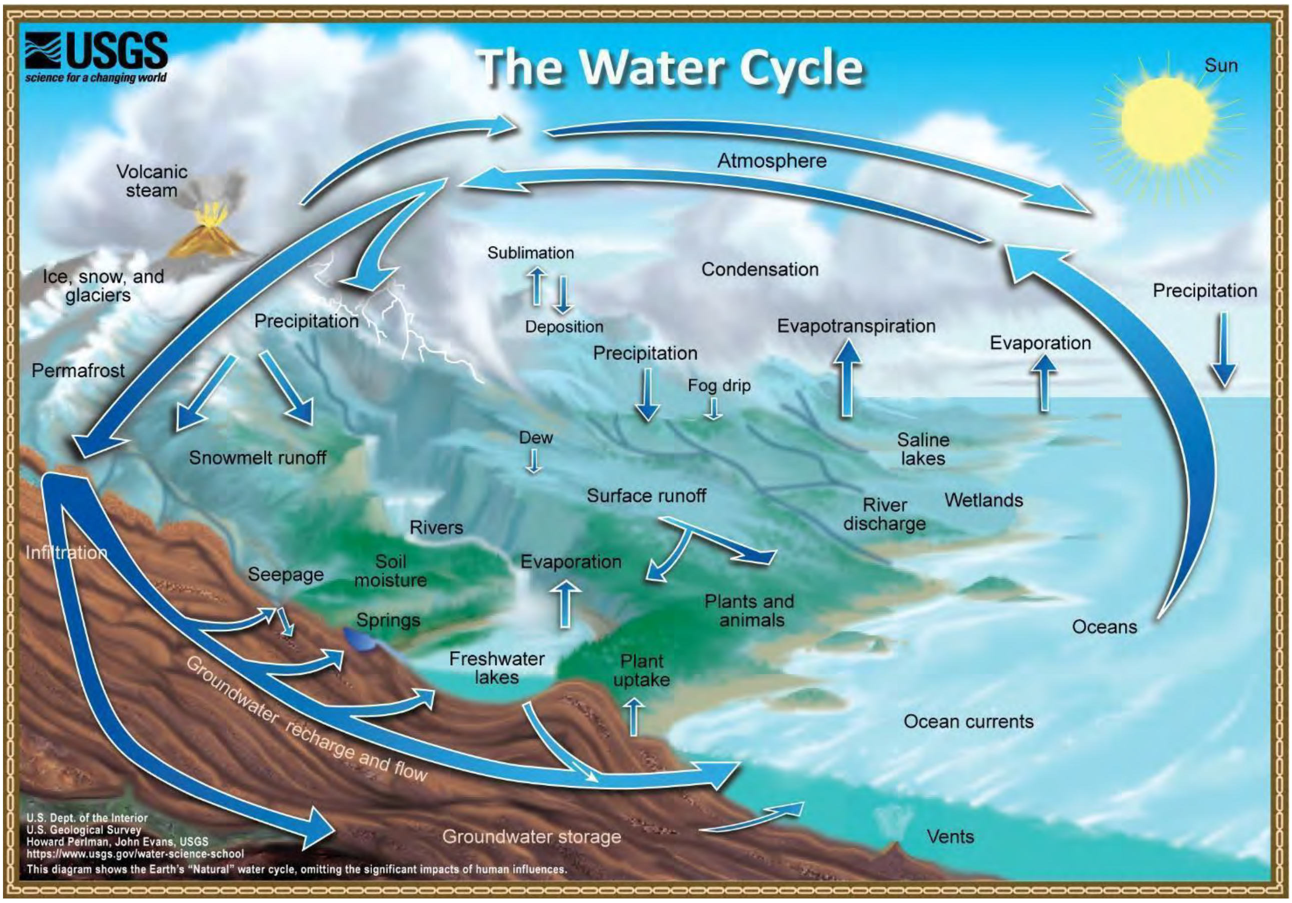


Figure 3.1 The natural Water Cycle (Source: U.S. Geological Survey [USGS])
Available online at: https://www.usgs.gov/media/images/water-cycle-natural-water-cycle

The situation shown in the above figure differs significantly in cities, as a result of the presence of human beings and urbanisation processes that have influenced and modified the natural water cycle by introducing complexities due to anthropogenic activities and interventions, all of which transform and regiment most of the river basin and groundwater reservoirs. The Urban Water Cycle (UWC) is "man-made", created to provide drinking water (high water quality) to homes and businesses, to remove wastewater and sewage efficiently, and to redirect storm water away from homes and businesses into waterways. Water is retained within the urban system for a longer time than in natural storage areas, fresh water is manipulated to make it drinkable and wastewater is treated artificially to remove nutrients

[2] See: https://www.usgs.gov/special-topic/water-science-school/science/water-cycle-adults-and-advanced-students?qt-science_center_objects=0#qt-science_center_objects

and pollutants in order to minimise the impact on the receiving water bodies (Brinquis, 2007).

The current urban water cycle is the result of human intervention that purposely modified the natural cycle in order to satisfy human consumption needs. The major components and interconnections that have been created between them are shown in Fig. 3.2 and schematically in Fig. 3.3, which displays only the main elements and pathways.

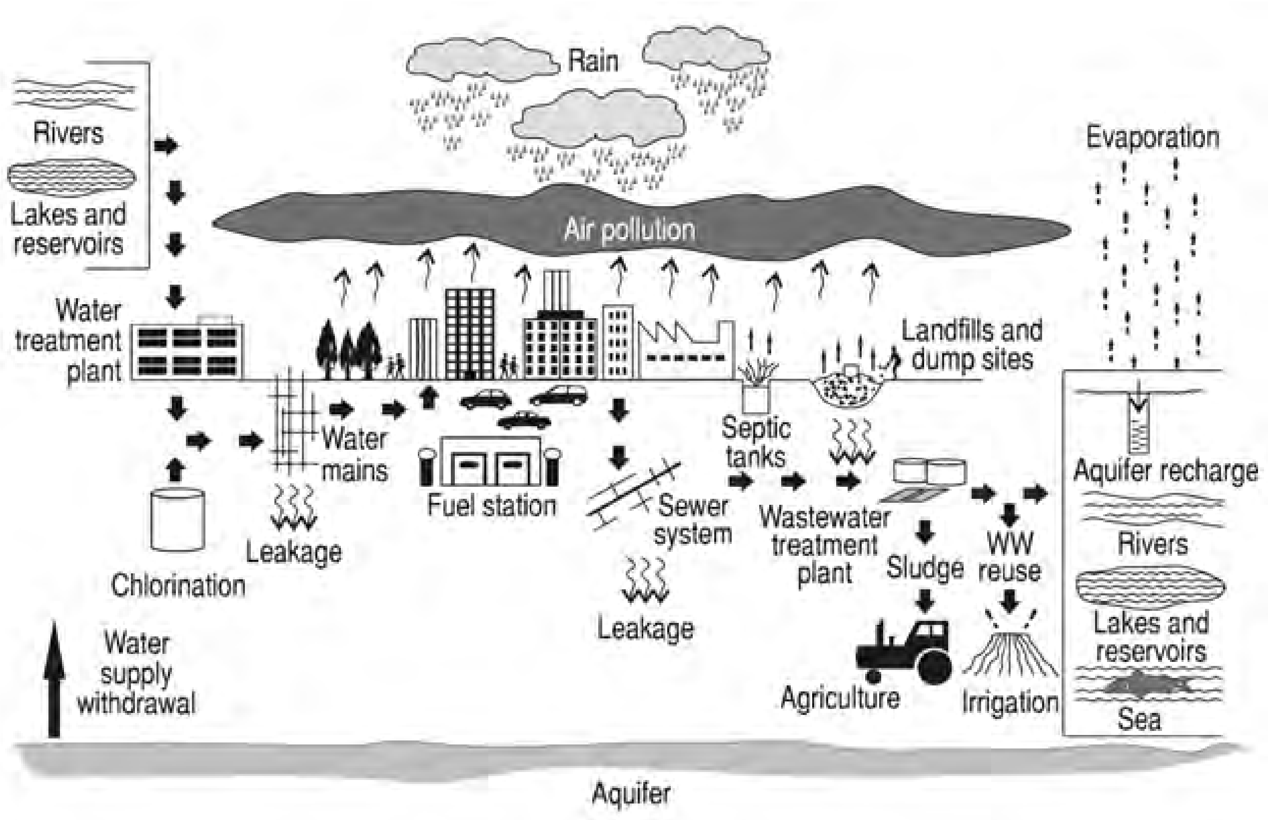


Figure 3.2 The Urban Water Cycle (Source: Adapted from Marsalek et al., 2006)

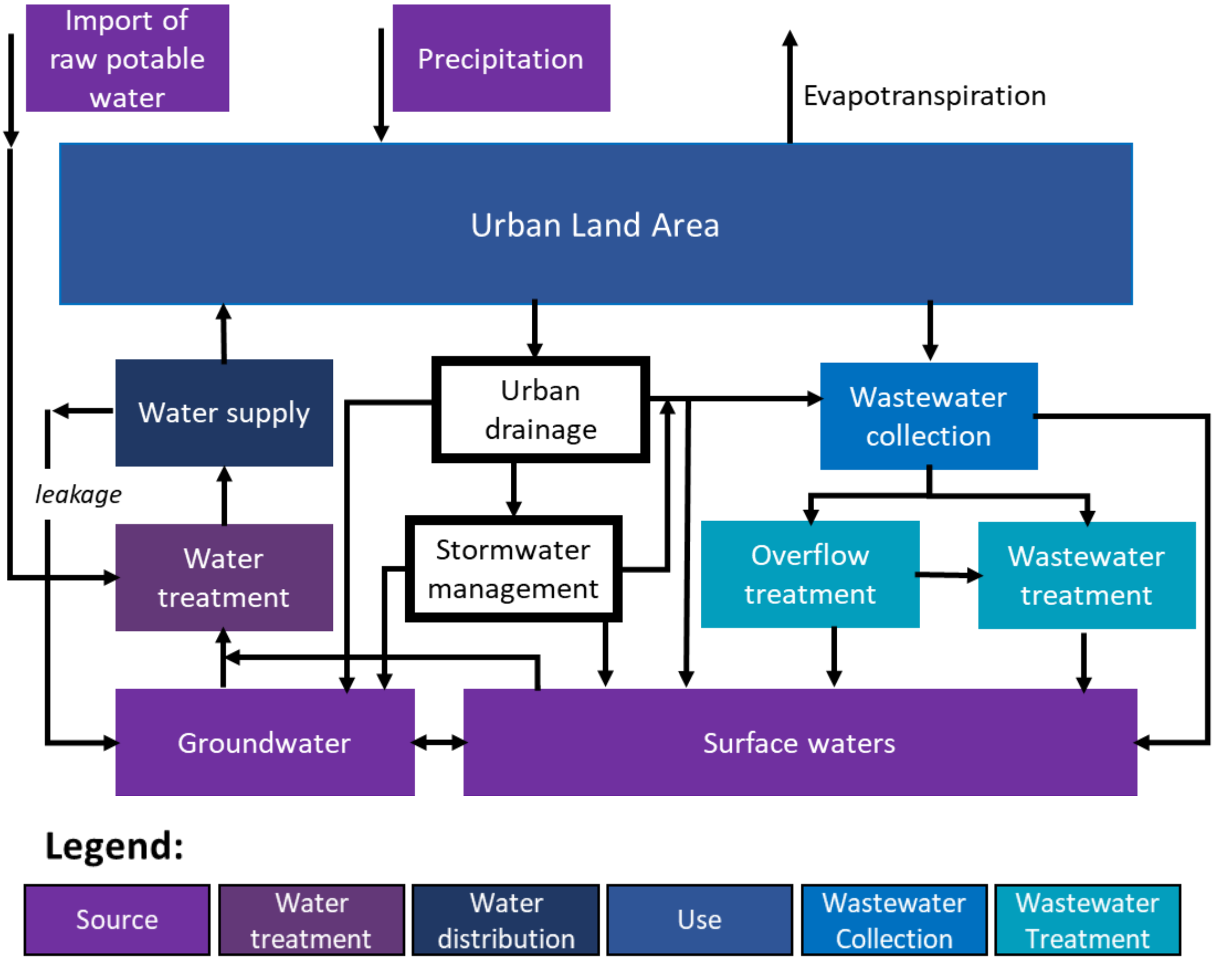


Figure 3.3 Urban Water Cycle: main components and pathways. The blocks of the diagram, composing the UWC, are coloured according to the corresponding main components identified by the Legend in order to cluster them in the six steps that forms, in its simplest configuration, the UWC. (Source: Adapted from Marsalek et al., 2006)

A brief description follows of the identified components of the cycle that can be summarized in the six steps[3], pertaining only to the ones considered that forms the simplified configuration of the cycle (according to the legend of the figure 3.3).

Source/Water intake

Many freshwater sources are found in the environment as a result of geological and meteorological phenomena. Surface waters such as lakes, reservoirs, and rivers are the most visible and are often tapped for public water supply. Another source that can be used is groundwater extracted through the use of wells from aquifer. The choice of water source depends on many factors, including quality, availability, proximity, economics, and legal matters. A further source of water input is precipitation, which enters in the cycle by soil infiltration, runoff or through collection and storage systems.

[3] See https://blog.nationalgeographic.org/2014/03/19/the-urban-water-cycle-sustaining-our-modern-cities/

Water Treatment

Raw water must be treated to remove contaminants and pathogens in order to be suitable for distribution and human use. The design of the most appropriate treatment process depends on water quality. As a main and important intervention, disinfection is necessary to deactivate harmful microorganisms. More advanced treatment involves a sequence of screening, settling, filtering, disinfection, and chemical adjustments at a water treatment facility.

Water Distribution

After treatment, purified water is distributed to customers through a pressurized system composed of pipes, pumps, valves, and storage reservoirs. However, not all of the treated water reaches users due to leakages in the water supply. While much of this infrastructure is buried and invisible, it is an important system that ensures that water is available when and where it is needed.

Use/consumption

Water customers use the supplied water for various purposes depending on their needs, such as industries use water for manufacturing and cleaning; businesses and offices use water for daily operations; at home, residents use water for cooking, bathing, laundry, drinking, and landscaping.

Wastewater Collection

Wastewater collection systems (commonly referred to as sewers) collect used and runoff water and convey it, possibly by gravity, to a wastewater treatment facility. This occurs usually through a network of pipes.

Wastewater Treatment

After use, water quality has been degraded and requires treatment before it can be reintroduced into the environment. Wastewater treatment plants use physical, chemical, and biological processes to remove forms of waste, pollutants or pathogens from the influent and restore water quality. Once treated, the effluent is discharged to the environment into water bodies.

Within the scope of the above discussion, the urban water cycle is considered as “linear”, without considering the possible direct reuse of water on site, but instead referring to it as being treated and reintroduced into the environment after its use. Opposed to the concept of “linear”, nowadays, the concept of “circular” water management is taking off which is based on reduce, recycle and reuse of water every time possible; but one thing shall be specified: water resources are naturally renewable and can be reintroduced into water bodies through naturally occurring activities; however, it is also possible to foster water reuse by increasing the use of rainwater and/or the use of treated greywater, in order to achieve a more “sustainable” and circular water cycle (a more detailed explanation about the topic is discussed in the paragraph 3.4).

In contemporary society, urban water sources are often overexploited, due to the high demand of water and sometimes to a wasteful and unnecessary water uses. In Europe, such a phenomenon is to be considered first and foremost as a management matter, given the fact that the issue does not stem, in the majority of the countries, from a lack of the primary water source, nor from drought-related concerns. Water resources are renewable and will continue to regenerate themselves; however, some attentions should be paid on the natural time-scale necessary for such regeneration processes.

The concept of the urban water cycle demonstrates the connectivity and interdependence between urban water resources and human activities, and the need for integrated management (Marsalek *et al.*, 2006); in fact human impact is an essential determinant of hydrological behaviours in most of the societally relevant catchments all over the world. Human impact plays a significant role on fresh water resources and in some regions it actually conditions water resource availability. Experience suggests that human impact assessment is an essential prerequisite to ensure the sustainable design of water resources systems. Human impact should be adequately considered when planning the exploitation of water resources and mitigation of natural hazards[4]. The problem is that there are not yet technical guidelines on how the human impact on water resources should be estimated, and this is out of the scope of this thesis; in fact, the influence of human activities on water resources will not be analysed and estimate directly, but some indicators referring to the use and demand of water will be used.

The detailed and technical description of each of the key components (water and wastewater treatment, water distribution, etc.) and the computation of urban water balances are also out of the scope of this thesis. This paragraph has introduced some key elements necessary for the following analysis and in order to give a better overview of the meaning of Urban Water Cycle and the elements considered, given that it constitutes the foundation of the urban water resources management topic.

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4 See: https://distart119.ing.unibo.it/albertonew/?q=node/116

The focus of the study is placed on the urban context because this will be the spatial scale of the analysis considered for the developing methodological framework of the thesis, which will be shown in the next chapter.

3.2 Water resources management in cities: Challenges

The management of water resources in urban contexts is a challenging issue that arises from the high complexity inherent in the water sector. This complexity is due to the intrinsic organisation of the system which is characterised by inter- and intra-sectoral dependencies, multi-stakeholders, multi-scale and wide diversity of problems and multi-level governance. These are only a few of the problems linked to water resource planning. Many other issues exist and are linked to the topic, but in this thesis only the previously mentioned concepts are analysed. In the following section, a brief explanation of such complexities, and their meaning within the context, is presented. After that, inclusive stakeholder engagement is shown as possible solution to overcome some of the criticalities; and, at the end, the concept of sustainable, circular and integrated water resources management, adapted for the CWC project, is introduced.

3.2.1 Multi-scale and multi-level governance

As reported by Moss & Newig (2010): "*Environmental governance and management are facing a multiplicity of challenges related to spatial scales and multiple levels of governance*", and such a statement can be applied also to the water sector, which in fact is a field particularly sensitive to these issues. This is due firstly to the fact that water logistics and hydrological boundaries cut across administrative frontiers and perimeters, from small catchments to large river basins. Secondly, because water governance and water resource management take place at various levels.

Therefore, it is apparent that the water sector is highly fragmented. Managing it involves a series of public, private and not-for-profit actors from local, (sub-) basin, regional, national to international levels. Governments, citizens, end users, private actors and financial institutions, as well as infrastructure and service providers, all have a stake in the outcome of water policy and projects. In many countries, the allocation of roles and responsibilities within water policy-making is scattered across different levels. Inherently, the multiplicity of actors, and their varying interests and concerns, complicates the decision-making process, given that typically the power to control the course of policy-making and projects, including relevant reform agendas, does not reside with any one single actor (Organisation for Economic Co-operation and Development [OECD], 2015), as it will be seen in more detail in the next paragraph.

For example, in Italy, the powers and responsibilities within the water sector have been allocated as follow (Guerrini & Romano, 2014):

1. A National Regulatory Authority (now The Italian Regulatory Authority for Electricity Gas and Water - AEEGSI[5]) that should define the national framework under which all firms must operate, choosing the tariff method and the service contract type; then, it should periodically monitor the implementation of the rules in every area.
2. A local Regulator Authority responsible for controlling the entities that locally manage the services.
3. An entrusted water utility company that is the owner of service delivery and the implementation of the necessary infrastructure.

But there are other relevant entities, such as: The Ministry of the environment that is in charge of setting minimum quality standards for drinking water and he is responsible of the monitoring of the environmental quality (i.e. quality of water, aquatic ecosystems, degradation of productive land, etc.) and the Basin Authorities that define and update water balance, promote agreements between Regions for joint management of water resources.

The OECD (2015) also highlights the fact that the decentralisation of water policies in the past decades has resulted in a dynamic relationship between actors at all levels of government. Complex competences have been allocated to lower levels of government and the sub-national actors do not always have the authority over the financial allocation required to meet the needs of the lower scale. At the same time, central governments may be constrained when promoting and assessing water resources and services strategies if they do not obtain information from sub-national governments. This kind of mutual dependence requires ways to facilitate multi-level relationships (OECD, 2015), where segmentation can be overcome through the engagement of all players and the adoption of effective coordination mechanisms.

In addition to the multi-level governance problem, a further issue concerns the levels of government and administration, which typically do not fit the environmentally relevant scales, resulting in inefficiencies, spatial externalities, gaps or overlap of responsibilities.

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[5] See: https://www.wareg.org/members.php?q=view&id=12

For example, competencies of political interventions have shifted both towards the national and supranational levels in the form of international agreements or the growing influence of the European Union; and towards the regional and local levels, in the form of decentralisation of water decision making and implementation involving a diversity of local non-state actors (Moss & Newig, 2010). In fact, depending on the problem faced, some adaptive management approaches call for local self-management of water resources, whereas water-related processes such as climate change transcend territorial boundaries and is perhaps best tackled on a global scale (Moss & Newig, 2010).

In Europe the scale configuration of water regulation is being currently re-ordered around river basins in accordance with the Water Framework Directive (WFD). The WFD has initiated a process of negotiation over the form and means of institutionalizing river basin management that is altering established power geometries, it has strengthened the need for inclusive and deliberative modes of governance suited to horizontal interplay between hydrological and political–administrative scales of operation and to vertical interplay within each of these scalar dimensions (Moss & Newig, 2010).

In the WFD, regional authorities play a leading or significant role in federal or regionalised countries, and a few other Member States (e.g. Poland, Sweden). In addition, local authorities (and local stakeholders) play a role in the development of River Basin Management Plans (RBMP) through stakeholder consultation and, in certain cases, they have the responsibility to establish follow-up local management plans, translating the RBMP at the local level (e.g. Denmark, France). (Milieu Ltd., 2017).

There are some inconsistencies in the organisation established by WFD, in fact, in a Study of the European Committee of Regions, it is argued (Milieu Ltd., 2017) that the implementation of the WFD in some Member States has led to ambiguities regarding the division of responsibilities and that stakeholders were unaware of the roles and tasks of all bodies involved. In particular this happened in Sweden where the role of the water boards at the local level and the role of municipalities in the Boards needed to be better clarified. It was also discussed that the re-organisation of governance required by WFD has led to more fragmentation of responsibilities because decisions are taken at river basin level, while implementation is expected to be carried out by national and local authorities, which has caused implementation problems.

This tension between different levels of spatial and governmental scales produces confusion, communication difficulties and also difficulties in funding and implementation procedures, thus constituting one of the main obstacles to the development of new regulations and policies in water management.

Taking into account this frequent mismatch between the scale of the environmental phenomenon and the boundaries of existing political or administrative jurisdictions at multiple levels, a way should be found to better coordinate the different layers involved coupled with the need to set the spatial and administrative scale considered.

3.2.2 Multi-stakeholders

The first question to be answered is: what is the meaning of the word "stakeholder" in water management? Following and adapting the definition given by Schmeer (1999), merged with what is said by the Food and Agriculture Organisation [FAO] (1995): "*stakeholders in a process are actors (persons or organizations) with a vested interest in the policy being promoted. They can be individuals, organizations or groups. These stakeholders, or "interested parties," can usually be grouped into the following categories: various levels of public-sector agencies in the water sector (state, regional or local), public-sector agencies involved in water resources (for example, departments of agriculture, of industry, of transportation, or of recreation), private-sector organizations and companies with water interests, environmental and professional NGOs, and representatives of those people likely to be affected (for example, civil society and consumers).*"

This given definition is suitable and can be applied also in the context of this thesis with an important specificity: in the water resource sector, stakeholders are not only interested in the policy process but also in its management and planning, adding the fact that they are also water users and so directly involved.

Due to the high fragmentation of the water sector, the wide diversity of problems that could rise, the economic, social, climate, urban and technological trends, and the different spatial and governance level, multi-stakeholders are an intrinsic characteristic of the water system and there is a need for multi-stakeholder solutions in order to face water challenges.

The type of actors contributing to decision-making and implementation processes varies largely across water governance functions, from policy making to regulation, service delivery, and water resources management and financing (OECD, 2015). However, it happens frequently that roles and responsibilities are not clearly defined between the spheres, thus creating confusion, misunderstanding and overlapping of roles. In order to avoid this kind of problem, first of all, stakeholder mapping should be carried out; in fact, mapping stakeholders is a key point in the decision-making process. It is necessary to decide who is involved, who does what and at which level they can act. It should be highlighted that it is not possible to develop a stakeholder analysis in general terms that is suitable for every water management decision-making process and valid at every spatial scale. Stakeholders mapping must be instead context-specific and the definition of roles and responsibilities should be tailored each time to the situation faced depending on the country, on the spatial level and on the function considered.

To give an idea of the possible actors that could be classified as stakeholders, an OECD (2015) study called "*Stakeholder Engagement for Inclusive Water Governance*" is used. It identified common institutions and stakeholders with recurrent roles, as shown in Fig, 3.4 where they are organised in three main functions that are: financing, water allocation and spatial planning, further being clustered as traditional, emerging and under-represented stakeholders. This is a list of the possible, most significant stakeholders without considering administrative divisions and the relationships between them.

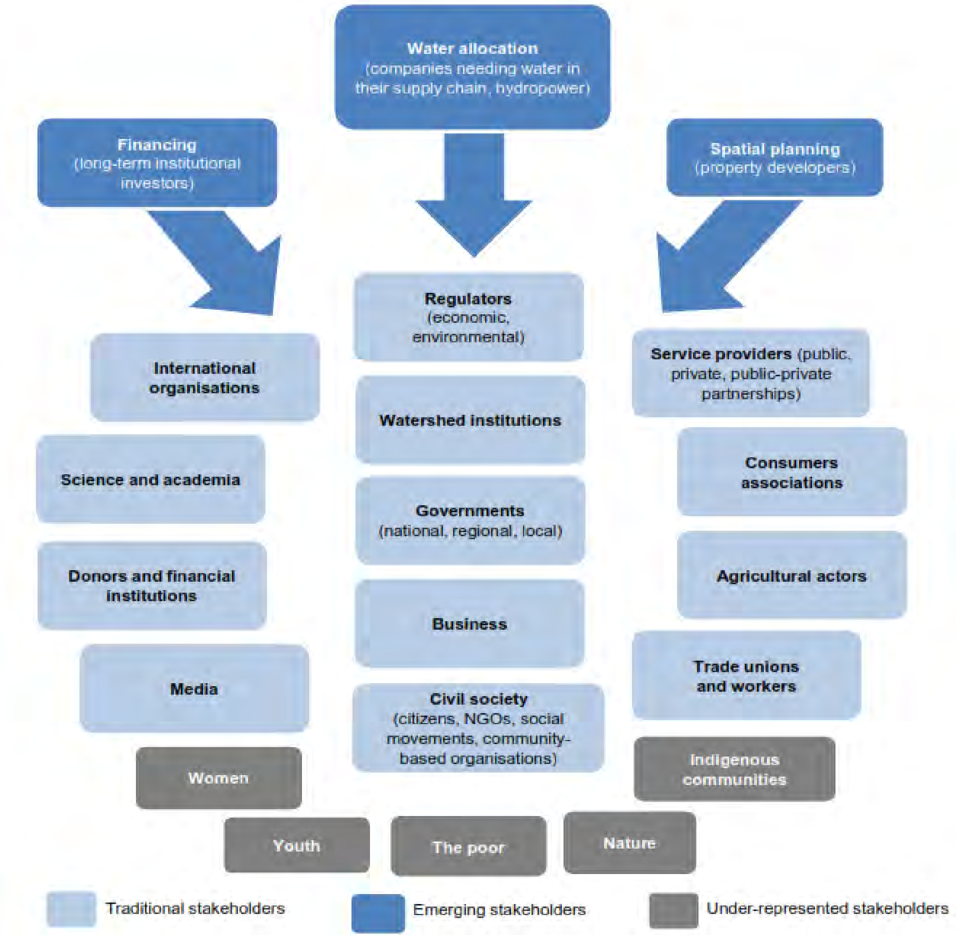

Figure 3.4 Traditional, emerging and under-represented stakeholders in the water sector (source: OECD, 2015)

Identifying stakeholders requires a holistic approach, given the fact that they can be interdependent and can influence each other depending on the water function they carry out

(OECD, 2015) and on the objective. Therefore, when they are mapped, the relationship and the interactions between them also needs to be clarified.
The coexistence of multiple stakeholders, possessing different needs and perspectives, constitutes one of the main challenges inherent in water resource management, however it is a fundamental aspect to consider and integrate the different perspectives because each one can give its contribution, experience and knowledge. For example, in order to make water management a more sustainable process, sustainability scientists generally agree that the assessment of water sustainability requires inter- and trans-disciplinary research approaches, which link the knowledge and perspectives of various scientific disciplines as well as non-academic stakeholders (Schneider, 2015).
The variety of stakeholders constitutes both an obstacle because of difficulties in coordination and the rise of conflicts but also an opportunity because it brings out many knowledges and perspectives that can have a positive effect on water management. The way to get the best from stakeholders for the implementation of effective and efficient sustainable and circular water resource management need to be found.

3.2.3 Wide diversity of problems related to different components of the water cycle in urban contexts

In addition to the complexities already explained, which can be classified as systemic or internal ones because they constitute some intrinsic characteristic of the water sector, such as multi-level governance, multi-spatial scale and multi-stakeholders, there are other problems that could arise. The latter are not linked with the organisational aspect of the sector, but they come from external drivers, such as human impact, climate change or population growth and they are linked to the management of the resources and to the components of the urban water cycle. This type of problems can be classified as external ones. An explanation follows.

Water cycles in urban contexts is comprised of many components, each creating potentially different types of problems, thus involving different types of stakeholders. The wide diversity of potential issues ranges from a lack of water resources to flood risks, from leakages in the water supply or in the sewage systems to water quality standards, and from overexploitation of water resources to pollution. The negative effects on water resources can be provoked both by unregulated human activities and by the natural variability of climate, but these are only some of the criticalities that should be addressed.

Water problems around the world are neither homogeneous, nor constant or consistent over time. They often vary quite significantly from one region to another, even within a single country, from one season to another, and also from one year to another. Solutions to water problems depend not only on water availability, but also on many other factors, among which are the processes through which water is managed, competence and capacities of the institutions that manage them, prevailing socio-political conditions that dictate water planning, development and management processes and practices, appropriateness and implementation statuses of the existing legal frameworks, availability of investment funds, social and environmental conditions of the countries concerned, levels of available and usable technology, national, regional and international perceptions, modes of governance including issues like political interference, transparency, corruption, etc., educational and development conditions, and status, quality and relevance of research that are being conducted on the national, subnational and local water problems (Biswas, 2004).

In this thesis the focus will be on the management of water resources and on how to develop plans and policy measures in a circular, sustainable and adaptive manner, and not on problems related to technical implementation or development.

In the context of this thesis, problems related to water sector have been grouped in two categories:

- Internal or systemic problems related to administrative, organisational and governmental issues;
- External problems related to the negative effects which human activities or climate variability have on availability of resources.

The first ones constitute obstacles in the implementation and elaboration of proper policy and regulations, the second ones are the problems that should be addressed by stakeholders to elaborate policy and regulations.

3.3 How to deal with complexity? Stakeholder engagement and cooperation

The challenges (too much, too little or too polluted water) and the complexity of water management previously shown, require water managers to change their perspective from the traditional top-down hierarchical approach to a more inclusive one which encourages stakeholder engagement, cooperation, involvement of public, non-state actors such as private and not-for-profit organisations and sectors at different levels to deal with water issues. This change in the organisation of the power has already started and has characterised public policy since the 1990s (OECD, 2015), but it should be encouraged even more.

The traditional role of "governments" as the single decision-making authority has gradually been replaced by multi-level, polycentric governance demonstrating that a series of stakeholders can contribute to and better guide decision making (OECD, 2015).

Water is affected by numerous external drivers and it influences many other policy areas that are critical for economic development and well-being, including health, agriculture, land-use and forestry, industry and energy. These policy areas tend to work in silos and further improvement is often needed in terms of consultation, participation and co-ordination to engage stakeholders in a coherent, holistic and integrated way (OECD, 2015).

Given the size and nature of water challenges, tackling them requires a co-ordinated effort among policy makers and stakeholders: those who play a role in, and those who are affected by, actions and outcomes in the water sector (OECD, 2015). It is therefore necessary to reduce the gap between decision-making and implementation of the policy, governance measure or action plan.

Each stakeholder has different needs, perspectives, backgrounds and visions; the question that arises is how to combine all of these aspects without the generation of additional conflicts. They should become active stakeholders with interests in the issue and they should be involved in the decision-making process because they are the relevant actors, from passive to active in order to foster bottom-up efforts with the final aim of developing outcome-oriented and context-specific policy measures and plans that manage water resources in a more efficient, sustainable and circular way.

Engagement processes range from local watershed groups negotiating over allocation practices to national committees debating priorities, or international meetings seeking consensus about the management of transboundary basins between sovereign states. The issue of scale also relates to questions of democratic legitimacy (OECD, 2015). The higher the level of decision making, the lower the possibilities for comprehensive participation of all relevant constituencies, and thus the higher the likelihood that conflicts may arise. It is not possible to involve everyone in every process because engagement should not be seen in absolute terms but it should be tailored to each context, stakeholders concerned, policy goals targeted and local needs. The mechanism and actors chosen should fit the purpose that, in this case, is the development of policy and planning measures for the sustainable and circular management of water resources in urban context. All stakeholders need to be informed of the various stages and outcomes of policy and project processes, but they do not need to be involved at each stage of the water project or policy creation.

Collaboration has been promoted as a means of enabling participation in water related decision-making with benefits to processes and outcomes. These benefits include the alignment of effort among stakeholders to promote more efficient and responsive management; the inclusion of a diverse range of perspectives; the management of conflict; the enhancement of social and institutional capacity to handle complex water management issues; and the translation and integration of knowledge (Margerum & Robinson, 2015). In addition, dialogue and co-operation among stakeholders allows for the testing and refining of policies and projects, and thus can yield short- and long-term advantages. Short-term benefits relate to the outcomes of engagement such as better quality decision making, increased willingness of stakeholders to collaborate to solve common water problems, easier access to funding or greater support for the implementation of a water project or policy. Long-term benefits relate to improved understanding and awareness raising, more confidence in governments' decisions or capacity-building and knowledge transfer.

Because water issues cross many jurisdictions and boundaries, as previously mentioned, a simple consolidation of power under a single entity is unfeasible, therefore government and non-government participants in many countries are looking for collaborative partnerships to engage the community, resolve conflicts and sustainably manage water. Collaborative partnerships have been created for a range of water management issues, operating at different scales in many parts of the world, particularly North America, Australia and Europe (Margerum & Robinson, 2015). Partnerships are a key component of collaboration, but in practice they are highly complex enterprises that involve substantial investment to develop and maintain (Margerum & Robinson, 2015).

In different ways, forms and terms and with other objectives, also the CWC project is carried out by a partnership, sustained by the EU, in which the partners strongly collaborate in order to reach the same purpose.

The need for a participatory approach to water management is not new, this concept was already pointed out at the International Conference on Water and the Environment[6], in Dublin, organised on 26–31 January 1992. The experts present defined four guiding principles for water and sustainable development and the second one was: *"Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels"*. It means that decisions taken at the lowest appropriate level should be made with full public consultation and involvement of users in the planning and implementation of water projects.

Also at the European level the importance of stakeholder engagement and participation is stressed, in fact in the Water Framework Directive, in the article 14, it is stated that: "*The success of this Directive relies on close cooperation and coherent action at Community, Member State and local level as well as on information, consultation and involvement of the public, including users"*. It means that stakeholders (public included) should actively participate in the planning process by discussing issues and contributing to the solutions, and also public can react to plans and proposals and the access to background information should be given at all times. According to the "Guidance document on Public Participation" (2012), the main reason for public participation is to ensure compliance with the directive: "Public participation improves decision-making by ensuring that decisions are soundly based on shared knowledge, experiences and scientific evidence, that decisions are influenced by the views and experience of those affected by them, that innovative and creative options are considered and that new arrangements are workable and acceptable to the public".

Decision makers will be forced to make tough choices about how to manage water for inclusive economic growth and sustainable environmental stability. Better engaging stakeholders both within and outside the water sector can help ensure that these choices are the right ones, and are implemented effectively (OECD, 2015).

With a view to sustainable water resource planning and circular urban water management, effective stakeholder engagement is vital for the implementation of new water laws, policies and plans that aim to protect water resources. It is very useful to co-design because it is important to understand the economic feasibility of intervention, the social feasibility and the governmental context in which the plan or strategy should be implemented. Many actors are at stake, who mutually influence each other and if someone is not involved there is the possibility of wrongful planning procedures. This might occur if not all of the aspects are

[6] See: http://www.wmo.int/pages/prog/hwrp/documents/english/icwedece.html

considered during the planning phase of the project, which may have catastrophic consequences on the sustainability nature of the intervention in question. The urban circular management may be negatively affected if not all of the fundamental elements are considered and engaged during the project cycle within urban contexts.
As it will be seen in more detailed in the next chapter, in the context of the CWC project stakeholder involvement is one of the key pillars because they should collaborate with the project partners' in the co-creation process to define smart governance solutions, planning measures and strategies to foster circular and sustainable water management.

3.4 Implementing circular urban water management

Urban water management is increasingly important, given the need to maintain water resources in compliance with global and local standards of quantity and quality. Its management is a challenge in terms of sustainability and administration, given the fact that there are many internal, systemic and external obstacles, added to future uncertainties created by climate change, population growth, cultural and political trends. In order to offer the best and efficient management of water resources, the development of a regulatory, more strategic and structured approach which looks at the system as a whole and not in single compartments or sub-sectors is required. There is the need to combine all the aspects simultaneously to create a framework that permits to achieve circular urban water management that does not generate negative environmental, social, sanitary or health effects and at the same time satisfy the demand of different sectors and find the agreement between stakeholders.
As previously discussed, one of the ways to face what are defined as internal and systemic issues (such as multi-level governance and multi-stakeholders), is to utilize an inclusive approach to water governance and management, which ensures the involvement of all stakeholders identified and the cooperation between them, but it is not sufficient, this is only the first key step for a satisfactory result.
Once the spatial scale of action has been identified, the objective of such an approach is to understand what the real challenges are in the policy process, and to subsequently elaborate an action plan aimed at tackling water resource management in a sustainable, circular and integrated manner; but the management of water resources in an integrated, circular and sustainable way is usually complex. This is due to the coexistence of many criticalities (internal, systemic and external ones), therefore it is difficult for policymakers, institutions,

and engineers to develop solutions which take into account the whole existent problem in one single time.

Historically, in fact, the main components of urban water systems and the provision of related water services, including water supply, drainage, sewage collection and treatment, and receiving water uses, were addressed separately (Marsalek *et al.*, 2006). Their interactions were often disregarded or underestimated; such an approach is obviously untenable. Consequently, an integrated approach to water management, sometimes referred to as an ecosystem approach, has evolved (Marsalek *et al.*, 2006). The whole system and the existing interactions should be addressed as much as possible simultaneously and with the cooperation of the stakeholders in order to give life to a co-creation process characterized by a cross-sectoral participation.

At this point, before proceeding with the discussion, it is important to clarify what is the meaning of "integrated", "circular" and "sustainable" within the context of this thesis and for the CWC project, because they acquire specific meaning and in literature many definitions are available.

In particular, with the use of the term "Integrated", I refer, as mentioned, to the need, for the different sectors involved, to enter into play simultaneously and to include water management into other disciplines, in order to facilitate a more efficient and effective management solution; therefore, integration both between the others sectors but also with the different levels.

This is also due to the fact, as previously discussed, that the scale of management implied by hydrological characteristics often comprises many layers of social, political, and economic institutions. Even at the sub-basin level there may be manifold users such as local small-scale farmers, large-scale commercial farmers, hydro-electric power companies, other industrial users, municipal water users, and those using water resources for leisure and/or tourism. The complexity of different water users is associated with the complexity caused by different uses to which water resources are allocated, including irrigation, domestic use, power generation, industrial production, environmental amenities, and recreation. The associated use and management rights are exercised through a variety of institutions that function at different scales (Berger *et al.*, 2007); this is why it is important to establish the scale of action and then define which are the actors, which role they have, and the relationship between them, and finally, to perceive water as a part of larger system.

Instead, it is more difficult to give an accurate and absolute definition to the term "Sustainable" because it can be associated to multiple explanations and to different fields and it changes depending on what is applied; furthermore, sustainable water management today encompasses a much broader set of issues, ranging from water supply to habitat restoration to water quality (Margerum & Robinson, 2015). Sustainability is a relative concept, but there is a common agreement on the general definition given for sustainable development by Burtland[7] (1987), which states: "*it is the developments that meets the needs of the present without compromising the ability of future generations to meet their own needs*." Applied to urban water management, it can be interpreted as the ability of satisfying the present demand of water without creating irreparable consequences to water resources for the future. In support for the claim, for instance, Wei, Wang & Wang (2018) argue that in order to make the water cycle healthy and sustainable, on the one hand, we should save water, reduce water consumption and pollution; on the other hand, we should carry on the regeneration treatment to the water, so that the receiving water body can maintain its self-purification ability. Otherwise, the urban drainage will pollute the water body thus compromising the resource. Loucks (2000) also claims that water resource systems that are managed to satisfy the changing demands placed on them, now and on into the future, without system degradation, can be called sustainable; and, on the same line of thoughts, he also states that sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity.

However, in the specific case of the thesis and of the City Water Circles project, it is better to speak about circular water management than sustainable one, because the final aim is to design solutions that can facilitate cities to become driving forces of circular urban water use. In fact, sustainability is conceived as one of the sub-components needed to reach the broader objective that is the circular urban water management. In the following, based on literature, the "circular" concept has been delineated and then shaped to the specific goals of the project and the context of use.

In order to reach the circular water management, the International Water Association developed the 5Rs approach that consist in: reduce, reuse, recycle, restore and recover water. The World Business Council for Sustainable Development (WBCSD), in 2017, gave the following explanations, see Fig. 3.5, to the 5Rs.

[7] See: https://www.un.org/waterforlifedecade/water_and_sustainable_development.shtml

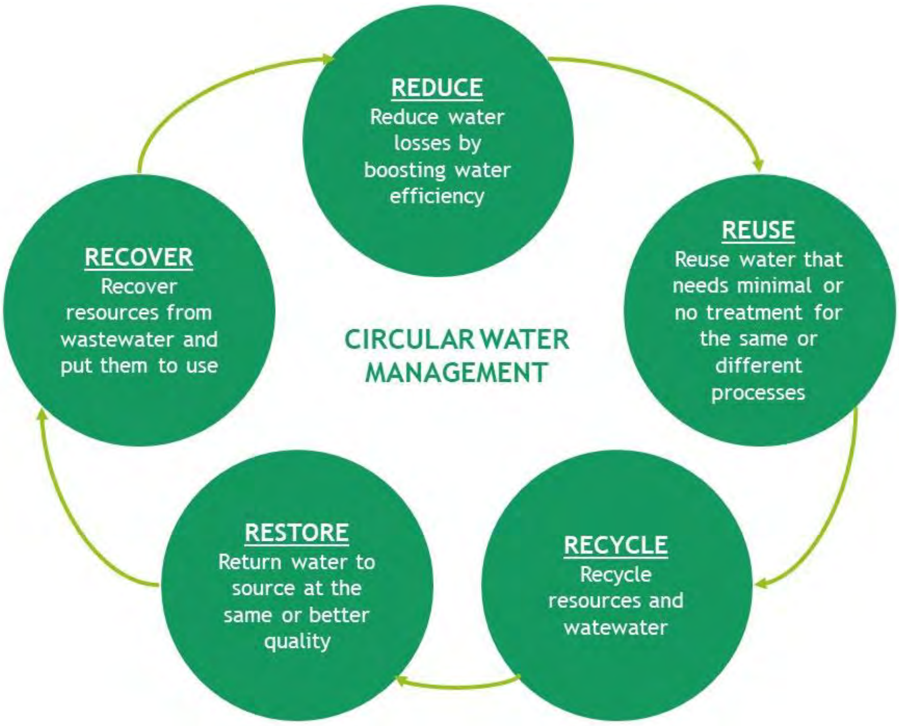

Figure 3.5 Principles of Circular Water Management (source: WBCSD)

These are the principles to reach circular water management. Starting from these, four areas of intervention in urban context had been identified for the CWC project, in which the specific goals need to be adapted according to the context.

Respectively, the four areas of intervention in urban context are:

- Water Governance
- Water efficiency and water loss reduction
- Rain water management
- Grey water recycling

The six specific goals for the CWC project are now introduced and classified as:

- Recycle and reuse wastewater
- Increase efficiency in water use and distribution
- Guarantee good quality of water bodies
- Retain water as long as possible on site
- Promote multiple water use and water sustainability
- Preserve flow in water bodies

It is important to develop planning and policy measures that integrate water in other issues and that meet the requirements imposed by the goals, to ensure new developments with regards to circular urban water use. Following this perspective, during the lifetime of the project, the CWC partnership joint their forces to develop innovative solutions, governance tools and strategic actions in the field of urban water efficiency, rainwater harvesting and greywater reuse to foster circular urban water management; applying participatory, cross-sectoral and multi-level approaches.

In conclusion, the intrinsic complexity of the water sector creates a fragmentation in the decision-making process, difficulties in the coordination between various entities and conflicts between institutions resulting in gaps and obstacles in water management. These criticalities, combined with the presence of many stakeholders with different needs, causes unsuitable management of water resources in urban contexts.

In order to create governance structures that attempt - to the best of their ability - to meet the needs of everyone involved, in the context of the CWC project, a learning process is designed to give tools to understand how to treat this complexity and training the cooperation between actors; with the final aim to bring to the creation of regulations, institutions and finally to the development of an appropriate action plan which reflects the economical productivity, the social acceptability and circularity principles with the cross-sectoral cooperation of the stakeholders.

In the next section this methodology will be presented and explained in more detail.

4. AP Methodology: a model to develop action plans for circular water management

The present process has been produced in the context of Interreg Central Europe project City Water Circles during my six months internship at Poliedra consortium in Milan. The idea behind this methodology is to create a process aimed at satisfying the needs of CWC project that, in short, wants to enhance water efficiency and reuse with an integrated circular economy approach. In order to achieve this objective, for the reasons explained in the previous chapter, it is necessary a coordinated approach between project partners and stakeholders involved, therefore the active participation of the latter is required in the co-design and co-creation of strategies, actions and plans that are in line with the principles of the project. The process drawn up is proposed as a learning tool, from which municipalities (or better the Functional Urban Areas) can take inspiration and ideas on how to manage difficulties and fragmentation and how to build the cross-sectoral capacity to cooperate and to respond to the local needs regarding water management.

Poliedra conceived the complete process, step by step, by combining the demands of the project and of different Deliverables. These Deliverables were developed by Poliedra separately and then they have been structured to create the learning process to be used during stakeholders meeting, scheduled by the project.

The methodology starts from the knowledge of the local situation built on a more technical part, which is the Status Quo Self-Assessment, and on the Public Perception Survey, in which the willingness to change and people's water usage habits are detected. This knowledge base constitutes the starting point from which stakeholders jointly develop the key elements which should form the action plan for circular urban water management.

This fact-finding activity is also part of the CWC project and has been created by Poliedra; the deliverables in which the different parts of the learning process are contained are:

- Deliverable D.T3.1.1: "*Common manual on FUA-level self-assessment and analysis of gaps & potentials of circular water use*";
- Deliverable D.T3.1.2: "*Common guideline to carry out public perception surveys in each FUA involved"*;
- Deliverable D.T1.3.3: "*Methodology of the core Master Training";*

In the figure below (Fig. 4.1) the framework of the methodology is shown; it is also pointed out the reference deliverable and who is in charge of the activity (FUAs or Poliedra).

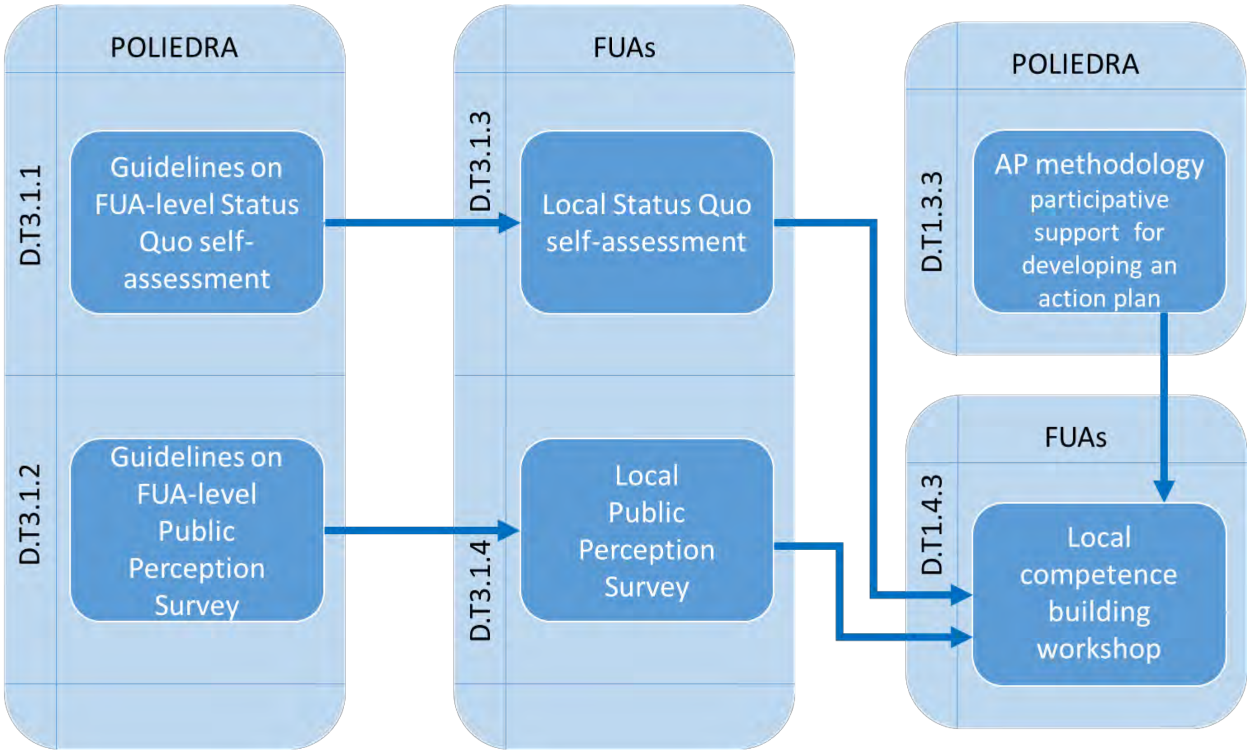

Figure 4.1 Framework of the complete process.

Being tailored to the context and to the needs of the project, before presenting in detail the methodology of the learning process, the spatial scale of action and the stakeholder group composition (i.e. people to be involved) are explained. The following study on the spatial scale comes from personal investigation, it is based on literature but it is also critically analysed and it goes beyond the project requirements.

4.1 Scale of action: Functional Urban Area Vs Urban level

The spatial scale of action and analysis of the CWC project is the Functional Urban Area (FUA in the following). This definition was first introduced by the Organisation for Economic Co-operation and Development [OECD] with the European Union, in 2012. Starting from that, the OECD in a paper called "*The EU-OECD definition of a functional urban area*" in 2019 defines FUA as composed of a 'city' (or core) and its surrounding, less densely populated local units that are part of the city's labour market ('commuting zone'), functionally interconnected to the city, thus encompassing the economic and functional extent of cities based on daily people's movements. They are, among all, economic units, therefore a powerful tool to compare socio-economic and spatial trends in cities and to design urban development policy.

In order to give the definition, two main different but complementary concepts to describe the extent of cities were considered. The first one accounts only for the agglomeration of people in space using a consistent threshold of density and total population. The second one considers the functional and economic extent of cities, beyond the consideration of density and population size only, including also other lower density areas surrounding the city but closely linked to the latter from an economic and functional point of view.

The methodology developed by OECD (2019) to define one functional urban area can be synthetize in four steps:

1. Identify an urban centre: a set of contiguous, high density (1.500 residents per square kilometre) grid cells with a population of 50.000 in the contiguous cells - overall, it focuses on the high concentration of population in space independently from political or administrative boundaries;
2. Identify a city: it is a local administrative unit with one or more local units that have at least 50% of their residents living inside an urban centre;
3. Identify a commuting zone: a set of contiguous local administrative units that have at least 15% of their workforce commute to the city - employed residents working in the city;
4. A functional urban area is the combination of the city with its commuting zone.

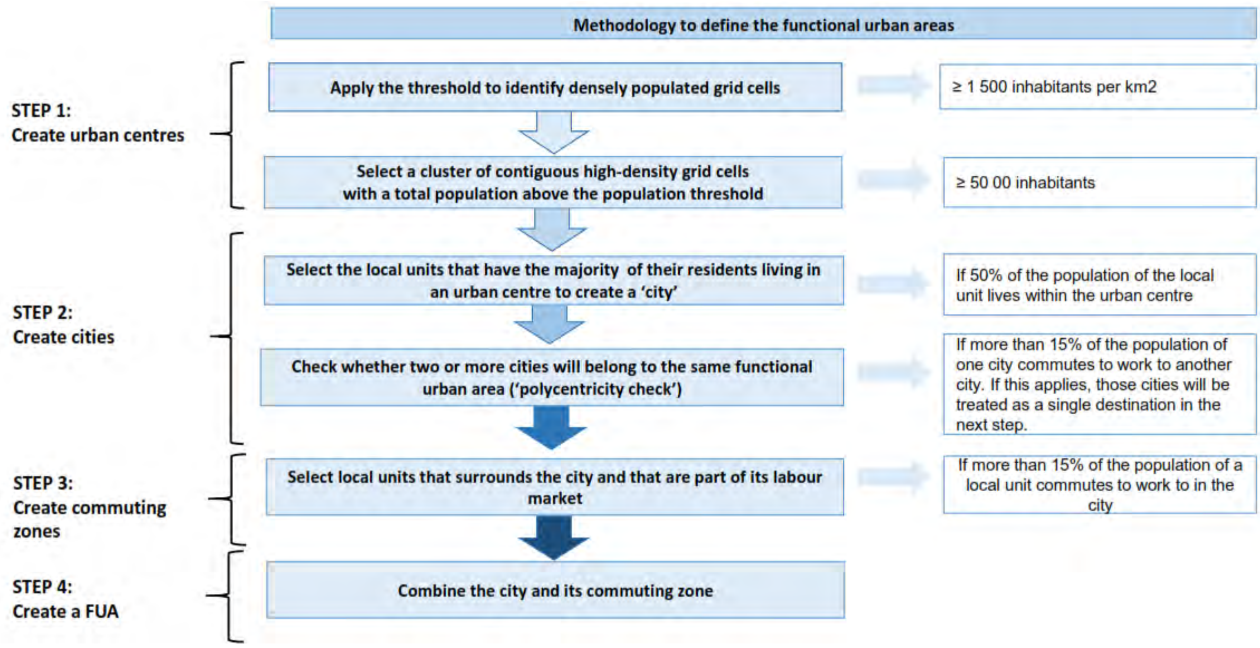

Figure 4.2 The algorithm to identify a functional urban area (source: OECD, 2019)

FUAs can be clustered by size, according to four classes that are listed below:

- Small FUAs, with population between 50.000 and 100.000,
- Medium-sized FUAs, with population between 100.000 and 250.000,
- Metropolitan FUAs, with population between 250.000 and 1.5 million,
- Large metropolitan FUAs, with population above 1.5 million.

The OECD (2019) also claims that "FUAs can trigger a change in the way policies are planned and implemented by providing the right scale to address issues that affect both the city and its surrounding commuting zone". FUAs can be considered as the correct territorial unit to potential policies and governance due to the strict link between the centre and its surroundings, in fact the FUA is indeed an area in which all the anthropic activities that take place (work, transport and various service) are correlated. Nonetheless, FUAs are usually not the territorial units for monitoring activities and data collection, it is very difficult to find statistical information at this spatial scale. Moreover, territorial planning, including rules and policies for water management, are developed locally according to administrative boundaries. This is also due to the fact that FUA has not yet had operational consequences, that is, there are no administrative units at the FUA level neither it corresponds to an operative level.

For these reasons, in the context of CWC project, it is very challenging to deal with this spatial scale and implementing plans and strategies to foster circular water management at this level; therefore involving all the FUA territory in the planning phase seems to be very difficult. Notice that the five FUAs involved in this project, with the relevant characteristics considered, are listed in the following table.

Table 4.1 List of the FUAs involved in the project with the related characteristics considered[8].

FUA Name	Country	Population	Classification	Number of municipalities composing the FUA
Budapest	Hungary	2.970.000	Large Metropolitan FUA	199
Maribor	Slovenia	320.000	Metropolitan FUA	41
Turin	Italy	1.740.000	Large Metropolitan FUA	88
Bydgoszcz	Poland	500.000	Metropolitan FUA	12
Split	Croatia	325.407	Metropolitan FUA	13

Consider, for example, the FUA of Budapest that it is classified as Large metropolitan area (population>1.5 million people), in fact it has 2.970.000 inhabitants and it is composed by

[8] Data retrieved from: https://www.oecd.org/cfe/regional-policy/functionalurbanareasbycountry.htm

199 municipalities. It is possible to deduce how difficult could be find an agreement between each municipality and apply the same strategy and governance measure on circular water management, also due to the fact of the heterogeneity between municipalities given by morphology, social characteristics, administration capacity etc.

Differences exist, not only inside the same FUA, but also between the ones involved by the project (see table 4.1), just think that for example the FUA of Split has 13 municipalities, therefore the complexity of designing a common process valid for everyone is increased.

In conclusion, for the reasons explained, think about the FUA scale of action seems to be very ambitious, considering also the timing of the project (3 years) and the budget available. Therefore, it is suggested to use the FUA level for the collection of data, surveys and as the reference spatial scale for the project; and focus on urban level when creating the action plans, strategies, measures and also for the methodological process here proposed.

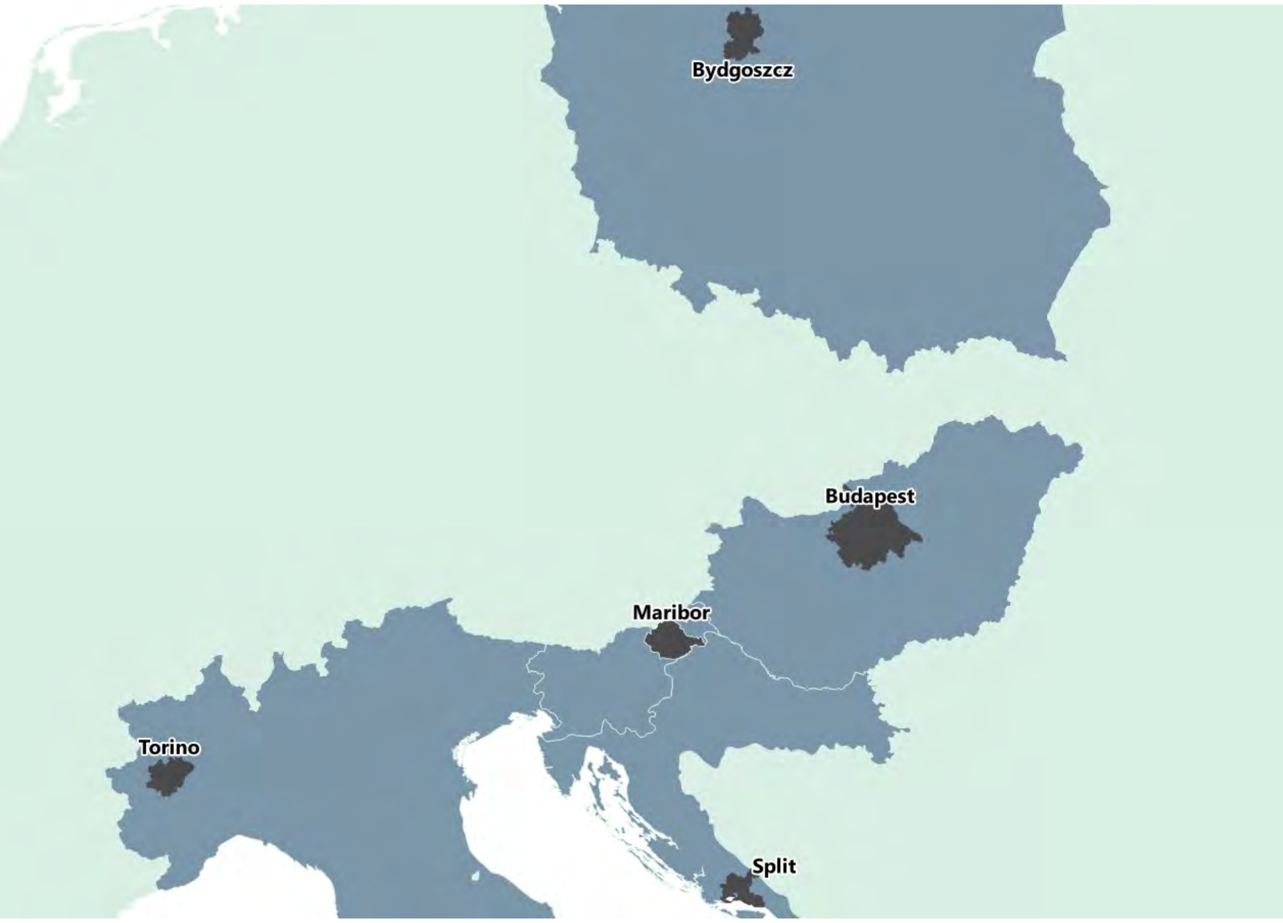

Figure 4.3 FUAs involved in the CWC Project.

4.2 Who is involved? Stakeholders' group composition and main tasks in CWC project

For the Interreg Central Europe project CWC, stakeholders have a key role. Their active engagement/participation is a fundamental part of any co-creation process, it is one of the pillars over which the project was structured. Because of the importance attributed to stakeholder groups (SGs) throughout the project, the aim now is to focus on the identification of stakeholders, because it is important to understand which are the roles and personalities to deal with, in order to effectively design the activities scheduled in the project in which they have to be actively involved. In fact, for a successful engagement, which leads to successful and usable results and better outcomes, a well-planned, inclusive and structured approach is needed. Therefore, thinking about who is affected or have an interest, and prioritizing the stakeholders represents an important step.

First, the SG composition is described and then their main responsibilities within the project are pointed out in order to have a better vision of their commitment.

The following information about the tasks, activities and group composition have been derived and extrapolated from the deliverable D.T1.1.1: "C*ommon methodology for FUA-level stakeholder involvement and co-creation processes"* of the project produced by Poliedra (in this case, I contributed to the project report by carrying out a preliminary analysis and by researching what was contained in the Application Form (AF) of the project about stakeholders). In this thesis, as already mentioned, the focus will be on the formulation of the co-creation and co-design process with project partners of strategies, actions and plans; therefore, one of the tasks will be analysed and a proper method is designed. In the following, it will be shown in more detail.

4.2.1 Stakeholder group composition

In this sub-section, the main categories of stakeholders that should be considered are presented. As previously mentioned, the reference spatial scale of the project is the Functional Urban Area, consequently for each of the five participating FUAs of the project, each one will have its own stakeholder group made of the same categories of people/with the same composition.

In the Application Form of the project target groups and target number of people to be involved are individuated. In such a way, stakeholder mapping is assumed to be done a priori by the writer of the AF, identifying useful categories in the water sector in Europe. This is the starting point and the target groups suggested are taken for granted. Therefore, it is not possible to know which approach was applied and which relationships and interactions between stakeholders were considered. In theory, as shown in the previous chapter, the holistic approach should be adopted and the relationship between stakeholders also needs to be clarified, but in reality the stakeholders mapping was not applied in the strict sense in the project.

Each FUA should do the mapping locally, but there are not enough monetary and time resources, therefore based on their own experience and on the knowledge of their local context they adapt the stakeholders group to their local needs and project partners engage stakeholders closest to them, in terms of working relationship and personal connections.

A target value, in terms of number of people the CWC project aims to actively involve, is also fixed. In order to have an estimate of the number of subjects that should be part of each SG, the target value is divided by the number of FUAs implementing pilot cases and having a SG (that is 5 for all subcategories, for exception of two subcategories, that should be considered only for three FUAs, therefore the target number is divided by 3). As a result, "FUA target" value is obtained; of course, it is not possible to have floating number, as for example 1.6 stakeholders representing regional level authorities or 2.2 representing sectoral agencies, but integer one because they represent number of people that should be present in the group. Therefore, these values have been rounded and they give a useful rough indication in order to achieve the final group composition; having in mind that, altogether, each SG should be composed by a minimum number and a maximum one, depending on the FUA considered because some categories do not have to be taken into account by every FUA. A detailed explanation follows.

The sub-categories composing the stakeholder group, a brief description, the target value for the project and for each FUA are shown:

1. Local public authority

$$\text{Target value} = 20 \xrightarrow{\div 5} \text{FUA target} = 4$$

   Neighbouring local authorities, most of all municipalities within the same FUA, but also others especially if facing challenges of urban flooding or water scarcity, to aid co-producing local outcomes.

2. Regional public authority

$$\text{Target value} = 8 \xrightarrow{\div 5} \text{FUA target} = 1.6 \xrightarrow{rounded} 1/2$$

Regional level authorities (e.g. councils, sectoral departments in charge of environment, water management and spatial planning) to tackle the multi-level governance aspects of circular water usages.

3. Sectoral agency

$$\text{Target value} = 11 \xrightarrow{\div 5} \text{FUA target} = 2.2 \xrightarrow{rounded} 2/3$$

Environmental, water, energy and regional agencies as well as geological surveys.

4. Infrastructure and (public) service provider

$$\text{Target value} = 15 \xrightarrow{\div 5} \text{FUA target} = 3$$

Public companies (mostly owned by municipalities) in charge of (fresh) water and sewage management systems, as well as further public utilities are key members of the SGs in all FUAs, being important direct future users of new tools developed by CWC.

5. Interest groups including Non-Governmental Organisations (NGOs)

$$\text{Target vale} = 20 \xrightarrow{\div 5} \text{FUA target} = 4$$

NGOs and institutes will be key target groups of CWC and active members in all SGs, such as institutes for environment, innovation, sustainable development, and infrastructure and water development/management.

6. Higher education and research

$$\text{Target value} = 12 \xrightarrow{\div 5} \text{FUA target} = 2.4 \xrightarrow{rounded} 2/3$$

Universities will be invited to accelerate knowledge transfer and elaborate novel solutions within the SGs. Relevant faculties will be those of e.g. civil, chemical, biotechnical, geodetic engineering, urban and landscape planning and economics.

7. General public

$$\text{Target value} = 25 \xrightarrow{\div 5} \text{FUA target} = 5$$

The general public is represented through actively involved community members (e.g. neighbourhood groups, students) in the co-working processes of the SGs (5 people/FUA) and communication activities e.g. shooting amateur promo movies linked to the pilots.

8. Small and Medium Enterprises (SMEs)

$$\text{Target value} = 15 \xrightarrow{\div 5} \text{FUA target} = 3$$

SMEs active in water industry, landscaping and social innovation will be involved in the SGs and will take important roles in the pilot actions developed under the project.

The previous sub-categorise should be present in each stakeholder group, instead for the FUAs of the countries specified below, the following additional typologies of subjects should also be involved in the SG.

9. Education/training centre and school

   Target value = 18 $\xrightarrow{\div 3}$ FUA target = 6 (only for Budapest, Maribor and Bydgoszcz)

   PPs of 3 FUAs, respectively in Budapest and in Maribor seek to invite representatives from kindergartens, primary schools and secondary schools to their SGs. In addition, Maribor and Bydgoszcz involve various training and education centres related to environment and agriculture.

10. Large enterprises

   Target value = 6 $\xrightarrow{\div 3}$ FUA target = 6 (only for Budapest, Maribor and Turin)

   PPs from 3 FUAs, respectively Budapest, Turin and Maribor will seek to invite larger companies to their SGs, made out of e.g. construction and manufacturing companies, banks and companies dealing with social innovation.

These are the categories and the number of people to be involved in each stakeholders group and they have to strongly collaborate. In order to make clearer the composition, for each stakeholder, Poliedra suggests that the following information should be specified:

- Stakeholder name;
- Target group (e.g. local public authority, general public, infrastructure provider, SME);
- Institution/Organization/Company;
- Specific role of the stakeholder within the organization (e.g. director of the water management department, biology teacher);
- Main competencies typology of the stakeholder: technical and/or administrative and/or political;
- Territorial coverage, when applicable (e.g. FUA, municipality, metropolitan city), and
- Reason for engagement.

It is a strong simplification, far away from the real mapping, but it is useful to understand roles and responsibilities of each one. In addition, they are also useful for a successful stakeholder management because they permit to tailor the content, the scope and focus to the interests and priorities of the stakeholders. Nevertheless, even if Poliedra suggested simple but fundamental information to be retrieved about stakeholder, no one of the project partners collected these information because it was not a project output neither a proper deliverable to be completed, therefore they did not collect this information.

It is one of the limits of the project not to have a structured mapping of the stakeholders. For further improvements this can be evaluated as one of the gaps to be overcome, but it is important to understand what CWC is seeking to achieve and stakeholders mapping is not among the objectives. The focus is on the importance of stakeholders and in their role within the project.

4.2.2 Stakeholder group activities and tasks

In this sub-section a general overview, not specific to this thesis but general for the project, of all the activities to which they should cooperate, coordinated by the Project Partners, and the tasks to be performed are pointed out in accordance with the Application Form, as mentioned above. They will be involved with different degrees and typologies of participation depending on the scope for which they have been invited to cooperate.

In each of the five FUAs, SG members take active part to:

- 5 stakeholder group meetings
- 1 FUA level competence building workshop

The tasks to be completed by the SGs are:

- Acquire knowledge and build self-competence regarding water efficiency and reuse;
- Co-develop with the Project Partners local vision, strategies, action plans and concepts with an official endorsement, take part in the participatory strategy building process;
- Co-design and verify local outcomes, through their regular meetings (5/each FUA) including those related to pilot actions;
- Aid the PPs to deal with the multi-level governance aspects of circular water management in the FUA creating a cross-sectoral cooperation, to be also used after the project closure.

In this thesis, among all the activities, the ones for which the methodology is developed concern the contribution of the SGs, in each FUA, to the participatory planning process building local strategies, visions and plans on urban circular water management. In particular, they co-develop local visions and co-create initial local documents paving the way to create the CWC strategies by setting the objectives, place-based targets and directions for circular urban water use, thus contributing to the design of the action plan and strategy, outlining desired interventions to utilize water efficiency measures and give suggestions for national policy recommendations and identify local (FUA-level) policy measures fostering urban circular water management. They provide their support based on their specific thematic background and experiences. A structured process to teach and train stakeholders to build cross-sectoral cooperation and to meet these needs will be produced in this context.

4.3 Ideation of the methodology

At this point, the spatial scale and people to be considered and involved to develop the learning process are pointed out. The questions that have been answered, until now, are: who and where; this was the starting point, coupled with the project objectives and requirements, for which the methodology was targeted.

Considering what has been said and what is contained in the Application Form, the idea at the base is to develop a framework that responds to the necessity of stakeholder active participation for each FUA. The engagement here is for the co-design and co-creation, with the project partners, of the basic elements for an action plan, strategies and policy measures in order to make the urban water management circular. This needs to be in line with the goals of the CWC project that are (see chapter 3):

- Recycle and reuse wastewater,
- Increase efficiency in water use and distribution,
- Guarantee good quality of water bodies,
- Retain water as long as possible on site,
- Promote multiple water use and water sustainability, and
- Preserve flow in water bodies.

These goals need to be achieved considering four areas of intervention in urban context:

- Water Governance,
- Water efficiency and water loss reduction,
- Rain water management, and
- Grey water recycling.

It is not so simple to find an agreement between all the parts because, as said in chapter 3, different stakeholders have different needs and perspectives. In addition to the problem of dealing with multi-stakeholders, there are the other problems, such as multi-level governance and the wide diversity of "external problems" (see chapter 3 paragraph 3.2.3) that arise in urban context, or even more when related to the FUA-level. As a consequence, a process that tries to consider, in its possibilities, all these aspects and that tends to coordinate and then to give the learning tools to overcome the problem related to the water sector will be the subject of this thesis. The final goal is developing plans and strategies that align the visions of the different stakeholders at stake and promote the cooperation between all the actors in order to reach the circular water management.

In addition to these difficulties, the process wants also to deal with the major problem related to the implementation of interventions that is to combine the political willingness, the social feasibility and the context in order to produce an effective solution and to implement it.

The learning process proposed is mainly made up by three components, each of which has a role in overcoming a specific problem in the organization of the water system to build cooperation:

1. FUA-level Status Quo self-assessment: analysis to highlight criticalities in the water system;
2. FUA-level public perception survey: analysis to detect possible social feasibility of intervention, education and population's priorities;
3. AP methodology: participative support for developing the key and essential elements of an action plan. This process is called "AP methodology" where AP stands for action plan.

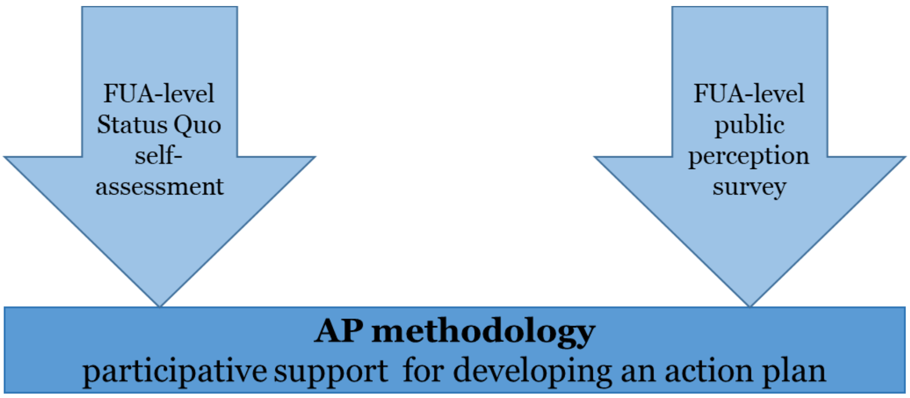

Figure 4.4 Structure of the complete process proposed.

The FUA-level Status Quo self-assessment and the FUA-level public perception survey are the input for the methodology because they constitute the basic knowledge stakeholders' need to have about the own local situation. They are the starting point from which the AP methodology can be implemented. The different components of the process are explained in detail and discussed below.

It is not a stringent procedure with defined rules but this is the nature of a participatory process like this one. It is not a mathematical process, it is a complex training and learning procedure suggested for dealing with complexities existing in the water sector. It is an educational tool both to allow to reach the final objective that is circular water management but also to build cooperation between stakeholders, each one can give its own contribution. Who will apply the process can make modifications or integrate steps to the proposed ones in order to improve the effectiveness in its precise context. Here the backbone is shown and it is characterized by enough flexibility in order to better adapt to the specific situations.

4.4 FUA-level Status Quo self-assessment: analysis to highlight criticalities in water system

The criticalities in the water system and in the management of water resources are multiple and differ one from the other. Thinking about what in the previous chapter was classified as "external criticalities", they can be clustered under: too much, too low and too polluted water. In order to deal with issues and make the water management circular many ways are possible and they are grouped under the CWC four areas of intervention.

In most of the cases it is very difficult to understand from where the real criticalities in the water system come from; due to the high complexity linked to the high interdependencies between the triggering factors and the high variety of causes. In order to understand what is behind, which are the most relevant factors on which actions are possible and what are the primary causes, a series of indicators are proposed to map the water-related situation at the FUA level.

The FUA-level Status Quo self-assessment constitutes the deliverable D.T3.1.1 named: "*Common manual on FUA level self-assessment and analysis of gaps and potential of circular water use*". Poliedra set the guidelines for the joint methodology for carrying out local self-assessment for mapping background conditions (legal, institutional, policy frameworks bottlenecks and good practices, local needs, potentials, etc.).

4.4.1 How to do the self-assessment?

The methodology constitutes a preliminary assessment to be carried out for each CWC FUA and then to be used as analysis instrument by stakeholder groups. The goal of this assessment is to map background conditions to understand real criticalities and challenges in order then to develop the most suitable and context specific policies, actions and strategies in line with the CWC principles. The assessment includes a wide range of information about different topics, everyone related to different impacts on water resources or on the management, such as: the environment, the population, the infrastructure related to the anthropic water circle and the climatic condition. Legal, institutional, policy frameworks bottlenecks and good practices, are also considered for analysing local needs and potentials.

The assessment requires both quantitative and qualitative baseline information that will help in understanding local critical issues and opportunities. The results of the assessments will allow stakeholders identifying the most suitable options of intervention in each FUA. The options will focus not only on water reuse intervention; but it will provide information to highlight local needs for intervention in a wider field than the sole water reuse, that are the four areas of intervention highlight in the project:

- Water Governance
- Water efficiency and water loss reduction
- Rain water management
- Grey water recycling

The assessment is not thought to be static: during the CWC project, it might be necessary to obtain more detailed data, depending on the water smart governance measures and techniques we will focus on. In addition, this is the common framework for every FUA, eventually, different FUAs can have different focus, in order to take into account different physical and legislative frameworks. This assessment is therefore to be intended as a common baseline shared by all the FUAs, which can be dynamically developed during the project.

The assessment is carried out based on 44 indicators revealing the status quo at the FUA-level regarding six main topics, identified among all the possible drivers that influence the urban water cycle:

- Climate, population and territorial configuration;
- Natural water resources;
- Infrastructures enabling the anthropic water cycle;
- Water consumption;
- Potential issues arising due to climate change;
- Local laws and rules regulating the anthropic and natural water cycle and good practices.

Most of the proposed indicators are quantitative, with the intent to be precise and allow a proper comparison with targets or scenarios. However, whenever, because of data scarcity, it is impossible to assign quantitative values to an indicator, qualitative answers are allowed and expected, in order to guarantee completeness to the assessment.

In the next paragraphs, the list of the indicators by topic is shown, a brief description of the motivation of the choice is present and it is also suggested how to assess the status quo. The role of stakeholder groups is to support populating the indicators and doing the evaluation. This assessment is one of the bases for the action plan co-development.

Indicators always refer to the FUA level, because according to the AF the self-assessment has to be done at this level. However, a few observations are needed in this regard. As mentioned previously, in the paragraph related to the spatial scale, FUAs are usually not the territorial units for monitoring activities and data collection. Most of the existing data collected and published by various sources (e.g. environmental agencies and public administrations) refers to different territorial units, such as administrative areas, or areas served by a single service provider (e.g. sewage and water treatment companies).

In some cases, therefore, populating a quantitative indicator at the FUA level can be too difficult or too costly given the available time and budget. Therefore, each FUA will be responsible to decide which data can be retrieved or easily reconstructed (e.g. by summing available partial data for the municipalities composing the FUA). The ideal situation would be that this happens for all of the indicators required, but this depends very much on the local situation. In order to populate those indicators for which data are not easily available at the FUA level, an alternative procedure is envisaged in the following.

When data for an indicator are not easily available at the FUA level, it is possible to start from data at a different territorial level and give an estimate of the indicator at the FUA level. Such an estimate can be quantitative or qualitative but, in any case, it is necessary to clearly explain the connection between the territorial unit considered, for which the data is available, and the FUA, and how the estimate at the FUA level has been obtained. Examples of territorial units considered can be a metropolitan area similar to the FUA, or one of the Municipalities belonging to the FUA.

The alternative procedure to populate indicators can therefore be synthesized in two steps:

1. Find measured data for a territorial unit as much as possible representative of the FUA specifying the territorial unit they refer to. Specify also the relationship between the territorial unit considered and the FUA;

2. On the basis of the data retrieved make an estimate at the FUA level, specifying how it has been done (procedure and hypotheses).

The alternative procedure should be used within each FUA self-assessment for the minimum number of indicators, only when retrieving data to populate an indicator at the FUA level is too demanding or impossible given the time and budget constraints; in addition, the procedure used and the spatial level considered must be always reported in the section "*Notes* " for each parameter where changes are made.

The compilation should be done by project partners with the help, if needed, of stakeholders. Involving stakeholders could be a good choice and the starting point for the cooperation process that allows also stakeholders having a first approach with the tool that they will use to develop strategies of intervention, as it will be seen in the last step of the process that is the "AP Methodology".

4.4.2 Indicators and questions

In this sub-section, all the indicators and questions are reported with a brief explanation of the choice of the parameter. The data should be always referred to the year 2018, or if time span are considered, the temporal span should finish in 2018 because data referring to 2019 are not still available. In addition, data should be represented in graphs, tables or maps as much as possible.

4.4.2.1 Climate, environment and population

The first group of indicators aims at providing a basic overview of the territory (FUA) in terms of population, weather conditions and soil use. These information, and especially their trends, are fundamental to frame all the further investigation.

Although most of the base indicators are numerical, a thematic map, if available, can provide a better information in terms of localization of the environmental components.

POPULATION

Indicator	unit	area	year	Notes
1) Population living in the FUA in 2018	-	FUA	2018	
2) Population change in the last 20 years in the FUA	%	FUA	1998-2018	If the data are not available a different time windows can be provided

Motivation: First of all, these data suggest the civil water demand to be addressed; then, a fast growing population can make necessary a further development of the fresh water and wastewater networks, or, with a CWC approach, the new development of water reuse facilities and recycling practices.

CLIMATE

Indicator	unit	area	year	Notes
3) Monthly average temperature (max and min)	°C	FUA	1998-2018	

4) Average relative humidity in summer months	%	FUA	1998-2018	

Motivation: These indicators are directly correlated to the evapotranspiration and soil infiltration, components of the natural water cycle.

SEALING SOIL

Indicator	unit	area	year	Notes
5) FUA total area	Km^2	FUA		Attach a map with municipalities' borders.
6) Percentage of sealed soil	%	FUA	2018	Attach a thematic (sealed soil vs not sealed soil) map if available
7) Time series of the percentage of sealed soil	%	FUA	1998-2018	If the data are not available a different time windows can be provided

Motivation: These parameters refer to the sealed soil and how it is changed during the past 20 years. The map here is very important because allows to understand also the distribution of these areas, thus highlighting in which parts of the FUA there will be more problems. They have different effects on urban water cycle, such as an increasing soil sealing negatively affects the recharge of the aquifer, but also causing urban floods due to the reduced soil infiltration and favouring the transport of contaminants to neighbouring areas, suggesting to take measures to as water reuse or increasing green and drainage areas to contribute in solving the issue.

GREEN SPACES IN URBANIZED AREAS

Indicator	unit	area	year	Notes
8) Green area in the entire FUA	Km^2	FUA	2018	
9) Percentage of green spaces within urbanized areas	%	Urbanized area in FUA	2018	Describe how the green spaces are positioned within the urban area: are they well merged (e.g. small green areas in between buildings), or green spaces and buildings areas are well separated (e.g. few large parks)? Attach a map of green spaces if available.
10) Time series of the percentage of green spaces within urbanized areas	%	FUA	1998-2018	If the data are not available a different time windows can be provided

Motivation: This section is directly correlated to the previous one, it is its counterpart. It is fundamental to compute the soil infiltration, component of the urban water cycle. The map here is very important because allows to understand also the distribution of these areas, thus highlighting in which parts of the FUA there will be more problems. It is an overview on the extension of green spaces within the FUA perimeters could help, for instance, in evaluating the significance of water reuse directed to the irrigation of plants and trees or where is the necessity to increase the amount of green spaces.

4.4.2.2 Water resources

The second group of indicators aims at providing a basic overview of the amount of natural water resources and of the natural processes in the FUA.

Quantitative and qualitative aspects are taken into account in order to highlight in each FUA potential local critical issues. The results of this part of the assessment can clarify the urgency and the type of water reuse facilities and practices to be adopted in each FUA.

ANNUAL PRECIPITATION

Indicator	unit	area	year	Notes
11) Average annual precipitation	mm	FUA	2018	
12) Monthly precipitation	mm	FUA	2018	
13) Trend of annual precipitation	mm	FUA	1978-2018	If the data are not available a different time windows can be provided

Motivation: Precipitations constitute one of the main sources of water. The monthly precipitation indicates the distribution during the year, indicating if there are drier or wetter periods or if the trend is constant over the year. Annual precipitation can provide information about the suitability of rain harvesting facilities and the need of water for irrigation. The trend during the years is instead indicating how the amount of annual precipitation varied.

RIVER, CHANNELS AND LAKES

Indicator	unit	area	year	notes
14) List of main rivers and channels within the FUA, and their flow rate (average 2018 and monthly flow 2018)	m^3/sec	FUA	2018	
15) Synthetic water quality evaluation for each of the rivers and channels identified	qualitative	FUA	2018	
16) List of main lakes and reservoirs within the FUA, and their water storage (average 2018 and monthly variation 2018)	m^3	FUA	2018	

17) Synthetic water quality evaluation for each of the main lakes and reservoirs identified	qualitative	FUA	2018	

Motivation: The presence of water bodies and their quality is here analysed. Information about the "general health" of water bodies can suggest possible uses of their water and the effects of directing water reuse towards the recharge of aquifer or surface water bodies. Specify also the location because they can present both an opportunity but also a threat.

GROUNDWATER

Indicator	**unit**	**area**	**year**	**notes**
18) Temporal variation of the Groundwater level	m	FUA	1998-2018	Graphs, if available, could be more significant. Extra info, if available, could be the water quality (chemical and biological).

Motivation: The groundwater level represents the sum of the anthropic and natural effects on the underground water system in quantitative terms, that is, the withdrawal of water and the recharge of the aquifer. The trend highlights the areas of the territory on which there is a quantitative environmental criticality, or the areas in which the availability of groundwater resources is threatened by the withdrawal regime and / or by the alteration of the natural recharge capacity of the aquifers. The extra information on water quality are useful to understand if there are contaminated sites.

Note: For future implementations and improvements of the questionnaire, the information regarding the flow rates withdraw (annual and monthly averages) by the aquifer should be added, which was not considered in this first version.

4.4.2.3 Infrastructures

The third group of indicators intends to list in each FUA the main infrastructures and facilities that convey the anthropic water cycle. Eventual critical issues could partially be solved by implementing actual water reuse facilities and policies. For example, a low treatment capacity could be solved by reducing the amount of water directed to the wastewater treatment plants increasing the reuse of greywater. On the contrary, some issues could rise the need for interventions other than those related to water reuse (e.g. water distribution network maintenance). Information about existing infrastructure for water reuse as dual network for water supply or wastewater collection can address the water reuse options in each FUA.

WATER DISTRIBUTION SYSTEM - POPULATION WITH ACCESS TO FRESH WATER

Indicator	unit	area	year	notes
19) Percentage of population with access to the water supply network	%	FUA	2018	
20) What kind of drinking water purification/treatment is used, what is planned?	-	FUA	2018	Open question
21) Tap water quality - lab test results (PH, Fixed residue 180 ° C , Hardness, Conductivity, Calcium, Magnesium, Ammonium, Chlorides, Sulphates, Potassium, Sodium, Arsenic, Bicarbonate, Residual chlorine, Fluorides, Nitrates, Nitrites, Manganese, ...)	-	-	2018	

Motivation: In European Union, there are usually no problem in the access of fresh water supply, but it is still a good information to be pointed out; also the purification system and the quality that they can provide, it allows to understand if they can provide potable water capable of satisfying European standards.

WATER DISTRIBUTION SYSTEM LOSS

Indicator	unit	area	year	notes
22) Percentage of loss in the water supply network	%	FUA	2018	In case of different values within the FUA, the average can be calculated weighting on the network length

Motivation: Water losses occur in every water distribution system during its overall operational lifetime. The aim to eliminate them completely, despite their environmental benefits, is unattainable and economically unprofitable, therefore water utilities try to reduce them to an economically reasonable level (which have been demonstrated to be approximated to 8 - 10% or 5 - 6%, depending on the water source (FBR, 2019)). Having in mind that they are mostly due to leakages, deteriorating infrastructure and illegal connections, it is possible to act on these factors to improve the efficiency of the system.

DUAL WATER DISTRIBUTION SYSTEM

Indicator	unit	area	year	notes
23) Description of eventual dual system water supply network within the FUA	-	FUA	2018	

Motivation: Dual distribution systems are used to supply potable water through one distribution network and non-potable water through a separate one. This technology allows the use of cheaper sources of water for non-consumptive purposes, which may currently be served from more expensive, and limited, potable water supplies.

FIRST FLUSH RAINWATER COLLECTION

Indicator	unit	area	year	notes
24) Qualitative description of the first flush rainwater collection technique implemented, if any	-	FUA	2018	Please specify and describe the different first flush rainwater collection typologies implemented

Motivation: This answer allows to understand if there are already forms of rainwater harvesting within the FUA.

WASTEWATER COLLECTION

Indicator	unit	area	year	notes
25) Percentage of households and percentage of industries connected to the wastewater collection network	%	FUA	2018	

Motivation: As said for the water supply, in European Union, there are usually no problems in the access of wastewater system, but it is still a good information to be pointed out.

SEPARATE WASTEWATER COLLECTION SYSTEM

Indicator	unit	area	year	notes
26) Description of eventual separate wastewater collection system within the FUA	-	FUA	2018	

Motivation: Separate sewerage consists in the separate collection of municipal wastewaters (black water from toilets, greywater and industrial wastewater) and surface run-off (rainwater and storm water). The separate collection prevents the overflow of sewer systems and treatment stations during rainy periods and the mixing of the relatively little polluted surface run-off with chemical and microbial pollutants from the municipal wastewater.

WASTEWATER TREATMENT PLANTS

Indicator	unit	area	year	notes
27) List of wastewater treatment plants and their population equivalent capacity compared to the actual population	-	FUA	2018	
28) What kind of wastewater treatment is realised, what is planned?	-	FUA	2018	Open question

Motivation: These answers are needed to understand if the existing and planned wastewater treatment plants can satisfy the needs of the FUA, now and in the future.

TREATED EFFLUENT

Indicator	unit	area	year	notes
29) Annual volume of waste water treated by the wastewater plants	m^3	FUA	2018	If available, more information could be useful about treated effluent: Quality Specifications of the Treated Effluent Treated Effluent Reused for Irrigation (Volumes) Uses of Treated Effluent (% to Irrigation, Aquifer Recharge, Reservoir/dam, Discharge to sea/river) Restriction on the type of crops irrigated

Motivation: Indicative number to be compared with water withdrawal and uses. Additional information on reuse of treated effluents, if there are, are much more important.

4.4.2.4 Water consumption

This section intent to show indicators that cross the information gathered in previous sections. The aim is to explicit if the natural resources and the facilities fulfil all the population needs in relation with water resources. Indicators about water consumption can explicitly show the actual need for water reuse intervention.

FRESHWATER EXTRACTED

Indicator	unit	area	year	notes
30) Annual volume of freshwater extracted from the ground, surface water, and other sources.	m^3	FUA	2018	

Motivation: Indicative absolute number to be compared with the following indicators.

FRESHWATER USED/CONSUMED BY POPULATION

Indicator	unit	area	year	notes
31) Daily volume of freshwater used by each person for civil uses	l/day per capita	FUA	2018	
32) Consumption of bottled water for drinking purposes	l/day per capita	FUA	2018	
33) Initiatives to reduce consumption of bottled water	qualitative	FUA	2018	Qualitative description

Motivation: These indicators are needed to understand civil water uses habits, to be compared with mean target values. In addition also the initiatives, if there are, to reduced bottle water are an information to understand if something could be done in this direction.

The last parameter is more related to sustainability than circularity. Considering this section, public raising awareness campaign can be a possible solution to increase sensibility to these themes.

WATER USE SHARES (CIVIL, INDUSTRY, AGRICOLTURE, ETC.)

Indicator	unit	area	year	notes
34) Percentages of water used by the civil, industry, and agriculture, etc. sectors	%	FUA	2018	

Motivation: To understand which is the sector that covers the largest part of the market. It indicates also the most relevant consumer and therefore the sector on which focus efforts for the planning of strategies.

WATER STRESS INDICATOR

<table>
<tr><th>Indicator</th><th>unit</th><th>area</th><th>year</th><th>notes</th></tr>
<tr><td>35) Class of water stress of the FUA according to Falkenmark Indicator</td><td>-</td><td>FUA</td><td>2018</td><td>Falkenmark Indicator: based on the measure of water availability per capita per year within the FUA.
<table>
<tr><td>Index (m^3/capita/year)</td><td>Class</td></tr>
<tr><td>>1,700</td><td>No stress</td></tr>
<tr><td>1,000 – 1,700</td><td>Stress</td></tr>
<tr><td>500 – 1,000</td><td>Scarcity</td></tr>
<tr><td>< 500</td><td>Absolute scarcity</td></tr>
</table>
</td></tr>
</table>

Motivation: Indicator that represents water scarcity. It is difficult to find this parameter at the FUA level because it is usually computed at country level. This is one of the possible indicators of the pressure on water resources, others exist. It is a fast and intuitive parameter to understand if there are problems related to availability of water resources.

WATER MANAGEMENT COMPANIES

Indicator	unit	area	year	notes
36) List of the private/public companies that manage the anthropic water cycle (extraction, sanitation, distribution, collection, depuration)	-	FUA	2018	

Motivation: Needed for the management part, it is important to delineate which are the companies who operate in the water system, therefore they will be one of the first people to deal with regarding policy and laws implementation.

4.4.2.5 Climate change

The section is intended as an open question where each CWC partner have the opportunity to report eventual critical issues risen in recent years, or expected in the near future, in relation with climate change. In the next years climate change could bring significant deviations from the present trends described in the previous sections. Even though a clear quantitative forecast could be uncertain, a qualitative assessment can provide huge support in envisaging the actions to be taken in the near future and, in particular, in understanding which water reuse facilities and practices to foster circular water use can be most suitable.

ISSUES ARISING DUE TO CLIMATE CHANGE

Indicator	unit	area	year	notes
37) Description of the issues, if any, raised by climate change (e.g. floods, high temperature, water scarcity, …)	-	FUA	2018	

Motivation: Due to the fact that, as highlight in chapter 2, climate change has an impact on water resources, if some forecasting has been made it is useful to point it out in order to plan adaptive strategies and policies capable to deal also with future trends and uncertainty.

4.4.2.6 Rules, laws and good practices

The last section of the assessment aims at framing the existing baseline in terms of rules and laws already existing in the FUA. This section is particularly important since the design and implementation of new governance measures and policies are the final goal of the CWC project and here below some are listed from which it is possible to take ideas or inspirations. As for instance, by applying water pricing system regulations that can act in two different ways, on one side by increasing the water selling rate of fresh water in order to inhibit the consumption of it and on the other side by reducing the water price of the reclaimed water with the aim to foster and encourage the use of recycled water.

It is not given the precise motivation of each of the following indicators, they are needed to delineate if there are already some “good practices” or not, so there will be much more difficulties in breaking the barriers and in implementing changes also in regulations.

PRICING SYSTEM FOR WATER

Indicator	unit	area	year	notes
38) Pricing system for different water uses (e.g. Irrigation, Civil, Industrial)	€/m^3	FUA	2018	

RESTRICTION IN WATER USE

Indicator	unit	area	year	notes
39) Description of restrictions in water use, if any	-	FUA	2018	

LEGISLATION ABOUT DUAL WATER DISTRIBUTION SYSTEM

Indicator	unit	area	year	notes
40) Description of the legislation about dual water distribution system, if any	-	FUA	2018	

LEGISLATION ABOUT WATER REUSE

Indicator	unit	area	year	notes
41) Description of the legislation about water reuse, if any	-	FUA	2018	

LEGISLATION ABOUT FIRST FLUSH RAINWATER COLLECTION (e.g. streets)

Indicator	unit	area	year	notes
42) Description of the legislation about first rainwater collection, if any	-	FUA	2018	

In conclusion, this is the proposed list of indicators and the guidelines produced by Poliedra. Improvements or modifications when applied in different context can be done to make it more specific, remembering that the aim is to delineate the existing scenario within the FUA to be dealt with. Remember also that this list is proposed as a tool to be used to clarify criticalities and opportunities in water system and develop reasoning.

In addition, this is the base list: in order to allow for comparisons between different FUAs the manual suggests not to delete indicators but eventually to add others because the data needs also to be comparable within the FUAs.

4.4.2.7 My contribution:

I did some initial researches on internet and in literature to understand which indicators could make sense and be effective in this context. After some studies, I proposed some of the indicators. The complete list was born from discussion and sharing of opinions with the whole working group of Poliedra, of which I was a member. I also contributed to the drafting and writing of some parts of the project report.

4.5 FUA-level public perception survey: analysis to detect possible social feasibility of intervention, education and population's priorities

The second part of the knowledge base which is used for the learning process is composed by the public perception survey. After having built the scenario related to the water system within the FUA, it is the time to detect the social feasibility of possible interventions and water usage habits, in order to elaborate plans and strategies that best suit public willing. One, among others, of the possible way to detect public perception has been found by using an online questionnaire in order to reach as much as possible citizens and the different categories of people. This method is chosen because it is thought to be the easiest and less time and money consuming in comparison, for instance, to personal interviews.

The questionnaire and the guidelines are developed by Poliedra. They are contained in the deliverable D.T3.1.2 named: "*Common guideline to carry out public perception surveys in each FUA involved*"; it consist of a questionnaire on water usage habits and on the attitude on water reuse to be filled in by the citizens of each FUA.

4.5.1 How to develop the survey?

The survey proposed is to be filled in by the population and the results needs to be analysed jointly by project partners with the stakeholders involved. The aim is to develop the most suitable policy, governance and planning measures for the city that tackle the problems identified with the status quo assessment, but that can be also socially acceptable. In addition, it permits to understand if and how much education is necessary, and what are the priorities from the point of view of the population. Starting from this idea the questions are created. The methods on how to develop the survey is shown and described in the following.

The objective of the survey is set, the second step is to decide the nature and the size of the sample of people to be interviewed from the whole population.

4.5.1.1 Sample nature and size

In line with the European rules on privacy (General Data Protection Regulation (GDPR), EU n. 2016/679), anonymity is guaranteed by the methods of the investigation and for the protection of minors we exclude from the survey the population below the age of 16. The target population of the survey is therefore the entire population of the FUA aged 16 and over. Surveying every single person of the FUA is obviously not an option. Therefore, it is necessary to address a population sample that should be as much as possible representative of all the citizens living in the FUA.

Here indications are given, based on statistical procedures, about the determination of the sample size and composition. These indications have to be adopted as much as possible in each FUA, compatibly with the time and budget constraints of CWC project. In order to obtain the best possible results, stakeholders' strong commitment and participation will be necessary.

The determination of the sample size (minimum number of questionnaires filled in) is crucial for the validity and accuracy of the survey, since if it is too small it will not yield to valid results. On the other hand, if it is too large it will lead to a waste of time and money.

In the literature there are several ways to determine the sample size given the population size, which is a known value. All the methods I refer to are valid for a perfectly random sample. The meaning of this, and how we can approach it in CWC survey, will be explained in the next paragraph. Just keep in mind that the sample size has to be combined with the condition about its distribution.

Most methods for the determination of the sample size are based on two parameters: the margin of error and the confidence level.

The margin of error expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter. To be meaningful, the margin of error should be qualified by a probability statement (often expressed in the form of a confidence level)[9]. For example, if you use a margin of error of 3% and 47% percent of your sample picks an answer, you can be "sure" that, if you had asked the question to the entire target population, between 44% (47-3) and 50% (47+3) would have picked that answer. The usually accepted margin of error is 5%.

The confidence level tells you how "sure" you can be. It is expressed as a percentage and represents how often the true percentage of the population who would pick an answer lies within the margin of error[10]. The 95% confidence level means you can be 95% certain; the 99% confidence level means you can be 99% certain. Most researchers use the 95% confidence level. When you put the margin of error and the confidence level together, you can say, giving values respectively of 5 and 95%, that you are 95% sure that, if 47% percent

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[9] According to the definition retrieved from: https://stattrek.com/statistics/dictionary.aspx

[10] According to the definition retrieved from: https://researchbasics.education.uconn.edu/confidence-intervals-and-levels/#

of your sample picks an answer, the true percentage of the population that would pick the answer is between 42% and 52%.

The required sample dimension increases as you lower the margin of error you are willing to accept and as you raise the confidence level you want to have.

The sample dimensions needed in CWC FUAs is computed keeping the margin of error and the confidence level to their most frequently accepted values of 5 and 95% respectively. In general, the exact dimension of the target population in each FUA is not known because the data of the overall population is available but the number of young people below 16 (excluded from the sample) is unknown, it could be better analysed when the data elaboration for each FUA is done, but for establishing the target number of questionnaire valid for each FUA, the overall population is considered. In CWC FUAs it ranges from 320.000 people of Maribor FUA to 2.970.000 people of Budapest. Therefore, it is considered a range of the target population going from 200.000 to 3.000.000 people, certainly including CWC FUAs range.

To define the sample dimension we used two different methods, the one by Yamane[11] (1967) and the one by Cochran[12]. The results of the two methods are reported in the following table:

Table 4.2 Sample dimension obtained by applying the Yamane and Cochran method.

	Sample dimension according to:	
Population	Cochran	Yamane
200000	383.43	399.20
300000	383.67	399.47
500000	383.87	399.68
1000000	384.01	399.84
3000000	384.11	399.95

These results can be compared with those of tables using other methods easily available in the literature and online (see for instance https://www.checkmarket.com/blog/how-to-estimate-your-population-and-survey-sample-size/ and https://www.surveymonkey.com/mp/sample-size/) obtaining similar results.

It is possible to notice that the sample dimension in all of the considered range should be substantially the same. The sample dimension in fact tends to be almost constant over certain population values. We can say that having 380-400 questionnaires with the proper distribution answered in each FUA is our goal. In order to get the proper sample stratification, it could be necessary to collect more answers and to discard some of them, in

[11] See: https://www.tarleton.edu/academicassessment/documents/Samplesize.pdf
[12] See: https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/find-sample-size/

order to obtain 380-400 with the proper distribution. In the next paragraph there is a more extensive explanation about that.

4.5.1.2 Sample composition

In addition to sample dimension, a second factor influences the reliability of the results is the sample composition. In principle, the sample should be extracted completely randomly among the whole target population. In our case, the target population is the whole population of the FUA from 16 years onwards. The sample should have the same stratification than the target population, i.e. the same percentage of males and females, the same income distribution, the same cultural characteristics, age distribution, etc.

A perfectly stratified sample is beyond the possibilities of CWC project, because many characteristics should be considered; therefore, we propose a simplified approach, considering only three main factors:

- Gender (% M/F)
- Age (% 16-25, % 26-65, %66+)
- Place of residence (within the FUA)

As for the gender consider the percentage of males and females of the target population.

As for the age, consider a simple distribution within the target population: percentage between 16 and 25, percentage between 26 and 65, percentage over 66 (sum of the three equal to 100%).

As for the place of residence, a possible approach is to consider the percentage of the target population living in each of the municipality of the FUA and try to respect in the sample the same percentages. However, this could be too complex to be done in some of CWC FUAs, for instance in Budapest where there are 199 municipalities. It is therefore suggested to subdivide the FUA into 2-3 “homogeneous areas”. A possible subdivision could be:

- Area1: central urban area;
- Area2: peri-urban densely populated area;
- Area3: area more distant from the central urban area, less densely populated and with more rural vocation.

This is only a possible and not strict suggestion, the real subdivision should be generated and detailed in each FUA - more precisely than in the example - according to its characteristics. Hence, consider the percentage of target population living in the individuated areas, the subdivision is a choice of each FUA.

If the data of the three categories proposed are not available nor easily computable for the target population, it is possible to take as reference the value for a different territorial unit, as much as possible similar to the FUA (e.g. metropolitan area).

Ideally, the sample (number of completed questionnaires) composition should respect the same percentages computed among the target population for gender distribution, age classes, and areas of residence distribution. This could again be a requirement too complex to be met precisely in FUAs, but efforts should go in that direction. In particular, all the areas should definitely be represented in the survey, since in the application form it is stated that the survey would be at the FUA level.

4.5.1.3 Survey distribution

The questionnaire was available online, through Google forms, and it is also possible to print it and distribute to the population during project events. The Google form questionnaire can be easily filled also with a mobile phone.

Questionnaires filled online have a series of advantages: the respondent's high sense of anonymity, the lack of intimidating direct contact with the interviewer and very low cost, including no need to copy all the answers in a proper analysable file. However online research is unable to draw representative samples for the population, as there is no proper sampling frame for this purpose and a low level of research implementation, cause gaps in the group composition.

Therefore, it is proposed to use a mixed technique in order to obtain a sample with the required characteristics. First do the randomly distribution of the questionnaire (in paper and online compilation) at fairs and events, then do the interviews knowing what need to balanced and to add. During the survey activity in events and fairs, a short web link and a QR code linking to the Questionnaire can be provided. Citizens can answer in real time on paper or online, eventually with technical assistance, using the paper questionnaire or their telephone or laptops connected to the Google form questionnaire. Then, the best way to balance the sample characteristics and obtain the needed number of answers is to send interviewers in public places (for instance public parks and places where people have to wait and get bored) and ask people to answer. The interviewer can select gender and (approximately) age, while the places (municipalities) where the interviewers go will strongly affect the dwelling place of the interviewees, in particular in the more remote areas.

4.5.1.4 How to customize the Questionnaire for each FUA

In the next section the questionnaire is shown, but some clarifications should be done because some adaptations are necessary:

1. The questionnaire is here proposed in English but each FUA must translate every question/answer in its national language;
2. Question 3 contains the list of municipalities of the FUA considered. The goal of this question is to determine if the interviewed belongs to the FUA, and if so to which of the FUA Areas. It is possible to modify this question, for instance asking the Post Code or letting the interviewed write his/her municipality;
3. Question 10 needs to be customized in each FUA by writing the name and the percentage of losses in water supply network;
4. Each FUA should take these questions as a shared basis and do not modify or delete the existing questions, to allow for a comparison between FUAs. Each FUA can decide to add questions if needed.

4.5.2 Questionnaire

All the questions proposed are multiple choices in order to make the elaboration of results easier. The complete questionnaire to be filled in by the citizens is reported below.

Table 4.3 Public Perception Questionnaire.

<table>
<tr><th colspan="2">SECTION 1 - GENERAL INFORMATION</th></tr>
<tr><td>1. Gender
Mark only one circle
◯ M
◯ F</td><td rowspan="2">3. Select the Municipality where you live. If you don't find it in the list, leave the field blank
Mark only one circle
◯ A…
◯ B…
◯ C…
◯ ….
Insert the complete list of the municipalities within the FUA</td></tr>
<tr><td>2. Age
Mark only one circle
◯ 16-25
◯ 26-65
◯ 66+</td></tr>
</table>

SECTION 2 - PERSONAL USES

4. How do you use water at home?
Mark only one circle per row

	Yes	Sometimes	No
I turn off the tap when I shave or brush teeth	○	○	○
I make sure that water installation at my home are tight (e.g. tube, taps,..)	○	○	○
I water the garden / flowers on balcony with rainwater	○	○	○
I collect water from washing fruit and vegetables and later use it for watering plants	○	○	○
I drink tap water	○	○	○

5. Do you have in your household these facilities?
Mark only one circle per row

	Yes	No	I don't know
Dual flush WC	○	○	○
Water saving faucets	○	○	○
Water saving shower head	○	○	○
Water meter	○	○	○

6. When you choose between tap water and bottled water, how important are the following factors?
Mark only one circle per row

	Low	Medium	High
Health effects	○	○	○
Taste	○	○	○
Cost	○	○	○
Convenience / Carrying comfort	○	○	○
Reduce plastic consumption and bottles transport	○	○	○

7. The products we use/eat consume water, e.g. for production and transport. For example: a sheet of paper requires 10 liters of water, a steak 2500 liters, 100 grams of bread require 160 liters, a coffee 130 liters, a T-shirt 1000 liters.

Mark only one circle per row

	Yes	No
Did you know these values, or similar ones?	○	○
Are you willing to change your habits to reduce your impact on water?	○	○

8. Do you know your annual water supply expenditure?

Mark only one circle

○ Yes

○ No

9. Do these factors motivate you in saving water

Mark only one circle per row

	Low importance	Medium importance	High importance
Environmental reasons	○	○	○
Economic reasons	○	○	○

SECTION 3 – PROPER WATER USE AND REUSE

10. In (FUA name), due to leaks in the water pipes, (% of losses) of the water from the aqueducts gets lost.

Mark only one circle per row

	Yes	No
Did you know this percentages?	○	○
Do you think that fixing the water leaks is a priority in the area where you live?	○	○

11. Rainwater can be collected and used for non-potable purposes (watering the plants, flushing the toilet, car washing, ...) through proper installations

Mark only one circle per row

	Yes	No
Did you know it?	○	○
Do you think these installation should be more widespread?	○	○

12. Water can be partially reused in houses through proper installations (for example the water from the shower or sink can be stored to feed the toilet flush)

Mark only one circle per row

	Yes	No
Did you know of this possibility?	○	○
Do you think these installation should be more widespread?	○	○

13. "Green roofs" are plant coverings of the buildings that serve several purposes such as absorbing rainwater, providing insulation, creating a habitat for wildlife, helping to lower urban air temperatures during the summer.

Mark only one circle per row

	Yes	No
Did you know about Green roofs?	○	○
Do you think Green roofs should be more widespread?	○	○

14. Due to climate change, the water cycle will undergo major changes in the coming years. Are you afraid of the following possible phenomena in your area?
Mark only one circle per row

	Very afraid	Moderately afraid	Not afraid
Short but heavy rains	○	○	○
Drought periods	○	○	○
Floods	○	○	○
Water supply problems	○	○	○
Raising costs for water supply and wastewater collection	○	○	○

15. How useful do you consider information campaigns to favor a proper use and reuse of water?
Mark only one circle

- ○ Not very useful
- ○ Useful
- ○ Very useful

4.5.2.3 My contribution:

I developed and structured the guidelines on the sample size, nature and composition after some studies and researches on internet. I wrote the related part on the project report.

The final version of the questionnaire comes from sharing of ideas between the working group of Poliedra, of which I was part.

4.6 AP methodology: participative support for developing an action plan

This is the core of the process, where the results coming from the previous analysis are examined directly by the stakeholders group during a workshop / meeting. The tools previously provided constitute the data and the knowledge base, starting from which stakeholders develop local visions, strategies, policy and planning measures, which municipalities (and FUAs) then can take as reference to develop “actions”.

The question is: how to combine different perspectives and needs to reach the common goal of circular urban water management? In a complex sector, like the water sector is, there is the need of cooperation between stakeholders: a structured group workshop, in which SG should actively participate and where they can give their contribution, seemed to be the best choice to open the discussion and collect the first proposals, according also to the Application Form of the project.

4.6.1 Methodology

Poliedra was in charge of the development of the methodology. It is born from the need to organise the core Master Training (MT) in Milan that is a 1.5 day long interactive core training session providing the essential knowledge base on circular urban water management, addressed to Project Partners and Associated Partners, but this complete process is proposed for stakeholders meeting.

In fact, the “AP Methodology” was designed for and constitutes the model for the 1-day long local competence building workshops that will be organised in the five participating functional urban areas (1 in each), in national language for the stakeholder group members. The validity of this process was tested during the core Master Training in order then to use and reproduce it in the other contexts (with appropriate modifications / adaptations).

The general methodology is described below and the application during the core MT will be shown in the next chapter.

In the context of the CWC project, this methodology can be found in the deliverable D.T1.3.3: “*Methodology of the core Master Training*”, prepared by project partner Poliedra. The deliverable contains the complete approach of the core MT, but in this thesis the focus is only on the AP methodology and in the following it is explained.

IDEATION: Poliedra was in charge of the ideation and management of the activities for the core MT and it was also specified that these one should be interactive. In particular, after some discussions between Poliedra's members, researches in literature and online, the idea of how to develop activities for the workshop arose. Specifically, the starting model was the European Awareness Scenario Workshop (EASW), taking it as reference and inspiration, then we designed the workshop by adapting and changing the model according to our needs, requirement and goals.

The "AP Methodology" is designed to last one day, it is mainly devoted to a "Group game" on case studies, exploring structured involvement of stakeholders for the building of a shared vision and the identification of strategies of intervention for circular water management in a city. The emergence of collective intelligence is favoured through facilitation and the use of appreciative gaze.

The aim of the game is to give participants the experience of a smart water governance process and of how to build it. The active and participatory approach is a key component of the game; participants, their knowledge, experiences and ideals are the protagonists of the learning process. It leads to find criticalities in the water system, analysing the public perception and social feasibility of intervention and then in developing the essential elements on which the action plan for the city should be based.

Table 4.4 Summary table with the key elements of the AP Methodology.

ORGANISER	Project Partner in charge within each FUA
DURATION	1 day-long
LOCATION	One in each FUA
PARTICIPANTS	Stakeholder group of the FUA (23-34 people)
LANGUAGE	National language
OBJECTIVE	Develop local visions, strategies, policy and planning measures, Create cross-sectoral cooperation
MATERIALS	FUA-level Status Quo Self-Assessment, Results of FUA-level Public Perception Survey

TIPS:

- Facilitators should be present for the entire duration of the activities, managing the interactive parts. They eased the dialogues, encouraged participants to think productively, express themselves and find solutions;
- In order to allow the active involvement of everyone, divide participants in sub groups of 10-15 people, each group working independently or it is also possible to give different time scales of intervention;

- The subgroup formation is done considering the role, area of expertise or stakeholder category from which they belong to, in order to make group homogeneous and with all the categories represented;
- The number of subgroups and the number of facilitators are determined by practical reasons, considering the available budget (i.e. how many facilitators can be paid) and the number of participating stakeholders, it is a decision of organiser. Consider also that in small groups it is easier to make everyone talk, but then it is more difficult to make the synthesis between all groups (when everyone works on the same real case).
- Before the starting of the core activity, predispose some icebreaking session in order to create cohesion and improve the atmosphere, increase participation and productivity and gain knowledge about the participant profiles.

4.6.2 "AP Methodology" vs the EASW method

In this paragraph, there is a brief explanation of the European Awareness Scenario Workshop (EASW) because it is the main model from which we took inspiration; we adapted and modified it to our needs.

The EASW workshop is a methodology of Workshop supporting the development of Sustainability at the level of local territories, launched in Denmark in 1994 by DGXIII -D "Innovation" program and promoted by the European Union. The purpose of EASW is to help the comparison between the various stakeholders in the area, it allows social actors to focus on the formulation of a common vision for sustainable development in the local / regional context and for identifying future scenarios for sustainable urban living.

In the table below the comparison between the EASW method and the AP Methodology is shown in order to highlight common points and differences.

Table 4.5 Comparison between the EASW method and the AP Methodology.

	EASW	AP METHODOLOGY
DURATION	2 days	1 day
CENTRAL THEME	Sustainable development	Circular urban water management
PARTICIPANTS	It involves four groups of participants: -residents, -policy makers, -technology experts, and -private-sector representatives	It involves stakeholder group of the CWC project within each FUA (for the complete composition see the paragraph 4.2: "*Who is involved? Stakeholders' group composition and main tasks in CWC project*").

HOW THE WORKSHOP IS ORGANISED	Participants from different social categories (residents, technical experts, policy makers and private-sector representatives) gather to discuss the future of their own city. In particular the discussion focuses on four specific themes: 1.water supply and use; waste water; 2.solid waste management and recycling; 3.energy supply and use; 4.daily living and housing	Stakeholder group of one FUA gather to discuss about how to make the urban water management circular. They develop action plan at the urban level within for the time frame considered.
PROCEDURE	Participants are divided into four groups, according to their expertise and social category. They discuss current and future problems, seek solutions and suggest changes that are crucial for the improvement of their city and its sustainable development. Participants develop their own "vision" of the possible future of their city with particular reference to the themes of the workshop and using the scenarios and other supportive aids as a stimulus to discussion and as a general framework of reference After that, each group present the visions they worked out. These results are restructured and reprocessed during the second part of the workshop, in which the participants are divided in theme-groups, that are living conditions, energy consumption, water management and waste disposal. Proposals are presented in the form of posters and could be subjected to voting, thus providing for the prioritisation of the subjects. In the end, responsibilities are defined and a commitment is held by the participants to follow the proposed actions.	Participants are divided into sub-groups and in each one all the categories of stakeholders should be present. After the individual analysis of the local context the group work starts. Following the SOAR analysis they discuss jointly the context and define a city based vision for a given timeframe. At the end each sub-group present the results. (a more detailed explanation of the procedure is in the following).
COMMON POINTS	These procedures promote dialogue between all interested parties, enhances understanding of local conditions or problems and facilitates consensus on proposed solutions. Information, dialogue, participation and co-operation between participants is requested.	

4.6.3 Step by step description

The "AP game" is a group work based on structured activities for stakeholders whose output are the essential and basic elements that should compose the Action Plan for circular urban water management co-created by participants. They should develop it starting from the real data available that are the FUA-level Status Quo Self-Assessment and the Public Perception Survey. The activities in chronological order are shown in Fig. 4.4, their complete explanation and the purposes are presented in the following.

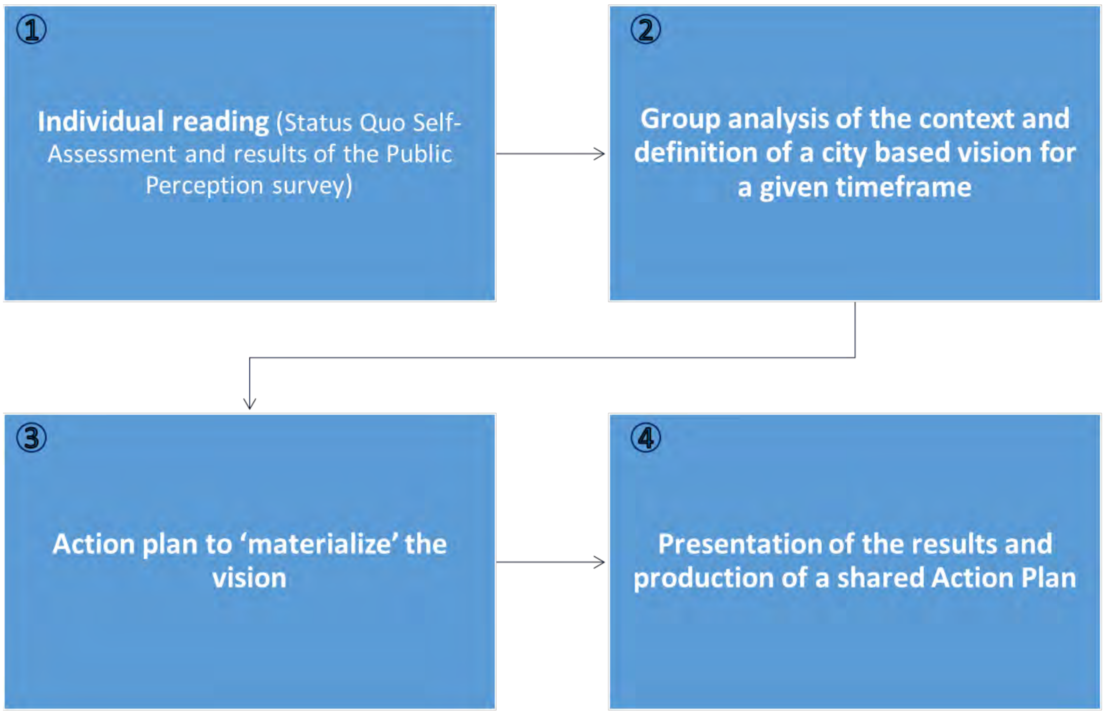


Figure 4.5 Steps of the AP process

In the opening, an introduction explaining the AP game and the division in subgroups is done.

4.6.3.1 Activity 1: Individual reading

Components individually read the "description" of their city, defined through the Status Quo Self-assessment and the results of a Public Perception survey. In this way each participant gets acquainted with the data and the scenario, and activates his/her knowledge and resources to understand the context. This favours the fact that no one is left behind in the following group work. It also helps participants to bring back home solutions and ideas. The individual reasoning allows to point out criticalities considering the individual experience and field of expertise.

DURATION: 1 hour

4.6.3.2 Activity 2: Group analysis of the context and definition of a city based vision for a given timeframe

Each group analyses the context with reference to a SOAR (strengths, opportunities, aspirations, results/response) analysis. SOAR analysis is intentionally used instead of the more common SWOT (strengths, weaknesses, opportunities, threats) in order to do a visioning process that focuses on what is desired and find out how to make it real enhancing what is possible and currently done well, rather than concentrating on perceived threats and/or weaknesses. Furthermore, in this way the context is studied with a positive attitude (appreciative gaze) from a perspective that privileges the inclusive thinking: "Yes and..." instead of the exclusive one: "No but...", thus encouraging the emergence of collective intelligence. The facilitators should encourage flow of ideas, everyone should express themselves and also they should allow an exchange of knowledge, opinions and ideas between technological experts, public administrators, researchers, private and public-sector representatives and the other personalities of the stakeholder group.

Focussing on S, O, and A of the SOAR analysis, the group develops a vision which makes the CWC goals (see Fig. 4.6) specific to the context (definition of specific objectives), and defines priorities among the objectives. Of the subgroups working, different time frames are assigned, for example one could refer to a 3-5 year timeframe (short term), the other to a 25 year timeframe (long term), this is only a suggestion if there are two subgroups but others time frame are possible.

DURATION: 2 hour

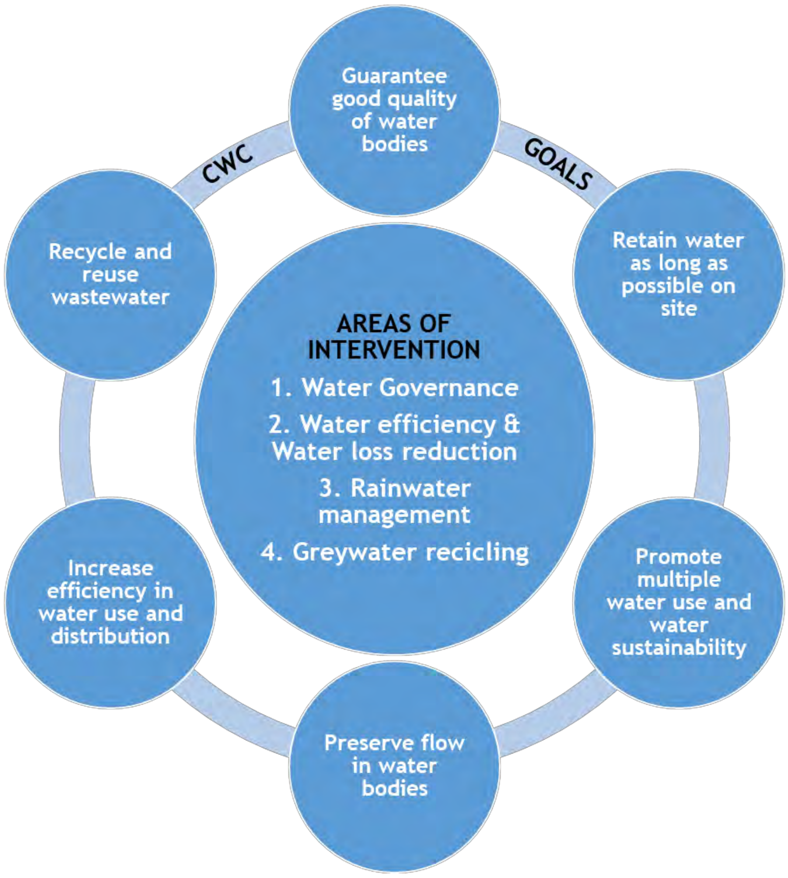


Figure 4.6 CWC goals and Areas of intervention

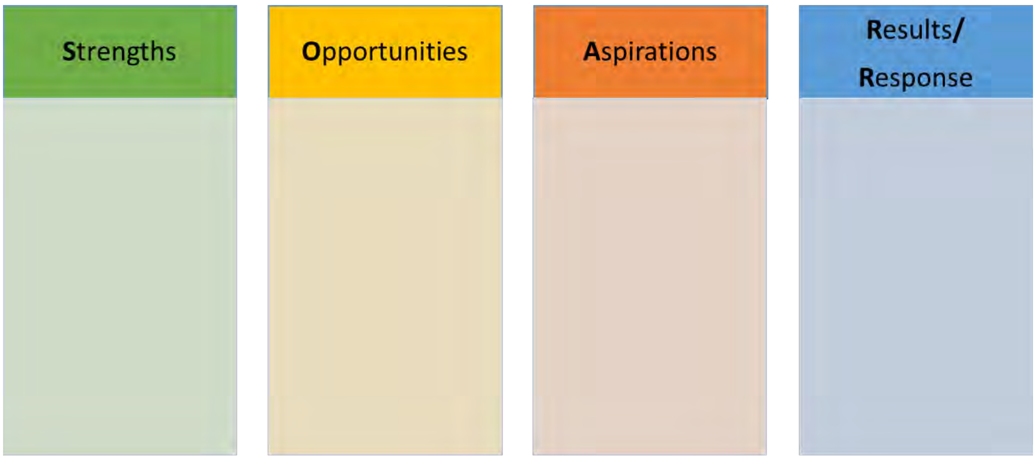


Figure 4.7 Template for the SOAR analysis

4.6.3.3 Activity 3: Action Plan to "materialize" the vision

Each group draws up the essential elements composing the Action Plan that can lead to the "materialization" of the objectives, this time focussing on the R (results/response) of the SOAR analysis. Each group is asked to consider the 4 CWC areas of intervention: governance, water efficiency and water loss reduction, rainwater management, grey water recycling. Are them all useful to reach the objectives? Which actions can be selected or created? How to combine them?

The group discussion here is fundamental, facilitators should encourage the cooperation and the flow of ideas and boost the achievement of a meeting point.

A SMART approach, i.e. specific to the context, Measurable, Achievable, Realistic, Time bound, is used to guarantee the feasibility of the Action Plans.

The goal of this step is to learn a process to give practical fulfilment to general ideas about Circular Water Management, learning how to select or create new actions to reach objectives and reach the vision.

DURATION: 1 hour and a half

4.6.3.4 Activity 4: Presentation of the results and production of a shared Action Plan

The groups then present the results of their work, so that for each of timeframe, both a short term (3-5 years) Action Plan and a long term (25 years) one are envisaged. After the presentation, they make the comparisons and match the results in order to integrate them to produce a unique "common and shared Action Plan" for the city.

DURATION: 45 minutes

This methodology suggests a possible way to reach the goal, highlighting some aspects that we consider necessary. Each one can then adapt the methodology to his own context, while maintaining the basic principles.

In the next chapter the Application of the AP Methodology to the core Master Training, the results and comments are presented, also to give a better explanation of the activities, of the obstacles encountered and the possible improvements that are possible to make.

4.6.3.5 My contribution:

Starting from the study of different kind of workshops, the method choose as a base was the EASW. From a comparison between the methodology of the EASW and the requirements and needs of the project I developed some proposals and possible solutions of workshops, taking into consideration that our objective was providing learning tools and producing interactive learning activities for the project. The final and used version of the methodology is the result of my proposals with exchange of opinions and discussion between Poliedra working group and suggestion from facilitators involved in the core Master Training. All the material explained previously is contained in the project report on which I worked. I also developed the imaginary contexts used during the core Master Training to test the methodology, as explained in the following chapter (section 5.4).

5. Applications of the methodology: the case of Turin and the core Master Training

In this chapter, I present the components application of the learning process described in chapter 4 to real cases. In particular, my aim is to show the results of the FUA-level Status Quo Self-assessment and of the public perception survey for the FUA of Turin, which is one of the FUAs involved in the project. However, it is also analysed the comparison between the public perception surveys of the other FUAs. I also demonstrate the application of the "AP Methodology" during the core Master Training, during which the validity of the complete process was tested.

I chose to deepen the specific case of the FUA of Turin because Turin Municipality is the other Italian project partner, closely collaborating with Poliedra. Turin Municipality mainly deals with local activities, it identifies the stakeholder group and creates contact with the territory (Stakeholder Group meetings, pilot, strategy building). Instead, Poliedra coordinates Turin in the project activities and develops methodologies to produce project's outcomes. It is also possible to get a feedback from the Turin project partner about the method developed.

This chapter gives the reader an overview about the methodology and its possible results, a more detailed understanding of its characteristics and a deeper comprehension.

5.1 FUA of Turin: context definition and stakeholders group composition

The FUA of Turin is composed of 88 municipalities with about 1.740.000 inhabitants (OECD, 2019). It is classified as "Large metropolitan area" by OECD.

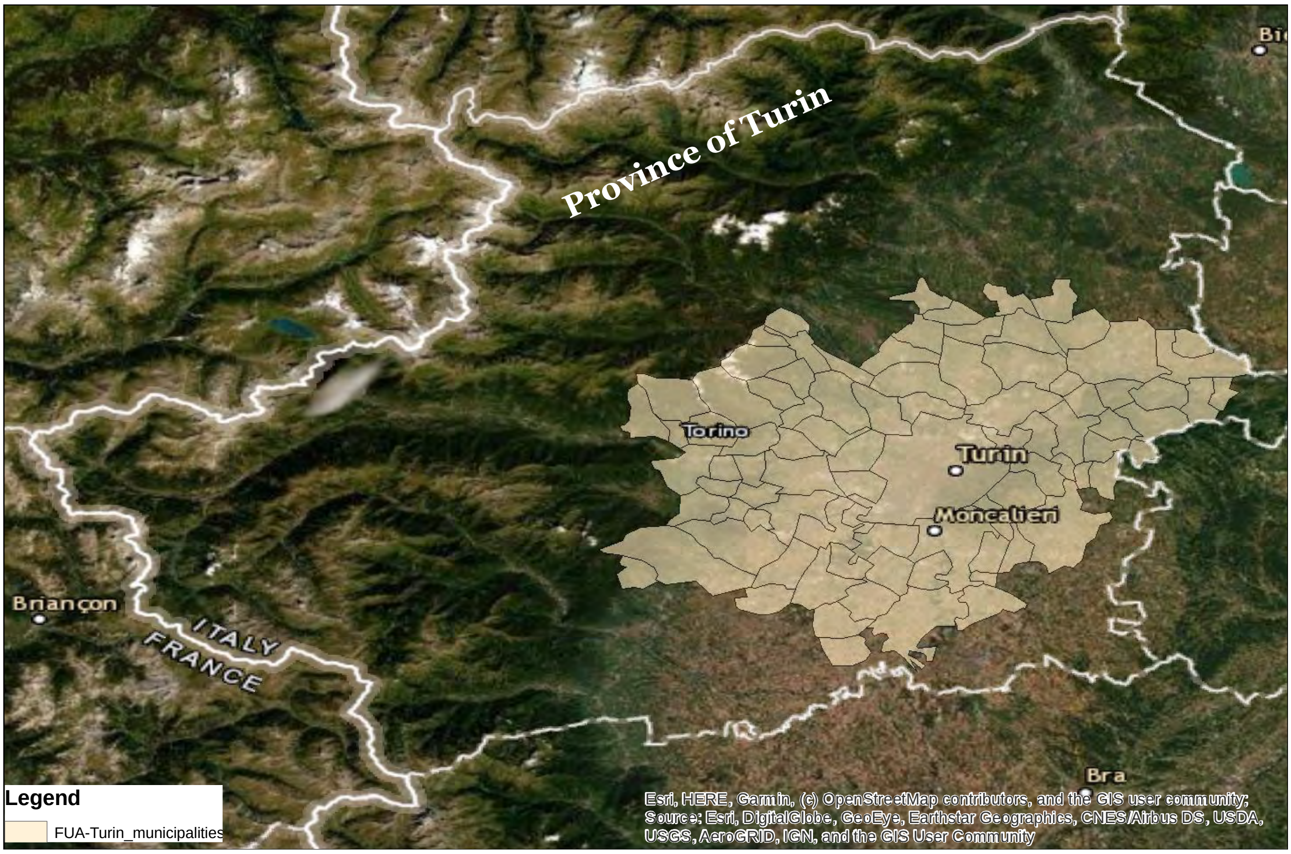


Figure 5.1 Location of the Turin FUA with respect to the province and Municipalities

The FUA stakeholder group composition is shown in the following.

Table 5.1 Stakeholder group composition for the FUA of Turin divided by categories.

	Expected number	**Actual number**	**Organisation**
Local public authority	4	**3**	Città Metropolitana di Torino
			Patto Territoriale zona ovest Torino
			Comune di Grugliasco
Regional public authority	1-2	**1**	ANCI
Sectoral agency	2-3	**2**	ENVIRONMENT PARK
			ENEA
Infrastructure and (public) service provider	3	**3**	SMAT
			IREN
			STET SPA
Interest groups including NGOs	4	**5**	HYDROAID
			Associazione Mercato Circolare
			D.O.C. s.c.s.
			PRONATURA
			LEGAMBIENTE

Higher education and research	2-3	**4**	MAcA – Museo A come Ambiente Politecnico di Torino-DIATI CNR (Consiglio nazionale Ricerca) Università degli studi di Torino
General public	5	**5**	Libero Professionista (formatore) Consorzio Ambientale Castello di Lucerna Consulta Ambiente Persona interessata Libero professionista
SMEs	3	**2**	HYDRODATA SPA Orti Alti
Education/training centre and school (only for HU, Sl, PL)	6	**…**	/
Large enterprises (only for HU, Sl, IT)	2	**1**	FCA
Other: …		**…**	

The composition of the stakeholder group corresponds very well to the requests of the application form of the CWC project about number of components for each stakeholder category (see paragraph 4.2.1). The main problem encountered during the recruitment phase concerned "large enterprises", nevertheless Turin Municipality managed to involve one.

This group should take part to the local activities scheduled by the project, including the local competence building workshop where the complete learning process presented in the previous chapter is applied. On this occasion, following the AP methodology the group should generate the inputs and basic elements to develop the action plan for the Turin FUA.

5.1.1 Major problems/difficulties

The municipality of Turin encountered the following obstacles in setting up the stakeholder group for the FUA:

- Identify stakeholders that were really interested in the subject;
- Involve the expected number of participants for each category, according to the requests of the stakeholder group composition.

In addition, the stakeholders are not used to working in terms of FUA but in different geographical areas such as Municipality "Metropolitan city" or "Region".

The municipality didn't do a mapping of the stakeholders: they involved the organisations that, according to their experience, seemed to be the best to take part and to give support and contribution, considering the scope of the project.

5.2 Turin FUA-level Status Quo Self-assessment

In this section the results of the FUA-level Status Quo Self-assessment are shown. This is one of the examples but for the other FUAs the template used is the same (see Appendix 1). Here the scope is to prove the effectiveness of the indicators proposed.

5.2.1 Self-assessment on background conditions and analysis of gaps and potential of circular water use

The complete form filled with the real data are collected in the Appendix 1. Here the comments of the results done by the Municipality of Turin are reported. In the analysis, for each of the main topics, Turin pointed out results highlighting challenges and strengths. This allows to understand if the indicators permit to figure out which are the weak points in the water system and which are the opportunities that should be taken to foster the circularity in the water management.

Here below the analysis of the Municipality of Turin about their self-assessment is reported for each of the main topic.

Table 5.2 Challenges and Strengths in Turin water system divided by topic.

1. Climate, Environment and population	
Challenges	Strengths
The percentage of soil consumed within the FUA is high and it should be reduced.	*The percentage of green spaces within the urbanized areas of the city of Turin has grown significantly in recent years.*
2. Water resources	
Challenges	Strengths
Average rainfall, especially in the winter months, is low.	*The FUA of Turin is rich in courses and water resources whose ecological quality is good.*

3. **Water infrastructures**	
Challenges	Strengths
The index of real losses in distribution is still high and therefore it would be appropriate to reduce the losses in the water supply network, it is also advisable to provide for a greater number of plants distributed for the collection, filtering and reuse of rainwater.	*Drinking water is distributed throughout the FUA territory and its quality is high.*
4. **Water consumption**	
Challenges	Strengths
The consumption of bottled water for drinking purposes is high and efforts should be made to reduce it as much as possible.	*In the last 10 years per capita water consumption has decreased considerably.*
5. **Climate change**	
Challenges	Strengths
The main climatic vulnerabilities in the area where action is needed to reduce their impact are heat waves and floods.	*The City of Turin is completing the preparation of the city's climate change adaptation plan.*
6. **Rules, laws and good practices**	
Challenges	Strengths
There is no specific legislation on the collection and reuse of rainwater and, therefore, it is important to have legislation on these issues.	*The city of Turin has started experimenting with various solutions also based on NBS for the reuse of rainwater and the reduction of drinking water consumption.*

5.2.2 Major problems/difficulties and comments

The Municipality of Turin claims that retrieving or estimating all the information requested was really difficult and in some cases, as planned by the methodology, approximations were made. They were able to complete the questionnaire but with a lot of efforts and with the support of external experts.

In conclusion, I think that the indicators requested are really useful for the comprehension of the criticalities in the water system but quantitative data should be coupled with a qualitative "translation", in order to produce more comprehensible results. Without quantitative data, the qualitative judgment can be unfounded, or in any case nobody can trace from where it comes from. Therefore, quantitative data are fundamental, but with qualitative explanations the results are more decipherable even for people who are not expert in the technical theme, as for the case of the stakeholder group, which is composed by different categories with different background and knowledge.

For example, the section related to topic 3 (Water Infrastructures) is really complex to understand and results are difficult to interpret for those with no experience in the field. In fact, some of the parameters are very specific, such as the laboratory test result about water quality. I propose, for the improvements of the methodology that, for instance, to this indicator is also added a qualitative judgment about water quality compared to the standard imposed, to see if they are match or not.

5.3 Turin FUA-level public perception survey

In this section, the reception of the guidelines and the results of the public perception survey for the FUA of Turin are shown.

5.3.1 Background

First of all, I give indications about the methodology carried out to determine the number of interviews that needs to be done for each category for the FUA of Turin that is how the guidelines were implemented and applied in this specific case.

Knowing that the sample should have the same stratification as the target population, the proposed simplified classification, as explained in the chapter 4 (more detailed description in section 4.5.1), considers:

- Gender (% M/F)
- Age (exclusion of the population below the age of 16 → %16-25, %26-65, %66+)
- Place of residence (within the FUA).

First of all, as suggested, the FUA of Turin has been subdivided into 3 “homogeneous areas” as follows:

- Area1: central urban area which corresponds to the city of Turin,
- Area2: municipalities neighbouring with the city of Turin, i.e.: Venaria Reale, Collegno, Grugliasco, Binasco, Orbassano, Nichelino, Moncalieri, Pacetto Torinese, Pino Torinese, Baldissero Torinese, San Mauro Torinese, Settimo Torinese and Borgaro Torinese. They constitute the first cordon around the city (1° cord.),
- Area3: area more distant from the central urban area, less densely populated and with more rural vocation (2° cord.).

The image below shows the subdivision of the FUA of Turin in the three areas:

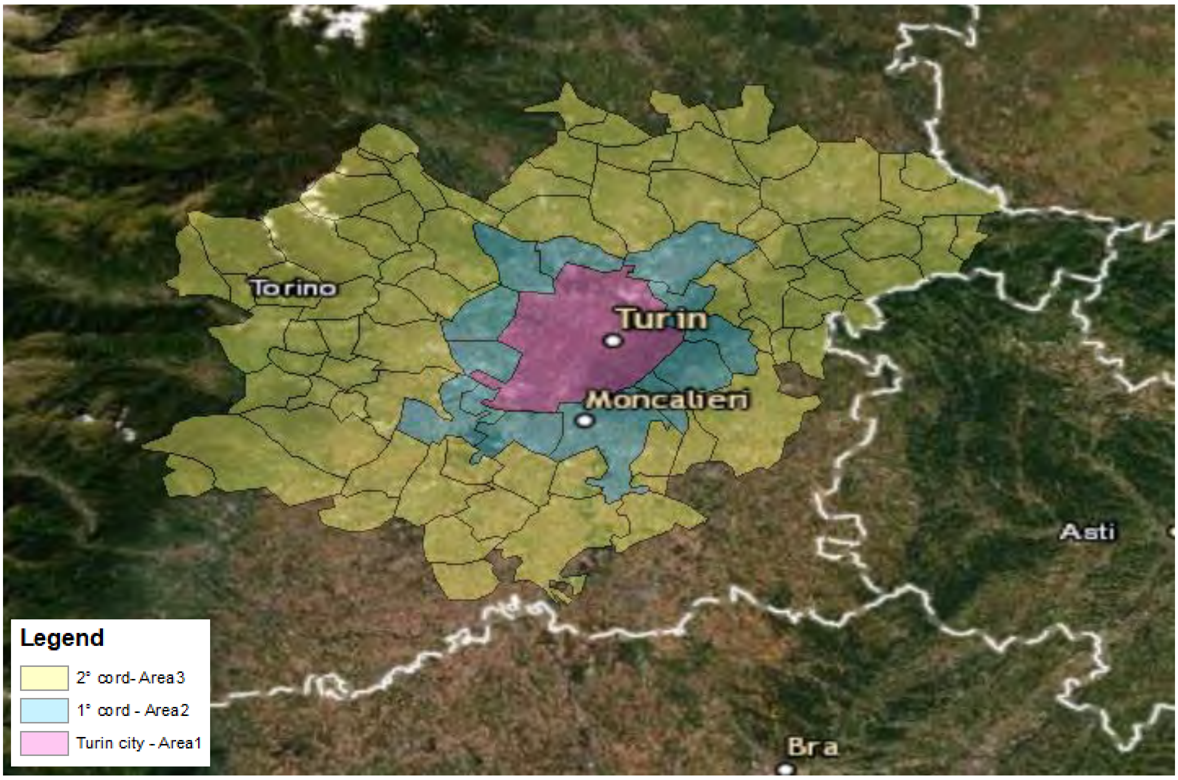


Figure 5.2 Subdivision of the Turin FUA

It is important to remember that the sample (number of completed questionnaires) composition should respect the same percentages computed among the target population for gender distribution, age classes, and areas of residence distribution. In the following, the percentages and the corresponding number of questionnaires to be filled in are computed and explained.

Taking as reference the territorial subdivision done, the total population living in each macro-zone, the population over 15 and the percentage of population living in the individuated areas are computed and reported below:

Table 5.3 Population living in each territory of the FUA and the corresponding subdivision, considering also people aged over 15.

	Total Population	Total population over 15	Percentage of the total
FUA (88 municipalities)	1.744.962	1.500.667	
Turin	875.698	**762.882**	**51%**
1° cordon	357.419	**311.574**	**21%**
2° cordon	511.845	**426.211**	**28%**

The data about the population comes from *http://demo.istat.it/* (2019) website where it is possible to find the number of people living in each municipality for every ages. The data from each municipality were taken and then summed up for the different areas.

From the previous table it is possible to know that the 51% of the target population (over 15) is placed inside the city of Turin (Area 1), the 21% is located in the 1°cordon (Area 2) and the 28% is in the 2°cordon (Area 3). Starting from that, the percentages of male and female subdivided for each age group have been computed, remembering that the percentages of male and females for each zone and for each age class are computed considering only the population over 15, in fact the total values are calculated without considering children under the age of 16.

Table 5.4 Percentages of male and females per age category for each area.

	TURIN - AREA 1		1° CORDON - AREA 2		2° CORDON - AREA 3	
	M	F	M	F	M	F
16-25	5.1%	4.8%	5.6%	5.2%	5.5%	5.1%
26-65	30.3%	31.5%	29.7%	31.3%	30.8%	31.3%
66+	11.7%	16.6%	12.5%	15.7%	12.1%	15.2%

The next step is to "translate" the percentages in the correspondent number of questionnaire to be filled in considering that the target value is 400 questionnaires. This step is necessary in order to find out how many questionnaires need to be collected in each area to facilitate the dissemination. The number were computed and then rounded to the nearest integer in order to give feasible indications. Here I report only the table with the rounded results.

Table 5.5 Number of questionnaire to be collected for each class and areas.

	TURIN - AREA 1		1° CORDON - AREA 2		2° CORDON - AREA 3	
	M	F	M	F	M	F
16-25	10	10	5	4	6	6
26-65	62	64	25	26	35	35
66+	24	34	10	13	14	17

So, for instance, in Area 1 – Turin city, we should have 62 questionnaires answered by males and 64 by females whose age ranges from 26 to 65.

The sum of all the cells of the previous table gives as result 400 that is the amount of filled in questionnaires needed.

5.3.2 Survey

The data were collected between 23rd October and 15th December 2019. The survey was conducted by the Turin project partner and was advertised through institutional web sites, social media and fairs, with the support of local administrations of municipalities in the FUA.

845 answers were collected during the period. The answers were then randomly selected in order to obtain a 400 answers sample, with composition as close as possible to the theoretical target composition considering Gender, Age and Residence.

The actual sample, both in terms of number of questionnaires obtained and percentages, are presented in the following two tables.

Table 5.6 Number of useful questionnaires obtained.

ACTUAL ANSWER	TURIN - AREA 1		1° CORDON - AREA 2		2° CORDON - AREA 3	
	M	F	M	F	M	F
16-25	11	11	6	5	7	7
26-65	68	70	22	28	38	39
66+	20	26	5	3	15	19

From the following two tables, it is also possible to understand the deviations from the theoretical targets.

Table 5.7 Corresponding percentages of the previous table.

ACTUAL %	TURIN - AREA 1		1° CORDON - AREA 2		2° CORDON - AREA 3	
	M	F	M	F	M	F
16-25	3%	3%	2%	1%	2%	2%
26-65	17%	18%	6%	7%	10%	10%
66+	5%	7%	1%	1%	4%	5%

Table 5.8 Target percentages of questionnaires needed to represent correctly the sample.

TARGET %	TURIN - AREA 1		1° CORDON - AREA 2		2° CORDON - AREA 3	
	M	F	M	F	M	F
16-25	3%	3%	1%	1%	2%	2%
26-65	16%	16%	6%	7%	9%	9%
66+	6%	9%	3%	3%	4%	4%

Gender

In the actual sample, the balance between answers from males and females is very close to the real one. Many answers from females were randomly discarded to obtain a correct balance.

Age

The group of over 66 years old is slightly under represented, in particular in area 1 and 2.

Residence

The answers collected well represent the actual distribution of the population in the three areas.

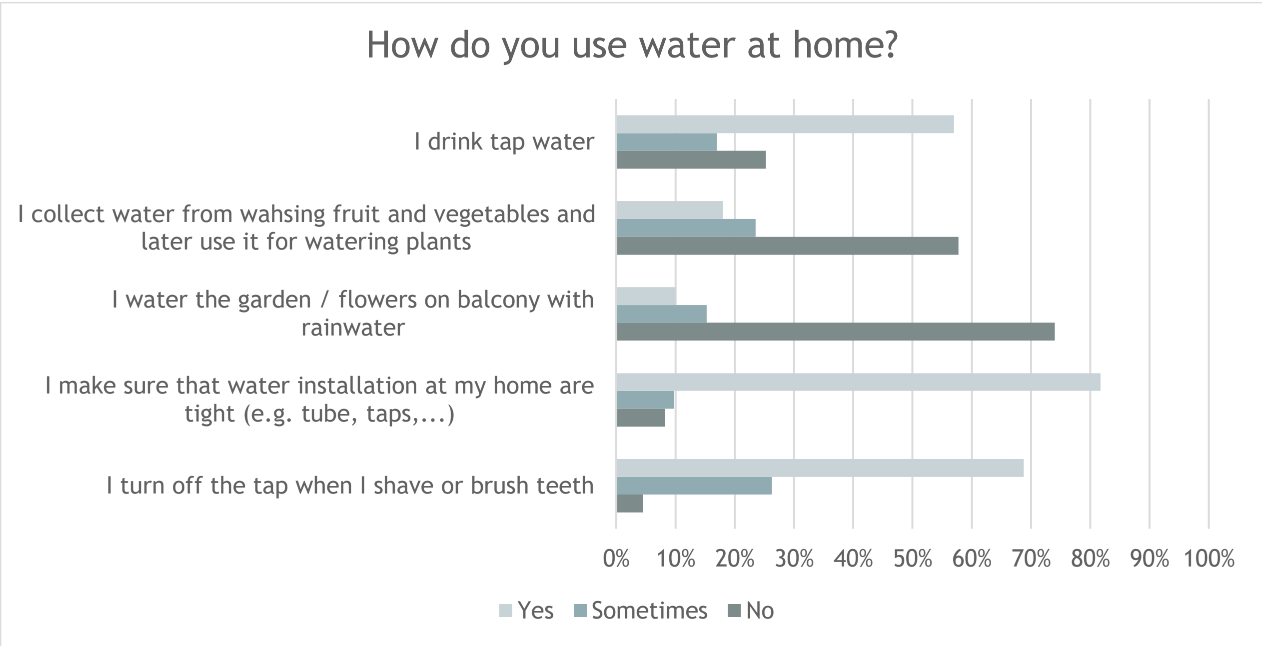
In the following the results of the public perception survey for the FUA of Turin are reported with comments.

PERSONAL USES

Habits

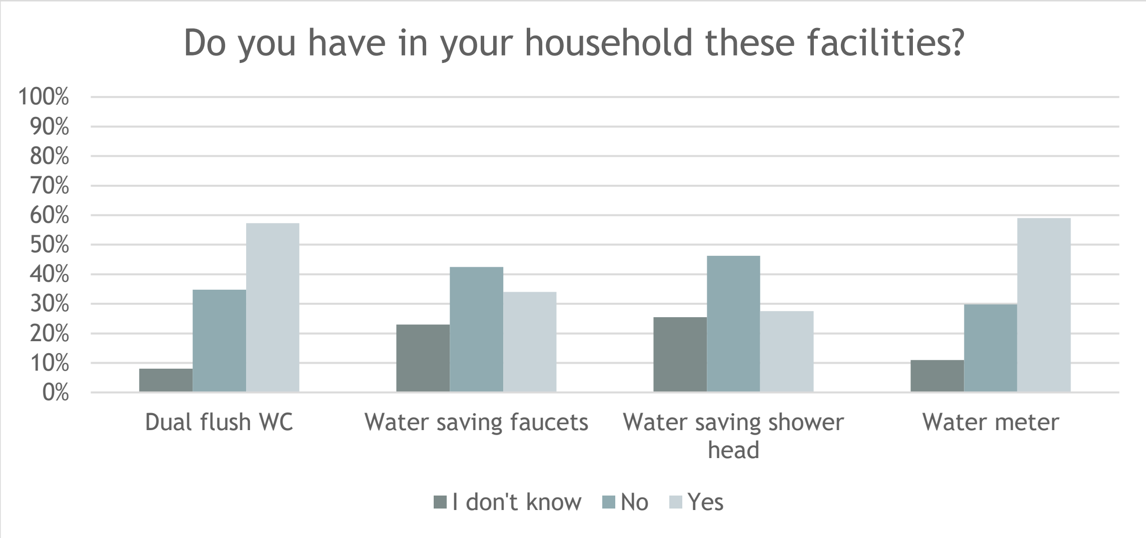
More than half of the respondents, nearly the 70% of interviewees, turn off the tap during saving and brushing teeth, 82% make sure to have tight water installation at home and 57% drink tap water. Population has good habits regarding saving water.

Collecting and reuse rainwater or grey water are not so popular, only 10% and 18% responded yes on this question.



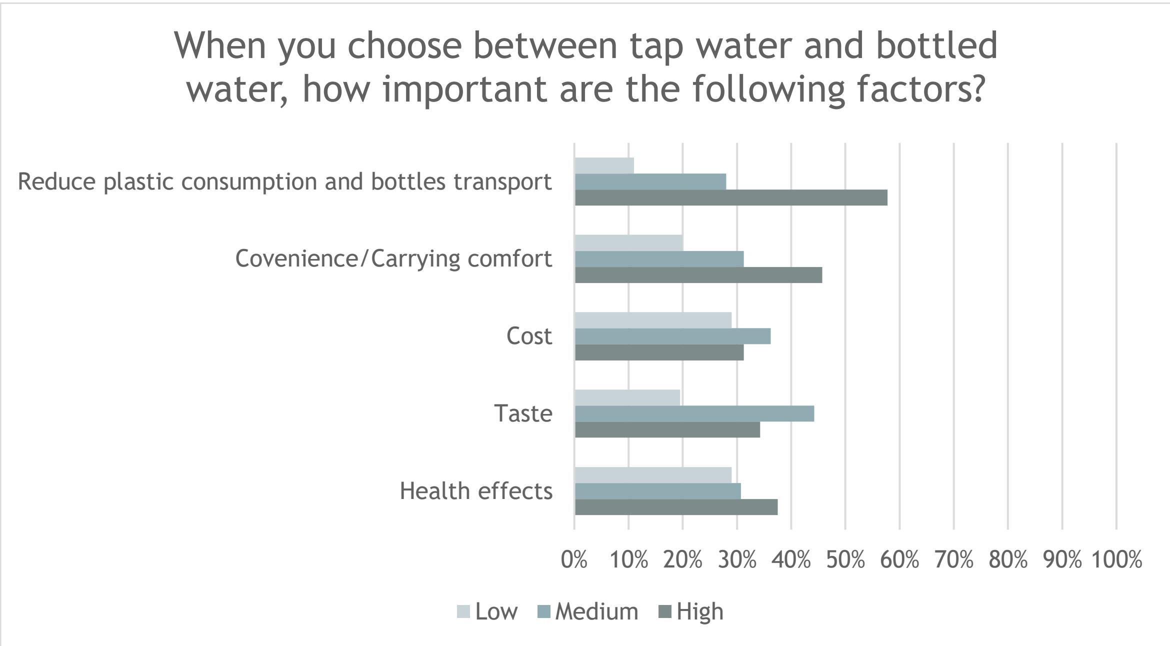
Facilities

57% of interviewees have dual flush toilet, while only 34% and 28% have water saving faucet and shower head. A significant percentage of interviewees, 23% for faucets and 26% for shower, don't know if they own water saving facilities. 59% have a water meter. Here there is the opportunity to increase the percentages, the facilities are not so common and widespread.



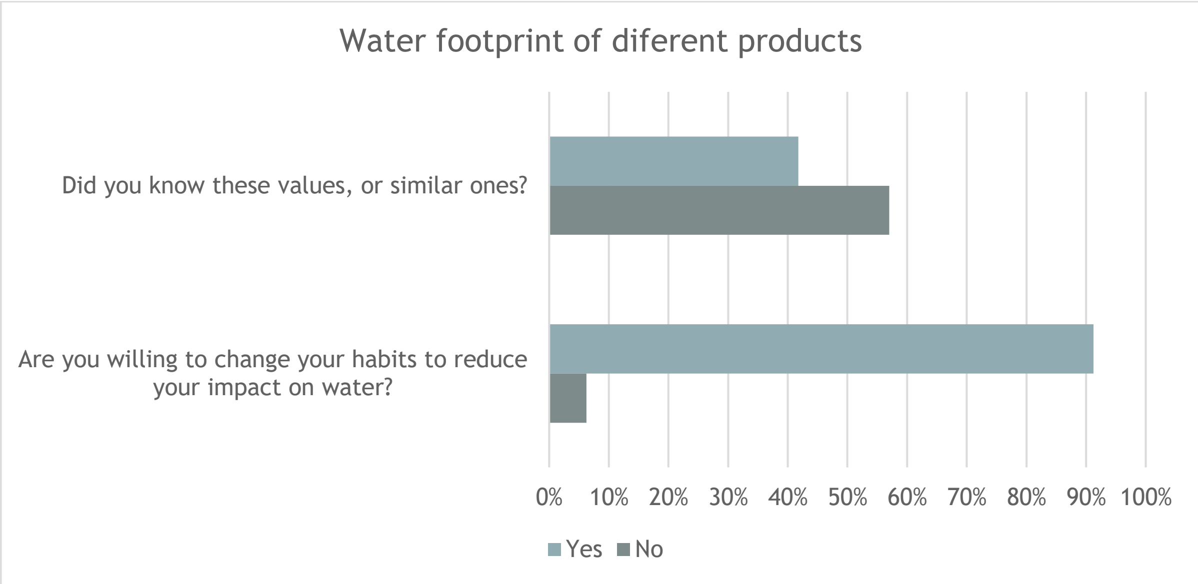
Bottle or tap?

When it comes to decide drinking bottled or tap water the following factors show high importance for the interviewees in Turin FUA: reducing the plastic consumption and bottle transport (58%) and convenience/carrying comfort (46%). Cost, health effects and taste have an average medium importance in Turin FUA.



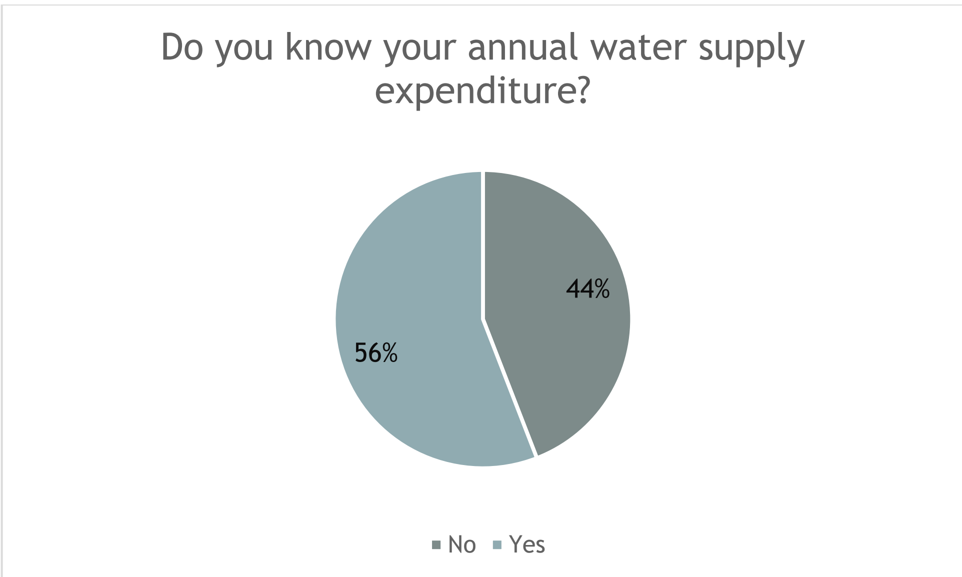
Water footprint

The data of the water footprint of different products were not known by most of the interviewees: 57% had no information about the water needs of the products in the example. 91% of the interviewees are open to change their habits to reduce their environmental impacts. People are open to change their habits but they need education and more information.



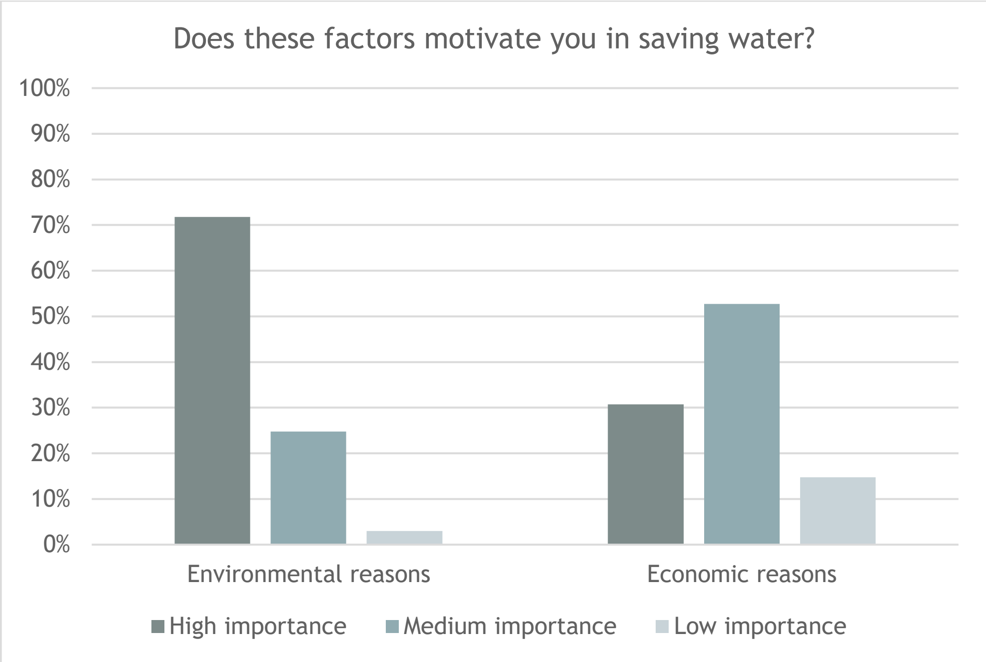
Annual costs

In Turin FUA only 56% of the interviewees are aware of the annual costs of the water supply. It is also found in other FUAs, it possibly suggests that prices are not so high.



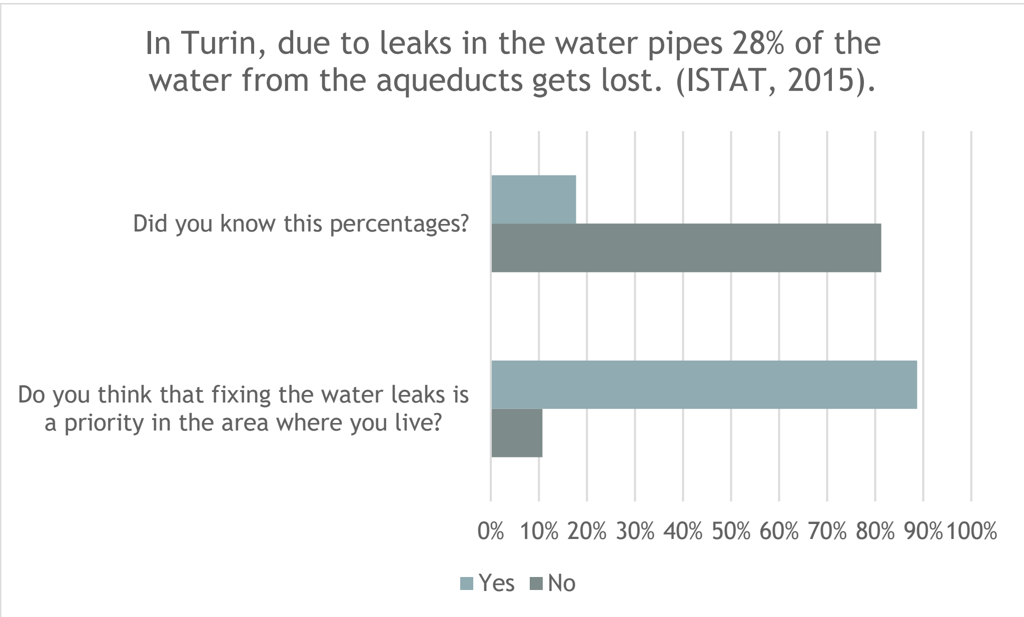
Motivation

The interviewees indicated environmental factor as the highest motivation factor in water saving. For 72% environment is high important driver in savings, money get 31% rate.



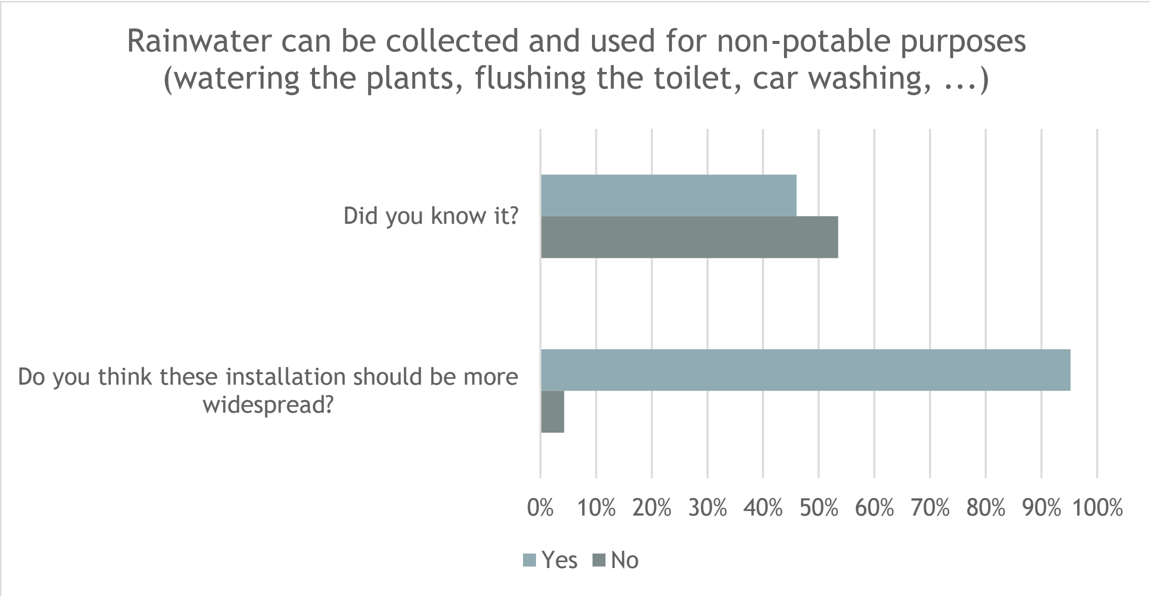
PROPER WATER USE AND REUSE

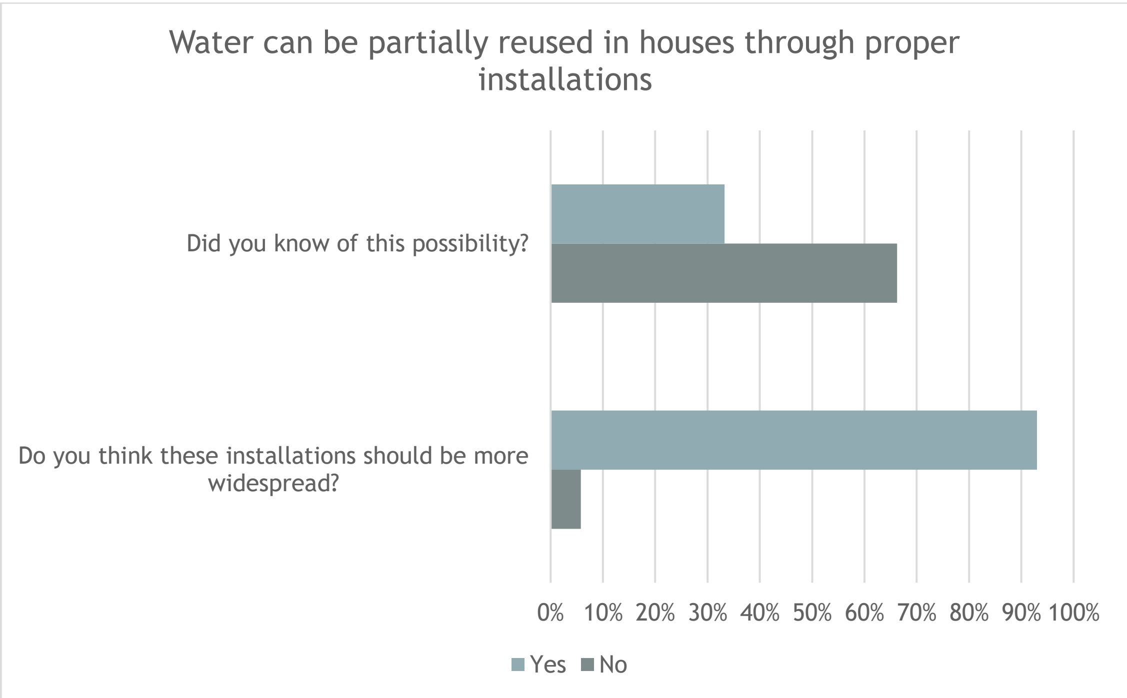
The actual state of water pipes in Turin is not well known by the population. 81% of the interviewees do not how significant are water pipes leaks. 89% think that fixing those leaks is a priority in the Turin FUA. Citizens are not aware of the losses but they recognize that it is a problem to be solved.

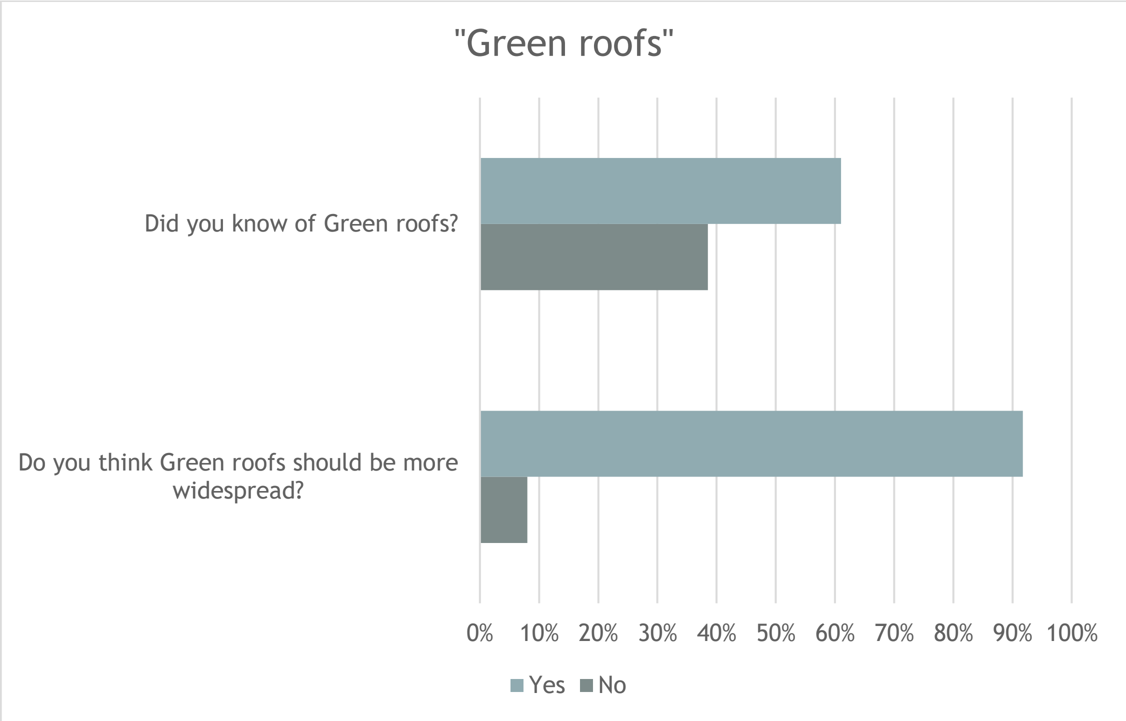


Rainwater use, greywater and green roofs

Not all the sustainable solutions for the urban water management are well known and very popular in the Turin FUA, they need more information and education. Only green roofs are known by most of the population (61%), while rainwater (46%) and grey water (33%) uses are less popular. More than 90% of the population think that all these three solutions should be more spread in Turin FUA.

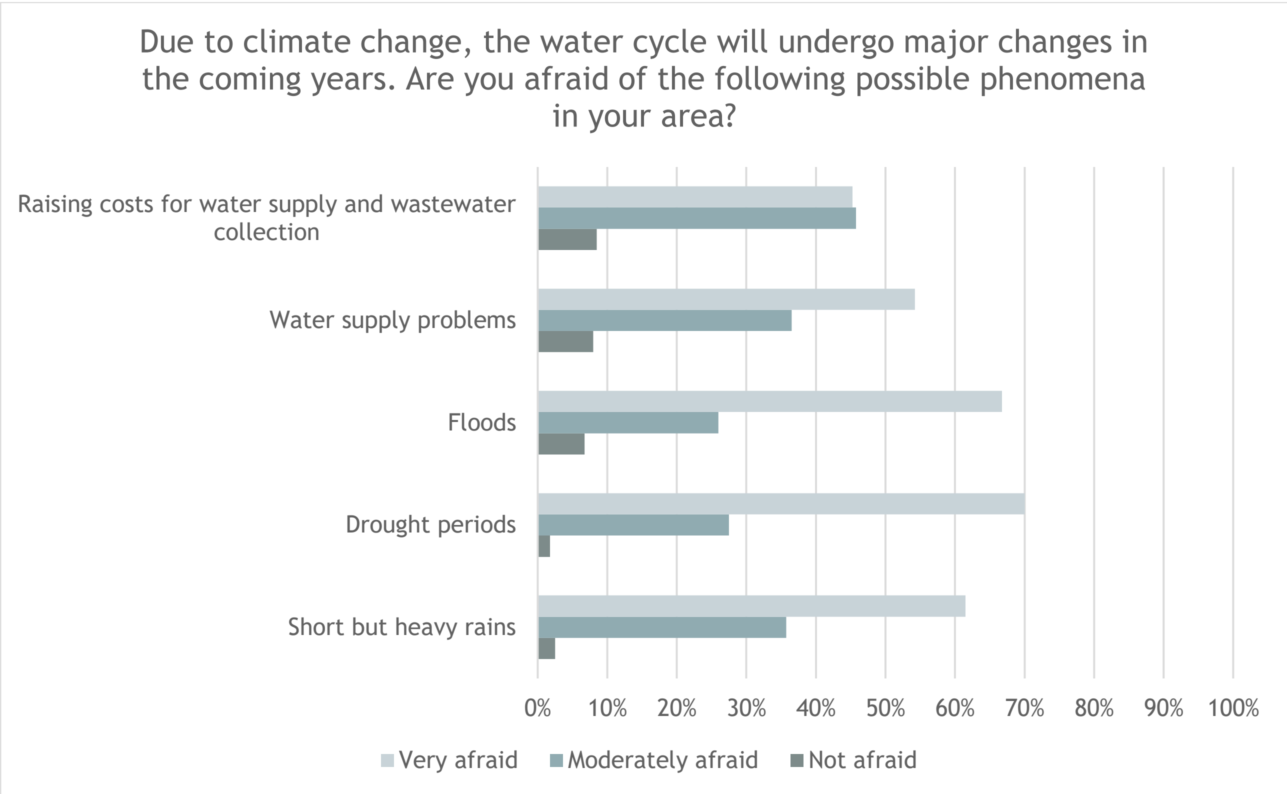






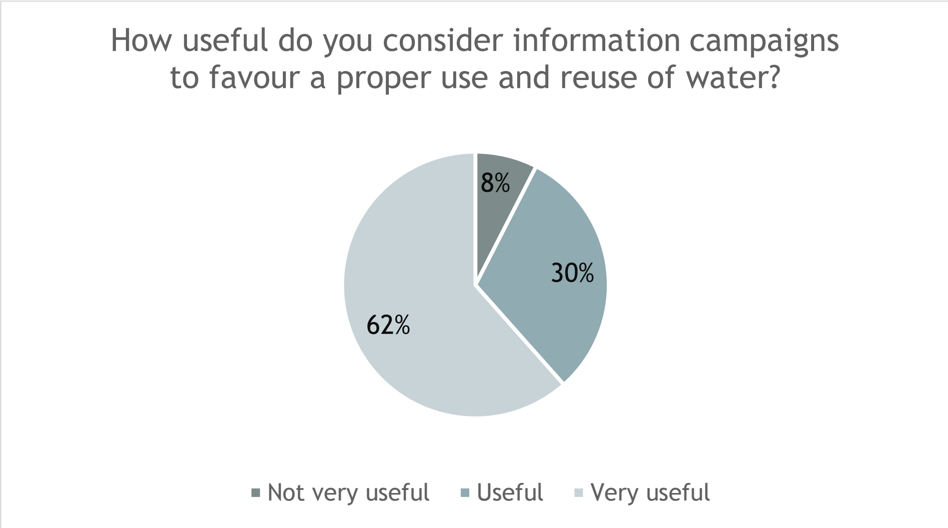
Effects of climate change: are you afraid?

The possible effects of climate change in water management cause general anxiety. The most threatening phenomena for the responders in Turin FUA are the drought periods (70% are very afraid of it), floods (67% are very afraid) and heavy rains (62% are very afraid).



Information campaigns

According to 62% of the interviewees, information campaigns are very useful to favour a proper use and reuse of water. Only 8% consider them not very useful.



5.3.3 Water efficiency and reuse related public perception assessments

The municipality of Turin summarises the results highlighting challenges and strengths, they give their feedback about the public perception and they conclude that:

"Challenges: Rainwater/greywater are rarely collected and used. In the houses water saving facilities are not always present. The interviewees acknowledge a lack of knowledge concerning water saving and reuse. The water loss in the FUA are not well known.

Strengths: Population shows a general attention to water saving good practices and seems to be willing to contribute if more infrastructures/facilities for water saving/rainwater harvesting/grey water collection and reuse are available. The interviewees agree on the need of more information campaigns on water saving and reuse. The population declare fixing of water losses as a priority."

According to me, from the comments that the municipality did, it is possible to conclude that the questionnaire that Poliedra developed is very effective. In fact, it is possible to catch the salient aspects regarding the public perception of the problem, at what level of education they are and what are the obstacles, which, according to citizens, are the main problems related to the water system of the city. In conclusion, I think the feedback is positive, but for further considerations I make also the comparison with the results coming from the other FUAs and the conclusions are in the following section.

5.3.4 Comparison of the results with the other FUAs

From the comparison of the results with the other FUAs involved in the project, with the exception of Bydgoszcz, some considerations can be done, in order also to improve the effectiveness of the questionnaire.

Bydgoszcz is not considered because of the lack of data when I analysed the results.

From the comparison, it is possible to derive some considerations on how to apply the methodology in different contexts. The complete analysis of the percentages of the data is not carried out because the focus is on the way the survey can be improved.

Considerations:

1. Turin, Budapest and Split reached the target number of answers needed (even more than necessary), while Maribor was not able to collect enough answers. Every FUA had to do many efforts to achieve the correct stratification of the population and not in every case they reached the objective. It is a question of commitment and of resources (time and money available) commensurate with the objectives. For instance, in Budapest FUA the sample focuses strongly on the city center (86% of responses comes from Budapest and only a 14% of the responders are living in other settlements of the FUA). In this case the FUA is really complex, composed by 199 municipalities, therefore with the budget and time available they do not reach the correct sample stratification. This is due to different causes. From one side, the composition of the partnership, in which the Budapest FUA is represented by entities that do not have the capacity or possibility to reach all parts of the FUA and they focus on the territory surrounding them. On the other side, the project does not allocate sufficient funds to distribute the questionnaire effectively in a complex FUA.
2. Collecting and reuse rainwater or grey water are not so popular in each of the FUAs analysed. In a new version of the survey this aspect should be better investigated with more detailed questions. This is in fact one of the main goals of the CWC project, therefore barriers to the implementation from the social point of view need to be understood.
3. It is possible to highlight in the FUAs a general lack of awareness by the respondents about the topic, showing the necessity of education of the population. For example, no information about the water footprint of the products were known. However, in each FUA more than 90% of the interviewees wants to change their habits to reduce the environmental impacts in order to positively affect water resources.

4. Almost 50 % of the interviewees in every FUA are not conscious of the annual cost of water supply, therefore this question is very relevant because it reveals that it is not given economic value to water.
5. Budapest removed the question about leaks in water pipes because of missing information. It is true that the personalization of the questionnaires for each context is allowed and it is one of the characteristics described in the previous chapter. However, if data are missing it would be better to approximate them and to not disregard a priori the question.
6. Nevertheless, in reference to the previous comment, the methodology provided is not fixed but it is important to adapt to the situation to be faced.
7. Results show low perception of water related problems that call for stronger engagement, dissemination, and communication campaigns raising awareness among citizens on the importance of water sensitive urban existence. To conclude, the citizens are extremely willing to learn and listen about proper use and reuse of water. But they have not yet been properly informed but also they have not yet the instruments to act appropriately to alleviate the water pressure and greatly benefit the environment. This is a target that should be prioritised in FUA-level communication activities and in the CWC project.

In the Appendix 2 there is the complete table with all the results of the FUAs considered.

5.4 AP methodology implementation during the core Master Training

5.4.1 Introduction

The core Master Training is a 1.5 day long interactive core training session, organised in Milan, consisting of 2 training modules, to serve as a hands-on, interactive train-the-trainers session resulting in experiential learning, prepared by Poliedra. The MT is addressed to Project Partners and Associated Partners.

The first module of the training (half-day) is focused on creating a shared knowledge base and a shared language on circular urban water management areas of intervention (Water Governance, Water efficiency and losses reduction, Rainwater management and Greywater recycling). In order to have an overview of the possible interventions, an expert in the field explained through the use of presentations the fundamental elements for each theme, in the current state of knowledge.

During the second day of the MT, the AP methodology is tested by the participants in the form of group game with hypothetical scenarios. The aim is to prove its validity and make the adjustments needed to make it ready to be used during the local competence building workshop by the stakeholder group.

The "group game" was done in the second part of the MT, as said. It is a sessions of group-work on case studies exploring structured involvement of stakeholders for the building of a shared vision and the identification of strategies of intervention to build the Action Plan.

Table 5.9 Summary table with the key points of the core Master Training.

ORGANISER	Poliedra
DURATION	1 day-long
LOCATION	Milan
PARTICIPANTS	Project Partners and Associated Partners (about 40 people)
LANGUAGE	English
OBJECTIVE	Testing the AP methodology and train the project partners about it in order then to reproduce during the local competence building workshop for stakeholder groups within the FUA
MATERIALS	Imaginary Status Quo Assessment, Imaginary Results of the Public Perception Survey

Below there is the agenda with all the activities performed for the AP methodology, this is the framework to take as model when the methodology is applied. The model has to be adapted to the local needs when applied.

Core Master Training Agenda	
9:00-9:15	Introduction to the MT game - steps (Poliedra)
9:15-9:40	Subdivision in 4 groups, presentation and creation of a circle.
9:40-10:00	2 groups working on the imaginary city of Agua, 2 groups working on the imaginary city of Voda. Components of each group individually read the description of their city, defined by Poliedra through a Status Quo-assessment and the results of a Public Perception survey.
10:00-10:30	Each group analyses its local context (here and in the following with reference to a SOAR analysis), develops a vision which makes the CWC goals specific to the context (definition of specific objectives), and defines priorities among the objectives. Of the two groups working on the same city, one refers to a 3-5 year time frame, the other to a 10-15 year time frame. PART1
10:30-10:50	*coffee break*
10:50-12:30	PART2: continuation and conclusion of the work done before the coffee break
12:30-13:45	*lunch break*
13:45-15:20	Individuation of lines of action to "materialize" the objectives. Consider the 4 areas of intervention: governance, water efficiency & water loss reduction, rainwater management, grey water recycling. Are them all useful to reach your objectives? Which actions would you select or create? How would you combine them?
15:20-15:40	*coffee break*
15:40-16:10	Plenary session: discussion of the results, evaluation and conclusions. Presentation of the results obtained from the joined groups for the two cities of Agua and Voda & what did I learn from the game?
16:15-16:30	Methodological recapitulation (Poliedra)
16:30-17:00	Evaluation of the Core Master training: contents, personal learning, practical organization, insights & food for thoughts
17:00-17:30	Conclusions

5.4.2 Step by step description

A brief explanation of the steps and of the activities follow. In the opening, Poliedra with the help of the facilitators began the workshop with an interactive ice-breaking session. Following the ice-breaking session, the whole day interactive workshop started with the activities scheduled as reported in the previous table.

The aim was to create hypothetic basis and the fundamental elements of the Action Plans for urban water management for hypothetic cities based on the Status Quo-assessments and public perception survey. In this case, two imaginary cities were created, the City of Agua and the City of Voda.

The two contexts are characterised for each city by a Status Quo-Assessment and a Public Perception Survey. The two different scenarios were built trying to simulate conditions that is possible to find in reality, and were designed after the careful evaluation of different possibilities. The two contexts are created considering different problems, starting from wondering what the effects that certain values of the indicators could have on the urban water cycle.

Before starting the game, it was necessary subdivide participants in groups, because there were 40 people. Since we wanted to have numerically homogeneous groups and each group had to be composed of about 10-15 people as suggested by the guidelines, we formed 4 groups of 10 people. The group formation is random, that is without considering the real role, job or area of expertise of the participants, the important thing is that they should be numerically homogeneous.

In synthesis, there are 4 groups, two groups are going to work and to analyse the city of Agua and the other two the city of Voda. For each group a facilitator is provided.

The next step is to distribute to each participant, depending on the group they belong to, the corresponding hypothetical Status Quo-Assessment and the Public Perception Survey.

At this point everything is set for the beginning of the activities.

Firstly there is the individual reading of the description of their group's city (Status Quo Assessment and the results of the Public Perception Survey). It is requested to participants, while reading, to link and make comparisons between their imaginary city and the city they belong to. This first session allows people to be acquainted with the city, to activate their own knowledge and resources to understand the context and to link the imaginary city with the real ones that helps to bring back home solutions and ideas. In addition, in this case, the individual reading allows to start from the same knowledge of the context therefore no one is left behind for the following, more active group work.

The workshop was then followed by creating a SOAR analysis: Strengths, Opportunities, Aspirations and Results (for more explanations see chapter 4, paragraph 4.6). Based on the findings of the individual reading of the hypothetical cities, sequentially, group work focus on strengths then opportunities and at the end on aspirations always considering the context (city assigned) they are working on. It is a collaborative work and not an individual one. Discussions are the main tool of this part, through which members confront each other, providing inputs for the upcoming parts of the workshop.

Figure 5.3 Group session where S, O and A are discussed.

Before proceeding with the R (results/response) analysis, to each group is assigned a timeframe (3-5 years or 25 years); in practice there are 4 groups, for each one working on the same city a different time span is allocated therefore the results for the same city are studied both on the short and long term.

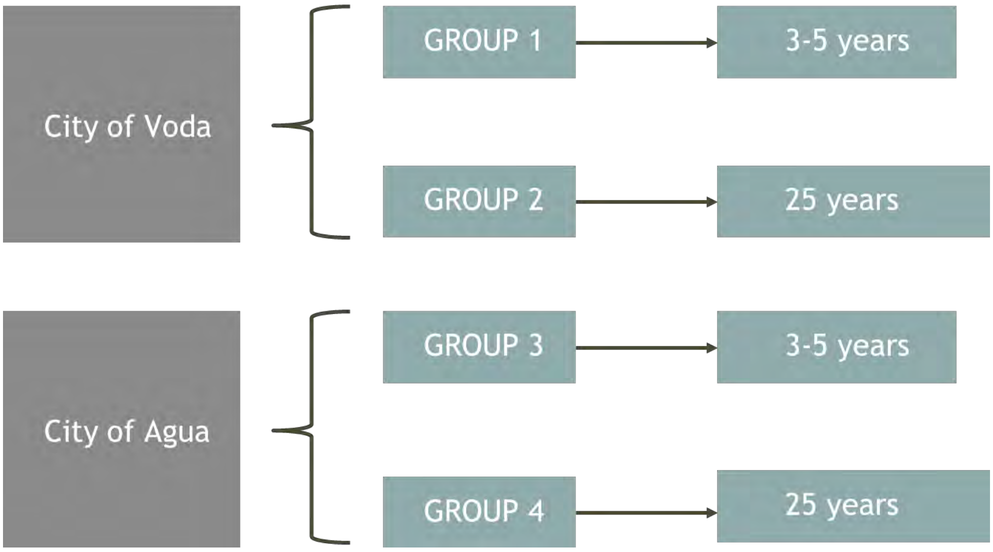


Figure 5.4 Group sub-division and scenario allocation

The definition of a city based vision is done starting from the CWC goals. In practice, groups make the goals specific to the context defining specific objectives and their priorities of intervention in the city for the given timeframe.

The next step is the design of the basic elements forming the Action Plan to "materialize" the vision, group work focus now on the R of the SOAR analysis. In order to define the basic elements, a SMART (Specific to the context, Measurable, Achievable, Realistic and Time bound) approach is used.

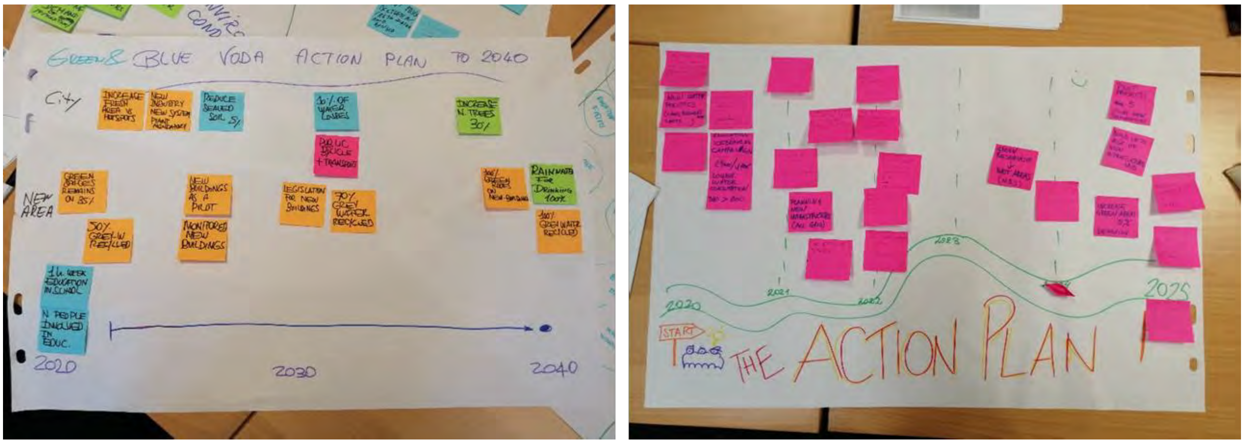


Figure 5.5 Example of the Action Plan Game proposed during the workshop

In this phase people consider the four areas of intervention (Water Governance, Water efficiency & Water loss reduction, Rainwater management and Greywater recycling) and think if they are useful to reach their specific objectives in the given time frame. Groups need to decide which actions, previously pointed out, should be used to build the action plan and how to combine them to reach the common vision of the city in the future.

Basically people can learn a process to give practical fulfilment to general ideas about Circular Water Management and learn how to select or create new actions to reach their goals and their vision.

Once each group has created the building blocks that shape its own "Action Plan" for the city, the results were then presented in plenary session concluding the MT game.

Figure 5.6 Presentation of the Hypothetical Action Plan to the participants

Facilitators were present for the entire duration of the MT, managing its interactive parts. They eased the dialogues, encouraged participants to think productively, express themselves and find solutions. In this workshop, four facilitators were present, one for each group.

5.4.3 Results, discussions and comments

The AP Methodology was tested during the MT in order to prove its validity, to identify what the implementation criticalities could be and find out modifications to make it more effective. Here below, I report some comments.

1. In this case it was decided to have subgroups of 10 people. The result was satisfactory, in fact in this way everyone interacted and expressed themselves. It is a good compromise between too large groups, where there is a risk of thoughts being dispersed, and too small groups, where thought flows risk to freeze and stall.
2. The use of facilitators constitutes a fundamental support for the success of the process, because they are able to accompany dialogues and stimulate the flow of ideas. They did an excellent work in the coordination and involvement of a group of over 40 people, keeping a long and demanding technical activity pleasant.
3. Here different timelines for the activities were used compared to those provided in the guidelines in chapter 4. In the guidelines, timing is more dilated because they

were modified after the application during the MT, in fact we realized that the times were too tight, especially in the first phase of individual data analysis.

4. The AP game was designed for a full day, but for the whole stakeholder team of each FUA it could be very difficult to arrange a full day free to participate to the workshop, therefore, according to the needs of each FUA changes can be done.
5. In reference to the previous point, it should be also considered that, when it will be implemented in the FUA it will be a real case with real data, therefore more complex and with greater interests to defend from stakeholders.
6. During the game, those with a technical role gave more importance to the indicators of the status quo assessment instead of considering the results coming from the public perception, while those who had less knowledge about the topic focused more on the analysis of public perception.
7. The fact of not giving budget constraints for the elaboration of the Action Plan lets people free to reason about the CWC goals and the areas of intervention. Participants pointed out that most of the time decisions are taken, as known, according to the monetary resources available. An improvement of the methodology could be budget insertion and cost estimates of the initiatives in order to balance the economic feasibility of intervention with the requirements of the project, but in this case it was not done because the focus was on the possible solutions to make and foster circularity and efficiency in urban context for the management of water resources. Nevertheless, even if the economic issue was not addressed but priorities of interventions considering economic values were put because everyone had in mind that, in reality, there are economic rights.
8. The contexts were invented from real bases and real data, they have been rearranged to build simplified scenarios, comprehensible even for those with less skills. But, in this way, some inconsistencies in the scenario designed arose due to little experience and knowledge on certain parameters. In fact, during the workshop, some participants with a lot of technical experience and experts in the field highlighted slight inconsistencies in the data used to create the two imaginary scenarios. Therefore, after the MT, Poliedra adjusted the two contests used for the MT game (City of Agua and City of Voda) according to the comments.
9. According to the facilitators of the group work, the Core Master Training has been a great moment of flow of collective intelligence. The participants were involved in many different ways and the different levels of knowledge and of roles have been a

wealth for the entire group. Some new perspectives are born thank to the technical knowledge brought by some people, thanks to the techniques used to help people think in a different way and thank to the desire of everybody to share ideas, experiences, point of views and best practices of each Country. When facilitators first asked participants for their "dream vision" for the city, they were met with predictable scepticism *("what's the point of dreaming?"*), but once participants started to express their visions they were very much engaged, and at the end, re-reading all the visions for the future city back to the table, the comment was *"where do I sign to go live in this city?" "how can we make this city happen for real?*". A vision anchors an action plan into long-ranging longings and aspirations for the future, leading to more ambitious and creative thinking.

10. The methodology has been tested with project partners so they can fully understand the process and its potentials, it is also a training for them in order then to better reproduce the methodology during the local competence building workshop, with adaptation and changes according to the contexts and the group of stakeholders to deal with.
11. In this occasion, when tested, it was not known which figures and personalities were at the MT and which are their real roles and area of expertise. Instead, when it will be replicated, the organiser will have a deeper knowledge of the stakeholders and on their areas of experience, thus obtaining more structured and realistic results and suggestions for the action plan.

In conclusion, the activities were performed successfully with the active participation and cooperation of those attending the meeting. Everyone took part to the activities with enthusiasm; even if in the starting phase there was some resistances in the participation but, fortunately, facilitators encourage the engagement and allow for high participation by introducing different conversation patterns (e.g. individual reflections and post-it clustering; paired/small group conversations etc.) for each step. The presence of facilitators is fundamental for the success of the process.

Having personally taken part to the workshop, I noticed that the basic data from which we started (Status-Quo self-assessment and results of the public perception survey) unleashes the flow of thoughts expected, in particular participants focused on the critical parameters planned and the reasoning they developed were in line with the final aim of identifying the measures to create the action plan for circular water management. But, in this regard, further comments are needed. During the core MT, as said, the methodology was tested with imaginary contexts and participants were the project partners and the associated ones already involved and familiar with the project and also sensitized to the issue; therefore they believe and are convinced that the circularity in water management leads to positive results. Instead, when it will be applied to real cases with the real stakeholder group, conflicts may rise because someone will argue that it is not useful and that there are other approaches more effective to water management.

Additionally, another aspect that has mitigated the occurrence of conflicts in the imaginary situation simulated is that, here people involved has not direct interests to defend, it is a not real situation, therefore they propose one-size-fit-all solutions for circular water management without going into too much detailed.

In reality, when real stakeholders, analysing their real situation, will apply the process, they will have a direct and concrete interest to defend, therefore creating debates and conflicts to support and protect their own interest, leading to more specific and well-founded results.

In conclusion, I think that the validity of the methodology was tested and positive results about its applicability were obtained. Remember that it is a learning and participative process, with no strict rules but it can be modified and adapted to the different contexts.

6. Conclusions

According to several studies, cities have always had to face problems related to the management of too much, too low or too polluted water resources. Nowadays, this kind of problems are exacerbated by global change trends, such as population growth, urbanization increases, climate change, etc. that directly affect water resources and compromise the fulfillment of quality and quantity needs. This, coupled with the increasing complexity and inter sectoral dependencies of the water system, makes today's management of water resources in urban context a challenging issue. This complexity is due to the intrinsic organisation of the system which is characterised by inter- and intra-sectoral dependencies, multi-stakeholders, multi-scale and multi-level governance. These are only a few of the problems linked to water resource planning. Many other issues exist and are linked to the topic, but in this thesis I had only focus on the previously mentioned concepts with regard to the European situation.

In this context, the thesis has been done with reference to the Interreg Central Europe project City Water Circles (CWC) that aims at enhancing circular water management in Central European Functional Urban Areas (FUAs).

Following this perspective, the main objective of the thesis was to provide tools and methods that try to deal with the intrinsic complexity of the water system in order to facilitate municipalities to become driving forces of circular management of water resources, fostering an approach that considers stakeholder involvement and participation.

For these reasons, a process composed by three parts is designed, each one with a specific purpose and conceived for overcoming and solving different problems of the water sector, because often these are analysed separately and in watertight compartments when instead they influence each other. Furthermore, there is the necessity to find an agreement between the interested parties and make them cooperate to create common solutions following the perspective of the CWC project that wants to enhance water efficiency and reuse with an integrated circular economy approach.

The methodology is composed by three components, of which, respectively, the first two are the input tools and knowledge base for the development of the third part:

1. Status Quo Self-Assessment: it analyse the local situation and background conditions regarding the water system, it is made up of 44 indicators about climate conditions, population and territorial configuration, natural water resources, water

infrastructures, water consumption, issues linked to climate change, existing local laws and rules regulating the anthropic and natural water cycle and good practices.

2. Public Perception Survey: it is a questionnaire addressed to the population in which the willingness to change, people's water usage habits, social feasibility of intervention and priorities are detected.
3. AP (Action Plan) Methodology: it is a structured workshop during which stakeholders, starting from the context shaped by the previous two inputs, jointly identify the key elements and co-design the strategies which should form the action plan for circular urban water management.

The complete reproduction of this process in all the FUAs with their stakeholder groups is scheduled by the project but the timing did not allow me to analyse the results. The analysis of the real applicability would give me more concrete and trustable results. The process should be applied in several real cases in order to draw more certain conclusions and to understand its real usefulness, nevertheless I can make some final considerations based on the analysis shown in the previous chapter.

The methodology is proposed to create cooperation between stakeholders in order to co-design action plans that allow to achieve the circular urban water management within the FUAs and it instructs on how to manage complexities and plan interventions that may be in line with the principles of the CWC project. It is an important meeting point between municipalities' authority and stakeholders, to give voice to the latter too because often in a top-down hierarchical system, stakeholders perspectives are not considered. But, it is also important to highlight that one of the main reason to involve stakeholders in a problem such as circular water management is that if the stakeholders do not collaborate it is impossible to foster circularity in the water management, their support and experience in this field is crucial. There are many actors involved and if everyone does not carry out his own task, there is the risk of creating gaps in the management leading to a wrongful circular water planning.

Certainly it is not a flawless process, in my opinion: the AP Methodology should be more structured but interesting inputs and key elements can be obtained for a more detailed drafting of the action plan. In fact, during the core Master Training the methodology was tested by the group of project partners and associated partners of the CWC project with the use of imaginary contexts, trying to simulate real situations shaped by hypothetical Status-Quo Self-Assessments and Public Perception Surveys. In this occasion, I noticed that some of the participants were more focused on their own idea of how to reach circular water management than on proposing solutions based on the time frame assigned and on the imaginary contexts provided. They disregarded the data provided and proposed measures for an action plan not tailored to the context but that could be valid in general for circular water management therefore the key elements identified on which to base the action plan were not specific. I think this is mainly due to the type of analysis used for the AP methodology that is the SOAR (Strengths, Opportunities, Aspirations and Results) one. In particular because when "*Aspirations*" are pointed out, the context on which they are working gets lost and participants free their mind thinking about their "dreaming city", they focus on the vision they have about circularity in the water management losing the perception of what can really be achieved in reality. This could also happen when the methodology is applied in the real situation with real data in the FUA causing inaccuracy in the results.

It is also possible to use the Status Quo self-assessment and the Public perception survey as learning tools on their own for different processes because they give essential but useful information about the background water situation.

I also think a strong limitation is the spatial scale to which the whole project refers, that is the FUA level. A better scale of action could be the urban context, disregarding the surrounding territories with more rural vocation, where the water problematics to be tackled are different, or the municipality level. Furthermore, it is very difficult to act at the FUA level because it does not correspond with any administrative level.

Despite the limits discussed above, according to me this process is very useful because it laid the foundations for a great design of an action plan for the management of water resources in urban context based on a circular approach. It allows to have sweepings 360 views of the situation detecting the background conditions with the Status-Quo Self-assessment, the social feasibility of interventions and education with the Public perception survey and the stakeholders' willingness with the implementation of the AP Methodology, it is a process that looks at the problem as a whole. It permits also to create cohesion and cooperation both between stakeholders but also with decision makers in order to arrive to shared and agreed outcomes for circular water management. It also allows to increase the sensitivity and raising awareness of stakeholders involved because there is low perception of the associated need to foster circularity in the water management, therefore an effort from everybody is necessary.

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Appendix 1

In the following the results of the FUA-level Status Quo Self-assessment made by the FUA of Turin is reported. The reference Deliverable in which they are contained is the D.T3.1.3: "*FUA-level self-assessments on background conditions related to circular water use*".

A. CLIMATE, ENVIRONMENT AND POPULATION

A1) POPULATION

1) Population living in the FUA in 2018 [inh.]

In 2018, the FUA's population was 1.784.753.

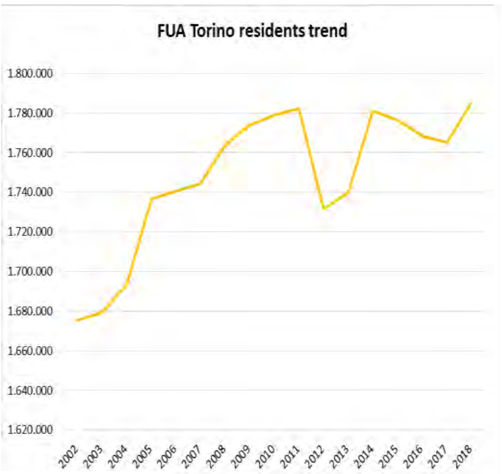
x Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: https://www.google.it/publicdata/explore?ds=g0io3het07c3h_&met_y=pop&idim=municipality:001002&hl=it&dl=it#!ctype=l&strail=false&bcs=d&nselm=h&met_y=pop&scale_y=lin&ind_y=false&rdim=country&idim=municipality:001272&ifdim=country&tstart=1011481200000&tend=1516402800000&hl=it&dl=it&ind=false

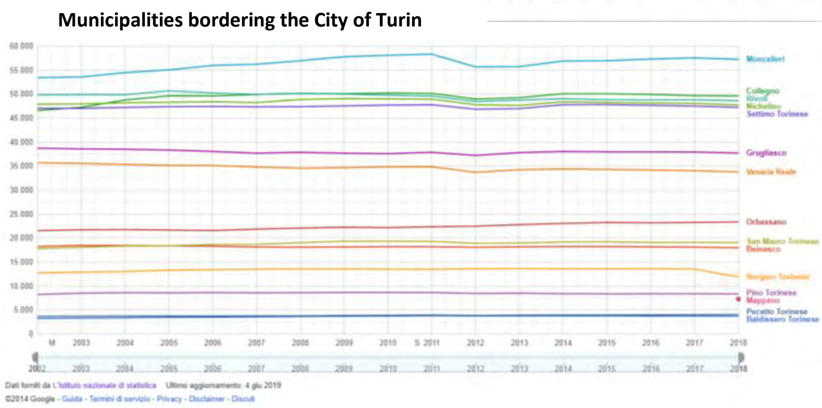
2) Population change in the last 20 years in the FUA [inh.]

Table:

FUA TORINO	RESIDENTI AL 1° GENNAIO - ANNO																
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
FUA - TORINO	1.675.419	1.679.301	1.693.682	1.736.813	1.740.577	1.744.470	1.763.812	1.773.885	1.778.987	1.782.158	1.731.400	1.740.036	1.780.988	1.776.462	1.768.465	1.765.147	1.784.754

Chart:





Trend of the population of the City of Turin and to generate other graphs

X Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: https://www.google.it/publicdata/explore?ds=g0io3het07c3h_&met_y=pop&idim=municipality:001002&hl=it&dl=it#!ctype=l&strail=false&bcs=d&nselm=h&met_y=pop&scale_y=lin&ind_y=false&rdim=country&idim=municipality:001272&ifdim=country&tstart=1011481200000&tend=1516402800000&hl=it&dl=it&ind=false

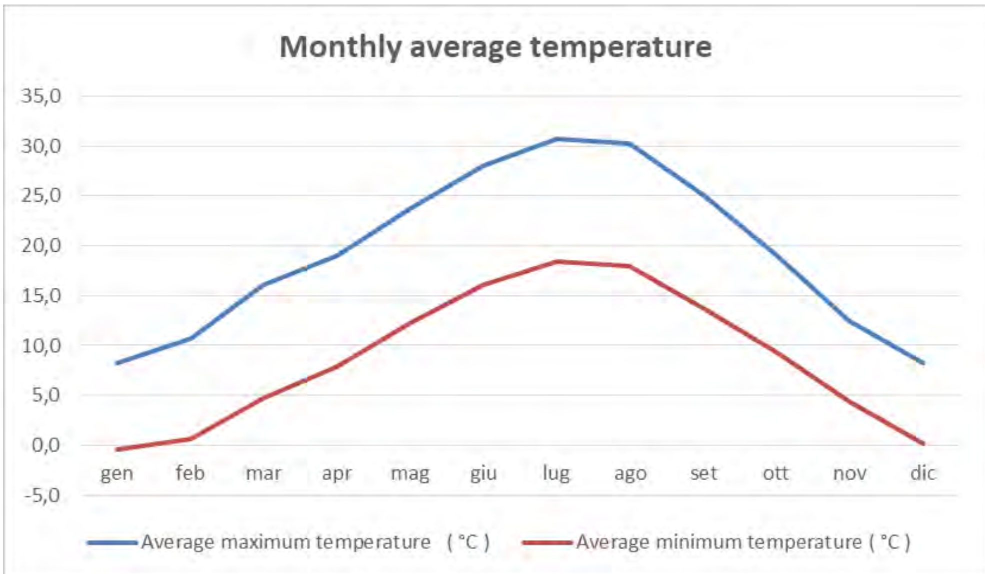
A2) CLIMATE

3) Monthly average temperature (max and min) [°C]

Table:

	jan	feb	mar	apr	may	june	july	aug	sep	oct	nov	dec
Average maximum temperature (°C)	8,2	10,7	16,1	19,0	23,7	28,0	30,7	30,2	25,1	19,1	12,5	8,3
Average minimum temperature (°C)	-0,4	0,7	4,7	7,9	12,2	16,1	18,4	18,0	13,8	9,3	4,3	0,2

Chart:

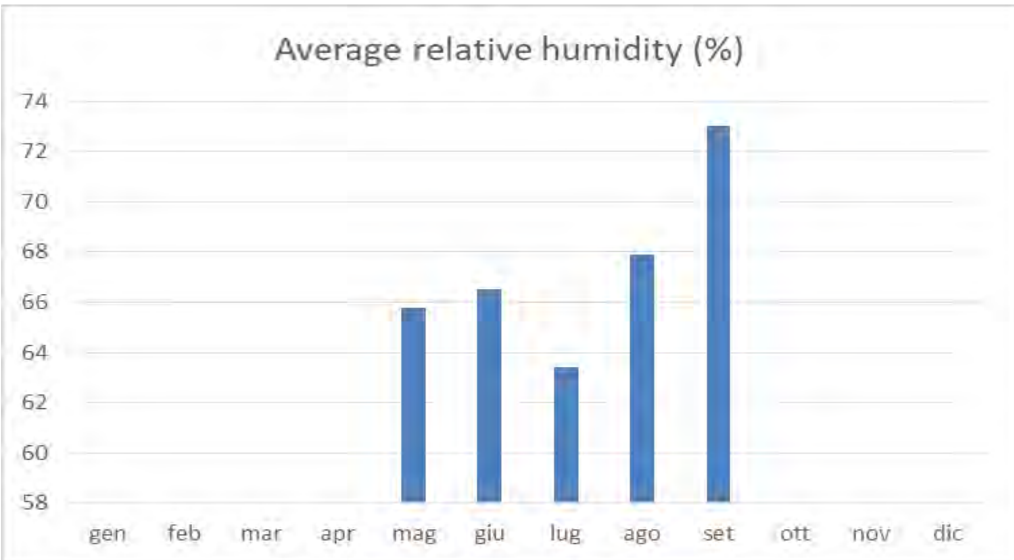


x Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: Arpa Piemonte

4) Average relative humidity in summer months [%]	
Table:	

	jan	feb	mar	apr	may	june	july	aug	sep	oct	nov	dec
average relative humidity (%)					66	67	63	68	73			

Chart:



x Measured at FUA level	Estimate procedure and hypotheses:
□Estimated at FUA level	Source of data: Arpa Piemonte

A3) SEALING SOIL

5) FUA total area [km²]

FUA total area: 1.701,357 Km²

Map:

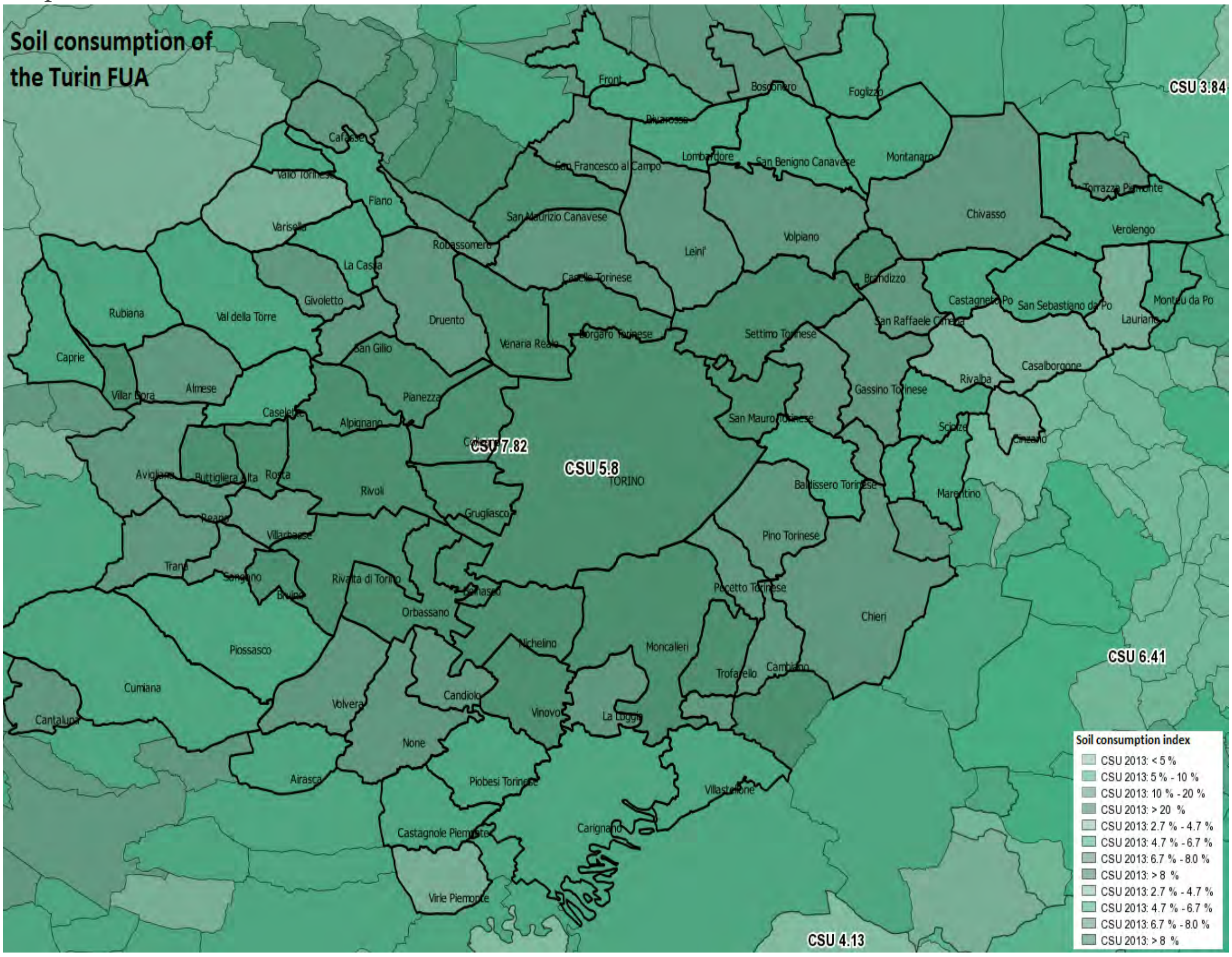
xMeasured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: Cartography of the territory

6) Percentage of sealed soil [%]

Table:

Soil consumption for the Turin FUA	
Years	**Percentage of soil consumed (%)**
2018	34,50%

Map:



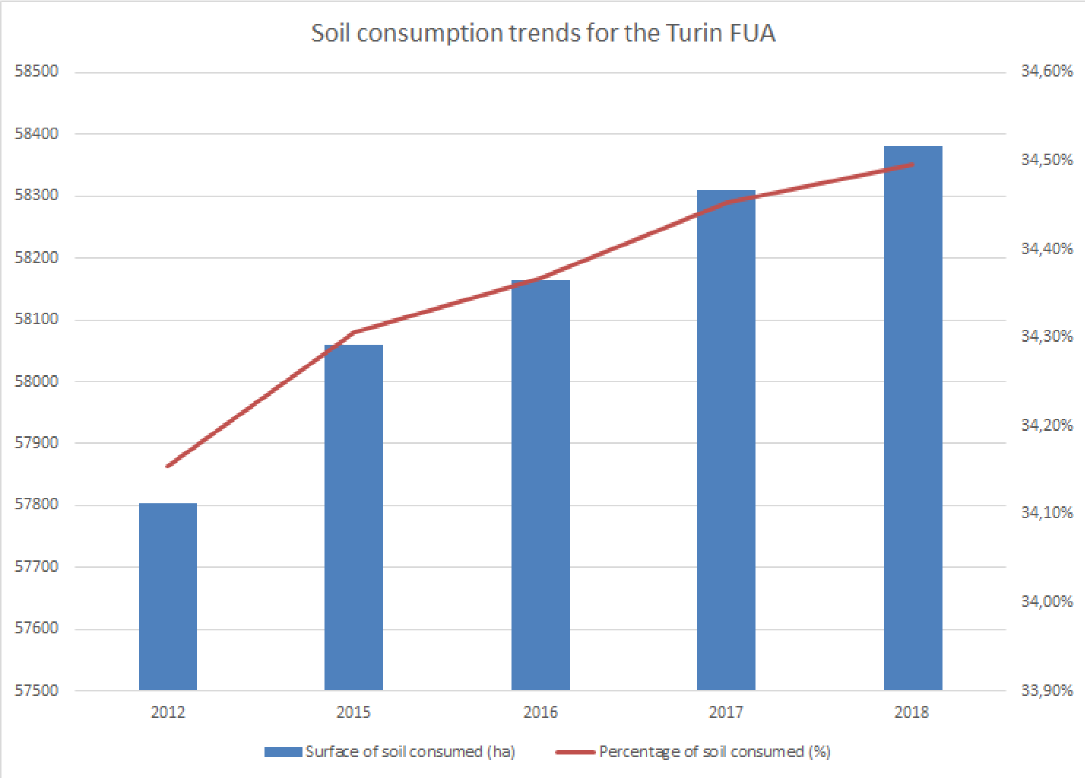
x Measured at FUA level	Estimate procedure and hypotheses:
□Estimated at FUA level	Source of data: geoportal of the metropolitan city of Turin

7) Time series of the percentage of sealed soil [%]

Table:

Soil consumption trends for the Turin FUA		
Years	**Surface of soil consumed (ha)**	**Percentage of soil consumed (%)**
2012	57803,13	34,15%
2015	58061,25	34,31%
2016	58164,87	34,37%
2017	58310,03	34,45%
2018	58381,67	34,50%

Chart:



x Measured at FUA level	Estimate procedure and hypotheses:
□Estimated at FUA level	Source of data: ISPRA annual report

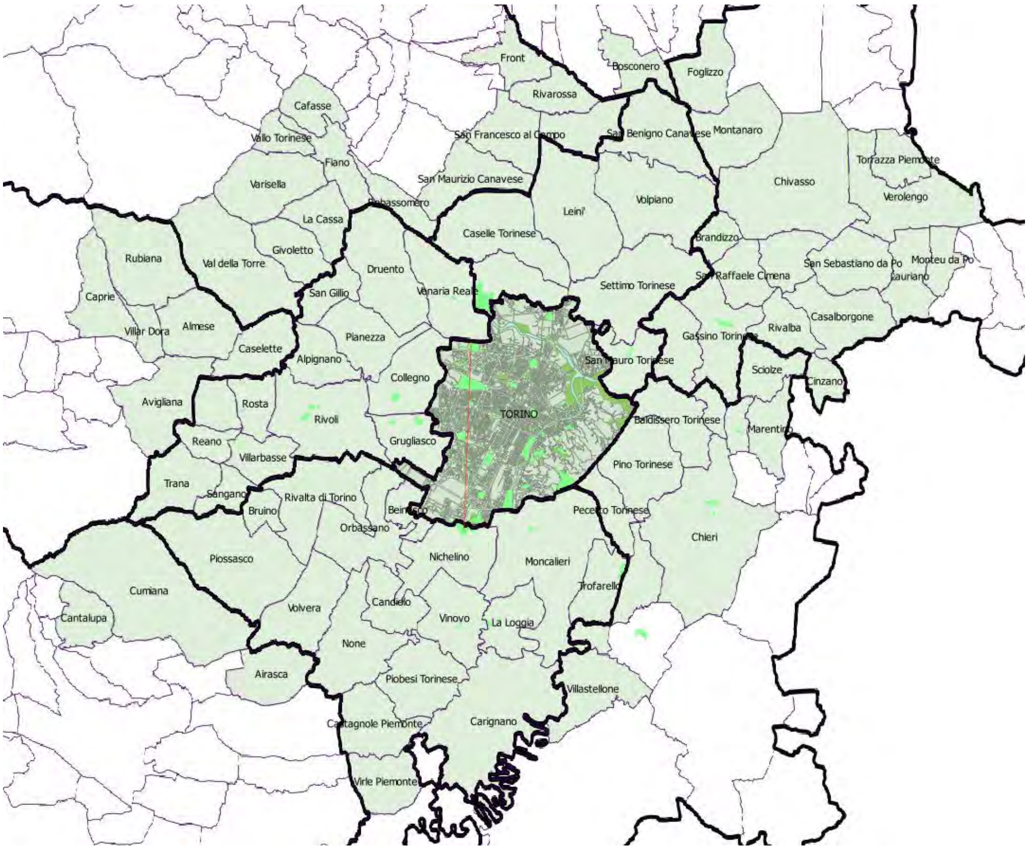
A4) GREEN SPACES IN URBANIZED AREAS

8) Green area in the entire FUA [km²]	
Green Area in the entire FUA: 1.320 kmq	
□Measured at FUA level	Estimate procedure and hypotheses:
x Estimated at FUA level	Source of data: ISPRA CLC 2018

9) Percentage of green spaces within urbanized areas [%]

Total urban green area – FUA: 24.530.341 mq

Map:



Description:

Detailed data of the city of Turin

Total area publicly managed green areas (municipal, provincial, state, etc.) in the municipal area: approximately 19.569.000 m² (in addition to 1.908.237 m² of agricultural areas)

Total surface public green areas with municipal management, direct or indirect: sqm. 19.210.729 (in addition to 1.908.237 m². Of agricultural areas)

Publicly managed green area out of the total municipal area: 16,5%

Green per inhabitant (excluding agricultural areas): 21,93 m²

Municipal property extraterritorial green: approximately 1.450.000 m²

Parks and gardens: about 12.733.000 m²

Flower beds: approximately 2.700 m²

Urban gardens and agricultural areas: 1.968.237 m²

Municipally managed forest: 1.636.000 m²

Total wooded areas: 7.925.186 m²

Play areas: n. 277 (updated September 2015)

Dog areas: n. 54 (update June 2016)

Urban arboreal heritage: about 110.000 specimens

Hilly tree heritage: over 50.000 specimens Protected areas at European level (Natura 2000 network) + Natural Areas Protected by regional legislation in the municipal area (both public and private property): 5.913.500 m²

□Measured at FUA level x Estimated at FUA level	Estimate procedure and hypotheses: Source of data: the data contained in the databases of the City of Turin and the Metropolitan City were used.

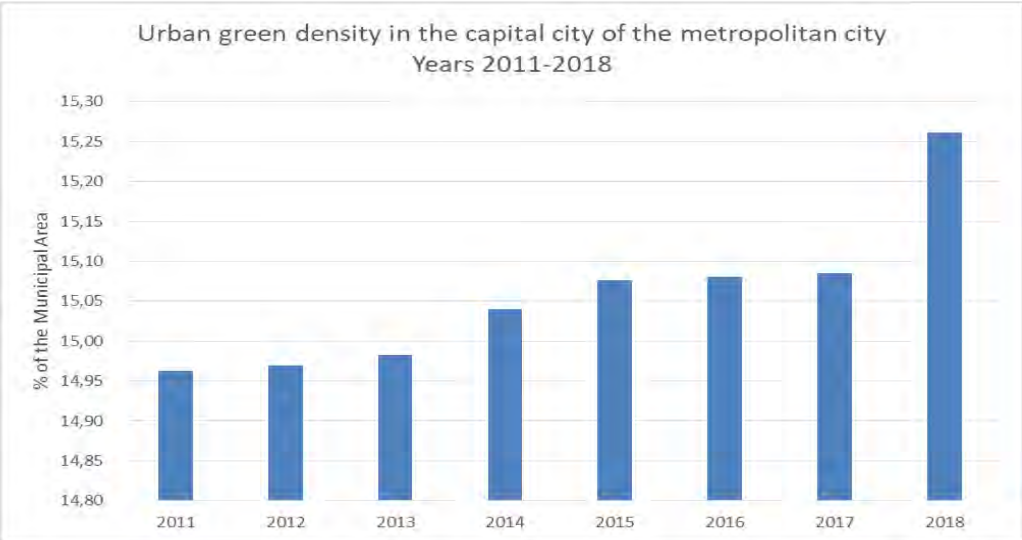
10) Time series of the percentage of green spaces within urbanized areas [%]

Table:

Urban green density in the capital city of the metropolitan city Years 2011-2018

	2011	2012	2013	2014	2015	2016	2017	2018
% of the Municipal Area	14,96	14,97	14,98	15,04	15,08	15,08	15,09	15,26

Chart:



X Measured at city of Turin level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: ISTAT environmental database

B. WATER RESOURCES

B1) ANNUAL PRECIPITATION

11) Average annual precipitation [mm]

Average annual precipitation: 927 mm

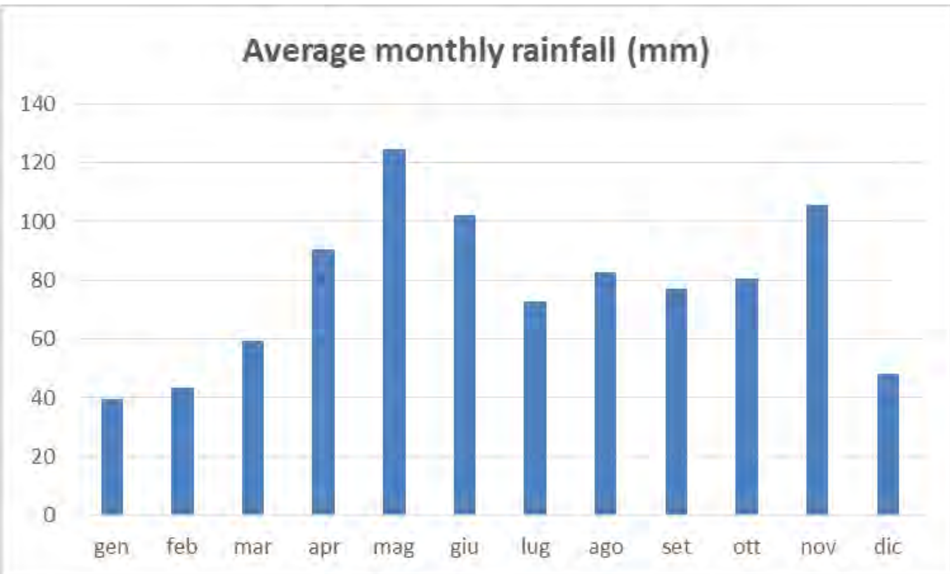
□Measured at FUA level x Estimated at FUA level	Estimate procedure and hypotheses: Source of data: Arpa Piemonte. Average of the annual average rainfall from 1990 to 2019.

12) Monthly precipitation [mm]

Table:

	jan	feb	mar	apr	may	june	july	aug	sep	oct	nov	dec
Average monthly rainfall (mm)	40	43	59	91	124	102	73	83	77	81	106	48

Chart:



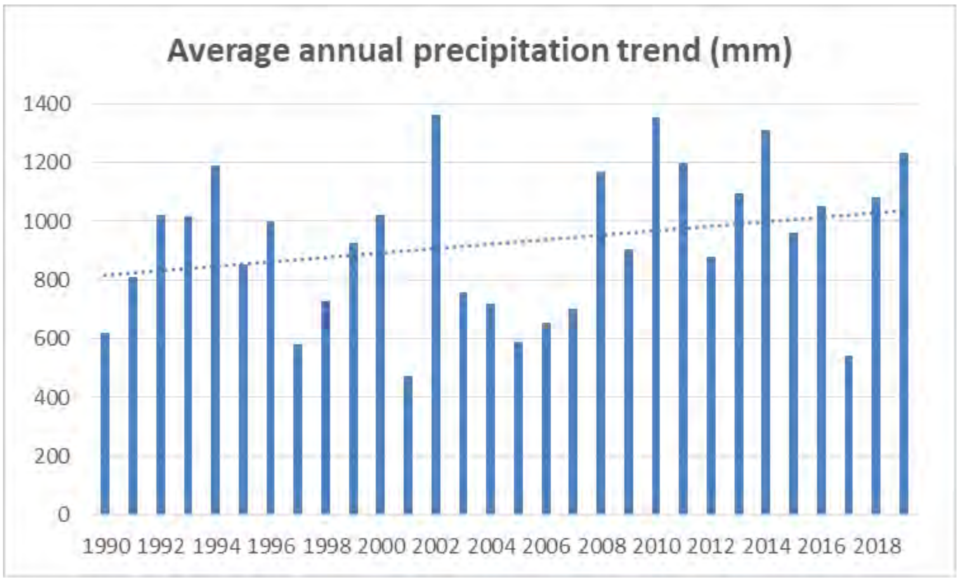
x Measured at FUA level	Estimate procedure and hypotheses:
□Estimated at FUA level	Source of data: Arpa Piemonte

13) Trend of annual precipitation [mm]

Table:

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Average annual precipitation (mm)	622	810	1021	1019	1191	853	1000	582	726	928
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Average annual precipitation (mm)	1021	474	1361	756	719	591	655	704	1166	904
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Average annual precipitation (mm)	1352	1196	881	1096	1309	962	1054	544	1080	1231

Chart:



x Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: Arpa Piemonte

B2) RIVER, CHANNELS AND LAKES

14) List of main rivers and channels within the FUA, and their flow rate (average 2018 and monthly flow 2018) [-]

Water body name	Flow rate [m³/s]
Chisola	4,28
Malone	5,78
Viana	1,27
Meletta	0,43
Noce	0,52
Oitana	1,69
Sangone	4,25
Po (Torino)	94,39
Stura di Lanzo	25,59
Sessi	0,63
T. Messa	0,96
Dora Riparia	24,83
Casternone	1,10
Orco	26,28
Canale Cavour	87,60
Banna	0,79
Ceronda	2,78
Bendola	0,91
Torto di Roletto	0,50

15) Synthetic water quality evaluation (ecological and chemical status) for each of the rivers and channels identified (include quantitative parameters, if available) [-]

Water body name	Water quality
Chisola	Chemical status: good Ecolofical status (SQA): adequate
Malone	Chemical status: good Ecolofical status (SQA): good
Viana	Chemical status: good Ecolofical status (SQA): very good
Meletta	-
Noce	-
Oitana	-
Sangone	Chemical status: good Ecolofical status (SQA): good
Po (Torino)	Chemical status: good Ecolofical status (SQA): adequate
Stura di Lanzo	Chemical status: not good Ecolofical status (SQA): good
Sessi	-
T. Messa	Chemical status: not good Ecolofical status (SQA): good
Dora Riparia	Chemical status: good Ecolofical status (SQA): very good
Casternone	-
Orco	-
Canale Cavour	-
Banna	Chemical status: good Ecolofical status (SQA): adequate
Ceronda	Chemical status: good Ecolofical status (SQA): very good
Bendola	-
Torto di Roletto	-

16) List of main lakes and reservoirs within the FUA, an their water storage (average 2018 and monthly variation 2018) [-]

Water body name	Water storage [m^3]
Lago grande di Avigliana	16.200.000
Lago piccolo di Avigliana	4.500.000

17) Synthetic water quality evaluation (ecological and chemical status) for each of the main lakes and reservoirs identified (include quantitative parameters, if available) [-]

Water body name	Water quality
Lago grande di Avigliana	Chemical status: good Ecolofical status (SQA): very good
Lago piccolo di Avigliana	Chemical status: good Ecolofical status (SQA): very good

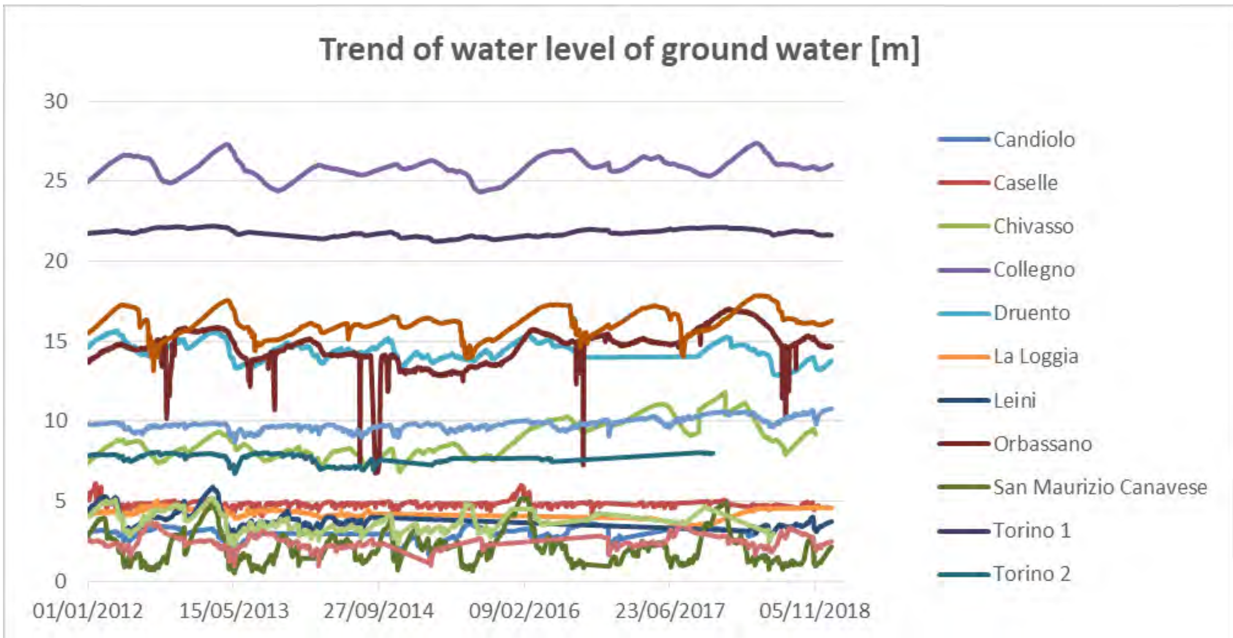
B3) GROUND WATER

18) Groundwater level trends [m]

Table:

	Trend of water level of ground water [m]						
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Candiolo	3,13	2,69	2,22	2,82	3,10	3,16	2,90
Caselle Torinese	4,90	4,80	4,79	4,83	4,93	4,87	4,74
Chivasso	8,19	8,39	7,77	8,06	9,73	10,51	9,65
Collegno	25,83	25,74	25,73	25,38	26,27	25,96	26,34
Druento	14,79	14,49	14,34	14,08	14,84	14,71	13,86
La loggia	4,44	4,37	4,14	N.A.	3,99	3,70	4,49
Leinì 1	4,22	4,04	3,64	N.A.	N.A.	N.A.	3,41
Leinì 2	4,97	4,80	4,18	N.A.	N.A.	N.A.	N.A.
Orbassano	14,62	14,73	13,75	13,31	15,10	15,35	15,56
San Maurizio Canavese	2,13	2,21	2,12	2,25	2,48	2,28	1,72
Torino 1	21,95	22,03	21,63	21,44	21,74	21,96	21,86
Torino 2	7,86	7,86	7,28	7,50	7,63	8,01	N.A.
Venaria	15,98	15,97	16,01	15,63	16,35	16,31	16,83
Verolengo	9,70	9,58	9,52	9,69	9,82	10,19	10,34
Virle Piemonte	2,65	2,47	2,15	2,02	2,41	2,71	2,51
Volpiano	4,20	3,71	3,26	3,53	3,90	4,02	2,91

Chart:



C. INFRASTRUCTURES

C1) WATER DISTRIBUTION SYSTEM - POPULATION WITH ACCESS TO FRESH WATER

19) Percentage of population with access to the water supply network [%]	
Percentage of population with access to the water supply network: 100%	
x Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino

20) What kind of water purification/treatment are in use, what is planned? [-]
Description for the entire area managed by SMAT: Over the years, SMAT has built drinking water plants for almost all types of pollutants, namely: • pollutants of natural origin: arsenic, iron, manganese, ammonia, sulphates, odorous substances, natural organic substances, microorganisms such as algae, bacteria, protozoa; • anthropogenic pollutants: nitrates, organic micro pollutants such as chlorinated compounds, aromatic compounds, pesticides and related metabolites. 93 drinking water plants are currently in operation (some plants simultaneously remove several pollutants) which can be classified, in relation to the complexity of the process adopted, in categories A1, A2 and A3 on the basis of Legislative Decree 152/2006 and subsequent amendments. The processes adopted by SMAT to guarantee the quality of the water supplied to users are as follows: aeration, chemical oxidation with chlorine, chlorine dioxide or ozone, clarification and precipitation, filtration on sand or on exchange resins, reverse osmosis, ultrafiltration, adsorption on activated carbon and other materials, disinfection with hypochlorite, chlorine dioxide and ultraviolet.

Almost all the water withdrawn by SMAT for drinking purposes is subjected to at least disinfection treatment to maintain the microbiological quality in the distribution networks. This process occurs mostly through the use of sodium hypochlorite and, in some cases, chlorine dioxide or ultraviolet (UV) radiation. About a third of the water withdrawn must also undergo drinking water treatment for the removal of chemical pollutants. For groundwater, other types of processes have been added to traditional sand and activated carbon filtration systems in recent years: among the main innovations in the field of water treatments we mention the use of granular ferric hydroxide for the removal of arsenic, while for surface waters the adoption of membrane treatments, which are preferable also in consideration of the effects on the quality of the resources expected due to climate change.

21) Tap water quality - lab test results[13]	
In annex n ° 1 are reported all the results of the laboratory analyses for the quality of drinking water for each municipality of the FUA.	
x Measured at FUA level □ Estimated at FUA level	Estimate procedure and hypotheses: SMAT Torino and other water service operators.

C2) WATER DISTRIBUTION SYSTEM LOSS

22) Percentage of loss in the water supply network [%]	
The index of real losses in distribution is 24.97 % in the City of Turin.	
□Measured at FUA level x Estimated at city of Turin level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

C3) DUAL WATER DISTRIBUTION SYSTEM

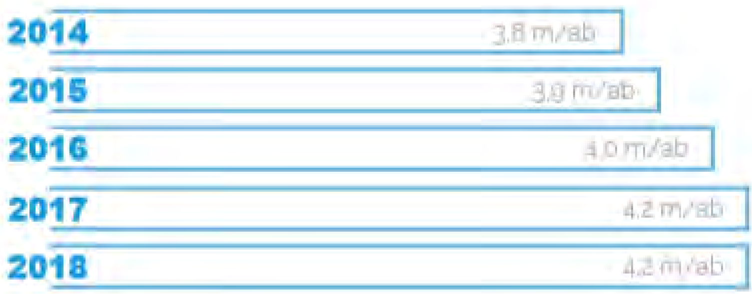
23) Description of eventual dual system water supply network within the FUA [-]	
System not present.	
□ Measured at FUA level □ Estimated at FUA level	Estimate procedure and hypotheses:

C4) FIRST FLUSH RAINWATER COLLECTION

24) Qualitative description of the first flush rainwater collection technique implemented, if any [-]
Art.8 bis of the Environmental Energy Annex to the City of Turin Building Regulations stipulates that for new construction and major renovations it is mandatory to store and reuse for irrigation purposes of meteoric waters, in the minimum measure of 10 litres of accumulation per sqm of green areas. With the Regional Law N.1/R of 20/02/2006, specific treatment and delivery of first-time water relating to certain production activities is provided in the public sewer.
Is your description representative of the entire FUA? Please give a short explanation. The Regional Law N.1/R of 20/02/2006 involves the whole FUA. The Environmental Energy Annex concerns only the City of Turin.

[13] Turin provided the entire set of laboratory test results for water quality for each of the municipalities of the FUA. For the scope of this thesis, they are not relevant therefore they are not reported here.

C5) WASTEWATER COLLECTION

25) Percentage of households and percentage of industries, connected to the wastewater collection network [%]	
In 2018 the extent of the sewerage network per inhabitant served (meters per inhabitant) which, at least indicatively, measures the collection capacity of civil and industrial waste, remained stable compared to the previous year. However, it is believed that it may grow in the next years, in relation to the works envisaged in the investment plan; on the other hand, its possible contraction can be traced back to the rationalization of the purification infrastructures on the territory.  	
□Measured at FUA level x Estimated at city of Turin level	Estimate procedure and hypotheses: Source of data: SMAT Torino sustainability report – year 2018

C6) DUAL WASTEWATER COLLECTION SYSTEM

26) Description of eventual dual system wastewater collection network within the FUA [-]	
The sewage system is the complex of works with which part of the rainwater (white) and domestic and industrial (black) wastewater are treated. In order to optimize the treatment of waste water, these are divided into two separate dedicated networks; in this way the dilution of black water (which makes the purification processes more expensive) and unnecessarily "dirty" rainwater (which by its nature is little polluted and requires simpler treatments) is avoided. For this reason, SMAT, in recent years, foresees the separation of the two types of network for new sewage constructions and for the remaking of the older ones. SMAT manages a sewer development of 9.526 kilometers of municipal networks, white, black and mixed, corresponding to 4.2 meters per inhabitant served	
□ Measured at FUA level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino

C7) WASTEWATER TREATMENT PLANTS

27) List of wastewater treatment plants and their population equivalent capacity compared to the actual population [-]

Class	Municipality of location of the plant	Plant name	Municipalities served	Total treated load (ab.eq.)
> 150.000 ab.eq.	Castiglione T.se	Po Sangone	Beinasco, Borgaro T.se, Bruino, Cambiano (parziale), Candiolo, Caselle T.se, Castiglione T.se (parziale), Chieri (Pessione), Cinzano, Druento, Gassino, Givoletto, Grugliasco, La Cassa (parziale), La Loggia, Leinì, Moncalieri, Nichelino, Orbassano, Pianezza (parziale), Piobesi T.se, Piossasco, Poirino, Rivalba, Rivalta, Robassomero, S. Benigno C.se (parziale), S. Francesco al Campo, S. Gillio, S. Maurizio C.se (parziale), S. Mauro T.se, S. Raffaele Cimena, Sangano, Santena, Sciolze, Settimo T.se, Torino, Trana, Trofarello, Venaria Reale, Villastellone, Vinovo, Volpiano.	1.931.129
	Collegno	C.I.D.I.U.	Collegno, Druento (parziale), Grugliasco, Reano, Rivoli, Villarbasse.	168.246
15.000<ab.eq.<150.000	Rosta	Rosta	Almese, Avigliana, Borgone di Susa, Bruzolo, Bussoleno, Buttigliera Alta, Caprie, Chianocco, Chiusa S. Michele, Condove, Mattie, Meana di Susa, Mompantero, Rosta, Rubiana, S. Didero, S. Giorio, Sant'Ambrogio, Sant'Antonino, Susa, Vaie, Venaus, Villar Dora, Villar Focchiardo.	84.729
	Pinerolo	Porte	Inverso Pinasca, Perosa Argentina, Pinasca, Pinerolo, Pomaretto, Porte, S. Germano Chisone, Villar Perosa.	91.722
	Chieri	Fontaneto	Andezeno, Baldissero T.se, Chieri (parziale), Marentino (parziale), Montaldo T.se, Pavarolo, Pino T.se.	54.135
	Feletto	Feletto-Rivarolo	Agliè, Bairo, Baldissero C.se (area PIP), Bosconero (fraz. Mastri), Castellamonte, Ciconio, Favria, Feletto, Lusigliè, Oglianico, Ozegna, Pertusio, Rivarolo C.se, Salassa, S. Giorgio C.se, S. Giusto C.se, S. Ponso, Torre C.se, Valperga (parziale).	54.820

	Pianezza	Pianezza	Alpignano, Caselette, La Cassa (parziale), Pianezza (parziale), Rivoli (parziale), Val della Torre	53.176
	S.Maurizio C.se	Ceretta-S.Maurizio C.se	Ciriè, S. Carlo C.se, S. Francesco al Campo (parziale), S. Maurizio C.se (parziale).	38.611
	Chivasso	Arianasso	Castagneto Po, Chivasso.	28.487
	Carmagnola	Ceis	Carmagnola.	27.778
	Ivrea	Ivrea est	Albiano d'Ivrea Burolo, Cascinette d'Ivrea, Chiaverano, Ivrea (est).	24.899
	Giaveno	Coccorda	Coazze, Giaveno (parziale), Valgioie.	22.350
	Cavour	Castellazzo	Angrogna, Cavour (parziale), Garzigliana (parziale), Luserna S. Giovanni, Torre Pellice (parziale).	19.277
	Nole	Loc. Battitore	Balangero, Grosso (parziale), Mathi, Nole, Villanova C.se.	17.583
	Valperga	Rivarotta–Gallenca	Borgiallo, Canischio, Cuorgnè, Pont C.se (parziale), S. Colombano Belmonte, Valperga (parziale).	17.472
	Mazzè	Caluso - Mazzè	Barone C.se, Caluso, Mazzè, Montalenghe, Orio C.se.	16.568
10.000<ab.eq. <15.000	Oulx	Gad	Oulx, Sauze d'Oulx.	13.213

x Measured at FUA level □Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino

28) What kind of wastewater treatment is realised, what is planned? [-]

In recent years, numerous small purification plants have been decommissioned which, due to their size and technology, could not allow high purification yields, with the transfer of waste water to the centralized plant of Castiglione Torinese or to other plants with greater treatment potential.

In particular, in 2018 small purifiers were dismissed in the Municipalities of Foglizzo, San Carlo, La Cassa, Front, Viù, Ingria and Rubiana.

x Measured at FUA level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino

C8) TREATED EFFLUENT

29) Annual volume of waste water treated by the wastewater plants [m3]

Water treated by the Castiglione T.se plant: 227.498 million mc

Water treated by the Collegno plant: 13.632 million mc

Water treated by other plants: 116.566 million mc.

x Measured at Metropolitan City of Turin level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

D. WATER CONSUMPTION

D1) FRESHWATER EXTRACTED

30) Annual volume of freshwater extracted from the ground, surface water, other sources. (Specify sources) [m3]

Most of the water withdrawn from the environment is of underground origin, i.e. from wells and springs (overall about 82%). Only 17,7% is of superficial origin (rivers, streams, rii).

Water produced from wells: 71%

Water produced from surface withdrawals: 17,7 %

Water produced from springs: 11,3%.

x Measured at Metropolitan City of Turin level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

D2) FRESHWATER USED/CONSUMED BY POPULATION

31) Daily volume of freshwater used by each person for civil uses [l/day per capita]

In 2018, the water supplied by SMAT was 177,2 million cubic meters in total, of which almost 79,12% was used for domestic use.

Considering that the residents of the municipalities served by SMAT are 2.247.449, an average of 171 l of drinking water per person for civil use was consumed per day in the Metropolitan city of Turin.

□ Measured at FUA level X Estimated at Metropolitan City of Turin level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

32) Consumption of bottled water for drinking purposes [l/day per capita]

Starting from national considerations, it has been estimated that for 2018 in the FUA the annual water consumption was equal to: 290.000.000 of 1,5-liter bottles (approximately 0,66 liter/day per capita).

□Measured at FUA level x Estimated at FUA level	Estimate procedure and hypotheses: It was considered that in Italy the production of bottled water was equal to 14.800 million litres and that the average per capita consumption was equal to 244 litres. It has been estimated that 44% of the population uses tap water and that in 2018 the water distributed in the FUA by the SMAT water houses was approximately 106934 litres.

33) Initiatives to reduce consumption of bottled water [-]

175 water points have been installed in the Metropolitan City of Turin.

The water points are designed to support the consumption of tap water for food purposes and allow the supply of "*zero kilometres*", natural, sparkling water at room temperature or refrigerated. Preferably located in gardens, squares and places of great aggregation, they also represent an opportunity to redevelop the spaces that host them. It's estimated that a water point, with a normal draw of about 4,000 litres of water per day, allows savings of about 1 million plastic bottles per year.

https://www.smatorino.it/punti-acqua/

Please specify which municipalities within the FUA are involved in these initiatives.

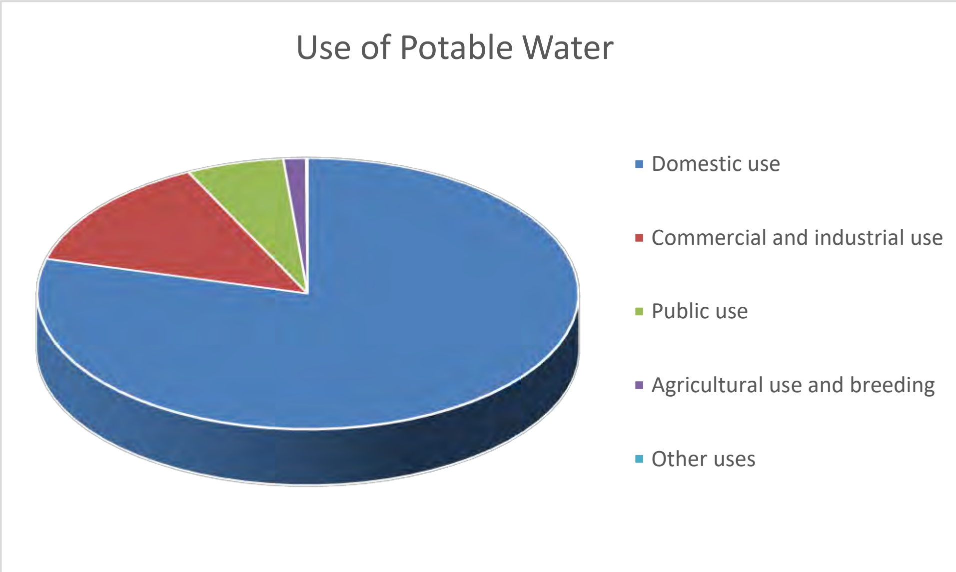
Airasca, Almese, Avigliana, Baldissero Torinese, Beinasco, Borgaro Torinese, Brandizzo, Buttigliera Alta, Cafasse, Cambiano, Cantalupa, Caprie, Caselette, Castagneto Po, Castagnole Piemonte, Castiglione Torinese, Chieri, Chivasso, Cinzano, Collegno, Cumiana, Druento, Foglizzo, Front, Grugliasco, Leini, Lombardore, Mappano, Marentino, Moncalieri, Montaldo Torinese, Nichelino, None, Orbassano, Pavarolo, Pecetto Torinese, Pianezza, Piossasco, Rivalba, Rivarossa, Rivoli, Robassomero, Rosta, San Benigno Canavese, San Francesco al Campo, San Gillio, San Maurizio Canavese,San Mauro Torinese ,San Raffaele Cimena , San Sebastiano da Po, Sangano, Sciolze, Settimo Torinese, Torino, Torrazza Piemonte, Trana, Trofarello, Val della Torre, Venaria Reale, Villarbasse, Volpiano.

D3) WATER USE SHARES (CIVIL, INDUSTRY, AGRICOLTURE, ...)

34) Percentages of water used by the civil, industry, and agriculture sectors [%]

Table:

Use of Potable Water	
Domestic use	79,12%
Commercial and industrial use	13,61%
Public use	5,83%
Agricultural use and breeding	1,35%
Other uses	0,09%

Chart:	
	
x Measured at Metropolitan City of Turin level □ Estimated at FUA level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

D4) WATER STRESS INDICATOR

35) Class of water stress of the FUA according to Falkenmark Indicator (water availability per capita per year within the FUA) [-]

Falkenmark Indicator: based on the measure of water availability per capita per year within the FUA.

Index (m3/capita/year)	Class
>1,700	No stress
1,000 – 1,700	Stress
500 – 1,000	Scarcity
< 500	Absolute scarcity

Falkenmark indicator: water availability (m3) per capita per year

From PTA (Piano di tutela delle Acque) Regione Piemonte, 422 l / day are available in the Turin ATO_3 (Autorità d'Ambitofor the integrated water service (about 154 m3 / inhabitant / year). But it does not consider potential availability (water balance) .WEI + index for basins and sub-basins has been calculated in the revision of the PTA

□ Measured at FUA level x Estimated at Metropolitan City of Turin level	Estimate procedure and hypotheses: Source of data: SMAT Torino – year 2018

D5) WATER MANAGEMENT COMPANIES

36) List of the private/public companies that manage the anthropic water cycle (extraction, sanitation, distribution, collection, depuration) [-]

Companies	Area served	Public/private	Function
SMAT Torino S.p.A.	84 Municipalities	Private companies owned by the municipalities served.	Integrated water service manager
Società per la condotta di acque potabili in Alpignano s.r.l.	1 Municipality: Alpignano	Private companies owned by the municipality served.	Integrated water service manager
Consorzio Comuni acquedotto Monferrato	2 Municipalities: Monteu da Po Lauriano	Public	Integrated water service manager
Municipality of Vallo Torinese	1 Municipality: Vallo Torinese	Public	Integrated water service manager
Municipality of Varisella	1 Municipality: Varisella	Public	Integrated water service manager

Is the list complete at FUA level? Yes.

E. CLIMATE CHANGE

E1) ISSUES ARISING DUE TO CLIMATE CHANGE

37) Description of the issues, if any, raised by climate change (e.g. floods, high temperature, water scarcity, ...) [-]

In 2018 Arpa Piemonte prepared the climate vulnerability analysis for Turin. The study highlights the rapidity with which local weather events are responding to global warming and indicates the forecast trend for the coming years.

From this analysis it emerges that in the city environment the main climatic risks identified are heat waves and intense precipitation events.

In parallel, the possible impacts were assessed, caused by the greater intensity and frequency of extreme events, on various areas: quality of life, socio-economic system, health, air quality, urban green, transport infrastructures, industrial processes, management of rainwater, etc.

In the FUA context, the risk associated with drought and the scarcity of water resources should not be underestimated.

The specific climatic challenges for the city concern the need to make the city fresher and livable even during a heat wave event and the city safer and able to manage the waters during extreme meteoric events.

F. RULES, LAWS AND GOOD PRACTICES

F1) PRICING SYSTEM FOR WATER

38) Pricing system for different water uses (e.g. Irrigation, Civil, Industrial) [€/m³]
The tariff system of the integrated water service (Drinking water + sewerage) updated to 2018 is shown in attachment n.2.[14] The tariffs are partly fixed and partly variable according to actual consumption and types of users.
Is the pricing system described above valid for the entire FUA? Please specify The tariff system is defined by ATO3-Torino (Turin authority) and it is valid for the entire FUA.

F2) RESTRICTION IN WATER USE

39) Description of restrictions in water use, if any [-]
During the summer, on the occasion of prolonged periods of drought, on the indication of the manager of the integrated water service, the Municipalities affected by water scarcity issues specific ordinances to prohibit the consumption of drinking water for uses other than human consumption.
Are the restrictions described above valid for the entire FUA? Please specify This type of restriction occurs punctually where water scarcity occurs.

F3) LEGISLATION ABOUT DUAL WATER DISTRIBUTION SYSTEM

40) Description of the legislation about dual water distribution system, if any [-]
Not available
Is the legislation described above valid for the entire FUA? Please specify

F4) LEGISLATION ABOUT WATER REUSE

41) Description of the legislation about water reuse, if any [-]
Not available
Is the legislation described above valid for the entire FUA? Please specify

[14] Turin provided the entire set of tariffs for each type of water, organised in tables, for each of the municipalities of the FUA. For the scope of this thesis, they are not relevant therefore they are not reported here.

F5) LEGISLATION ABOUT FIRST FLUSH RAINWATER COLLECTION (e.g. streets)

42) Description of the legislation about first rainwater collection, if any [-]
With the Regional Law N.1/R of 20/02/2006, specific treatment and delivery of first-time water relating to certain production activities is provided in the public sewer.
Is the legislation described above valid for the entire FUA? Please specify The Regional Law N.1/R of 20/02/2006 involves the whole FUA.

F6) RULES FOR GREEN SPACES IRRIGATION

43) Description of the rules about urban green spaces irrigation, if any [-]
Art.8 bis of the Environmental Energy Annex to the City of Turin Building Regulations stipulates that for new construction and major renovations it is mandatory to store and reuse for irrigation purposes of meteoric waters, in the minimum measure of 10 litres of accumulation per sqm of green areas.
Are the rules described above valid for the entire FUA? Please specify The Environmental Energy Annexconcerns only the City of Turin

F7) DIFFUSION OF WATER SAVING GOOD PRACTICES

44) List of good practices in place for water saving [-]

Water houses
Since 2009, the Turin area has hosted several Water Points or "water houses", systems for distributing natural, sparkling water at room or chilled temperature to the public (the supply of chilled natural water is free of charge), made to support the consumption of tap water for food purposes and which allow the supply of "zero kilometer" network water.
https://www.smatorino.it/punti-acqua/

Central Registry Fountain
In April 2019, a fountain was installed at the offices of the Central Registry of Turin for the free distribution of water, for employees and users. The initiative is part of "Urban Wins", a European project that aims to reduce the production of waste in the city.
https://www.urbanwins.eu/

Green Public Procurement
Since 2004 the City of Turin has joined the A.P.E. (Acquisti Pubblici Ecologici) which provides specific procedures for the purchase of goods and services that take into account, in addition to monetary costs, also the environmental impacts that these can generate over the life cycle. The A.P.E. outlines the environmental criteria divided between minimum technical specifications and evaluation criteria of the most economically advantageous offer or guidelines to be followed for green purchases by product / service category.
http://www.comune.torino.it/ambiente/ape/index.shtml

Sustainability in school canteens
In school canteens the meat is completely traced and comes from farms that comply with a specification that provides that the entire production cycle takes place in Italy. Also most of the fruit and vegetable products are produced with organic method or with the integrated production method, i.e. an agricultural production system with low environmental impact, they are entirely Piedmontese (cultivated, packaged and distributed in Piedmont).
The use of locally sourced products, i.e. supplies close to direct producers, favors forms of cooperation between the growers themselves, allows you to limit the intermediate steps, also educates the knowledge of typical products, guarantees freshness and seasonality of the products, offers a guarantee quality and food safety, ultimately reducing pollution levels in support of the environment. The remaining fruit and

vegetables must come from organic crops, that is, they must be grown without using pesticides, from the supply chain.
The water comes entirely from the city distribution network, allowing significant savings in plastic and energy.
http://www.comune.torino.it/servizieducativi/ristorazionescolastica/index.html

Project "Growing in the City" - Climate change
Within the "Growing in the City" project, a series of meetings have been included, proposed by the Environment Area of the Municipality of Turin, addressed to primary school children in the city on the topic of climate change and sustainable lifestyles. The in-depth themes also touch, through the quiz game aimed at students, the topic of access to water and daily consumption and simple solutions are provided on saving water in our routine.
http://www.comune.torino.it/crescere-in-citta/scuole-primarie/citta-torino-altri-servizi/il-clima-cambia-siamo-tutti-responsabili/

Sustainable tourism
The Environment Department of the City of Turin in collaboration with the Culture and Tourism Department Turin has launched a project to promote and develop sustainable tourism in the city, with the creation of a specific dedicated section on the Turismo Torino website. Even tourism can in fact have a heavy environmental impact on the urban ecosystem. The experience of other cities, especially in Northern Europe, shows that green tourism triggers a positive economic return for hotels, restaurants and services.
http://www.comune.torino.it/ambiente/turismosost/index.shtml

EU Ecolabel for accommodation
The City of Turin promotes the diffusion of the EU Ecolabel certification for the "accommodation service". European Ecolabel is the eco-label to guarantee that a structure intended for tourist accommodation is managed with the utmost attention for environmental protection.
http://www.comune.torino.it/ambiente/turismosost/ecolabeleuropeo/index.shtml

Sustainable events
In order to pursue the objectives of utmost care in the preservation of the environment, of attention to sustainable development and attention to other global challenges, first of all to climate change, the city of Turin intends to obtain certification of the sustainable management system, according to the UNI ISO 20121: 2013 standard for public events organized by the Municipality, such as the Turin Jazz Festival, ToDays, Torino Estate Reale and Mito Settembre Musica.

Torino Plastic free Challenge
The City of Turin adheres to the "Plastic free challenge" campaign launched by the Ministry of the Environment and gives some guidelines for sharing its objectives. With this campaign, the ministry intends to free its offices from disposable plastic by activating some good practices in its offices and inviting other administrations and institutions to do the same.
https://www.minambiente.it/content/plastic-free-challenge

Ecosystem services
The City of Turin is committed to getting to know its greenery better, and in particular the value generated for the community by the natural capital present in the city. For this purpose, an activity is underway to carry out a fact-finding study that:

- map the green of the city, highlighting its ecosystem functions, present or to be increased;
- identify the value generated;
- establishes how to increase its ecological value;
- establishes how to preserve it in urban planning transformations.

Smart Tree project
The city of Turin has launched the Smart Tree project, intended as a virtuous container and chain of good environmental practices related to the "tree" theme, which entail the compensation of large events (events, concerts, conferences, etc.) or large construction sites through the planting of trees in the city.
http://www.comune.torino.it/ucstampa/2014/article_553.shtml

My office is sustainable
The City of Turin has drawn up a small Guide to the Environmentally Friendly Office, in the belief that, without renouncing the comfort to which we are accustomed, we can all modify some wrong behaviors, often

involuntary or due to the lack of correct information, but which if correctly implemented they will certainly contribute to improving the quality of work and life in our offices.
http://www.comune.torino.it/ambiente/bm~doc/2016_ilmioufficiosostenibile-e-2.pdf

Use of NBS in urbanization works
In recent years, the City of Turin has carried out various experiments in the context of urbanization works with the aim of not losing the permeability of the soil and maximizing the collection and use of rainwater. Building solutions with green cover were also created.

Appendix 2

The following results come from the FUA-level Public Perception survey made in each of the FUA, based on the common guidelines set by Poliedra. The data are retrieved from the Deliverable D.T3.1.4: "*FUA-level water efficiency and reuse related public perception assessments*", in which each project partner in charge reported its own results. Their results have been taken and listed below.

	Turin	Budapest	Split	Maribor
Period of the data collection	23rd October and 15th December 2019	30th October and 10th December 2019	January and February 2020	23th October 2019 and 28th February 2020
Method	Advertised through institutional web sites, social media and fairs, with the support of local administrations of municipalities in the FUA	Targeting online the inhabitants of Budapest FUA. Additional paper-based data collection was performed in municipal institutes of Zugló	The data collection was conducted online as well as through field research	Targeting the inhabitants of Maribor FUA online. Employees in public utility companies and in the municipality of Maribor have been encouraged to fill out the survey online
Number of questionnaires filled in and processing of the results	845 answers were collected during the period. The answers were then randomly selected in order to obtain a 400 answers sample	623 answers were collected during the period, 550 answers are from the FUA of Budapest. Only the FUA related data were considered in the analysis.	402 answers were collected during this period	229 answers were collected. Even though the number has not reached the expected targeted audience of approximately 400 people, they consider comparatively to other FUAs in the project that are more than 10 times larger in size, that Maribor's sampling represents a sufficient representative pattern for relevant analysis.

	Turin	Budapest	Split	Maribor
Habits	Nearly 70% of interviewees turn off the tap during saving and brushing teeth, 82% make sure to have tight water installation at home and 57% drink tap water. Collecting and reuse rainwater or grey water are not so popular, only 10% and 18% responded yes on this question.	91% of responders turns off the tap during saving and brushing teeth, 95% responded of tight water installation at home and 81% drinks tap water. Collecting and reuse rainwater or grey water are not so popular, only 18 and 10 % of responded yes on this question.	More than 70% the responders turn off the tap while shaving or brushing their teeth. Moreover, more than half of them responded that they make sure that water installations at their home are tightly closed and more of 90% of them drink tap water. Collecting water after washing fruit and vegetables and using it for watering plants/the garden/flowers on the balcony are not so popular. Namely, less than 10% of the responders answered affirmatively to the first mentioned habit while almost every 9/10 of the responders answered negatively and about 10% of the responders answered affirmatively to the second mentioned habit and more than 70% answered negatively to that question.	Approximately 65% of responders turn off the tap during saving and brushing teeth, whereas 22% turn it off sometimes, and 12% never. Using tap water for watering gardens and flowers on balconies is more evenly distributed, since around one third of respondents uses tap water for watering 38% of time, whereas around 29% never uses it and 33% sometimes. Water collected from washing fruit and vegetables is seldom reused for watering plants (only 18%), but a vast majority of people (90%) use tap water for drinking.
Facilities	57% of interviewees have dual flush toilet, while only 34% and 28% have water saving faucet and shower head. A significant percentage of interviewees, 23% for faucets and 26% for shower, don't know if they own water saving facilities. 59% have a water meter.	A significant rate of the households owns water saving facilities: 62% has dual flush toilet, 41% and 43% has water saving faucet and shower head and 92% has water meter.	A significant rate of the households does not own water saving facilities: about third of the responders own a dual flush toilet, 10% own water saving faucets and less than 20% own a water saving shower head. A lot of the responders do not even know if they have the aforementioned facilities in their household. Most of them, what is almost two thirds of the responders, have a water meter.	Water meters are quite widespread, (60%). The standardisation of dual flush WC utilities in Slovenia's suppliers has resulted in 50% of households having installed at least one, whereas the water saving faucets and shower heads have not yet reached FUA's households (just 19% have water saving faucets and 21% shower heads).

	Turin	Budapest	Split	Maribor
Bottle or tap?	When it comes to decide drinking bottled or tap water the following factors show high importance for the interviewees in Turin FUA: reducing the plastic consumption and bottle transport (58%) and convenience/carrying comfort (46%). Cost, health effects and taste have an average medium importance in Turin FUA.	When it comes to decide drinking bottled or tap water the following factors show high importance of the responders in Budapest FUA: reducing the plastic consumption and bottle transport (77%), health effects (65%) and taste (49%).	When responders choose between tap water and bottled water, the following factors are marked as important: reducing plastic consumption and bottle transport and health effects (more than half of the responders answered that it was of high importance while choosing between tap water and bottled water). After that, the responders believe that taste and cost are very important (more than half of the responders answered that it was of high importance while choosing between tap water and bottled water). Convenience/carrying comfort was mostly of medium and high importance.	The undisputed quality of water provided to the FUA by Maribor Water Supply Company has a strong recognition among the citizens, since 80% of them use it because of it health effect and 65% because of taste. The appropriate price point of our water is reflected in 53% of people using it to save money. The most surprising answers reaching almost 80% is that citizens do not use bottled water because of plastics reduction, putting Maribor FUA level at the top of conscious citizens environmental awareness and fortifies the success of Maribor in going circular since 2015.
Water footprint	The impressive data of the water footprint of different products were not known by most of the interviewees: 57% had no information about the water needs of the products in the example. 91% of the interviewees are open to change their habits to reduce their environmental impacts.	The impressive data of the water footprint of different products were not in the evidence of the responders: 60% had no information about the water needs of the products in the example, and 94% of them are open to change their habits to reduce the environmental impacts.	Four fifths of the responders had no information about the water footprint of the products in the example/questionnaire. On the other hand, almost every ninth of ten of them are open to changing their habits in order to reduce their environmental impacts.	More than 90% of respondents would be willing to change their habits in order to positively affect the impacts on water, but the awareness among them is quite low (25%).

	Turin	Budapest	Split	Maribor
Annual costs	In Turin FUA only 56% of the interviewees are aware of the annual costs of the water supply.	However, 92% of the households has water meter, only 69% of responders are aware of the annual costs of the water supply.	Almost half of all responders are not aware of the annual costs of the water supply.	58% of people are aware of their annual water supply expenditure. There is still some confusion among citizens on exact water cost, since the water supply data is used to calculate the cost for sewage and sewage sludge. Even though the monthlies come in separate bills, the popular perception is still confused sometimes.
Motivation	The interviewees indicated environmental factor as the highest motivation factor in water saving. For 72% environment is high important driver in savings, money get 31% rate.	The responders indicated environmental factor as the highest motivation factor in water saving. For 76% environment is high important driver in savings, money get 42% rate.	When considering motivation, environmental reasons motivate the responders more than economic reasons in saving water. For more than two-thirds of the responders, environmental reasons were of high importance while almost half of them consider economic reasons highly important.	Respondents prioritise the economic reasons far beyond the environmental ones, when it comes to water savings.
Leakages in the water supply	The actual state of water pipes in Turin is not well known by the population. 81% of the interviewees do not how significant are water pipes leaks. 89% think that fixing those leaks is a priority in the Turin FUA.	Due to missing information, the question on leakage of pipes in the FUA was left out.	The actual state of water pipes and water lost in Split FUA is not well known by the population. 70% of the responders do not know how significant water loses are. Almost 80% of them consider that fixing those leaks is a priority in Split FUA.	More than 80% of respondents are aware that repairing leakages in the water supply systems should be a priority in the FUA, but more than 60% are not familiar with the data on water leakages.

	Turin	Budapest	Split	Maribor
Rainwater use, greywater and green roofs	Not all the sustainable solutions for the urban water management are well known and very popular in the Turin FUA. Only green roofs are known by most of the population (61%), while rainwater (46%) and grey water (33%) uses are less popular. More than 90% of the population think that all these three solutions should be more spread in Turin FUA.	The sustainable solutions of in city water management are well known and very popular in the groups of responders. The awareness of the technologies is over 80% (92% of rainwater collection and use, 80% of greywater and 84% of green roofs). 98% of responders agree with the spread of rainwater technologies, 95% are OK with greywater use and 97% would be happy with more green roofs in cities.	More than four fifths of the responders knew about some possibilities of rainwater use (excluding drinking), such as watering plants, flushing toilets, washing cars, etc. Additionally, more than 95% of them consider that installations relating to it should be more widespread. According to the survey, more than 40% of the responders did not know about possibility of water re-use at their homes, however, more than 90% of them consider that installations relating to it should be more widespread. Almost 80% of the responders knew about green roofs and more of 90% of them consider that "Green roofs" should be more widespread. It can be concluded that the sustainable solutions of city water management are known by the responders, but what's more important is that every ninth of ten of the responders consider that the aforementioned installations should be more widespread, so it is safe to assume that they would probably gladly accept changes regarding the matter.	Almost 100% of respondents are familiar with use of rainwater, which is quite a common practice in Maribor FUA, especially in family houses each capturing and storing in around 1m3 large water tanks the rainwater directly collected from their roofs. About 95% of citizens are also familiar with the greywater use and green roofs installations, but only 55% are of the opinion that these installations should be more widespread, calling for further awareness raising in these areas as well.

	Turin	Budapest	Split	Maribor
Effects of climate change: are you afraid?	The possible effects of climate change in water management cause climate anxiety. The most threatening phenomena for the responders in Turin FUA are the drought periods (70% are very afraid of it), floods (67% are very afraid) and heavy rains (62% are very afraid).	The possible effects of climate change in water management cause climate anxiety. The most threatening phenomena for the responders in Budapest FUA are the drought periods (87% are very afraid of it), water supply problems (82% are very afraid) and floods (77% are very afraid).	The responders are most afraid of water supply problems. Nearly 40% of them stated that they are very afraid and more than 40% are moderately afraid. The responders are either moderately or not afraid about the short but heavy rains (less than 15% of them are very afraid). Also, they are in general moderately afraid of the drought periods and very or moderately afraid of floods.	Results in this section show overall concern about climate change (approximately 60% across the board are very concerned about floods, droughts, cost increase and supply shortages).
Information campaigns	According to 62% of the interviewees, information campaigns are very useful to favour a proper use and reuse of water. Only 8% consider them not very useful.	According to of responders 88% campaigns are useful (52%) or very useful (36%), only 12% consider info campaigns not very useful in the proper use and reuse of water.	The most of the responders consider that campaign information is useful (about 50% of answers) and very useful (more than one third of answers). Only around 15% of the responders consider information not very useful.	The citizens are extremely willing to learn and listen about proper use and reuse of water. But, they have not yet been properly informed.