Even though this document shows a wide range of ISWM measures and approaches, it is not a comprehensive collection of them. Therefore, in looking at possible measures, we encourage you to cast your net as widely as possible. Look at the different types of measures and the information on them. Try to understand how it works and can thus contribute to your objectives.

To achieve the best results at the lowest costs, it is recommended in stormwater management to use the following three principles framework:

1. **Prevention** – Trying to avoid as much as possible any undesirable situation, like the increase in runoff volume, stormwater pollution, or damages to buildings and infrastructures. Under this principle you can find all the non-structural solutions (e.g. planning, education, regulations, etc.).
2. **Source Control** – Once the runoff appears we need to use structural solutions to detain or retain it. The decentralized solutions working at the source, or near the source, are the controls used in this principle.
3. **Structural Control** – Using large infrastructures assets in the SWM (i.e. centralized structural solutions).

According to these principles, we group the ISWM measures in four categories:

- **Preventive Measures** – Low Impact Development (LID) measures
- **Structural Measures** – known as Sustainable Draining Systems (SuDS), Water Sensitive Urban Design (WSUD) or Best Management Practices (BMP)
- **Adaptive Measures** – like protection against climate extremes
- **Curative Measures** – repairing damages

Bellow you can find the different categories explained in more detail. For examples in each category, please refer to the **ISWM Planning Workshop** presentation (document 6.8 in the ISWMtools folder).
PREVENTIVE MEASURES

Preventive measures, also known as non-structural solutions, are the first ones to be considered and applied to the factors situated in the upper part of our system model.

Non-structural measures involve managing people’s behaviour rather than just large infrastructure assets. They are intended to protect the quality or limit the quantity of urban run-off. They include:

- planning
- education
- regulation and policies (price approach policies like market-based environmental policies, non-price approaches like pollution regulation or voluntary adoption of stormwater harvesting solutions)

Non-structural solutions work as prevention measures, since they are used before the run-off appears. For example, planning measures are decisions that can be made at the urban planning and urban design levels, like:

- Conservation of undisturbed natural areas and riparian buffers
- Preserve topography and natural hydrology
- Locate development in less sensitive areas
- Use compact development and transit-oriented development principles
- Use already-developed land
- Reduce and disconnect impervious surfaces
- Use natural features for storm water management
Non-structural centralised solutions are seen as “top-down” approach, where a top level in certain hierarchy decides what results are to be achieved and how, and passes the plan down the hierarchy to lower levels.

Planning is considered a non-structural centralized solution, where the outputs of a certain planning level become the requirements of the next lower level in the hierarchy. This approach is very helpful when analysing the impact of urban development at a watershed scale, and transferring the findings down to keep the coherence of the stormwater management solutions at the different planning levels. For example, planning can be used to prevent infrastructure damage in areas subjected to flooding. This could be done by restricting land use in those areas to low intensity uses, such as recreation and agriculture, and discouraging development. Marketplace mechanisms, such as offset schemes, can be also introduced in planning for off-site cooperative mitigation measures (e.g. mitigation banking or In-Lieu programs).

Non-structural decentralised solutions like regulation, education and capacity building can solve the problem at the source. They are also faster to deliver than the structural centralised solutions, and easier to modify or stop than any other solution.

For example, Education and Capacity Building solutions contribute to awareness rising and thus they can create demand for new and innovative stormwater management solutions.

Well applied, non-structural solutions can lead to lower cost. Therefore they should be given preference over structural controls. Where it is not possible to fully meet the stormwater requirements with non-structural solutions, they should be then used in conjunction with structural solutions.

It is also advisable to organise non-structural solutions from decentralized to centralized, that is from the lightest and easiest to apply (education, regulation) to those that would need the highest amount of resources (time, budget, etc.) like planning (especially master planning).
Structural measures involve construction, moving earth and planting vegetation to reduce or delay stormwater flow and/or to intercept or remove pollutants. Structural solutions are measures used after the runoff appears.

Structural measures include:

- rainwater harvesting
- pervious pavements
- filter strips
- swales
- green/brown roofs
- ponds
- infiltration basins and trenches
- underground storage
- bioretention
- wetlands
- etc.

Find structural measures defined with example pictures provided in iWater Toolbox.

Structural measures can also be divided into centralised and decentralised controls (also known as source controls). Decentralised controls are small infrastructures placed at the source, or near the source, to catch part of the runoff from a plot or small site; while centralized controls are large infrastructures collecting the runoff generated in much bigger areas including private and public spaces.
Since centralised controls are much bigger than source controls, they can minimize the risk of flooding more effectively in urban areas than decentralized controls, but in doing so it does not address the ecological requirements of maintaining variation in stream flow that is recognised as necessary for healthy aquatic ecosystems. On the other hand, decentralised stormwater management can better mimic pre-development stream flow patterns by infiltration and retention controls throughout watersheds.

Centralised controls’ larger size makes their maintenance cheaper, but fitting is more difficult because they require more space. However, decentralized stormwater management requires a great deal of coordination between landowners and municipal authorities, posing legal, social, economic, hydrologic and ecological challenges and constraints.

Therefore, the combined use of both centralised and decentralised controls is advisable to take advantage of the two types of mitigation measures.
CENTRALISED maintenance is cheaper

e.g. large infrastructure assets like bioretentions and wetlands

CENTRALISED "top down" approach

NON STRUCTURAL managing people's behaviour

DECENTRALISED solving the problem at the source

REGULATIONS e.g. command-and-control approach like pollution regulation but also voluntary adoption of stormwater solutions

EDUCATION e.g. capacity building or awareness rising

ISWM Solutions

PLANNING e.g. restricting land use in areas subjected to flooding

POLICIES e.g. market-based environmental policies like mitigation banking or In-Lieu programs

STRUCTURAL managing infrastructure assets

DECENTRALISED OR SOURCE CONTROLS easier to fit

e.g. smaller infrastructures to stormwater control at the source or near the source like green roofs or rain gardens

ISWM Structural vs. Non-structural

PLANNING

POLICIES

NON STRUCTURAL

ISWM Solutions

DECENTRALISED

REGULATIONS

EDUCATION
ADAPTIVE MEASURES

When the use of any of the previous measures is not possible, we can still protect and adapt our buildings and infrastructure to better resist damages caused by the increase of runoff volumes and flow velocity.

Designs options for new buildings are:

- Dry proof / resistant design
- Wet proof / or resilient design (also suitable for retrofit buildings)
- Elevated
- Floating
- Amphibious

The use of streambank protection measures against erosion is necessary when it is not possible to slow down stormwater flow velocity. Methods of streambank erosion control can be divided into:

- Structural methods, which use steel, wood, rock or other aggregate, concrete, or a combination of these materials to protect the streambank.
- Bioengineering methods, which use grasses, trees, or other living plants to restore natural streambank protection.

In many cases, a combination of structural and bioengineering practices are used.
CURATIVE MEASURES

Curative measures are those that need to be applied to repair the damages to ecosystems and infrastructures when all the previous measures fail, or have not been used at all.

Curative measures are expensive and can cause negative side effects, most of them unknown beforehand. Sometimes it is necessary to use them, especially when an ecosystem cannot repair the damages by itself. Curative measures’ intended effect will not last long if none of the previous measures are put in place to avoid future damages. Therefore, curative measures should always be used in combination with preventive, structural and/or adaptive measures.