

# ADAPTATION OF THE CITY TO FLOODS AND DROUGHTS.



EUROPEAN UNION  
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Operational Programme Prague -  
the Growth Pole of the Czech Republic



# ADAPTATION OF THE CITY TO FLOODS AND DROUGHTS

**Photo on the title page:**

## **Polder for capturing surface runoff from paved surfaces**

The dry polder is located in the Kyje area, where a new building complex was built. The implementation of this type of measure testifies to the professional competence of the designers aiming to capture the runoff from the paved areas and subsequently gradually infiltrate the captured volume of water into the soil profile. At the same time, the temporary water surface cools and improves the microclimate around the polder.

Author of photography: Jana Balvínová

T. G. Masaryk Water Research Institute, Public Research Institution  
Prague 2020

Dear readers,

we live in an environment that has been exposed to strong hydrological extremes in the form of alternating droughts and floods for more than 20 years. Man is an animal species that, as one of the few, has been able to constantly adapt to new living conditions. Times have not changed. We are still fighting, and we will continue to fight the influences that teach us that nature will always be above us. The present and near future require our adaptation to climate change to harmonize human coexistence with the environment. This publication aims to acquaint the reader with the basic measures that can be implemented especially in the peripheral areas of cities and communities. The publication *City Adaptations to Floods and Drought* offers specific solutions to implement measures that will be possibly of universal use. In times of drought, the measures retain water, thus improving living conditions and at the same time minimize damage to the lives and property of the population in the event of a flood event. The content of the publication emphasizes the prevention and involvement of the general public in the decision-making processes, such as the approval of the zoning and regulatory plans of cities and communities.

This publication is available free of charge in printed form at the T. G. Masaryk Water Research Institute, Public Research Institution, and also in an electronic format on the website [heis.vuv.cz/projekty/praha-adaptacniopatreni](http://heis.vuv.cz/projekty/praha-adaptacniopatreni). It is part of a 3-part series that includes the following titles: *City and Water*, *Groundwater in the City*, and *Adaptation of the city to floods and droughts*.

We believe that all three of these publications will help you to expand your knowledge of water and nature around us.

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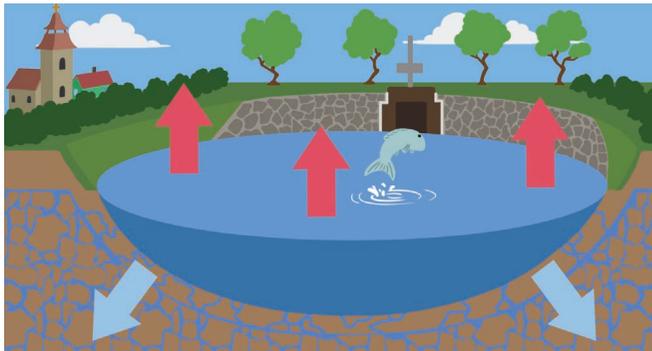
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# 1. ADAPTATION MEASURES FOR PROTECTION AND PREVENTION

In the context of climate change mitigation, adaptation measures represent a set of preventive and protective tools in combatting hydrological extremes such as floods and droughts. There are several adaptation measures, and therefore let us start with a few basic examples of measures that can differ fundamentally in their concept:

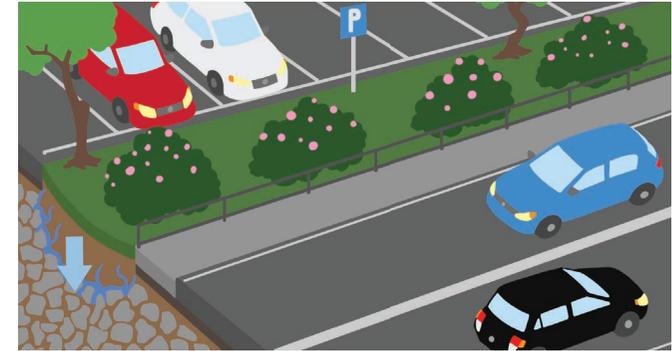
- **SMALL WATER RESERVOIR WITH A DEDICATED RETENTION SPACE FOR FLOOD RETENTION**  
Supports the small water cycle (evaporation) and thus cools its surroundings, subsidizes groundwater. This can also serve for small water abstractions and creates a landscape element and a richer habitat.



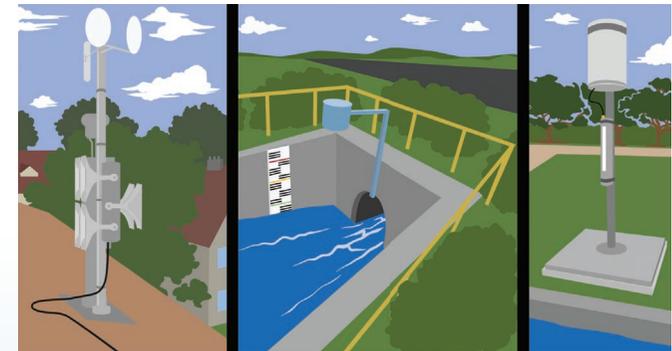
- **GRASS AND INFILTRATION BELTS**  
Break up plots of agricultural land, slow down run-off, reduce soil erosion, while retaining water and increasing soil moisture.



- **RETENTION OF WATER FROM PAVED AREAS IN THE URBAN AREA OF MUNICIPALITIES**  
Reduces direct run-off, allows the use of water in the period of its scarcity or recharge of groundwater by artificial infiltration.



- **ESTABLISHMENT OF LOCAL WARNING SYSTEMS**  
Protects the lives and property of residents, collects important hydrological information in the long run.



- **THE IMPLEMENTATION OF ADAPTATION MEASURES AS PART OF SPATIAL PLANNING DOCUMENTATION**  
Draws attention to the need for risk management in advance, is binding and it is discussed in the presence of the public.



These examples show that it is currently beneficial to implement measures that not only protect against the effects of floods, but also function at times of drought. An important preventive measure is also the communication with the public, only with its help it is possible to draw attention to the mutual interconnection of measures and enforce comprehensive solutions, such as ensuring the protection of the municipality from the effects of floods from torrential rains.

For technical measures, it is easier to quantify their effects. Conversely, for nature-friendly measures, these are still based on considerations or assumptions that are not yet supported by direct observation or measurement or cannot be directly demonstrated.

When implementing individual measures, it should be borne in mind that no technical or nature-friendly measure provides 100% protection from a hydrological extreme. There may always be more floods or droughts than those for which the measure was originally proposed for. The level of protection proposed is therefore always proportional to its purpose, target group and economic costs associated with its implementation.

## Categorization of adaptation measures

Adaptation measures represent a set of technical or nature-friendly elements or human activities that can be implemented in preventing the occurrence of hydrological extremes and mitigating the effects of climate change. The measures can be divided into several basic groups:

- Measures on agricultural land
- Measures on forest land
- Measures on watercourses
- Measures in urban areas
- Measures concerning the technical security of buildings
- Measures within spatial planning
- Measures in the form of warning systems and information to the population

This set of measures, in its complexity, are suitable not only for small villages, but also for large settlement areas, where agricultural, forest and built-up areas overlay with the catchment areas of small watercourses.

## 2. MEASURES ON AGRICULTURAL LAND

Due to its recent history of cooperative land farming, the Czech Republic is one of the countries with the largest land blocks. The consequences of this land management method are the long sloped land plots, acceleration of surface run-off and the subsequent origin of accelerated water erosion or intense wind erosion. Together with the increased use of chemicals in agriculture, this leads to a reduction in soil quality, which, in addition to a reduction in production capacity, is also reflected in the reduced ability to retain and absorb water.

Measures on agricultural land are mainly intended to slow down surface run-off and reduce soil erosion. On the other hand, the same measures can, to some extent, act as a prevention against the effects of drought by retaining water and increasing soil moisture.

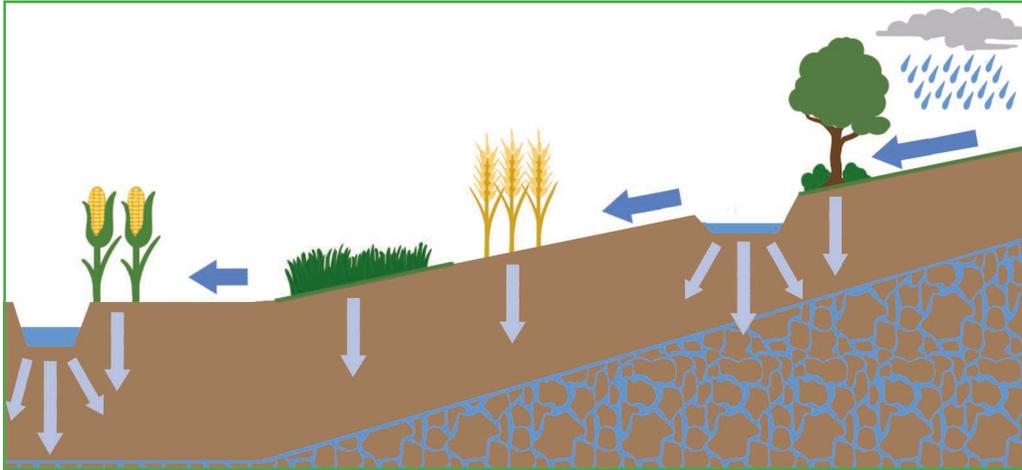
The resulting effect is not only the protection of the soil itself from erosion, but also the protection of built-up areas downgradient of the exposed slopes or land with improperly chosen management methods. Significant measures on agricultural land are divided into:

- TECHNICAL
  - Terracing, balks
  - Stabilization of concentrated run-off pathways
  - Contour furrows, ditches, retaining levees
  - Infiltration wells
  - Dry polders
  - Small reservoirs
  - Afforestation of upper parts of basins and slopes



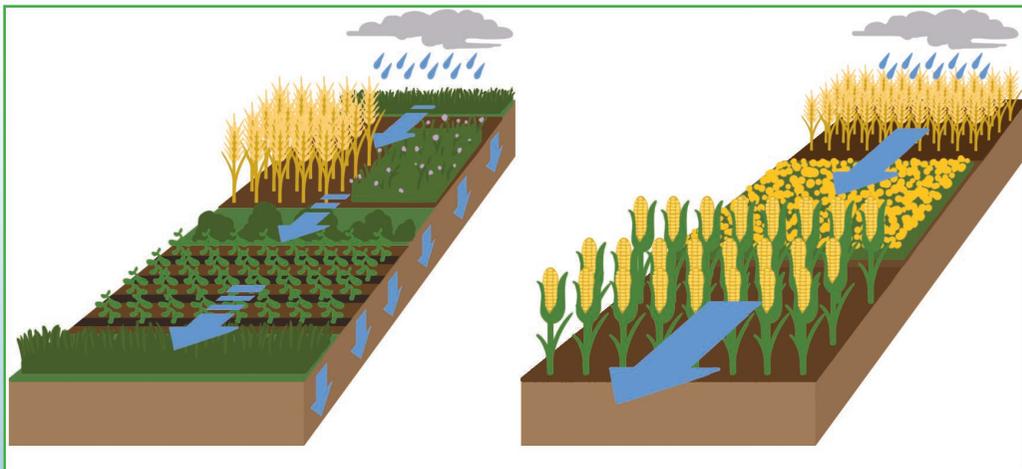
Technical measure

- AGROTECHNICAL
  - Suitable crop rotation, sowing crops in strips, use of cover crops
  - Direct sowing, mulching, cultivation of soil along elevation contours
  - Infiltration and catchment belts
  - Preservation of existing meadows and pastures



**Agrotechnical measure**

- ORGANIZATIONAL
  - Size and shape of land plot
  - Grass planting or afforestation – delimitation of land



**Suitable diversification of agricultural cultivation**

**Unsuitable diversification of agricultural cultivation**

## 3. MEASURES ON FOREST LAND

Afforested land significantly contributes to reducing the impact of hydrological extremes in the form of torrential rains and draught. They can partially contain torrential rain and also spread the run-off from the area over time. In afforested areas, a number of measures can be implemented that can increase the effects on run-off in torrential rain events.

In afforested land, these are mostly the so-called nature-friendly flood protection measures, accompanied by technical measures. The important measures on forest land include:

- Restoration of natural mixed forests
- Regular care and rejuvenation offorests
- Reducing the risk of damage of forest land during logging
- Quick reforestation of damaged land affected by natural events
- Revitalization of forest roads and their regular maintenance
- Wetland restoration
- Support natural succession
- Torrent damming and elimination of erosion furrows
- Building of small water reservoirs



## 4. MEASURES ON WATERCOURSES

Watercourses are an important element for the drainage of water from river basins. They play a crucial role in the safe drainage of flood flow and, at the same time, represent an important landscape forming element that can significantly contribute to water retention in the landscape. In urbanized areas, streams relocated to tubing predominate, with the aim during their modifications being to drain the flood flow from the affected area as quickly as possible. However, in recent years, a strong trend has prevailed aiming to revitalize streams in tubing even in built-up areas, so that the lives, health, and property of the population are not endangered. The measures below can make a significant contribution to finding a compromise between flood protection and the natural ecological character of the stream. Significant adaptation measures on watercourses include:

- Flood risk mapping (flood maps, depth maps)
- Evaluation of flood damage
- Restoration of natural floodplains
- Slowdown of run-off in the upper parts of the river basin (meandering of streams, revitalization)
- Construction of small reservoirs
- Construction of dry polders
- Ensuring sufficient flow capacity of bridges and culverts and their protection against water clogging during floods by floating debris
- Regular maintenance of stream channels to ensure the required capacity to manage flood flow



**Torrent damming**



**Forest road**



**Wetland**



**Meander**



**Removal of trapped floating debris**

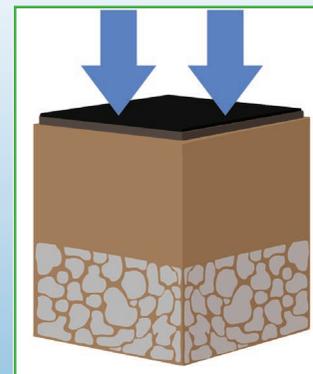


**Flow channel maintenance**

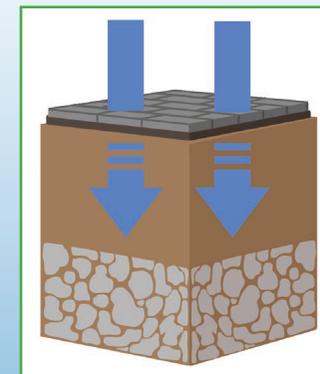
## 5. MEASURES IN URBAN AREAS

The built-up areas with a high density of paved areas currently represent a major risk regarding impaired run-off conditions. They cause shortening of the post-peak flow rate curve, minimum infiltration, and consecutive overloading of the drainage systems. The result can then be local floods and damage to the property of residents and the infrastructure of cities and municipalities. The aim of the measures below is to slow down the run-off from paved areas, to capture and infiltrate as much water as possible. Some of these measures reduce the impact in the event of torrential rain and at the same time allow the use of retained water in the longer term.

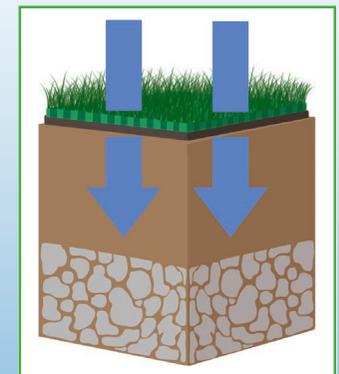
- Slowing down and reducing the volume of run-off from paved areas (car parks, roofs, roads – permeable paving or its roughening the surface)
- Use of paved areas as temporary retention areas
- Optimum capacity of rainwater drainage system
- Backflow check valves on drainage systems
- Temporary water retention in underground tanks with the possibility of its later use
- Infiltration and slowing the run-off from grassed areas (infiltration belts, furrows, ditches, etc.) concentrated/increased run-off pathways
- Dry polders or the use of terrain depressions to retain run-off
- In new building construction - the appropriate spatial location of property to avoid the
- Limiting construction in high risk areas
- Green roofs (reduction of surface run-off, reduction of temperature on hot days)
- Green walls – similar to green roofs, but in a vertical direction



**Minimum retention**



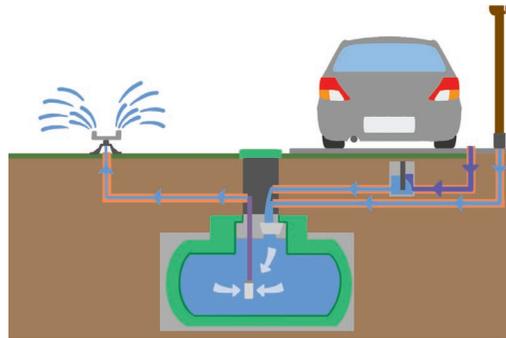
**Partial retention**



**Increased retention**



**Use of greenery for microclimate improvement**



**Underground tank for rainwater**

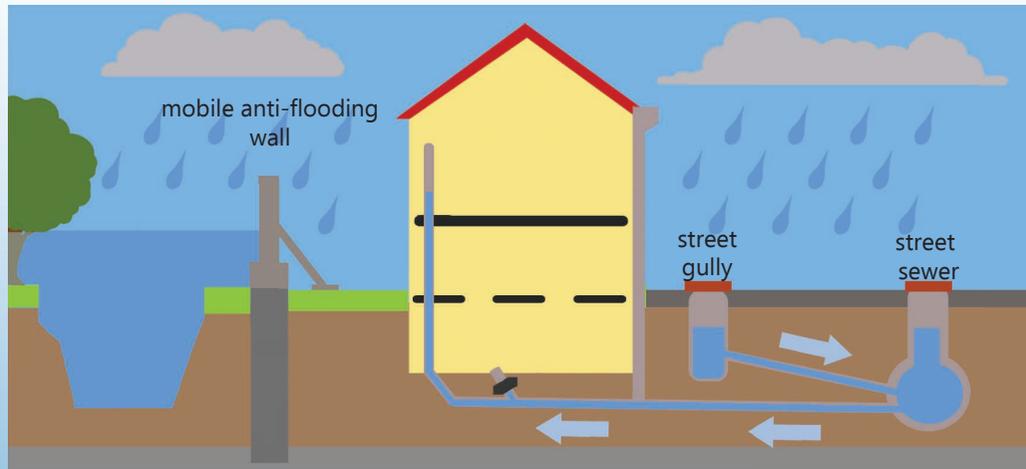
It is not always possible to take measures ensuring that the infrastructure concerned is not affected by concentrated surface run-off and is temporarily flooded. For these reasons, it is possible to introduce preventive technical measures on these exposed structures, which will ensure the least possible damage to the structure.

● **TECHNICAL PROTECTIVE MEASURES FOR BUILDINGS**

- Mobile flood protection
- Insulation of underground parts of buildings
- Elevated vertical position and protection of skylights and cellar entrances and their flood protection
- Elevated ground floor level
- Sealing of holes, openings, and penetrations for pipes
- Predefined water outflow from building



**Mobile anti-flooding wall**



**Protection of buildings from floods**

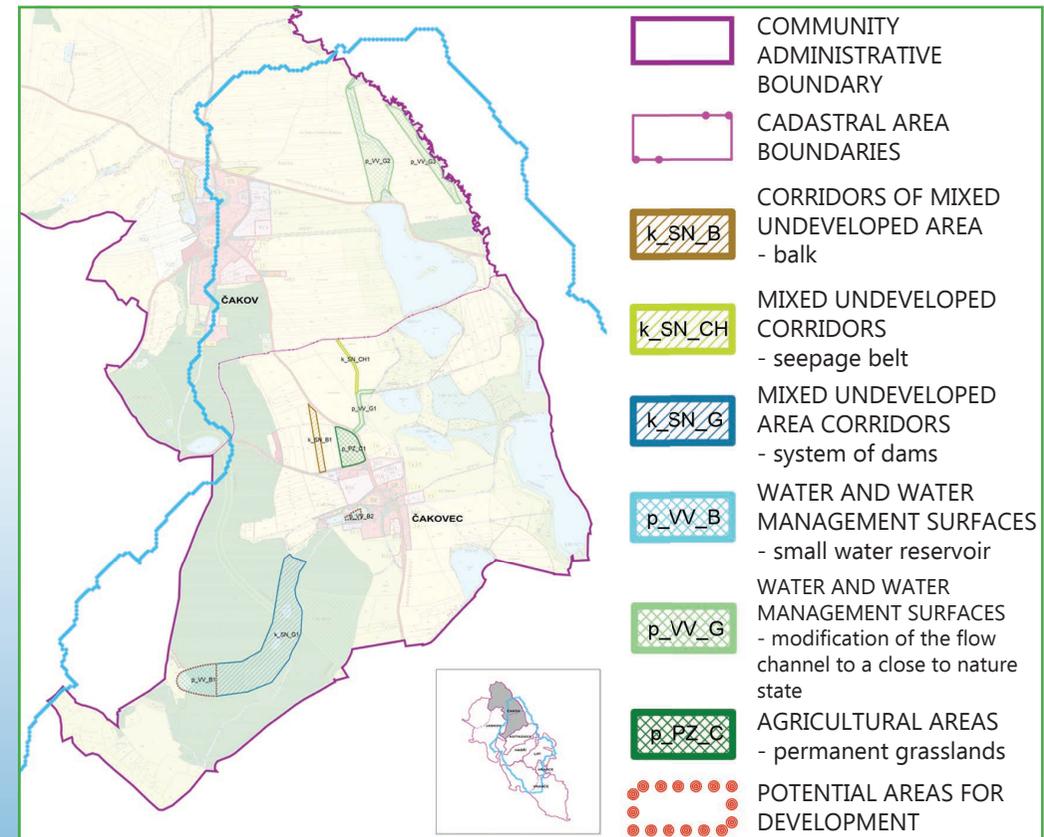
## 6. ADAPTATION MEASURES IN SPATIAL PLANNING DOCUMENTATION AND DEVELOPMENT CONCEPT

Implementation of adaptation measures already within the spatial development plans of towns and municipalities represents one of the most important preventive tools for the protection of lives, health and property of the population. The actual implementation of specific adaptation measures into spatial planning documentation depends on the type of documentation that is developed within the spatial development.

Spatial planning documentation is a documentation which, if developed, represents binding conceptual requirements and conditions for decision-making in the area concerned. In the conditions of the Czech Republic, there are several types of spatial planning documentation. According to the extent of the area concerned, we differentiate three types – the principles of regional development, the regional plan and the regulatory plan, from which the scale of the documentation and thus its final detail are derived.

When selecting the adaptation measures that can be included in the regional planning documentation (ÚPD), use of two categories is considered:

- ZONING PLAN (LP)
- REGULATORY PLAN (RP; IT INCLUDES THE ZONING PLAN OPTIONS OF WITH ELEMENTS OF THE REGULATORY PLAN)



**Regulation plan**

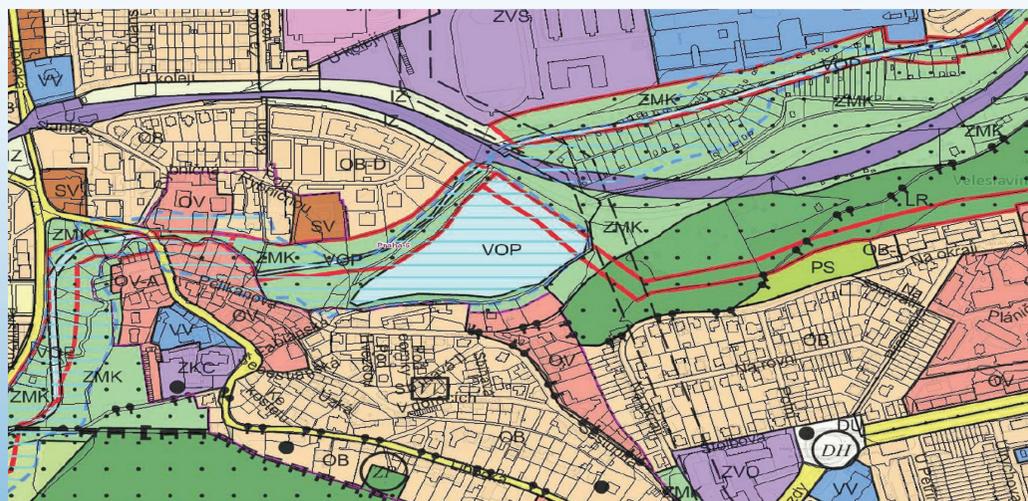
Within the community area, the zoning plan sets a comprehensive concept of its development, including protection, established in particular by the proposed areas, corridors, or routes and defining conditions for their use. The regulatory plan, due to its focus on a smaller part of the community, proposes specific locations and appearance of buildings and the associated detailed conditions.

The main criterion of adaptation measures is the detail of the proposed measure and the question of whether it can be reflected only in the zoning plan or whether it is possible to solve it in a more detailed way within the regulatory plan.

Since the regulatory plan addresses the location and arrangement of buildings, their connection to the infrastructure and other conditions only to a certain detail, there are also such measures that in detail exceed the scale of the regulatory plan. In this case, these measures would have to be the subject of zoning and construction permit proceedings, which is not dealt with in this material. In some cases, the result is the inclusion only in the regulatory plan, because it would be too detailed for inclusion in the zoning plan. Regarding the detail of the proposed adaptation measures, the zoning plan is a certain conceptual model which will then be developed in greater detail in the regulation plan.

● GENERAL ADAPTATION MEASURES IN THE CONCEPT OF URBAN AND COMMUNITY DEVELOPMENT PLANNING:

- Setting the development concept regarding flood risks, including floods from torrential rainfall
- Delimitation of areas suitable for development in zoning plans regarding flood risk
- Application of flood risk of requirements within the permitting process
- Delimitation of suitable areas for infiltration or controlled drainage in spatial planning documentation
- Not placing buildings in areas with flood risk
- Identification and mapping of risk areas
- Identification and implementation of appropriate measures at the level of communities and private entities
- Inclusion of areas at risk of torrential rainfall into spatial planning
- Effective management of water retention sites in within the river basins



Example of a zoning plan

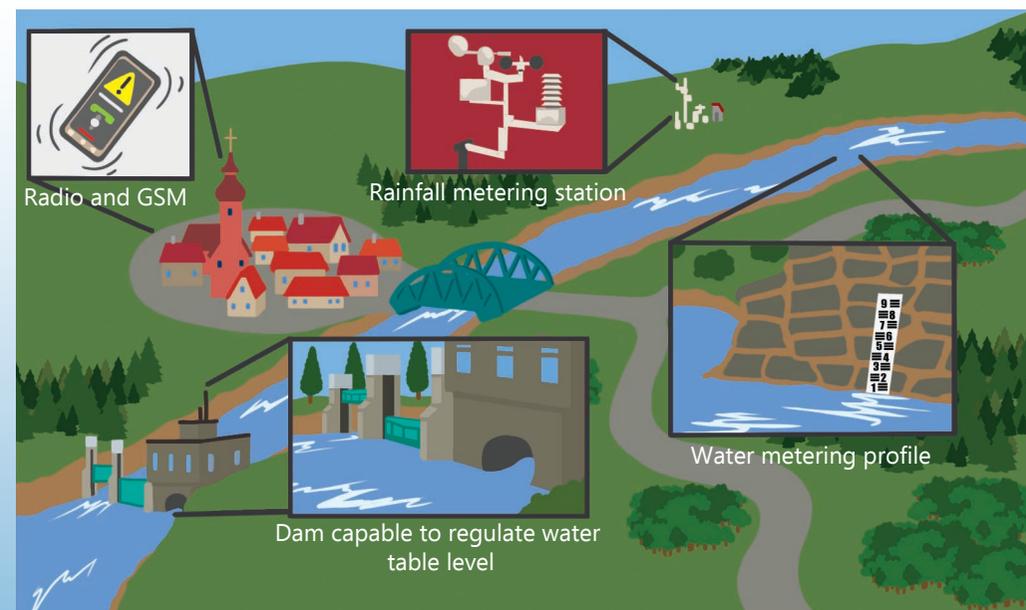
## 7. MEASURES IN THE FORM OF LOCAL WARNING SYSTEMS AND PROVISION OF INFORMATION TO THE POPULATION

Local warning systems (LVS) are systems used to warn the population of imminent danger. Floods from torrential rains can also pose a danger. The systems work on the principle of early warning, where the imminent danger is identified by the appropriate measurement (rain gauge, water meter profile) and this information is passed to the responsible persons or a person who evaluates it and then performs the necessary actions.

The most common way of warning of the flood danger is to identify the precipitation event causing flood using a rain gauge station, or directly in the riverbed in the water flow rate metering profile. The design of the local warning reflects most these parameters:

- GEOGRAPHICAL AND HYDROLOGICAL CHARACTERISTICS OF THE AREA
- THE INCIDENCE OF TYPES OF FLOODS IN THE AREA OF INTEREST
- CRITICAL LOCATIONS IN THE PROTECTION AGAINST FLOODS
- EXISTENCE OF THE ALREADY INSTALLED METERING PROFILES OF THE CZECH HYDROMETEOROLOGICAL INSTITUTE AND OF THE RIVER BASIN MANAGEMENT AUTHORITIES
- PROXIMITY OF ALREADY OPERATE LOCAL WARNING SYSTEMS IN THE AREA OF INTEREST
- EXPERIENCES OF LOCAL RESIDENTS

In the selected locations, on-line measuring systems (rain gauges, water table level meters) are installed, recording the monitored parameters and when the set limit value is exceeded, they send alarm information to the receiving station. In addition to the limit states, the measuring technology usually continuously measures the monitors parameters at regular time intervals.



Warning systems





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