D.T3.3.3 FUA-LEVEL CONCEPT ON INTEGRATED CUW MANAGEMENT

Subtitle

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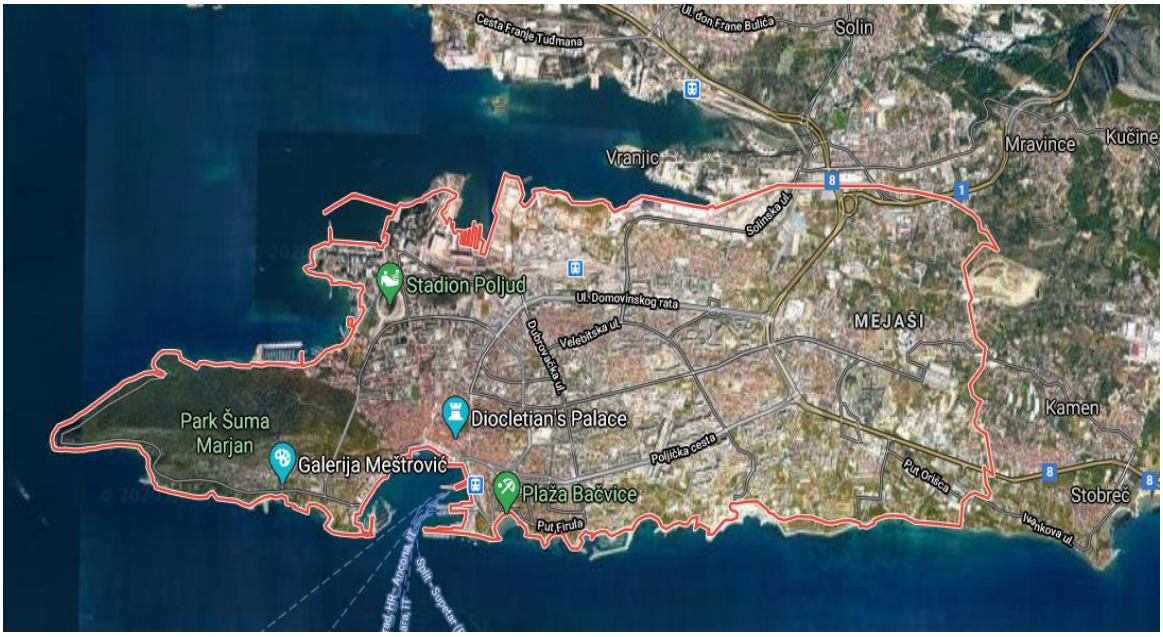
CONTENT

INTRODUCTION

The document summarizes Functional Urban Area (FUA) Split baseline assessment, its vision, strategic goals, and objectives together with the set-up target indicators. The first chapter of the document determines Split FUA territory, while the second chapter describes the stakeholders' involvement in the process of building the Strategy's vision, goals, and objectives. Furthermore, the third chapter shows a baseline assessment divided into the following subchapters (main CWC areas): population and territorial configuration (climate, environment); natural water resources; water infrastructure; water consumption; potential issues arising due to climate change and local laws and rules regulating the anthropic and natural water cycle and good practices. The baseline assessment represents an overview of the FUA Split current situation and it is based on the synthesis of the following project deliverables: FUA level self-assessment on background conditions related to circular water use (D.T3.1.3), FUA level water efficiency and reuse related public perception assessments - a public survey conducted during January and February 2020 targeting the city of Split residents and daily migrants from the surrounding area (D.T3.1.4), and the Comprehensive FUA level status Quo studies (D.T3.1.5). Finally, the vision that presents the desired future state of the Split FUA in 2030 is shown in the fourth chapter. In order to define the vision, the strategic planning technic – the SOAR analysis (Strengths, Opportunities, Aspirations and Results) along with the strong participatory approach was used. Upon defining the vision, strategic goals and objectives together with the indicators and appropriate descriptions were determined in the final, fifth chapter.

1. Determination of the territory covered by the strategy

The City of Split is the second-largest city in Croatia and the largest city on the eastern Croatian Adriatic coast. Administratively, it belongs to Split-Dalmatia County. The City of Split consists of several urban and suburban settlements. The peninsula of the City of Split was determined as a Project functional urban area (FUA), excluding the suburban settlements (Donje Sitno, Gornje Sitno, Kamen, Slatine, Srinjine, Stobreč, and Žrnovnica). Hence, Split FUA does not correlate to any administrative area. Total area of the FUA is 79.38 km^2 and it refers to the urban area of the City as shown in the map below. It is important to state that although the key water supply source of Jadro spring as well as the key wastewater treatment plant (WWTP) Stupe (submarine discharge) do not belong territorially to FUA Split, they represent an integral part of its circular urban water system[1]. Water supply and sewerage services in Split FUA are managed by the public company Water Supply and Sewerage Ltd. Split. In 2018, according to the report from the Croatian Bureau of Statistics, Split FUA had 170,419 inhabitants. However, a broader area around the city counts to 400,000 inhabitants that gravitate to the City's urban area.



Source: Google Maps, processing: Author

Picture 1: Split FUA

[1] This strategic document is dealing with circular waters in FUA Split, the circulation of matter and energy is not included.

2. Stakeholder involvement

Stakeholder group (SG), as well as stakeholder advisory panel (SAP), includes stakeholders who are responsible for water resources management via policy-making, legislation, regulation, infrastructure development, water, and wastewater treatment at the Split FUA level. Stakeholders involved in the Split FUA strategy building process belong to the following categories: local public authority, regional public authority, sectoral agencies, infrastructure and (public) service providers, interest groups including NGOs, higher education and research, general public, and SMEs. The stakeholders provided their contribution through the local competence building workshop, the second stakeholder meeting (SGM2) and the third stakeholder meeting (SGM3). Since the COVID-19 pandemic occurred, all the events were conducted online. The aim of the aforementioned events was to engage all relevant stakeholders in order to obtain important expert insights, educate and cooperatively build a strategy for circular water management at the FUA level and the goals of the meetings have been met. The stakeholders proactively shared their professional knowledge relevant to the subject of interest. Specifically, at the SGM2, the stakeholders contributed to determining the vision, strategic goals with relevant objectives and indicators. Finally, at the SGM3, the state of the art and further steps in FUA Split Strategy building process have been presented and discussed with the stakeholders, who agreed with the presented matter and confirmed their future engagement.

3. Baseline assessment

The following chapter provides a synthesis of quantitative and qualitative assessments of the previously produced project deliverables (FUA level self-assessment on background conditions related to circular water use - D.T3.1.3, FUA level water efficiency and reuse related public perception assessments - D.T3.1.4 and the Comprehensive FUA level status Quo studies D.T3.1.5). The synthesis illustrates the current situation at the Split FUA level, at the same time identifying the key issues related to circular water use. It presents all the relevant aspects of Split FUA circular water management: population, environment, climate, natural water resources, water infrastructure, water consumption, potential issues arising due to climate change, and local laws and rules regulating the anthropic and natural water cycle and good practices.

3.1. Population and the territorial configuration (climate, environment)

According to the report from the Croatian Bureau of Statistics, Split FUA had 189,388 inhabitants in 1991 and 170,419 in 2018 (an estimation) which indicates a 10% decrease. However, considering the broader city area, approximately 400,000 inhabitants are gravitating to the City's urban area. In addition to the number of inhabitants and daily migrants, it is worth mentioning the number of tourist visits and overnight stays during the year. According to the available data from the Croatian Bureau of Statistics for 2018, there were: 846,308 arrivals and 2,480,598 tourist overnight stays at the Split FUA level (90% from May to September, with peak months July and August). Even though available data show a decrease in the number of inhabitants in Split FUA over the observed years, tourist visits during the year present a significant seasonal population influx.

The pleasant and mild Mediterranean climate is one of the most important attractive factors generating many tourist visits to the City of Split. The data from Table 1, observing the highest and lowest average monthly temperatures, shows that January records the lowest average temperature of 7,9°C, while the highest average temperature is observed during July - 26°C. These values, as well as humidity values during the summer months (varies from 49.3% to 59.1%), indicate favorable weather conditions.

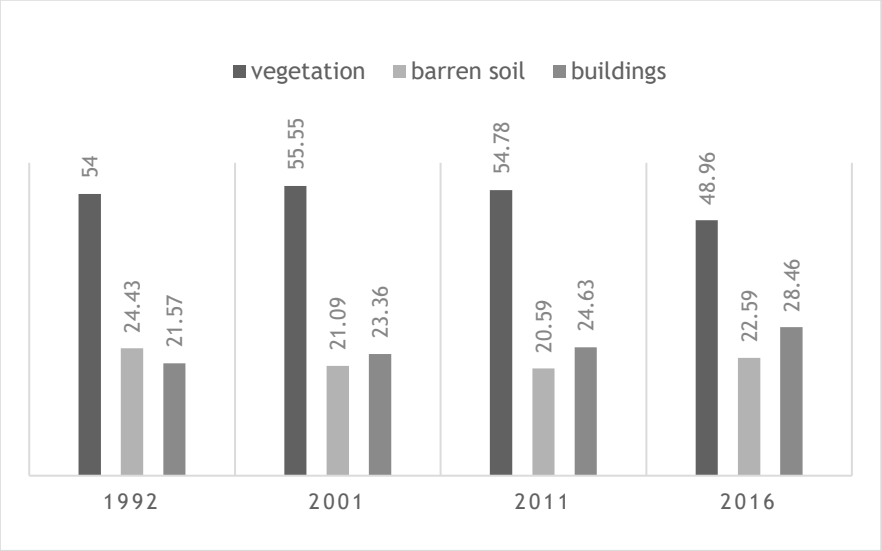
Table 1. Monthly average temperature and average humidity (Weather Station Marjan)

Period	Average temperature 1948 - 2018 (°C)	Average humidity in summer months 1971 - 2000 (%)
January	7,9	/
February	8,3	/
March	10,8	/
April	14,4	/
May	19,1	/
June	23,2	54.9
July	26	49.3

Period	Average temperature 1948 - 2018 (°C)	Average humidity in summer months 1971 - 2000 (%)
August	25,7	51.7
September	21,5	59.1
October	17,1	/
November	12,6	/
December	9,3	/

Source: Croatian Meteorological and Hydrological Service, processing: Author

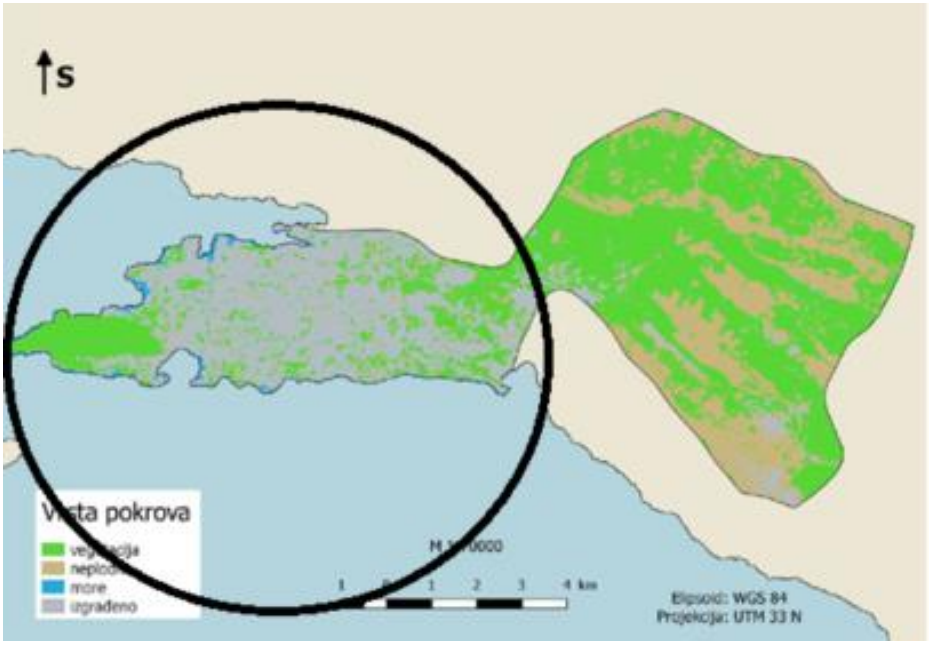
Furthermore, regarding the sealed soil at Split FUA level, it is important to state that seasonal population influx due to tourism activities causes an overload of the city's infrastructure. Hence, the available data show the tendency of reducing the percentage of green spaces (vegetation) and tendency of increasing the area covered by buildings, as presented in the Chart 2 below.



Source: Gudelj, M. (2017) *The Analysis of Urbanization of Split*. Graduate thesis. Zagreb: University of Zagreb, Faculty of Geodesy. Processing: Author

Chart 2: Sealed soil

Concerning green spaces, the Marjan Forest Park dominates in Split FUA (the peninsula's edge). Besides Marjan, there are several city parks which are mostly separated and disconnected. Some of the larger parks in the urbanized section are: J.J. Strossmayer Park, Emanuel Vidović Park, Turska kula, Zvončac and Sustipan. In addition to these parks, there are small parks in separate districts within the FUA, which are generally located between buildings.



Source: Gudelj, M. (2017) *The Analysis of Urbanization of Split*. Graduate thesis. Zagreb: University of Zagreb, Faculty of Geodesy. Processing: Author

Picture 3: Sealed soil

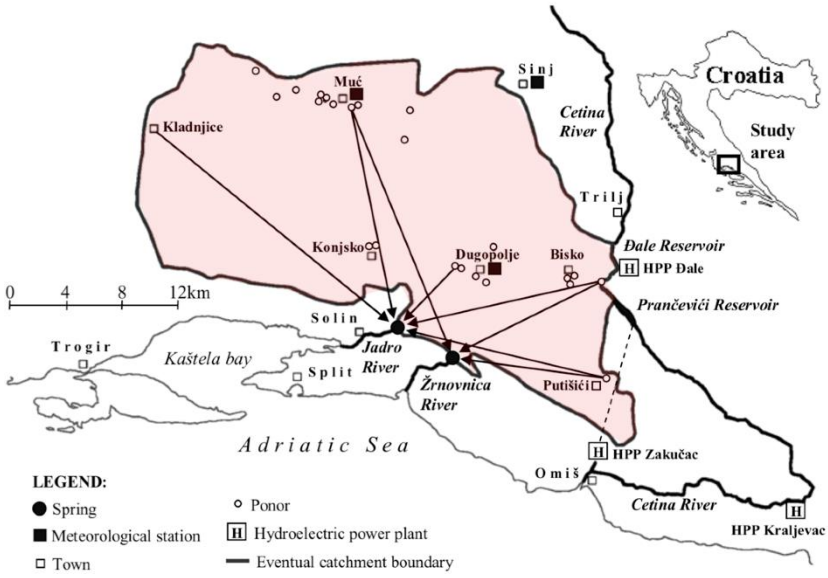
- **Key challenges:**
  - Seasonal population influx due to tourism activities
  - Reduced percentage of green spaces
  - High percentage of sealed soil.
- **Key strengths:**
  - Favorable geographic position
  - Pleasant Mediterranean climate.

3.2. Natural water resources

Jadro is the only river at the Split FUA level with its average annual flow rate of 8,818 m^3/s. Moreover, its karstic water spring is the main water supply source at the FUA level and beyond. It supplies the City of Split with water since the Roman times. Jadro water spring is affected by a sharp increase in the number of people in the area during seasonal months which makes it highly vulnerable to different pollution sources. Even though FUA Split does not receive water from other karstic springs, the Jadro karstic spring is

interconnected with other karstic springs and waters, especially rivers Cetina and Žrnovnica. Additionally, the Split peninsula area (FUA Split) is rich in groundwater resources, from which some are interconnected with sewage system, which has favorable impact on dilution processes.

Characteristic karst environment indicates a high vulnerability of karstic recharged area of Jadro water spring and significant oscillation in the average monthly spring water discharge. The recharge area of Jadro Spring covers an area significantly larger than FUA Split, and it is located in the City's hinterland as shown in Picture 4.



Source: Jukić D. & Denić-Jukić V. (2008) Estimating parameters of groundwater recharge model in frequency domain, Calibration and Reliability in Groundwater Modelling: Credibility of Modelling (Proceedings of ModelCARE 2007 Conference, held in Denmark, September 2007). IAHS Publ. 320, 2008.

Picture 4: The map of recharge area of Jadro spring and its lateral outlet Žrnovnica spring

It is located at an elevation of 35 m above sea level. The catchment is located in the central part of the bare Dinaric karst. It is mainly formed of carbonate rocks and partly of impermeable flysch. Carbonate layers differ in age, lithologic composition bedding and in structural-tectonic position. Different authors using different models and methods estimated that catchment is between 450 and 530 km^2.

The yield of the Jadro spring is directly related to precipitation. Annual precipitation for 2018 in Split FUA was 72,4 mm. Table 2 shows monthly precipitation in mm for 2018 as well as a trend of monthly precipitation from 1948 – 2018. It can be seen from the table that the highest monthly precipitation value occurred in November (120.6 mm in 2018) and the lowest one in the summer months July and August (July – 14.1 mm and August – 11.1 mm in 2018).

Table 2: Average monthly and annual precipitation

Month	Monthly Precipitation for 2018 (mm)	Annual Precipitation 1948 - 2018 (mm)
I	76.0	78,3
II	118.5	67,5
III	145.3	64,4
IV	56.5	62,6
V	65.0	56,6
VI	50.9	51,1
VII	14.1	27,3
VIII	11.1	39,2
IX	20.9	71,1
X	97.4	79,6
XI	120.8	112,6
XII	91.9	100,7

Source: Croatian Meteorological and Hydrological Service, processing: Author

The water quality of river Jadro is monitored once a month. Chemical, biological, and physical parameters of groundwater indicate high tap water quality. However, occasional mild to significant increase in water turbidity occurs suddenly after heavy rainfall and can last for a few days. The turbidity values above 4 NTU appear from 8.2% to 13.5% of the days per year. The statistical analysis of water quality indicators (1975 to 2014) and its comparison with prescribed limited values (maximum allowable concentrations - MAC) show that spring water is usually polluted by occasional bacteriological contamination and other oxidizable substances, probably of organic origin.

Regarding the surface flows, at FUA Split level there are numerous intermitted water creeks and few permanent ones. The permanent ones such as Smrdečac creek are mostly channelized, with smaller parts in open stream flow. The main challenge in the future will be the restauration of natural flow and natural regeneration. Rainwater harvesting does not exist in the FUA Split at the moment, while its development represents one of the key challenges in the future.

It is important to mention that FUA Split circular urban waters are the integrated part of water food nexus of the broader area. Moreover, there are many present anthropogenic influences in FUA and its surrounding area on the water and its circulation: wildfires in the FUA hinterland which usually increase the influx of nutrients in sea water around peninsula, leachate waters from the landfill Karepovac that are interconnected with the sea (through underground karst massive) and are not currently treated, combined system overflow, stormwater, solid waste, and litter.

- **Key challenges:**
  - High vulnerability of Jadro water spring to different pollution sources
  - High vulnerability of karstic recharged area of Jadro water spring

- Occasional increase of turbidity values of Jadro spring water
- Constantly high bacteriological pollution
- Significant oscillation in the average monthly Jadro spring water discharge (especially between summer and winter months)
- Influence of Cetina and Žrnovnica rivers on Jadro spring recharge (spring water quantity and quality)
- Restauration of natural water flows and natural regeneration
- Lack of rainwater harvesting infrastructure

- Many present anthropogenic influences on the water and its circulation (wildfires, leachate waters, combine system overflow, stormwater, solid waste, and litter).

- **Key strengths:**
  - Jadro karstic water spring as the main water supply with sufficient average capacity
  - Good Jadro spring water quality according to its physical and chemical indicators
  - Many existing groundwater resources at Split peninsula
  - High-quality bathing water during most of the year.

3.3. Water infrastructure

The water distribution system facilitates the access to the water supply network to 93% of the population. However, the water infrastructure itself is facing some major challenges in the form of seasonal load on infrastructure due to tourism activities, lack of a dual system, poor pipe and infrastructure conditions as well as high pressures in distribution system which result in increased water loss. Due to the current pipe conditions, the water supply network has a significant water loss of 58.2%. On the other hand, it is important to state that certain developed plans for reconstruction and expansion of water infrastructure exist. Furthermore, based on the results of the conducted public perception survey, it can be concluded that the actual state of water pipes and water loss in Split FUA is not well known by the population, even though they consider fixing this problem to be a priority. Concerning the purification treatment of spring water, Croatian Waters co-financed drinking water disinfection facilities at the spring of Jadro river.

The existing chlorination system that is based on gas chlorine (Cl_2) is currently in use but has raised the questions of acceptability due to increasingly stringent handling measures of new bottles. Therefore, Water Supply and Sewerage Ltd. Split started installing new technology for disinfected water, using sodium hypochlorite ($NaOCl$), a method of membrane electrolysis from freshwater and tableted salts. The treatment is practically harmless, and the devices are flexible and adapted to the current needs of the system. Now, devices are tuned with each parametrization required and the test run of the devices has been completed.

The full operational drive of the new devices is expected after the consumption of current gas chlorine supplies.

Regarding the wastewater collection network, Split FUA has a sewerage system that is mostly made for the combined type of sewer (until 1995 a mixed system). The system is characterized by numerous overflows into the coastal sea which consequently cause pollution. In some parts, the modification and installation of a dual – separate sewerage system for wastewater and rainwater is planned. The percentage of households connected to the wastewater collection network is currently 78%. Table 3 shows Split FUA wastewater treatment plants and their population equivalent capacity compared to the actual population, as well as treated effluent values.

Table 3: Wastewater Treatment Plants

WASTEWATER TREATMENT PLANT	INHABITANT EQUIVALENT (IE)	TREATED EFFLUENT Per day/Per year		Treatment level
Treatment plant *Katalinića brig*	110,000 IE	42,000 m^3	15.512.500 m^3	Mechanical/screens
Treatment plant *Stupe*	135,000 IE	37,500 m^3	13.687.500 m^3	Mechanical/preliminary
Treatment plant *Duilovo*	5,000 IE	4,000 m^3	1.460.000 m^3	Mechanical/preliminary

Source: Development strategy of the Urban Agglomeration of Split processing Author

Wastewater treatment plant *Katalinića brig* is designed to receive and treat the wastewater from the southern basin of Split, with a capacity for 110,000 population equivalents. The average flowrate around 42,000 m^3/day with some oscillations during the year. The treated wastewater is discharged by a pumping station through submarine outfall with a diffuser. The key problems are related to poor treatment technology with no biological treatment, no nutrient, or sludge removal. In addition, the system combines rainfall-runoff and sewage wastewater. As a separate system within the Southern basin is the *Duilovo* sub-basin (separate system), which covers the area of Pazdigrad and Žnjan settlements. In this area, a separate sewerage system is built, which collects stormwater from separate channels and connects it to the Duilovo stream. Sanitary wastewater is taken to WWTP *Duilovo* and then discharged into the sea by a long submarine discharge. The existing solution represents only a transitional phase. Namely, the long-term solution according to the *Development strategy of the Urban Agglomeration of Split* project documentation envisages that this subsystem will be connected to the Stobreč drainage system and taken to the WWTP *Stupe*. The average flowrate of WWTP *Duilovo* is around 4,000 m^3/day with some oscillations during the year. Wastewater treatment plant *Stupe* is located in the eastern part of Split, and it is designed to receive and treat the wastewater coming from the north-eastern part of Split as well as surrounding municipalities (Solin, Podstrana, Klis, Dugopolje). The design capacity is equal to 135,000 population equivalents. The average inflow is equal to approximately 37,500 m^3/day with significant oscillations. The key problems are related to poor treatment technology with no primary and biological treatment. In addition, wastewater from septic tanks with unknown content is received at the facility. According to the Feasibility Study for the Split-Solin agglomeration project (major project implemented within NSRF 2014-2020) there are several plans for upgrading and reconstruction of wastewater drainage systems such as: a) reconstruction and

optimization of existing drainage system (construction of 7 retention pools, construction and reconstruction of 6 rainwater overflows, construction of 3 pumping stations, construction of 6,265 meters of a pipeline, reconstruction 16,565 meters of existing channels due to poor condition), b) Construction of compound objects for a unique system of drainage and wastewater treatment (construction of 9,875 meters of collectors and construction of 4 pumping plants), c) Upgrading the *Stupe* WWTP as a centralized WWTP and upgrading the wastewater treatment to primary and biological (secondary) level, d) Installation of additional submarine discharge pipeline for WWTP *Stupe*. There are also plans for expansion of treatment plant *Katalinića brig* up to 160,000 IE and treatment plant *Stupe* up to 250,000 IE.

Regarding the rainwater and stormwater retention and reuse, currently there is no existing infrastructure for retention and reuse nor for wastewater recycling and reuse. At the moment high intensity rainfalls at FUA Split level in combination with steep sealed terrain cause an overload of the drainage system which results in numerous overspills, higher runoff coefficients, and significant pollution loads in runoff water. Natural drainage systems in urban areas filter and recycle the water and ensure peak flows are detained and safely conveyed to waterways and the sea. This concept is applied on small and large scales, with multifunctional areas combining blue, green, and grey infrastructure as integral parts of the urban environment. At the moment FUA Split does not have a water recycling system, but the natural-based solutions have a good perspective to be implemented. The implementation of these solutions would result in decrease in urban floods, rise of bathing water quality, reduction of heat island effects, and improvement of urban life quality (public health, security, economy, environment). It is important to emphasize that further reduction of water loss will ensure additional supplies of drinking water with lower prices, so the water recycle profitability will be questionable.

On the other side, regarding the possibilities of rainwater use and recycling, the conducted project research on Split FUA level indicates that four-fifths of the respondents knew about the possibilities of rainwater use (excluding drinking), such as watering plants, flushing toilets, washing cars and similar possibilities. Additionally, more than 95% of them believe that installations relating to it should be more widespread. Following the survey results, more than 40% of the respondents did not know about the possibility of water reuse at their homes - greywater (i.e. storing water from the shower or the sink for flushing toilets). Still, more than 90% of them believe that installations related to it should be used more often. Considering the attitude of the respondents concerning sustainable solutions of city water management, it can be assumed that they would probably accept changes on the aforementioned matter. Still, the results emphasize that the level of awareness is quite poor.

- **Key challenges:**
  - Deterioration of infrastructure
  - Seasonal variation, load on infrastructure due to tourism activities
  - Change in rainfall patterns (sudden rainfall episodes with high intensity)

- Combining system overflows and coastal water pollution
- Insufficient capacity of the drainage system
- Lack of a dual system for the water supply network
- Poor pipe condition which causes significant water loss in the water supply network
- The non-existence of water purification plant on Jadro water spring
- The non-existence of infrastructure for rainwater retention and reuse as well as for wastewater recycling and reuse
- Significantly low public awareness of the high water loss level in the water supply network
- Significantly low public awareness in relation to the possibility of water reuse at home
- No integration with the local hydrological system
- The non-existence of green solutions in the drainage system.

- **Key strengths:**
  - High tap water quality during the most time of the year
  - Installation of a new water disinfection technology and treatment plant
  - Developed plans for reconstruction and expansion of water infrastructure
  - Significant recipient capacity of the sea (auto-purification)
  - Public perception survey results indicate a positive attitude towards fixing the leaks in the water supply network as the priority in the Split FUA
  - Public perception survey results present awareness regarding some of the possibilities for rainwater use as well as the belief that the related rainwater use installations should be more widespread
  - Existing public interest in life improvement through installation of green solutions.

3.4. Water consumption

Water Supply and Sewerage Ltd. Split is a public company that manages the public water supply and sewerage services in Split FUA and surrounding cities and municipalities. Specifically, the company serves an area and inhabitants of the following cities and municipalities: Split Solin, Kaštela, Trogir, Podstrana, Marina, Okrug, Seget, Klis, Muć, Dugopolje, Lećevica, and Šolta. The main water consumers on FUA Split level are: the civil sector (residents and tourist during the summer season), the industry, and the public sector (public area maintaining, hydrants, green areas watering, fountains etc.). The annual volume of fresh water extracted in 2018 was 55,755,423.00 m^3, while the daily volume of freshwater used by each person was 149.95 l/day per capita.

The results of the conducted public perception survey (N - 402) provided an insight into citizens' water consumption habits, as presented in Table 4. It turns out that more than 70% of respondents turn off the tap while shaving or brushing teeth. More than a half of them responded that they make sure that water installations at their home are tightly closed and more than 90% of them drink tap water. While these results show a positive tendency regarding habits of water consumption, the following are not as quite positive. Namely, collecting water after washing fruit and vegetables and using it for watering plants as well as watering the garden/flowers on the balcony with rainwater are rarely practiced.

Table 4: Water use habits

HOW DO YOU USE WATER AT HOME?	YES	SOMETIMES	NO
Respondents turning off the tap when they shave or brush teeth	75%	21%	4%
Respondents making sure that water installation at their homes are tight (e.g. tube, taps)	60%	18%	22%
Respondents watering the garden/flowers on the balcony with rainwater	10%	17%	73%
Respondents collecting water from washing fruit and vegetables and later using it for watering plants	3%	9%	89%
Respondents drinking tap water	94%	4%	2%

Source: Author's own processing

Regarding the water-saving facilities, a significant rate of the households does not own these facilities, in specific about a third of the respondents own a dual flush toilet, 10% of them own water-saving faucets and less than 20% own a water-saving showerhead. A lot of respondents do not even know if they have the aforementioned facilities in their households. Still, most of them (63%) have a water meter.

Furthermore, public perception about bottled or tap water highlights the following factors as highly important while choosing between tap water and bottled water: reducing plastic consumption and bottle transport (59%) as well as health effects (58%). In addition to environmental awareness, taste (49%) and cost (43%) have proven to also be of high importance, while convenience/carrying comfort was mostly of medium and high importance. Regarding the water footprint of different products, four-fifths of the respondents had no information about the products' water footprints (a piece of paper requires 10 liters of water, a steak 2,500 liters, 100 grams of bread requires 160 liters, coffee 130 liters, a t-shirt 1,000 liters). Nevertheless, almost every nine out of ten are open to change their habits in order to reduce their environmental impacts, which is commendable. Furthermore, almost half of all respondents (45%) are not aware of the annual costs of the water supply. On the other hand, motivation to save water is driven more

by environmental reasons than economic ones. For more than two-thirds of the respondents, environmental reasons were of high importance while half of them believe economic reasons are highly important.

- **Key challenges:**
  - Low water supply and sewerage service prices not stimulating users for water savings
  - No available data on bottled water consumption
  - Lack of CE solutions in water consumption (water reuse)
  - A significant number of respondents do not collect water after washing fruits and vegetables and use it for watering plants, neither they water the garden/balcony flowers with rainwater
  - A significant rate of households does not own water-saving facilities, the respondents are not even aware of whether they have them in their households
  - Extremely low public awareness about the water footprint of the production processes
  - Almost half of the respondents are not aware of their annual costs for water supply.

- **Key strengths:**
  - Existing initiatives for reducing the consumption of bottled water
  - Centralized water management (single water utility)
  - Public perception survey shows positive tendency regarding water-saving habits, in specific, turning off the water tap while brushing teeth or shaving, tightly shut water installations at home and drinking tap water
  - Respondents consider reducing plastic consumption and bottle transport as most important when choosing between tap or bottled water
  - A significant number of respondents are open to changing their habits in order to reduce their environmental impact
  - Environmental reasons motivate the respondents more than economic reasons in relation to saving water.

3.5. Potential issues arising due to climate change

Split FUA is facing arising issues due to climate change that will affect not only the lives of residents but also the economy with an emphasis on tourism. European Centre for Medium Term Weather Forecasting (ECMWF) clearly indicates that, compared to the last century, temperatures in major European cities are increasing significantly. The data collected from a variety of sources (weather stations, meteorological balloons, buoys, satellite data) result in a fact that the City of Split is warmer by 1.3°C. Furthermore, according to the data of the Institute of Oceanography and Fisheries in Split, there is a possibility and an estimate that the sea level could be raised by half a meter by 2100. This scenario would significantly affect

the population of the City of Split as well as tourism (floods in the key tourist sites - Riva and Diocletian's palace). The aforementioned increase in temperature will also affect fisheries. Moreover, a potential problem is the disappearance of some of the fish species as well as the reduction of freshwater fish. An increase in sea temperature or an increase in sea acidity in some areas will make it impossible to grow shellfish. Furthermore, high rain intensity and extreme meteorological situation could cause the drainage system overload which will result in more frequent urban floods, property damages, soil and water pollution and bathing water quality decrease. Increased temperature of wastewater will result in increase of gas emissions (CO_2, methane, H_2S, etc.) as well as odor, while increased temperature in potable water system will results in increase of water loss and deterioration of drinking water quality. All mentioned will cause negative impact on public health. Another potential issue arising due to climate change is drought. There are longer and more frequent droughts (especially in the summer) that will surely affect other vital industries of Split FUA, such as urban agriculture and urban green areas. Floods and droughts, combined with unfavorable rainfall distribution (lower availability in the summer, higher availability during the winter) present extreme hydrological conditions that will cause many problems. Flooding of low-land coastal areas and urban water infrastructure may cause interruptions and decline in water supply and related infrastructure. Sea level rise and storm surge will compromise functionating the submarine discharges and other coastal infrastructure, especially transport infrastructure. All this will lead to problems in energy and water supply. It is important to mention the document "Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070" which has the main long-term goal to reduce the vulnerability of social and natural systems to the adverse impacts of climate change, i.e. to strengthen their resilience and the ability to recover from these impacts. The Strategy is in the function of preserving the values of the society, the environment and the economy and ensuring the sustainable development of the Republic of Croatia in a long-term perspective.

Given the prior issues, survey respondents were asked about their attitude towards the effects of climate change. Water supply problems scare respondents the most (39% of them are very afraid). Concerning short but heavy rains, respondents are moderately afraid (49%) or not afraid (38%). In general, they are mostly moderately afraid of drought periods (52%) and very (32 %) or moderately (42%) afraid of floods. However, most of them (almost 60%) are moderately afraid of raising costs for water supply and wastewater collection. Taking into account the usefulness of information campaigns about proper use and reuse of water, interesting results emerge. Most respondents believe that information campaigns are useful (about 50% of answers) and very useful (more than one-third of answers), while only around 15% of the respondents believe that information campaigns are not very useful.

- **Key challenges:**

- Rising temperatures due to climate change
- Extreme hydrological conditions seen through droughts and flash floods
- Sea level rise and impact on coastal water infrastructure

- Flooding of low-land areas and urban water infrastructure
- Increasing temperature of supply water and wastewater
- Climate change impact on the economy, especially tourism
- Public perception reflects the biggest fear of water supply problems when asked about the effects of climate change.

- **Key strengths:**

- High resilience of Jadro water spring on different climate change scenarios
- The existence of "Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070"
- Informational campaigns are perceived as useful according to survey results.

3.6. Local laws and rules regulating the anthropic and natural water cycle and good practices

Under the current Water Services Act (NN 66/19) by Article 13, a public water service provider may not perform activities other than water services. Exceptionally, the supply of water treated on a wastewater treatment plant for the purpose of reuse, including a sale, is permitted. The law does not regulate greywater and rainwater in Croatia. A proposal of the European Parliament and Council to the Republic of Croatia, for a regulation on minimum requirements for the reuse of water is worth mentioning. May 28, 2018, Bruxelles, 2018/0169 (COD).

Water Supply and Sewerage Ltd. Split – a company that manages the public water supply and sewerage services in Split FUA adopted a business development strategy for the period from 2019 to 2030. The strategic vision aims for Water Supply and Sewerage Ltd. Split to be a role model in sustainable water and sewage utility sector. In order to reach the aforementioned vision, four main strategic goals were set, aiming to: improve communication and develop capacities for consumer support; improve the existing infrastructure; develop conditions for a stable and sustainable business; improve human resources management and capacity building.

A categorized pricing system for different water uses at Split FUA level is shown in Table 5.

Table 5: Pricing system

CATEGORY	PURPOSE	PRICES (HRK and EUR)
1	Housing purposes	1m^3= 3.50 HRK =0.47 €
1a	Clinic hospital centre Split	1m^3= 3.50 HRK =0.47 €
1b	Socially disadvantage citizens	1m^3= 1.40 HRK =0.19 €
2	Industry	1m^3= 6.0 HRK =0.80 €
2a	Consumers of water covered by item 2 (industry) who do not charge a water protection fee under the current Water Act	1m^3= 6.0 HRK =0.80 €

Source: Water Supply and Sewerage Ltd. Split, processing: Author

It can be stated that the current water supply price is low, and it does not stimulate the users for water savings. The reason behind this is the underdeveloped drainage system characterized with a lack of centralised WWTP, and water disinfection plant at river Jadro spring. Further investments in water supply and drainage system improvements (including the new WWTP) will cause significant rise in capital and operational expenses which will consequently lead to a rise of the overall water supply price. It is expected that this will result in growing public interest in water savings.

Furthermore, water supply and sewage management at Split FUA level is characterized by the jurisdictional fragmentation. Water Supply and Sewerage Ltd. Split manages the water supply and sewerage. The local public authority - The City of Split is in charge of the urban drainage system, while the Croatian Waters have jurisdiction over surface flow.

Regarding the good practices, the Conference “Energy and water efficiency” organized by the Croatian Chamber of Economy, County Chamber of Split about efficiency in energetics and water management is noteworthy. There is also the Split-Solin agglomeration project which involves certain interventions on the water supply system. Interventions will lead to a significant reduction of losses (58% to 35%) and consequently to an increase of efficiency on the Split FUA water supply system. Furthermore, it involves an extension of the water supply network in order to cover about 10% of the population that is currently not connected to the water supply.

- **Key challenges:**
  - Lack of legislation on greywater and rainwater in Croatia
  - Water supply and sewage management at Split FUA level is characterized by the jurisdictional fragmentation
  - No restrictions in water use.
- **Key strengths:**
  - Implementation of the integral major project (Split-Solin agglomeration)

- The existence of Water Supply and Sewerage Ltd. Split business development from 2019 to 2030
- Organized conferences on energy & water efficiency
- Different research initiatives on energy & water efficiency.

4. Vision

This chapter shows the vision that presents the desired future state of the Split FUA in 2030. The vision was developed by using the strategic planning technic – the SOAR analysis along with the strong participatory approach. The following table shows key strengths, opportunities, aspirations, and results, generated on the basis of stakeholders' involvement.

STRENGTHS	✓ Favourable geographic position and pleasant Mediterranean climate ✓ High spring Jadro karstic water quantity as well as quality according to its physical and chemical indicators ✓ High resilience of Jadro water spring on different climate change scenarios ✓ High tap water quality ✓ High bathing water quality ✓ Centralized water management (single water utility) ✓ Developed plans for reconstruction and expansion of water infrastructure – Integral major project – agglomeration Split-Solin ✓ Existing different research initiatives on energy & water efficiency ✓ Conferences on energy & water efficiency ✓ Positive tendency of the local community regarding water-saving habits which are motivated more by environmental reasons than economic reasons ✓ Present awareness regarding the possibilities for rainwater use and widespread of the related rainwater installations ✓ A significant number of respondents is open to changing their habits in order to reduce their negative environmental impact
OPPORTUNITIES	✓ Development and participation in projects which aim to increase the percentage of FUA's green spaces ✓ The implementation of new water disinfection technology ✓ Further realization of plans for reconstruction and expansion of water and sewerage infrastructure ✓ Installation of rainwater retention and reuse infrastructure ✓ Participation in the initiatives and projects on energy & water efficiency in order to promote water reuse in households ✓ Participation in the initiatives and projects that emphasize raising awareness about the water footprint of the production processes and reducing the consumption of bottled water ✓ Impact mitigation and increase of resilience of climate change impacts and potential extreme hydrological conditions ✓ Advocacy on creation and implementation of legislation on greywater and rainwater in Croatia

ASPIRATIONS	✓ Preserved and increased FUA green spaces ✓ Preserved spring water quality ✓ Improved tap water quality and reduced turbidity values ✓ Increased efficiency in water distribution ✓ Improved wastewater collection, recycle and reuse processes (CE solutions) ✓ Increased public awareness on water (re)use and sustainable water usage ✓ Established legislation on greywater and rainwater in Croatia ✓ Climate change and extreme hydrological conditions adaptation
RESULTS	✓ Percentage of the FUA territory covered by green spaces ✓ Dual system for the water supply network installed ✓ Water purification plant on Jadro water spring installed ✓ Infrastructure for wastewater management developed according to WFD requirements ✓ Infrastructure for rainwater retention and reuse built and installed ✓ Water loss reduction ✓ Water supply network coverage ✓ Local community awareness on water (re)use and sustainable water usage

The vision on the desired future state of the Split FUA in 2030 developed based on the results of the conducted SOAR analysis will rest on the principle of "one water" solution. It implies holistic approach to manage the urban water cycle as a single integrated system where water streams are recognized as potential resources. A resource that must be managed holistically, viably, and sustainably. Hence, water supply, ground water, surface waters, stormwater, and wastewater management are all viewed as interconnected and optimized. Guided by "one water" principle, FUA Split vision in 2030 is:

Split FUA is an area with a sustainably managed circular urban waters, which ensures efficiency in water use and distribution, by preserving high tap and bathing water quality and managing wastewater and rainwater sustainably, thus preserving water bodies and guaranteeing their quality, while promoting efficient multiple water (re)use at the same time.

5. Strategic goals and objectives

The practical fulfilment of the vision will be achieved through strategic and related specific objectives. The detailed description of all the strategic and specific goals is shown below.

5.1. Strategic goal 1

To increase efficiency in water use and distribution

As shown in the previous analysis there are few key challenges regarding water infrastructure that affect water use and distribution such as: lack of a dual system for the water supply network; poor pipe condition which causes significant water loss in the water supply network and no integration with the local hydrological system. Hence, the first strategic goal is to increase efficiency in water use and distribution at the FUA level. This goal will be achieved through the realization of the following specific objectives:

5.1.1. Objective 1.1.

To expand the water supply network

Currently, 93% of the population has access to the water supply network. This objective aims to ensure that the entire FUA Split population is covered with access to water supply network by 2030. In order to achieve this goal, the integral major project Split-Solin agglomeration has started and aims to reconstruct and expand the water supply network, thus ensuring that 100% of the FUA Split population has access to the water supply network.

5.1.2. Objective 1.2.

To improve water supply network

As stated before, the FUA Split water supply network has poor pipe condition which causes significant water loss – 58%. This specific objective aims to reduce that percentage by 2030 to 35%. For the realization of this goal, the existing pipes will be repaired and reconstructed, and the dual system for the water supply network which currently does not exist will be installed. This will directly reduce the current high percentage of water loss.

5.1.3. Objective 1.3.

To increase resilience of the urban water system to climate change impacts

The urban water system is heavily affected by climate change. Impacts of climate change can be seen through extreme hydrological conditions (droughts and flash floods), sea-level rise and impact on coastal water infrastructure, flooding of low-land areas and urban water infrastructure, as well as increasing temperature of supply water and wastewater. A holistic approach of all stakeholders is needed in order to overcome the impact of emerging climate issues. The set goals of the *Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070* represent guidelines and instructions for increasing resilience of the urban water system to climate change impacts. By 2040 FUA Split aims to reach the goals of the before mentioned strategy concerning the urban water system through encouraging and engaging relevant stakeholders to implement necessary changes.

5.2. Strategic goal 2

To guarantee good quality of water bodies

The City of Split is located on the eastern Croatian Adriatic coast and Jadro is the only river at the Split FUA level, with its karstic water spring as the main water supply source at the FUA level and beyond. Accordingly, preserving and guaranteeing the good quality of water bodies is imperative. This goal will be achieved through the following two specific objectives:

5.2.1. Objective 2.1.

To preserve excellent bathing water quality

According to the Regulation on sea bathing water quality parameters, the quality of bathing water is excellent. Such quality needs to remain preserved due to numerous reasons (ecological, social, economic, etc.). In order to preserve bathing water quality at Split FUA level this matter will be advocated and promoted among all relevant stakeholders as well as local community. Hence, this specific objective primarily implies raising awareness regarding seawater quality through organizing promotional campaigns and specific workshops. This objective aims to ensure that bathing water quality remains excellent by 2030.

5.2.2. Objective 2.2.

To preserve Jadro recharge area water quality

The recharge area of Jadro Spring covers an area significantly larger than FUA Split, approximately over 500 square kilometres and it is located in the FUA's hinterland. The characteristic karst environment indicates high vulnerability of karstic recharge area of Jadro Spring and significant oscillation in the average monthly spring water discharge. According to the Regulation on water classification parameters, water quality is currently falling into the first (I) class during most time of the year, with occasional mild to significant increase in water turbidity which occurs suddenly after heavy rainfall, thus indicating problems in the Jadro spring recharge area. This specific objective aims to maintain the existing water quality constantly by installing a water purification system at Jadro Spring, which will ensure high water quality in 2030.

5.3. Strategic goal 3

To improve wastewater management

Split FUA has a sewerage system that is mostly made of a combined type of sewer. The system is characterized by numerous overflows into the coastal sea which consequently causes pollution. The improvement of wastewater management implies building necessary water infrastructure according to WFD requirements, and it will be achieved through the realization of the following specific objective:

5.3.1. Objective 3.1.

To reconstruct and improve the wastewater drainage system

Currently, 78% of the FUA Split households are connected to the wastewater collection network. In order to achieve this goal, integral major project Split-Solin agglomeration has started and aims to reconstruct and expand the wastewater collection network. This will result in 95% of the households connected to

wastewater collection network by 2030. FUAS Split infrastructure for wastewater management will be developed according to WFD requirements.

Strategic goal 4

To retain water as long as possible on site

Retaining water as long as possible on site is extremely important in order to improve water use efficiency, water sustainability and favourable micro climate conditions of urban area. Population, urbanization, climate change, and many other factors are adding pressure on sustainable water supplies. Therefore, achieving this goal will be enabled by implementing circular water management solutions, shown in the following specific objectives:

5.4.1 Objective 4.1.

To harvest rainwater and stormwater for non-potable purposes

Harvesting rainwater and stormwater for non-potable reasons will drastically improve water sustainability at the FUA level. One of the excellent solutions for circular water management is a green roof, which allows the reuse of rainwater and stormwater for non-potable reasons. A green roof is a layer of vegetation planted over a waterproof system that is installed on top of a flat or slightly-sloped roof. Currently there is only one green roof installation at the FUA Split level, while FUA Split aims to install at least five green roofs by 2030.

5.4.2 Objective 4.2.

To interpolate green solutions into existing stormwater infrastructure

Sustainable urban drainage systems (SUDS) are systems designed to efficiently manage the drainage of surface water in the urban environment. This green solution delivers multiple benefits such as high-quality drainage, supporting areas to cope better with severe rainfall, making urban spaces more vibrant and sustainable and resilient to change by improving urban air quality, regulating building temperature, etc. At the FUA Split level there are no operational sustainable urban drainage systems, but it is planned to build at least two operational sustainable urban drainage systems by 2030.

5.5 Strategic goal 5

To promote multiple water use and water sustainability

In order to implement circular urban water management at the FUA level, technical and green solutions are not sufficient. It is crucial to influence local community and relevant stakeholders' awareness. Water sustainability will be preserved by changing water consumption habits. Thus, this goal implies the accomplishment of the following specific objectives:

5.5.1 Objective 5.1.

To raise awareness about saving and efficient use of water, its reuse, and climate changes as well as promoting urban water systems (UWS) as the engine for circular economy development

The results of the conducted public perception survey (N - 402) provided an insight into citizens' water consumption habits and showed a positive tendency about water-saving habits, but at the same time extremely low awareness regarding water footprint of the production process as well as existing green and technical solutions and/or modes to save water. Therefore, by 2030, 25 promotional campaigns are planned to be held at the FUA Split level. These

campaigns will raise awareness regarding water consumption, saving and efficient use of water, its reuse, and climate changes. They will also promote urban water systems (UWS) as the engine for circular economy development, among common people and relevant stakeholders.

5.5.2 Objective 5.2.

Continuous multi-stakeholder involvement in the system management activities

As stated before, achieving circular urban water management is a complex process, which requires the awareness and involvement of various relevant stakeholders. To influence the stakeholders' attitudes, besides the organized promotional campaigns, the specific workshops will be organized as well. Therefore, the target indicator implies that 10 workshops will be organized at the FUA level by 2030. The workshops will emphasize relevant topics concerning multiple water use, water sustainability and water management, thus educating different stakeholders and encouraging their future involvement.

5.6 Strategic goal 6

To preserve flow in water bodies

Preserving flow in water bodies presents an important strategic goal that will contribute to the accomplishment of circular urban water management. The extraction of fresh water significantly affects the flow in water bodies. The main challenge in the future will be the restauration of natural flow and natural regeneration. Overcoming this challenge will be accomplished due to the realization of the following specific objective:

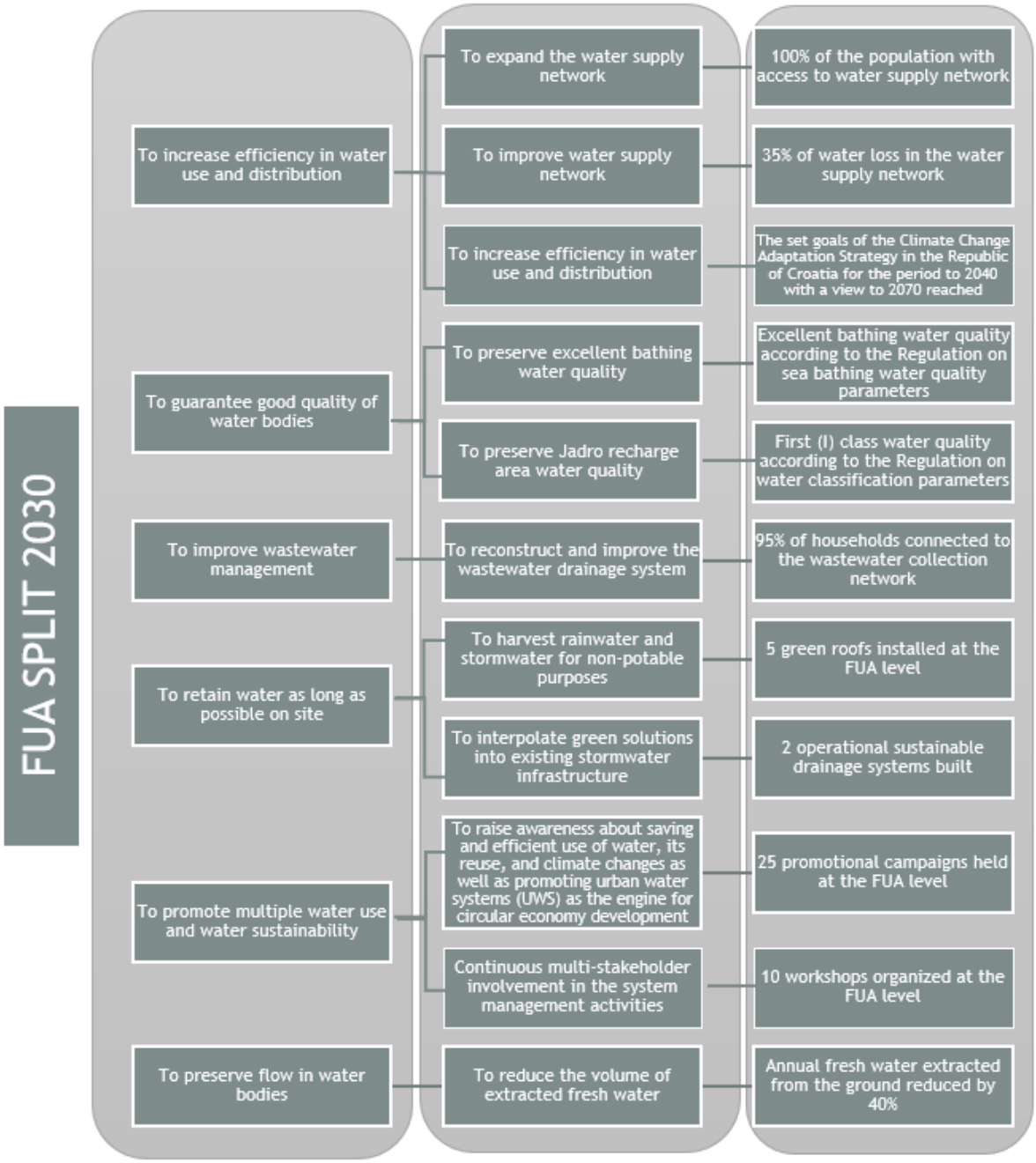
5.6.1 Objective 6.1.

To reduce the volume of extracted fresh water

The annual volume of fresh water extracted from river Jadro source in 2018 was 55,755,423.00 m3, while the daily volume of freshwater used by each person was 149.95 l/day per capita. The specific objective targets to reduce the annual fresh water extracted from the ground by 40% in 2030. To reduce fresh water extracted from the ground, the water loss will be reduced through implementation of the integral major project Split-Solin agglomeration. Furthermore, the demand for the extraction of fresh water will be reduced by: implementing water saving habits, installing green solutions, advocating on creation and implementation of legislation on greywater and rainwater in Croatia, allowing re-usage and recycle of non-potable rainwater, stormwater, and greywater.

The following table shows all the described FUA Split strategic goals with related strategic objectives as well as their baseline and target indicators.

	STRATEGIC GOAL	SPECIFIC OBJECTIVE	BASELINE INDICATOR	TARGET INDICATOR
VISION	To increase efficiency in water use and distribution	To expand the water supply network	93% of the population with access to water supply network	100% of the population with access to water supply network
		To improve water supply network	58% of water loss in the water supply network	35% of water loss in the water supply network
		To increase resilience of the urban water system to climate change impacts	The set goals of the Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070	The set goals of the Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070 reached
	To guarantee good quality of water bodies	To preserve excellent bathing water quality	Excellent bathing water quality according to the Regulation on sea bathing water quality parameters	Excellent bathing water quality according to the Regulation on sea bathing water quality parameters preserved
		To preserve Jadro recharge area water quality	First (I) class water quality according to the Regulation on water classification parameters	First (I) class water quality according to the Regulation on water classification parameters preserved
	To improve wastewater management	To reconstruct and improve the wastewater drainage system	78% of households connected to the wastewater collection network	95% of households connected to the wastewater collection network
	To retain water as long as possible on site	To harvest rainwater and stormwater for non-potable purposes	1 green roof installed at the FUA level	5 green roofs installed at the FUA level
		To interpolate green solutions into existing stormwater infrastructure	0 operational sustainable drainage systems built	2 operational sustainable drainage systems built
	To promote multiple water use and water sustainability	To raise awareness about saving and efficient use of water, its reuse, and climate changes as well as promoting urban water system (UWS) as the engine for circular economy development	0	25 promotional campaigns held at the FUA level
		Continuous multi-stakeholder involvement in the system management activities	0	10 workshops organized at the FUA level
	To preserve flow in water bodies	To reduce the volume of extracted fresh water	55,755,423.00 m^3 of annual fresh water extracted from the ground	Annual fresh water extracted from the ground reduced by 40%


FUA SPLIT 2030
To increase efficiency in water use and distribution
To guarantee good quality of water bodies
To improve wastewater management
To retain water as long as possible on site
To promote multiple water use and water sustainability
To preserve flow in water bodies
To expand the water supply network
To improve water supply network
To increase efficiency in water use and distribution
To preserve excellent bathing water quality
To preserve Jadro recharge area water quality
To reconstruct and improve the wastewater drainage system
To harvest rainwater and stormwater for non-potable purposes
To interpolate green solutions into existing stormwater infrastructure
To raise awareness about saving and efficient use of water, its reuse, and climate changes as well as promoting urban water systems (UWS) as the engine for circular economy development
Continuous multi-stakeholder involvement in the system management activities
To reduce the volume of extracted fresh water
100% of the population with access to water supply network
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The set goals of the Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070 reached
Excellent bathing water quality according to the Regulation on sea bathing water quality parameters
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95% of households connected to the wastewater collection network
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10 workshops organized at the FUA level
Annual fresh water extracted from the ground reduced by 40%