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JOINT EVALUATION OF LESSONS LEARNT IN PILOTS WITH TRANSNATIONAL CROSS-ADAPTATION ROADMAP

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Content

1. Introduction

Water resources management in cities is jeopardised by megatrends such as demographic growth and climate change, requiring a rethinking of how water as a resource is used and reused. The number of cities at risk of droughts and floods is likely to increase in the coming decades. Significant challenges in terms of updating and renewing the urban water infrastructure are becoming urgent, which call for innovative practices and a long-term vision to make the best use and reuse of the available water resources. This requires a systemic approach that would take into account water policies in relation to other ones, such as land use and spatial planning policies.

Water resources across Europe are unevenly distributed. The European Environment Agency (EEA) estimates that approx. one-third of the European Union (EU) territory is exposed to water stress (1000 – 1700 m^3 per year and capita of available water resources), either permanently or temporarily and this is not only limited to countries like Portugal, Spain and Greece but also in the more Northern water-rich countries, such as Germany, the United Kingdom and Belgium[1]. The decreasing trends in water abstraction which is observed in Western and Northern Europe is attributed to improvements in water efficiency and management of the water supplies showing a 19% decrease between 1990 and 2017.

Water reuse is central to the implementation of a circular water model in urban areas and is also a key strategy to water security and system resilience. The use of non-conventional water resources such as rainwater, greywater and treated wastewater will augment the water supply and support water resiliency. These systems are more easily adaptable to demographic and climate changes and the problems associated with them than the conventional, centralised infrastructure. Resource recovery, which should also include energy and nutrients recovery from wastewater will additionally offer environmental, social and economic benefits in line with the circular economy model.

Green and blue infrastructures (nature-based solutions “NBS”) tend to be decentralised and their role in providing sustainable water services is well understood, although still undervalued. They support a cost-effective, resilient approach to managing increased flood and drought events and support the potential of the environment to restore its natural balance.

1.1. Purpose and scope of the document

The City Water Circles (CWC) project aims at demonstrating urban cooperation models to enhance water efficiency and reuse in central European functional urban areas (FUAs) with an integrated circular economy approach. The primary goal of the implemented pilot actions is to create a base knowledge for urban circular water management taking into consideration the specific local needs and requirements.

The different implemented tools and measures included nature-based solutions such as rain gardens and green roofs, rainwater harvesting, greywater recycling and reuse, treated wastewater reuse and food production from rainwater. In addition, smart water tools were developed and tested to increase water efficiency in buildings and other sectors and raise public awareness towards water saving and conservation.

The purpose of this document is to summarise the 5 pilot achievements and lessons learned within the CWC project and offer recommendations for improvements/adjustments of the tested CWC tools. A cross-

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[1] European Environment Agency (2019) Use of Freshwater Resources in Europe. European Environment Agency. Copenhagen, Denmark, 2019. https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-/assessment-4

adaptation plan for potential implementation and upscaling of these measures in the other FUAs is also proposed.

2. Short description of the pilot actions

The 5 implemented pilot actions adopted different solutions and measures for rainwater management and waste(grey)water recycling which are summarised in Table 1.

Table 1 : The 5 pilot actions implemented within the CWC project.

	Pilot	Rainwater harvesting	Greywater recycling & reuse	Treated wastewater reuse	Urban food production from rainwater	Smart metering & water efficiency
1	Combined rainwater and greywater reuse in a Kindergarten in **Zugló, Hungary**	✓	✓			
2	Rainwater recovery rooftop garden and aeroponic greenhouse in **Turin, Italy**	✓			✓	
3	Use of rainwater and purified wastewater for producing recycled construction material in **Maribor, Slovenia**	✓		✓		
4	Rainwater utilisation via rooftop rainwater harvesting serving rain gardens in **Bydgoszcz, Poland**	✓				
5	Demonstrating water saving via smart metering and developing a supportive mobile application in **Split, Croatia**					✓

2.1. Implementation of combined rainwater and greywater reuse in a Kindergarten in Zugló, Hungary

The pilot demonstrates circular water use (CWU) via rainwater harvesting and greywater recycling in a Kindergarten in Zugló district in Budapest. Treatment of the collected rainwater and greywater streams takes place in a constructed soil filter and the stored water is reused to flush the toilets and for irrigation of green space.

Outputs:

- Rainwater harvesting system from roof surface areas of the Kindergarten
- Greywater network system collecting greywater from 9 hand washbasins and one shower
- Two underground cisterns for the storage of rainwater and greywater
- A constructed soil filter (sand and gravel of different grain sizes) for the treatment of rainwater and greywater
- Eight toilet flush units connected to the water recycling system
- Booster pump for the distribution of treated water with corresponding piping network, shafts, filters, etc.

Challenges:

- One of the biggest challenges was the economic impact of Covid-19 pandemic which resulted in the central government making radical financial restrictions in municipal budgets. Under the initial retrofit plans of the municipality, the kindergarten should have undergone a complex renovation work and the circular water management elements were to be harmonised with these renovations. Changes in design plans were also made. For example, green roofs were found unsuitable for the outdated structure of the existing roof which was also in a poor statical condition, and thus was deleted from the concept
- Increasing prices in the construction industry in the post Covid-19 period, for which a concept redesign with a lower budget war necessary
- It was a challenge to bring the finalised concept into conformity with the parallel interventions of the Zugló Asset company, which was responsible for the investment tasks but only joined at a later stage of the project
- Unforeseeable problems during excavation works (e.g. presence of an old oil tank in the soil which had to be removed; an old huge tree had to be uprooted; a gas pipe was not indicated on map, etc.)

Impacts:

- Preserve water resources and save drinking water
- Increase onsite rainwater retention
- Reduce stormwater flow and drainage on site and protect against flooding
- Relieve the load on public sewer network
- Reduced drinking water bills
- Raise awareness on circular water use and water saving. As a member of the “Hungarian Green Kindergartens Network”, the pilot site offers high potential for dissemination and spread of knowledge on circular water use

- ***Monitoring results:***
- Monitoring activities included chemical and microbiological parameters of the collected and reused rainwater and greywater
- The first water quality assessment was realised by the accredited laboratory of Budapest Water Works in early April 2022, after the first significant rain of the year
- Water quality requirements should follow the EU Directive for Bathing Water[2] for indoor use of recycled water for toilet flushing

2.2. Rainwater recovery rooftop garden and aeroponic greenhouse in Turin, Italy

The pilot demonstrates rainwater management at the building level by adopting Nature Based Solutions (NBS). Rainwater from roof surfaces is harvested to feed a rooftop garden (intensive green roof) and a greenhouse-based aeroponic cultivation system for urban food production. Excess rainwater is drained into a rain garden built at the entrance of the building to promote infiltration on site and thus close the water cycle.

Outputs:

- Harvested rainwater which is stored, reused and infiltrated on site
- Intensive green roof
- Aeroponic system for food production from harvested rainwater
- Two storage tanks for harvested rainwater
- Rain garden

***Challenges*:**

- Unforeseen retrofit works in the building. Since the building was built in 1940 some technical, aesthetic, and infrastructural barriers had to be solved, which required modifications in the original design concept
- A long procurement phase due to bureaucratic hurdles, in addition to the long time required to check and approve the financial soundness of the contracted company
- Lack of material in the post Covid-19 period, in addition to the significant increase in material costs

Impacts:

- Flood prevention and runoff reduction on site through rainwater retention
- Reuse rainwater to support green infrastructure and food production
- Improve the microclimate and decrease heat island effects
- Increase urban amenity and biodiversity
- Enhance services offered by ecosystems and NBSs
- Generate consciousness, engagement and awareness among citizens

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[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0007

Monitoring results:

The local water utility (SMAT) has been subcontracted by the municipality of Turin to conduct the monitoring activities on site. Flow metres and data loggers are installed to measure the amount of harvested and reused rainwater for the green roof and aeroponic system as well as the amount of backup water (drinking water) used. Water quality analysis of the harvested rainwater upstream, and rainwater in the storage tank and downstream following UV disinfection will be conducted. The monitored parameters include E. coli, enterococci, total coliforms, turbidity, pH, TSS and colour.

2.3. Use of rainwater and purified wastewater for producing recycled construction material in Maribor, Slovenia

The pilot demonstrates the usability of harvested rainwater and treated wastewater for the production of secondary raw materials (SRM) based construction products. Rainwater is harvested on site and stored in an underground reservoir, whereas reclaimed wastewater is transported from the nearby wastewater treatment plant and stored in a second reservoir. Both water flows are mixed and used for the production process in a mobile onsite plant.

Outputs:

- Harvested rainwater
- Two underground cisterns for the storage of rainwater and treated wastewater
- Two booster pumps with corresponding piping network, shafts, filters, etc.
- Water metres

Challenges:

- The interdependency of the CWC project on the Cinderela Project (Horizon 2020 Circ-01-2016-2017), as regarding certain equipment and construction works was a challenge. This dependency involved the construction of the building, from where roof rainwater was to be collected, stored and used in the production process. Delay in the Cinderela project and some difficulties in coordinating the activities affected the implementation of this part of the pilot action. In the meantime, a temporary solution was found to collect surface runoff and water used to wash the concrete blocks produced on the building foundation (mobile onsite plant). A drainage was built to collect this water and store it in the underground cistern for reuse in the production process.

Impacts:

- Increase rainwater retention on site
- Reduce stormwater flow and drainage on site and protect against flooding
- Preserve water resources and save drinking water
- Enhance and encourage the use of rainwater and treated wastewater in industrial processes

Monitoring results:

- Samples taken from the construction material which was processed using recycled water and analysed according to SIST EN 1008 standard were tested for oils and fats, detergents, colour, settleable solids, suspended solids, smell, pH and chlorine and Sulphate contents. According to MBVOD and Nigrad, results have shown that treated wastewater is suitable for the manufacturing of SRM based construction products

- The Biochemical Oxygen Demand (BOD_5) of the effluent from the treated wastewater reservoir was < 5 mg/l, thus meeting the requirements for service water for indoor use, such as for toilet flushing

2.4. Rainwater utilisation via rooftop rainwater harvesting serving rain gardens in Bydgoszcz, Poland

The pilot demonstrates nature-based solutions (NBS) using rain gardens for onsite rainwater attenuation and retention at two selected locations in the Municipality of Bydgoszcz. The role of blue-green infrastructure in reducing runoff peak flow and volume and in relieving the local rainwater sewer is emphasised here. Decentralised rainwater management is demonstrated by harvesting rainwater from the roofs of buildings, which is fed into constructed rain gardens and/or infiltrated into the ground.

Outputs:

- Sealed and non-sealed rain gardens connected with a system of stone channels (Location 1)
- Sealed rain gardens in containers (Location 2)
- Rainwater barrels

Challenges:

- A challenge was to find the appropriate site for Location 2 for the implementation of NBS measures
- Lack of regulations and standards for the construction of rain gardens in Poland
- Lack of products for the monitoring activities on the local market

Impacts:

- Improve rainwater management in buildings and protect their foundations against floods
- Reduce load on rainwater sewer
- Enhance groundwater recharge
- Enhance evapotranspiration and improve air quality and urban microclimate
- Enhance amenity and biodiversity
- Improve governance and citizens' participation and awareness
- Provide knowledge and promote uptake of innovative rainwater measures by demonstrating NBS in public buildings

Monitoring results:

Monitoring activities were undertaken at 3 locations: Locations 1 and 2 and the Municipal Waterworks Headquarters at Torunska Street. Rainwater samples were collected from the roof surfaces of the buildings at the outlet of the downpipes and analysed for their physico-chemical and microbiological quality.

The following quality parameters were measured: Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD_5), Oxygen concentration, Dissolved organic Carbon (DOC), pH, Conductivity, Polycyclic Aromatic Hydrocarbons (PAHs), coliforms, *E. coli* and enterococci.

Additionally, automatic monitoring of soil moisture measurements is conducted at Location 2 during rainy and dry periods to assess plant health and growth conditions, using a weather station and four soil moisture sensors.

For the rainwater quality, the parameters tested showed good results. *E. coli* was always less than 1,000 CFU/100 ml and 4 out of 6 samples measured intestinal enterococci > 330 CFU/100 ml.

This is not in accordance with the EU Directive for Bathing Water but better than the requirements for reclaimed water for agricultural irrigation (Class C) according to the EU Regulation on minimum requirements for water reuse[3]. This is sufficient for the use purposes set in this pilot.

The automatic monitoring station was commissioned on 25th of April 2022 taking rainfall (mm) and soil moisture (m^3/m^3) measurements in two of the ten rain garden containers, with measurements taken at 5-minute intervals. No rainfall was recorded from 25th to 28th of April this year. In the following days, a gradual decrease in soil moisture was observed in the containers.

2.5. Demonstrating water consumption via smart metering and developing a supportive mobile application in Split, Croatia

The pilot demonstrates real-time water consumption at three different locations in a public building (University of Split) using wireless technology and the development of a mobile application to monitor and analyse water consumption, in order to achieve a higher water efficiency in the building and raise awareness towards sustainable water use. The data is publicly displayed on an LCD monitor at the entrance of the building as well on mobile applications. Faculty students and employees are able to download the data and analyse it. LoRaWAN offered the most reliable coverage among the 3 tested IoT radio technologies.

Outputs:

- Three smart water meters based on LoRaWAN radio technology
- LCD screen at the entrance of the public building showing water consumption and other data
- Mobile application to measure water consumption data and other parameters for staff and students

Challenges:

- Continuous updates of the *IoT Wallet* services were required

Impacts:

- Increase public awareness for rational water use and water conservation
- Potential water saving effects
- Promote smart water metering technologies and their benefits
- Educational effects shared by faculty students and staff through continuous monitoring and application updates

Monitoring results:

Water leaks have been detected during operation of the system using the three smart water metres.
Potential water savings made during the monitoring periods still need to extrapolated and evaluated.

Monitoring activities performed from 01.03.2021 are divided into several groups:

1. Technical maintenance of the system which involved:
   a) Major software updates of the IoT Wallet system
   b) Continuous monitoring of the system functions including hardware performances, which required replacements due to the bug in water-metres
2. Dissemination activities for the purpose of raising awareness:

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[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0741

a) Data was analysed by scientific personnel and contributions were peer-reviewed and accepted as a scientific paper in the 6th International Conference on Smart and Sustainable Technologies (SpliTech 2021), September 08-11, 2021. Preliminary analyses gave indications on peak hours of water consumption, as well as leaks in every building block. It was shown that building blocks B and C have smaller losses due to the newly installed pipes with a higher quality

b) During the spring semester at the Faculty of Civil engineering, Architecture and Geodesy, 20 graduate students enrolled at “Hydrotechnical Systems” course and took data for its analysis. Students enrolled at undergraduate study course “Water Supply and Sewerage Systems” will have the same opportunity.

3. Challenges

On the way to a sustainable water resources management, numerous challenges exist, not only in most CE countries, which need to be overcome in order to achieve the needed paradigm shift in the water sector towards a circular water economy. Too often, the water problems are still being denied or ignored and decision-makers sometimes wait too long before they earnestly act. „A smart person solves a problem. A wise person avoids it”[4].

These challenges include:

Institutional challenges: A knowledge gap and a lack of political will and dialogue uphold the status quo. There is a general lack of understanding regarding the concept of water reuse and resource recovery and how to implement it in practice. Wastewater is still considered a waste to be disposed of rather than a resource. This results in a lack of political will to develop policies and regulations that encourage circular water use.

Economic challenges: Water is generally undervalued, which usually leads to improper pricing of water resources and water services. For example, if water costs are very low, there is little incentive to exploit or use alternative water resources (e.g. rainwater, recycled greywater or wastewater). There is general emphasis on promoting and financing new infrastructure, instead of optimising the existing one or complementing it with sustainable and circular solutions. The damage caused by today's use of water is generally not included in the water costs.

Technological challenges: Although the technology for circular water use is available, it continues to develop with emphasis on the on an economic operation. The best technology is always dependent on the site and boundary conditions and the reuse options.

Regulatory challenges: Regulatory frameworks can be important drivers but also barriers in reducing, reusing and recycling water. In general, there is a lack of regulatory frameworks and guidelines for water reuse. Current regulatory standards are often too restrictive or inconsistent and they may act as a barrier to circular water use. Certain regulations need to change to enable a circular approach to water management. More flexible standards that can be introduced gradually will encourage new circular solutions

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[4] This quote is attributed to Albert Einstein, but probably this is not true. Nevertheless, I believe that it is still an interesting quote. It is about the three stages of learning, clueless, cleverness, and wisdom. The clueless people don’t see an obstacle until after they have bumped into it, they have no idea what to do and have to puzzle their way out. The clever people, as noted in the first part of the quote, while still don’t see the obstacle in advance, know what to do after bumping into it. The wise people, according to the quote, not only see the obstacle, but they also manage to avoid it. Getting to that point takes a bit of learning. First you are clueless, then you figure out how to get out of the situation. Finally, with some attention to a detail a person can begin to spot the situation before it gets there.

and create value from water reuse and resource recovery. The EU Regulation on minimum requirements for water reuse in agriculture is a first step in this direction.

Social challenges: There is still low social acceptance of recycled water and wastewater and negative perceptions of recycled water have not been adequately countered. Positive experience has been also rarely disseminated in the past. To overcome barriers of public acceptance, information is needed. Public awareness and education campaigns can change negative perceptions and show the benefits of water recycling and reuse. The new EU directive for water reuse in irrigation, once applied, is likely to help improve the image of wastewater recycling and reuse.

4. Lessons learned

Depending on the different basic conditions of a specific location, appropriate solutions for decentralised, sustainable and resilient circular water reuse systems (e.g. rainwater harvesting and greywater recycling) can differ significantly. Strategies and design concepts need to be developed that are adapted to the specific local basic conditions and which follow specific local needs.

Table 2 presents a summary of lessons learned by the pilot partners during the different phases of pilot implementation, using different measures in the background of different local conditions and requirements.

Table 2: Summary of lessons learned during the piloting process.

SUMMARY OF LESSONS LEARNED
➢ A good planning, preparation and project management are key factors to successful implementation. Changes (technical, organisational, etc.) should be possibly kept to a minimum
➢ Presence/lack of guidelines and technical standards on circular water use (CWU) can act as driver/barrier to implementation and dissemination of water reuse projects
➢ Public tenders and procurement procedures demand a long time, which need to be simplified and updated in accordance with EU law, as already requested by the European Commission within the framework of NextGenEU
➢ Policy makers should be involved at a very early planning stage of the project in order to avoid long decision-making process and delays in the implementation
➢ Good and transparent communication and information flow among all pilot participants are essential for a flawless, successful and timely implementation
➢ Shortage/lack of products on the local market for rainwater and greywater recycling systems is a barrier for a quick implementation, also connected with higher prices as a result of the COVID-19 pandemic
➢ Lack of companies with specific knowledge, experience and references on greywater reuse and rainwater harvesting and the availability of construction companies can be a limiting factor for implementation
➢ It is generally more difficult and costly to realise projects in existing buildings than in new ones. Therefore, it is imperative to implement circular water solutions in new building projects
➢ Site inventory, especially when dealing with underground infrastructure need to be conducted at an early planning stage to avoid problems and unpleasant surprises during construction
➢ With already existing buildings, the extent of the retrofit work cannot be estimated at an early project phase. Therefore, it is advisable to foresee a flexible budget (at least ± 20%) for future retrofit projects, which should better fit the site's upgrading needs
➢ The long-term, successful operation of the pilot beyond the lifetime of the project should be ensured at an early phase including capacity training measures for operation and maintenance
➢ The low prices for water and high infrastructure costs, or a combination of both, make it difficult to achieve a return on investment (ROI) in projects related to circular water management. Making prices transparent and understanding the true costs of water in business processes is fundamental to successfully reduce water consumption and promote water recycling and reuse
➢ Lack of awareness can be a barrier and can lead to missed opportunities. There is a need to raise awareness amongst engineers, urban planners, designers and decision makers, but also among the general public about the potentials and benefits of CWU
➢ The interdependency of one project's activities on another project's progress should be well coordinated at an early stage to avoid delays in implementation
➢ NBS are easy to implement and their positive impacts can be directly mediated to the public and other stakeholders

5. General evaluation of the CWC pilot actions

Water-relevant planning must take place at the very beginning concurrently with the development of the site, which usually extends over a longer time period. None of the 5 pilot projects were implemented at a new construction site, but each time the existing building was used, which posed further challenges.

Different CWU measures were adopted with in the different FUAs and under different boundary conditions. The smart metering system implemented and tested in Split can be transferred to all other FUAs and applied in different sectors and at different levels (municipality, waterworks, household level, industry, etc.) in order to improve water efficiency and increase awareness on the conscientious use of the water resources.

The rain gardens in Bydgoszcz and Zugló are found in a location open to the large public. The location and good design should promote imitation and implementation of similar and other measures and increase awareness to NBS. More greenery in the city, especially near to the ground, creates a favourable urban microclimate and should therefore be increasingly implemented. De-sealing of surfaces will increase the infiltration potential, reduce floods and counter impacts of heavy rains on infrastructure and environment.

A step further was taken in Turin, where the extensive green roof and terrace design offer an additional amenity benefit for a broad public. Rainwater is fully utilised on site by the implemented measures, such that no rainwater enters the rainwater sewer. Moreover, rainwater is also used for urban farming at a small scale to show the benefits of reusing rainwater in different settings.

Water recycling using rainwater and treated wastewater in the building construction sector was implemented in Maribor with demonstrably positive results. This can play a role model to other industries and sectors and encourage water recycling and reuse, where drinking water quality is not mandatory for the production process.

Altogether, we are at the very beginning of a positive development to understand how to deal with rainwater and wastewater as a resource for new water, nutrients and energy and recognise the broad application potential. All implemented CWC pilots act as demonstration sites to show the wide potential and many benefits of rainwater harvesting and water recycling.

5.1. Proposals for adjustments and improvements

Proposals for adjustment and improvements in the demonstrated pilots, which have been largely undertaken by the partners, have been made during the mentoring process (reports) and are presented here in brief.

5.1.1. Zugló pilot

- It was proposed to install the drinking water backup system in such a way, that no backflow from the sewer can take place at any time
- To protect the pumps from running dry it is advisable to install filling level sensors to detect the water level in the cisterns at all times
- Labelling of all pipes and use taps is essential to distinguish between potable and non-potable water networks and avoid misuse.

5.1.2. Turin pilot

- Proper maintenance is indispensable for a long-term and successful operation of all implemented measures. For this purpose, qualified personnel should be trained for operation and maintenance and Turin Municipality will be responsible for this service
- Proper designation and labelling of all pipes, tapping points and plant components is necessary to differentiate between potable and non-potable water networks
- Backup water supply (drinking water) should be designed according to technical standards to ensure that there is no cross-connection between the drinking water and the non-potable water networks at any time.

5.1.3. Maribor pilot

- It was proposed to harvest rainwater from the paved traffic surfaces, in addition to the roof runoff, in order to augment the amount of rainwater made available for the production process. In this case, the installation of a filter/sieve or a pre-sedimentation stage for the reduction of particulate matter in rainwater is necessary. This has been already executed at a later stage of the pilot implementation
- Overflow from the underground reservoirs is discharged into an infiltration trench built on site. In this case, it should be ensured the onsite infiltration of treated wastewater is in accordance with the local environmental regulations.
- Once the utility building is completed, project partners plan to use rainwater to flush the toilets. In this case, a standard drinking water backup system will be required in order to ensure a continuous water supply for toilet flushing, especially when the water reservoirs are empty
- It is advisable to take water samples for quality measurements at the point of use, i.e. from the underground cisterns. This reflects best the real quality of the stored water used in the production process
- The considerably high turbidity of the treated wastewater should be possibly less than 2 NTU, when recycled water is used for toilet flushing. Values exceeding 2 NTU can lead to deposits on water fixtures and/or odour nuisances. However, the high turbidity measured as suspended solids should have no negative impact on the production process itself. Nevertheless, it would be important to monitor the rainwater and treated wastewater quality in the cisterns over a longer time period.

5.1.4. Bydgoszcz pilot

- Rain gardens are flexible NBS measures for rainwater retention and treatment, if enough space is available. Therefore, urban planners and designers have broad design options which can be exploited in future projects
- Since a rainwater fee is levied by the Municipality of Bydgoszcz for the amount of rainwater entering the rainwater sewer, studies should be conducted in the future on the impact of the implemented rainwater measures on reducing the rainwater fees for the Waterworks Museum location. Calculations have not been made yet to determine the level of fee reduction. Therefore, it is recommended to follow up on this topic, since the financial benefits of these measures, besides the social and environmental ones, can also be of significance
- An important factor for a successful and long-term operation of rain gardens is a regular maintenance to detect any blockages and remove litter and excess soil. Clearing of inlets, outlets and overflows,

cutting back and trimming are also required. Rain garden plantings require care and watering until they are established, generally the first 1-2 years after construction.

5.1.5. VILK-Split pilot

- The implemented smart metering system can be developed further and extended to other sectors, such as the water utility sector, where employees, for example, no longer need to enter the property or a building to read the water metres and invoice the tenants' water consumption. Further information can be also provided, for example, on water consumption peaks or water leaks and ton optimising the water supply network. The application field offered by this system is broad and can increase the water efficiency and use
- Other applications are also conceivable, for example, if the individual water consumption data under a different setting (e.g. apartments in a multi-storey building or hotel rooms) were to be recorded with the aim of monitoring the water consumption to induce a change in user behaviour and raise awareness towards water saving
- A longer monitoring period is also required to evaluate more water consumption data which can provide information on any change in the consumption behaviour and awareness towards water use and water saving at the Faculty.

5.2. Monitoring results

Monitoring activities over a period of at least one year are necessary in order to reach an comprehensive assessment of the pilot and be able to measure some impacts. For a variety of reasons such as the Covid-19 pandemic, short project duration (3 years), administrative restrictions and delays, lack of rain, this could not be achieved during the project lifetime.

Not all monitoring activities have been conducted yet and thus a final and conclusive evaluation will not be possible. Although the pilot plant in Turin was completed some time ago, no monitoring was yet possible due to the simple reason that it did not rain for several months in Turin. The scarce rainfall in Bydgoszcz and Zugló in the months following pilot implementation has also been a challenge and caused delays in the planned monitoring activities.

In order to determine the quantitative impact on relieving the load on the sewage system and the reduction in the drinking water consumption, a monitoring plan over several years will be necessary and which will also allow for some technical optimisation. For such activities, public financial reserves should be made available beyond the project's lifetime.

As far as the quality regulations for non-potable water are concerned, some uncertainties arose during the pilots' implementation. Drinking water quality is not required for every application. Water quality requirements for water reuse should be based on the type of application to ensure that there is no hygienic risk (and no loss of comfort) for the users. For many applications, the quality requirements of the EU Directive for Bathing Water have proved to be adequate for uses, which do not require a drinking water quality. These guidelines are followed in Germany since 1995 with a very good experience and results which also guarantee a high and safe service water quality for reuse.

Based on the monitoring results available so far, there is no evidence that a hygienic risk for users is to be expected. This assumes that the pilots will continue to be professionally monitored and maintained in the future.

6. Cross-adaptation plan

The targets of the implemented pilots are in line with the EU Circular Economy Action Plan[5] which promotes circular approaches in water reuse and efficiency and material recovery, including the industrial sector. The pilots thus act as role models for future urban circular water projects.

All applied measures in the 5 CWC pilots can be implemented and adapted in the other FUA's, as has also been communicated and concluded from the peer-review visits with more or less restrictions and obstacles as pertaining to the specific local conditions and to policy framework and requirements.

A brief summary of the situation in the 5 FUAs regarding the dissemination of NBS and water reuse technologies:

In **Maribor**, some NBS measures have been implemented at different levels mainly by private investors. Rainwater harvesting measures are being also implemented in single-family houses but are missing at a larger scale such as in housing estates and multi-storey buildings. Rainwater fees, as one mechanism to promote rainwater retention measures and increase water efficiency and reuse is in discussion since several years with no adoption yet by law.

In **Hungary**, there is a lack of rainwater retention measures in Zugló and the 18th District in public institutions and public spaces, but green roofs are evolving. In Budapest, rain gardens are part of the actions planned under the climate and green space management strategies (Radó Dezso Plan). Local regulations and guidelines for the establishment of green roofs for non-municipal buildings are also being developed. Several municipalities provide free rainwater barrels for citizens to harvest rainwater. The 12th district of Budapest is the first municipality which announced green roofs as being mandatory for all new and renovated flat roofs. Cities in Hungary are planning further water and rainwater management schemes as climate change adaptation activities.

Croatia has three climatic zones with variable water resources availability, thus requiring a feasibility study for each zone when considering water reuse schemes, making the transferability of such measures more complex. Particularly in the coastal region of Croatia there is a period of five dry months which generates a problem for the water supply for irrigation and competing with the water resources during the high water demand the tourism season.

In **Poland** the government finances rainwater harvesting and green roofs for the private sector. However, there is generally low awareness and interest for water efficiency and water saving on the part of the residents and public investors and a lack of knowledge and understanding for new solutions.

The pilot in **Turin** will help the Municipality of Turin and other public authorities to define innovative green and blue infrastructure strategies" to feed the future "Local Environmental Adaptation Plan". In addition, an R&D project (proGIreg: Productive Green Infrastructure for post-industrial urban regeneration) has been already cross-fertilised the with the CWC concepts.

A summary of joint conclusions made by the planning and visiting partners and based on the peer-review visits regarding the transferability of tested measures to the other FUA's are listed in Table 3.

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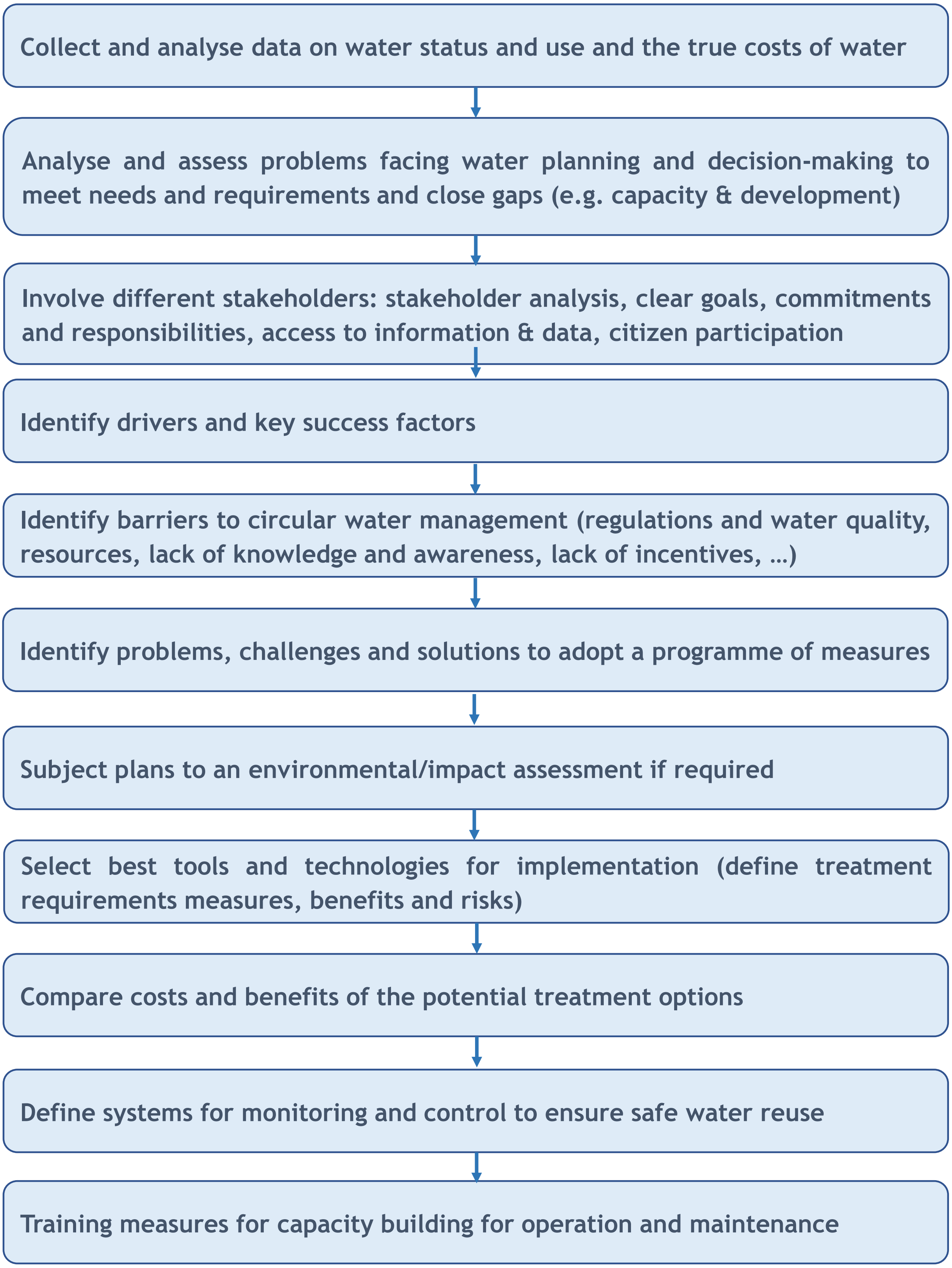
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

Table 3: Summary of joint conclusions by partners on pilots resulting from the peer-review visits.

SUMMARY OF JOINT CONCLUSIONS ON PEER-REVIEW VISITS
➢ Partners recognise a great potential for the implementation of similar solutions in their countries in public institutions such as government buildings, Kindergarten, schools, sports facilities, state-owned enterprises and public urban spaces, but also at the household level. This will raise awareness towards water recycling and reuse and increase public acceptance
➢ Lack of strategies and policy instruments (regulations and standards) for rainwater management and water reuse is a barrier towards implementation
➢ Funding and political will are prerequisites for implementation of CWU projects
➢ It is important to show successful case studies to convince and engage stakeholders, especially authorities and policy makers
➢ Innovative solutions and successful projects also need to be presented and made known to the private building investment sector and the wide public to promote CWU
➢ There is a need to promote national and local incentives and programmes (subsidies, rainwater fees) for onsite rainwater management and water reuse, especially for private households and home owners
➢ Generally, there is low awareness, knowledge and interest for water saving and efficiency by residents and public investors and lack of understanding for new solutions. A lack of data showing the need and opportunities to reduce, reuse and recycle water often makes this barrier more difficult to overcome
➢ Consideration of rainwater retention solutions by designers is still low and inadequately understood
➢ There is a need to raise awareness amongst engineers, urban planners, designers and decision makers about the potentials and benefits of circular water use to be integrated in the spatial planning and urban and landscape design of climate resilient cities
➢ Implementation of these measures in new buildings is easier than in already existing buildings (dual-pipe network needed for water reuse)
➢ The rising energy and water prices and future water scarcity scenarios highlight the importance of CWU and increase the trend towards water reuse
➢ Stakeholder engagement is an important factor in bringing about knowledge and in developing local visions and strategies to foster urban circular water use
➢ The trends in prices and legal requirements are similar in the CE region

Figure 1 is a proposal for the cross-adaptation of circular water use in the other FUAs.

Figure 1: Steps for cross-adaptation of circular water use in the FUAs.



Collect and analyse data on water status and use and the true costs of water

Analyse and assess problems facing water planning and decision-making to meet needs and requirements and close gaps (e.g. capacity & development)

Involve different stakeholders: stakeholder analysis, clear goals, commitments and responsibilities, access to information & data, citizen participation

Identify drivers and key success factors

Identify barriers to circular water management (regulations and water quality, resources, lack of knowledge and awareness, lack of incentives, …)

Identify problems, challenges and solutions to adopt a programme of measures

Subject plans to an environmental/impact assessment if required

Select best tools and technologies for implementation (define treatment requirements measures, benefits and risks)

Compare costs and benefits of the potential treatment options

Define systems for monitoring and control to ensure safe water reuse

Training measures for capacity building for operation and maintenance

7. Future outlook

Cities are challenged today to supply their residents with clean and safe drinking water while being constantly faced with aging, costly infrastructure, a price of water that is not reflective of its true value and the need for the infrastructure to remain resilient in times of increasing periods of drought and floods. Thus, the linear approach of water management remains short-sighted and unsustainable in view of the impacts of climate change and other challenges.

Decentralised water systems are often regarded as more sustainable than centralised systems because they increase the potential for water conservation and reuse, increase the resiliency of the water infrastructure and reduce the costs for infrastructure rehabilitation and maintenance. Decentralised solutions, as a complementary alternative to the current centralised infrastructure, should be promoted to solve problems associated with unsustainable rainwater management and water shortages in urban areas. It is important to emphasise that there is no “only one” solution. Water reuse is one of the measures which can be used following a thorough assessment in the context of the EU Water Framework Directive (WFD).

The new Regulation on minimum requirements for water reuse for irrigation, which will apply in all EU member states from 26 June 2023 onwards is the first step in the right direction. This will encourage water reuse and promote local, decentralised solutions that can be realised with more legal certainty. The next step would be to adopt similar requirements for the use of non-potable water in buildings. In Germany, quality guidelines for indoor water use of rainwater and treated greywater had been already defined in 1995 and are being applied today for these systems. Professional associations also developed technical rules and standards for water harvesting and water recycling and reuse which encourage their implementation at different levels.

A legal and regulatory framework is needed to foster water reuse and bring about the paradigm shift towards circular water economy in the CE countries. More transparency in the water sector and costs allocation according to the polluter-pays principle, especially for industries, are also required to encourage users to adopt circular water measures and shift to using rainwater or treated wastewater instead. Economic instruments, such as rainwater fees, can positively contribute to the implementation of onsite rainwater retention measures and reduce the burden on the wastewater treatment plants, save water, protect the environment, in addition to reducing the fees.

In the examined FUAs, priorities regarding sustainable water management need to be identified and met:

- Drinking water should have the highest quality. For all non-potable uses, for which drinking water is not mandatory, rainwater harvesting and water recycling and reuse should be applied
- Set priorities for rainwater management in cities and identify the use potential such as in buildings for a year-round use of rainwater
- Desealing of surfaces to retain rainwater on site and/or reuse should become one of the first steps in a rainwater management plan
- Water saving measures should be exploited to a large extent and wastewater generation reduced or avoided as much as possible to increase water efficiency
- Application of smart water metering can act as a building block for monitoring and evaluation of the water reduction and saving potentials
- The construction of a dual-pipe network in all new constructions for the integration of water recycling in buildings should become mandatory
- Financial incentives should be offered to encourage onsite water reuse and rainwater retention such as rainwater fees, which should be levied according to the polluter-pays principle and programmes and subsidies for the widespread installation of rainwater harvesting and greywater reuse systems.