Interreg
CENTRAL EUROPE
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CWC

City Water Circles

Transnational online handbook on circular urban water management and use

Summary

This publication has been developed within the framework of the CWC 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). This project is supported by Interreg CENTRAL EUROPE programme 2014-2020 funded under the European Regional Development Fund. Read more on: https://www.interreg-central.eu/Content.Node/CWC.html.

This brochure is the summary of the "City Water Circles transnational online handbook on circular urban water management and use".

Read more on: https://www.interreg-central.eu/Content.Node/37.html.

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Content

1. Introduction

Water is both a resource and a hazard for cities. The supply of good-quality water is crucial for the well-being of residents. The access to water is also critical for many economic activities.

Freshwater is a limited resource and its availability is threatened by overexploitation, pollution and a changing climate. An excess and a scarcity of water are two extreme urban threats resulting from climate change.

In the 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** (CWC) we propose adaptation solutions increasing the city's resilience towards decentralised water and wastewater systems, rainwater harvesting systems and the recycling and reuse of greywater.

The general objectives of the CWC project to achieve circular water management can be classified as:

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

According to the concept of a circular economy, rainwater, greywater and treated wastewater are resources that can be used to reduce the pressure on conventional water resources.

The increasing frequency of extreme weather events, such as heat waves and heavy rainfalls, rising sea levels and changes in the quality and quantity of surface water and groundwater put additional pressure on existing urban water and sewer systems. Land development and surface sealing deprive cities of their ability to absorb and retain rainwater. As a result, heavy rainfalls increase the volume and speed of water flowing on the ground surface, causing an overload on the sewerage systems and local flooding. Overloaded combined sewer networks during heavy precipitation events will lead to the discharge of untreated wastewater directly into nearby water bodies. Changes in water demand (for example during a heat wave) can cause deficits in urban water supply and limited availability. Under these circumstances, water management has become a key challenge for Central European and others cities.

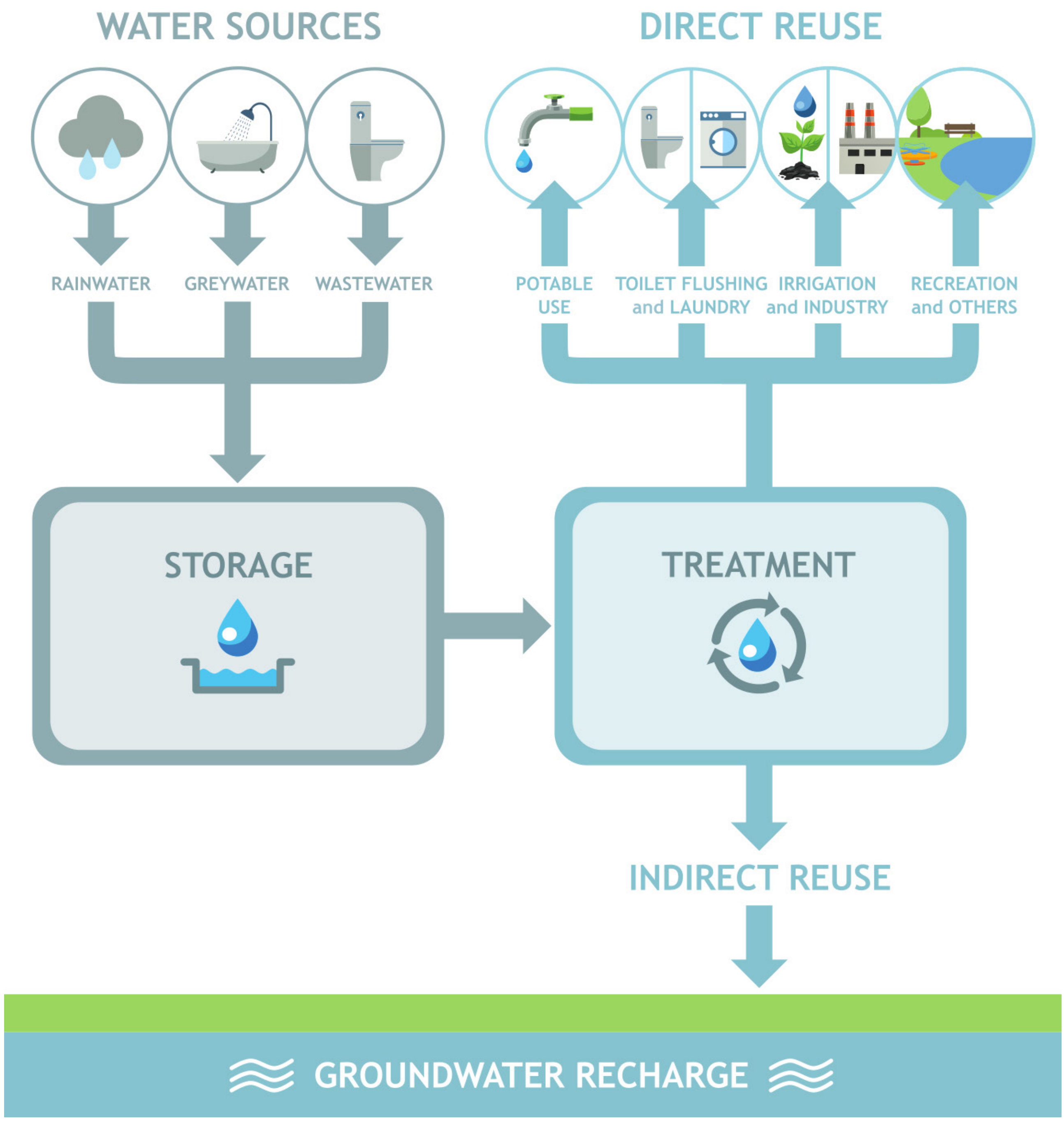


Figure 1: Fate of water resources in a circular water management system.

The goal of the CWC project is to find solutions to this new challenge. Project partners have built up a knowledge base for urban circular water management for different stakeholders: public authorities, water suppliers, agencies or NGOs.

Figure 2: Circular water management concept.

For all willing to learn about these topics, you can find available, i.a.:

- Digital Learning Resources in English, Croatian, Hungarian, Italian, Polish, Slovenian;
- The mid-term Strategies and Action Plans for 5 Functional Urban Areas (FUA) co-developed with local stakeholders;
- Transnational strategy for creating an enabling policy framework on circular water use;
- Pilot actions in 5 partner cities demonstrating innovative technological solutions and providing a collection of practical experiences;
- CWC Transnational Online Handbook on circular urban water management and use.

The Handbook is a set of innovative tools and solutions presented in 4 Thematic Catalogues:

1. Smart assessment tools for potentials' mapping of urban water use;
2. Innovative engineering and nature-based solutions for circular water usage;
3. Smart governance tools fostering circular urban water usage;
4. Novel Digital Tools Promoting Water Efficiency Among Citizens/Consumers.

In the following summary, we briefly present the content of the 4 Thematic Catalogues and the 5 pilot actions.

Would you learn more about the topic? Get the full version from the website: https://www.interreg-central.eu/Content.Node/37.html.

2. Summary

What problems will the city be faced with in the future if there is no change in the way of dealing with water? What is the performance of alternative water reuse solutions compared to the current (conventional) ones?

The Thematic Catalogue 1 - Smart assessment tools for potentials' mapping of urban water use shows how to find the answers to these questions and it presents the assessment tools, which can support decisionmakers in their planning of future investments in the urban circular water measures.

The **Chapter 2 - Assessment Criteria, Performance Indicators and Methodologies** identifies examples of possible technical, environmental, economic and social assessment criteria and performance indicators. It includes also basic descriptions of six methodologies: Life Cycle Analysis (LCA), Material Flow Analysis (MFA), Environmental Risk Assessment (ERA), Ecological Footprint Analysis, Health Risk Assessment and Multicriteria Analysis (MCA) and their purpose.

We wanted to present how to comprehensively tackle assessment challenges and how to plan and implement water management investments in the urban areas, in accordance with circular water management goals.

This is why **Chapter 3 - Decision and Assessment Process of Urban Water Management Investments** includes the **didactic example**: "Use of rainwater and purified wastewater for producing recycled construction material", which is a pilot investment in the functional urban area (FUA) of Maribor, Slovenia, in the framework of the CWC project.

In this case, to enable the assessment of investment alternatives also from an environmental and social perspective, the monetary valuations, which are usually based on the cost-benefit analysis (CBA), are complemented with a multi-criteria analysis (MCA) with identification of the selection criteria and the weighting system including economic, environmental and social perspectives.

Chapter 4 presents two good practice examples of developed and tested assessment tools in the framework of EU initiatives: the iWater tool- Integrated Storm Water Management Toolbox and the AQUAENVEC tool – Environmental and Economic Assessment.

The use of tools in the decision-making process requires clear vision and goals of future policies, a lot of knowledge capacities and experience related to implementation of public investments, good data background, team effort and a lot of time for preparation.

Therefore we have included in **Annex** our lessons learnt and conclusions from four other CWC project pilot investments – in Budapest, Bydgoszcz, Split and Torino.

Rainwater and wastewater are valuable resources for water, energy and nutrients which can be collected, treated, recycled and reused to close the water cycle and pave the way towards a circular water economy.

The Thematic Catalogue 2 - Innovative engineering and nature-based solutions for circular water usage provides authorities, planners, land developers, engineers, property owners and other stakeholders with information on the state-of-the-art technology on sustainable rainwater management and greywater reuse within an urban context.

The catalogue is divided into two parts:

Part 1: Rainwater Management;

Part 2: Greywater Recycling.

The potential of sustainable rainwater management systems to adapt to various conditions and requirements is limitless.

Part 1 Offers tools and guidance on selecting the appropriate rainwater management scheme for a specific site. Rainwater can be infiltrated or harvested and stored for household needs, irrigation, greening or adiabatic cooling.

Chapter 2 - Tools for sustainable rainwater management is dedicated to various aspects of rainwater harvesting systems for potable and non-potable reuse, but also measures for rainwater retention, evapotranspiration and irrigation including green roofs and facades, retention ponds, rain gardens, wetlands, permeable paving, swales, infiltration basins and trenches, etc. These technologies and measures can reduce and offset the impacts of stormwater and flood events on the environment and infrastructure.

Chapter 3 gives an overview matrix on the potentials and impacts of different measures for rainwater management.

Chapter 4 - Best Practice includes nine examples of implemented rainwater management concepts.

Figure 3: Rainwater management tools.

In circular water management, greywater is perceived as an alternative water resource that can be exploited to meet the increasing water demand for applications that do not require potable water quality. This approach is described in Part 2 of the catalogue. **Chapter 2 - What is Greywater?** describes the characteristics and composition of greywater, greywater reuse guidelines and regulations, water quality, technical installation, and operation and maintenance requirements for greywater recycling. It also includes possible applications, benefits and risks of greywater recycling.

Greywater, once appropriately treated, is considered suitable for non-potable applications such as toilet flushing, laundry, cleaning, irrigation, car washing, fire protection, hydroponic and aquaculture systems. The water quality requirements are site and application-specific and the level of treatment needed depends on the quality of the raw greywater as well as the intended reuse application, both equally affecting the choice of the treatment technology. Issues related to greywater treatment are the subject of **Chapter 3 - Greywater Management and Treatment**. Chapter 3 describes the physical, chemical and biological treatment technologies and disinfection of the treated greywater. Maintenance expenditure, performance, as well as health aspects, environmental impacts and the economic benefits of greywater reuse are also covered.

Paramount to the acceptance of greywater reuse is health security. Therefore, the proper treatment, operation and maintenance of greywater recycling systems is indispensable. Greywater recycling is not yet widely propagated, also due to the apparently low economic benefit. However, with the rise in water costs and the increased pressure placed upon ageing and deteriorating water and wastewater infrastructure, solutions which reduce the freshwater demand, such as greywater recycling, are becoming financially more viable. **In Chapter 4 - Best Practice**, five realised greywater recycling systems in multi-storey residential buildings, hotel and research centre are presented.

Catalogue 2 is also supplemented with fact sheets on the different rainwater management tools (Annex).

Access to water and sewage systems seems obvious to the inhabitants of European cities. Water supply, consumption and the collection of contaminated water require a wise management of the entire process.

CWC aims at defining and introducing an innovative approach to the circular management of water resources. This approach, the Smart Water Governance, intends to foster the active involvement and engagement of the stakeholders and to make a good use of technological tools. **The Thematic Catalogue 3 - Smart governance tools fostering circular urban water usage** describes smart approaches already in use or that can be suitable to improve the current state of the art in 5 categories of intervention that compose a Smart Water Governance:

1. Water pricing system;
2. Water conservation programmes;
3. Monitoring Rainwater harvesting and Greywater: quantity and quality level;
4. Incentives and Financial support (for recycled water project & construction of harvesting systems);
5. Education programmes.

Figure 4: Smart Water Governance tools.

Water pricing is an important economic instrument for improving water use efficiency, enhancing social equity and securing the financial sustainability of water utilities and operators. **Chapter 2 - Water pricing** system discusses the design of water and wastewater tariffs, their types and importance.

Water conservation programmes aim at reducing the exploitation of water resources. They can vary significantly by the specific goals they need to pursue and can be composed of many smart water governance features. **Chapter 3 - Water conservation programmes** provides three good practices from the USA, Italy and the UK.

Monitoring can be applied in several contexts related to water, from users behaviour to the facilities installation or application of policies. Monitoring can regard the use of fresh water, waste water and also the harvesting of rain water or the reuse of grey water. **Chapter 4 - Monitoring the water cycle** gives indications for the effective realization of a monitoring system and some technical suggestions about the smart approach to monitoring rainwater harvesting, and the usefulness of smart water meters for operational managers and end users.

Water resources management is currently underfinanced and in need of greater attention from governments. Climate change threatens water resources management, increases the risk of weather-related events, and affects the availability and quality of water and sanitation services. However, it also presents an opportunity: to leverage climate finance mechanisms to provide additional funding to improve water management. The multiple mechanisms, institutions, programmes and activities at various scales are the content of **Chapter 5 - Incentives and Financial support**. Additionally, the case study of the city of São Paulo (Brazil) shows an example of the economic incentives for water consumption reduction.

Chapter 6 - Education Programmes describes a wide water UNESCO Educational programme and its five focal areas:

1. Enhancing tertiary water education and professional capabilities in the water sector;
2. Addressing vocational education and the training of water technicians;
3. Water education for children and the youth;
4. Promoting awareness of water issues through informal water education;
5. Education for trans boundary water cooperation and governance.

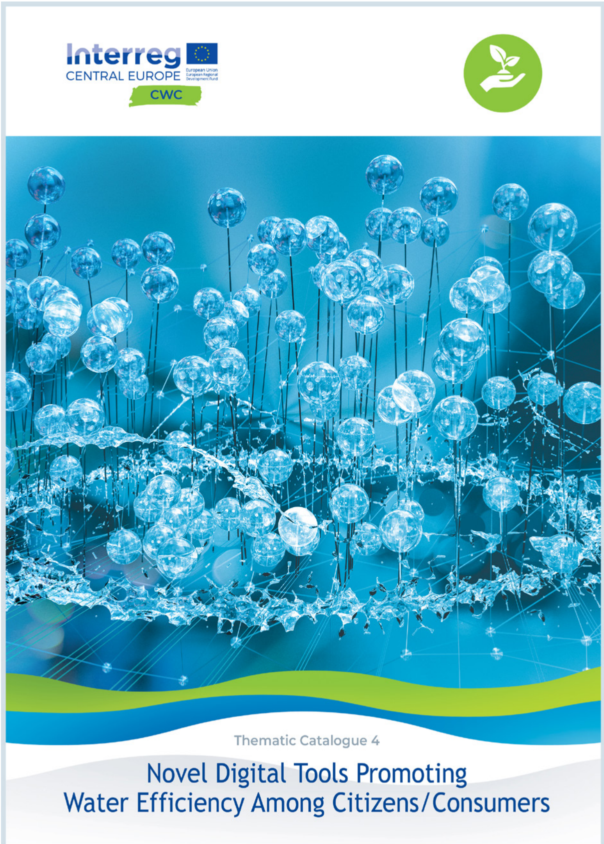
As an innovative educational tool, gamification, with the related use of smart devices, is suggested. The gamification can be used especially in raising citizens awareness and promoting behavioural change.

During the last several decades the world has seen remarkable development in the Information and Communications Technology (ICT) field.

Because of its availability, accessibility, diversity and speed, ICT is seen by many as being extremely beneficial for raising awareness and improving knowledge in many application sectors.

Digital tools and ICT in general, while used here to increase water efficiency, do not only serve as useful technological and smart governance tools, but also as tools which can stimulate behaviour change among the general public along with raising knowledge on water consumption and saving potentials.

The **Thematic Catalogue 4** is a knowledge base introducing **novel digital tools** and solutions promoting efficient water use and a sustainable consumer behaviour among citizens/consumers such as water saving, detection of leaks in the water network, use of non-conventional water resources such as rainwater or recycled greywater, etc.



Chapter 1 summarizes a conducted EU-wide research and includes concepts, prototypes and close-to-market solutions based on the research of different resources such as Cordis, EU Science Hub, and the database of the European Institute of Innovation and Technology.

The presented solutions are based on the Internet of Things (IoT), in other words, they refer to web-based applications, online tools, mobile apps and other software. In order to follow the future trends in water efficiency promoting tools, a list of EU clusters and platforms for water management are also presented, as well as a list of ongoing H2020 projects that develop and promote ICT solutions for water management.

Figure 5: Digital tools for water management.

Chapter 2 is devoted to the potentials of smart water metering to increase water efficiency and bring positive changes in user behaviour. Implementing smart water metering (SWM) infrastructure allows utility companies to collect data faster and more efficiently and overall it increases customers' engagement by allowing them to visualize and predict their water consumption. Accordingly, the implementation of smart water meters and the induced behavioural change will result in higher water savings for the consumers. It will also provide a better understanding of the digitalisation needed in the water industry as well as the benefits and limitations it brings.

Chapter 2 also gives a comprehensive introduction of the smart metering digital tools, which includes their use, constructional and application requirements, application areas, differences between systems on the market, costs and benefits, as well as several examples and case studies from the United Kingdom, France, Spain, Denmark and Croatia.

3. Pilot actions

3.1 Secondary raw material from rain and wastewater in Maribor

Pilot plant building. Photo: Aleš Erker, MBVOD.

Produced concrete blocks (CWC and Cinderella projects). Photo: Aleš Erker, MBVOD.

The pilot action demonstrates the potential of using treated wastewater and rainwater to produce secondary raw materials (SRM) based construction products.

The materials produced from recycled water will be used for road maintenance works and to revitalise degraded areas by Nigrad, a public company, the majority of which is owned by the Municipality of Maribor, which is also a concessionaire for public road maintenance.

Rainwater is harvested from the roof surface, drainage of the building and from land around the pilot action location. Treated wastewater is transported from the nearby wastewater treatment plant. The pilot plant consists of two 16 m^3 underground plastic reservoirs, one for rainwater and the other for treated wastewater, the hydro booster station with two automatically regulated pumps at the reservoir outflows to provide water for the production process, and two ultrasonic water meters DN40.

The location of the demonstration project is inside the Municipality of Maribor at the degraded urban area in Dogoše, Maribor, where the pilot is directly connected to the production plant from producing secondary raw materials based construction products operating at the same location.

The quality of the reused water will be tested by National Laboratory of Health, Environment and Food for its suitability for the SRM production process. The pilot shows strong synergies with the Horizon 2020, Circ-01-2016-2017, Cinderella project, which aims to produce new construction materials from different types of wastes.

Impacts:

The expected impacts from this pilot action include rainwater retention, increased reuse of recycled water in industrial processes, drinking water conservation and water and soil protection. The pilot also increases the awareness in the local community of rainwater and recycled water potential uses and safety.

Budget:

43,500 EUR

Contact:

Mariborski vodovod: Matej Levstek, matej.levstek@mb-vodovod.si, Aleš Erker, ales.erker@mb-vodovod.si, Boštjan Hostnik, Bostjan.Hostnik@mb-vodovod.si

3.2 Rainwater harvest and greywater reuse in the Hétszívirág kindergarten in Zugló

Backyard of the kindergarten. Photo: Zugló Municipality.

Filter gravel bed. Photo: Zugló Municipality.

The CWC pilot investment installed at the Hétszínvirág Kindergarten in Zugló (Budapest, XIV. district) includes the harvest of rainwater run-off from the roof of the building and reuse of greywater from the handwashing units at the nursery.

Both water sources are drained to a pre-filtration zone. This zone is waterproof ditch, filled with fractions of different sized gravel and sand and planted with suitable species. The gravel and roots perform the filter effect. Most of the pollutants are filtered out here: organic matter, heavy metals, biological pollutants, and colloids are reduced. The pre-filtered rainwater and greywater are collected in two, 7 m^3 capacity tanks sunk into the ground in the courtyard.

This purified and stored water is recycled in two ways:

1. A part of it is used for flushing the toilets. The wastewater from the toilets follows the 'traditional route' into the public sewer.

2. The other part of the collected water is used to irrigate the garden.

The water collected in tanks must not enter the drinking water network (it must not contaminate the drinking water). The water quality will be tested and its proper quality is a boundary condition of the operation.

Impact:

The pilot action has multiple benefits: the reduced drinking water consumption saves money for the municipality, the harvested rainwater ensures proper sourcing for watering the garden in dry periods, while the retained amount of rainwater alleviates the water stress on the sewage system by heavy rainfall. It also contributes to the early education of the pupils and increases the awareness of the parents, teachers, and other stakeholders.

Budget:

84,000 EUR

Contact:

City of Budapest, District 14 Zugló Municipality: Viktor Merker, merker.viktor@zuglo.hu

3.3 Rainwater utilisation via rooftop rainwater harvesting serving rain gardens in Bydgoszcz

Rain gardens at Waterworks Museum in Bydgoszcz. Photo: Jacek Cieściński, Bydgoszcz Municipal Waterworks.

Rain garden in containers at Bydgoszcz City Hall, Grudziądzka Street. Photo: B. Katarzyna Napierała, City of Bydgoszcz.

The pilot project aims at the demonstration of an alternative solution for rainwater management in buildings by collecting rainwater from the rooftop and using it on site instead of directing it to rainwater sewers. Put plainly, building the raingardens.

At the historic building on the premises of the Museum of Waterworks at Gdańska 242, various systems of rainwater management were used: barrels, dry streams, rain garden in the container and in the ground. The water from the roof with an area of 265 m^2 supplies the garden with an area of approximately 390 m^2.

The average annual amount of managed rainwater is 147 m^3. In a social event over 200 hydrophytic plants were planted, which purify and store water. The main purpose of the raingarden is to retain rainwater, but another important function is that of providing a demonstration as part of the museum’s educational activities.

The second pilot project was carried out at the building of the Bydgoszcz City Hall at Grudziądzka 9-15, in the very centre of the city, where greenery is rare. The raingarden was created in pots equipped with bench and exposed gutters supplying water from the roof. The storage capacity of the pots is 3,37 m^3.

Impacts:

The rain garden at the City Hall protects the vicinity of the building against flooding during heavy rainfall and reduces the effect of the heat island. In the future, similar solutions will be introduced by the city in other locations as mentioned in the Action Plan elaborated within the CWC project.

The variety of demonstrated systems is an inspiration for residents to implement their own home rainwater solutions. In addition, the large green area next to the Museum building will be maintained thanks to the rainwater, so no more drinking water is used for watering the greenery in a dry season.

Budget:

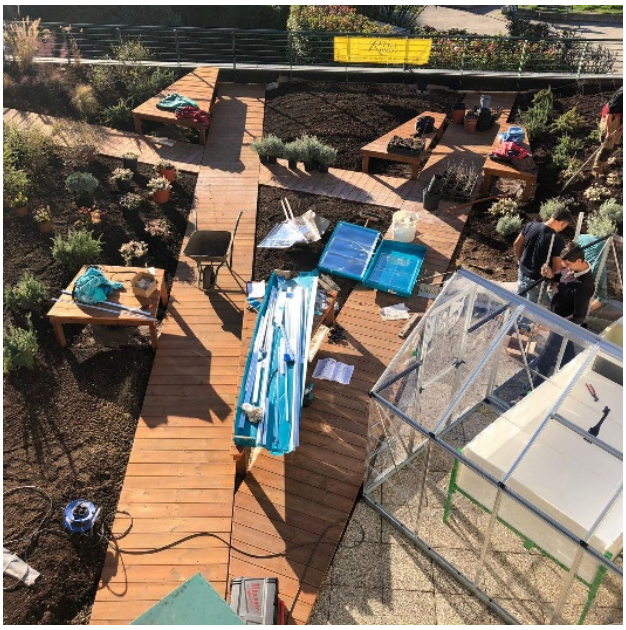
48,500 EUR

Contact:

Municipality of Bydgoszcz: Aleksandra Kowalska, Deputy Director of the Integrated Development and Environment Department, aleksandra.kowalska@um.bydgoszcz.pl

Museum of Waterworks: Aleksandra Rajczyk, Design and Investment Planning Department, aleksandra.rajczyk@mwik.bydgoszcz.pl

3.4 Rainwater recovery rooftop garden and aeroponic greenhouse in Turin



Green terrace. Photo: Alessandra Aires.

Project of green terrace. Author: Alessandra Aires.

The pilot action is being implemented at “Open 011”, a youth hostel built for the 2006 Winter Olympics in Turin in a former 1940’s factory. The building is EU ECOLABEL which is certified and already employs ICT devices to monitor the building’s environmental performance: a temperature monitoring system and a weather station.

The pilot action applies different nature-based solutions (NBSs) to deal with rainwater: an intensive green roof with garden and greenhouse on its big south terrace, rain garden near the building.

Rainwater harvested from approx. 230 m^2 of roof surface is collected in an underground cistern with a 13 m^3 capacity and used to irrigate the green roof. Rainwater from approx. 100 m^2 of roof surface is harvested and separately collected in a small rainwater tank (350 l) placed on the terrace to be used for aeroponic irrigation in the greenhouse. Rainwater from the green roof (180 m^2) and the overflow of the rainwater storage tank are fed into the rain garden for infiltration, thus closing the water cycle (the system is not connected to the rainwater drainage or the sewage network). The pilot action also includes participatory activities with the student community of the youth hostel, thus promoting and elevating the education and dissemination potentials.

Impacts:

The expected impacts of the adopted measures include climate change adaptation, flood and heavy rainfall mitigation, increased retention in urban areas, an improved urban air quality and microclimate, increased awareness of NBS measures, amenity enhancement and improved governance and citizens’ participation. The green roof is also a pleasant space for gathering with friends and for leisure.

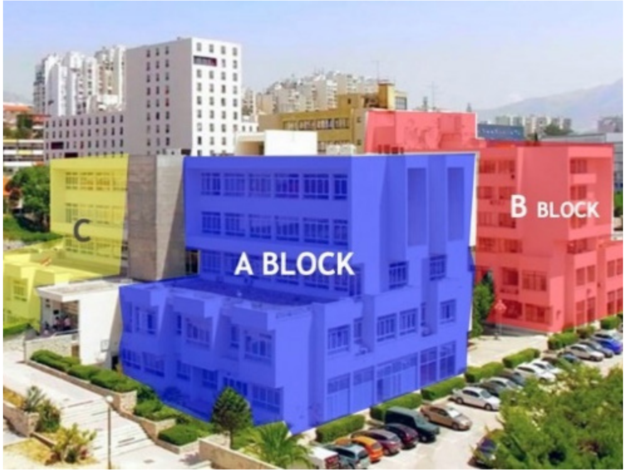
Budget:

57,160 EUR

Contact:

City of Turin: CWC@comune.torino.it

3.5 State-of-the-art IoT radio technologies and smart water meters for water consumption monitoring in Split



A, B and C-Blocks of Faculty of Civil Engineering, Architecture and Geodesy, University of Split.

The monitored data on dashboard. Photo: VIK-Split.

The pilot action is implemented at the University of Split, Faculty of Civil Engineering, Architecture and Geodesy. The faculty building consists of three blocks: A- and B-Blocks contain lecture and measurement rooms, while C-Block only classrooms.

At the entry points of each Block a smart water meter was installed for monitoring real-time water consumption using wireless technology. Smart water metering is able to register different daily water consumption as well as seasonal fluctuations at each location. The monitored data are available on dashboards (LCD screens) in a public space of the building as well on mobile applications. Faculty students and employees can download the data and analyse it in order to achieve a higher water efficiency in the building.

Since the smart water meters were installed underground, radio signal propagation (wireless communication) was tested at each location prior to the pilot's implementation. Three different, low-power state-of-the-art IoT radio technologies were considered: Sigfox, LoRaWAN, and NB-IoT.Upon testing the communication reliability between water-meters and dedicated receivers, LoRaWAN technology was chosen.

Based on this, three LoRaWAN smart water meters were installed at the 3 building blocks to remotely monitor water consumption (DN50 Axioma LoRaWAN in A-Block, DN40 Axioma LoRaWAN in B- and C-Blocks).

Impacts:

The expected impacts from the implementation of IoT tools to measure water consumption and use are an increase in awareness for rational water use and water conservation, combined with potential water saving effects. The educational effect will be also shared by the faculty students and staff through continuous monitoring and application updates.

Budget:

5,000 EUR

Contact:

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University of Split, Faculty of Civil Engineering, Architecture and Geodesy: Ivo Andrić, ivo.andric@gradst.hr

Waveform j.d.o.o.: Petar Solić, petar@waveform.hr

Project Partners

City of Budapest, District 14 Zugló Municipality

Webpage: www.zuglo.hu

Budapest Sewage Works Pte Ltd.

Webpage: www.fcsm.hu

Turin Municipality

Webpage: www.comune.torino.it

Poliedra - Service and consultancy centre at Politecnico di Milano on environmental and territorial planning

Webpage: www.poliedra.polimi.it

E-Institute

Webpage: www.ezavod.si

Maribor Water Supply Company

Webpage: www.mb-vodovod.si

City of Bydgoszcz

Webpage: www.bydgoszcz.pl

Institute for Sustainable Development Foundation

Webpage: www.pine.org.pl

Public Institution RERA SD for Coordination and development of Split-Dalmatia County

Webpage: www.rera.hr

Split water and sewerage company Ltd.

Webpage: www.vik-split.hr

Federal Association for Rainwater and Water Reuse

Webpage: www.fbr.de

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