Interreg CENTRAL EUROPE

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RAINMAN

D T2.2.5 RETENTION CONCEPTS AND OPTIMIZATION FOR STORAGE MANAGEMENT

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1.1. Project context

Heavy rain events are a major environmental risk in Europe: they can hit any location with only very short warning time. Every year people die, loose their homes, and environmental damages like water pollution occur. And the risks of heavy rain events are increasing all over Europe. In the project RAINMAN, partners from six countries have joined to develop and test innovative methods and tools for the integrated management of heavy rain risks by local, regional & national public authorities. These will be included in the RAINMAN-Toolbox, a set of five transferable tools and methods for municipalities and regional stakeholders.

The module for Risk reduction measures to reduce damages of heavy rain (RAINMAN_Tool_2) of the toolbox contains a chapter (T2.2.5) that is dedicated to specify the types and the possibilities of different retention forms. This is guideline will involve a description of the storages, and will give advice to municipalities upon good practices.

1.2. Goals

This document contains basic level scientific and technical background to retention related issues, gathering best practices as well. Hereby we have recommendations for municipalities for reasonable storage designing and management. These hints can be used for further municipal developments (settlement plans), or to create restrictions for risky areas.

We will gather all the existing approaches –from the participating countries- related to water retention and storage concepts.

The goal of the document is to:

- give hints to municipalities for proper storage designing and management
- show best practices from Hungary and Participating countries
- show solutions for harmonization of urban and rural retentions

This study is aiming to have common understanding and a broad view on retention measures and best practices in the participating countries. The collected best practices could be used internationally, and based on common knowledge. The gathered best practices can be transferred to the Rainman toolbox as a catalogue of specific measures.

2. Levels of urbanization

In this chapter we will describe the levels of urbanisation from the aspecst of rainwater management and retention

In means of characteristics there are four levels of urbanization from rural to urban:

2.1. Rural:

In general, a rural area or countryside is a geographic area that is located outside towns and cities. Typical rural areas have a low population density and small settlements.

photo 1.: Rural area landscape

2.2. Semi-rural:

The Semi-Rural category identifies areas of the County that are appropriate for lower-density residential neighbourhoods, agricultural operations, and related commercial uses that support rural communities. Semi-Rural areas often function as a transition between the Village and Rural Lands categories, providing opportunities for development.

photo 2.: Semi -rural area landscape

2.3. Semi-urban (suburban):

Partly urban. It is a mixture of single family houses, asphalt and greenery on the fringe of the city. These areas forms and functions as suburb ring around the city core with mixed-density of landscape and houses, usually located along the major transport paths, railways, and highways. Commercial and industrial structures in these semi-urban areas are usually multi-story, but not high-rise. Two levels malls and shopping plazas are common.

photo 3. : Semi –urban area landscape

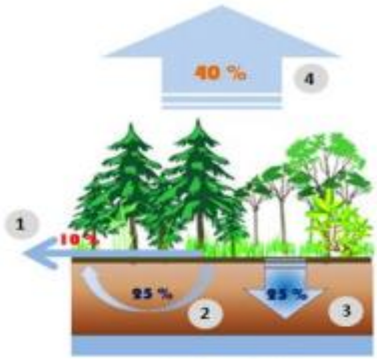
2.4. Urban:

Different countries use different measures to indicate the urban areas (population, density of inhabitants). The urban areas have large density of buildings and population, with large percentage of roads and pavements, very little greeneries (parks, playgrounds). Usually with high buildings. A classical city centre, in means of economy, education, health care, etc.

photo 4: Urban area landscape

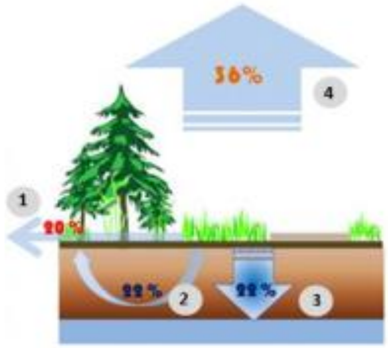
This kind of characterisation is crucial, to assign rainwater management issues, and retention types to different kinds of area types.

Hereby the main water management specifics are demonstrated depending on the level of urbanization.



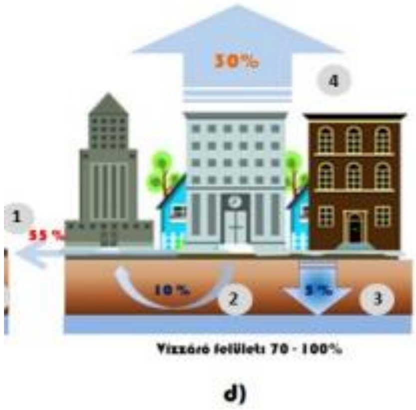
Natural surface

Paved, covered area: 0%



Paved, covered area: 10-20%

Paved, covered area: 35-50%



Paved, covered area: 70-100%

Figure 1: Change of storm water balance features according to urbanization

1 - Surface runoff, 2 - Shallow infiltration, 3 - Storage in groundwater, 4 - Evapo-transpiration

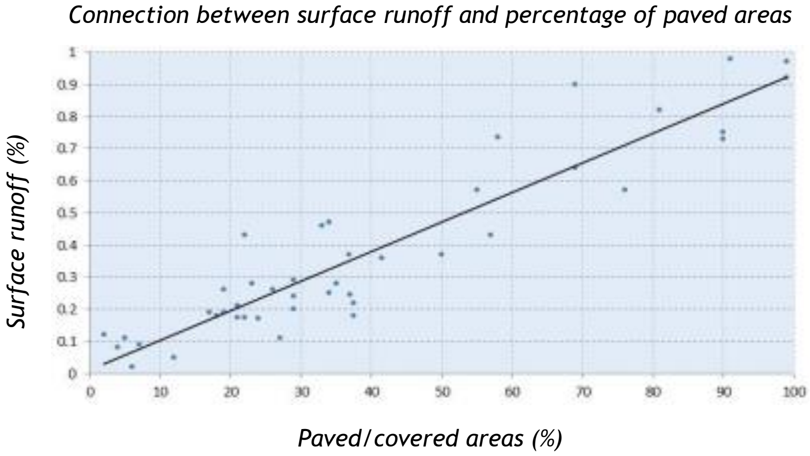


Figure 2: Dependence of runoff coeeficient according to paved area percentage

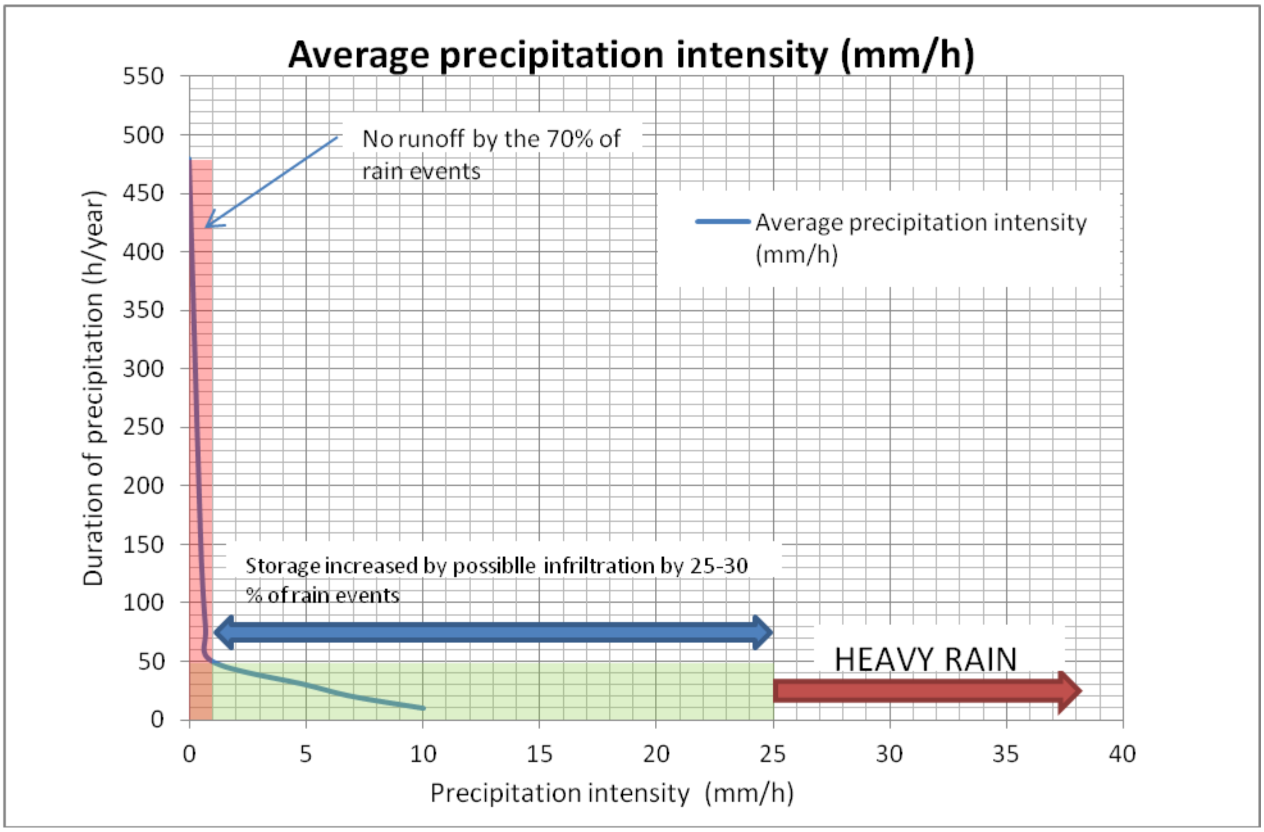


Figure 3: Yearly dispersion of rainfall intensity

The figure above explains, that at almost 70% of the rain events, there is no or not accountable runoff from the surface. At 25-30% of the cases the local storage can be increased by extension of the infiltration capacity of the surface. And the rest part is heavy rain from 25 mm/h intensity.

3. Retention types (urban-rural)

In this chapter we will charaterise the different types of retentions. Storage areas can be divided to five groups by their utilization.

3.1 Surface storage

Intermittent surface storage is created to delay the runoff. This storage area can be a natural or artificial greenery area, or pit that endures short time inundation.

These assigned areas' inundations cannot obstruct their normal use for long time, and with damage. Three hours of inundation is permitted within cities.

3.2 Cross-flow storage

A cross-flow storage should be created where it is needed by hydraulic disencumbering or by alluvium elutriation causes. The rainwater flows through it, and the storage capacity is used to reduce the flood peaks, and the amount of discharge. The storage should be created considering rainwater utilize possibilities. The bottom and the bed should be built to be maintained easily, with a low-water bed within the storage. It should be easily accessed with maintaining machines.

3.3. Overflowing storage

The overflowed storage is a cross-flow storage with overflowing possibility. It is built with a spillover and should be capable to transmit the whole flood volume.

3.4 Elutriating storage

An elutriating storage could be built upon water quality causes, on the upper sections of the rainwater drainage system, where a large amount of alluvium is expected. Because of the upper section location large volume of flood storage cannot be calculated, it is for water quality reasons and to protect the lower section of the rainwater system. After a rain event, the storage should be drained, and the sludge should be excavated.

3.5 leaking storage

The use of a leaking storage is rainwater retention for ground infiltration. It should be sized for the duration of the infiltration for the whole rainwater volume. It is used where there is no rainwater receiver river or channel. It should be built with gravel bottom reduce the obstruction of the soil. The bottom should be 0,5-1,0 m higher than the highest groundwater level.

4 Simple palnning guide

4.1 Hydrological design

The usual designing method is if, the drainage system is designed for 2 years return time (50 percent probability), the storage volume should be planned for minimum 4 years return time precipitation

4.2 Hydraulical design

The Hungarian standard regulates, that the retained excess water should be drained, leaded to the receiver water body within 3 hours. Because of this the water regulator facilities (culverts, sluices, etc) have to be sized for these charge, flow.

Volume of the storage area (surface storage)

Intermittent surface storage is created to delay the runoff. This storage area can be a natural or artificial greenery area, or pit that endures short time inundation.

These assigned areas' inundations cannot obstruct their normal use for long time, and with damage.

Volume of the storage area (cross flow storage)

The Hungarian Standard regulates how to design the volume of storage area. The first step is to define hydrological scale. The equation below represent this method.

$$c = \frac{q_p}{Q_{1,p}}$$

where:

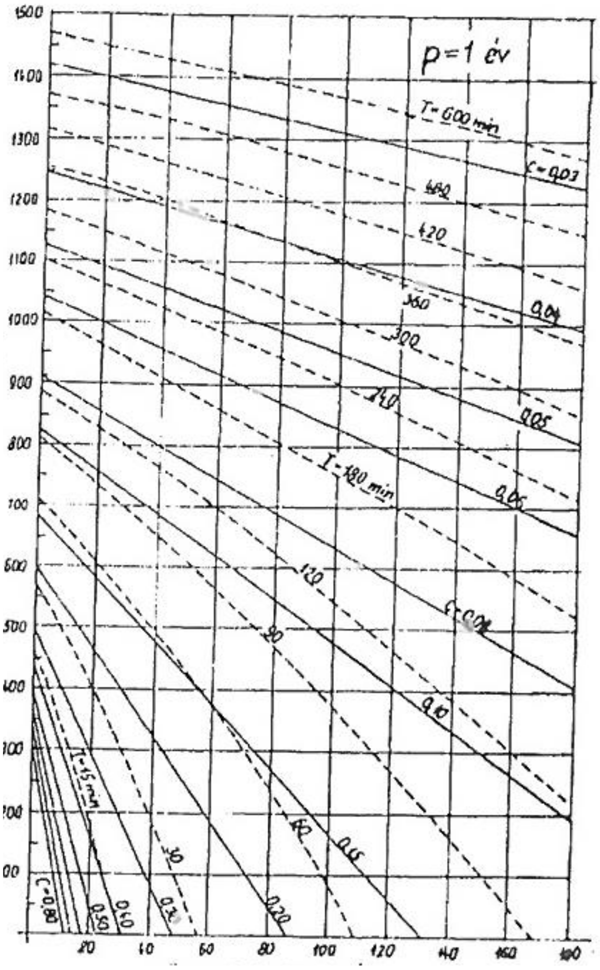
c – mitigation parameter, reduce the intensity of precipitation

q_p - the greatest outflow through the sluice

$Q_{1,p}$ - rational method for define the standard precipitation

After this point, the standard has instructions for the specification of the parameter of volume. This parameter depend on the mitigation parameter (c) and the runoff time. If we know those values, we can define the volume parameter from the figures. These figures are shown below.

Volume parameter



Ponding time (min)

Figure 4: 1 year return time rainfall

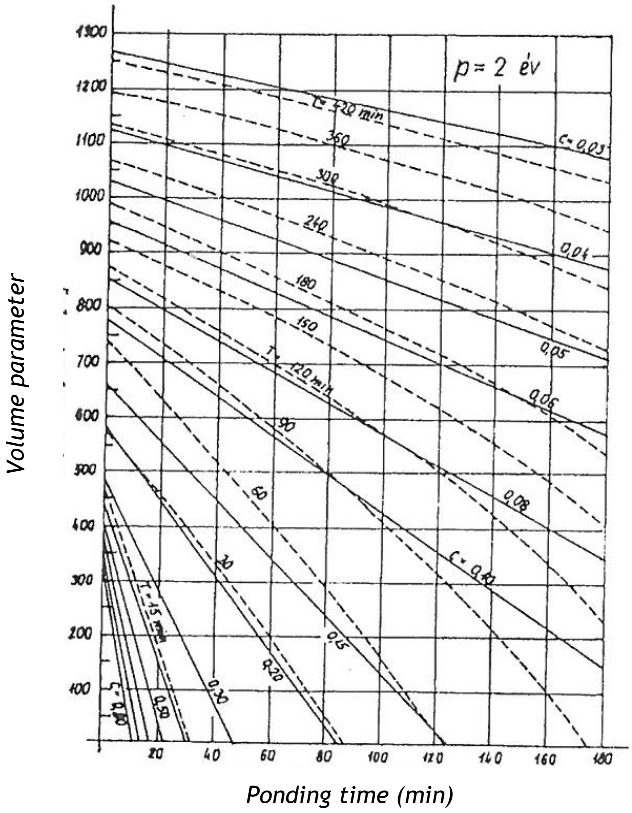


Figure 5: 2 years return time rainfall

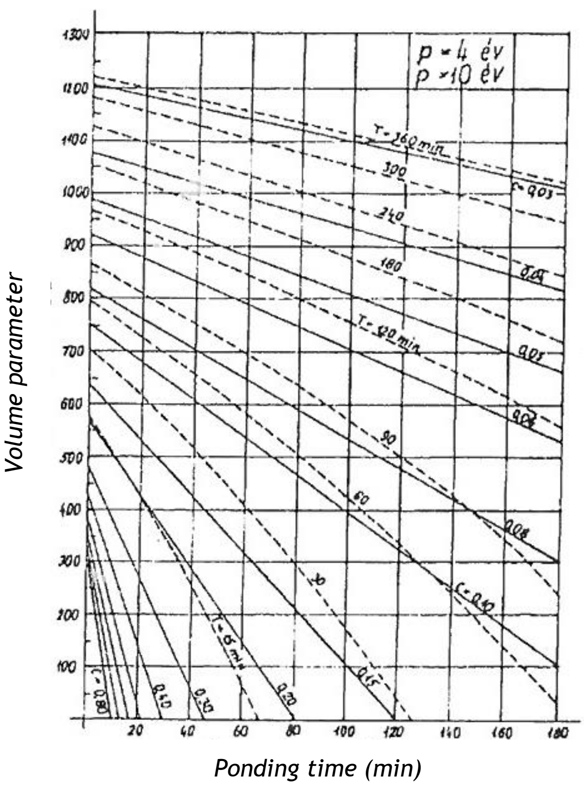


Figure 6: 4 and 10 years return time rainfall

where:

c - mitigation parameter

M – volume parameter

t_c - gathering time/runoff time

T – duration of standard precipitation

It known, the equation formula is:

$$V = \frac{M * Q_{1,p}}{1000}$$

Volume of the storage area (overflow storage)

Within this type of storage area, the primary point of view is that the volume have to be greater than the dissolved amount of rainwater (at the beginning of the duration of precipitation the rainwater contains pollutant).

After this, the method of design is the same than the previous one (the figures also).

Volume of the storage area (leaking storage)

The method of design is the same than the cross flow storage.

5 Best practices - recommendations

This chapter will reveal the background for using good practices in utilization of grey and green rainwater.

The intended solution are esentially reasonable runoff regulation and retention. According to this there are several systems:

- grey sytstems: engineering structural measures, regulation and facilities connected to it.

- green systems: local, within-site solutions for runoff regulation and retention

- hybrid systems

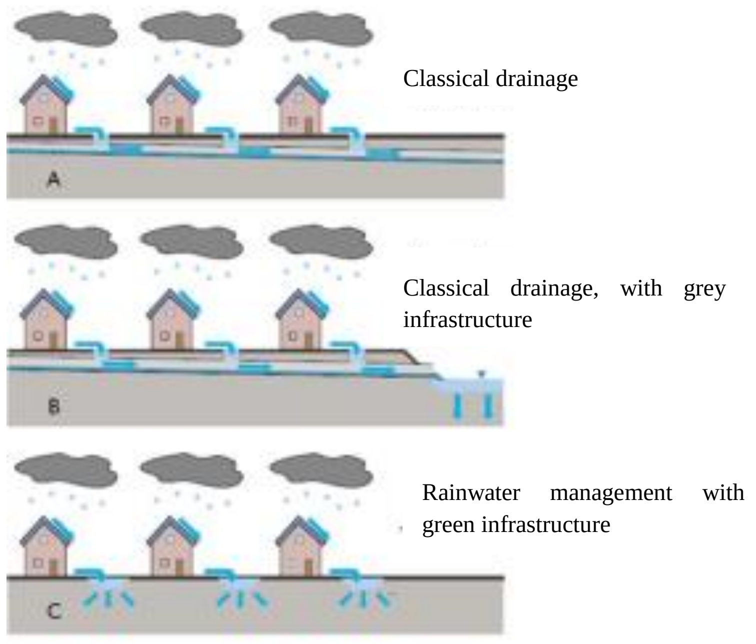


Figure 7: Schematic figure of *grey and green infrastructural solutions*

The figure above shows the differences between grey and green solution. The main difference is that green systems manage retentions (and pollution spreading) within sites (domestic rentetions, water tanks), and the surplus water is drained from the site. It is decentralized rainwater management.

The desinging cases should be departed into three groups.

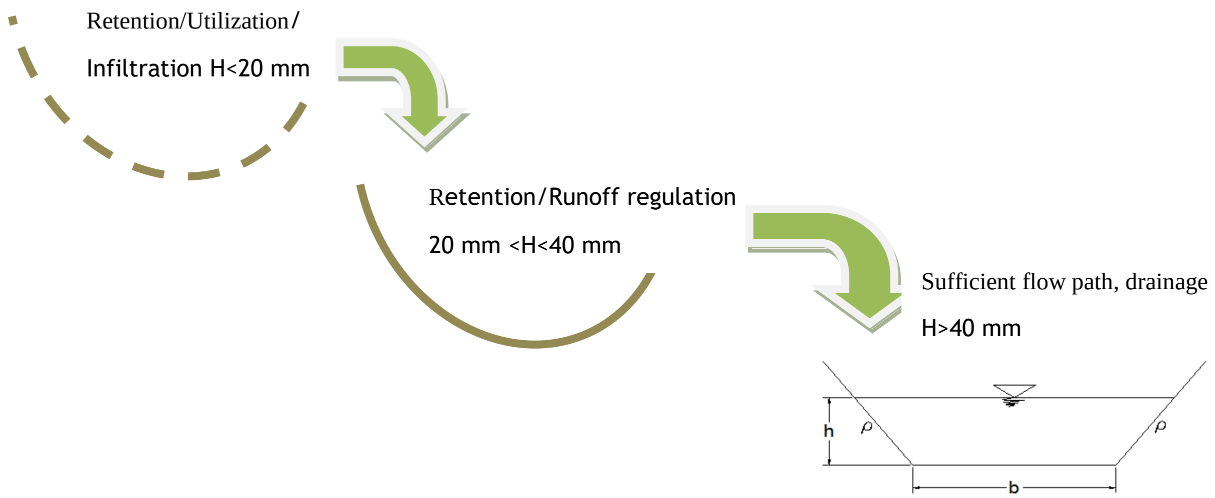


Figure 8: *Strategical basis of urban rainwater management*

With grey infrastructure we paste facilities the modify flood peaks. Reasonable surface or underground storage areas, which not permanently inundated. The main target in the design process is not the mainly the retention of the whole rainwater volume. These facilities can help the purification of rainwater such as wetlands, but meanwhile these items have large catchments, (in case of main canals) so they need large space, and volume. In an urbanized area it usually needs large investment cost, especially if facilities could be placed only underground.

If we compare grey infrastructure with green infrastructure, the benefits can be easily seen. The green system can be built with small construction cost and flexible timing. The possible benefits are greater than grey systems.

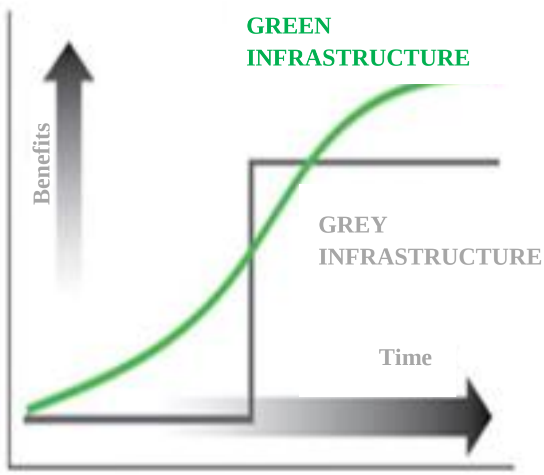


Figure 9: Advantages of green infrastructure

The green rainwater management, has large literature in the United Kingdom, and describes the following solution:

- **R**ainwater **H**arvesting, **RH**(domestic retentions, water tanks)
- **G**reen **W**ate **I**nfrastructure, **GWI**
- **L**ow **I**mpact **D**evelopment, **LID**

The topic and the aim of Rainwater Harvesting is to pond the rainwater from roofs, gardens, other paved areas within sites. Green Water Infrastructure is a method taking cityscape designing and water management issues into account.

The LID (Low Impact Development) is a part of the sustainable urban rainwater management system. It is usual, that the designing process considers pollutant transport retention besides classical hydrological, and hydraulical aspects. These aspects are useful also for the cityscape and microclimate.

The LID runoff regulation types are the followings:

- Change of the runoff/flowing paths: Draining waters from paved to unpaved areas. This usually need a land use regulation in the catchment, eg: infiltrating pavements. Almost 70% -of yearly precipitation can be retained depending soil and groundwater.

- Building infiltrating facilities: These facilities are capable to reduce flood peaks.

- Building storage areas: Reducing flood peaks, with permanent or non-permanent inundation.

-LID landscape, cityscape planning: planting drought capable plants, trees, creating grass flow paths**.** These solutions reduce runoff and improves the aesthetics of urban environment, with long lifetime and small maintenance costs.

5.1 Examples for best practices

5.1.1 Infiltrating cells:

Filtering soil, with plants based on gravel zone. These cells modify the runoff by infiltration and storage in the gravel zone, with evapo-transpiratio.

Figure 10: *Infiltrating cells*

5.1.2 Rain Gardens:

Artificially created pit areas planted with plants. Infiltrates and evaporates.

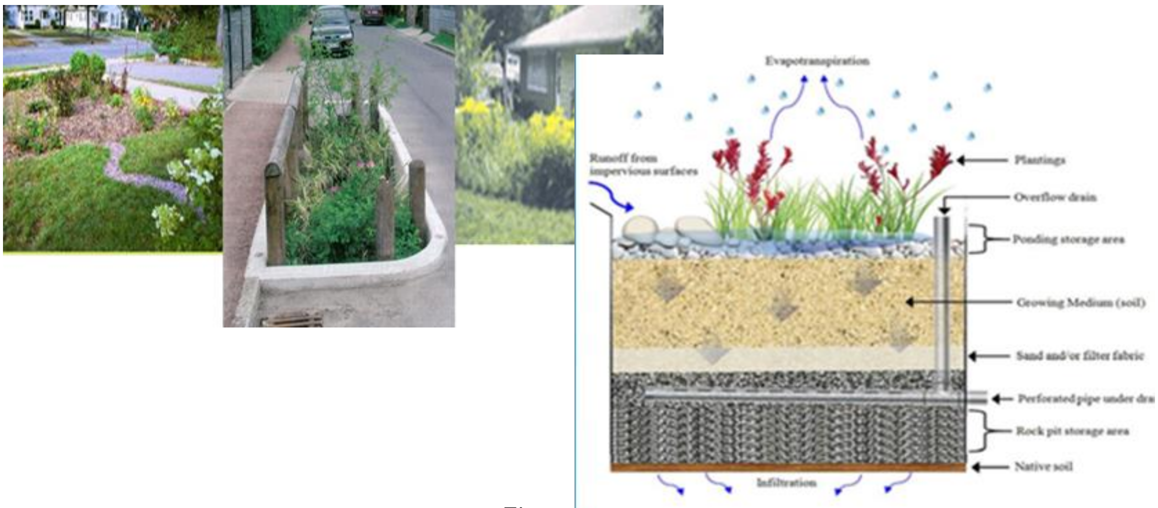


Figure 11: *Rain Gardens*

5.1.3 Infiltrating gravel drains:

It is created for areas without runoff (pit areas), retaining rainwater

Figure 12: *Infiltrating gravel drains*

5.1.4 Grassy ditches and slopes:

The unpaved, grassy ditches slows the speed of flow, making the percentage of infiltration higher, reducing flood peaks.

Figure 13: *Grassy ditches*

5.1.5 Temporary inundated areas:

Temporary inundated areas can be assigned to reduce the flood peaks, and to increase infiltration. There are extreme examples for these kind of reduction solution eg. football fields, tennis courts, which are usually not used while rain events. The normal draining times for these facilities is 2-3 hours.

Figure 14: *Temporary inundated areas*

5.1.6 Wetlands:

As a matter of fact wetlands are artificial ponds or swamps. They are facilities that regulates runoff and besides they can form cityscape and can be utilized for recreation.

Figure 15: *Wetlands*

5.1.7 Infiltrating pavements

Traffic areas upon gravel zones. The upper layer can be porous concrete, a mixture of asphalt or plastic grid.

Figure 16: *Infiltrating pavement*

5.1.8 Underground tanks for roof rainwater retention

These tanks retain rainwater coming from roofs, increasing infiltration. The rainwater can be utilized for e.g. irrigation. Upon these tanks parking zones can be built.

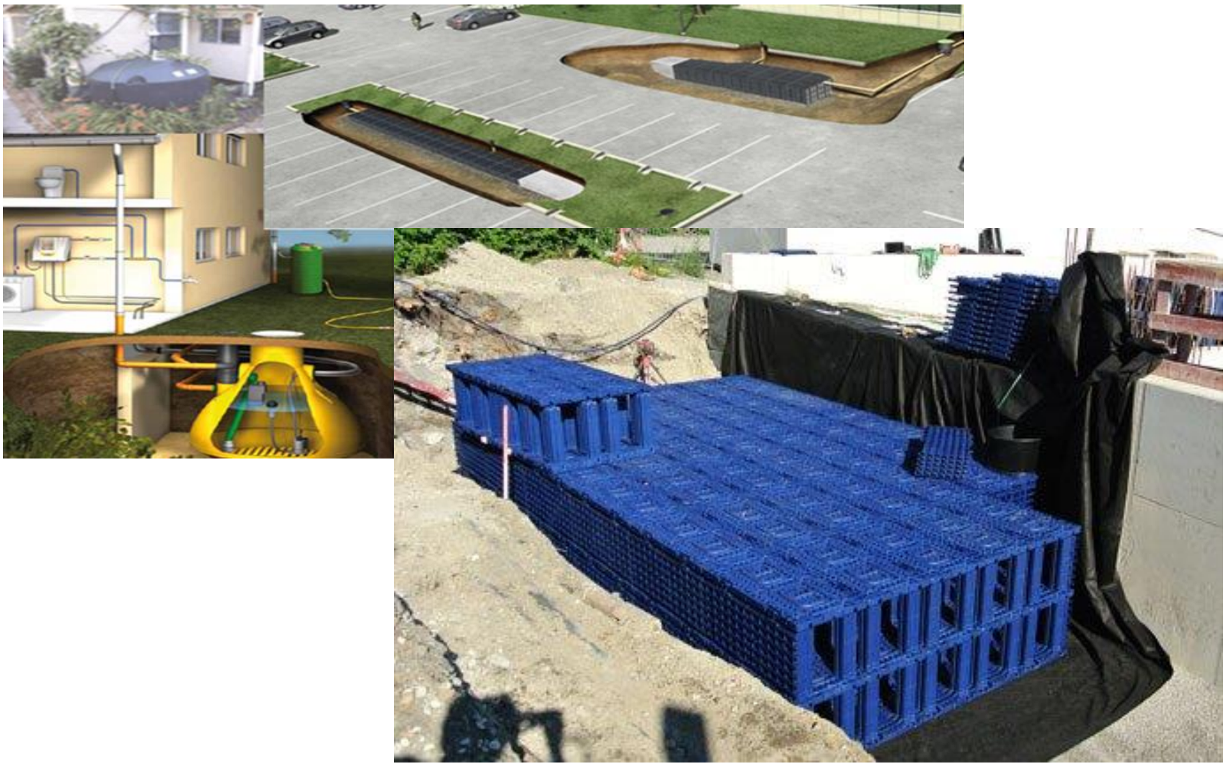


Figure 17: *Underground tanks for roof rainwater retention*

Masterplan of Coppenhagen (combining *good practices)*

Figure 18: *Masterplan of Coppenhagen*

Figure 19: *Masterplan of Coppenhagen*

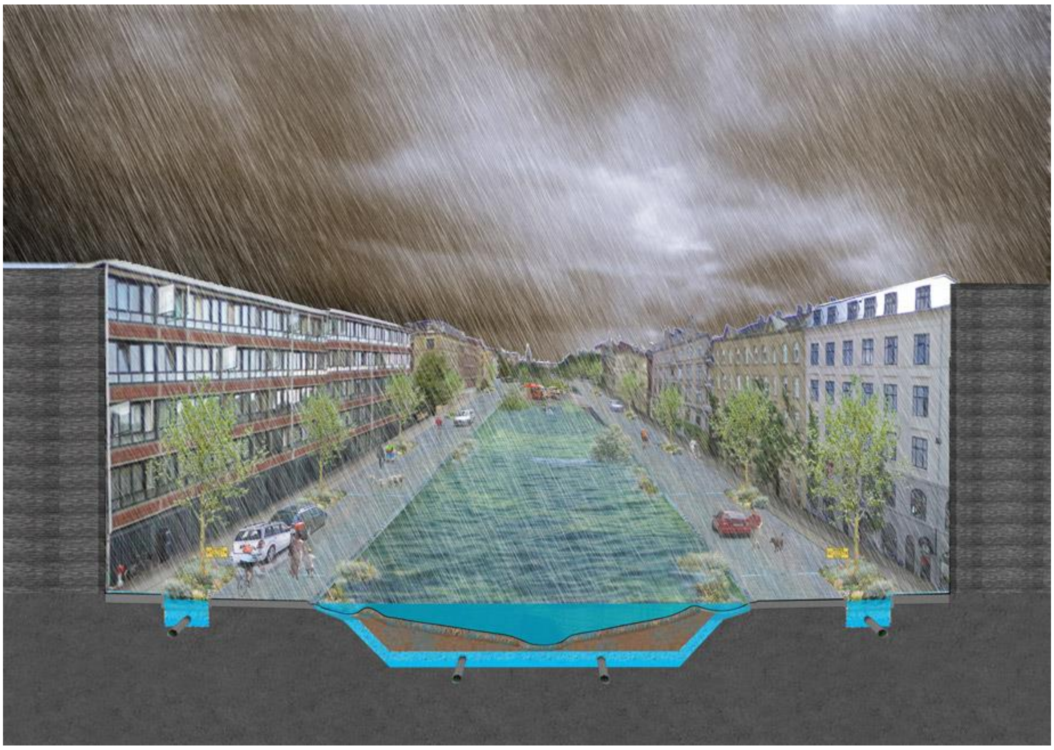


Figure 20: *Masterplan of Coppenhagen*

Figure 21: *Masterplan of Coppenhagen*

6. References

photo 1: https://en.wikipedia.org/wiki/Rural_area

photo 2: https://www.yourdictionary.com/semirural

photo 3: https://mathieuhelie.files.wordpress.com/2008/06/tract-housing.jpg

photo 4: https://www.imperial.ac.uk/news/184656/global-project-reduce-health-inequalities-cities/

Figure 1-3, 7-16: **Vízgyűjtő-gazdálkodási Terv - 2015 8-6 melléklet: Települési csapadékvíz-gazdálkodási útmutató, Buzás Kálmán (2015)** http://www.kornyezetvedok.hu/vgt/vgt2/orszagos/8_6_melleklet_telepulesi_csapadekviz_gazdalkodas_utmutato.pdf?picture=pic2

Figure 4-6: MI-10-455/4:1988 (Hungarian standard)

Figure 17-21: http://www.landezine.com/index.php/2015/05/copenhagen-strategic-flood-masterplan-by-atelier-dreiseitl/

RAINMAN Key Facts

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