Interreg
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European Regional
Development Fund

RAINMAN

SCOPING STUDY
COLLECTION AND DEVELOPMENT OF RISK REDUCTION MEASURES

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Our Project is funded by the Interreg CENTRAL EUROPE Programme that encourages cooperation on shared challenges in central Europe and is supported under the European Regional Development Fund.

D T2.1.1 Scoping Study

Collection and development of risk reduction measures

Version 1 06.09.2018

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Acknowledgements

This document is a review on the governmental attitudes, legislative frame works and existing risk reduction measures in participating countries obtained through a questionnaire and discussions during project meetings. The literature consists of available guidelines, project results, websites, and other sources of information.

We highly appreciate feedback and support in the design, structure and editing of the document from the Saxon State Office for Environment, Agriculture and Geology, specifically support from Sabine Scharfe, and Anna Goris from Infrastruktur & Umwelt.

We would like to thank all participating project partners for their contributions, fruitful discussions and feedback.

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1. Context and goals of this study

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, thousands lose 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 6 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.

One of these tools is a risk reduction tool to select and implement heavy rain risk mitigation measures. The tool will include a catalogue of risk reduction measures in specific situation and guidance for the application and implementation of the measures.

The other tools support stakeholders e.g. in assessment and mapping of heavy rain hazards and risks as well as awareness raising and stakeholder involvement. Furthermore, a catalogue of good-practise examples from all partner countries for the integrated reduction of heavy rain risks will be set-up.

1.2. Goals

This Scoping Study summarizes approaches in each of the project partners' countries in terms of legislation regarding pluvial floods and measures that enable flood risk reduction. The study is also includes EU legislation providing a basic framework, which is further developed in each country on national and/or regional levels.

The present document comprises of the scoping study on the collection and development of risk reduction measures. It represents the basis for the development of the risk reduction tool to select and implement heavy rain risk mitigation measures.

The goal of this scoping study is to provide an overview on the main existing legal frameworks and catalogues of measures in the partner countries and the EU. Hence, the scoping study builds a common knowledge basis within the project partnership in the field of risk reduction measures. Nevertheless, the content described cannot be exhaustive as no common approach or catalogue exists in the different partner countries.

With the scoping study, the starting point for the development of a joint catalogue of risk reduction options and management measures is set, which will be tested in the pilot activities. The catalogue will be tested and specified in the pilot regions and will be an integral part of the RAINMAN toolbox.

1.3. Approach and structure

The study was developed in close cooperation with the project partners (Austria, Croatia, Czech Republic, Germany, Hungary and Poland). The basis of this study is a survey sent out by the Project Partner 5 (VUV T.G.M., Czech Republic), where project partners were asked to provide information on the legislation

regarding pluvial floods, governmental attitudes towards pluvial floods and available risk reduction measures (structural and non-structural).

Chapter 2 focusses on the legislation concerning pluvial floods in the project partners' countries. It includes also a section that focusses on European legislation. The third chapter describes the basis for the development of a catalogue of risk reduction measures and possible classification.

In the annex, a collection of risk reduction measures from each partner country is provided. This annex was added to complete the picture of existing tools and measures to mitigate negative consequences of heavy rain events.

2. Legislation concerning pluvial floods

This section summarizes the answers given by project partners on the legislation in their countries on pluvial floods. We list the laws considered of most importance in each country. For some countries this includes limitations of the present law noted by the respective project partners.

2.1. EU

European legislation regarding floods is defined in DIRECTIVE 2007/60/EC of the European parliament and of the council of 23 October 2007 on the assessment and management of flood risks. The flood problem is mainly focused on fluvial floods. Pluvial floods are mentioned only marginally in Article 10-11:

Throughout the Community different types of floods occur, such as river floods, flash floods, urban floods and floods from the sea in coastal areas. The damage caused by flood events may also vary across the countries and regions of the Community. Hence, objectives regarding the management of flood risks should be determined by the Member States themselves and should be based on local and regional circumstances.

Flood risks in certain areas within the Community could be considered not to be significant, for example in thinly populated or unpopulated areas or in areas with limited economic assets or ecological value. In each river basin district or unit of management the flood risks and need for further action — such as the evaluation of flood mitigation potential — should be assessed.

The Flood directive mainly focuses on fluvial flood. As mentioned in Article 11 all types of floods which might occur under regional conditions should be assessed and suitable tools should be used.

2.2. Austria

In Austria, the main law that deals with pluvial floods is the Water Right Act 1959 (Wasserrechtsgesetz 1959, WRG). The WRG covers flood risk management and water management planning. Further pluvial flooding is covered in the Forestry Law 1975 and the Hydraulic structures Promotion Act (WBFG 1985).

Austria is a federal republic with different legislation in its federal states. The Austrian federal state is Styria is one of the project partner's and legislation in Styria includes the Styrian Spatial Planning Act 2010 (LGBl. Nr. 49/2010), Styrian Construction Law (LGBl. Nr. 61/2017), Styrian Structural Engineering Order 2015 (LGBl. Nr. 126/2015), Styrian Disaster Relief Law (LGBl. Nr. 61/2017). The Program for the flood-proof development of settlement areas 2005 (LGBl. Nr. 117/2005) is planned to soon include pluvial floods as well.

During the first implementation cycle of the Flood directive 2007/60/ES, pluvial floods were not considered decidedly. However, during the second implementation cycle pluvial flood already were already considered during the preliminary flood risk assessment and the identification of areas of potential significant flood risk by expert judgement. Therefore, flow paths and their entry point in settlement areas have been considered.

In Austria, no general method for the identification and mapping of pluvial hazards exists. However, in the recent years several federal states have started pilot actions in order to map pluvial flood risks. Therefore, different methods and software tools have been used with different accuracies. Basically, the end results have been indicative hazard maps (e.g. rollingball-method, GIS-analysis). In individual cases hydrodynamic models have been tested for small areas.

2.3. Croatia

In Croatia, the legislative framework addressing the problem of pluvial floods in Croatia is composed of:

- Water Act (Official Gazette (OG) 153/09, 63/11, 130/11, 56/13, 14/14) in the part concerning the definition of floods and authority to specify and implement pluvial flood risk reduction measures in Croatia (on the national level).
- Under the Water Act, in accordance with the derogations permitted by the Directive, floods from public sewerage systems imply floods caused by sewerage systems that don't function or have failed, and these are not covered by flood risk management. With that remark in mind, the Water Act regulates all the activities related to the reduction of pluvial flood risks both in urban and in rural areas.
- Water Management Financing Act (OG 153/09, 90/11, 56/13, 154/14, 119/15, 120/2016, 127/2017) regulates the matter of financing flood risk management activities.
- Utility Management Act (OG 36/95, 70/97, 128/99, 57/00, 129/00, 59/01, 26/03, 82/04, 110/04, 178/04, 38/09, 79/09, 153/09, 49/11, 84/11, 90/11, 144/12, 94/13, 153/13, 147/14, 36/15), according to which the municipal services of wastewater collection and treatment include storm water drainage.

In Croatia, the reduction of pluvial flood risks is under the competence of Hrvatske vode, whereas urban drainage (storm water drainage from urban areas) is regulated by a number of regulations, with the competence divided between Hrvatske vode and municipal service companies in charge of storm water drainage.

The Croatian River Basin Management Plan (RBMP), with the Flood Risk Management Plan (FRMP) as its integral part, deals with pluvial floods with the exception of urban drainage.

The RBMP 2016-2021 consists of two components of river basin district management:

- Component I: Water status management, substantially complying with the provisions of Article 36 of the Water Act;
- Component II: Flood risk management, substantially complying with the provisions of Article 112 of the Water Act.

Component II contains the conclusions of the Preliminary Flood Risk Assessment (PFRA), the description of flood hazard and flood risk maps, the flood risk management objectives and the programme of measures to achieve such objectives, including preventive measures, protection, preparedness, flood forecasting and alert and warning systems, aimed at reducing the potential adverse consequences of floods on human health and safety, valuable goods and assets, and the aquatic and terrestrial environment.

Based on the Water Act, storm water drainage (i.e. management of storm water risks) is planned on the national level when it concerns storm water drainage from agricultural areas. Storm water drainage (i.e. management of pluvial flood risks) in urban areas is under the competence of municipal service companies in charge of storm water drainage (combined sewerage and direct urban drainage); boundary channels and other similar water engineering solutions related to the protection of urban areas are planned, built and maintained on the national level.

2.4. Czech Republic

In the Czech Republic, legislation concerning pluvial floods includes the following Acts:

- Act No. 254/2001 Coll., on Waters,

The Water Act determines hydrological events, which might be considered as a flood. There are no exact parameters defined for pluvial flood but it is stated that pluvial flood is one of the possible flood events:

Floods for the purposes of this Act means a transient significant increase of water level of the watercourses or other surface waters where water is already flooding out of the watercourse and can cause damage. Flooding is also a condition where water can cause damage by failing to temporarily drain from a certain area or its runoff is insufficient, or flooding the area with concentrated drainage of rainwater. The flood can be caused by natural phenomena, particularly melting, rainfall or ice (natural flood), or other influences.

The Act also describes and determines all the issues concerning flood events like, flood plain area, risk management, prevention measures, flood plans, forecasting and warning system, flood evaluation, flood authorities their responsibility and so on.

There are other acts which are link to events like pluvial floods but they are mainly focused on emergency management and rescue system:

- Act No. 238/2000 Coll., on the Fire Rescue Corps,
- Act No. 239/2000 Coll., on the Integrated Rescue System,
- Act No. 240/2000 Coll., on Crisis Management,
- Act No. 12/2002 Coll., on State assistance in the renewal of areas affected by a natural or other disaster.

In terms of pluvial floods there is a method which is used on national level. This method, also called Method of Critical Points (CP), is a repeatable process able to identify areas, which are significant in terms of formation of surface runoff and erosion. In addition to the preliminary flood risk assessment according to EU Directive 2007/60/ES on the Assessment and Management of Flood Risks, the presented methodology was applied for the entire area of the Czech Republic. A total of 9,261 critical points were chosen for the whole Czech Republic which have a greater (unknown) probability of occurrence of negative impact of torrential rain flooding. The overall area of contributory areas of selected critical points in relation to built-up areas in CZ is 18,112.2 km2, which represents 23% of all land in the whole country. The results are available on the www.povis.cz portal.
For the districts in question this provides information on places where concentrated surface runoff can be expected to infiltrate built-up areas, and on what property may be at risk in the event of torrential rain. Local and national government have thus gained the basis for preparation of landscape planning and development. In the second round of planning (according to Directive 2007/60/EC), which ended in

2015, this basis was used in drawing up chapter V.2.3.3 Danger of torrential rain flooding in individual plans of partial catchment basins.

2.5. Germany

Regulations of the Flood Directive 2007/60/ES were transposed into German national law through the Federal Water Act (Wasserhaushaltsgesetz, WHG) in 2010. Pluvial floods or flash floods were not explicitly incorporated by name into WHG but implicitly recognized under the general term "flood" as temporary inundation of land not normally covered by water by surface waters in § 72 WHG. In the first implementation cycle of the directive, assessment and mapping was done for areas with potential significant flood risk (§ 75 WHG). For the second cycle of implementing the flood risk management directive, different types of floods shall be included. The risks driving from of heavy rain events are hereby considered as being a general risk, but not a significant one. The main reason for this approach is that heavy rain events and subsequent flooding can occur everywhere and identifying significant risk areas is hence not possible or at least at the moment suitable data, methodologies and approaches are lacking. According to the Federal State Water Consortium (Bund/Länder-Arbeitsgemeinschaft Wasser, LAWA) an assessment and mapping of heavy rain risks is only possible on the local level (Bund/Länder-Arbeitsgemeinschaft Wasser, 2017).

In 2018, LAWA published a heavy rain risk strategy, summarising background knowledge available in the German Federal and States' administration and defining future tasks for all levels of administration. While future implementation of heavy rain risk management measures is clearly addressed to local administrative level, responsibility of state and federal level is stated for supportive and strategic measures. Responsibility is also given to property owners (Bund/Länder-Arbeitsgemeinschaft Wasser, 2018). According to § 37 Par. 1 WHG the natural drainage of water should not be interfered or increased if there are disadvantage for lower or higher lying properties or general changes of runoff.

Further German acts address pluvial floods or are important when thinking about measures which may help to reduce heavy rain risks in urban and rural areas:

The Federal Building Code (Baugesetzbuch, BauGB) addresses in § 1 Par. 6 (8) the prevention of flooding (explicitly including flooding after a heavy rainfall) as issue for urban land-use planning. § 1a Par. 5 (BauGB) requires climate protection via land-use planning. Measures for flood prevention are justified by this, because they are considered as a consequence of climate change.

Furthermore, the Federal Regional Planning Act (Raumordnungsgesetz, ROG) needs to be mentioned. It addresses the protection and development of nature and landscape, regulates the compensation of impairments of ecosystems and focuses especially on the interlink of soil and ecosystem. Landscape structures for water retention and against soil erosion by water are subject of the act.

Climate protection is not comprehensively regulated in Germany, at least not yet. Different approaches for climate change legislation exist on the state level. For example, the federal states Nordrhein-Westfalen, Baden-Württemberg, Bremen und Schleswig-Holstein have a separate climate protection law. These laws do not only include climate protection goals, but also adaption to climate change, which always contains adjustment to heavy rain events.

However, there is a "variety of laws and extra-legal rules" (Altvater et al., 2015, p.40) concerning the protection of soils. Although they do not explicitly talk about pluvial floods they offer opportunities for heavy rain risk management. The most important one is the Federal Soil Protection Act (Bodenschutzgesetz, BBodSchG) which focuses on conservation and restoration of soil and its protection from erosion by water. §

4 BBodSchG provides for obligations and requirements to prevent risks. § 17 BBodSchG meet the requirement of taking precautions in accordance with § 7 BBodSchG and the principles of good agricultural practice in agriculture. However, it is judged that "this does not entail an enforceable compliance obligation. Due to the very generic formulations and lacking specificity, the principles shall be understood as mere guidelines and, apart from this, only apply with regard to agricultural use of the soil." (Altvater et al., 2015, p.43). Further, laws that are somewhat connected to pluvial floods are the Federal Forest Act (Bundeswaldgesetz, BWaldG), and the Federal Nature Conservation Act (Bundesnaturschutzgesetz, BNatSchG). Under some preconditions, they may help to protect existing water retention structures, e.g. on agricultural land.

2.6. Hungary

In Hungary different approaches on federal/national and regional level do not exist. Pluvial floods are involved among floods in methodology of the pluvial inundation hazard assessment, the pluvial flood risk assessment map in Hungary and also the pluvial flood risk management plans.

Nearly 50 % of Hungary's area is lowland. Lowland areas are typically low sloped, which causes low velocity of runoff water. Pluvial floods hit Hungary almost every year and they typically cause damages by the long residence time of water on settlements and arable land. For the protection of people and their property artificial water structures (pumping stations, drainage systems,…) are the only solution.

In Hungary, several laws address pluvial floods:

- The Act LVII of 1995 covers rules regarding water management. The law contains a lot of general rules in connection with water management. (Responsibilities to hydraulic facilities, control of emergency defence operations during floods, data handling)
- The Ministry of Transport Communications and Water Management decree No. 10/1997. (VII.17.) covers flood control and land-drainage operations and determines protection plans and warning levels in case of pluvial or fluvial floods.
- The Ministry of Environment and Water-Ministry of Interior decree No. 18/2003. (XII. 9.) defines settlements classification based on fluvial and pluvial flood risk (A - high risk, B - medium risk, C- low risk).
- Government decree No. 232/1996. (XII. 26) covers protection against damages caused by flood. This Decree determines the authorities responsible for the technical aspect of local, regional and national level. Flood means not only outflowing of water from watercourses but the high level of inland water on settlement and on arable land as well. The minister responsible for water management is the nominated government commissary for the period of an emergency situation, and this person coordinates and manages the related works of protection.
- Government decree No. 83/2014. (III. 14.) on rules of use and utilization of the flood beds, maintenance zone along the channels, vulnerable territories by undersee pages, and rules of making high-water management plants. The decree determines the maintenance zone along the channels in order to maintenance of the channels be insured. The decree determines use and utilization of the flood beds. The decree determines of the use and utilization of the vulnerable territories by underseepage. The decree determines the rules of preparing high water bed management plans.

- Government decree No. 147/2010. (IV. 29) on rules of activities and facilities for the recovery, protection and damage prevention of waters. The decree determines the general rules of watershed management in rural and urban area. The decree determines the rules of crossing water structures (channels, dams, rivers, hydraulic structures).

2.7. Poland

In Poland, a new Water Law (Prawo wodne, Journal of Laws 2017 item 1566, dated 20.07.2017) was passed and has become active on 1/1/2018. This new Water Law lead to the reorganization of government administration units responsible for water management on both, national and regional level, scope of their actions and responsibilities and introduction of the principle of guaranteed reimbursement for water services (no more exemptions from the obligation to pay fees for using the environment due to, among others, water abstraction, sewage discharge and other water services). A wider catalog of water services covered by fees has been introduced. New instruments appeared that will provide an economic incentive to take into account the proper development of urbanized areas, i.e. to take into account the drop in the amount of rainwater discharged, the preservation of green areas and the introduction of green - blue infrastructure.

In the new Act on Water definition of flood is temporary coverage of the area by water, which in normal conditions is not covered with water, in particular caused by water spills in watercourses, water reservoirs, canals and from the sea, excluding water coverage of land caused by water spurt in sewerage systems (similar to definition in Flood Directive, where pluvial flood are mention only marginally in the preamble).

The Water Law does not regulate the issue of local floods caused by rainwater and sustainable management of rainwater comprehensively.

There is a lack of the definition of a sustainable rainwater management system as a whole, as well as the definition of individual components of the system. This is an important issue because it has a direct impact on the approach of how designers, investors and operators build rainwater management systems on the plot, which is important for fees for water services.

The flood definition in the Water Law excludes water coverage by water spurt in sewage systems and does not explicitly cover pluvial floods. For several years, the subject of limiting the effects of flooding in urbanized areas has been discussed - by slowing down the outflow of rainwater through the use of blue-green infrastructure. Interest in the above this aspect is related to cases of local rain floods after rainstorms in urban areas. In some cities analyzes of retention capacity of urban catchments, as well as studies and water management programs in the municipal or city area were performed. The assumption of these documents is to increase local retention and reduce the effects of urban floods caused by heavy rainfall events. The use of blue-green infrastructure solutions has been gradually spreading.

The current approach to rain water is based on its capture and referral to the sewerage systems, which increases the load in the combined sewage system. This increases the cost of sewage and can cause overloads, especially after heavy rain fall.

In Poland, some regional laws exit that define the use of rainwater in municipalities (mainly in cities). In the literature there are definitions of pluvial flood caused by rainfall, often heavy rains. It is emphasized that they often have a short but rapid course. It is emphasized too that often, despite the short duration of rainfall, it causes large losses. Precipitation usually occurs in the summer months (although they may occur from April to October). (Czech, 2013; Januchta-Szostak, 2011; Riegert, 2014; Wojciechowska et al., 2016)

Also after implementation of Flood Directive in Poland, there is no clear separation and analysis of floods caused by heavy rains as part of the implementation of the flood directive. There are no flood hazard and flood risk maps dedicated to rainfall floods (after rainstorms). There are no flood hazard and flood risk maps, for areas outside the immediate vicinity of the watercourse, and indicating the possibility of danger after heavy rainfall.

As a part of the KLIMAT project, a catalogue of the occurrence of local emergency floods from thy years 1971 – 2010 was created. Results of the work were – Flash flood floods in Poland in the years 1971 – 2010, map of regions of the most frequent occurrence of local floods in Poland in the catchment system, flood hazard maps in administrative terms, a map of the frequency of floods and information layer in the GIS system.

2.8. Conclusions

Different legislative approaches exist in the participating countries. In federal states (Austria, Germany), pluvial floods are solved on local and federal levels. In the recent years, several federal states have started pilot actions in order to map pluvial flood risks. Therefore, different methods and software tools have been used with different accuracies. Basically, the end results have been indicative hazard maps (e.g. rollingball-method, GIS-analysis). In some cases, hydrodynamic models have been tested for small areas.

Contrarily, in other countries such as Hungary there is no difference between approaches on federal/national and regional level. In Hungary, pluvial floods are involved among floods in the methodology of the pluvial inundation hazard assessment, the pluvial flood risk assessment map and also the pluvial flood risk management plans. In Croatia, the reduction of pluvial flood risks is under the competence of Hrvatske vode, whereas urban drainage (stormwater drainage from urban areas) is regulated by a number of regulations, with the competence divided between Hrvatske vode and municipal service companies in charge of stormwater drainage. In Poland, the Water Law lead to the reorganization of government administration units responsible for water management on both, national and regional level, scope of their actions and responsibilities and introduction of fees for using the environment. The Water Law does not regulate the issue of local floods caused by rainwater and sustainable management of rainwater comprehensively. In the Czech Republic, the GIS-based method of Critical Points (CP) is used on national level and implemented in the law. It is a repeatable process able to identify areas, which are significant in terms of formation of concentrated surface run-off and erosion.

Information provided by the project partners indicate that there is usually no single method used on a national level. The only country using a single method on a national level is the Czech Republic, where the method is part of legislative framework. Pluvial floods are generally solved on a federal or regional level, due to their accidental occurrence and the intensity of the heavy rain event. Generally, it is difficult to compare legislative frame work in each country because of different governmental structure and distribution of competence.

3. Catalogues and projects of risk reduction measures

This chapter discusses catalogues of risk reduction measures related to heavy rains and pluvial floods. Based on the questionnaire and discussions during meetings, we provide an overview of existing catalogues in each country participating in the RAINMAN project. We also list local projects and refer to their guidance documents on flash and pluvial floods.

3.1. Overview of catalogues of measures

Existing catalogues of measures are rare. There are existing catalogues not focused on pluvial floods, but on drought prevention (Czech Republic), although some of the measures can be used for pluvial flood protection (/prevention). A catalogue of measures is currently tested in Upper Austria. Table 1 shows the current status of existing catalogue of measures in countries of the project partners.

Table 1: **Summary of existing catalogues of risk reduction measures in the participating project countries**

Country	Catalogue of measures	Accessibility	Notes
Austria	Federal level, categorization: • Prevention • Protection • Awareness Raising • Preparedness • After-Care Upper Austria, categorization: • Prevention • Protection	Unknown	Federal republic, catalogue only used in the state of Upper Austria
Croatia	Not available		
Czech Republic	Katalog přírodě blízkých opatření pro zadržení vody v krajině (engl. Catalogue of green water retention measures in the environment) (Výzkumný ústav vodohospodářský T. G. Masaryka.v.v.i., 2018) as part of Projekt Sucho (engl. drought project)	Public, website: http://www.suchovkrajine.cz/vystupy/katalog-opatreni	Only available in Czech Only structural measures
Germany	**Not available**		
Hungary	**Not available**		
Poland	**Not available**		

3.2. Categorization of risk reduction measures

Categorization is an important issue when creating and organising a suitable catalogue of measures. The most general categorization divides measures into structural and non-structural. Structural measures can be defined quite easily and include all civil works. However, the definition of non-structural measures is much broader and can include measures from a vast range of different disciplines such as land-use planning, policy, soil management, insurance, public information access and emergency systems and many more (Colombo et al., 2002).

A new categorization was prepared by the (Working Group F of the Common Implementation Strategy for the Water Framework Directive, 2012) of the European Commission (Table 2). It is important to keep in mind that the list of categorization was prepared solely for the purposes of reporting types of measures in the FRMP Reporting Sheet. A number of different measures, and hence types of measures, may be linked to any one area of potentially significant flood risk (APSFR) or other defined area to which the measure, or aggregated set of measures, applies. Where the nature of a measure does not correspond to the terms used in the tables, MS may select the "Other" option (which should be the default). Importantly, more than one option can be selected.

It was difficult to construct a summary of measures based on the questionnaire as the resulting measures acted on many different levels and its categorization was too challenging at this stage of the project. The appendix includes a more detailed list of structural and non-structural measures from each project partner.

Table 2: **Categorization developed by the working group flood of the European Commission (2012)**

Aspects of flood risk management	Description
No Action	**No measure is proposed to reduce the flood risk in the APSFR**
Prevention	**Preventing damage caused by floods :** • **by avoiding construction of houses and industries in present and future flood-prone areas;** • **by adapting existing receptors to the risk of flooding; and ensure that future developments take flood risk into account;** • **by promoting appropriate land-use.**
Protection	**Taking measures, both structural and non-structural, to reduce the likelihood of floods in a specific location.**
Preparedness	**Informing the population about flood risks and what to do in the event of a flood; including emergency response: developing emergency response plans in the case of a flood.**
Recovery and Review/Lessons learn	**Returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.**
Other	**Other type of measure.**

3.3. Projects

In this section, we list exemplary projects and published guidance documents dealing with heavy rain risk in the project countries (Table 3). Although there is a lack of catalogues of measures, many projects created guidance documents or guidelines, where measures are thoroughly discussed (Colombo et al., 2002; RISA, 2012). Pluvial floods tend to be approached on a local level, therefore, existing catalogue of measures and guidance documents are usually published with limited or no translation. Table 3 clearly shows that many projects took place or are available in Germany and some in Poland. This indicates a strong bias across central Europe.

There a already many lessons learnt from past research projects. These include studies looking at cost-effectiveness of flood mitigation measures (Kreibich et al., 2011; Poussin et al., 2015) or potential improvements of flood management plans (Montz and Gruntfest, 2002; Nquot and Kulatunga, 2014). The catalogue of risk reduction measures can only be one tool helping to design a flood management plan. Colombo et al. (2002) and Montz and Gruntfest, (2002) stress the importance of the social component in the creation of flood management plans. A recent study in Germany concluded that raising awareness needs to be improved for better flood management and that receiving an early warning is vital for damage mitigation (Rözer et al., 2016). This shows that it is not only important what is implemented, but how.

Table 3: **List of past projects and guidance documents dealing with heavy rain in the project countries**

Country	Projects
EU	NEDIES Project • Guidelines on Flash Flood Prevention and Mitigation (Colombo et al., 2002)
Austria	
Croatia	
Czech Republic	Strategie ochrany před negativními dopady povodnía erozními jevy přírodě blízkými opatřeními v české republice (engl. Strategies to protect against negative impacts of floods and erosion with environmental measures in the Czech Republic) • Website: www.vodavkrajine.cz (Czech)
Germany	• **RegenInfraStrukturAnpassung (RISA, Hamburg)** ○ **Website: www.risa-hamburg.de (German and English)** ○ **Documents: Final report** (Waldhoff and Bischoff, 2015) **and Guidance document** (RISA, 2012) • **KLimaAnpassungsStrategie (KLAS, Bremen)** ○ **Website: www.klas-bremen.de (German)** • **KLIMPRAX (Hesse)** ○ **Website: www.hlnug.de/themen/fachzentrum-klimawandel/forschungsprojekte/siedlungsraeume/klimprax-starkregen (German)** • **Starkregenleitfaden *engl. Heavy rain guidance document* (Baden-Wuerttemberg)** (Koch et al., 2016) • **Heavy Rain Risk Management for urban sewer systems (German Association for Water Management, Waste Water and Waste)** • **Heavy Rain working group (Länderarbeitsgemeinschaft Wasser)** ○ **Website: www.lawa.de** • **Hochwasserpass engl. Floodpass (Hochwasser Kompetenz Centrum)** ○ **Website: www.hochwasser-pass.com (German)**
Hungary	
Poland	• **KLIMAT:** (Marosz et al., 2011) • **Polski Atlas Natężeń Deszczów Miarodajnych (PANDa):** ○ **Website: www.retencja.pl/en/about-us/eu-projectspanda / (English)** • **Miejskie plany adaptacji do zmian klimatu (MPA, engl. Urban adaptation plan, Polish and English)** ○ **Website: www.44mpa.pl**

4. Summary and Conclusions

4.1. Discussion of approach

The scoping study focused on the collection of national or federal attitude, data sets and tools used in the countries participating in this project (Austria, Croatia, Czech Republic, Germany, Hungary and Poland). For the data collection a questionnaire was used, which was sent to all project partners. Due to the phrasing of the questions used in the questionnaire, some project partners interpreted the meaning of the questions differently to the intended meaning. This resulted in the evaluation of some contributions to be more difficult. Nonetheless, all of the contributions were evaluated and processed to be used in the scoping study. There was an attempt to summarize the measures collected, which was later disregarded and the list of measures was placed in the annex of the scoping study.

4.2. Conclusions for the catalogue of risk reduction options and management measures

The questionnaire and categorization of measures was discussed during the project meeting in Prague, February 2018. A draft of this scoping study was discussed during the project meeting in Zagreb, 13th-14th June 2018, where the majority of the points of the discussion were focused on how to use the scoping study in the ongoing project. This scoping study shows that there is a strong project bias among the participating countries. The scoping study and the completed questionnaire have shown the need of a catalogue of measures, which is applicable and accessible everywhere in central Europe, especially in regions where no or little guidance is currently available. With the uneven distribution of projects, we also show the necessity of this project fostering knowledge transfer across central Europe.

Furthermore, the scoping study crystalized the questions key to the final catalogue of measures and management of measures. For example:

- Who will be the final user or group of users of the catalogue?
- How should measures be categorized? Should the catalogue correspond to the categorization developed by the working group Flood of the European Commission (2012)?
- How to use or involve existing catalogues of measures which are used as fluvial flood protection or draught prevention?

The next step in the development of the catalogue of measures will be the proposal of categorization. We conclude that there is a need for a complex and official catalogue of measures, which is accessible all over Europe. This requires the categorization of the measures to be simple and yet complete. Literature research has shown that for a flood management to be successful non-structural measures need to be considered and the public needs to be well-informed. Therefore, we feel that a holistic and effective catalogue will also contain non-structural measures. We further conclude the importance of best-practice examples.

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Hochwasser Pass (engl. flood pass, German)
www.hochwasser-pass.com

KLAS (Bremen, German)
www.klas-bremen.de

Bund/Länder-Arbeitsgemeinschaft Wasser (engl. Federal State Water Consortium, German and English)
www.lawa.de

Povodňový informační systém (engl. Flood information system, Czech)
www.povis.cz

PANDa (English)
www.retencja.pl/en/about-us/eu-projectspanda

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7. Annex – Project partners' contributions

Austria

Project internal contribution on Austria from 08.02.2018

Contributing authors: Cornelia Jöbstl, Rudolf Hornich – project partner 4 (Land Steiermark.), Yvonne Spira – project partner 3 (Umweltbundesamt)

This catalogue of measures was generated for the 1st implementation period of the EU Floods directive in Austria. It is applied mainly for fluvial events. Currently it is evaluated, how well these measures fit for pluvial events. Below, a selection of measures is listed, which are also suitable for pluvial floods. In the rows "Short description" and "Effect / Deficit" information and examples are given based on experiences in Styria.

Field of Action	Measures	Short description	Effect / Deficit	Type[1]
PREVENTION	**M01: Identifying risk areas**	Identifying endangered areas via flow path maps for pilot areas, such as the city of Graz	Indicative only	N
	M02: Considering pluvial flooding in spatial planning and building legislation		Hazard and risk maps need to be available	N
	M03: Developing catchment based concepts and plans for improving the water and solid material budget			N
	M04: Establishing and considering of local and regional land-use planning			N
	M05: Establishing of framework conditions for implementation and maintenance of protection measures			N

[1] Type: s=structural; n=non-structural

PROTECTION	**M06:** **Retention effective surface management in catchment areas**	▪ Unsealing, Avoidance of new sealing ▪ Reduction of soil erosion ▪ Change of crop management The Styrian Chamber of Agriculture is working intensive on this topic. Main points are the use of modern technology (e.g. grubbers) in order to establish surfaces, which are less endangered by erosion. Furthermore they work on the topic of soil water storage capacity in order to retain more water in the ground. Information and results from experiments are passed on to interested farmers in information events. E.g. in 2018 already about 1.200 farmers participated in these events.	Increase of water retention and decrease of soil erosion. Earnings increase, because valuable ground remains in the cropland. Authorities do not have direct influence on the crop management. Only indirect measures can be set like awareness raising.	S
	M07: **Re-establish flood plains and deposition areas**			S
	M08a: **Planning and building of protection- and regulation water constructions: flood and sediment retention constructions**	▪ Retention Basins ▪ Infiltration systems ▪ Seepage reservoir	Peak discharge is stored temporally and released delayed and buffered. Need to safeguard the quality of groundwater. Dependent of the soil infiltration ability.	S
	M08b: **Planning and building of protection- and regulation water constructions: linear protection measures**	▪ Dams, backfills and walls ▪ Water drains (enhancement, removal of obstacles) ▪ Strom water drainage and culverts ▪ Emergency waterways, flood channels, floodable areas ▪ Road drainage in case of new constructions and refurbishment	With controlled and organized drainage of water in problematic areas, it is possible, that heavy rain events do not cause damages. Accelerating and redirecting of water may shift the problems and influence third parties in a negative way. Prohibition on allowing property to deteriorate.	S
	M08c: Planning and building of protection- and regulation water constructions: Other measures			S

	M09: **Taking and adapting property protection measures**	▪ Heightening of entrance points ▪ Backwater protection for sever water ▪ Mobile Elements ▪ Fixing of oil tanks against buoyancy ▪ Adapted use of buildings and cellars (no storage of valuable goods in endangered rooms) ▪ Water-resistant floors and walls ▪ Flood doors, Flood windows ▪ Pumps	In many cases, damages can be avoided by personal provision. Municipalities can require measures in the course of building approval proceedings inform the citizens and conduct awareness raising. Personal provision is done on a voluntary basis. Problem of barrier-free building for real-estate developers. Maintenance of private protection structures is challenging for the people and often not done on a regular basis. No funding possibilities for private persons for property protection measures through public funding or insurances. (There are funding options for raising the security level for fire or burglary)	S
	M10: **Examining and implementing resettlement and reallocation**			N
	M12: Maintaining, operating and improving flood protection structures			S
	M13b: **Generating operating regulations for flood endangered facilities: commercial and industrial plants**			N
AWARENESS RAISING	**M14:** **Preparing and providing information about flood hazards and flood risks for the public in a proper way.**	An information-campaign is carried out from autumn 2017 until end of 2018 in Styria in order to increase people's awareness regarding pluvial and fluvial flood hazards and risk. It is planned to hold an information event in each of the 287 municipalities in Styria. Additionally, special information material has been developed to help people to assess their flood risk (e.g. checklists) and to prepare for flooding (e.g. template for a personal flood emergency plan).		N

	M15: **Promote participation regarding the topics flood hazards and flood risks**	In the course of the presented information events in measure 14, people have the possibility to ask questions. In one municipality in Styria meetings with the citizens are held after pluvial flooding has occurred. Hot spots and problems are discussed. By this, the population has the possibility to take actively participate in the process.		N
	M16: **Conduct educational activities regarding flood hazards and flood risk**			N
PREPARATION	**M17:** **Establishing and operating monitoring systems, forecast models and warning systems**	Warnings regarding heavy rain are, amongst others, distributed by the Austrian Central Institute for Meteorology and Geodynamics. In case of an expected heavy rain event, a municipality in Styria give the civil defense alarm “alert”. The population is informed about this procedure. In this way, the citizens have the possibility to prepare for the event.		N
	M18: **Establishing disaster control plans for coping**	▪ Organisation (responsibilities, information chain) ▪ Personal flood emergency plans		N
	M19: **Ensure preconditions for the implementation of disaster control plans**			N
AFTERCARE	**M20:** **Conducting emergency measures at protection structures immediately after an event**			N
	M21: **Assessing and clearing flood damages at constructions and infrastructure and safeguard claim**			N
	M22: **Conducting event and damage documentation, as well as analysis events**	Federal professional data base to record historic flood events. Until now predominantly fluvial events are documented.		N

Upper Austria

This catalogue of measures is used in the province Upper Austria. It comprises only the action fields "prevention" and "protection".

Field of Action	Name	Short description; effect	Type[2]	Scale[3]	OOE No.
PREVENTION	adaptation/shifting of building area		n	p	7
	refusal of building permission		n	p	8
	consideration of pluvial flood paths in land development plans / zoning plans		n	p	9
	Shift the location of the planned building outside the hazard area of the property		n	p	10
PROTECTION	Protection of building openings - permanent or temporarily	e.g. cellar windows, doors	s	o	1
	runoff paths through subsidiary buildings		s	o	2
	Application of pluvial flood protection construction rules	e.g. floor level, building material, no cellar	s	o	3
	enclosure of the property		s	p	4
	drainage ditches, depressions, pipes		s	p	5
	infiltration facilities, retention facilities		s	p	6
	building permit provisions	building permit contains measures for avoiding negative consequences of pluvial floods on buildings and third parties	n	p	11
	specific grassland zoning, protection zones	for retention and / or planned runoff	n	c	12
	drainage ditches, depressions		s	c	13
	walls, dams	no adverse consequences up to design event	s	c	14
	protection forest	retention, erosion protection	n	c	15
	use space dedicated as public thoroughfare for retention	parking areas, streets for temporary retention	s	c	16
	use space dedicated as public thoroughfare	directed runoff	s	c	17

[2] Type: s=structural; n=non-structural

[3] Scale: o=object; p=property; c=catchment

	for runoff				
	rotation farming design, intertillage	e.g. erosion prevention	n	c	18
	presevation / improvement of soil structure	avoid consolidation / compaction	n	c	19
	mulch seeding, direct seeding, strip seeding		n	c	20
	cultivate lateral to the slope	avoid preferred runoff paths and slow down surface water	n	c	21
	avoid skid marks in slope direction	avoid preferred runoff paths	n	c	22
	coarse seedbed preparation		n	c	23
	field subdivision	avoids long runoff paths	n	c	24
	grassland retention edges, buffer edges	slow down surfacce runoff	n	c	25
	preservation/creation of meadows and pastures	decrease runoff	n	c	26

Croatia

Project internal contribution on Croatia

Contributing authors: Project partner 7 (Hrvatske Vode)

Structural Measures

Standard measures;

Amelioration systems;

Combined systems and stormwater drainage systems;

Stormwater overflows;

Flash flood + retention basins;

Anti-erosion measures;

Pumping stations.

Non-structural measures

Flood Risk Management Plan

Water management in Croatia is regulated by the Water Act (OG 153/09) and the Water Management Financing Act (OG 153/09). Both Acts, adopted in 2009, are in compliance with the EU Acquis communautaire in the field of water. In accordance with the Water Act, Hrvatske vode is obligated to undertake preliminary flood risk assessment, produce flood hazard maps and flood risk maps, and produce flood risk management plans.

Physical planning

Physical planning implies methods used by the public sector to influence the spatial distribution of people and activities to a different extent. Physical planning includes all the levels of land use planning, including urban planning, regional planning, environmental planning, national physical planning, including also the international level in the EU.

Warning system and rainfall forecasting systems

Warning and forecasting system for harmful and dangerous hydrological events.

Aimed at timely warning and reduction of adverse effects of flash floods, the Croatian National Meteorological and Hydrological Service (DHMZ) has together with other NMHSs from SE Europe and global institutions – World Meteorological Organization (WMO), Hydrologic Research Center (HRC) and National Oceanic and Atmospheric Organization (NOAA) – participated in the project “South East Europe Flash Flood Guidance”.

The Flash Flood Guidance System (FFGS) is based on estimation of the precipitation amount from satellite imagery and ALADIN model and provides an indication as to whether it would generate a bankfull discharge. It is used in operational practice for the generation of warnings and forecasts about the arrival of dangerous and harmful hydrological events.

Flash floods are an exceptional hydro-meteorological phenomenon with strong and rapid oscillations in flow, most frequently as the result of intensive rainfall over a very short period. Due to particular complexity and local character, they represent a challenge in hydro-meteorological forecasting.

National Protection and Rescue Directorate (DUZS)

DUZS is an independent, professional and administrative organisation tasked with preparing plans and managing operational forces as well as co-ordinating the activities of all participants in the protection and rescue system.

DUZS is the leading organization for the protection and rescue of people, assets and environment in the Republic of Croatia, in harmony with the needs of a modern society.

Its mission is to constitute and maintain a modern system of protection and rescue in the Republic of Croatia, which will be able to respond with all available resources to all needs for the protection of people, assets and environment in events of disasters, accidents and other needs of a modern society, and if necessary, extend or obtain help from other countries in the emergency situations.

It is in regular contact with the DHMZ and Hrvatske vode, with which it permanently exchanges information about meteorological and hydrological indicators aimed at monitoring the situation if a flood occurs. Through its Regional Protection and Rescue Offices, DUZS in in contact with the representatives of local and regional self-government units and emergency services, recommending that all the activities between operational forces of the civil protection system to increase preparadness for a flood event are coordinated through the civil protection headquarters (HQ).

The situation is continuously monitored, with the operational forces of the civil protection system ready to provide assistance to the population at any moment. County 112 Centres can be contacted 24/7. National civil protection intervention forces are on stand-by for possible field intervention in case of a flood. If needed, the civil protection system on the local, regional and national level is activated. If needed, DUZS, Hrvatske vode, the police, firefighters, civil protection, public health, Croatian Red Cross, Croatian Mountain Rescue Service (HGSS), municipal service companies, civil protection HQ and the Croatian Armed Forces are included in flood protection, controlling the situation on the field by taking adequate measures.

The occurrence of floods increases the risk of contagious diseases, in particular contagious diseases borne by contaminated water, food, contact and rodents. Timely preventive activities can reduce the risk of adverse consequences associated with floods, and it is recommended to implement preventive measures of the Croatian Institute of Public Health for the sanitary quality of water and food and people’s health.

Croatian Mountain Rescue Service (HGSS)

Czech Republic

Project internal contribution on the Czech Republic

Contributing authors	Project Partner 5 (Výzkumný ústav vodohospodářský T. G. Masaryka.v.v.i.)	
Picture credit	Torrent regulation:	Lubo Augustinsky
	Barrage (3rd picture):	Petr Kupec, Mendel University, Brno
	Other:	Katalog přírodě blízkých opatření pro zadržení vody v krajině (2018) (engl. Catalogue of green water retention measures in the environment) developed as part of the Projekt Sucho (engl. drought project)

Structural measures

Measures on arable land

- **Furrow**

  Furrow is a shallow and wide ditch with mild slopes and small longitudinal gradient. It allows to intercept, infiltrate and alternatively to drain the surface runoff. It should be dimensioned to the corresponding N-year discharge and meet the functional requirements.

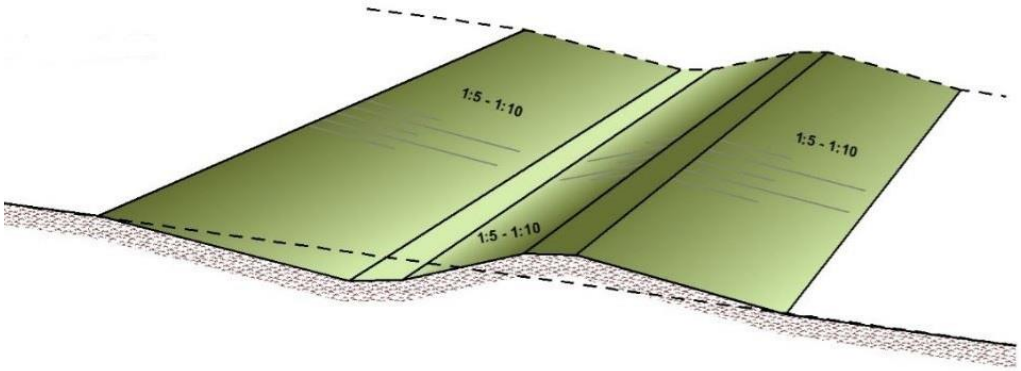


Figure 1: Schematic of the technical design of a furrow. (source: VÚV TGM, v.v.i.)

Figure 2: Realization of a furrow in the landscape (source: VÚV TGM, v.v.i.).

- **Ditch**

  Ditch is a measure similar to a furrow and serves the same purpose. The side slopes are steeper. Thus, the retention volume is smaller. It is usually projected in areas where the space for constructing of a furrow is limited.

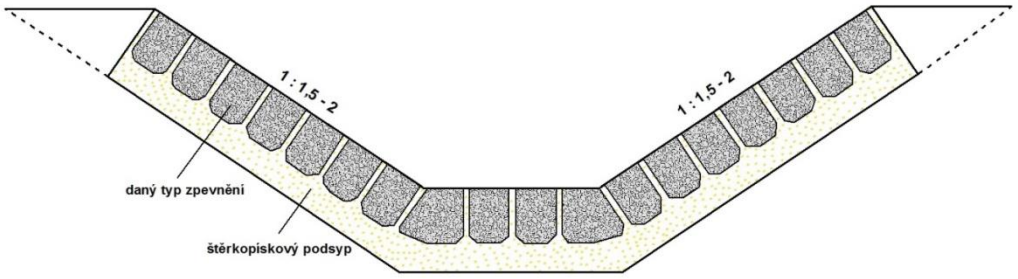


Figure 3: Cross-sectional profile of a ditch with basic technical parameters (source: VÚV TGM, v.v.i.)

Figure 4: Realization of a ditch in the landscape (source: VÚV TGM, v.v.i.).

- **Infiltration belt**

  Infiltration belt is a grass belt, usually projected on a sloping terrain. It is oriented in the direction of a contour. It can also be found in the vicinity of reservoirs where it serves as a protection against penetration of an eroded material into the water.

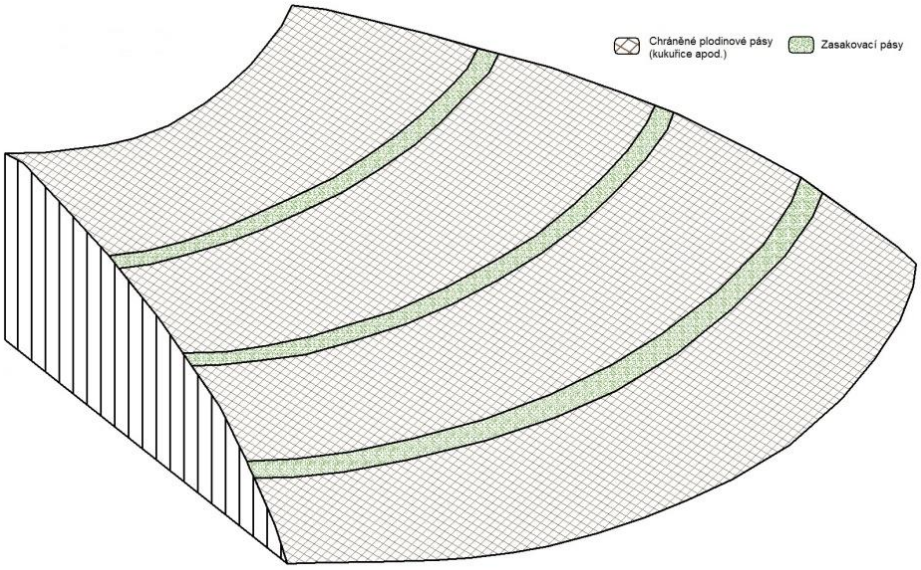


Figure 5: Schematic of an infiltration belt with a longitudinal slope profile (source: VÚV TGM, v.v.i.).

Figure 6: Realization of an infiltration belt on a selected slope in the landscape (source: VÚV TGM, v.v.i.).

- **Stabilization of pathways of concentrated surface runoff**

  Pathways of concentrated runoff are stabilized most frequently by grassing, so that they are able to transfer the surface runoff without the occurrence of erosion in the body of the pathway. The most common shape is parabola with a small depth. Such a shape is most similar to that of the naturally created pathways. In addition, it reduces the probability of meandering.

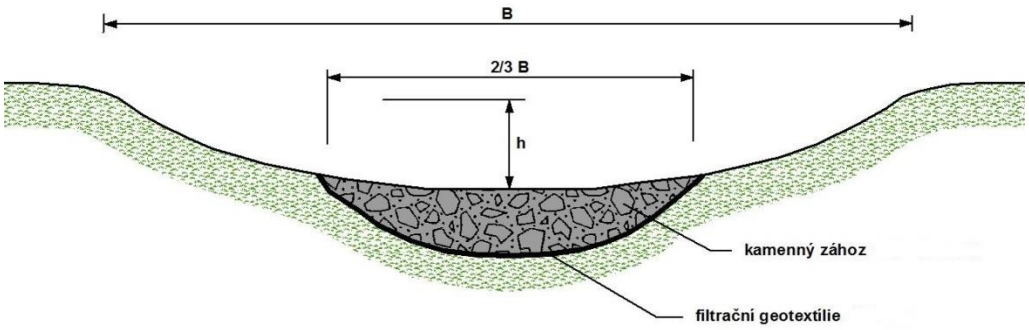


Figure 7: Cross-sectional profile of a stabilization pathway with basic technical parameters (source: VÚV TGM, v.v.i.).

Figure 8: Realization of a stabilization pathway in the landscape (source: VÚV TGM, v.v.i.).

- **Dike**

  Dikes have a zero longitudinal slope. They are constructed in the direction of contours. Both the area in front of the barrier and its height must be corresponding to the need for retention volume of water, including the volume of deposited eroded material. Most frequently, they are in the form of an earth embankment reinforced by grass.

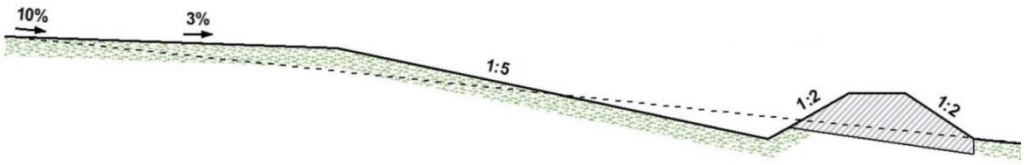


Figure 9: Schemata and basic technical parameters of a dike (source: VÚV TGM, v.v.i.).

Figure 10: Technical realization of a dike in the landscape (source: VÚV TGM, v.v.i.).

- **Baulk (country lane)**

  Baulk is a belt of uncultivated land that separates two agricultural fields. It is usually oriented in the direction of a contour, so it acts as a reduction of the velocity of surface runoff and supports the infiltration. The highest efficiency of is achieved when accompanied by an infiltration belt located above and a furrow under the measure.

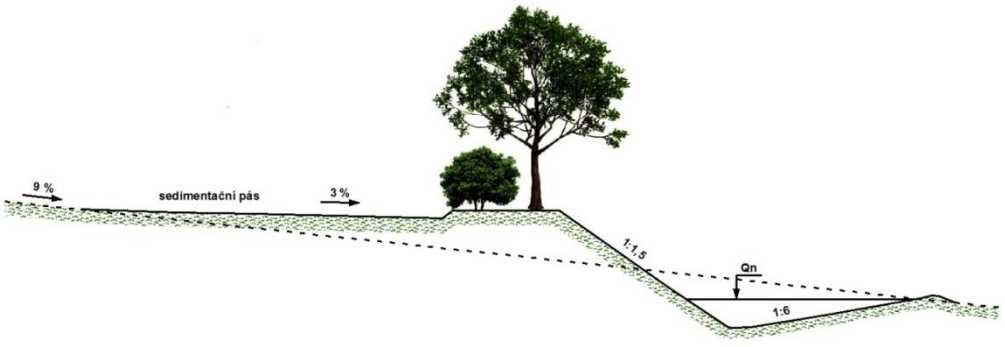


Figure 11: Schemata of basic technical parameters of a baulk in the slope profile (source: VÚV TGM, v.v.i.)

Figure 12: Characteristic realization of a baulk in the landscape (source: VÚV TGM, v.v.i.).

- **Barrage**

  Barrage acts as a barrier to swift creeks and gullies. It can also be constructed over a pathway of concentrated surface runoff. It can be in form of a sill or a step. The measure reduces the longitudinal slope, serves the accumulation of surface waters and controls the velocity of the concentrated surface runoff during intense rainfall events.

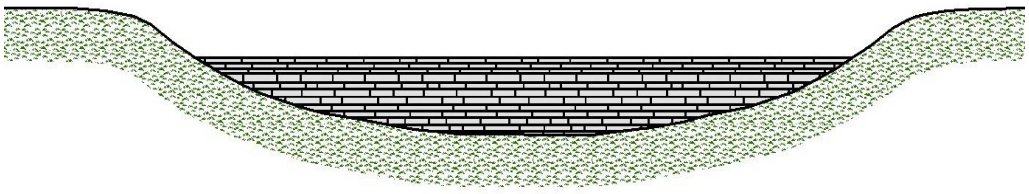


Figure 13: Schematic cross-section of a barrage (source: VÚV TGM, v.v.i.).

Figure 14: Upstream view of the barrage realized on an agricultural field (source: VÚV TGM, v.v.i.).

Figure 15: Upstream view of the barrage realized in a forest area. (source: Petr Kupec, Mendel University, Brno.)

- **Terrace**

  Terracing allows utilization of a land in a steep and indented terrain, where current agricultural methods would not make it possible to use it in an efficient way. A terrace consists of a terrace platform and a terrace slope. The measure is recommended for slopes > 15 °, which can be divided into segments, so that the surface runoff is not able to reach the erosive effect. Terraces pose a significant disruption of geology, geomorphology, pedosphere and biology of a landscape. The can, therefore, violate the landscape's ecological mechanisms. For this reason, they should be considered as the ultimate solution.

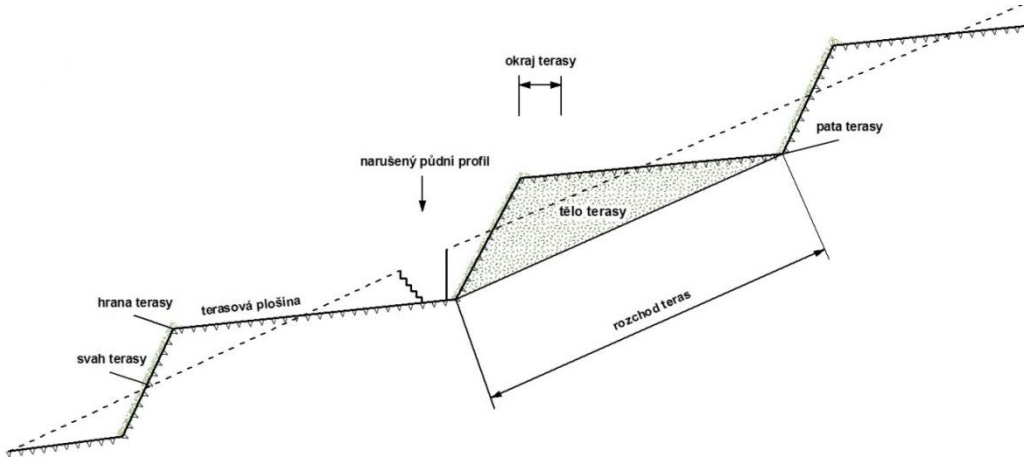


Figure 16: Schematic slope profile with basic description of terraces (source: VÚV TGM, v.v.i.).

Figure 17: Realization of terraces in the landscape (source: VÚV TGM, v.v.i.).

- **Small reservoir**

  Small reservoirs (protective reservoirs) are constructed to intercept surface runoff and transform flood waves, so they can protect objects underneath them from the negative effects of floods and from the transported soil particles from erosion processes. The ideal is the design of multipurpose reservoirs that can perform multiple functions simultaneously.

Figure 18: Small reservoir realized in an agriculture area (source: VÚV TGM, v.v.i.).

Measures in the forest

- **Torrent regulation**

  It is usually in form of sets of barrages built in a direction perpendicular to a stream's direction. The aim of the measure is to modify the erosion and accumulation processes in torrent streams through the retention of water and eroded material.

Figure 19: View of the torrent regulation in the forest area (source: Lubo Augustinsky.)

- **Multifunctional forest and forest fragmentation**

  Multifunctional forest is a type of forest, where all the functions are integrated into one economic structure. In fact. It means a forest in which none of the functions is predominantly preferred, taking into account the ability of the forest to provide individual functions. The multifunctional forest should be formed by species and spatial structure close to natural forests. Fragmentation of the forest means the division of its texture in the space so that larger areas include forest cover of all ages and structures.

- **Reduction of spruce in the 3rd altitudinal zone**

  This measure means a gradual reduction of spruce monocultures and dominant mixtures in the 3rd and 4th altitudinal zones. In the future, the spruce should be replaced with another suitable economic tree species in the 3rd altitudinal zone. In the 4th altitudinal zone, the spruce should be grown only in form of admixture of individual trees or small groups.

- **Uniform shelterwood system and partial system**

  Types of forest management which include a complex of measures in forests in temporal and spatial relations within optimal rotation period. It expresses the way of forest restoration.

  Partial system – the restoration of forest cover is carried out on continuous excavated areas, the width of which does not exceed the average height of the excavated stand, or is under the protection of a 5-year stand.

Uniform shelterwood system – the restoration of forest cover is carried out under the protection of the excavated stand.

- **Implementing remediation of mining and transport erosion damages**

  The substance of this measure is to eliminate the damage to forest soil during and after a cut, or, respectively, to remediate it immediately, so that the impacts on the natural processes in the forest soil are as small as possible. The technical parameters result from specific conditions. The basic requirement is in particular the harmless transportation of wood. This can be achieved by the use of cable transport systems, belt systems, etc. The number of travels in one route during the extraction and bunching the wood. Preferably, the wood excavation should be carried out in winter or in the dry season of the year.

- **Coppice forest**

  Coppicing is a traditional method of woodland management based on the repetitive vegetative propagation of some species of trees. The felled trees put out new shoots from their stump or roots. Such a forest is characterized by low rotation period (5 - 40 years).

Non-structural measures

Digital flood management plans

It represents information connected with flood protection and planning in case of flood emergency. It contained text, data and maps. It is provided on regional (district) and local level (municipality). There is information what should be done when flood is coming, during and after flood. It provide on detailed knowledge of local conditions.

Land Parcel Identification System (LPIS)

LPIS is a database in which all the agricultural area (reference parcels) of the Member State is recorded. It is used as the management and control systems for agricultural expenditure. It contains information about level of erosion and connected restriction. For each parcel (or part of parcel) is set specific measure according to Good Agricultural and Environmental Conditions (GAEC). The fulfilment of measures has impact on subsidy.

Sheet of measures (translated)

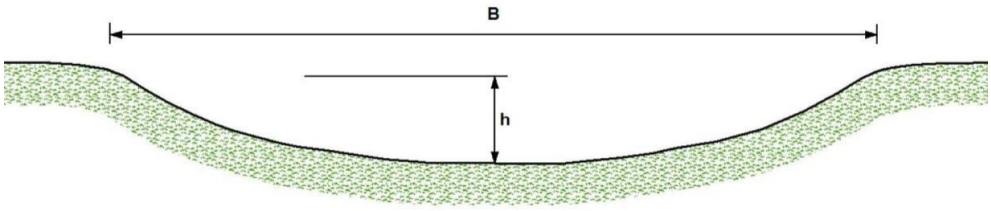
On the next pages, we provide an example of the layout from the Katalog přírodě blízkých opatření pro zadržení vody v krajině (Výzkumný ústav vodohospodářský T. G. Masaryka.v.v.i., 2018, p.30–32) to mitigate risk of droughts. The following pages were translated for general information content only, but do not represent an official translation.

STABILIZATION OF PATHWAYS OF CONCENTRATED SURFACE RUNOFF

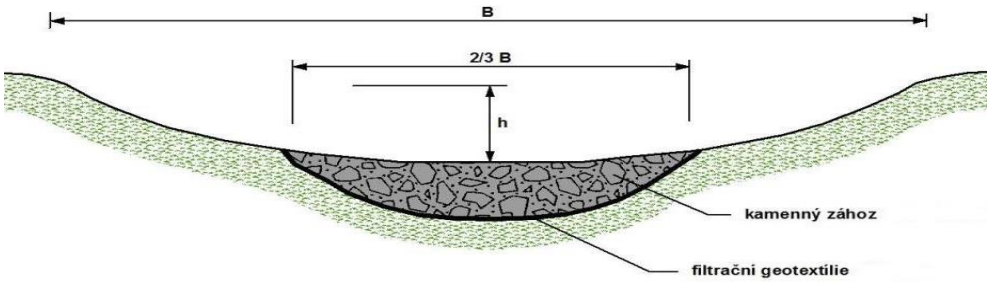
Measure ID	***001***
Type	**Biotechnical**
Name of measure	**STABILIZATION OF PATHWAYS OF CONCENTRATED SURFACE RUNOFF**
Description	Pathways of concentrated surface runoff are usually stabilized by grassing. They can be reinforced by stones so that they are able to transfer the concentrated surface runoff without the occurrence of erosion on the pathway. The most common shape is a parabola with a low depth, which is most similar to that of the naturally created pathways.
Technical parameters	• Shape cross-sectional profile – parabolic or trapezoidal, bottom reinforced by boulders. • Width of grass – defined based on mean flow velocity, designed peak flow, longitudinal slope of a thalweg.
Requirement of realization	Construction in case of ineffectiveness or inability to implement other measures (organizational and agrotechnical measures) or as a supplementary measure.
Possible conflicts	The measure requires an occupation of agricultural land. Therefore, settlement of property rights relations is necessary.
Interaction / synergy	The grassy thalwegs can be accompanied by greenery and can serve as an element of the territorial system of landscape- ecological stability. To increase its effect, a stabilized pathway of concentrated surface runoff can be supplemented by systems of aerial organizational, agrotechnical and/or linear biotechnical measures. A barrage can be built in the pathway of concentrated
Cost analysis	The costs are significantly dependent on the 1. selected grass mix during the realization of the measure, and 2. on the extent of terrain works. The costs on grassing are approximately 6500 CZK (i.e., 255 €) per hectare.

Temporal aspect	Preparation and realization	short-term	0-3 years	x
		medium-term	4-6 years	
		long-term	7 and more years	
	Effect speed	short-term	0-3 years	x
		medium-term	4-6 years	
		long-term	7 and more years	

Design



Sample cross section of measure - grassing



Sample cross section of measure − backfill

Photodocumentation of realizations

Stabilized pathways by grassing at Chvalkovice (Vyškov) (source: VÚV TGM, v.v.i.)

Stabilized pathways by backfill at Němčany (Vyškov) (source: VÚV TGM, v.v.i.)

Stabilized pathways by grassing at Nenkovice (Hodonín) (source: VÚV TGM, v.v.i.)

Evaluation of the measure´s effect	
A) water quantity	Reinforced pathways of concentrated surface runoff transfer the concentrated surface runoff in a harmless way, reduce the time of concentration and prolong the retention of water in the landscape. They also increase the infiltration of water
B) hydro-morphology	Pathways of concentrated surface runoff have a slightly positive impact on hydromorphology of streams: They impede the intake of fine soil particles and inorganic sediments into streams, thus positively influencing the size structure of sediments in streams and the environment of aquatic animals.
C) water quality	Pathways of concentrated surface runoff can contribute to the improvement of surface water quality by reducing the intake of fine soil particles due to erosion and by reducing the intake of phosphorus and further pollutants associated with them.
D) Aquatic and water-related ecosystems	Pathways of concentrated surface runoff improve the water regime in the soil and reduce the consequences of erosion, which is positive for aquatic organisms.
E) landscape and terrestrial ecosystems	The effect on landscape: enhancement of biodiversity, improvement of opportunities for animal migration, restoration of the landscape and the extension of the territorial system of landscape ecological stability. They have a positive influence on the retention of water in the landscape, reduction or even stopping disturbances and consequent degradation and soil erosion (root system can consolidate the soil).
F) socio-economic impact	The stabilized pathways of concentrated surface runoff increase the aesthetic value of landscape. They can be used as a source of feed for livestock, thus contributing to the production of natural fertilizers.
N) costs on construction and operation	Costs: extraction of land from the land resources, terrain works, plantation of greenery, subsequent maintenance.

Germany

Project internal contribution on Germany from 15.02.2018

Contributing authors	Project partner 1 (Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie) with contributions from project partner 2 (Sächsisches Staatsministerium des Innern), project partner 10 (Leibniz-Institut für ökologische Raumentwicklung) and Infrastruktur & Umwelt.

Structural measures

There are different ways to structure measures, e.g. according to the flood risk management-cycle (prevention/protection/awareness raising/preparation/emergency management/aftercare) or according to the object reference: e.g. infrastructural, water bodies related, area-related, object related and behavioural measures. Whereas the last type clearly is non-structural, for all other categories, structural measures can be named.

1. **Infrastructural**
   - Multifunctional use of areas: e.g. use of streets as water ways or use of playgrounds / parks for retention
   - Building of emergency water ways / wadis
   - Adapted drainage and Sewage system management (optimise hydraulic capacities, control etc.; project “COLABIS”)
   - etc.
2. **Water-bodies-related**
   - Removal of obstacles to an open discharge (casings, narrow bridges etc.)
   - Building of retention space (e.g. sinks, basins)
   - etc.
3. **Area-related**
   - Decentralised rainwater management (especially in urban areas; consists of a bundle of measures with the aim to enhance seepage and evaporation and slow down drainage) [see also water sensible spatial planning (projects “MURIEL”, “KLAS”, “RISA”)]
   - Rain water retention outside and within settlement structures
   - etc.
4. **Object-related**
   - Risk adapted buildings
   - Technical protection against flooding (non-return flaps, safeguarding vulnerable building elements [e.g. light wells, basement windows])
   - Improvement of drainage
   - etc.

Then, in the context of heavy rain risk reduction measures, definitively the topic of prevention of erosion has to be named (also a big bundle of measures, comprising e.g. retention oriented farming but also structural measures like stabilising of slopes etc.).

Non-structural measures

Tax benefits

Flood risk management

Warning systems

Integrated rescued system

Early warning systems

The responsibility to disseminate official heavy rain weather warnings is with the German Weather Service (DWD), which is a national institution under the national ministry for transport and digital infrastructure (BMVI). Additionally the DWD provides special products for civil protection institutions (mostly fire squads) with radar-based information on storm cells and their movement (by tracking them).

The publication of flood and flash flood early warnings is in the responsibility of the state water management authorities. Especially flash flood early warning systems are only operational within the states of Baden-Wuertemberg, Hesse and Rhineland-Palatinate. In spring 2018, a Saxon (flash) flood early warning system will be publicly available.

Hungary

Project internal contribution on Hungary from 14.02.2018

Contributing authors: Péter Gergő Katona, project partner 8 (Közép-Tiszavidéki Vízügyi Igazgatóság)

Structural measures

Lowland urban area

1. **Water retention on properties, (according to recommend of Hungarian River Basin Management Plan every property owner have to hold back one part of precipitation)**
   - Short description (picture with technical description if possible): According to recommend of RBMP every property owner have to hold back the rain water from the roof surfaces and covered surfaces. Increase the rate of green areas.
   - Effect of the measure: The water retention on properties is decreasing the quantity of water in the drainage system.
   - Deficit of the measure: Inside the properties it is a basic need to provide a big space.
   - Aims of the measure: The main aim to decrease the quantity of the water in the drainage system.
   - Financing: Property owner

2. **Cleaning of the drainage system**
   - Short description (picture with technical description if possible): Cleaning of the drains provides the runoff.
   - Effect of the measure: The scaling discharge can flow without inundation.
   - Aims of the measure: Keeping clean the drainage system in order to safe runoff.
   - Financing: Maintenance is financed by the settlement the defence by the state

3. **Increase of capacity of drainage system**
   - Short description (picture with technical description if possible): Increasing of the channel bed cross section, increasing of cross-section of culverts or other hydraulic structures, increasing of the capacity of pumping station.
   - Effect of the measure: The drainage system can safety runoff in case of bigger precipitation.
   - Deficit of the measure: The measure demand greater space.
   - Aims of the measure: Increasing of the drainage capacity.
   - Financing: Investment

4. **Insuring surface runoff**
   - Short description (picture with technical description if possible): Removing the barriers from runoff way.

- Effect of the measure: Water can flow to the drainage system.
- Aims of the measure: Insuring the safe runoff to the drainage system.
- Financing: Partly supported by state

5. **Making rain reservoirs, the oxbows connect to the drainage systems**
   - Short description (picture with technical description if possible): Rain reservoirs and oxbows increase storage capacity of the drainage system.
   - Effect of the measure: The drainage system can provide safe runoff in case of bigger precipitation.
   - Aims of the measure: Bigger precipitation safer runoff.
   - Financing: Investment

Lowland rural area

1. **Increase of the natural water retention in the ground by appropriate agricultural technologies**
   - Short description (picture with technical description if possible): Plowing with deeper level provide faster seepage to the ground.
   - Effect of the measure: Less water flow to the channels.
   - Aims of the measure: Increasing storage capacity of the ground.
   - Financing: NR

2. **Reconstruction of the hydraulic structures**
   - Effect of the measure: The reconstructions provide the reliable operation.
   - Aims of the measure: Insuring the reliable operation.
   - Financing: Investment

3. **Boostem pump, pumping station which increase the slope of water surface**
   - Short description (picture with technical description if possible): A little slope with a pumping station increases the watersurface slope.
   - Effect of the measure: More important watersurface slope causes faster runoff.
   - Aims of the measure: Quicker water runoff.
   - Financing: Investment

4. **Regulated filling of reservoirs next to the channels or in oxbows**
   - Effect of the measure: The higher storage capacity provide higher level of protection.
   - Aims of the measure: Decreasing of the risk of inundations.
   - Financing: Investment

5. **Water retention in the channel bed**

- Short description (picture with technical description if possible): Water retention by weir or other hydraulic structures.
- Effect of the measure: Appropriate operation can decrease amount of water to the receiving water.
- Financing: If there are hydraulic structures the finance is not relevant. If there aren't hydraulic structures is financed by investment

6. **Useless hydraulic structures remove from the channel bed**
   - Short description(picture with technical description if possible): Removing useless hydraulic structures cause runoff barriers.
   - Effect of the measure: Water can flow faster in the channel beds.
   - Aims of the measure: Quicker water runoff.
   - Financing: Investment

7. **Protection of valuable territories by localization dike**
   - Short description(picture with technical description if possible): Taking into consideration the naturally terrains have to build localization dams.
   - Effect of the measure: Localization dams save the valuable territories to inundations.
   - Aims of the measure: Saving the valuable territories.
   - Financing: Investment

8. **Maintenance of channels and hydraulic structures**
   - Short description(picture with technical description if possible):Cleaning the channel beds and hydraulic structures control vegetation and dredge the sludge.
   - Effect of the measure: Insure the runoff way.
   - Aims of the measure: Safer runoff to river.
   - Financing Maintenance is financed by the state

9. **Increase of cross-sections of the channel beds**
   - Short description(picture with technical description if possible):
   - Effect of the measure: Bigger cross-section of the channel bed provides a saver water runoff.
   - Aims of the measure: Increasing the safe runoff in case of bigger precipitation.
   - Financing: Investment

10. **Increase of capacity of pumping stations**
    - Short description(picture with technical description if possible): Increasing of the capacity of pump or operations more pumps.
    - Effect of the measure: Pumping more water from the channel to the receiving channel
    - Financing: Investment

11. Increase of cross-sections of the hydraulic structures

- Short description(picture with technical description if possible): Rebuilding the hydraulic structures with bigger cross-section.
- Effect of the measure: The bigger cross-section of the hydraulic structures in channel bed provide a saver water runoff.
- Aims of the measure: Increasing the safe runoff in case of bigger precipitation.
- Financing: Investment

12. Water retention on the fields or sub branches of the channels.

- Effect of the measure: Water retention can decrease amount of water to the channels.

Non-structural measures used in Hungary

Changing of the land use, do not use on agricultural production the constantly water covered territory

Construction ban by settlement planning on vulnerable areas

Reducing the risk by spatial planning

Poland

Project internal contribution on Poland from 16.02.2018*

Contributing authors: Iwona Lejcuś, Agnieszka Kolanek, Joanna Kryza, Iwona Zdralewicz, Mariusz Adynkiewicz-Piragas

* As the questionnaire was filled out with much appreciated detail, only the already extensive table version were considered for the scoping study.

Structural measures

No.	Measure	Short description	Effect	Deficit	Aims	Need for action
1	Green roofs	green roofs are a system of interconnected layers together with vegetation located on their outer surface	The multi-layered layout of green roofs functions in a comparable way to the operation of dry retention reservoirs. During rainfall, some rainwater is used to wet the surface of plants and their life needs, while the part returned to the atmosphere in the form of evapotranspiration.	Urbanization processes (significant sealing of the ground), construction requirements (not for every roof)	They purify the air, increase biodiversity and perform a decorative function, affect the local microclimate	Compensation for large sealing, increasing biodiversity, increasing the retention capacity (green roof stops 15-90% of precipitation)
2	Living walls	walls using in its construction vegetation fed with atmospheric precipitation	During rainfall, some rainwater is used to wet the surface of the plants and their life needs, while the part returned to the atmosphere in the form of evapotranspiration.		They purify the air, increase biodiversity and perform a decorative function	Large sealing, increasing biodiversity, improving the aesthetic value of the environment, improving the microclimate
3	Absorbent pan/basin	overgrown slopes with low gradient, high water penetration rate and low speed (<0.15 m / s)	Increased infiltration of rainwater, groundwater supply, pre-treatment of rainwater		They can be used as water pre-treatment devices	Increasing the retention capacity of the area, reducing the intensity of surface runoff

4	Absorbent tanks	solutions similar in construction and operation to absorbent pits, however, larger, deeper and used to dewater larger surfaces (over 1 ha)	Increased infiltration of rainwater, groundwater supply, improvement of the local microclimate		They can be used as water pre-treatment devices	Increasing the retention capacity of the area, reducing the intensity of surface runoff
5	Absorbent wells	wells filled with infiltration material and covered with soil, stones or other covering that absorb water from nearby paved surfaces	Increased infiltration of rainwater		They can be used as water pre-treatment devices	Increasing the retention capacity of the area, reducing the intensity of surface runoff (reduction and delay of the flood wave), relieving the existing traditional rainwater drainage systems
	Rain gardens	Depressions, typically permeable bottom (drainage), and planting of plants adapted to any temporary flooding surface	Improvement of local retention, groundwater supply (significantly relieves traditional rainwater drainage systems	Reduced surface retention or inefficient sewage system	Retention of rainwater, pre-treatment of rainwater, enabling groundwater supply	rainy garden absorbs 30-40% more water than a normal lawn, improving the aesthetics of the surroundings, groundwater supply, increasing groundwater supply, reducing rainwater run-off, relieving existing traditional rainwater drainage systems

6	Absorbent ditches (otherwise rigola) and grass ditches	linear infiltration devices (built, for example, along a road) filled with infiltration material, covered with stones, loose cubes or overgrown with vegetation.	Rainwater infiltrates into the soil or perforated pipe, and its excess can be directed to a traditional overflow		They can be used as water pre-treatment devices	
7	Wooded hummocks and rigole	solutions integrating underground retention with high greenery. The connection of the shelter belt coherent with the underground retention, infiltration and/or retention system, allowing water flow between the plants.	Increased infiltration of rainwater			
8	Grassy buffer zone	are slightly sloping and grassy surfaces that slow down levels and side runoff of rainwater from adjacent areas	they effectively help to remove suspended solids and associated impurities		They can be used as water pre-treatment devices	
9	Dry retention reservoirs	basin, which are filled with water only during heavy rains. Water flowing from roads or densely built-up areas is retained until the end of flood risk, after which it is discharged to the receiver.	Periodic interception of rainwater in the form of surface retention			

10	Dry retention reservoirs with constant flow	variety of dry reservoirs often located on watercourses. They consist of a large, dry, upper level, which is submerged during heavy rainfall and from a trough in which there is always water or shallow wetland	Periodic interception of rainwater in the form of surface retention			
11	Retention reservoirs	located in river channels or in their vicinity. They are used to keep water, fed to the river directly from surface runoff or through rainwater and combined sewage systems.	Absorbing rainwater in the form of surface retention		The reservoirs are designed to increase the river's retention capacity by mitigating extreme storm flows.	
12	Hydrophilic treatment plants	vegetation-covered systems with extended retention time, permanently and in varying degrees saturated with water. Thanks to the large capacity and bandwidth, they are best suited to the conditions of violent urban flows.	Treatment of rainwater purification using macrophytes rainwater on the border of the receiver, for example. river, reservoir, lake. Particularly important in the case of inflow of heavily polluted waters (from streets, car parks, car service stations)		Treatment of rainwater	

13	Sequential sedimentation and biofiltration systems	variety of a hydrophyte treatment plant, using ecohydrological regulation. It consists of three zones: intensive sedimentation (in which a combination of fixed and portable structures modifies the hydrodynamics of the chamber and increases sedimentation); intensive biogeochemical processes (where thick limestone fractions capture phosphorus compounds); and biofiltration (for the removal of biogenic compounds using macrophytes). The zones are separated from each other by gabions from thick gravel, which additionally filter water.	Treatment of rainwater purification using macrophytes rainwater on the border of the receiver, for example. river, reservoir, lake. Particularly important in the case of inflow of heavily polluted waters (from streets, car parks, car service stations)		Treatment of rainwater	

14	Buffer zones of coastal vegetation with a biogeochemical barrier	Pollutants are removed as a result of intensive sedimentation and assimilation by aquatic vegetation and adsorption in biogeochemical barriers in the form of gabions filled with dolomite or limestone and covered with a coconut mat. This solution can be used to pre-treat rainwater supplied to rivers and reservoirs dotted storm sewer outlets				

Non-structural measures

No.	Measure	Short description	Effect	Deficit	Aims	Financing	Need for action
1	Reduction of the share of sealed surfaces	These are all activities aimed at water retention in situ, increasing infiltration and reducing surface runoff. These measures are particularly crucial in the urban area. The basic action is to designate and exclusion from development of retention, infiltration and surface runoff areas that naturally retain water.	one of the fundamental activities for water retention in the urban areas	Urbanization processes (Reduction of the share of sealed areas in urban areas)	increasing the share of permeable areas		Development of Urban Adaptation Plans for cities with more than 100,000 inhabitants in Poland (MPA project) - catalogue of adaptation activities, Spatial management

2	Application of blue and green infrastructure	Increase of the retention capacity, preservation of diversity of elements of blue and green infrastructure in the city landscape (rivers, river valleys, water reservoirs, natural and artificial wetlands, parks, squares, orchards, gardens, allotments, green street strips, grasslands and other).	relieving traditional rainwater drainage systems, increasing the city's natural and health value (increasing biodiversity), improving the microclimate and the aesthetics of the area	Urbanization processes Insufficient share of greenery and / or water areas	Increase the retention capacity of the landscape improvement of the microclimate		MPA project - catalogue of adaptation activities, Spatial management
3	Ensuring spatial continuity of the city's natural system	The green areas should be as large and compact as possible and as close as possible to each other or combined with each other.	Integration of green areas with the best rainwater management practice, will contribute to better functioning of these areas.	Urbanization processes	Increasing resistance to external factors and strengthening the potential for providing ecosystem services		Spatial management
4	Citizens education and information campaigns on alternative methods rainwater management	All educational activities aimed at disseminating information and practices on the subject of sustainable management of rainwater	Raising social awareness	Insufficient level of awareness about rainwater management	Awareness of society, the possibility of implementing good practices / solutions		
5	Strategic documents	All planning documents for public space management in order to counteract	regulations aimed at determining directions of proceedings to reduce the	Lack of definitions of threats, ways to counteract these	Defining the directions of activities	public funds	MPA project - catalogue of adaptation activities, communes

		dangerous phenomena or minimize their effects (e.g. natural retention programs, urban adaptation plans for climate change, etc.)	occurrence of risk	threats			funds
6	Monitoring funds	continuous and long-term way of observing occurring phenomena	Long-term data series give the possibility of forecasting dangerous phenomena and effective counteracting	too large dispersion of measuring points, eg rain gauges	observation of natural phenomena, the possibility of predicting them	usually public funds; Environmental Fund and communes funds	
7	Crisis management system	public administration activity, which is aimed at preventing crisis situations, reacting in case of crisis situations, removing their effects, but also restoring resources and critical infrastructure.	comprehensive organization of the state in the period of danger		Clarity about the responsibilities of state services, including the mutual information and warning	public funds	

RAINMAN Key Facts

Project duration:	07.2017 – 06.2020
Project budget:	3,045,287 €
ERDF funding:	2,488,510 €
RAINMAN website & newsletter registration:	**www.interreg-central.eu/rainman**

Interreg CENTRAL EUROPE
RAINMAN
European Union
European Regional Development Fund

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Office of the Styrian Government — Das Land Steiermark → Wasserwirtschaft

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Region of South Bohemia — The Region of South Bohemia

Croatian Waters — HRVATSKE VODE

Middle Tisza District Water Directorate

Institute of Meteorology and Water Management National Research Institute — IMGW

Leibniz Institute of Ecological Urban and Regional Development — Leibniz Institute of Ecological Urban and Regional Development

Project support

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