INTEGRATED STORM WATER MANAGEMENT

System guidelines

iWater project – City of Turku, Environmental Division

CITY OF TURKU

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iWater

Interreg Central Baltic

EUROPEAN UNION
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EU STRATEGY FOR THE BALTIC SEA REGION FLAGSHIP

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ABBREVIATIONS AND ACRONYMS

BMP – Best management practice

DPSIR – Drivers, Pressures, States, Impacts, Responses

ISWM – Integrated storm water management

LID – Low impact development

PESTLE – Political, Economic, Socio-Cultural, Technological, Legal and Environmental

SuDS – Sustainable drainage system

SWOT – Strengths, Weaknesses, Opportunities, Threats

TSS – Total suspended solids

1 INTRODUCTION

One of the main objectives of the iWater project[1] was to improve urban planning in the cities of the Baltic Sea Region (BSR) by developing integrated stormwater management system that would allow cities to increase resilience to the negative effects of climate change.

The iWater project team believes that our stormwater management solutions can be applied successfully in many other BSR cities, therefore we are proud to share with you our experience compiled in the (present) Integrated Storm Water Management (ISWM) guidelines elaborated by the iWater project.

The main purpose of these ISWM guidelines is to help other cities establish a comprehensive stormwater management approach and integrate it into the urban development processes at all levels, thus creating an ISWM system in the city. This ambitious objective may only be reached if all relevant stakeholders are actively involved in the process, offering them an opportunity to cooperate in the development of the ISWM system.

ISWM guidelines shall guide public servants working on any of the city's planning, development, operation and/or maintenance processes through this highly complex ISWM development process.

2 HOW TO READ THE ISWM GUIDELINES?

The writing of the ISWM guidelines was a challenging work since the process is not linear, and the reader's background knowledge level is unknown. The iWater project solved these challenges partially by using multiple references to annexes within the ISWM guidelines.

All the annexes are in the "ISWM Annexes" folder. Some of the annexes, like PESTLE analysis and SWOT analysis materials (documents 6.1.–6.4.), need to be read when you are going to make use of them. Others, like the "ISWM Measures & Approaches" (document 6.9.), should be read as soon as they are mentioned in the ISWM guidelines.

Finally, there are two documents in the "ISWM Annexes" folder, the "ISWM planning Workshop" and the "ISWM Implementation Workshop" (documents 6.8. and 7.1.). These documents should be kept open and read simultaneously with the guidelines as soon as they are mentioned for the first time in the guidelines.

3 BACKGROUND

Current stormwater management practices consider just one unique solution, pipes. Either separate or combined, sewer systems are designed for maximum capacities based on scenarios up to 10-year storms.

During the last decades, the pipe solution, also referred as conventional stormwater drainage, has been proved insufficient to manage all impacts related to urban runoff. Cities all over the world are facing common challenges of increasing stormwater floods, and degradation of natural resources and infrastructure caused by climate change and densified urban areas.

How land is initially developed has tremendous bearing on the prospective quantity and quality of urban streams.

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[1] *EU Interreg Central Baltic Programme's 2014-2020 project No. CB 187 "Integrated Storm Water Management" (iWater):* www.integratedstormwater.eu.

Urban development removes the vegetation that intercepts, slows and returns precipitation to the air through evaporation and transpiration. These changes not only increase stormwater runoff, but also accelerate the rate at which runoff flows across the land. Conventional stormwater drainage systems such as gutters, storm sewers and lined channels designed to quickly carry runoff to rivers and streams, further exacerbate this effect.

Besides, the trend in land development towards densifying urban areas and increasing impervious surfaces has a direct impact on stormwater quality by increasing both the concentration and types of pollutants carried by runoff, and therefore the degradation of aquatic habitats.

Nature-based solutions to manage stormwater have been already developed and tried. They range from capturing stormwater and preventing runoff to aquatic habitat protection. A combined use of multiple stormwater management solutions is not just possible, but also advisable to increase resilience to extreme weather and climate events. This is possible with an integrated stormwater management approach.

4 WHAT IS INTEGRATED STORM WATER MANAGEMENT?

The Integrated Storm Water Management (ISWM) is a comprehensive approach to stormwater management. Instead of a narrow focus on a single problem, the ISWM undertakes a holistic stormwater management approach: studying the characteristics of specific sites and areas, understanding the relevant impacts, and tailoring a comprehensive array of tools to individual situations.
Success requires the integration of the ISWM system into the urban development processes of the city at all levels, from urban planning to operation and maintenance.

With an ISWM system a city can:

- achieve their goals of water quality protection and flood mitigation to protect the natural and built environment,
- design for not just the worst case scenario, but also for average and minimal events to minimize the impact of stormwater on neighbouring lands,
- determine what solutions and infrastructure together with their interconnections are required to manage the stormwater runoff that results from different storms events, and
- ensure that stormwater is treated as a resource that enhances our cities, rather than treat it as waste that needs to be removed through underground storm sewers.

Besides, the ISWM approach has a number of added advantages compared to conventional stormwater drainage. It enhances urban environment by applying greener and more eco-efficient planning principles, thus promoting additional environmental benefits and multiple ecosystem services. Further, the ISWM approach promotes transition from conventional to sustainable stormwater drainage where the priority is given to the “Green Infrastructures” over the “Gray Infrastructures”.

5 INTEGRATED STORM WATER MANAGEMENT CYCLE DESCRIPTION

The Integrated Storm Water Management (ISWM) consists of two main phases -**planning** and **implementation-** each of them divided into 3 sub-phases. These steps are graphically illustrated in figure 1 and described later in further detail.

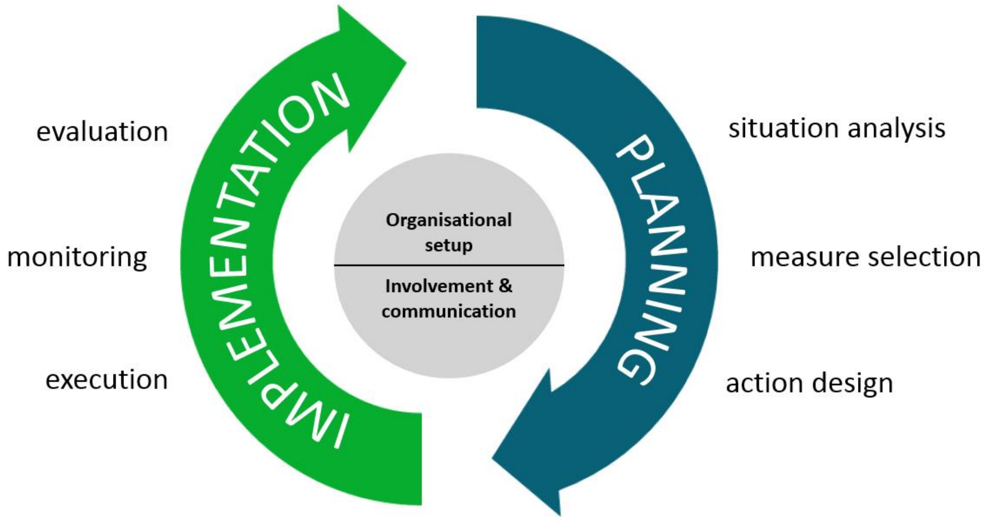

Figure 1. The ISWM system.

There are two crosscutting elements in the ISWM system – **organizational setup** and **involvement & communication** – that are essential to ensure transparency and cooperation between various departments and other stakeholders, and support from the council and the senior management.

Please note that, even though the sub-phases are shown as steps to be performed one after the other, the **planning sub-phases** may be overlapping each other, while the **implementation sub-phases** can be executed at the same time. The system follows an annual cycle, but full revision will be required only every 3–5 years, if evaluation of achievements and results at the end of the cycle does not suggest reconsideration.

Note: For the purposes of these guidelines, we will use the term ISWM programme to refer to any programme, plan or strategy intended to implement an ISWM system in the local administration of a city or a municipality.

6 ORGANISATIONAL SETUP

An ISWM requires structured processes and people who know their responsibilities and work together towards common goals in accordance to a certain plan.

The structure of the ISWM should incorporate and make use of the existing structures in municipal administration and not the other way around. The core part of the organizational setup is a cross-departmental coordination team. The ISWM has to be organized centrally in the city management and not in a single department, as has often been the case with traditional stormwater management approaches.

Kick-off meeting: Start by calling-up a cross-departmental kick-off meeting. At least one representative from each of the following municipal units and institutions should take part in the meeting:

- City departments involved in the urban development process like urban planning, urban design, public areas design, building permit, public works, maintenance, etc.
- Municipal institutions involved in water management like water utility, wastewater treatment plant, etc.
- Emergency services

The main tasks for the kick-off meeting are:

- Check together that all municipal units and institutions mentioned before are represented in the meeting
- Find a common agreement on the need for preparing the ISWM programme for the city by presenting shortly the current challenges and opportunities of stormwater management
- Decide who will be the coordinator responsible for the whole process of preparing the ISWM programme and who will form the coordination team (you should be now sitting in the meeting more or less with the upcoming coordination team)
- Prepare a proposal for the City Board to get political mandate for the ISWM process at the very beginning
- You can either use the same stormwater working group or name within that group a person and a coordination team which will take overall responsibility of the Baseline Review process

ISWM is a challenging and complex objective that requires special and updated knowledge. Capacity building for the staff involved is therefore an important aspect within the organizational setup.

The approval of the ISWM strategic programme and the organizational setup by the city council as the highest decision-making body represents a minimum requirement within ISWM. The involvement of the central political body in the situation analysis and in evaluation, in line with the annual budget cycles, ensures political commitment, legitimization and maximized impacts.

7 INVOLVEMENT & COMMUNICATION

While the coordination is based within the local administration, the strategic objectives and targets are to be implemented via a range of actors including administrative departments, private companies and relevant stakeholders. Besides, our ISWM system can only be considered successful when its key stakeholders acknowledge it as a success and have a common understanding of it (i.e., a common vision, objectives, etc.).

That is why we should engage with our stakeholders early and often to learn about and understand their values, needs and interests. Then we should ensure those values, needs and interests are addressed in our internal decision-making and in the ISWM execution processes.

To achieve this, an effective communication and involvement strategy is needed. In the ISWM Annexes folder, there are instructions and templates to help you to analyse, involve and communicate with your stakeholders (documents 5.1.–5.3.).

Engage relevant stakeholders in all the steps of the ISWM system. Make the rules public to keep stakeholders informed about when they are expected to be involved in, and how they can be a part of shaping a liveable and safe city.

Once the stakeholders are involved, it needs to be clear how the communication both within the system, and from the system outwards is handled. In case you have many stakeholders or your city administration is rather big, you should use flow charts like the example in figure 2 below to show how the data will flow from the place where is created up to the managements team and back to the stakeholders.

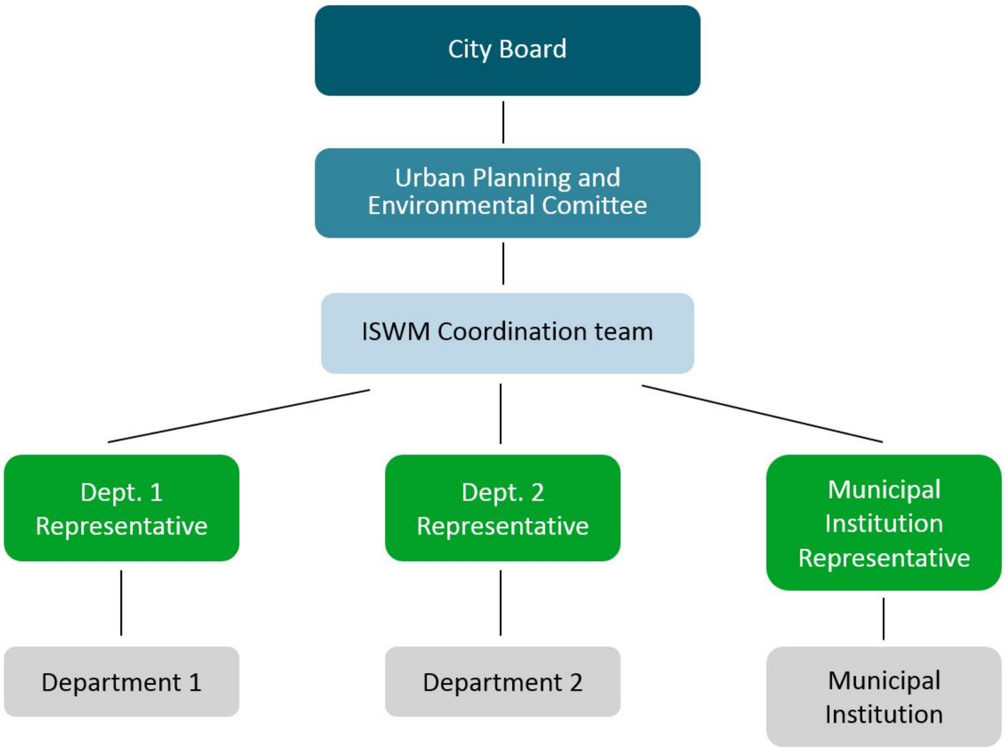

Figure 2. City administration data flow example.

Involvement and communication are baseline steps that initiate and give the power to the implementation of the ISWM system and are closed related to the organizational setup. The degree and therefore the success of exchange of ideas and approaches through cross-departmental working groups as well as cooperation in cross policy areas, is a result of the involvement and communication.

8 PLANNING

Planning is a process that brings you from "what you want to achieve" to "how to actually do it". It starts with identifying the problems and/or opportunities in your current stormwater management system in order to determine the objectives for the solution.

The Planning phase includes the following steps:

- Situation Analysis
- Measure Selection
- Action Design

8.1. Situation analysis

Situation analysis is an assessment of the current stormwater management situation, including potential future issues due to climate change, and the expectations and needs of the city. It starts with collecting the necessary information to assess it and find the gaps between the current and the desired conditions.

8.1.1. Collecting information

A robust situation analysis might include an assessment of:

- expectations, including current and future needs, as well as social expectations
- stormwater management system performance and performance gaps in responding to needs and expectations
- stormwater management capacity to respond to current and anticipated future challenges
- stormwater management system resources (human, physical, financial, informational) and resource gaps in responding to needs and expectations
- stakeholder analysis (including external partners)

For a systematic collection and study of the available stormwater management data in your city, use the PESTLE and SWOT analysis instructions and templates from the ISWM Annexes folder (documents 6.1.–6.4.). In the same ISWM Annexes folder, you can also find the instructions and template for a stakeholder analysis (documents 5.1. and 5.2.).

The expectations refer to the vision and objectives a city is seeking in its stormwater management system. It is important that local decision-makers, rather than professionals, determine the vision and objectives which they use to pursue in discussion with other stakeholders and the public.

Has your city a strategic plan or city strategy approved after following extensive consultation? There you can find your city's vision and objectives. The vision describes how you would like your city to be by the end of a certain period. Such vision statements may well not mention stormwater management at all, but instead focus on aspirations such as liveability, competitiveness and sustainable development. However, they prompt the all-important question of *how a stormwater management strategic programme can contribute to such a vision*. The answer to this question should help in specifying the objectives of your ISWM strategic programme.

In case your city doesn't have a strategy, you can use the Vision workshop from the ISWM Annexes folder (document 6.5.). You can also use the workshop as a stakeholder involvement tool. Since we try to implement superficial open systems to manage stormwater, we might want to make sure that the impact of these new infrastructures in the environment and landscape is positive to everyone. This means the involvement of many organisations from the community, public and the private sectors.

To help you in the process of creating a vision and objectives for your ISWM system we created the Strategic Plan instructions and example that you can find in the ISWM Annexes folder (documents 6.6. and 6.7.).

8.1.2. Assessing information

After completing the previous activities, you:

- Know the vision and objectives of your ISWM programme.
- Have collected available data about the current situation of the stormwater management system in your city, as well as the social, economic, political, and legal context in which it exists.

In this step, we will assess all the information you collected to find the gaps in your stormwater management system. In the ISWM Annexes folder, you can find the ISWM Planning Workshop (document 6.8.) that will guide you through the analysis process. The ISWM Planning Workshop is also intended to guide you through the rest of the sub-phases in the Planning phase, i.e. Measure Selection and Action Design.

All the information that we have been collecting shows us a gap between the current situation and the desired conditions, vision and objectives (figure 3). Success in finding appropriate solutions to bridge the gap depends mostly on how well we describe the current conditions and defines the desired conditions. Current conditions description will require much more detail because we need to identify the "root" causes of the problem.

Figure 3. The gap between current conditions and desired conditions.

CURRENT CONDITIONS

Use the weaknesses and threats sections of your SWOT analysis to find problems in your city's stormwater management system. Then group them into three categories following the example showed below:

CORE PROBLEMS	LACK OF RESOURCES	SYSTEM PROBLEMS
Flooding	Funding	Fragmented responsibilities
Erosion	Personnel	Resistance to change
Water pollution	Knowledge	etc.
	etc.	

You can brainstorm more problems under each category in addition to those you got from your SWOT analysis.

We will focus now just in the **Core Problems**. These are the problems related to, or directly causing flooding, erosion and water pollution problems. Prioritize the core problems based on the criticality of the problem, and the consequences of ignoring it. Starting with the most critical problem, we will analyse each of them as it is explained below.

Before jumping into the solution, it is important to explore all of the causes that could lead to the problem. This step will answer questions like:

- What sequence of events leads to the problem?
- What conditions allow the problem to occur?
- What other problems surround the occurrence of the central problem?
- What approaches have we tried?

You can use different tools to identify causal factors and impacts. The result would be a system model of each core problem or major concern that would look more or less like figure 4.

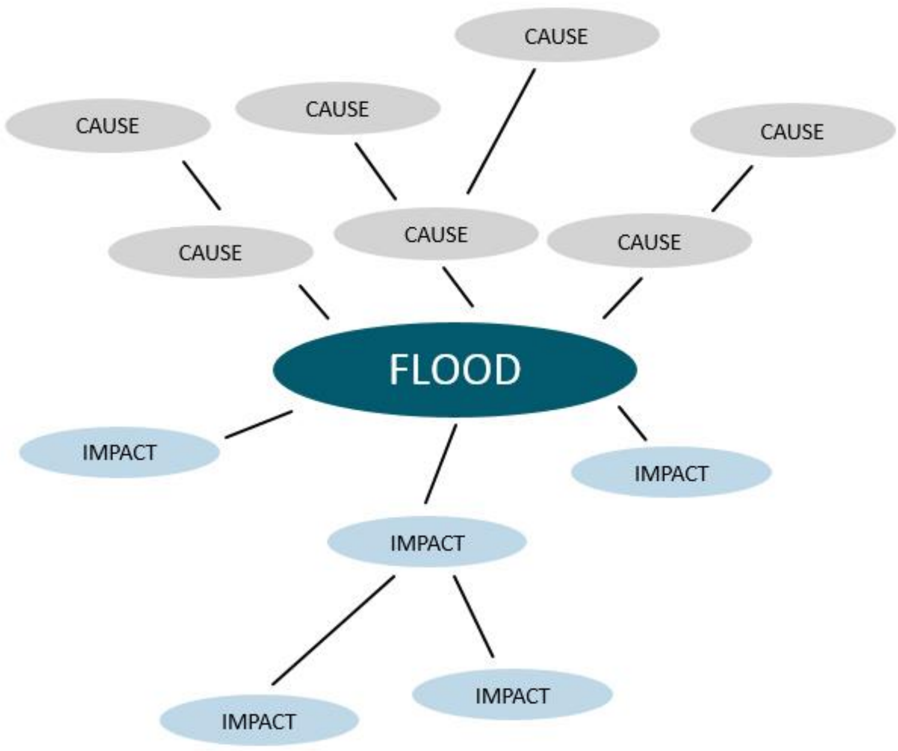

Figure 4. Theoretical system model of causes and impacts of a core problem in stormwater management.

In these guidelines we will use the DPSIR Framework which was invented by the Dutch National Institute of Public Health and Environment in association with the European Environment Agency (EEA). The result will be similar to the previous example, except for the inclusion of the **responses or solutions** that we apply on the system (figure 5).

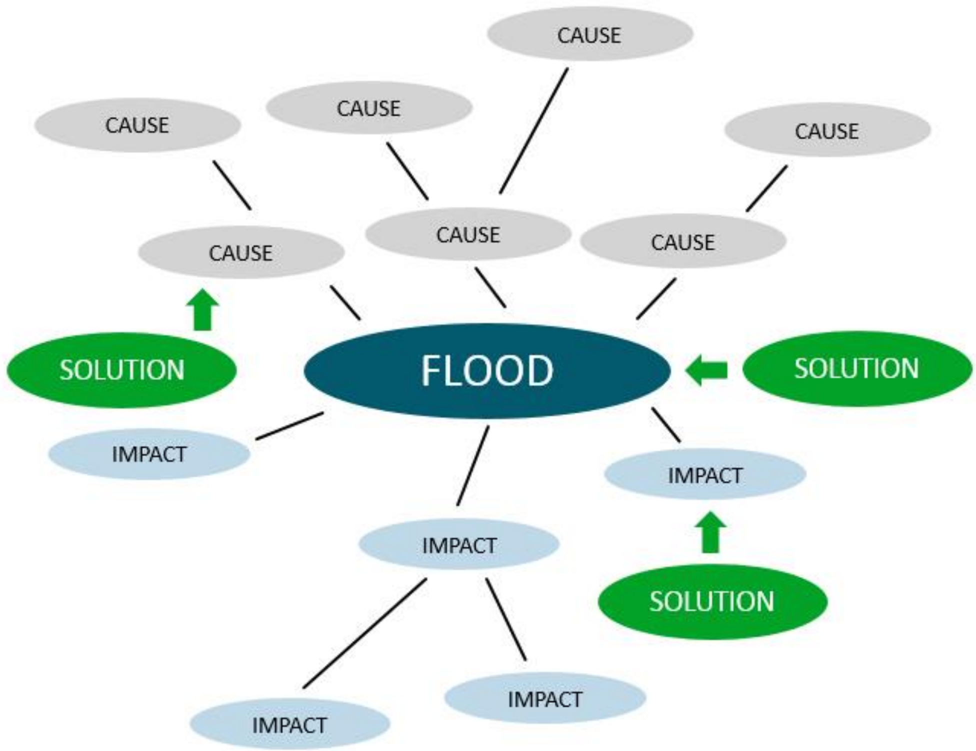

Figure 5. Theoretical system model of causes, impacts and solutions of a core problem in stormwater management.

The **DPSIR framework** is formed by 5 components: **D**riving forces, **P**ressures, **S**tates, **I**mpacts and **R**esponses (figure 6).

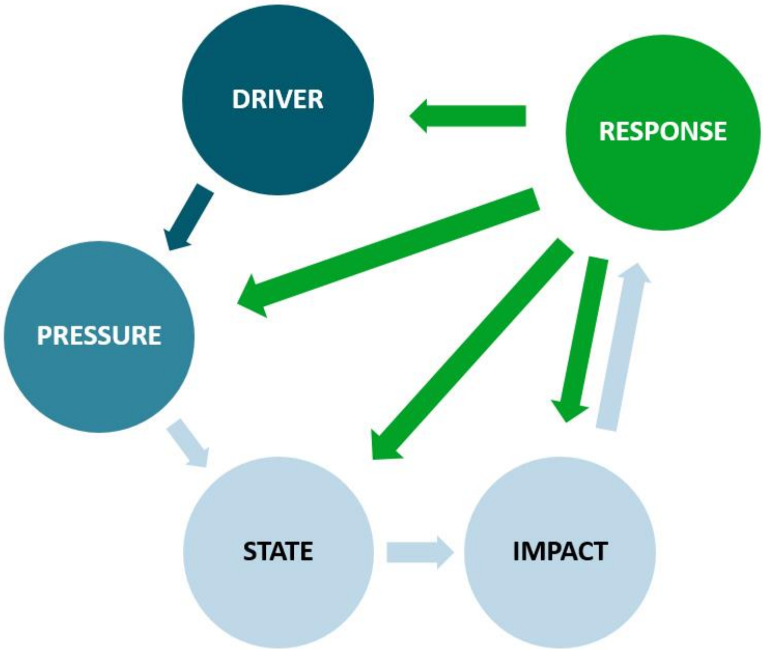

Figure 6. The DPSIR framework.

According to this systems analysis view, **D**rivers like population growth in a city exert **P**ressure on the environment (increased pavement and building) and, consequently, the **S**tate of the environment changes, such as the increase of runoff and erosion. Finally, this leads to **I**mpacts on human health, ecosystems and materials (e.g. infrastructure damages, lower water quality and decreased fish habitat) that may elicit a societal **R**esponse that feeds back on the **D**riving forces and **P**ressures (like a new policy to regulate land use), or on the **S**tate or **I**mpacts directly, through adaptation or curative action (adapted from EEA. Technical report No 25/1999).

DPSIR Model workshop: Draw the DPSIR framework on a whiteboard, or print it on a poster to place it on the wall. Place in the "State" circle the core problems, writing them on post-its (one item per post-it). Ask everybody to brainstorm pressures that might be causing the problems in the "State" circle. Ask them to write one item per post-it and place it in the "Pressure" circle. Repeat the process for the "Driver" and the "Impact" circles. Finally brainstorm the solutions you have already applied in your city. You can place the solutions in the "Response" circle, or even better on the red arrows depending on where the solution was applied. Were they applied to a driver, to a pressure, an impact, etc.?

The following is an example applying the DPSIR framework to a stormwater quality problem (figure 7).

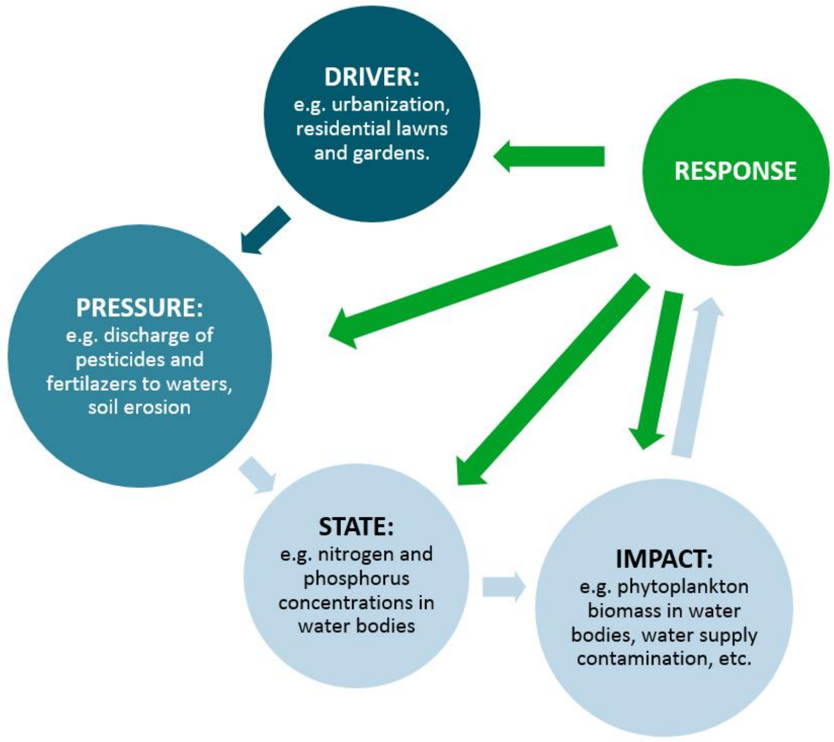

Figure 7. Example of DPSIR framework applied to a stormwater quality problem (adapted from Rekolainen S., Kämäri J., Hiltunen M., Saloranta T. 2003).

Below in figure 8 there is another example applying the DPSIR framework to a stormwater quantity problem.

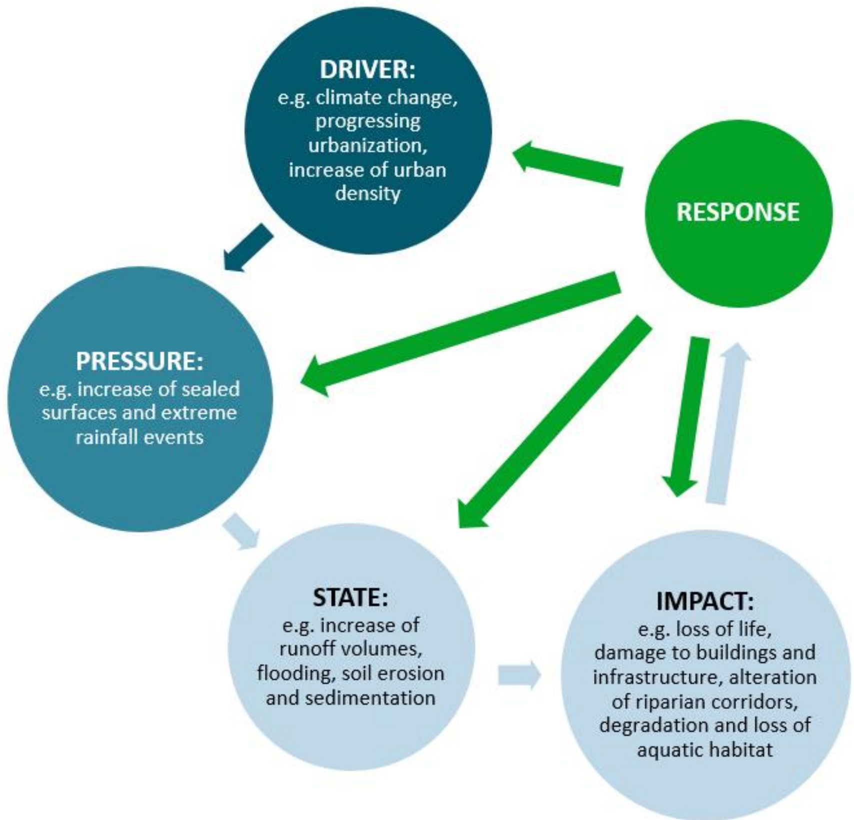

Figure 8. Example of DPSIR framework applied to a stormwater quantity problem.

System Model workshop: Once you have your DPSIR model ready, you can start building the system model from it. Take the post-its from the DPSIR model and place them on another whiteboard or poster on the wall. You can start again from the "State" circle, taking one of the problems and placing it in the middle of the new whiteboard. Place then in the "Pressure" circle the direct causes of the problem that you can find. Draw the links between those causes and the problem with arrows. Repeat the process for the "Impacts" and "Drivers". Finally, place the solutions showing where the solution was applied. The result would be similar to the example in figure 9.

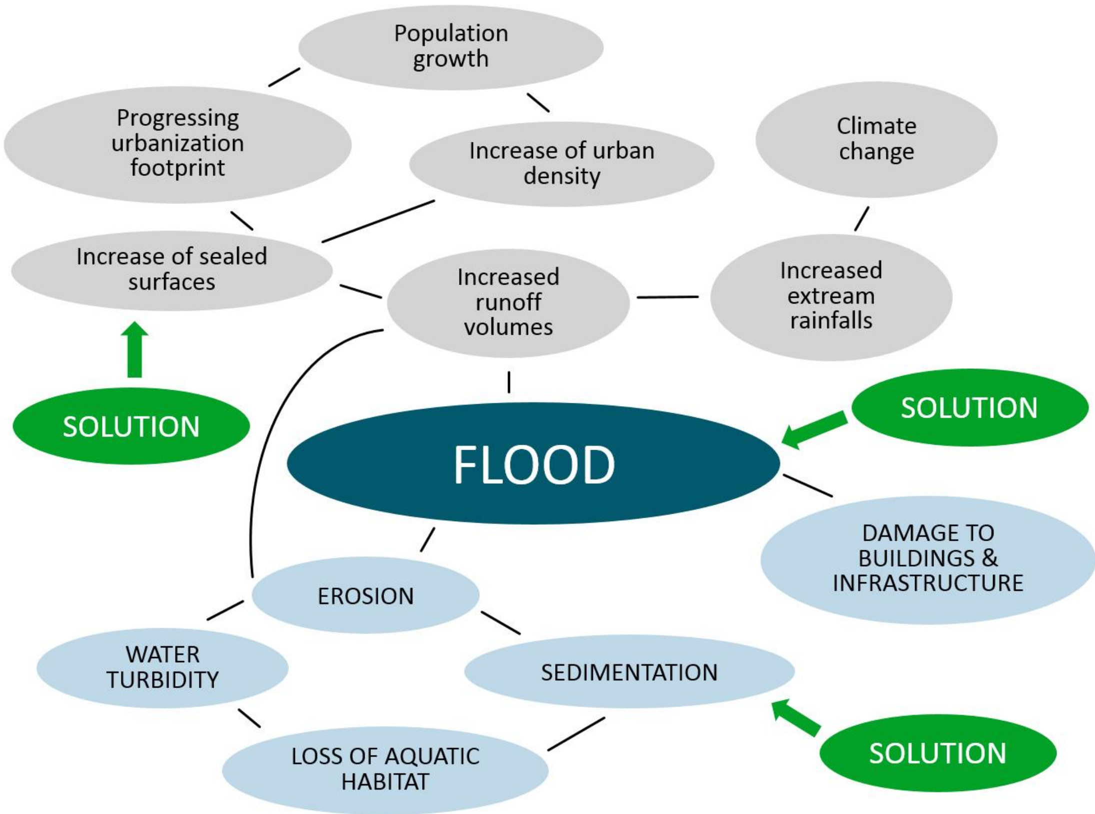

Figure 9. System model example of causes, impacts and solutions of flooding.

Try to find linkages between different DPSIR models as it is showed in figure 10 below. For instance, **soil erosion** due to the **increase of runoff** can also create **stormwater quality problems**. And both **runoff quantity** and **stormwater quality problems** contribute to the degradation and loss of aquatic habitat.

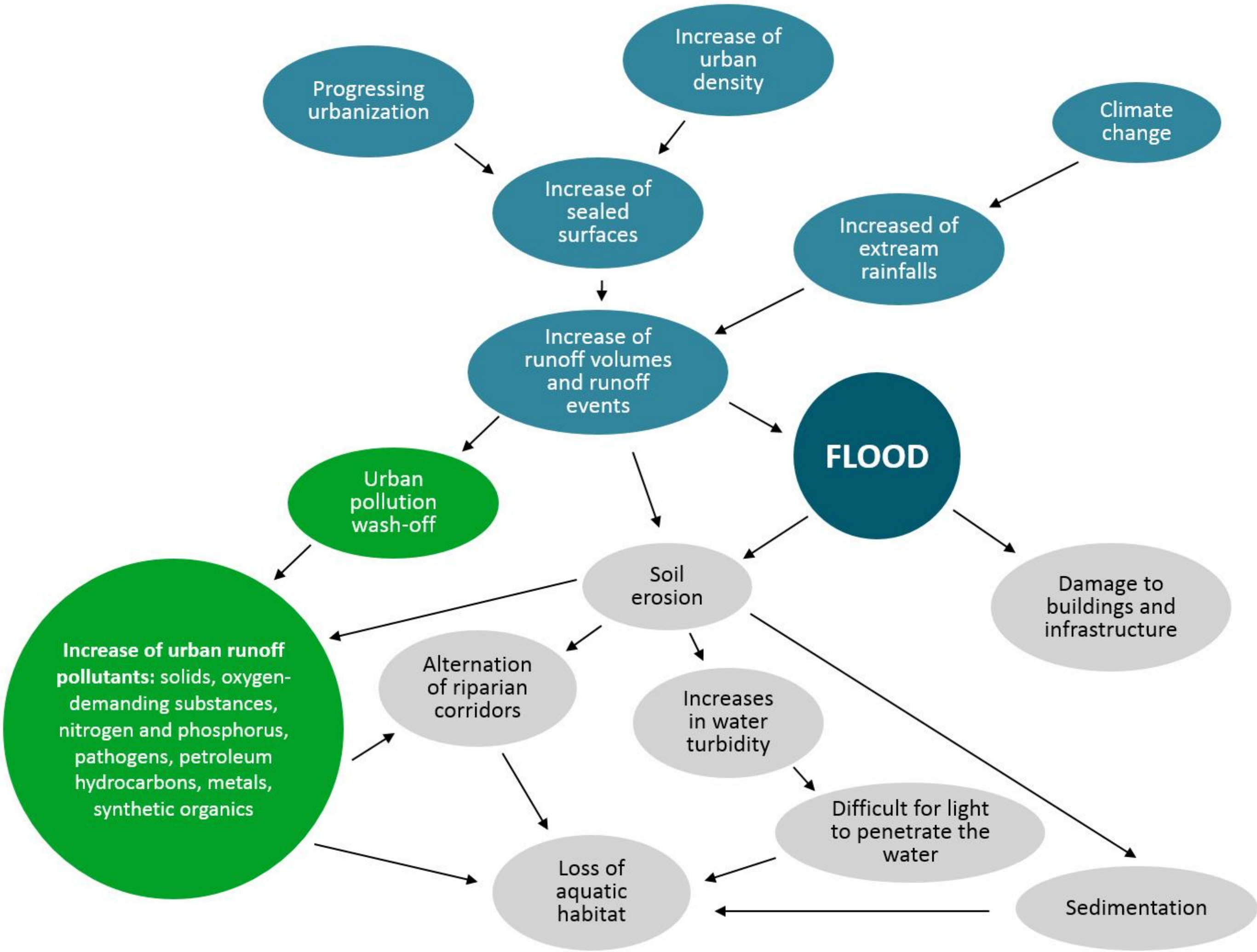

Figure 10. Example of combining DPSIR models about quality and quantity together to better perceive linkages between different factors.

Keep in mind that the real world is far more complex and many of the relationships between the human system and the environmental system are not sufficiently understood, or are difficult to capture in a simple framework. Nevertheless, we need models like the **DPSIR framework** to better grasp the cause–effect links between different factors.

Note: Combine the use of system models and maps (figure 11). In case there are problems affecting different areas of your city, the problems themselves and/or their causes may differ considerably. That means that you will need to work with maps in addition to system models, and even build different system models for different areas in your city.

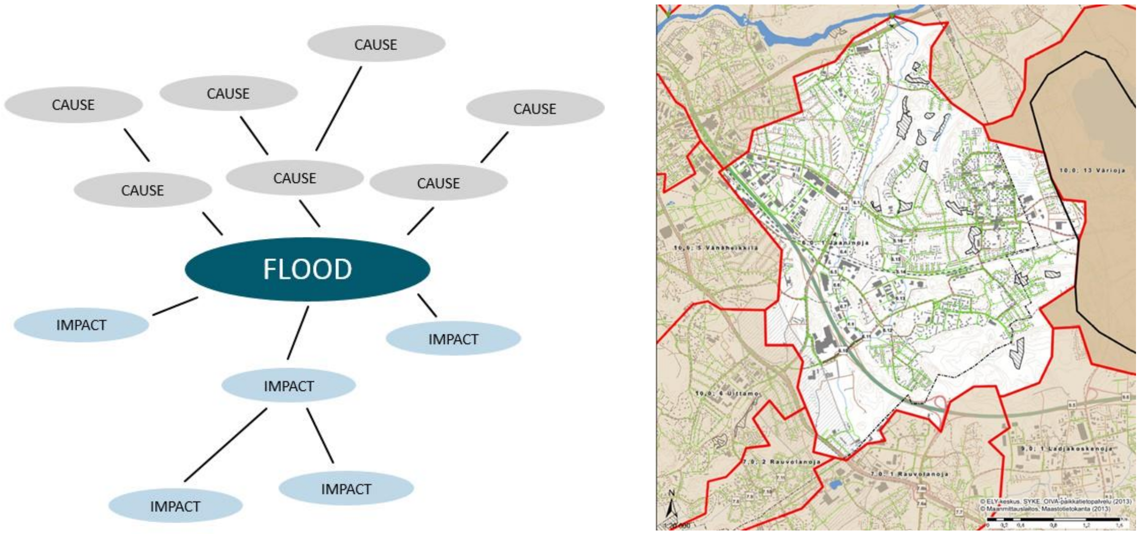

Figure 11. Combining maps and system models to take into account different problems in different parts of the city.

DESIRED CONDITIONS

The desired conditions are the vision and objectives your city is seeking in its stormwater management system. We already explained in the 8.1.1 Collecting information section how to create them. Now, we will use the vision and objectives for setting targets and looking for possible solutions.

The system model you have been creating is also known as “problem tree analysis”. To turn the “problem tree” into a “solution tree” you need to use the objectives you set for your city’s stormwater management system. The best way to show how to do it is by using the problem tree example we used before (figure 9).

To turn the above problem tree into a solution tree we will use the objectives in the Strategic Plan example from the ISWM Annexes folder (document 6.7.):

- Flood prevention
- Waterway health protection

Workshop: Use your own objectives for your city’s stormwater management system. Starting from the impacts situated at the bottom of the model, place the objectives that are related to those impacts. Then moving uphill in the model, turn your problem tree into a solution tree by reversing the negative statements that form the problem tree into positive ones. Follow the example in figure 12.

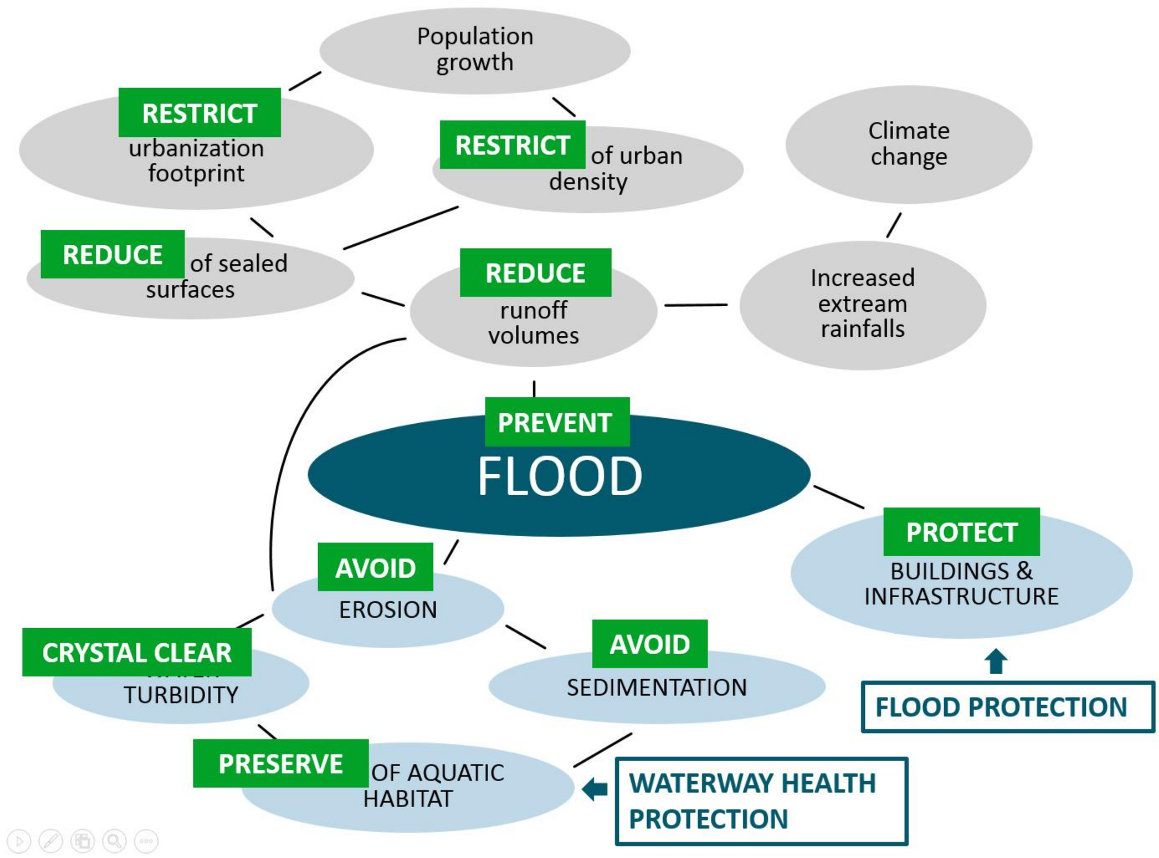

Figure 12. Example of turning the problem tree into a solution tree by using Strategic Plan objectives and reversing the negative statements into positive ones.

It is advisable to go through the solution tree and check to see if all the statements are clear, and if there are any missing steps between a means and an end. If so, you may need to revise both the problem and solution trees by adding more statements.

Workshop: The solution tree is showing now the goals you should accomplish to meet your objectives. To set more specific targets, use the environmental information you were collecting in the PESTLE analysis. Look for thresholds or critical limits, minimum or maximum levels that should not be exceed in order to achieve your objectives. Then, following the examples below, set the targets for the impacts directly linked to your objectives, and then continue setting uphill targets to the rest of the factors in the solution tree (figures 13 and 14).

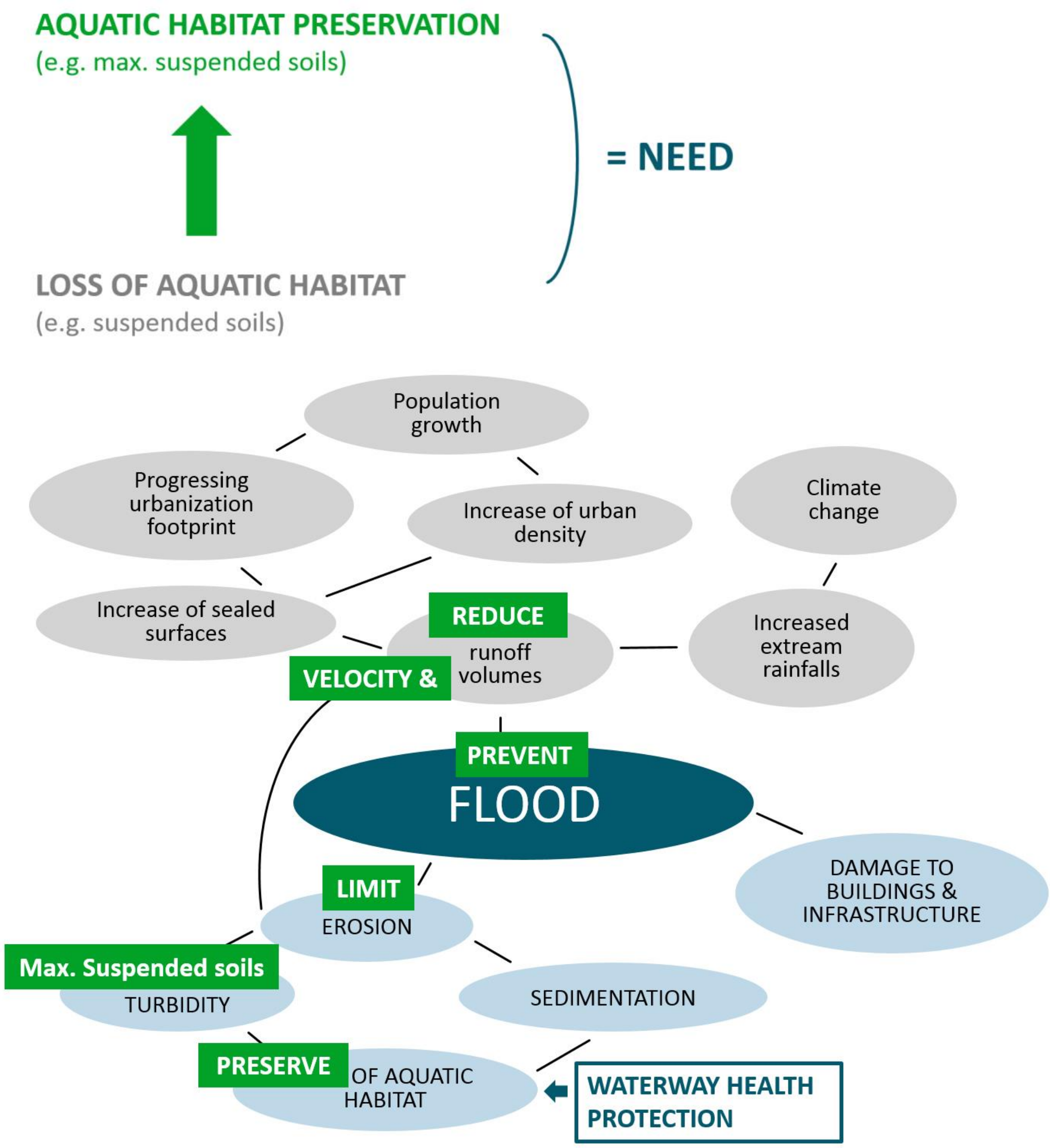

Figure 13. Combining PESTLE analysis results with the solution tree to set more specific targets, example of waterway health protection.

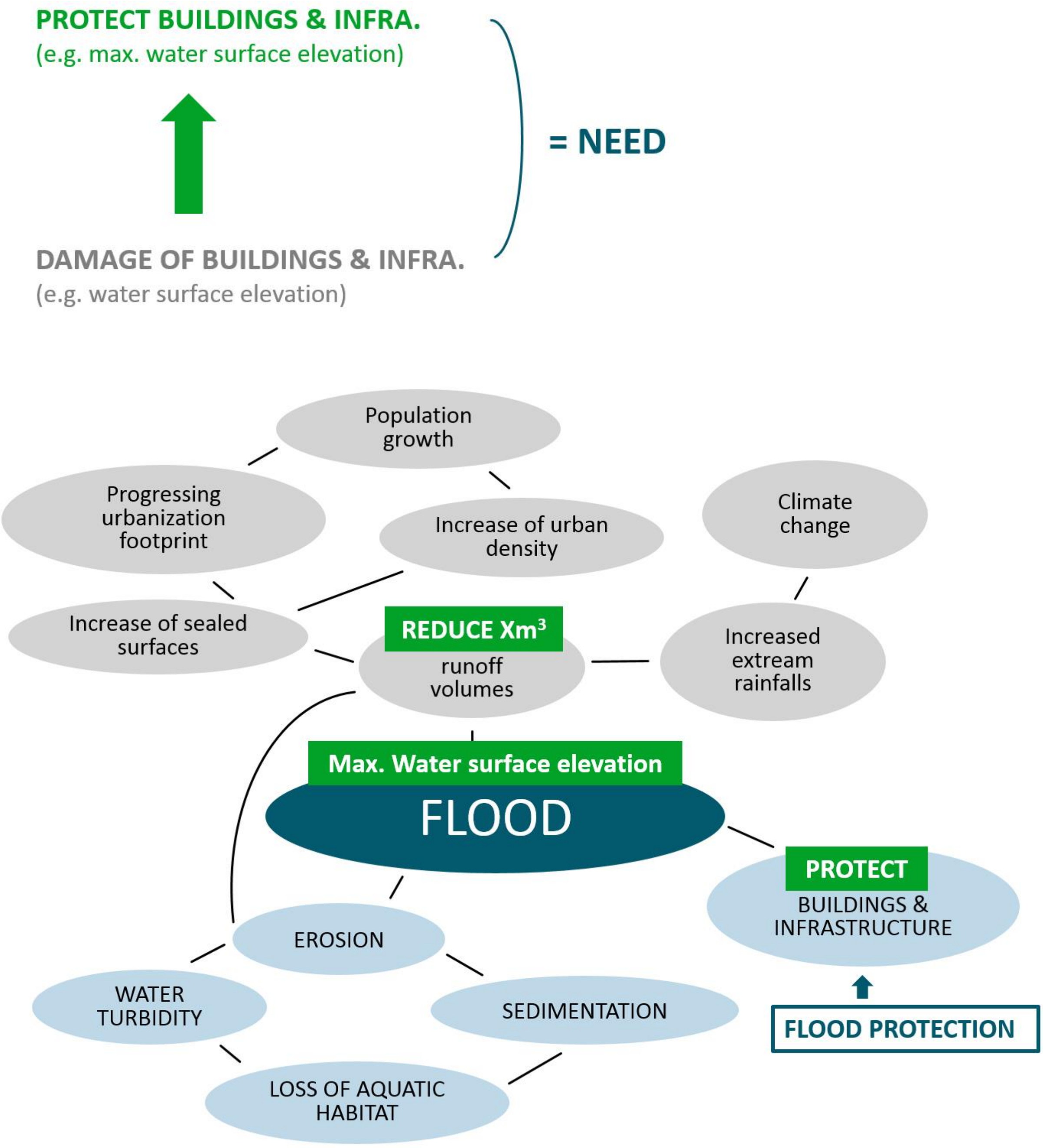

Figure 14. Combining PESTLE analysis results with the solution tree to set more specific targets, example of flood protection.

8.2. Measure selection

Measure selection is the process of identifying the most suitable and cost effective stormwater management options to achieve your vision and objectives and to overcome the identified problems.

First, you will generate and examine potential solutions (Option Generation) and then you will evaluate and rate those (Ranking Solutions) before selecting the most suitable measures.

OPTION GENERATION

Generate and examine potential solutions (figure 15). When generating potential solutions, do not limit them to those that seem more feasible since we need to know all possible solutions available to meet the targets.

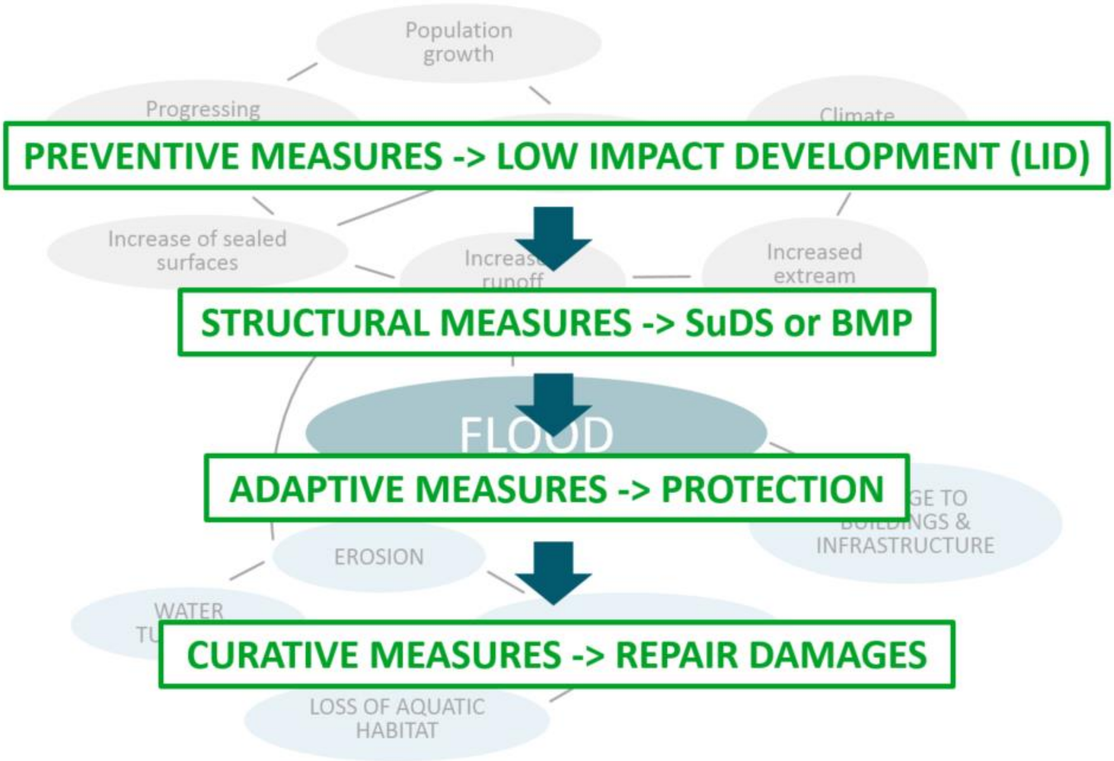

Figure 15. Option generation between different stormwater management solution measures.

Workshop: Generate possible solutions starting from those that would prevent or reduce the runoff volumes. Use the ISWM Measures & Approaches document in the ISWM Annexes folder (document 6.9.) to guide you through the selection. In the "Measures" section of the ISWM Planning Workshop in the ISWM Annexes folder (document 6.8.) you can find examples of some of the measures and approaches explained in the previously mentioned document (document 6.9.). Finally, ISWM Non Structural Solutions document in the ISWM Annexes folder (document 6.10.) classifies measures and approaches according to the urban development processes (horizontal axis) and the intended objectives or problems to overcome (vertical axis).

No measure on its own will be sufficient to achieve your city's objectives or overcome its problems, so you may need to combine the implementation of two or more measures. You can "package" the measures you are interested in creating different alternative solutions. Packaging can help in achieving enhanced performance, but it can also help to overcome barriers to implementation. You should also look at the list of problems you listed before (section 6.1.2) under "Lack of Resources" and "System Problem" categories. You need to put in place measures that will help you overcome those problems.

It is advisable to place each alternative solution (packaged measures) in **your solution tree model** to evaluate how these different measures will interact and whether they will drive toward the **objectives** and **the desired outcome** or whether they will push in a different direction.

RANKING SOLUTIONS

First, we need to set criteria (or standards) for judging the merits of alternative solutions. You can use the list of values and principles of your strategic plan.

The **three principles framework** explained in ISWM Measures & Approaches in the ISWM Annexes folder (document 6.9.), recommends giving preference to prevention measures over structural, adaptive and curative solutions.

Other criteria that should be taken into account:

- Cost-benefit analysis. Including the solution's maintenance or upgrade need.
- Impact. The effect on other parts of the system (or on other needs than the one is targeted) when a specific solution is applied.
- Feasibility of the solution.

Evaluate and rate each **solution** separately against the **evaluation criteria**. You can use a **Multi-attribute** utility analysis (table 1).

Multi-attribute workshop: From the **evaluation criteria** take all the **attributes** needed to evaluate the alternative solutions. They are assigned a weight that reflects their importance to the decision. You may assign a value of 3, 2, or 1 to each attribute, depending on its importance.

You then give a score to each of the solutions for each attribute. You may use a scale of 1–10. Each solution's score for each attribute is then multiplied by the weight of that attribute, and the total is calculated. That is:

(Solution 1 score x Attribute 1 weight) + (Solution 2 score x Attribute 2 weight) + (Solution 3 score x Attribute 3 weight) = TOTAL

The total represents the value (or utility) of that alternative solution, and it can be compared to the same calculation for the others. In case it appears that some attribute is too important in determining the results, you can adjust its weight. Based on all the information, you can now select one from the high-ranking alternatives.

Table 1. Example of multi-attribute utility analysis table.

	ATTRIBUTE 1 **3**	**ATTRIBUTE 2** **1**	**ATTRIBUTE 3** **2**	**TOTAL**
SOLUTION 1	**4**	**2**	**7**	**28**
SOLUTION 2	**1**	**4**	**6**	**19**
SOLUTION 3	**3**	**8**	**2**	**21**

8.3. Action design

The ISWM programme should be more than a wish-list of measures. Prior to implementation, each measure needs to be defined in detail by breaking them down into smaller steps. For that you can use the Backcasting method. Then we will integrate those steps into your city's existing processes.

DEFINING ACTIONS

Backcasting workshop: Start with defining the expected outcome or output for each measure you chose. Then work backwards to identify necessary steps to connect the outcome with the present conditions. Find the backcasting example shown below in figure 16 in the ISWM Planning Workshop in the ISWM Annexes folder (document 6.8.).

Figure 16. Example of backcasting of a stormwater retrofit.

Risk Analysis Workshop: Take into account constraints that you face. You should look again at the list of problems you listed before under "Lack of Resources" and "System Problem" categories. What level of funding is available? How acceptable are different measures likely to be? However, do not take these constraints as reasons for not pursuing a given measure. Instead, use packaging and careful design to overcome them. Find the risk analysis example shown below in figure 17 from the ISWM Planning Workshop in the ISWM Annexes folder (document 6.8.).

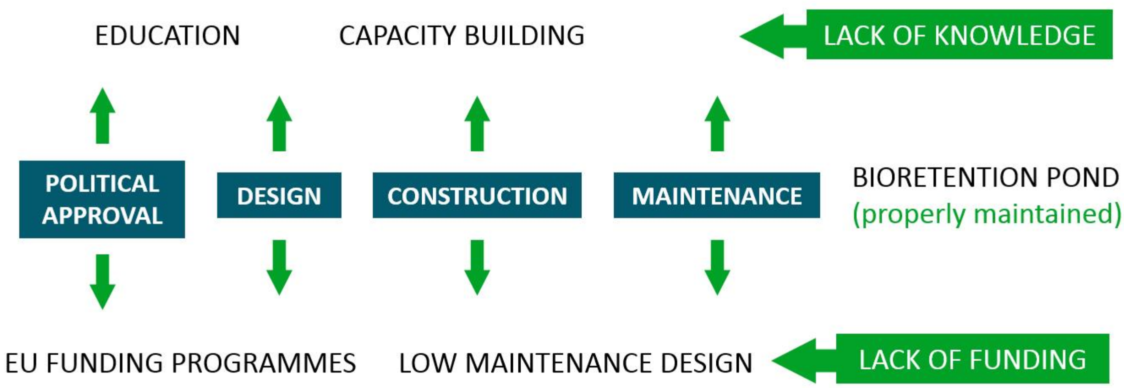

Figure 17. Example of backcasting and risk analysis of a stormwater retrofit.

INTEGRATING ACTIONS

Integrating Actions workshop: Who is responsible for each of the types of measures that you are considering? Start by determining the departments responsible for each measure as we show you in figure 18. ISWM Non Structural Solutions in the ISWM Annexes folder can help you in this task (document 6.10.).

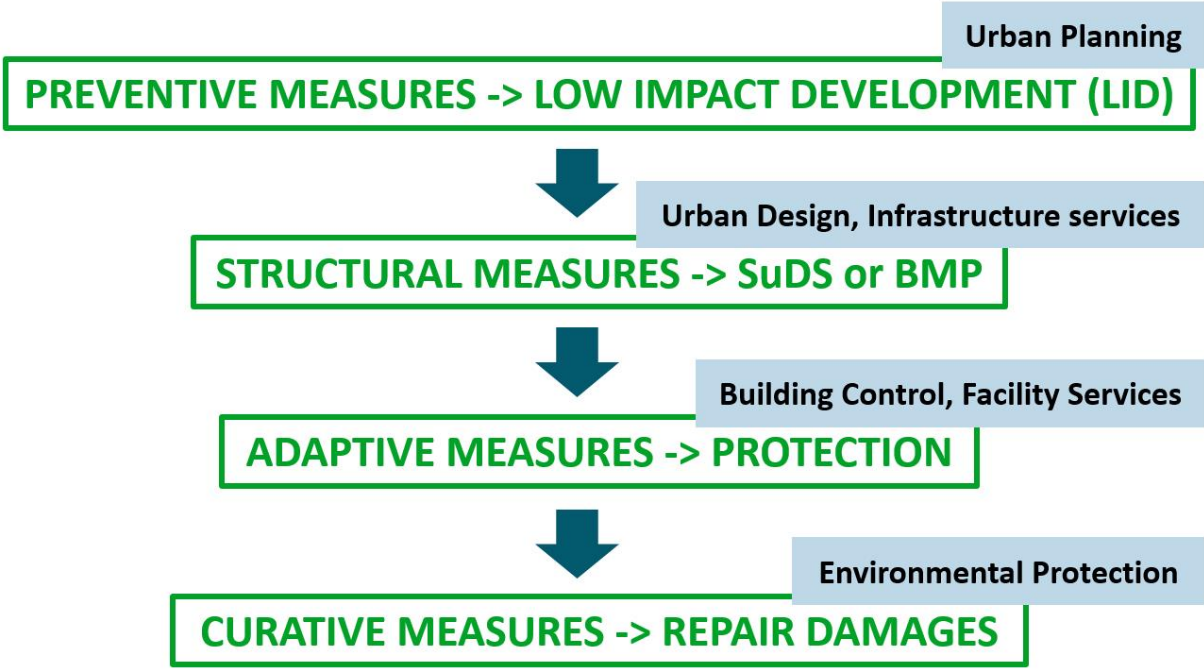

Figure 18. Example of division of responsibilities based on type of measure.

Now use a swimlane diagram to link the processes or actions you defined before and integrate them into the existing processes in your city (figure 19).

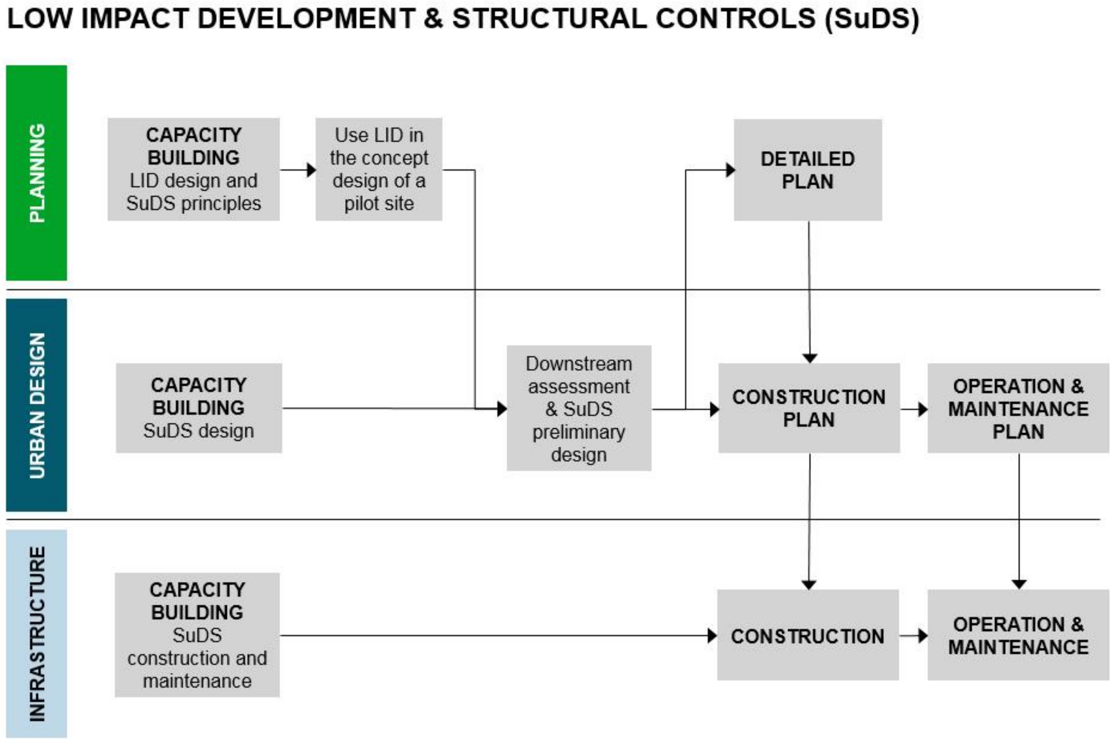

Figure 19. Example of a swimlane diagram.

You can still break down and design in more detail each activity by assigning responsibilities (to an individual or a team) planning the necessary resources, work plan, etc.

9 IMPLEMENTATION

The Implementation is not just delivering activities and outputs, but also managing and controlling those activities during this phase. For that, you will need to implement a range of management processes, which will help you to manage time, cost, quality, risks, stakeholder acceptance and communications, tasks and resources coordination, etc.

Since the implementation process is highly specific to the activity, and there is a lot of literature on project management, these guidelines will not detail the management processes mentioned above. Instead, the ISWM guidelines will focus more on the monitoring and evaluation processes. For more information on implementation and project management, please look for books or search on the internet.

The implementation will include the following steps (figure 20):

- **Setting up the implementation**, including the establishment of a project team and the creation of a work plan.
- **Implementation of the activities**, which includes managing the activities itself, providing inputs, managing risks, etc.
- **Monitoring, evaluating and reporting**, including in addition to monitoring activities, the deployment of supervision, as well as technical reporting covering the delivery of outputs, results, and impacts.
- **Adjusting implementation**, updating the annual work plan based on the results of monitoring and other management decisions.

In the ISWM Annexes folder, you can find the ISWM Implementation Workshop (document 7.1) that will guide you through the process explained in these guidelines.

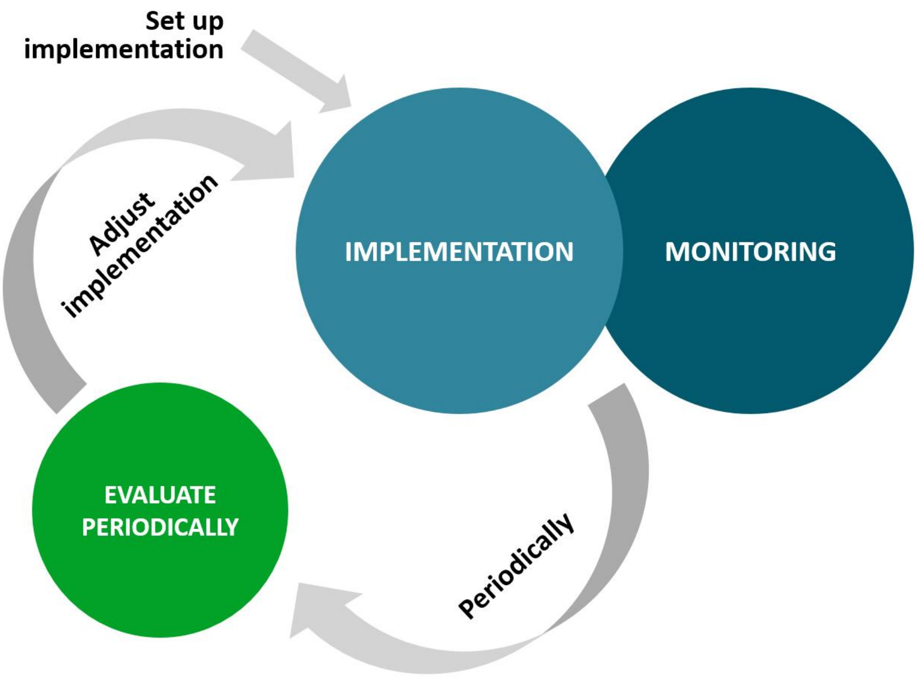

Figure 20. Different steps of the implementation process.

9.1. Monitoring and evaluation

Monitoring and evaluation activities need to be carried out in a structured way and on a regular cycle, although their frequency might vary with evaluation taking place at longer time intervals.

The implementation of the ISWM programme undertakes monitoring and evaluation at three levels (figure 21):

- **ISWM programme level:** to gather evidence of delivery of results and impacts as defined in the ISWM programme.
- **Portfolio level:** to assess the overall health of a group of projects in both financial terms and progress on implementation
- **Project level:** to assess progress in implementation of each project in terms of activities and outputs, delivery of results and impacts, and use of resources.

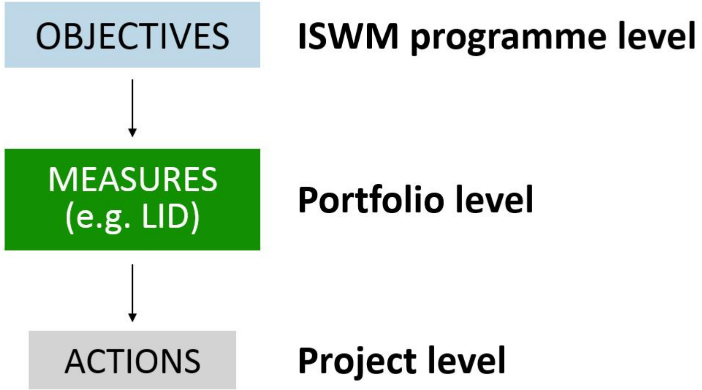

Figure 21. Monitoring and evaluation levels.

MONITORING

Monitoring is the systematic process of collecting, analysing and using information to track a project's progress toward reaching its objectives and to guide management decisions. When monitoring, the information we are looking for is changes in certain specific, observable and measurable characteristics of a project that we call indicators. Indicators should be defined before the project starts, and allow us to monitor or evaluate whether a project does what it said it would do.

Indicators can be classified in many ways. For example, in figure 22 we can see that the day to day implementation of a project involves the implementation of activities and expenditure of budget. These are examples of input indicators (i.e. *expenditure of budget* and *progress of implementation*). In addition to the inputs, at the project level we will also monitor the outputs. Finally, after the project implementation, we can monitor the outcomes and the long term impacts to evaluate the efficiency of the action, and the overall ISWM programme level.

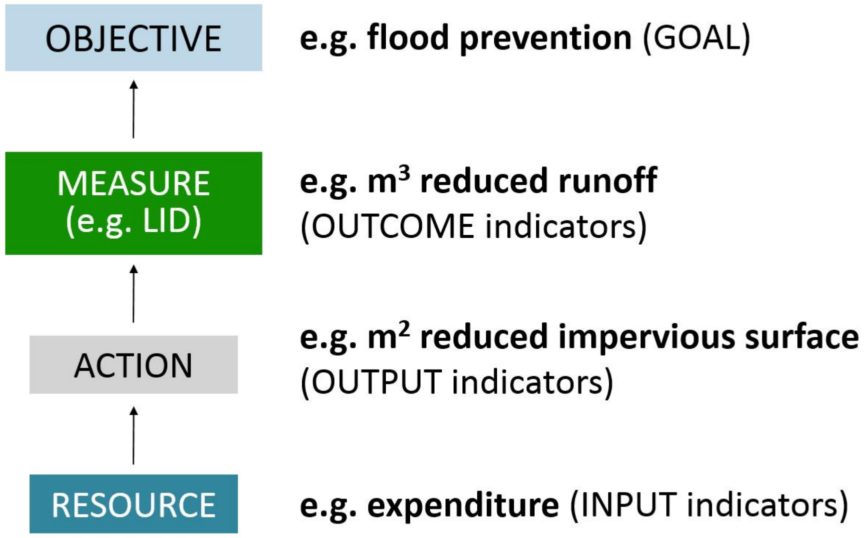

Figure 22. Different types of indicators.

In addition to the previous indicators, we can also collect contextual indicators to provide information on external factors that can have an influence on the successful implementation of ISWM programme (e.g. demography, lifestyle changes, economic development etc.).

Monitoring may be needed before implementation to establish a baseline situation against which to assess the project outcomes. When monitoring activities during the implementation of an individual project it is useful to identify whether resource inputs and project outputs comply with the original plan, or whether corrective actions are required.

Monitoring can focus on different dimensions of the water resource:

- **Biological monitoring** (e.g. e. coli, fish)
- **Physical monitoring** (e.g. flow, suspended sediment, streambank stability)
- **Chemical monitoring** (e.g. phosphorus, heavy metals)

Social indicator like changes in knowledge, attitudes and behavior of people are important for two reasons:

- Because some ISWM programme's goals and actions can be related to increasing knowledge and awareness and changing attitudes among groups such as residents, business owners, and municipal employees.
- Because they can work as intermediate benchmarks in a successful ISWM programme when many years are needed to measure a water quality response.

According to the sampling methods, indicators can be also divided into:

- Quantitative (e.g. Total Suspended Soils TSS (mg/L)
- Qualitative (e.g. streambank stability: regular photography of critical locations)

EVALUATION

Evaluation generally needs to be done at the end of the implementation cycles, but in practice, monitoring and evaluation activities will often be carried out in parallel with implementation, for example to review intermediate outcomes. It is advisable to carry out evaluations during the implementation process at crucial decision points, especially in long lasting projects.

Evaluation is the systematic and objective assessment of an ongoing or completed project or plan to determine how well a measure or a policy has performed. When carried out before the implementation, it is known as appraisal or ex-ante evaluation. This kind of evaluation is part of the measure selection process and thus it was covered before.

9.2. Monitoring and evaluation plan

A monitoring and evaluation plan (M&E plan) is a document that helps to track and assess the results of the interventions throughout the life of a programme. It is a living document that should be referred to, and updated on a regular basis. While the specifics of each program's M&E plan will look different, they should all follow the same basic structure and include the same key elements.

An M&E plan will include some documents that may have been created during the planning phase, and some that will need to be created. The M&E plan takes those documents and develops a further plan for their implementation.

Example of the structure and content of the M&E plan:

1. **Introduction**
2. **Logical framework**
3. **Monitoring Plan**
4. **Evaluation Plan**
5. **Analysis and Evaluation Methods**
6. **Roles and responsibilities**
7. **Reporting & dissemination**

INTRODUCTION

The introduction will include the purpose (goal) of the M&E plan and other information related to it, like:

- Beneficiaries
- Target area
- Duration
- Starting date
- Cost
- Funding source
- etc.

LOGICAL FRAMEWORK

Depending on the number of objectives and activities in your project or ISWM programme, create one or more logical frameworks. In ISWM Annexes folder, you can find two examples of logical frameworks (document 7.2.).

A standard logical framework is divided into four rows, which are your long- to short-term objectives ranging from top to bottom (figure 23). These are achieved and measured by the headings from left to right: indicators, means of verifications and risks/assumptions.

Once you have all your goals, outcomes, outputs and activities down on the table, think how can you measure the progress of the project against the aims you have set out. Write these in the “Indicators” and “Means of verification” columns. Choose indicators that will let you measure whether the different levels in your project have been achieved. Set out the information required for the indicators in the “Means of verification” column. This could be sourced from documents, field surveys, training reports, etc.

The fourth column is called “Risk/assumption” – which essentially means a risk analysis. This is about being prepared for external circumstances, and how you will reduce the severity of those risks, so you should budget for that. To make sure that the mitigation actions you wrote in the “Risk/assumption” will help you get your intended objectives, it is advisable to analyse the logical framework using the “if” and “then” statements as it is explained in the example given in figure 23.

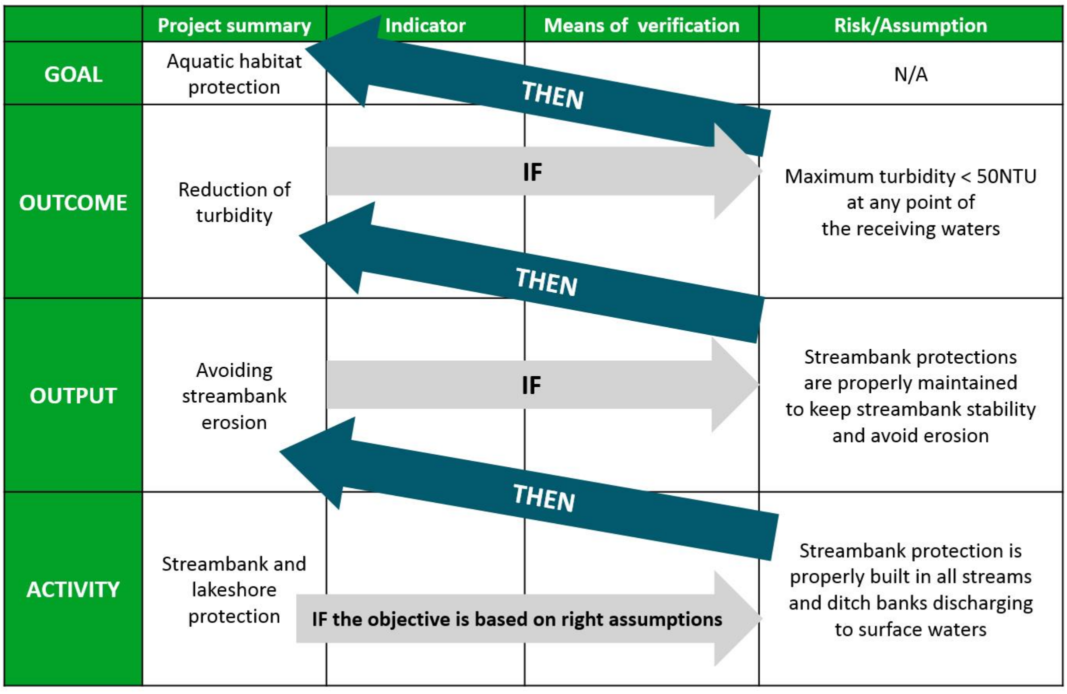

Figure 23. Example of a logical framework.

Starting from the bottom of the logical framework (activity) and following the example above:

- If the streambank protection is properly built in all streams and ditch banks discharging to surface waters, then we will avoid streambank erosion.
- If streambank protections are properly maintained to keep streambank stability and avoid erosion, then we have a reduction of water turbidity.
- If the maximum turbidity is below 50 NTU at any point of the receiving waters, then we will achieve habitat protection.

MONITORING PLAN

Create a table with indicators, data sources, collection timing, and staff member responsible (table 2).

Table 2. Example of what a monitoring plan table can include.

Activity	Output/ Outcome	Indicator	Purpose	Baseline	Target	Data source	Frequency	Responsible persons

ANALYSIS AND EVALUATION METHODS

You can use the Appendix A of the Taylor &Wong 2003 document to find one or more suitable styles of evaluation for your M&E plan. The seven styles are listed from the easiest and less resource demanding (style 1) to the most complicated and expensive (style 7).

For instance, if you plan and implement an educational programme with the objective of raising awareness of stormwater pollution within a target audience, then style no. 2 (monitoring changes in people’s awareness and/or knowledge) would be appropriate. However if the objective is to reduce littering of public spaces, style no. 5 would be the most appropriate as it would monitor actual changes in people´s behavior. For multiple objectives, several styles of evaluation may be needed.

EVALUATION PLAN

Indicate planned evaluations and proposed schedule, including the purpose of the proposed evaluations, as well as links between evaluations and data collection. You can use for example a Gantt chart indicating the planned tasks, frequency, timeline, responsible persons, etc., for both monitoring and evaluations.

ROLES AND RESPONSIBILITIES

First define how the data and reporting will flow from the place where it is created up to the management team and then to other stakeholders (figure 24).

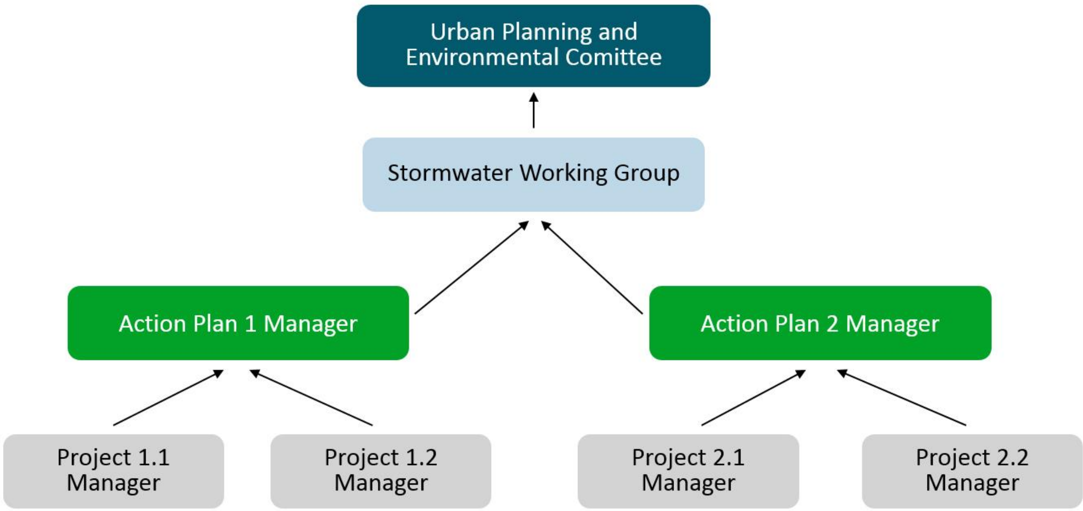

Figure 24. Example of a flow chart depicting data flow.

Then, make a description of each staff member's role in M&E data collection, analysis, and/or reporting (table 3).

Table 3. Example of a table depicting roles and responsibilities of different persons/units.

PERSON/UNIT	ROLES & RESPONSIBILITIES
Urban Planning and Environmental Committee	Oversight of the ISWM programme evaluation function. Use of evaluation results.
Stormwater Working Group	Global evaluation of the ISWM programme implementation. Monitoring progress of ISWM programme implementation and quality control. Use of the evaluation results.
Action Plan Managers	Individual project evaluations. Monitoring progress of action plan implementation and quality control. Use of evaluation results.
Individual Project Managers	Individual project M & E plan development. Monitoring individual project outputs and progress of implementation. Support evaluations. Use evaluation results.

REPORTING & DISSEMINATION

Create a reporting template and a description of how and when data will be disseminated internally and externally.

10 CONCLUSION

The uniqueness of the iWater project is in its holistic approach to highly complex ISWM development process. During the iWater project partnership realized that this process of planning and implementing an ISWM system can be too demanding for the cities, thus some of the iWater project partner cities used specialized consulting services to assist them in development of their own ISWM system.

The word "integrated" in the ISWM system means combining and interrelating multiple new solutions to make them work cooperatively. Besides, planning, implementing and maintaining these solutions are new processes that you should coordinate with the existing urban development processes as well as with multiple stakeholders involved in stormwater management in your city.

To create an ISWM system for your city, firstly you will need extra human resources for the whole process since it is highly time consuming, and secondly you will need expertise in new subjects and areas you have never used before in your city. Relying just on your own means could lead to an unsuitable result.

However, the iWater project team encourages you to make the effort, as managing stormwater runoff becomes a growing challenge for many cities around the BSR. We hope that our experience and lessons learnt will be helpful to you in your work, addressing such challenges of urban sustainability as creating more resilient and higher quality urban environment, preventing erosion, regulating local climate, maintaining biodiversity, improving water quality and air quality, and public health in your city!

More information on the iWater project results: www.integratedstormwater.eu.

11 GLOSSARY

Activity – That set of tasks which are organized and broken down into a set of procedures to accomplish a specific goal. The distinction between a sub-function and an activity is as much a matter of interpretation as it is a matter of scope.

Analysis – The separation of an intellectual or substantial whole into its constituent parts for individual study. The stated findings of such a separation or determination.

Application – The specific set of activities under analysis. An application may consist of one or more activities within a functional area, or it may include all activities within a functional area. In some cases the application may cross functional areas. In some firms an application is synonymous with a system.

Attribute – An aspect, quality, or characteristic of either an entity or a relationship which describes it. An attribute may be a physical characteristic, such as size, weight, or color, or a locational attribute, such as place of residence or place of birth. It may be a quality such as level of a particular skill, educational degree achieved, or the dollar value of the items represented by the order.

Baseline – An item or collection of items of a particular shape and form used as a reference. A baseline configuration is a reference point for evaluating modifications and enhancements and a starting point for making those changes.

Backcasting method – A planning method that starts with defining a desirable future and then works backwards to identify policies and programs that will connect that specified future to the present.

Best Management Practices or BMPs – Multiple treatment methods, activities, facilities and structures that, used together, help protect water quality by preventing or reducing pollution of stormwater and removing pollution from runoff before it is discharged to ground or surface water.

Biodiversity – The term biodiversity describes the variety of life on our planet or a specific region, measurable as the variety within species, between species, and the variety of ecosystems.

Biofiltration – Biofiltration refers to the use of plants and other biological materials to enhance infiltration of water into the soil. Biofiltration incorporates the chemical, biological, and physical properties of plants, microbes, and soils for the removal of pollutants from stormwater runoff.

Biofiltration swale – A broad, open, vegetated channel that filters flowing stormwater. The most common form is a wide, shallow, inclined depression planted with grasses.

Bioretention – Bioretention is the process of collecting stormwater in a treatment area consisting of soil and plant materials to facilitate infiltration and remove sediment and other contaminants through physical, chemical, and biological processes.

Brainstorming – A situation where a group of people meet to generate new ideas and solutions around a specific domain of interest by removing inhibitions. People are able to think more freely and they suggest many spontaneous new ideas as possible. All the ideas are noted down and are not criticized and after brainstorming session the ideas are evaluated.

Catch basin – An underground concrete structure, typically fitted with a slotted grate, to collect stormwater runoff and route it through underground pipes. It allows sediment and debris to settle out of the runoff and can have inserts or other fittings to trap oils and floatables. A catch basin also can be used as a junction in a pipe system and have a solid lid. Maintaining a catch basin often requires special expertise and equipment.

Closed detention system – An underground structure, typically a concrete vault or series of large diameter pipes, which temporarily stores stormwater and releases it slowly. A closed detention system typically is used for sites that do not have space for an above-ground system. It is accessed through a manhole lid.

Curb inlet or storm drain – A catch basin that collects and conveys stormwater runoff. Usually found along a curb, a storm drain has a slotted cover and a curb inlet has an opening in the curb.

Data analysis – That process by which the data requirements of a functional area are identified, element by element. Each data element is defined from a business sense, its ownership is identified, and users and sources of that data are identified. These data elements are grouped into records, and a data structure is created which indicates the data dependencies.

Detention facility – A pond, vault or pipe which temporarily stores stormwater runoff and slowly releases it through a specially designed outlet. Detention facilities are designed to drain completely within a few hours or days.

Detention pond – An open basin built by excavating below ground or constructing above-ground embankments. It temporarily stores stormwater runoff and slowly releases it through a specially designed outlet.

Diffuse pollution – Pollution from widespread activities with no one discrete source, e.g. acid rain, pesticides, urban run-off, etc.

Direct point source – A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Discharge point – The place where a stormwater system empties into a stream or other body of water.

DPSIR – The causal framework for describing the interactions between society and the environment adopted by the European Environment Agency: **d**riving forces, **p**ressures, **s**tates, **i**mpacts, **r**esponses (extension of the PSR model developed by OECD).

Drywell – An underground, concrete structure that allows stormwater to soak into the ground through holes in the walls and/or open bottom. Maintenance often requires special expertise and equipment.

Eutrophication – A process of pollution that occurs when a lake or stream becomes over-rich in plant nutrient; as a consequence it becomes overgrown in algae and other aquatic plants. The plants die and decompose. In decomposing the plants rob the water of oxygen and the lake, river or stream becomes lifeless. Nitrate fertilizers which drain from the fields, nutrients from animal wastes and human sewage are the primary causes of eutrophication.

Filter strip – A strip of grass, usually along edges of parking lots and roads, which filters stormwater by removing sediment and oils before the water soaks into the ground.

Filter vaults or stormwater filters – Underground vaults, manholes or specialized catch basins that include a series of filter cartridges to capture sediment and pollutants before stormwater flows into a pipe system. Types of pollutants removed depends on the medium used in the filter cartridge.

Flow control structure/flow restrictor – A structure that restricts or slowly releases stormwater at a specific rate to reduce flooding and stream erosion and filters pollutants.

Grey infrastructures – A network that includes the pipes, pumps, ditches, and detention ponds engineered by people to manage stormwater.

Green infrastructures – A network of high quality strategically designed nature/semi-nature areas. Green infrastructure is a cost-effective, resilient approach that reduces and treats stormwater at its source while delivering environmental, social, and economic benefits

Hydrological cycle – The water cycle, technically known as the hydrological cycle, is the continuous circulation of water within the Earth's hydrosphere, and is driven by solar radiation. This includes the atmosphere, land, surface water and groundwater. As water moves through the cycle, it changes state between liquid, solid, and gas phases. Water moves from compartment to compartment, such as from river to ocean, by the physical processes of evaporation, precipitation, infiltration, runoff, and subsurface flow.

Impervious – A hard surface which either prevents or retards the entry of water into the soil as under natural conditions prior to development; and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Impervious surfaces seal the soil surface, eliminating rainwater infiltration and natural groundwater recharge.

Infiltration – Infiltration is the process of water moving into the soil from the soil surface.

Infiltration basin – An open basin built by excavating below ground or constructing above-ground berms, or embankments. It temporarily stores stormwater runoff and disposes of it by letting it soak into the ground.

Interview – A formal face-to-face meeting, especially, one arranged for the assessment of the qualifications of an applicant, as for employment or admission. A conversation, as one conducted by a reporter, in which facts, or statements are elicited from another.

Large basin management – A large basin is a natural or artificially created pond, lake or other space used for storage, regulation or control of water.

Low impact development – A term used in Canada and the United States to describe a land planning and engineering design approach to manage stormwater runoff as part of green infrastructure. LID emphasizes conservation and use of on-site natural features to protect water quality.

Manhole – An underground, concrete structure that provides maintenance access to pipes that transport stormwater runoff. It is usually found in paved areas and has a solid lid.

Method – A means or manner of procedure, a regular and systematic way of accomplishing something. An orderly and systematic arrangement. Procedures according to a detailed, logically ordered plan.

Methodology – The system of principles, practices, and procedures applied to a specific branch of knowledge.

Model – A representation, either graphic, narrative, or a combination of both, of a physical or conceptual environment. A model must identify the major components of the environment, describe those components in terms of their major attributes, and depict the relationships between the components and the conditions under which the components exist and interact with each other.

Multi-attribute utility model – Mathematical tool for evaluating and comparing alternatives to assist in decision making about complex alternatives, especially when groups are involved.

Nutrients – Nutrients are chemical elements which are involved in the construction of living tissue and which are needed by both plant and animal. The most important in terms of bulk are carbon, hydrogen and oxygen, with other essential ones including nitrogen, potassium, calcium, sulphur and phosphorus.

Oil-water separator – An underground vault that treats stormwater by mechanically separating oil from water. The oil rises to the surface and floats on the water and sediment settles to the bottom. Oil-water separators are typically used where high oil concentrations are anticipated in the stormwater runoff. For example, parking lots, service and fuel stations.

Permeable surface – Specially constructed paving surfaces that allow water to pass through and soak directly into the ground.

PESTLE analysis – A mnemonic which in its expanded form denotes P for Political, E for Economic, S for Social, T for Technological, L for Legal and E for Environmental. It gives a bird's eye view of the whole environment from many different angles that one wants to check and keep a track of while contemplating on a certain idea/plan.

Plan – That sequence of activities which are to be followed. A plan states each task, the estimated time to complete it, the persons assigned to perform it, and any task-to-task dependencies. Plans are updated on a periodic basis with actual results, and new estimates are determined. At any point, the plan should reflect actual progress and remaining work.

Pollution – Pollution is the introduction of substances or energy into the environment, resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment.

Programme – A set of related measures or activities with a particular long-term aim.

Precipitation – In meteorology, precipitation is any product of the condensation of atmospheric water vapour that is deposited on the earth's surface. It occurs when the atmosphere becomes saturated with water vapours and the water condenses and falls out of solution. Air becomes saturated via two processes, cooling and adding moisture. Precipitation that reaches the surface of the earth can occur in many different forms, including rain, freezing rain, snow, sleet, and hail.

Procedure – The specific steps which must be followed in order to accomplish a specific task or activity.

Process – A sequence of related activities, or it may be a sequence of related tasks which make up an activity. These activities or tasks are usually interdependent, and there is a well-defined flow from one activity to another or from one task to another.

Rain garden – Specially designed, site-specific stormwater facility that use plants and soils to capture pollutants and allow stormwater to soak into the earth.

Relationship – An association, linkage, or connection, either real or suspected, between entities of the same or different set which describes their interaction, the dependence of one upon the other, or their mutual interdependence.

Resilience – the capacity to recover quickly from difficulties; toughness. (Climate resilience) the ability of systems to recover from extreme weather and climate events.

Retention – Retention is the process of collecting and holding stormwater runoff.

Retention facility – A drywell, vault, infiltration basin or pond that holds stormwater while it soaks into the ground.

Retrofit - A retrofit is a management practice constructed or implemented in an existing developed area.

Review – A re-examination or reconsideration. A retrospective view or survey. An inspection or examination with the intention of evaluating and correcting flaws or errors.

River basin – The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.

Risk analysis – A process that helps you identify and manage potential problems that could undermine a project.

Runoff – Water originating from rainfall and other precipitation that ultimately flows into drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow groundwater.

Standards – The rules which must be followed in order to accomplish a specific activity or task. Standards are established to ensure that all work is performed in a uniform manner.

Storm drain or curb inlet– A type of catch basin that collects and conveys stormwater runoff.

Stormwater – Stormwater is water that originates during precipitation events and snow or ice melt. Stormwater can infiltrate into the soil, be held on the surface and evaporate, or run off surfaces such as rooftops, paved streets, highways, and parking lots. It can also come from hard grassy surfaces like lawns, play fields, and from gravelled roads and parking lots.

Stormwater runoff – Water from rainstorms, irrigation or other sources, that flows across and off a hard area, such a street, paved lot, roof or sidewalk, that prevents it from soaking into the ground.

Stormwater system – A system of catch basins, pipes and/or facilities for conveying, detaining or treating stormwater. Not to be confused with a sanitary sewer, which carries wastewater to a treatment facility.

Stormwater treatment facility – A landscaped feature or structure that captures, conveys, slows, detains and/or treats stormwater. They include detention facilities and retention facilities.

Strategy – A plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem.

SuDS – Sustainable drainage systems are a natural approach to managing drainage in and around properties and other developments. SUDS work by slowing and holding back the water that runs off from a site, allowing natural processes to break down pollutants.

System – A group of interacting, interrelated, or interdependent (business functions, processes, activities or) elements forming a complex whole. A functionally related group of elements, for instance, a network of structures and channels, as for communications, travel, or distribution.

System analysis – System analysis is the process of studying a procedure or business in order to identify its goals and purposes and create systems and procedures that will achieve them in an efficient way. System analysis can also be viewed as a problem-solving technique that breaks down a system into its component pieces for the purpose of the studying how well those component parts work and interact to accomplish their purpose.

Swale – A shallow drainage conveyance with relatively gentle side slopes.

SWOT analysis – A strategic planning technique used to help a person or organization identify the Strengths, Weaknesses, Opportunities, and Threats related to business competition or project planning.

Topography – The representation of a portion of the earth’s surface showing natural and man-made features of a given locality such as rivers, streams, ditches, lakes, roads, buildings and variations in ground elevations for the terrain of the area.

Treatment wetland – A shallow man-made pond designed to treat stormwater through the biological processes associated with aquatic plants. These facilities use dense wetland vegetation and settling to filter sediment and other pollutants out of stormwater.

TSS – Total suspended solids is a water quality parameter used to measure solid materials, including organic and inorganic, that are suspended in the water.

Water body – Any mass of water having definite hydrological, physical, chemical and biological characteristics and which can be employed for one or several purposes.

Water pricing – Applying a monetary rate or value at which water can be bought or sold.

Watershed – The dividing line between two adjacent river systems, such as a ridge.

Water stress – Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.).

Water table – The top of the water surface in the saturated part of an aquifer.

Wetpond – An open basin, built by excavating below ground, that has a year-round pool of water. The volume allows sediment to settle out. Wetponds also have additional temporary storage above the permanent water level to detain and slowly release stormwater.

This manual was developed within the iWater - Integrated Storm Water Management project (2015–2018).

iWater aims at improving the urban planning in the cities of the Baltic Sea Region through development of integrated storm water management system. Project provides new approaches and tools for urban planning – for greener, safer, more sustainable and attractive cities.

For more details please visit project website at www.integratedstormwater.eu

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