Project no. 4CE439P3

URBAN_WFTP

Introduction of Water Footprint (WFTP) Approach in Urban Area to Monitor, Evaluate and Improve the Water Use

WP 5.5.4 Joint Report

on water footprint improvements

Start date of project: 1 November 2012 **Duration: 25 months**

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1 Introduction

After having developed the urban water footprint models for three labs in three project countries, and having explored the structure and level of the footprints in these locations, WP5 set out to use these tools in order to improve water management in the three urban areas through lowering the water footprints and testing the previously developed concept in practice.

In this report first the best practices for water footprint improvement are briefly reviewed, then for each of the labs the experience under WP 5 is summarised. Lastly, the results of the water use and management data gathering survey are described, with relevance to the future application of the methodology developed within the project.

It should be acknowledged that this report is based on the contribution of all partner organisations, especially the partners responsible for the operation of the water footprint labs in the three countries.

2 Recap of best practices

Under WP 5.1 best practices for the reduction of water footprints have been identified and reviewed by the project partners, following the listed steps:

- A survey instrument was developed in order to collect information from the three case study municipalities on their local water management problems and measures that can be deployed to address these problems.
- The survey instrument was distributed among project participants and clarifications on the data to be collected were made.
- The Water footprint labs, in cooperation with their local partners, filled in the survey and submitted it for review.
- A review took place, followed by communication to clarify any data or measure related uncertainties and questions.
- A best practice report was developed based on the three surveys and a review of local water management literature.
- Finally, the project partners reviewed the draft document and corrections were made to complete it.

The identified best practices, together with the local water management goals that they can be utilised for, are listed in the table below.

Table 1 Local water management goals and potential tools and measures to attain them

Goal	Tool/Measure
Saving drinking water	Setting water and wastewater tariffs at cost recovering levels Metering of consumption Supporting the penetration of water saving technologies Education of citizens, students Reducing leakage Rainwater harvesting Changes to the building code
Improved storm water management	Less soil sealing Green roofs Rainwater harvesting Separation of storm water collection and the sewer Rehabilitation of the existing sewer Changing the building code and other technical guidelines
Mitigation of climate change related heat waves	Green roofs Reducing soil sealing
Lower effluent discharge	Extended collection of wastewater Separation of storm water collection and the sewer

	Improved wastewater management Constructed wetlands
Lower risk of ground water pollution	Extension of the sewer Rehabilitation of the existing sewer
Reducing the virtual water footprint	Education of citizens, students
Improved retention of precipitation	Reduced soil sealing Green roofs Rainwater harvesting Changing the building code

Within the report all best practices were supported by detailed information from the three urban water footprint labs, supplemented by a number of additional examples from other cities within the project partner countries.

One of the conclusions of the report was that most urban water management goals can be achieved through a number of different measures, and vice versa, most measures contribute to more than just one goal. Therefore when devising improvement plans for the UWFLs there is indeed a choice. Moreover, many of the measures deliver benefits outside the narrower realm of water management, improving the micro-climate, enhancing local ecology, creating recreational areas etc. The measures have different implications in terms of costs, feasibility and ease of implementation as well. In short, a careful assessment of the measures is needed before the most optimal ones can be selected for the improvement plans.

Furthermore, some of the best practices are universally applicable, while others are site specific. Green roofs, for instance, under the Central European climate always contribute to storm water management, while the feasibility of constructed wetlands for the purpose of cleaning wastewater streams is rather site specific, depending e.g. on the available space as well as the pollution content of the water.

Yet another lesson is that aiming merely for a reduction of the water footprint is not always sensible. For example, if there is no water stress then saving water does not have to be a priority. As another example, reducing wastewater flows might be contra productive, i.e. the sewage network (pipes, etc.) are designed for a certain amount of flow and getting below this flow might have negative consequences of network operation. Calculating the water footprint for water management measures, however, is a useful exercise as it generates an important factor for the evaluation of the measure.

Another lesson for the future is the time scale of the best practice measures. Most of the measures require a long time horizon of years and even decades. This on the one hand fits well with the timeframe of urban planning, and on the other hand the impact of some of the external factors (e.g. climate change) will also be apparent.

Within the report distinction was made between easy to develop, low cost measures and expensive investments requiring careful design. An example for the former is soil sealing, turning formerly sealed unused asphalt areas into green areas is not very costly and brings almost instant benefits. An example for expensive investments was taken from Wroclaw, where the upgrade of the wastewater treatment plant took years of preparation and construction and required both external funding and the raise of service charges. The same applies to the extension of the sewer, constructed wetlands, or reduction of water losses from the drinking water network.

One other lesson is the need for cooperation among local stakeholders. Even though the task of water management related urban planning mainly lays with the municipality and the water utility, a lot of the best practices require a strong collaboration with other entities. For instance, building green roofs depends on the owner/developer of the building, and they may not fully understand the implications, and they may not consider themselves as beneficiaries of such a project. Thus, education is important not only with respect to students and citizens, but also for other stakeholders in key roles for the best practice measure discussed.

At the end of the project respondents to the water use and management data gathering survey were asked to evaluate the best practices of water footprint reduction as well as the public support for each of the measures. The results are presented in Chapter 6.

3 Water footprint improvement in Vicenza

In this summary we cover the targeted improvements, the results and the lessons of the water footprint improvement exercise. There are a large number of supporting documents with details on the actions which can be found under WP 5 of the project website.

3.1 The targeted improvement

In Vicenza, after having assessed the water footprint and reviewed the local water management situation and options, the following two areas have been singled out for improvement:

- On the one hand, the improvement plan aims to achieve an improvement of stormwater management to prevent the depletion of the aquifer and the release of rainwater into the drainage system. A point of consideration concerns the sealing of urbanized areas with particular reference to the fact that rainfall has a negative effect on the treatment of municipal wastewater, especially during heavy storms, and re-entry into the subsoil of precipitation can be advantageous for the environment. The objective is to improve the management of urban rainwater at both private and public buildings. Separation of sewerage and rainwater is a priority. Interventions that induce water savings in private wells are also targeted.
- The other goal is to improve people's knowledge of the water cycle and water conservation. There are evident knowledge gaps especially in relation to the processes of wastewater collection and treatment. The enhancement of awareness on water use in order to reduce wastewater generation, and to facilitate the return of water that is not affected by our use to the environment is the first objective of the workshop. This will be verified by a specific "Monitoring Plan". In sum, the objective is to enhance the knowledge of the water users in order to reduce the quantity of wastewater and improve the quality of water returned to the environment.

3.2 The measures

The following measures have been planned for the two objectives.

With respect to storm water management and increased infiltration:

1. Meeting with the technicians of private housing and city planning in order to disseminate monitoring results and improvement objectives.

2. Preparing a document that contains the proposed adjustment to the planning and building regulations, aimed at encouraging a reduction of water consumption and reuse of rainwater where possible, for both private and public buildings. For work carried out by private actors "public support" may be desirable..
3. Proposal to the political institutions of the City of approving the draft document.
4. Controls and persuasion actions aiming at owners of private wells to stop the habit of continuous water extraction. Verifying the installation of closures of the spouts of private wells.
5. UWFP method dissemination to highlight the necessary indicators for monitoring.

Concerning the education of water users the planned steps were the following:

1. Presentation of Model C results and SWOT analysis and improvement targets during a public event (Festambiente).
2. Collection during the event, of names and e-mail contacts of people who intend to adhere to the "Monitoring Plan".
3. Redaction of a summary document to be sent to users who have collaborated in the data collection that contains both results and indications of good practices to be implemented in order to reduce water consumption and improve the quality of the water returned to the environement, containing also the consent to subsequent requests for data collection
4. Redaction of a dedicated page on the website of Acquevicentine and the City of Vicenza containing the results, good practices and a specific section on the treatment that came up from the analyzed data, showing the weak point of knowledge of the user.
5. Preparing a model for data collection that allows the users to monitor their water consumption.
6. Preparing a document containing general information about the project, its objectives, monitoring results, best practices and the invitation to participate in the improvement program, disseminated to colleagues of the companies involved in the project (City of Vicenza, Acquevicentine, Centro Idrico di Novoledo, CPV, University of Padova).
7. Sending invitation to users who have given their consent to participation in the improvement program (Festambiente - previous questionnaires).
8. Coinciding with the lessons provided in the training program for students, an invitation to participate in the improvement plan.

9. Processing of the collected data.
10. Analysis of the processed data with verification of the expected improvement.

3.3 Assessment of the results

The measures indicated above have all been implemented by the Vicenza Lab, although in some cases the deadline was postponed or minor adjustments were carried out. The quality of the implemented measures is considered satisfactory.

The major difficulty in the prosecution of the measures was the lack of time available.

Even for those actions started immediately after the opening of the Lab, as the administration-processing of the questionnaires, suffered from the lack of time available that did not allow in-depth reflections on the results, but only a rough guide on any bad habits on which to act and there were shortcomings of information provided to the public on issues related to water. Moreover, the measurements of the results of the measures were carried out almost exclusively in a holiday period that is usually not characterized by a consumption similar to the other months of the year. Additionally, this year consumption has also been impacted by an abnormal summer, characterized by continuous and heavy rains that may have offset the normal city summer consumption.

Furthermore, being able to process the data to be used for the purposes of the project and to make known the same people participating in the survey and the entire city through publications on the website of the City of Vicenza Vicenza and water, has led to the deployment of considerable energy and economic work.

From the organizational point of view it was very difficult to be able to establish contacts with schools and be welcome to present the project and for training. Accomplice first of all the incoming summertime, but also the programming contained in POF (Educational Offer Plan) that had already defined the activities of the just started school year.

With respect to artesian wells, the rules and penalties related to water saving was disseminated among households. It was proposed in the final document presented to the Town Council, to launch a serious campaign of controls on private wells to verify the attachment of sealing and the installation of flow meters. This action is expected to generate a significant reduction in waste water.

Another action from which a major achievement is expectedare the positive consequences that would result from the adoption of the Technical Standards proposed by the Vicenza U_WFTP Lab and submitted to the City Council for the inclusion of statutory provisions on "water-saving" in the Building Regulations and the Intervention Plan.

3.4 Corrective actions

As for any corrective actions that relate specifically the Improvement Plan elaborated by Vicenza U_WFTP Lab, and experience gained from the analysis, there were only a few aspects that the Laboratory would like to improve. These adjustments relate to the methods of self-monitoring proposed to citizens, municipal employees, public administrators and schools, through various channels.

Vicenza U_WFTP Lab has widespreadly disseminate flyers on "Good Practices on water use" proposing also to build an appropriate model for the reporting of weekly household consumption of water of each family. The models have been disclosed as follows: e-mailed to the sample of 800 citizens who were already participating in the survey suggested by the U_WFTP Lab (composed of the 2 questionnaires sent in February and April and monitored by the Lab till 2016) published on the websites of the City of Vicenza and Acque Vicentine, sent to all the e-mailing list of Vicenza Municipality directors and employees, sent to all employees of Acque Vicentine and finally offered during "face to face" meeting during various public events sponsored by the Lab (workshops, local meetings, open days, school visits, training). Obviously, the aim of this work was to verify the possibility of autonomously reducing consumption associated with the application of the measures and suggestions.

Vicenza U_WFTP Lab, critically reviewing, in retrospect, the actions taken, found that the proposed model of self-monitoring has a limit, that is the fact that the request for the weekly household consumption requires the value expressed in cubic meters, as such data is easy to read from the meter. We believe, however, that this does not allow those who apply the "Good Practices" to verify the significant improvements in fuel economy. These are in fact more perceptible when taken as units per litre. Unfortunately, the counters applied to the water network of the city make the data immediately visible in mc, and to understand the value in litres required to read a special small ring present in the quadrant within others.

A weakness of the action taken is therefore not having the value of consumption in litres and, consequently, not giving specific information to users on how and where to find that measure in the counter.

This intervention would probably favoured the possibility of self-monitoring especially for those families with few components and for which the value expressed in mc has not given any reason for efforts made and the small measures adopted to save water. This fact could lead to discouragement and the decision not to pursue measures to reduce consumption.

The corrective action that is deemed useful, therefore, is to express the consumption of water weekly report in patterns of self-monitoring proposed by the U_WFTP Lab, in litres instead of cubic meters, mainly to give the right consumption measurement and to show the results of greater efforts to reduce it.

This small adjustment could ensure the most successful action of "spontaneous" self-monitoring, which has proved rather weak.

As regards the monitoring programmed until 2016 on the sample of users of which is stated above, and that will be made by the company of the management of the water cycle, Acque Vicentine, this will be carried out through the control system centralised inside the Company and through periodic measurements related to billing.

4 Water footprint improvement in Innsbruck

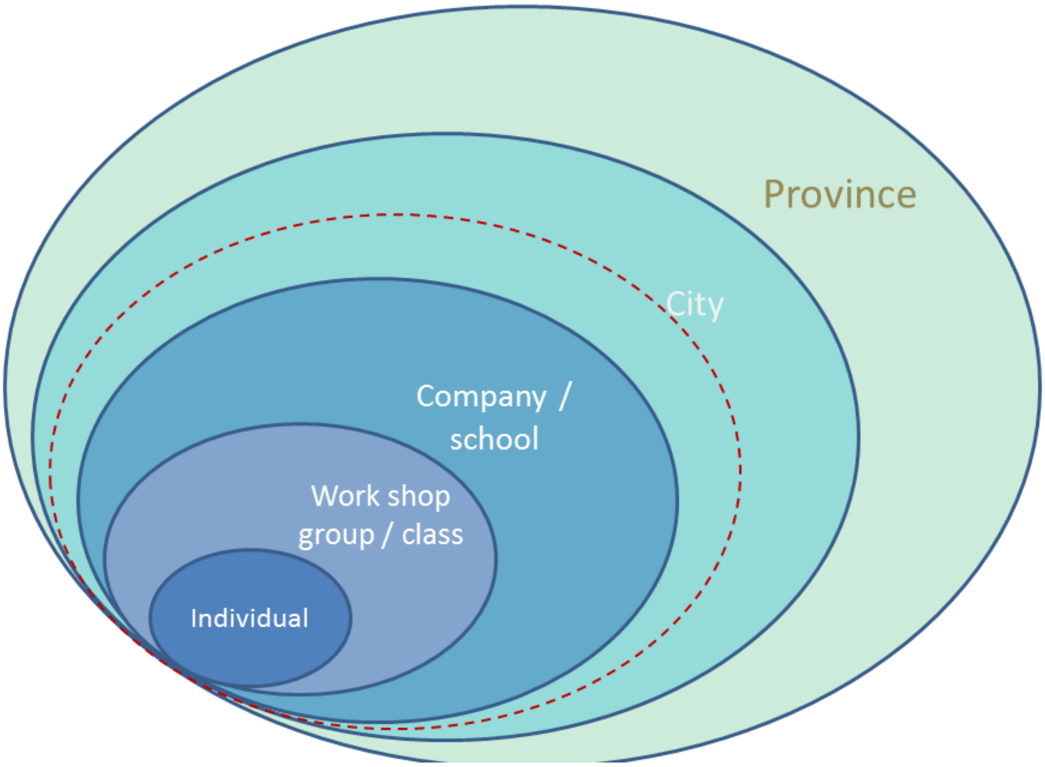
4.1 The targeted improvement

Based on the best practice "awareness building regarding direct and indirect water consumption" (Deliverable 5.1.2), the UWF Lab Innsbruck could identify the improvement objective "extending the awareness building programme" in order to reduce the water footprint.

During Work Package 4 the UWF Lab Innsbruck developed an "awareness building tool", consisting of 4 workshops, and was tested and implemented in cooperation with a school (Reithmann Gymnasium) in Innsbruck. Two classes of this school participated this workshop cycle. In an urban area such as Innsbruck two classes, with over 40 students, might not leave a measurable impact on the overall water consumption of the city. Therefore it was decided to extend the awareness building programme.

For this a step-wise approach was chosen (see Figure 1). Each step uses different kinds of methods and media. Within this project the declared objective of the UWF Lab Innsbruck is to extend the programme at least to the red line.

Figure 1 Step-wise extension of target groups within the awareness building programme. The red line indicates the declared object within the project duration.



Lastly, the two aims of the awareness building programme need to be distinguished:

1) Quantitative: This pursues to increase the amount of people who have been informed and/or taught about the topic of water footprint. This includes: i) What is the water footprint, ii) How can the water footprint be measured, iii) What is virtual water, iv) How can the water footprint (including virtual and direct water) be reduced?

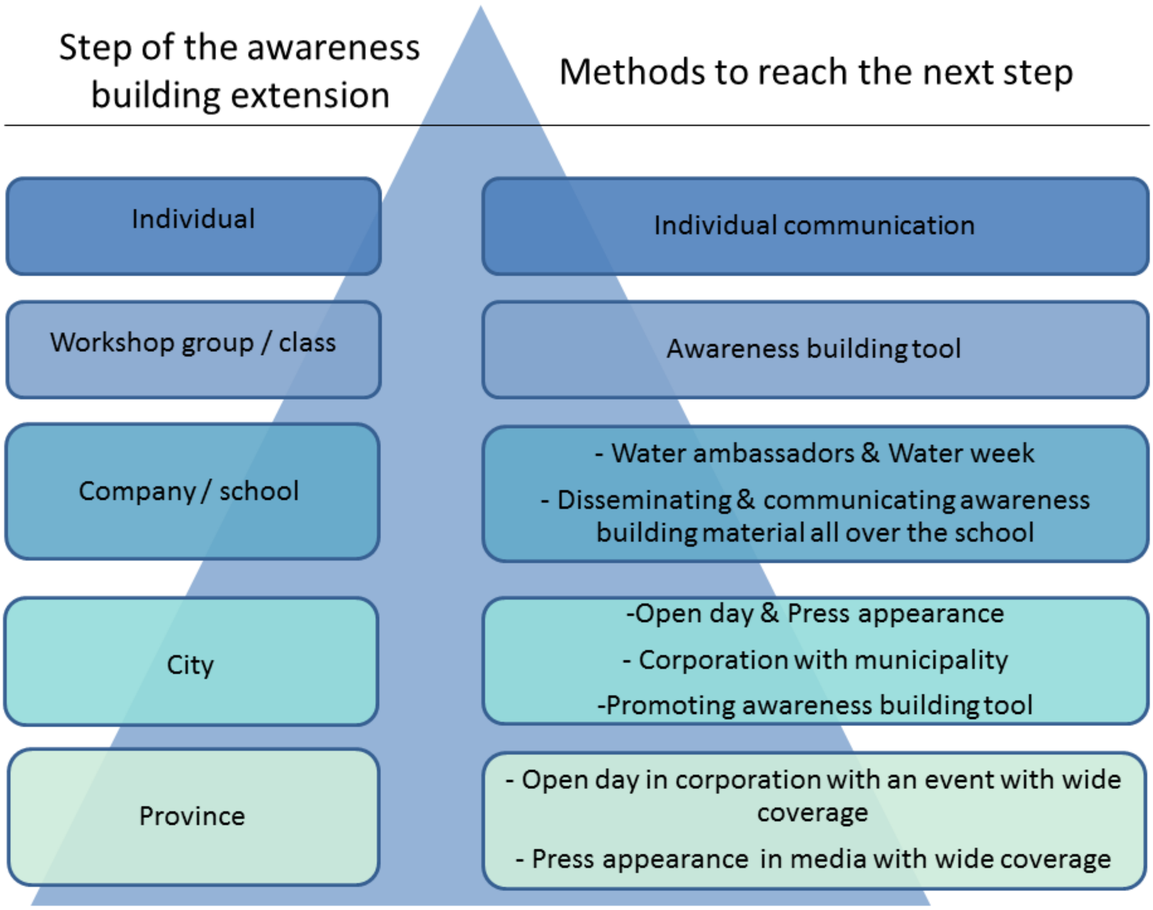
2) Qualitative: This aim pursues to increase the sample size of water footprint consumption of individuals and to quantify the amount WFTP reduction. For this the UWF Lab will compare WFTP consumption before and after the awareness building programme.

4.2 The measures

Multiple methods and approaches need to be used in order to reach the declared objective.

To reach the "workshop group/class" level the UWF Lab Innsbruck developed an awareness building tool. This tool was tested and applied successfully. Based on this, the newly educated students become "water ambassadors" within their school and organise a "water week". Here a moderate-constructivistic learning approach was applied. Within this water week all the awareness building material has been disseminated.

Figure 2 The variety of methods applied to reach each of the target groups



In order to reach the next target group "all citizens" an Open day has been organised, which was accompanied by some press appearances. Also, in cooperation with the municipality the awareness building tool has been promoted and "sold" to other schools and education organisations. To get beyond the city boundaries basically the same methods as before could be applied, but with a wider coverage.

4.3 Assessment of the results

Two different improvement aims were set.

Aim 1 was the quantitative extension of the awareness building programme. Here it was planned to extend the awareness building tool (developed in WP4) from the original 45 school kids and 2 teachers to ca. 1000 school kids and ca. 100 teachers.

To achieve this ambitious aim it was not possible to apply the entire awareness building tool. Instead it was decided to spotlight the issues of water resources and water footprint during a so called *water week*. During this *water week* some of the original 45 school kids informed their school mates on these issues. Ca. 700-800 school kids were informed during this *water week.*

Additionally, the teachers were in focus. As part of the training session (WP 6.2.5) the teachers were trained in the method how to monitor and calculate the water footprint. Originally this was planned to be done with all the teaching staff (ca.100 teachers) at the partner school. However, due to administrational and organisational reasons, instead all class teachers (35 teachers) were involved. 17of those teachers monitored with their classes their water footprint for 1 week. Thereby it was possible to increase the sample size from 45 to 224 participants.

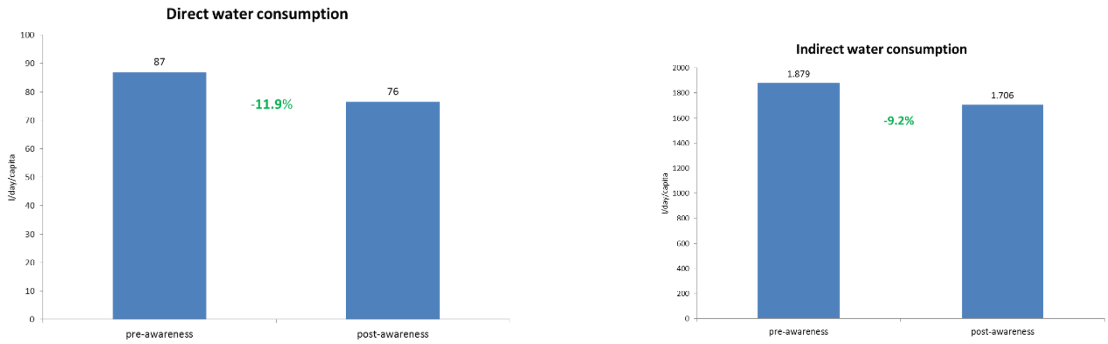
<u>Aim 2</u> focused on the qualitative extension of the awareness building programme and potential WFTP reduction. Here it was planned to analyse whether the awareness building programme had any effect on the water footprint. This analysis is based on the sample size of the original 45 school kids, by comparing their water footprint before the awareness building (10.2013) and after (09.2014). The potential reduction was calculated as approx. 21% virtual water consumption. This in turn would reduce the overall water footprint consumption by 11%.

It was not possible to achieve this very ambitious aim. Instead virtual water could be reduced by 9.2%. However, in addition to virtual water, also the direct water could be reduced. Both direct and virtual water together add up to a reduction of 9.3% of the total water footprint (see Table 2).

Table 2 Comparison of targeted and achieved results.

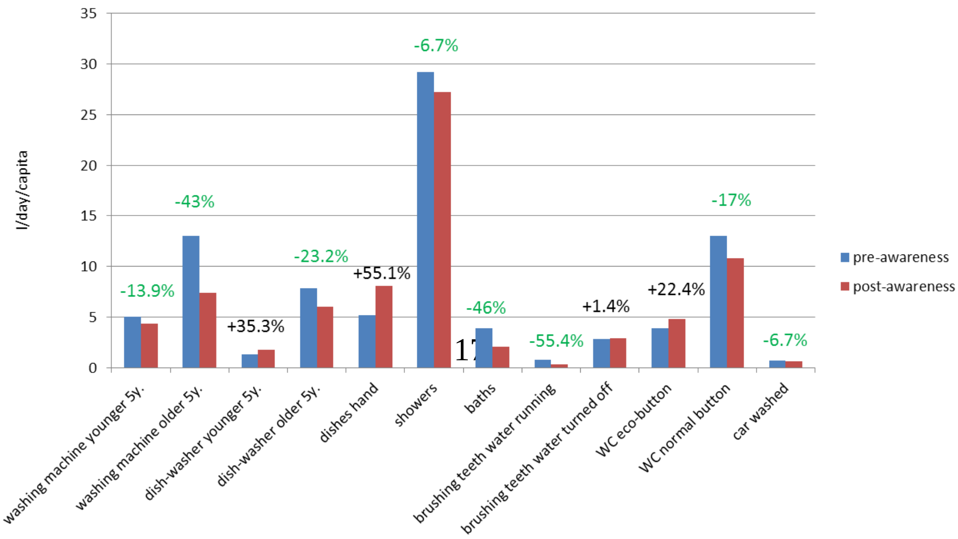
	Targeted results	**Achieved results**
Virtual water reduction	21%	9.2%
Direct water reduction	--	11.9%
Total water footprint reduction	11%	9.3%

Figure 3 Reduction of direct and indirect water consumption. Shown are the water consumption in litre before the awareness building campaign and after.



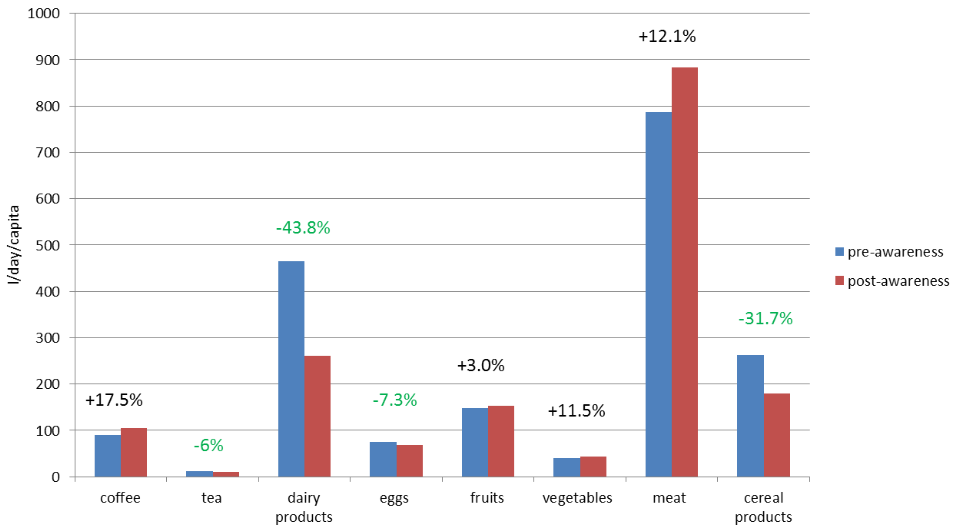
Direct water consumption was reduced by 21 litre/day/capita (l/d/c). This change was mainly caused by a reduced use of washing machines. Furthermore, some households had bought new washing machines during the monitoring period and thus reduced their water consumption. With both of these changes together on average ca. 6 l/day/capita could be saved alone. In addition to this, the school kids were able to reduce their water consumption which accrues from having showers and using a normal toilette buttons. Both behavioral changes together accounted for ca. 2 l/day/capita to the direct water reduction. Remarkably, cleaning the teeth whilst the tab was running could be reduced by over 55%.

Figure 4 Changes of direct water footprint.



Indirect water consumption was reduced by 173 l/d/c. Despite an increased water footprint of meat products, the overall virtual water footprint decreased by 9%. This reduction is mainly caused by a reduced consumption of dairy products.

Figure 5 Changes of indirect water footprint



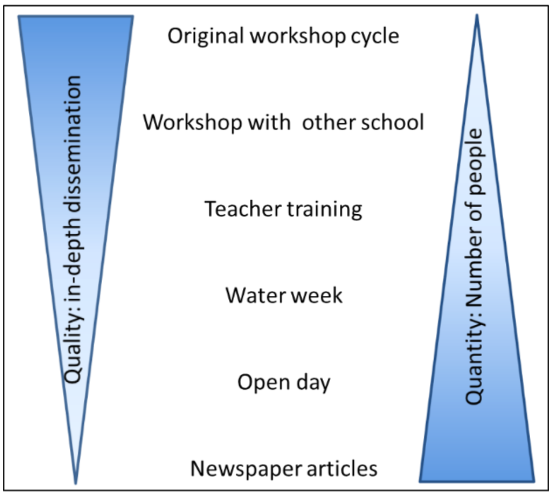
In order to review the time horizon for the improvement plan, also the overall project time span needs to be considered. The project duration was 25 months. During this period several phases had to be covered: Developing a methodology for WFTP assessment → Implementing this method and collecting data on WFTP → Analyzing the WFTP → Setting up of an improvement plan → Implementing this improvement plan → Evaluating the improvement.

This was a very ambitious aim for the duration of 25 months and therefore there was only little time for some of the phases, in particular, “implementing the improvement plan” and “evaluating the improvement”.

For this reason, the improvement plan and its implementation was designed to be carried out within a short period of time. During the improvement implementation it was possible to increase the sample size from 45 to 224 participants. Due to limited time, however, a second "post-awareness" assessment with all of these participants was not feasible. Only for the original 45 participants there was sufficient time for this second assessment. Also, in order to analyse these data more into detail more time would be necessary.

In order to achieve the targeted results several measures and methodologies had to be applied. This methodological mix proved to be very effective (Figure 4). Only by doing it this way, it was possible to have an in-depths evaluation of WFTP reduction on the one hand, and to inform as many people as possible about water consumption and the water footprint on the other hand.

Figure 6 Mix of measures to achieve the improvement aims.



4.4 Corrective actions

To achieve the targeted results it would be beneficial to include more teachers and more schools and thus to reach a larger number of pupils, alongside with their families. This will increase the sample size and allows a more comprehensive overview on the citizens´ water consumption behaviour. By reaching more citizens, more water consumption reductions measures would be implemented and more water could be saved.

Additionally, the monitoring of the water footprint could be further improved. The existing monitoring sheets focused on the amount of direct and virtual water, which was consumed at home. For future improvements this monitoring should be extended to include all water consumptions during the entire day. Furthermore, the items (categories) which were to be monitored could be more detailed. This will help to break down direct and indirect water more exactly. For this a smartphone application could simplify the monitoring process. People who use this application would be able to compare their personal consumption and motivate each other to improve their water footprint. The results can easily be shared via social networks and encourage friends to join in. Even more, a smartphone application is a great opportunity to reduce the effort of evaluating these data. Data can be provided in real-time and can be processed automatically. This way a more detailed analysis is possible, e.g. on daily distributions, differences between weekdays and weekends. What is not clear, however, is if people are willing to spend time monitoring their water consumption in real time, when there are so many other activities and smart phone apps competing for their attention.

Limitations in budget and staff also lead to difficulties in the work of a future Lab. Applying for several funding programmes may help to acquire additional financial resources.

Lastly, more time would have been necessary, e.g. to set up and conduct a complete post-awareness evaluation.

5 Water footprint improvement in Wroclaw

5.1 The targeted improvement

The waste water treatment plant in Wroclaw was designed to not exceed the limit values for pollutants' concentration and this aim is met. However, in order to be always on the safe side and reduce the sewage impact on the environment it is worth analysing the impact of some modifications and adjustments of the installation on the effluent quality. The capacity and composition of sewage might change with city development and connection of the new customers to the sewage system, so it is worth to increase the margin for Nitrogen concentration in the sewage and consequently, in the treated effluent.

Therefore, as the water footprint improvement, the Municipal Water and Sewage Company concentrates on potential investments that improve the Nitrogen removal from sewage. However, before the new solution is implemented it is important to carry out the appropriate theoretical and practical studies and analyses, and perform the pilot tests. If the tested solutions prove to be effective, and there will be enough investment means for their implementation, it will be carried out in the future.

With regards to progressing urbanization and limited ability of the storm water system (especially combined sewer system in Wroclaw city centre) to handle extreme events, it can be improved by implementing the Sustainable Drainage System. Different solutions improving the rainwater management within the city are to be promoted and presented to the stakeholders in order to convince them to encourage investors and design engineers to implement such solutions. This can be done by their promotion and by introducing relevant regulations, for examples incentives for rainwater harvesting, and/or fees for its discharge into the sewerage system.

5.2 The measures

Specifically, the improvement plan consists of four measures with regard to wastewater treatment:

- The first one is based on the change of the operational scheme at the biological treatment stage, i.e. transformation of the anaerobic reactors into denitrification rectors in order to increase the denitrification volume. This should contribute to Nitrogen concentration reduction by approximately 0.5 mg/l, thus $WFTP_{Grey}$ decrease by 5%.
- The next solution is improvement of internal recirculation capacity by nearly 50%. This will increase the amount of nitrates recirculated from nitrification to denitrification reactor and further improve the efficiency of Nitrogen removal by enabling full utilization of increased denitrification volume. Initially, the test is carried out on one of ten sequencing batch reactors in order to verify, if the proposed solution is effective. Full scale implementation of this solution should cause Nitrogen concentration decrease by approximately 0.5 mg/l, and $WFTP_{Grey}$ reduction by 5%.
- With higher internal recirculation flow more oxygen will be transported to the denitrification reactor. This may decrease Nitrogen removal efficiency so the third step is optimization of the aeration conditions in the aerobic reactor.
- The last project is implementation of anammox or nitrification/denitrification process of sludge dewatering liquor on a pilot scale. This is an ongoing research project. If the tested solutions prove to be effective, they will be possibly implemented on a full scale. Then a Nitrogen concentration decrease by at least 1 mg/l is expected, causing $WFTP_{Grey}$ reduction by 10%.

The example measures associated with implementation of the Sustainable Drainage System, which could improve the rainwater management and flood control in the city, are:

- Permeable green areas enabling rainwater drainage into the ground, improving water retention within the city drainage area. Having less concrete and more green space in an urban setting has also ecological and micro-climate benefits.
- Constructed wetlands, which are artificially created wetland ecosystems to treat e.g. collected rainwater or wastewater, similarly like ponds and creeks, are also a beneficial solution enhancing ecology and aesthetic value, enabling water retention for reuse for irrigation.
- Another sustainable solution, which reduces the risk of urban floods, is rainwater harvesting, which is the accumulation and storage of rainwater for reuse before it

could reach the aquifer. Harvested rainwater can be used e.g. for garden watering, car washing, as well as flushing toilets. It relieves some of the pressure on other sources of water supply and it reduces the costs associated with treatment of polluted rainwater.

These solutions contribute to a reduction of $WFTP_{Blue}$ and $WFTP_{Grey}$, and a positive increase in $WFTP_{Green}$, which is a dominating WFTP in green areas.

5.3 Assessment of the results

There were taken a few measures to fulfill the above described objectives. However, some of them could not have been implemented within the duration of the project due to the long scale of the Improvement Plan. There were also required some minor deadline adjustments.

The initial measures for implementation of Sustainable Drainage System required an implementation of specific technological solutions such as permeable green areas, constructed wetlands and other solutions contributing to reduction in risk of urban floods (e.g. rainwater harvesting and reuse). These solutions contribute to a reduction of $WFTP_{Blue}$ and $WFTP_{Grey}$, and a positive increase in $WFTP_{Green}$, which is a dominating WFTP in green areas. As these cannot be directly influenced by the Municipal Water and Sewage Company, it was decided to concentrate on their promotion among the stakeholders and municipality representatives responsible for storm water management and spatial development of Wrocław. The following actions were undertaken within 2014:

- Carrying out and analysing questionnaires on water and sewage management behaviours among citizens and students (future stakeholders).
- Media, conference and trade fair appearances as well as publications to promote the project methodology and sustainable water and waste water management solutions among scientists and stakeholders.
- Workshop addressed to students (future stakeholders), at which they have calculated their water footprints and monitored their water consumption for different household purposes and learned about the methods of water saving (reduction in $WFTP_{Blue}$).
- Workshop dedicated to representatives of municipal water and sewage companies from Lower Silesia region, at which the water footprint of their cities was calculated using Model A and the solutions for water footprint reduction were discussed.

- One week training for municipality representatives responsible for storm water system management and spatial development of Wroclaw, during which the technological solutions of sustainable city management, especially those related to local rainwater management, and the examples of the regulations and incentives favouring their implementation were presented.
- The Letter of Intent between Municipal Water and Sewage Company and Municipal office of Wrocław was signed to agree for future cooperation in terms of increasing the awareness and disseminating the knowledge about sustainable water management in urban areas.
- Open day addressed especially to architects and design engineers as well as workers of Municipal Water and Sewage Company responsible for investment permissions, on which the sustainable city management solutions were introduced and their implementation experience was discussed.

It is believed that the implementation of these measures was successful.

The measures for reduction in Nitrogen concentration in treated effluent applied in the Waste Water Treatment Plant were only partly implemented:

- The anaerobic reactors were transformed into denitrification reactors so the denitrification volume was increased.
- The internal recirculation was implemented in one of four sewage treatment lines in the old part of the Waste Water Treatment Plant. It will be implemented on a full scale within 2015.
- The optimization of the aeration conditions was conducted via computer modelling. The model was built on the basis of the data for one year of Waste Water Treatment Plant operation plus the results were confirmed by the extra measurements. The indicated most effective aeration algorithm will be implemented within 2015.
- The pilot scale plant for implementation of annamox or nitrification/denitrification process of sludge dewatering liquor was built and the test runs are carried out. The research will last for two years and if one of the methods proves to be effective and cost efficient, it might be implemented on a full scale until 2019.

The major difficulty of implementation is associated with the lack of time for implementing some measures within the time frame of the project. The Improvement Plan was written in

June 2014, while the project ends in November 2014, which gives only 5 months for the activities.

Regarding the implementation of the Sustainable Drainage System the emphasis was shifted from implementation of particular solutions (on which the Municipal Water and Sewage company does not have an impact) to awareness building and their promotion among the stakeholders and decision makers, which might have a direct and/or an indirect impact on their implementation. It is believed this modified objective was achieved. The municipality representatives and stakeholders are willing to cooperate in this field, however more actions are required in the future to achieve any significant changes and progress.

If more time is available, the wider scale questionnaires could be carried out among larger number of citizens. In addition, the informative and promotional campaign could be carried out. More workshops could be organized for more students and stakeholders. The completion of all planned activities has generally required a lot of organizational effort for the Wrocław Lab.

Regarding the reduction in Nitrogen concentration projects, some stages have been carried out within the time frame of the project, while some might last even until 2019.

5.4 Corrective actions

Based on the experiences already gained by Wroclaw Lab it is possible to reflect on what could be improved and plan further activities.

The surveys carried out within the time frame of the project applied only to small sample of citizens (166 out of 631 000) however, they gave a view on the general society behaviours. In order to gain more complete knowledge on users behaviours and also be able to estimate water intake from private wells and sewage disposal into septic tanks and private sewage treatment plants it would be good to include related questions in Polish census. However, this is carried out seldom. The last two took part in 2002 and 2011, so the next one might be around 2020.

The informative and awareness building campaign should also reach much more citizens. Once they are convinced of the advantages of local rainwater management and are willing to support such investments and buy such properties, investors will start implementing such solutions on a larger scale.

The workshop at the university was addressed only to 73 students, which are simultaneously water consumers and future stakeholders. It would be good to improve students' knowledge on sustainable water and waste water management by implementing relevant content into the lectures, and thus reaching much wider group of recipients.

Further promotion of sustainable solutions and meetings with relevant stakeholders and decision makers are required in order to discuss possible changes in local regulations favouring/forcing such solutions. This will ultimately motivate/force the investors to implement them. The activities carried out among stakeholders up to now were very effective and initiated future cooperation on this topic.

With the involvement of stakeholders, decision makers and experts it might be possible to define the model for water footprint determination for specific investments. The values should be specified with regards to investment location as the Model B results indicated that water and waste water management varies in different areas of the city.

Before implementing sustainable drainage system solution on a significant scale it is impossible to justify the water footprint changes (calculated using model A and B).

The achievements of the Lab should be shared with the municipalities from Lower Silesia region interested in cooperation. Once the actions prove to be effective, they are possibly willing to implement the worked out solutions in their cities.

Any further actions involve time and money, thus require further funding.

The projects associated with reduction in Nitrogen concentration are constantly implemented. The transformation of the anaerobic reactors into the denitrification reactors was already completed. However, the results cannot be measured yet as longer term observations are required to verify the changes. In addition, simultaneous implementation of different projects also does not allow for reliable comparison.

6 Results of the water use and management data gathering survey

A survey was developed and shared with a participant from each of the project countries. The goal of the survey was to assess the experience relevant to the future application of the water footprint methodology in each of the countries. The survey questionnaire itself is in Annex 1. This chapter serves to review the results of the survey.

As Table 3 shows, environmental problems in the urban setting were scored by each participant. The biggest challenges are

- traffic related air pollution,
- lack of urban green space and poor ecology, and
- storm water management.

Less critical, but still important problem areas include micro climate related problems, pollution of surface water, pollution of ground water and contaminated soil. With the exception of the last item and traffic related air pollution, all of the challenges and the related responses can be assessed with the water footprint methodology, underlining the importance of the water footprint tool.

Interestingly, the least critical problem is the quality of the drinking water, which seems to be high in all of the case study locations.

Table 3 Evaluation of environmental problems in the five countries (higher values indicate more critical problems)

Problem area	AUS	GER	HUN	ITA	POL	AVERAGE
Collection of municipal solid waste	1	1	2	3	3	2.00
Treatment/disposal of municipal solid waste	1	1	2	3	3	2.00
Selective collection and recycling of municipal solid waste	1	1	4	2	4	2.40
Traffic related air pollution	2	3	4	5	5	3.80
Other air pollution (e.g. industry, heating, power plants, regional polluters)	1	2	2	5	3	2.60
Lack urban green space and poor ecology	3	3	4	2	3	3.00
Micro climate related problems (e.g. summer heat islands)	3	3	3	3	2	2.80
Drinking water quality	1	1	2	2	1	1.40
Water scarcity (for drinking water supply)	5	2	2	1	1	2.20
Water scarcity (for other purposes, e.g. industrial water, hydropower, irrigation)	5	1	2	1	1	2.00
Pollution of surface water	4	2	3	2	3	2.80
Pollution of ground water	3	2	3	3	3	2.80
Storm water management	2	3	2	4	4	3.00
Contaminated soil (from industrial activities)	4	3	3	2	2	2.80
Risk of industrial accidents	1	1	3	2	3	2.00

Table 4 below summarised the information provided by country experts on the replicability of the water footprint approach, that is, on which level are the direct and virtual water footprint methods most relevant. For each combination participants were allowed to select from "yes", "no", and "maybe". For the purpose of quantitative assessment we transformed the answers to scores, with "yes" worth 2 points, "maybe" 1 point and "no" zero point. There are two general conclusions: 1) the direct water footprint method is viewed as more wildly applicable than the virtual water footprint concept, and 2) lower levels (or smaller units, such as households, schools and businesses) are preceived to benefit more from the methodology than higher levels (or larger units, like regions or countries). The most attractive use for the direct water footprint is within water utilities, households, schools and small municipalities, while the virtual water footprint has the best standing in schools and small municipalities.

Table 4 Assessment of the replicability of the water footprint methodology (higher values indicate ease of replication)

Level	Direct	Virtual
Household	9	6
School	9	8
Business entity	8	4
Small municipality (village)	9	8
Large municipality (town/city)	8	5
Water and wastewater utility	10	7
River basin district	8	7
Region (within a country)	6	5
Country	6	6
Central Europe region	5	5
European Union	5	5

According to the participants to the survey the factors the most hinder the application of the water footprint method are the time of needed staff and experts, specific expertise (e.g. engineering, modelling), communicating the footprint concept and attaining practical actions (Table 5). Interestingly, access to good data and municipal support are not viewed as problematic.

Table 5 Key obstacles to successfully using the water footprint methodology (higher values indicate challenges/obstacles)

What do you see as the key obstacles to the successful application of the water footprint methodology on the urban level? Please underline your answers.	
• Good quality data	1
• Knowledge (engineering, modelling expertise)	2
• Time of needed staff and experts	3
• Lack of dedication of municipal decision makers	1
• Lack of interest by the population	1
• Difficulty of communicating the water footprint concept	2
• Difficulty of translating the theoretical results into practical actions	2
• other: ……………………………………………….	

In the early phases of WP5 water footprint related best practices were identified and during the survey (close to the end of the project) their applicability was assessed (Table 6). The most relevant or most effective measures are indicated with green colour and they include separation of storm water from the wastewater sewer, green roofs, reduced soil sealing, improved retention and use of storm water via changing the building code in cities.

The least attractive measures are more widespread metering of consumption (since metering is already at a high level), improved wastewater treatment (also highly effective in many locations) and cost recovering tariffs (due to consumer resistance and the relatively low price elasticity of demand).

Table 7 reviewed how supportive the public is of given measures. The least attractive measure is the application of cost recovering tariffs, even if they would ensure sustainable water services in the long run. This suggests that there is a lack of long term perspective in the public, or lack of trust that tariff revenues are indeed used to make water services more sustainable.

Table 6 Evaluation of best practices to reduce the water footprint (higher values indicate more effective practices)

Practice	AUS	GER	HUN	ITA	POL	AVERAGE
More widespread metering of water consumption (if not all connections are metered, as the introduction of metering helps reduce water use)	1	1	1	3	5	2.20
Leakage reduction programs (e.g. district metering program)	3	2	2	4	4	3.00
Cost recovering tariffs (resulting in lower water consumption and more revenue for the water utility which can be used to finance activities that lower the water footprint as well)	2	1	3	2	5	2.60
Promotion of water saving technologies for households	3	1	3	4	3	2.80
Promotion of water saving technologies for industrial facilities	4	2	1	5	4	3.20
Education of citizens on water saving measures	4	1	3	5	4	3.40
Education of citizens on the relationship of their consumption and the virtual water footprint	4	4	3	5	3	3.80
Measures to reduce soil sealing (e.g. permeable surface instead of concrete, contributes to retention of water and less pressure during storms)	4	3	5	5	3	4.00
Extension and rehabilitation of the sewer	3		3	5	3	3.50
Separation of the storm water and wastewater collection systems (ensures better treatment of wastewater during storms, reduces the pressure on the sewer, and helps to retain storm water for other uses)	5	3	4	5	4	4.20
Improved wastewater treatment (contributes to a lower grey water footprint)	1	1	2	5	3	2.40
Changing the building code (better retention of storm water, possibility for reuse of water)	3		4	5	4	4.00
Rainwater harvesting by households	3	2	4	5	3	3.40
Rainwater harvesting by commercial entities and public institutions	3	2	4	5	4	3.60
Green roofs (to retain water)	3	5	4	4	5	4.20

Table 7 Public support of water footprint reducing practices (higher values indicate more support)

	AUS	GER	HUN	ITA	POL	AVERAGE
Leakage reduction by the drinking water company	5		3	3	4	3.75
Cost recovering tariffs (= higher service price) resulting in more sustainable services	3		2	2	3	2.50
Water saving technologies and measures to be implemented by households	3		3	4	3	3.25
Gradual shift to consumption with a lower virtual water footprint	3		2	4	4	3.25
Reduced soil sealing, resulting in more green surface and lower risk of urban flooding (e.g. permeable pavement)	4		4	4	3	3.75
Extension and rehabilitation of the sewer	3		4	5	4	4.00
Improved wastewater treatment generating lower pressure on surface waters, but at higher sewage tariffs	3		3	2	4	3.00
Stricter building code, increasing the costs of construction, but making buildings more sustainable	3		2	5	3	3.25
Individual solutions of rainwater harvesting	3		3	5	3	3.50
Green roofs on top of public buildings	3		5	4	3	3.75

Lastly, respondents shared their views on how the water footprint concept could be further improved. The results are contained in Table 8.

Table 8 Steps taken to further improve the water footprint methodology (higher values indicate higher importance)

Combining the footprint with site specific indicators of water scarcity (e.g. drought index)	1.00
Supplementing water footprint values with the results of environmental valuation (e.g. the monetary value of a cubic meter of different colours of water footprint in a given location)	3.00
Combining different footprints (e.g. ecological, carbon, water) into one indicator.	3.00

7 Conclusions

Concerning the implementation of the water footprint improvement time has been too short, as many of the measures require longer periods for the results to become visible, or even for the steps of introducing the measures. This, however, is not to be blamed on the measures. Simply, the project timeline is too short for many of the steps to be fully followed. Furthermore, the implementation period extended into the summer, the traditional holiday season when any meaningful progress is substantially slowed.

Most measures are resource intensive in some way, requiring either financial sources, or time, or specific innovation. As such, the benefits and the costs (resources needs) should be weighed against each other and those water footprint reducing measures should be selected, where the benefits are likely to exceed costs by a wide margin. This is certainly possible, as any one target can usually be achieved through the implementation of several different measures.

Stakeholder engagement is critical for most measures, especially those that effect a wide range of different actors. This can take the form of information dissemination (e.g. providing knowledge on water saving techniques), active consultation (developing urban plans), or even direct involvement in implementation (introduction of water meters).

In some cases different active actors also need to cooperate: e.g. reducing soil sealing may require the collaboration of the municipality, the water utility, and citizen groups.

8 Annex: Survey questionnaire - water use and management data gathering

Project no. 4CE439P3

URBAN_WFTP

Introduction of Water Footprint (WFTP) Approach in Urban Area to Monitor, Evaluate and Improve the Water Use

WP 5.5.1

Water use and management data gathering

SURVEY

Data gathering sheet concerning the application of the WFTP approach to be filled in by local municipalities and/or local organization responsible for water management issues.

Name of respondent: ………………………………………..

Organisation: ………………………………………………..

Country: …………………………………………………….

City: …………………………………………………………

Date: ………………………………………………………...

Lead contractor for deliverable *WP 5.5.1*: ENEREA

Start date of project: 1 November 2012 **Duration: 25 months**

Submission date: October 2014

Scale of water management problems in relation to other urban environmental problems

Please score each of the listed problems on a scale of 1 to 5 (1: not a problem at all … 5: serious problem) with respect to your own city

Problem area			**Score**		
Collection of municipal solid waste	1	2	3	4	5
Treatment/disposal of municipal solid waste	1	2	3	4	5
Selective collection and recycling of municipal solid waste	1	2	3	4	5
Traffic related air pollution	1	2	3	4	5
Other air pollution (e.g. industry, heating, power plants, regional polluters)	1	2	3	4	5
Lack urban green space and poor ecology	1	2	3	4	5
Micro climate related problems (e.g. summer heat islands)	1	2	3	4	5
Drinking water quality	1	2	3	4	5
Water scarcity (for drinking water supply)	1	2	3	4	5
Water scarcity (for other purposes, e.g. industrial water, hydropower, irrigation)	1	2	3	4	5
Pollution of surface water	1	2	3	4	5
Pollution of ground water	1	2	3	4	5
Storm water management	1	2	3	4	5
Contaminated soil (from industrial activities)	1	2	3	4	5
Risk of industrial accidents	1	2	3	4	5

Replicability of the water footprint methodology in other locations

Based on your understanding of and experience with the water footprint approach do you think its application is useful on the following levels:

Level	Direct water footprint			Virtual water footprint		
Household	yes	no	maybe	yes	no	maybe
School	yes	no	maybe	yes	no	maybe
Business entity	yes	no	maybe	yes	no	maybe
Small municipality (village)	yes	no	maybe	yes	no	maybe
Large municipality (town/city)	yes	no	maybe	yes	no	maybe
Water and wastewater utility	yes	no	maybe	yes	no	maybe
River basin district	yes	no	maybe	yes	no	maybe
Region (within a country)	yes	no	maybe	yes	no	maybe
Country	yes	no	maybe	yes	no	maybe
Central Europe region	yes	no	maybe	yes	no	maybe
European Union	yes	no	maybe	yes	no	maybe

What do you see as the key obstacles to the successful application of the water footprint methodology on the urban level? Please underline your answers.

- Good quality data
- Knowledge (engineering, modelling expertise)
- Time of needed staff and experts
- Lack of dedication of municipal decision makers
- Lack of interest by the population
- Difficulty of communicating the water footprint concept
- Difficulty of translating the theoretical results into practical actions
- other: ……………………………………………

Best practices to reduce the water footprint

In your view how relevant are the listed water footprint related best practices in your city? (1 not relevant for us … 5 very relevant)

Practice	Score				
More widespread metering of water consumption (if not all connections are metered, as the introduction of metering helps reduce water use)	1	2	3	4	5
Leakage reduction programs (e.g. district metering program)	1	2	3	4	5
Cost recovering tariffs (resulting in lower water consumption and more revenue for the water utility which can be used to finance activities that lower the water footprint as well)	1	2	3	4	5
Promotion of water saving technologies for households	1	2	3	4	5
Promotion of water saving technologies for industrial facilities	1	2	3	4	5
Education of citizens on water saving measures	1	2	3	4	5
Education of citizens on the relationship of their consumption and the virtual water footprint	1	2	3	4	5
Measures to reduce soil sealing (e.g. permeable surface instead of concrete, contributes to retention of water and less pressure during storms)	1	2	3	4	5
Extension and rehabilitation of the sewer	1	2	3	4	5
Separation of the storm water and wastewater collection systems (ensures better treatment of wastewater during storms, reduces the pressure on the sewer, and helps to retain storm water for other uses)	1	2	3	4	5
Improved wastewater treatment (contributes to a lower grey water footprint)	1	2	3	4	5
Changing the building code (better retention of storm water, possibility for reuse of water)	1	2	3	4	5
Rainwater harvesting by households	1	2	3	4	5
Rainwater harvesting by commercial entities and public institutions	1	2	3	4	5
Green roofs (to retain water)	1	2	3	4	5

Public support of water footprint reducing practices

In your view how supportive is the public of the following measures in your city? (1 not acceptable … 5 very much in favour)

Measure					
Leakage reduction by the drinking water company	1	2	3	4	5
Cost recovering tariffs (= higher service price) resulting in more sustainable services	1	2	3	4	5
Water saving technologies and measures to be implemented by households	1	2	3	4	5
Gradual shift to consumption with a lower virtual water footprint	1	2	3	4	5
Reduced soil sealing, resulting in more green surface and lower risk of urban flooding (e.g. permeable pavement)	1	2	3	4	5
Extension and rehabilitation of the sewer	1	2	3	4	5
Improved wastewater treatment generating lower pressure on surface waters, but at higher sewage tariffs	1	2	3	4	5
Stricter building code, increasing the costs of construction, but making buildings more sustainable	1	2	3	4	5
Individual solutions of rainwater harvesting	1	2	3	4	5
Green roofs on top of public buildings	1	2	3	4	5

Product labelling

Do you think that placing information on products about their environmental load (ecological footprint, carbon footprint, water footprint) would shift consumer behaviour toward sustainability? Please underline.

- Definitely not
- Probably not
- Maybe
- Probably yes
- Definitely yes
- No opinion

<u>In your opinion how can the water footprint concept be further improved?</u>

Please underline.

- Combining the footprint with site specific indicators of water scarcity (e.g. drought index)
- Supplementing water footprint values with the results of environmental valuation (e.g. the monetary value of a cubic meter of different colours of water footprint in a given location)
- Combining different footprints (e.g. ecological, carbon, water) into one indicator.
- Other: ……………………………………………………………………………..