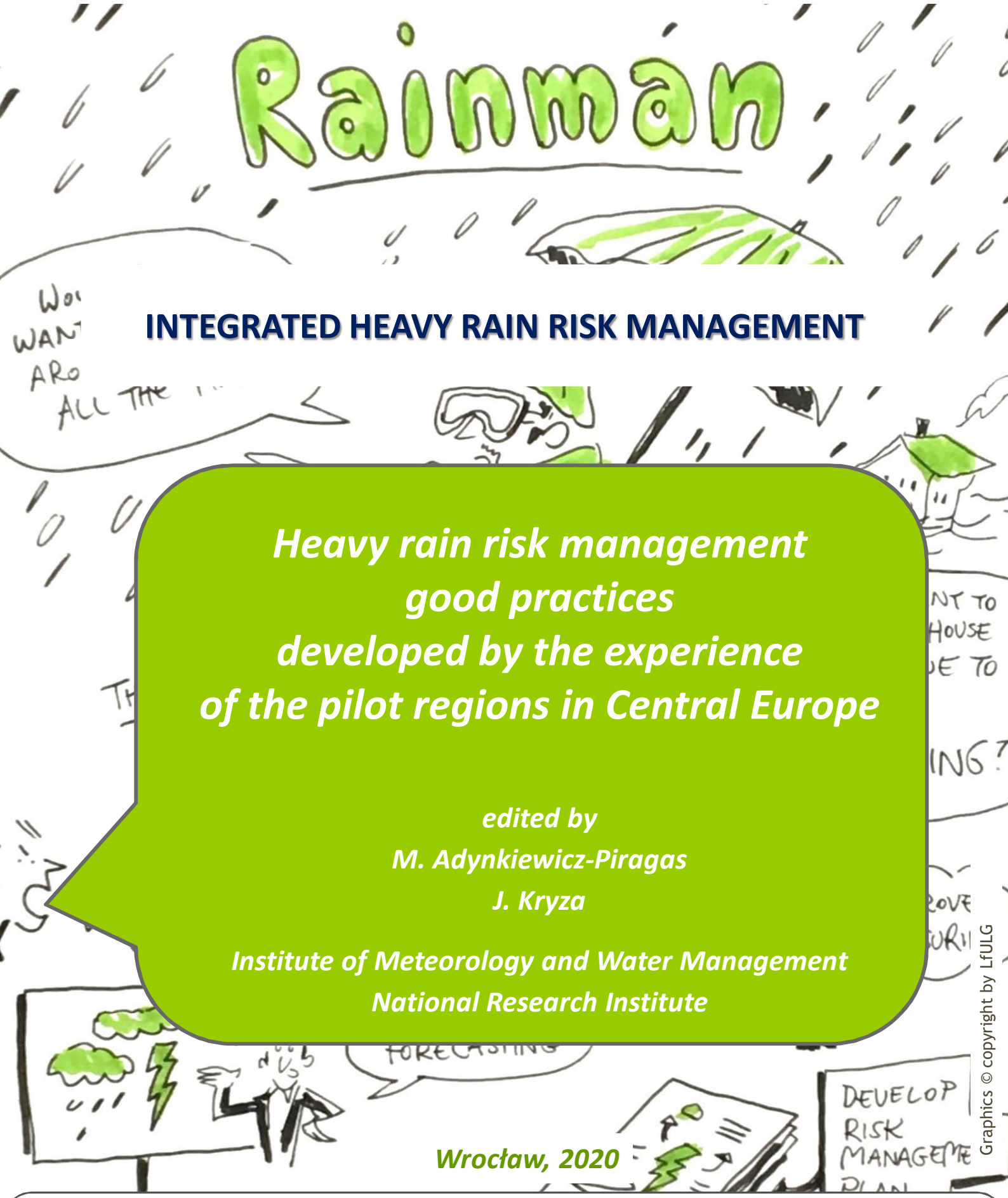

INTEGRATED HEAVY RAIN RISK MANAGEMENT

Heavy rain risk management good practices developed by the experience of the pilot regions in Central Europe

edited by

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Institute of Meteorology and Water Management

National Research Institute

Wrocław, 2020

The work was done for the purposes of the project RAINMAN, that is founded by the INTERREG CENTRAL EUROPE Program and co-financed by the Regional Fund for Environmental Protection and Water Management in Wroclaw.

Project Partner no. 9:
Institute of Meteorology and Water Management
National Research Institute (IMGW-PIB)

Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej we Wrocławiu

Partner 9 (PP9)
Institute of Meteorology and Water Management
National Research Institute

Interreg CENTRAL EUROPE
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European Regional Development Fund
RAINMAN

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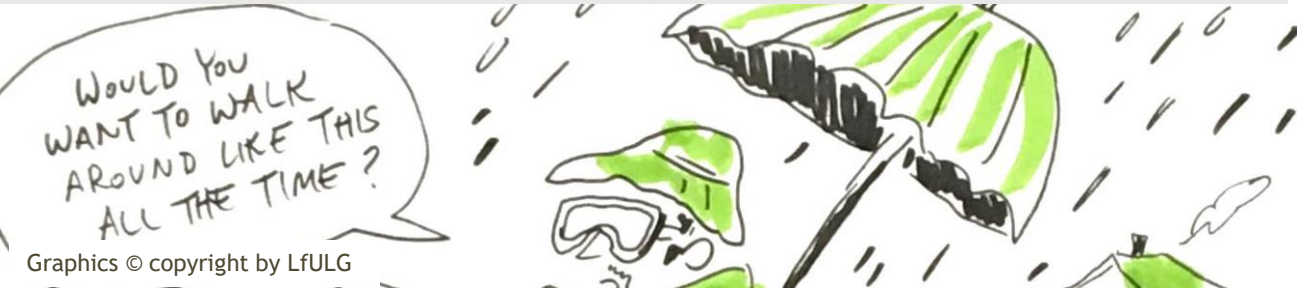
Wrocław, 2020



1. Introduction

Heavy rain is an extreme phenomenon which frequency has significantly increased in recent years. They are concerned with both climate changes and change in land use of a catchment. Heavy rains can occur anywhere and are local phenomenon. They often cause numerous damages, including flooding, damage to crops, urban floods. Therefore, 9 countries from Central Europe (11 partners) have taken the initiative to develop good practices in the field of prevention against the effects of heavy rain and to test them in selected pilot areas under the RAINMAN project.

The presented catalogue of good practices contains a brief description of activities implemented in Poland and in the remaining 6 pilot areas located in Central Europe.

The assumption of the catalogue is to familiarize the local community with practical solutions related to assessment and mapping activities, risk communication and activities regarding reduction in heavy rain risk.

2. The RAINMAN project goals

The Risks of heavy rain events are increasing all over Central Europe.

The goal of the RAINMAN project is to support local and regional stakeholders in Central Europe in dealing with the risks of heavy rain. The main goal of the project is to improve integrated management capacities of public authorities to mitigate heavy rain risks. We develop practice-oriented new tools and innovative methods to reduce fatalities and damages.

We built on an extensive theoretical knowledge base from 6 Central European countries: in exchange with stakeholders in heavy rain risk management, methods and measures were tested and implemented in our pilot activities.

The present document includes a summary of pilot activities covering different methods including different focuses to test the variety of developed methods: all focus on heavy rain risk assessment & mapping (with different specifics of joint methods) and on different measures in rural, urban or semi-urban areas.

Catalogue covers all good practices of the tested measures developed by all project partners in 7 pilot actions from with different characteristics to give a wide range of application conditions.

Partner	Pilot Area (PA)
LfULG, SMI, IÖR	PA1. Saxony
SoBoh/VUV	PA2. South Bohemia
Stmk	PA3. City of Graz
MTDWD	PA4. City Tiszakécske, Kunhegyes
HRVode	PA5. Zagreb, Istria
IMGW-PIB	PA6. Lower Silesia
UBA	PA7. Upper Austria

3. Project partner description

Lead Partner (LP):

SAXON STATE AGENCY FOR ENVIRONMENT, AGRICULTURE AND GEOLOGY (LFULG)

Project manager: Dr. Sabine Scharfe

The LfULG is a public body in Germany, subordinated to the Saxon State Ministry of Energy, Climate Protection, Environment and Agriculture. As Lead Partner, the LfULG takes care of a sound project and finance management and contributes to all key components of the project. Additionally, it is responsible for the coordination of the creation of the crosscutting project results website "RAINMAN-Toolbox".

Partner 2 (PP2)

SAXON STATE MINISTRY (SMI)

Project manager: Dirk Dressler

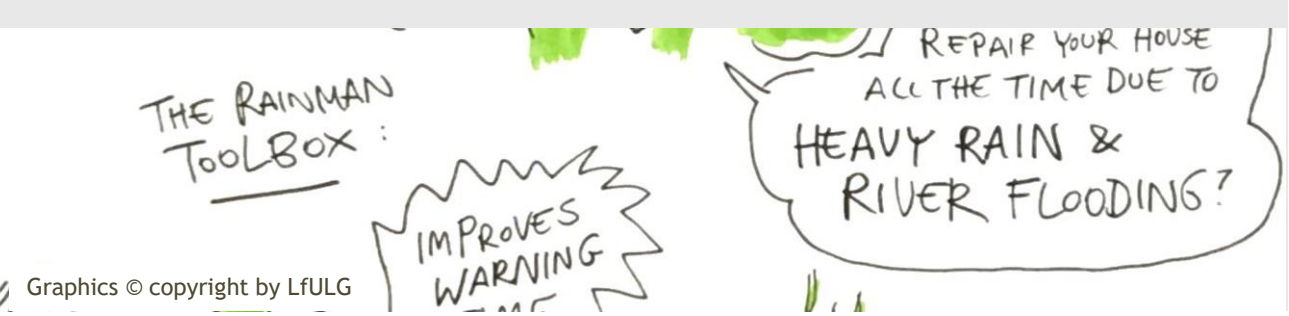
The SMI is part of the Saxon government. The main responsibility for the implementation of activities within the project is in the "Division for European spatial planning, regional development" within the department "Territorial State Development and Survey". SMI's role is to ensure the link between the sector approaches and tools with the territorial development instruments and applications. The partner develops communication and implementation tools for risk reduction and focusses on activities that evaluate and initiate risk communication and implementation of advanced risk oriented planning processes. SMI is also responsible for the work package "Project Communication".

Partner 3 (PP3)

ENVIRONMENT AGENCY AUSTRIA (UBA)

Project manager: Dr. Yvonne Spira

The UBA is an independent organisation with expertise in all environmental issues. UBA takes over the role of "method-developer" and methodological support for the partnership, especially in heavy rain risk assessment/mapping and development of innovative risk reduction measures. It coordinates the Austrian partners' contributions on national level. The pilot implementations take place in close cooperation with the provincial governments of Styria and Upper Austria as well as further stakeholders in order to guarantee coordinated and accepted approaches.



Partner 4 (PP4)

OFFICE OF THE STYRIAN GOVERNMENT (Stmk)

Project manager: Rudolf Hornich

The institution is a public body, subordinated to the Office of the Styrian Government. It is responsible for the regional administration of the Styrian province. The department Water Management, Resources and Sustainability is involved in the project implementation. It contributes its regional expertise to the joint method and tool development. A focus will lie on the collection and development of risk reduction measures.

Partner 5 (PP5)

MASARYK WATER RESEARCH INSTIT (VUV)

Project manager: Pavel Balvín

The partner organisation is a public research institution, established by the Czech Ministry of the Environment. It delivers methodological support for the partnership, especially in risk mapping and development of innovative risk reduction measures and coordinates the Czech partners' contributions. The organisation leads the joint collection and development of risk reduction measures in a work package.

Partner 6 (PP6)

REGION OF SOUTH BOHEMIA (SoBoh)

Project manager: Daniela Řežábková

The South Bohemia Region is the regional administration of a Czech district. The Department of Regional Development, Territorial Planning, Building Regulation and Investment is mainly involved in the project. The role of the partner as a regional partner is to bring experiences into the project that were gathered on local and regional levels regarding management of heavy rain risks, to cooperate on the development of best solutions and to test them in pilot implementations.

Partner 7 (PP7)

CROATIAN WATERS (HRVode)

Project manager: Alan Cibilić

Hrvatske vode is a government agency founded by the Republic of Croatia and a legal entity for water management. Main business of Hrvatske vode is the water management as public service. Hrvatske vode participates in the development of joint methodologies, their application on pilot areas and production of materials for raising public awareness. A focus of its activities lies on risk assessment and risk mitigation measures.

Partner 8 (PP8)

MIDDLE TISZA DISTRICT WATER DIRECTORATE (MTDWD)

Project manager: Gábor Harsányi

The partner is a public body in Hungary subordinated to the national water administration. The operational area of the Middle Tisza District Water Directorate is more than 7000 km² in East-Hungary including 102 municipalities. Pilot actions are planned to become implemented in two highly endangered cities.

Partner 9 (PP9)

INSTITUTE OF METEOROLOGY AND WATER MANAGEMENT - NATIONAL RESEARCH INSTITUTE (IMGW-PIB)

Project manager:

Dr. eng. Mariusz Adynkiewicz-Piragas

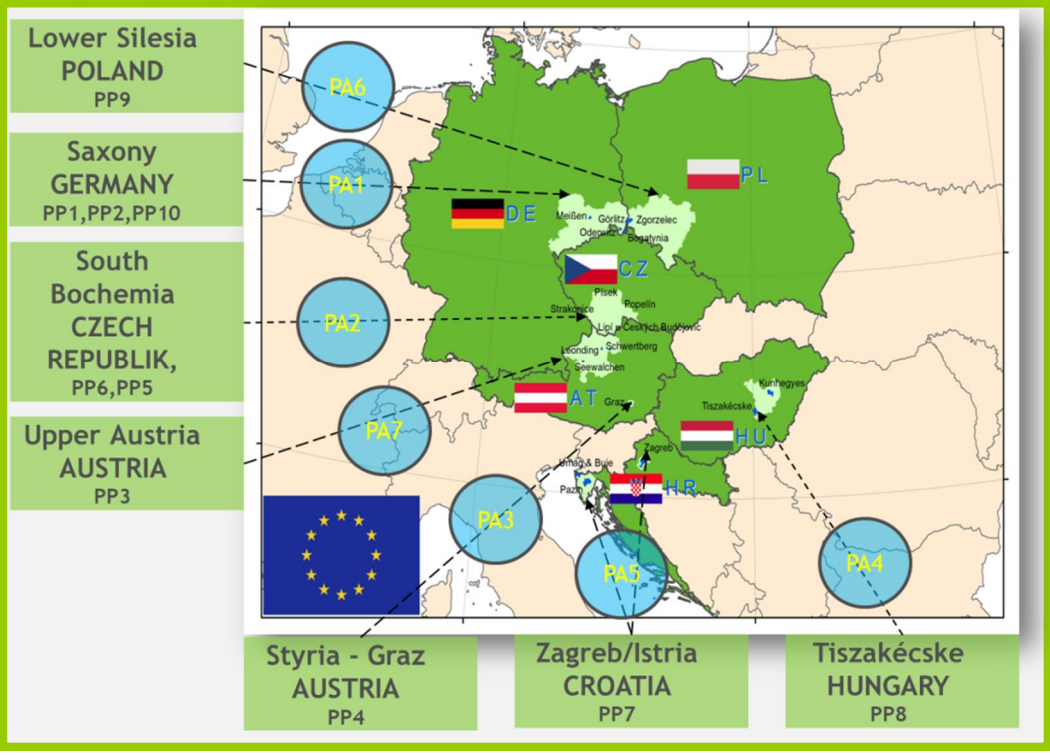
The IMGW-PIB is a Polish research and development unit, supervised by the Ministry of Marine Economy and Inland Navigation. Its role in the project is to participate in all joint activities of thematic work packages, development of heavy rain risk mapping, risk reduction measures, tools and to link these with implementation. It is the leader for the thematic work package "Pilot Action", in which all partners implement jointly elaborated methodologies.

Partner 10 (PP10)

LEIBNITZ INSTITUTE OF ECOLOGICAL URBAN AND REGIONAL DEVELOPMENT (IOER)

Project manager: Dr. Regine Ortlepp

The IOER is part of the German Leibniz Association for research in the spatial science. The research institute's main concern is to form the scientific basis for the sustainable development of cities and regions. The IOER contributes its expertise in the field of method development, user oriented research and development work for the project implementation. The IOER uses the implementation in the pilots to improve the applicability of methods and to make them available for a broader application at a European scale.



Source: IMGW-PIB

4. Scope and aims of Pilot Actions

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 were included in the RAINMAN-Toolbox, a set of five transferable tools and methods for municipalities and regional stakeholders.

In 7 pilot areas with different characteristics, the process of identifying data necessary for risk mapping and for implementing risk reduction measures to reduce damages of heavy rain was started.

In addition, examples of good practices used in pilot areas have been inventoried. Good practices can be a contribution to the catalogue of measures for different risk situations, which is connected with risk reduction tool and deliver a input to further planned products in RAINMAN project.

The identification process in the scope of data necessary for risk mapping will allow the development of risk mapping with different levels of detail depending on the availability and quality of the data. These priorities and procedures will be implemented into different conceptions of the pilot regions.

The RAINMAN project details:

Project duration:	july 2018 – june 2020
Project budget:	EUR 3.045.286,89
ERDF co-financing:	EUR 2.448.510,22

5. Methodological approach in RAINMAN

Four work packages describe the methodology of RAINMAN project.

WORK PACKAGE TOOL 1 - TOOLS AND METHODS FOR THE ASSESSMENT AND MAPPING OF HEAVY RAIN RISK:

Work Package Tool 1 is focused on Heavy Rain Risk Assessment and Mapping. The project partners develop methods for heavy rain risks assessment for different physiological conditions and land use in the regions of the Central Europe. The tool specifies possibilities for adaptation of the selected methods for urban and rural land use in mountainous and lowland areas.

It is a review for joint development of transferable tool and methods of heavy rain risks assessment for different physiological and land use conditions in CE areas (RAINMAN_Tool_1). The tool enables support of the identification and communication of high risk areas. The tool is the base in the context of reaching objectives of the project in terms of improvement in risk management capabilities and reduction in heavy rain risks in the future.

The methods are customised to a different complexity levels and different geographical and physiological conditions of the European regions. Thus, the methods will be adapted for i.e. specified rural, urban and agriculture/forestry purposes.

The outputs (tool for assessment, mapping and trainings) form the base for pubic authorities to adapt their regional and local development to the existing risks. It will be also the basis for improvement in their management capacities.

WORK PACKAGE TOOL 2 - RISK REDUCTION MEASURES TO REDUCE DAMAGES OF HEAVY RAIN:

In Work Package Tool 2 the Project Partners together create a tool (RAINMAN_Tool_2) and a strategy on heavy rain risk reduction for the Central Europe.

The tool includes a catalogue of risk reduction measures for different risk situations and framework conditions. It also forms a kind of guidance to select the best measures options for specific situations and to applicate and implement them. Additionally, the PPs jointly develop a risk management strategy for heavy rain risk in a) urban areas and b) rural areas.

There are two goals of the strategy: the first one is the guidance for local and regional actions in terms of how to deal with increasing heavy rain risks and how to implement them to local and regional policies throughout the Central Europe; the second goal is to submit the guidance to the EU-COM-WG-Floods as "bottom-up" contribution in order to improve flooding policies, especially the EU-floods directive.

Thus, Tool 2 is a significant contribution for the integrated environmental management strategies improvement in the public sector in the Central Europe. It concerns two specific objectives of the project and is related to risks reduction by improving heavy rain risk prevention and risk management capacities.

WORK PACKAGE TOOL 3 - PILOT ACTIONS TO TEST AN IMPROVE THE DEVELOPED METHODS FOR RISK ASSESSMENT AND PREVENTION:

In the regions of the partners participating in the project, the pilot activities are implemented. Commonly developed methods and tools were examined for their feasibility and applicability. There are 7 pilot actions as an output. They were characterized by variability in order to consider vast range of conditions. The pilot actions are differently focused to test the differently developed methods: all are focused on heavy rain risk assessment & mapping (with different specifics of joint methods) and on different measures for rural, urban or semi-urban areas.

The pilot actions are the base for testing the methods of development, to improve them with experiences from the pilot actions and make them transferable. The pilot actions also deliver cases for implementations that help the target groups to anticipate the project deliverables.

Furthermore, the pilot actions create a kind of platform for the local stakeholders who can be often involved as Associated PPs. Intensive consultation processes on the website make the joint results be tailored for the needs of local and regional target groups. In all the pilot actions, an ex-ante evaluation on the status of heavy rain risk management was carried out with the use of online survey, filled by target groups and stakeholders. The survey was presented in national languages and considered regional specifications. It provided expectations and requirements on the methods and tools from the potential users.

WORK PACKAGE TOOL 4 – WEBSITE "RAINMAN-TOOLBOX"

The core output of Work Package Tool 4 was development and realisation of the "RAINMAN-Toolbox". It was a website with several tools focused on reduction in heavy rain risk and improvement in integrated environmental risk management capacities of the regional and local administration in the Central Europe.

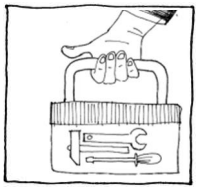
The toolbox contains the following tools:

- ✓ Tool ASSESSMENT and MAPPING
- ✓ Tool RISK COMMUNICATION
- ✓ Tool HEAVY RAIN RISK REDUCTION including a catalogue of good-practise examples for the integrated reduction of heavy rain risks and further tools and guidance

Furthermore, the toolbox contains recommendations for the improvement in flood risk management plans and provides guidance for decision makers, based on gathered experiences from the project and local practice.

The Toolbox-content is created partly from WPT 1-3 or developed within WP in separate activities. The toolbox provides a low-threshold access to the complex topic and main project results in a systematic and appealing way.

6. Activities and good practices in Pilot Area 6: Lower Silesia



Graphics
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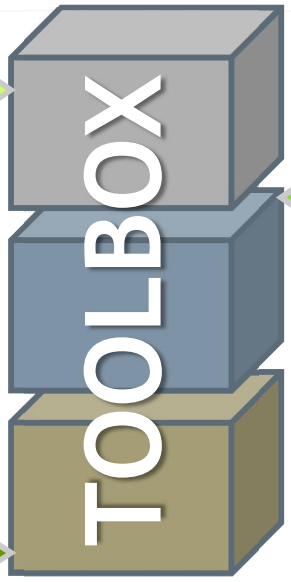
TOOL
ASSESSMENT AND MAPPING

Three stages of analyses:

- Physiographic and hydrological conditions and land use
- Identification of the areas affected by heavy rain
- Areas with soil prone to water erosion

TOOL
HEAVY RAIN RISK REDUCTION MEASURES

- Review of good practices that allow rainwater retention
- Catalog of good practices
- Action plan - recommendations for spatial planners and end-users



TOOL
RISK COMMUNICATION

- Package of training kit about heavy rain issues
- Lessons for students
- Board game
- Questionnaire
- Conferences
- Workshops and trainings
- Surveys

Source: IMGW-PIB

Graphics © copyright by LfULG

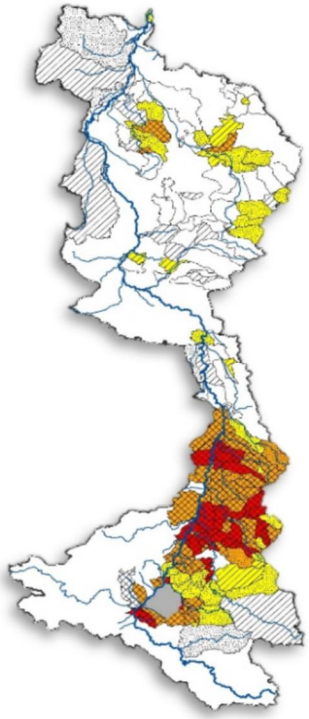
6. Activities and good practices in Pilot Area 6: Lower Silesia

TOOL
ASSESSMENT AND MAPPING

Flash flood hazard and vulnerability maps for Lower Silesia (PA 6; contact: Dr I. Otop irena.otop@imgw.pl). Local physical-geographical conditions of the catchment and land use contribute to the development of flash floods. A number of factors that actively influence the process of surface runoff were considered. Based on the method developed by T. Bryndal (2011, 2014), the identification of small catchments prone to flash flood in Nysa Łużycka river basin located in the Zgorzelec county pilot area was applied.

The applied method involves the following steps:

1. Identification of catchments where pluvial flash flood events occurred within 1971-2010. In our study the set of 33 small catchments affected by FF were selected. Those selected catchments are located in Sudety Foreland and Western Sudety Mountains (Province of Lower Silesia).
2. Selection and calculation of the physiographic and hydrological parameters and land use in the catchments affected by pluvial flash floods. Finally 21 parameters were calculated. The parameters describe:
   - physiographic conditions of the basin e.g.: catchment size, maximum length of the catchment, average width of the catchment, shape index, relative height, average slope gradient, average slope inclination of the main valley condition,
   - hydrological conditions of the basin e.g.: stream network density, the CN parameter (calculated on the basis of soil and land use maps),
   - structure of land use e.g.: low-density housing, high-density housing, forest area, arable land, road network density.
3. Typology of catchments (types: A, B and C) prone to flash floods generation based on the cluster analysis.
4. Identification of small catchments prone to flash flood in Nysa Łużycka river basin based on developed types.



Source: I. Otop IMGW-PIB

The GIS-database of elementary catchments for Nysa Łużycka river basin was created. Parameters describing: physiographic and hydrological conditions, structure of land cover were calculated for each of the elementary catchments. These parameters were analyzed in order to identify catchments similar to particular types (type: A, B, C).

The applying method allows to identified elementary (small) catchments prone to flash flood development in Nysa Łużycka river basin. The verification of the results showed a good agreement with independent databases i.e.: locations flash flood events (1971-2010) in the Nysa Łużycka basin and locations affected by heavy rain events (e.g.: flooded roads) provided by State Fire Service in Zgorzelec County.

6. Activities and good practices in Pilot Area 6: Lower Silesia

TOOL
ASSESSMENT AND MAPPING

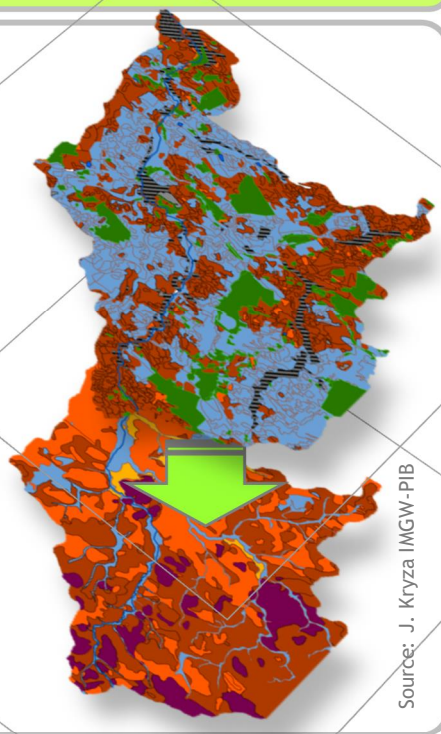
Mapping of areas vulnerable to soil water erosion - Determination of problem areas in the Czerwona Woda catchment - Case Study (PA6; contact: Dr. Eng. M. Adynkiewicz-Piragas mariusz.adynkiewicz@imgw.pl or Dr J. Kryza joanna.kryza@imgw.pl). Soil degradation might be a result of surface runoff caused by precipitation. Surface runoffs are formed as a result of limited infiltration of water into the soil, resulting in a flood hazard in neighbouring areas. The occurrence and intensity of water erosion is affected by declines in land, soil type, rainfall intensity, the way of land use.

Methodical approach to determine the problem areas was multi-criterial analyses of soil type, declines in land, and also the way of land use.

Analyses were carried in Czerwona Woda catchment in 4 stages:

1. Analysis of soil susceptibility to water erosion,
2. Selection of the areas with soils of considerable water capacity on impermeable undersoil,
3. Detailed analysis of the slope map,
4. Analysis of land use

The aim of the analyses was to identify the places where there are factors contributing to the occurrence of water erosion.



Source: J. Kryza IMGW-PIB

TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Source: Lejcuś K. at all "Katalog dobrych praktyk ..." Wroclaw 2017

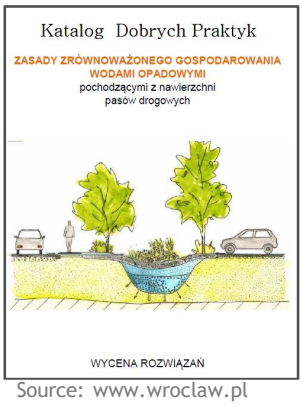
Good Practice Catalogue - the Rules for Sustainable Management of Rainwater from Road Surface (PA 6; contact: Dr hab. K. Lejcuś krzysztof.lejcus@upwr.edu.pl) contains 19 measures aimed at increasing the retention of these waters (e.g. swale, water absorbing geocomposite, rain garden, curb extension, stormwater tree trenches, green roofs, pervious pavements, hydrophyte pond, infiltration basin, openwork plate, filter-bed channel, etc.). It also contains criteria for the selection of an appropriate measure: retention, costs, maintenance, water purification and additional indicators. A list of the most suitable plant species is also provided for each measure. The proposed measures help to minimise the negative impact of urban development on the environment.

6. Activities and good practices in Pilot Area 6: Lower Silesia

TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Good Practice Catalogue - the Rules for Sustainable Management of Rainwater in an urbanized area - part II (PA 6; contact: Dr hab. K. Lejcuś krzysztof.lejcus@upwr.edu.pl) contains a set of 16 solutions aimed at increasing the retentions of these waters (e.g. swale, water absorbing geocomposite, rain gardens, stormwater tree trenches, green roofs, pervious pavements, hydrophyte pond, infiltration basin, openwork plate, filter-bed channel, etc.). Solutions are recommended for single-family and multi-family service facilities and sports as well as recreation areas. It is a practical guide with information on how residents can manage rainwater on their own (catch, hold and use it). It includes information on how to check the ground conditions themselves, how to calculate the amount of rainwater draining from the roof surface or what plants can be planted depending on the ground conditions and type of measure. The catalogue also provides a lot of pictures and photos. It consists of a descriptive part and 16 so-called solution cards. For all 16 solutions, optimisation possibilities for coastal regions are also given.

Source: Lejcuś K. at all "Katalog dobrych praktyk ...", Wrocław 2019



Source: www.wroclaw.pl

Price estimation for solutions from the "Good Practice Catalogue - the Rules for Sustainable Management of Rainwater from Road Surface" (PA 6; contact: Dr hab. K. Lejcuś krzysztof.lejcus@upwr.edu.pl) contains 36 schemes. Each scheme contains a description of the measure's components and a table with the prices for each component and the total amount for each measure (in PLN) proposed in the Good Practice Catalogue. The given costs are estimated for a specific unit size (e.g. 1 m or 1 m2), so in order to calculate the total cost of the investment it is necessary to adapt it to the real size of the planned investment. This elaboration (Price estimation for solutions from the "Good Practice Catalogue") is a part of the overall concept shown in the factsheet "Good Practice Catalogue - the Rules for Sustainable Management of Rainwater from Road Surface.

The municipal Wroclaw subsidy program „Catch the Rain" (PA 6; contact: Biuro Wody i Energii Urzędu Miejskiego Wrocławia bwe@um.wroc.pl) The program allows co-financing of measures for residents to catch the rain in their household or garden. The level of co-financing reaches up to 80% of the costs for building a rainwater retention solution (the costs of purchasing, constructing and assembling elements necessary for the retention and use of rainwater and snowmelt are included, but limited to 5000 PLN / 250 Euro). The first subsidy programme ran from 02.08.2019 to 30.09.2019 and the second subsidy programme is running from 03.02.2020 to 30.09.2020.

Source: https://bip.um.wroc.pl/artykul/842/43956/zlap-deszcz-2020

6. Activities and good practices in Pilot Area 6: Lower Silesia

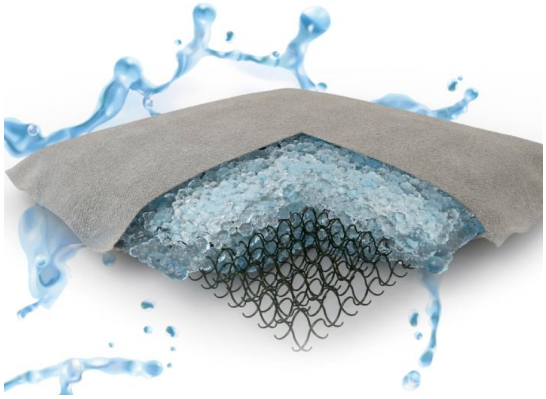
TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Project Climate Change Adaptation Plans in 44 Polish Cities (Urban Adaptation Plans - UAP) PA 6: Wrocław, Legnica, Wałbrzych (Lower Silesia), Poland; contact: Environment Protection Institute — National Research Institute (leader) Barbara.Rajkowska@ios.gov.pl - 44 Polish cities with more than 100,000 inhabitants participated in the project in cooperation with the Ministry of the Environment. The project aimed to adapt the cities to the climate change. The project took place from 12.01.2017 to 12.01.2019. In Lower Silesia the cities of Wrocław, Legnica and Wałbrzych were involved.

Source: http://44mpa.pl/wp-content/uploads/2018/12/MPA_NET-ENG-20-12.pdf

The main aim was to shape modern urban policies in response to the identified climate risks. IMGW-PIB participated in the implementation of the project. Numerous analyses on the sensitivity, adaptive capacity, vulnerability and resilience were conducted. Also hazards due to climate change as well as the most vulnerable sectors and areas have been identified. The plans and activities for adapting to climate change have been prepared for 44 cities.

Source: profi.hydrobox.pl/home-en/



Source: K. Lejcuś UP Wrocław

Water absorbing geocomposite (GSW) - (PA 6; contact: Dr hab. K. Lejcuś krzysztof.lejcus@upwr.edu.pl) is a technology used to retain water in the soil, so that it is later available for plants. In this way, the GSW help plants to grow faster and under better conditions. Water is available to the plant when the plant needs it. GSW reduces water stress, prevents wilting of plants, boosts plant growth, reduces watering frequency up to three times.

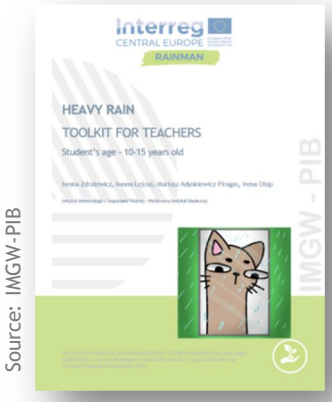
The technology retains rainwater coming from infiltration (rainfalls) or waterings. This solution is neither expensive nor complicated and does not require a suitable surface. Wherever vegetation solutions are used to support retention, whether it is grass, trees, shrubs, plants for green roofs or green walls, the development of these plants can be supported by GSW.

6. Activities and good practices in Pilot Area 6: Lower Silesia

TOOL
RISK AWARENESS AND COMMUNICATION

Presentation for lesson 1 (topic "Heavy rain risk") - (PA 6; contact: Dr I. Lejcuś iwona.lejcus@imgw.pl). Preparation of a comprehensive presentation on the topic "Evaluation of risk related to heavy rains". The presentation is structured as follows: ➢ Climate and weather ➢ Climate factors ➢ Meteorological measurements and observations ➢ Weather and weather-related indices; how do the results on basic indices look like in terms of multiannual measurements – presentation of changes noticed in the last years indicating climate changes (on the basis of data for Lower Silesia) ➢ Climate changes (reference to climate warming, greenhouse effect) ➢ Observed consequences of climate changes ➢ Heavy rains – definition, characteristics, examples and consequences ➢ Storm (including safe behaviour) ➢ Weather forecasts and warnings.

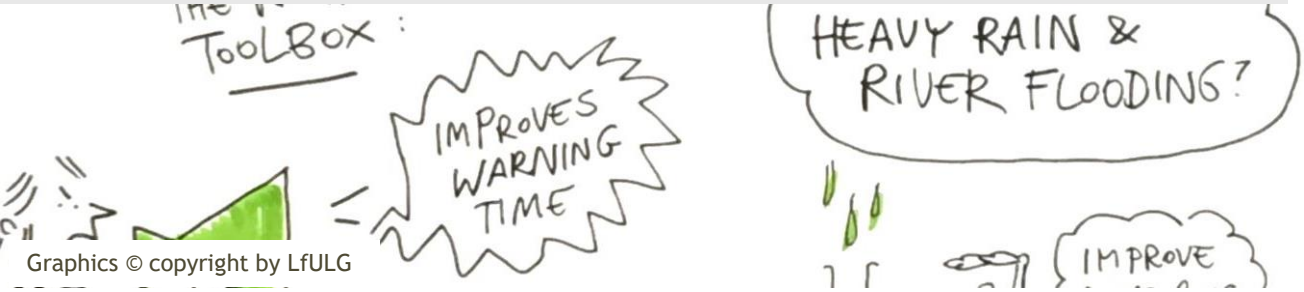
Presentation for lesson 2 (topic "Ways of dealing with floods after heavy rainfall") (PA 6; contact: Dr I. Lejcuś iwona.lejcus@imgw.pl). Preparation of a comprehensive presentation on the topic "Ways of dealing with floods after heavy rainfall". Content: river basin, retention, flood definitions, effect of heavy rain (local flood), monitoring of flood phenomena (including warning systems), strategy of mitigation of flood effects, description of „tools" elaborated in the RAINMAN project, solutions on blue-green infrastructure.



Source: IMGW-PIB

Teaching instruction (for two lessons) - (PA 6; contact: Dr I. Lejcuś iwona.lejcus@imgw.pl). Comprehensive and extensive content-related help is offered for two lessons on dealing with the risks of heavy rain: lessons 1 is dealing with heavy rain risk and lesson tool 2 explains ways of dealing with floods after heavy rain events. The teaching materials include presentations with comments and explanatory additions. This supports the teacher in preparing and carrying out the lessons. The teaching instructions allow the teacher / educator to adapt the content of the lesson to the level of the students without having to search for additional content in other, external sources of knowledge. To increase the impact of the training package, the aim is to place it on the European Commission's education website.

Board game (with question cards) (PA 6; contact: Dr I. Lejcuś iwona.lejcus@imgw.pl). The concept of the game was created as an attractive form of checking knowledge on heavy rain risks and risk mitigation measures after lessons . The game consists of a board, instructions and cards with questions to be answered during the game. By using the question cards, the content of the lesson on the subject of heavy rain can be repeated and the knowledge acquired in the lessons can be consolidated. The game can also be used without any relation to the lessons.



6. Activities and good practices in Pilot Area 6: Lower Silesia

TOOL
RISK AWARENESS AND COMMUNICATION

Conference on Integrated Emergency Services in Crisis Situations - Session I - Innovative solutions in crisis situations (PA 6, Lower Silesia, Legnica city, Poland; contact: Dr. Eng. M. Adynkiewicz-Piragas mariusz.adynkiewicz@imgw.pl) - As part of a conference on Integrated Emergency Services in Crisis Situations, a lecture on the management of heavy rain was presented. The lecture covered the following issues: definition of pluvial floods, examples of flood effects in Europe, examples of unexpected heavy rain events in Legnica, effects of heavy rain in Poland and also the climate change projections related to heavy rain. Furthermore, the RAINMAN project and its work packages were presented.

Source: M. Adynkiewicz-Piragas IMGW-PIB

IMGW-PIB showed the progress of work in the field of mapping and provided information on activities to reduce the risks associated with heavy rain. In the next part of the lecture the pilot action and the RAINMAN-Toolbox were presented as two main outputs of the RAINMAN project.

Source: IMGW-PIB

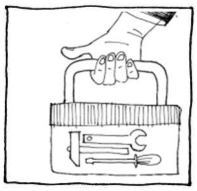
Dissemination meeting at the Institute for Territorial Development (PA 6; contact: Dr. Eng. M. Adynkiewicz-Piragas mariusz.adynkiewicz@imgw.pl **or Dr. Eng. A. Kolanek** agnieszka.kolanek@imgw.pl**).** The professional exchange with the Insitute for Territorial Development improves the use of the project results. Based on the results of the hazard mapping, recommendations for spatial planning can be elaborated. Risk reduction measures that can be included in the local spatial development plan can positively influence negative effects of heavy rain.

Source: I. Lejcuś IMGW-PIB

Local scale informative event - increasing awareness on heavy rain phenomena, together with consequences and mitigation measures at local scale conference of TRANSGEA project (PA 6, Zgorzelec, (Lower Silesia), Poland; contact: dr I. Zdralewicz iwona.zdralewicz@imgw.pl**).** The purpose of the RAINMAN project presentation was to inform conference participants about the phenomenon of heavy rain and its consequences in the context of the changing climate. Experts assume that such events will happen more often in the future.

During the presentation, results of mapping hazard associated with heavy rain have been shown. It was also informed about measures aiming to reducing the threat associated with intensive rains.

7. Activities and good practices in other RAINMAN Pilot Areas



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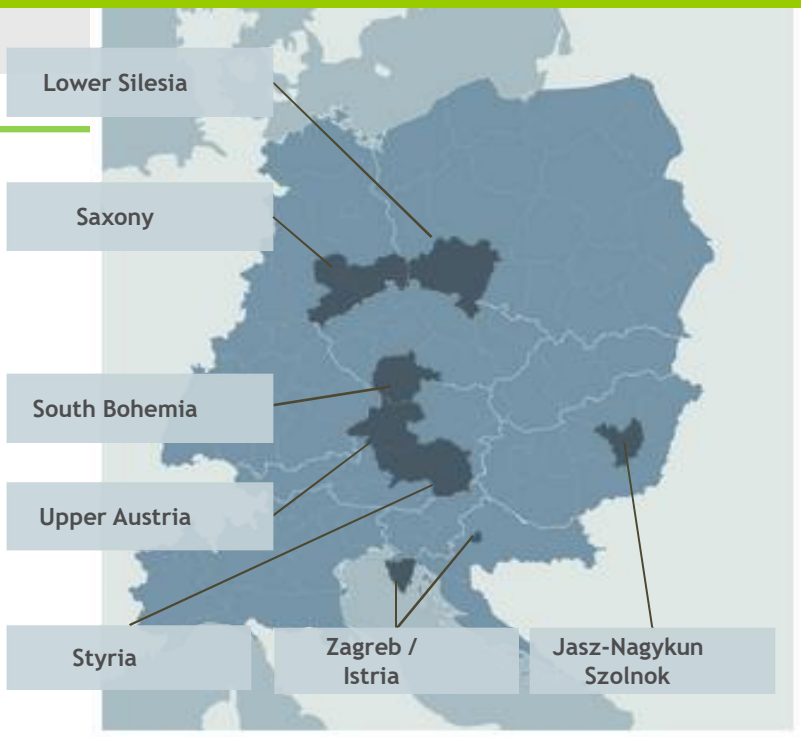
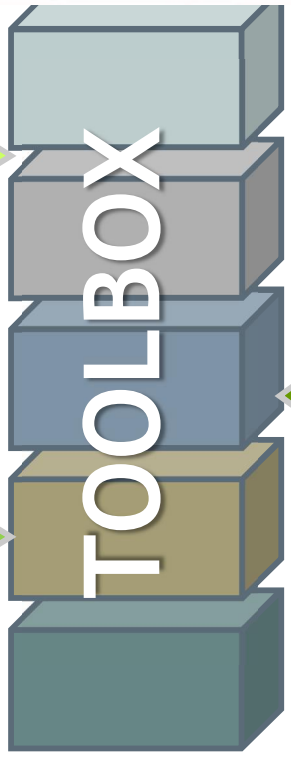


TOOL
ASSESSMENT AND MAPPING

- Heavy rain hazard and risk maps
- Guideline for numerical simulations

TOOL
RISK COMMUNICATION

- Catalogue of risk reduction measures
- Adapt spatial planning
- Prevent damages
- Retain rainwater
- Organise emergency response



TOOL
HEAVY RAIN RISK REDUCTION MEASURES

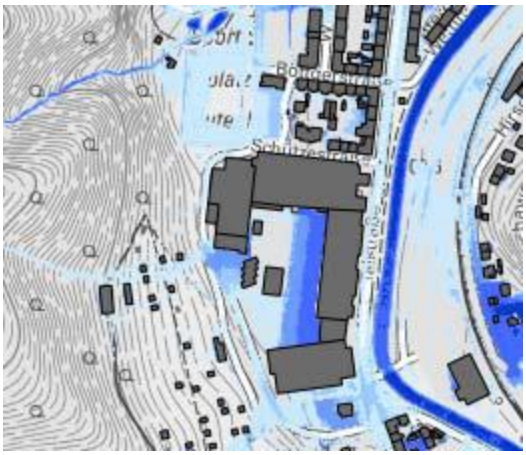
- Improve early warning
- Organise emergency response
- Select suitable measures
- Prevent damages
- Retain rainwater
- Adapt spatial planning

Graphics © copyright by LfULG

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Heavy rain hazard map (hydrodynamic simulations with HiPIMS) (PA 1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). The hydrodynamic model HiPIMS solves the fully dynamic form of the shallow water equation based on a finite volume approach on a regular grid. Details about the model and examples are given in Smith & Liang (2013), Liang & Smith (2014), Smith et al. (2015) and Liang et al. (2016). A uniform or gridded rain is used as driving input and routed over the surface of a digital elevation model. Currently there is no infiltration approach implemented, i.e. the runoff coefficient is 1. To account for losses, a global drainage/loss rate can be set. The Gauckler-Manning-Strickler hydraulic roughness value can be set for the whole domain or on a raster basis. The model runs on CPU as well as on GPU. The runtimes on GPU a very fast (minutes to hours) compared to "classic" hydraulic modells of the same class (hours to days).

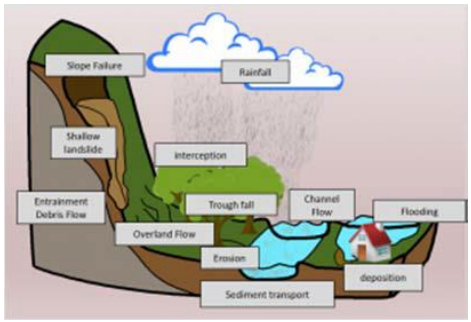


Map example

Map example

Heavy rain hazard map (hydrodynamic simulations with Hystem-Extran (PA1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). With the hydro-dynamic rainwater, runoff and pollution load system HYSTEM-EXTRAN, sewer system simulations with design storms as well as long-term series simulations can be carried out. Besides the classic sewer system simulations, HYSTEM-EXTRAN can be used even in other related fields, thanks to its flexible structure. Combined with the rule interpreter CONTROL, control strategies for sewer systems, for example, can be developed and checked.

Heavy rain hazard map (hydrodynamic simulations with OpenLISEM) (PA 1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). OpenLISEM is a spatial hydrological model that simulates runoff, sediment dynamics and shallow floods in rural and urban catchments. It is an event based model, that can be used for catchments from 1 ha to several 100 km^2. The model is designed to simulate the effects of detailed land use changes or conservation measures during heavy rainstorms. It is a model designed to be used indisaster risk management, not for long term estimates (https://blog.utwente.nl/lisem/).

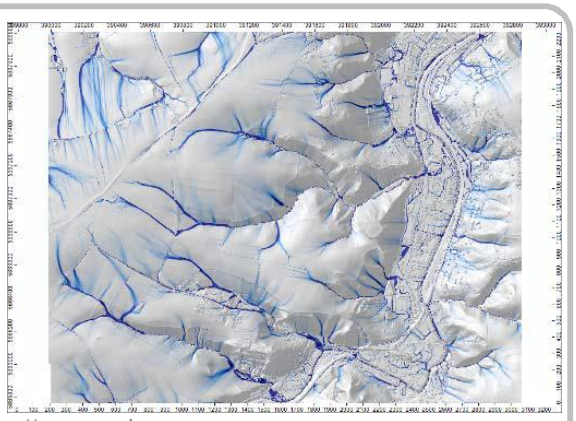


Map example

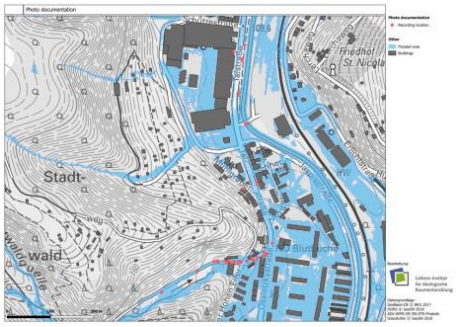
7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Heavy rain hazard map: Flow pathway analysis (PA 1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). The flow pathway analysis method uses a digital elevation model in raster representation and calculates where a unit of water from each cell might flow to. It is a kind of neighbourhood analysis that looks from each cell to the lower neighbours and distributes the potential flow based on different algorithms. The simplest version "Deterministic 8" puts everything to the neighbouring cell with the steepest slope, what causes a very strong concentration with one cell wide flow pathways. More realistic algorithms take into account that the other lower lying cells also receive runoff,e.g. Rho 8, deterministic infinity or multiple flow direction.



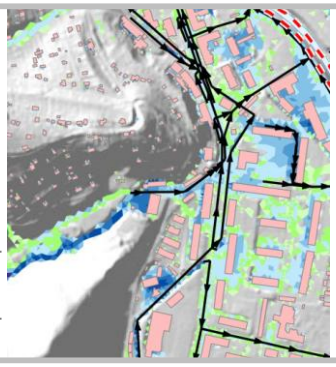
Map example



Map example

Heavy rain hazard map based on event documentation with FloodDocumenter for the City of Meißen (Germany) (PA 1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). FloodDocumenter is a desktop database developed with Microsoft Access. It enables the user to document flood-or watermarks (table "watermarks"), that means all kind of traces of a past observed event that give hints where the water was flowing, which direction it took and how fast it was flowing. The primary information source are currently digital images connected to a table where information is stored about date and time of the photo, the geographic location as well as the viewing direction (table "images").

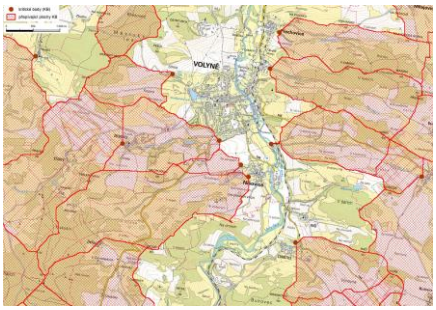
Heavy rain hazard map (hydrodynamic simulations with Hystem-Extran2d) (PA 1: Germany, Saxony, Meissen; contact: Dr. Axel Sauer IOER a.sauer@ioer.de). With the hydrodynamic rainwater, runoff and pollution load system Hystem-Extran 2d, sewer system simulations with design storms as well as long-term series simulations can be carried out. Besides the classic sewer system simulations, Hystem-Extran 2d can be used even in other related fields, thanks to its flexible structure. Combined with the rule interpreter CONTROL, control strategies for sewer systems, for example, can be developed and checked.



Map example

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING



Source: South Bohemia Region

Critical points analysis (PA 2: Czech Republic, South Bohemia; contact: T. G. Masaryk Water Research institute, info@vuv.cz). The methodology of critical points generally aims at the identification of urban (built-up) areas potentially endangered by concentrated surface runoff. The computation is carried out as follows: • A digital elevation model (DEM) is used for the identification of the surface runoff direction. • The accumulation of surface runoff is computed in order to delimit the pathways of concentrated surface runoff. • The intersections of such pathways with the built-up areas are identified as preliminary critical points. • Each intersection is an outlet of a contributing area of which basic parameters are analysed (mean slope, percentage of arable land). The contributing areas must not exceed 10 km^2. • For each contributing area, a risk factor is calculated, based on statistical analyses of data from other experimental watersheds. • The preliminary critical points of which the contributing areas exceed a given threshold of the risk factor, are finally selected as priority points.

Integrated heavy rainfall risk maps for the City of Graz (PA 3: Austria, Steiermark, Graz, catchment Annabach; contact: Office of the Styrian Government, Department 14 Water Management, Resources and Sustainability, Cornelia Jöbstl, cornelia.joebstl@stmk.gv.at). Parts of the City of Graz were frequently affected by heavy rain events. E.g. on 16th April 2018 severe flooding occurred due to such event. In case of a heavy rain the city is facing the challenge of a combined flooding from slope water, urban streams and sewer system. Within the RAINMAN project Graz University of Technology has developed a guideline entitled "Model-based urban flood provision", which explains how to take into account all three subsystems, when creating hazard and risk maps.

Source: RIOCOM – Engineering office for environmental engineering and water management

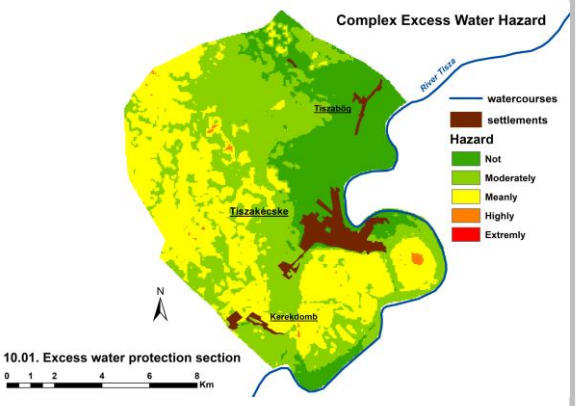
The guideline includes an exemplary application for the study area Annabach. In order to test the guideline hazard and risk maps were created for four additional study areas by the companies RIOCOM and Hydroconsult (Schloss Eggenberg, Stufenbach, Stiftingbach, Katzelbach). Different software solutions were tested and the feedback of the practical test was included in the final version of the guideline. Hazard and risk maps for all study areas are now available for the scenarios 10-year, 30-years, 50-year and 100-year precipitation.

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

High-resolution excess water hazard and risk mapping of agricultural areas (PA 4: Hungary, Bács-Kiskun, Tiszakécske; contact: Middle Tisza District Water Directorate (KÖTIVIZIG) Csaba Bozán, Harsányi Gábor harsanyi.gabor@kotivizig.hu). For modelling the complex relationship, we collected suitable and available spatial information on the predictor variables, which properly represent the influencing factors. Topography (relief) has a primary influence on runoff conditions. The position and type of the geomorphologic features determine the potential location of inland excess water occurrence. The topography was characterized by a high-resolution digital elevation model. In this case, we used the relevant part of the HYDRODEM provided by the General Directorate of Water Management. HYDRODEM is a countrywide digital elevation model (DEM) with 50 m spatial resolution and corrected for hydrological errors.

Map example



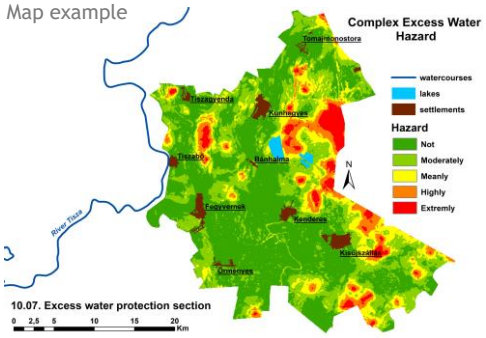
The geomorphologic features were taken into consideration based on numerous derivatives calculated from the HYDRODEM by System for Automated Geoscientific Analyses (SAGA) GIS tools.

In the present case, we have built up the regression kriging model as follows. The target variable of the modelling was the inland excess water inundation frequency. The multiple regression analysis was carried out on the generated inundation frequency point data (as dependent variables) and the influencing factors (soil, agro-geology, relief, groundwater, land use, and hydrometeorology) of inland excess water (as independent variables). A 5% significance level was applied. The explanatory variables used by the multiple regression, were selected by a stepwise method. Regression residuals were calculated from the resulted models and the original data set, which were subjected to exploratory analysis. Semivariogram models were fitted to the calculated empirical semivariograms by a semi-automated method provided by SAGA GIS environment. The vectors of the kriging weights assigned to the original point data set were determined by the semivariogram models. An interpolation was carried out to spatially extend the local residuals made by ordinary kriging. The final result of inland excess water inundation was derived by the integration of the regression model and the kriged residuals. Besides the predicted map, its spatial reliability was also obtained in the form of kriging variance map. By the validation of the map results, the overall accuracy of the prediction was checked by the validator data set. The predicted inland excess water inundation frequency and reference values were compared in 5,000 points. The following error parameters were calculated: mean error, mean absolute error, root mean square error (RMSE), and root mean normalized square error. The best performing model was selected based on the smallest RMSE value.

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Map example



High-resolution excess water hazard and risk mapping of agricultural areas (PA 4: Hungary, Jász-Nagykun-Szolnok, Kunhegyes; contact: Middle Tisza District Water Directorate (KÖTIVIZIG) Csaba Bozán, Harsányi Gábor harsanyi.gabor@kotivizig.hu). For modelling the complex relationship, we collected suitable and available spatial information on the predictor variables, which properly represent the influencing factors. Topography (relief) has a primary influence on runoff conditions. The position and type of the geomorphologic features determine the potential location of inland excess water occurrence.

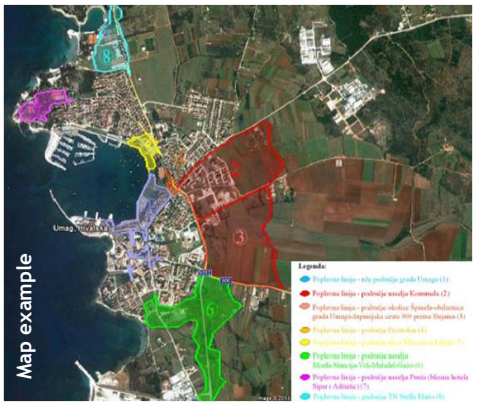
The topography was characterized by a high-resolution digital elevation model. In this case, we used the relevant part of the HYDRODEM provided by the General Directorate of Water Management. HYDRODEM is a countrywide digital elevation model (DEM) with 50 m spatial resolution and corrected for hydrological errors. The geomorphologic features were taken into consideration based on numerous derivatives calculated from the HYDRODEM by System for Automated Geoscientific Analyses (SAGA) GIS tools. The hydrometeorological conditions were described by long-term averages of yearly mean temperature, precipitation, evapotranspiration, aridity index, and a humidity index (HUMI).

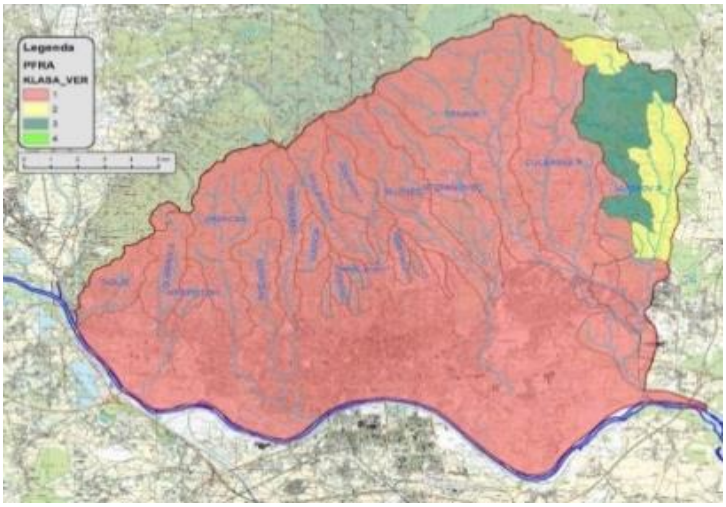
In the present case, we have built up the regression kriging model as follows. The target variable of the modelling was the inland excess water inundation frequency. The multiple regression analysis was carried out on the generated inundation frequency point data (as dependent variables) and the influencing factors (soil, agro-geology, relief, groundwater, land use, and hydrometeorology) of inland excess water (as independent variables). A 5% significance level was applied. The explanatory variables used by the multiple regression, were selected by a stepwise method. Regression residuals were calculated from the resulted models and the original data set, which were subjected to exploratory analysis. Semivariogram models were fitted to the calculated empirical semivariograms by a semi-automated method provided by SAGA GIS environment. The vectors of the kriging weights assigned to the original point data set were determined by the semivariogram models. An interpolation was carried out to spatially extend the local residuals made by ordinary kriging. The final result of inland excess water inundation was derived by the integration of the regression model and the kriged residuals. Besides the predicted map, its spatial reliability was also obtained in the form of kriging variance map. By the validation of the map results, the overall accuracy of the prediction was checked by the validator data set. The predicted inland excess water inundation frequency and reference values were compared in 5,000 points. The following error parameters were calculated: mean error, mean absolute error, root mean square error (RMSE), and root mean normalized square error. The best performing model was selected based on the smallest RMSE value.

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Heavy rain risk map for Umag river estuary (PA 5: Istria, Umag, Croatia). The Umaški potok basin was selected as a representative of the consequences of heavy rainfall events on specific torrential basins in the mostly rural as well as coastal region –with a (part of the) area in carbonate karst. Besides, the Umaški potok stream drains into the sea, so its capacity to receive high waters also depends on the backwater effect of the sea, which in the context of the present climate change and seawater level rise gives a special significance to the issue of protection from the consequences of heavy rain in the coastal regions. The final objective is to develop hazard and risk maps for the selected parameters in the pilot area for floods caused by heavy short-lasting rainfall – Hydrodynamical model is in testing faze.





Map example

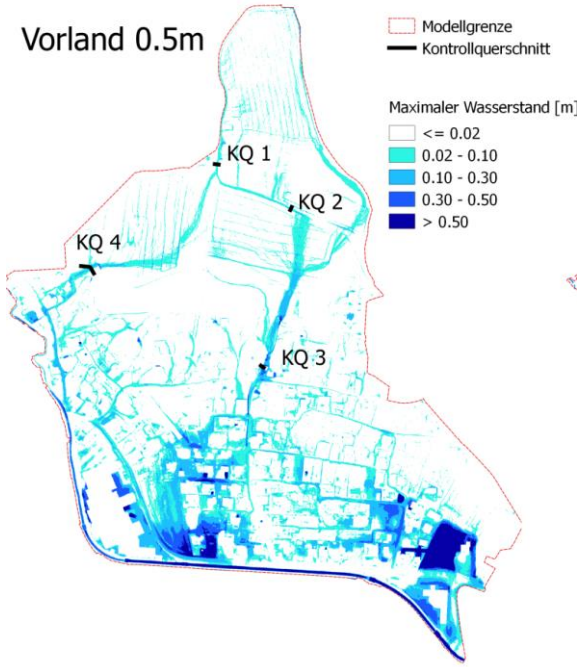
Heavy rain risk map for Zagreb (PA 5: Zagreb, Croatia). The last ten years have experienced more frequent events with extreme rainfall causing fluvial and pluvial floods in Croatia. Heavy short-lasting rainfall poses a particular threat to urban environments, including the City of Zagreb, which in such events gets flooded. Such floods develop due to heavy intensity rainfall in a short period of time, as well as due to public sewer systems which are not designed to transport such extreme volumes of water that fall in a short period of time. The situation is in some locations additionally aggravated due to insufficiently maintained public sewer systems. The concentration of stormwater from torrential streams from the Medvednica mountain massif also contributes to the intensity of floods.

During such events, material damage was recorded in the Zagreb area, not only in its immediate centre, but also in the wider city area, so far with no casualties. The final objective is to develop hazard and risk maps for the selected parameters in the pilot area for floods caused by heavy short-lasting rainfall.

7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Guideline for numerical simulations for surface flow induced by heavy rain events (PA 7: Upper Austria, Austria; contact: Dr. Yvonne Spira Oberflächengewässer Umweltbundesamt). A comprehensive numerical study was undertaken, starting with an overview of four available software packages for simulation of surface flow and their basic features. Performing and extending benchmark tests from earlier studies allowed to assess which aspects of surface flows can be simulated in a physically reasonable way. Based on these results, two software packages with different characteristics (one raster-based, one working with unstructured meshes) were selected and applied to actual real world test sites.
Based on datasets from two test-sites different aspects of the two selected software packages were investigated. In a first step the impact of varying grid- or mesh-resolutions on model results was analysed. In a further step the sensitivity of model results to varying model inputs (precipitation) and model parametrizations (flow resistance, runoff parameters) was investigated. Eventually, also the capabilities of the two models to consider hydraulically relevant structures (e.g. walls, culverts) were tested and the effects of considering/omitting these structures in the modelling process were assessed.



Map example

The aim of the investigation was to provide an up-to date overview on software packages with their relevant technical features, and to condense the experiences from the simulation studies into recommendations.

The conclusions from the numerical studies are enclosed in the present guideline. This guideline has two purposes:

- on one hand, it can be used to support administrative authorities in developing requirements for surface flow simulations, in order to achieve results with comparable results and in adequate quality.
- on the other hand, the guideline can be used by civil engineers in practice, to update their knowledge on surface flow softwares, to benefit from the documented experiences, and to make better informed decisions in surface flow modelling.

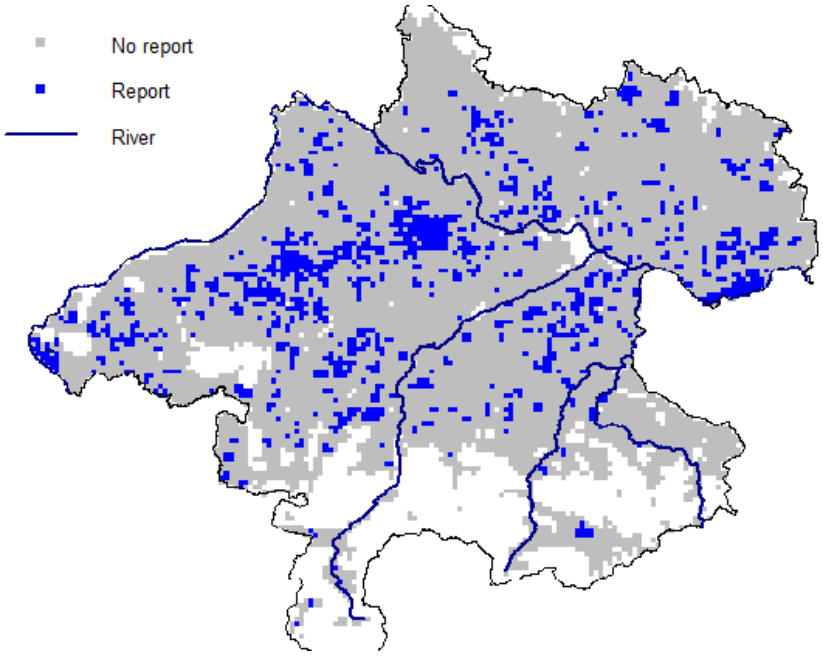
7. Activities and good practices in other RAINMAN Pilot Areas

7.1 TOOL ASSESSMENT AND MAPPING

Statistical assessment of pluvial flood risk for rural areas in Upper Austria (PA 7: Upper Austria, Austria; contact: Dr. Yvonne Spira Oberflächengewässer Umweltbundesamt, Assoc. Prof. Gregor Laaha Institut für Statistik Universität für Bodenkultur Wien).

The aim of this study was to evaluate the value of statistical methods for pluvial flood risk estimation. One objective was to assess if statistical methods can deliver significant relationships between meteorological events, soil and landuse parameters and agricultural damage events.

Additionally, it was an objective to find out if for agricultural areas the statistical methods could be a cost-efficient alternative to deterministic surface run-off models.



Map example

The data investigated were damage event locations from the Austrian hail insurance for Upper Austria for the years between 2007 and 2013, precipitation data, terrain data, soil and land use data, summing up to 16 location parameters investigated.

The data was checked for plausibility and applicability to the required spatial and temporal resolution. A location analysis revealed that in Upper Austria, in the years between 2007 and 2013, the most severe agricultural damages were triggered by intense rain events, and only in one case the damage was caused by longer lasting low intense rain. By means of logistic regression models and random forests the relationships between the location parameters and damage events were investigated.

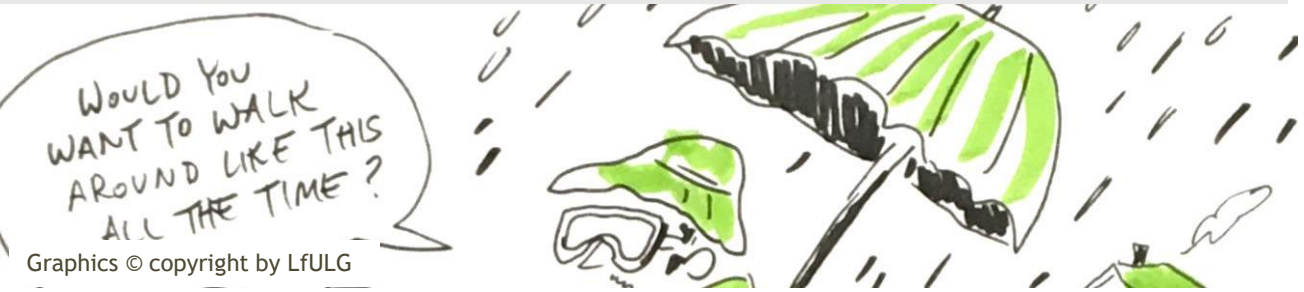
A specific focus was laid on comparing the skills of continuous versus classified parameters, and on methods for dealing with collinearity. Both models delivered results with acceptable reliability. However, the results strongly depend upon the quality of the input data and the length of the observation period.

7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL RISK COMMUNICATION

Source: City of Meissen (2017), URL: https://www.stadt-Meissen.de/Aufforstung.html

Accompanying information and dialogue during implementation of reconstruction and flood prevention measures for increasing risk awareness and acceptance by citizens - Meissen (PA 1: City of Meissen, Saxony, Germany; contact: City of Meissen presse@stadt-meissen.de). The City of Meissen conducted many risk reduction measures after a heavy rainfall event. Almost 20 press releases and several journal articles were published by the municipality to inform the public about the heavy rain event including damages and later on about ongoing repair and (re-)construction activities. Additionally, the City of Meissen showed commitment on conferences to share their experiences with the expert audience and organised public information events for their citizens. By making use of a diversity in communication methods and dialogue formats, several stakeholders and citizens across different ages were addressed and reached. Regular and continuous information of the public improve the acceptance of planned and implemented measures. When citizens are involved in the participation process in an early stage, better solutions for all parties involved can be found and conflicts are avoided. Positive press work about flood prevention, especially the communication of best practice examples to other stakeholders, citites and communities with similar problems and interests raises risk awareness, the consciousness about the necessity of prevention as well as the need for choice of suitable prevention.



7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL
RISK COMMUNICATION

Source: Ch. Wirrig, Oderwitz

Showing and explaining risk and risk reduction measures in the landscape - Establishment of a flood trail in Oderwitz (PA 1: Oderwitz, Saxony, Germany; contact: Municipality of Oderwitz gemeinde@oderwitz.de). Not all structural measures taken after a heavy rainfall event are always visible in the landscape or their functioning needs to be explained to non-expert persons. Information boards contribute to a better understanding of the functioning and objective and, if necessary, acceptance of implemented measures. They visualise the local risk situation and also remind people of past events and their consequences.

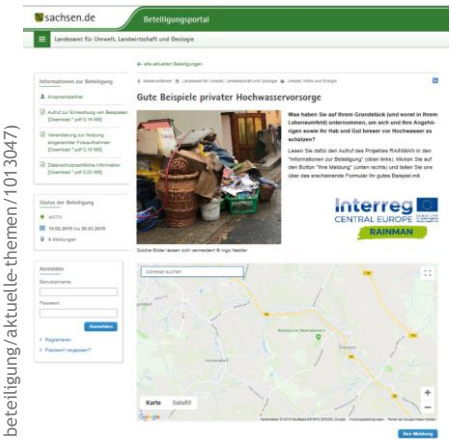
Signs, monuments, flood level marks etc. also inform those who are not familiar with the area and sensitise them to the risk as they keep it up among local residents. They should be either placed at particularly prominent locations, such as gauging stations or technical objects for flood protection, or at locations where risk reduction measures are NOT visible and therefore need explanation. If possible, you should always use historical pictures of the events, eyewitness reports or something similar to keep memories alive and to support imagination. Information boards can also be used to provide information on how to behave when it comes to an incident or on remaining risks. Educational trails can be linked to virtual information or geocaches. This creates an incentive to discover them and to deal with the message.

Organisation and realisation of a public information event about heavy rain in Oderwitz (PA 1: Oderwitz, Saxony, Germany; contact: City of Meissen gemeinde@oderwitz.de). An information event entitled "Facing heavy rain, floods and soil erosion" was organised for citizens affected by floods and other interested persons in Oderwitz. The event was intensively prepared in cooperation with the municipal authorities, and scientifically and medially accompanied and evaluated. The aim of this event was to provide transparency about the current state in flood risk management, increase acceptance for planned measures and to bring responsible representatives, who must push pending measures forward, together. The first part contained informative presentations, followed by bilateral interactions and dialogues. In the second part, participants took part in discussions organised in parallel working groups, focussing on private self-provision and adapted agricultural methods. Amongst citizens, the event contributed to keeping memories of past flood events alive. They were made aware of certain fields of responsibility (e.g. private self-provision) and knowledge about suitable measures and contact persons for further help and questions was imparted. The event provided orientation and motivated to gain a deeper insight into the topic to push it forward.

7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL RISK COMMUNICATION

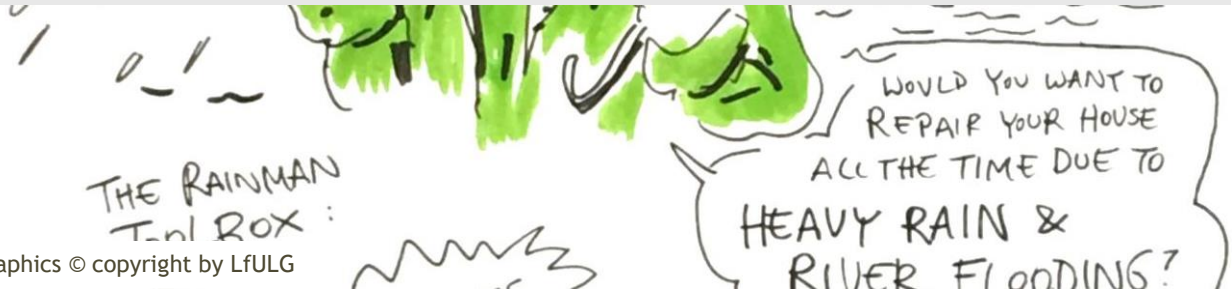
Individual risk assessment with the use of the flood protection certificate (HWVA) (PA 1: Oderwitz and Leutersdorf, Saxony, Germany; contact: Municipality of Oderwitz gemeinde@oderwitz.de). "Am I affected by floods? Which measures might be suitable and what does it cost? Which kind of use of my property contributes to a higher flood risk and should be avoided?" Such questions are raised by property owners, but cannot be answered by themselves. An expert for damages caused by floods is required. Prior to a public event in Oderwitz on how to cope with heavy rain, floods and soil erosion, the Saxon State Office for Environment, Agriculture and Geology and the municipalities Oderwitz and Leutersdorf commissioned an engineering company to prepare the Saxon flood protection certificate (German: Hochwasservorsorgeausweis (HWVA)) for two typical, previously affected homesteads. It is a valid tool for supporting private self-provision in Saxony. Results of both reports and related private mitigation measures taken have been presented and discussed during the public event. Experts' opinions brought certainty that privately taken prevention measures were suitable and actually mitigate the risk. Other affected property owners gained knowledge about the concept and principle of the flood protection certificate. It served as an orientation for further action. Employees of the municipal administration recognised by positive feedback of participants that the topic needs to be coped with more offensive in the future.



Source: Website of the Saxon State Officefor Environment, Agriculture and Geology. https://buergerbeteiligung.sachsen.de/portal/lfulg/beteiligung/aktuelle-themen/1013047)

Internet-supported participation opportunities for identification of damage areas and for private risk prevention measures (PA 1: Saxony, Germany; contact: Saxon State Office for Environment lhwz.lfulg@smul.sachsen.de and State Capital Dresden wawur@dresden.de). Individual's action is of particular importance for an integrated flood risk management. The project "RAINMAN" has established a web-based participation offering at the Saxon eParticipation platform, where citizens are asked to hand in good practice examples of private flood prevention measures and share their activities and experiences. In ideal circumstances, information about further possibilities of private flood prevention on the website can attract the participants' attention.

In contrast to feedback on paper, an online version is a convenient and quick alternative and may convince more citizens to participate. Once established, the systems runs automatically. Initiators of the participation portal, e.g. public authorities, gain an insight into recurring damages at certain locations, the current state of privately initiated prevention measures, can get access to illustrative examples and can plan further steps on that basis, e.g. enhancing risk communication.



7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL RISK COMMUNICATION

Source: Screenshot from the Saxon Flood Centre web page, URL: www.hochwasserzentrum.sachsen.de

Establishing a (flash) flood early warning system in Saxony by making end users familiar with it (PA 1: Saxony, Germany; contact: Saxon State Office for Environment lhwz.lfulg@smul.sachsen.de).

After the launch of the (flash) flood early warning system (FEWS) of the Saxon State Office for Environment, Agriculture and Geology, it was crucial to make the system known and the target group familiar with its skills. The pure availability of warning information on a website does not mean that the information is taken up by recipients at risk. To make the FEWS known to the target group, the Saxon Flood Centre promoted the launch via intense press work, presentations and scientific articles. For the public, a low level and easy access to the warning information in combination with easy understandable visuals was created.

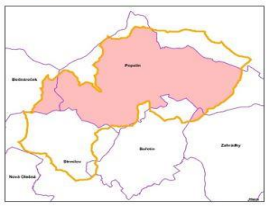
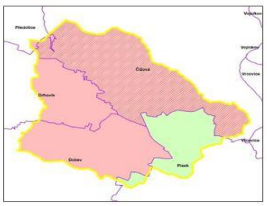
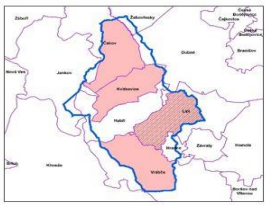
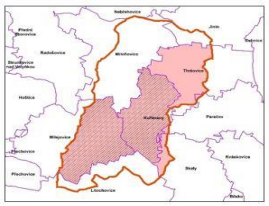
The target group oriented communication and training of the recipients has to be recognized as probably the most important part of an early warning SYSTEM itself. Continuous promotion and maintenance of the system in interaction with the target group is essential. Designing and implementing an EWS is a long-term process and requires a lot of effort in making the end users familiar with the provided information. Training and consultation options are crucial as well a clear communication of the limitations of warning information.

7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL RISK COMMUNICATION

Trainings on implementing the developed tools within the pilot regions in South Bohemia (PA 2: The South Bohemia Region, Czech Republic; contact: The Region of South Bohemia, The Section of Territorial Planning, Contact list: https://www.kraj-jihocesky.cz/ku_tseznam/os?id_os=94). The South Bohemian Region, in co-operation with the Research Institute of Water and the Architecture Studio Štěpán, organized four public discussions in pilot areas. The public discussions took place from 20 to 23 May 2019. Each meeting consisted of a presentation and a discussion. The first part of the meeting was devoted and the main output "RAINMAN-Toolbox" was presented. In the second part to basic information about the project. The project's contents, objective, involved organisations, duration of the meetings the Water Research Institute (VÚV) explained professional water management solutions based on the critical point method for each of the four pilot sites on the basis of the critical point method. With the critical point methods areas, which are expected to be at high risk of losses in built-up and undeveloped areas in the event of heavy rain, have been identified. For each of these pilot sites, VUV carried out an evaluation of the outflow conditions at the location and proposed risk reduction measures. These outputs build the basic for the "Study of applicability of risk reduction measures in spatial plans" conducted by the Architecture Studio Štěpán under the guidance of the RAINMAN project partner "The Region of South Bohemia". Experts of urban planning and water management presented a comparison of the proposal developed by VÚV with the applicable land use plans. The discussion with mayors of municipalities and local farmers was the last part of meetings. A lot of important data about local conditions were heard in the discussions.

Source: The Region of South Bohemia, The Section of Territorial Planning

POPELÍN	PÍSEK	LIPÍ	STRAKONICE
			
			

Name	Popelín
AREA (km2)	18
INCLUDED MUNICIPALITIES	6

Name	Písek
AREA (km²)	26
INCLUDED MUNICIPALITIES	5

Name	Lipí
AREA (km²)	26
INCLUDED MUNICIPALITIES	7

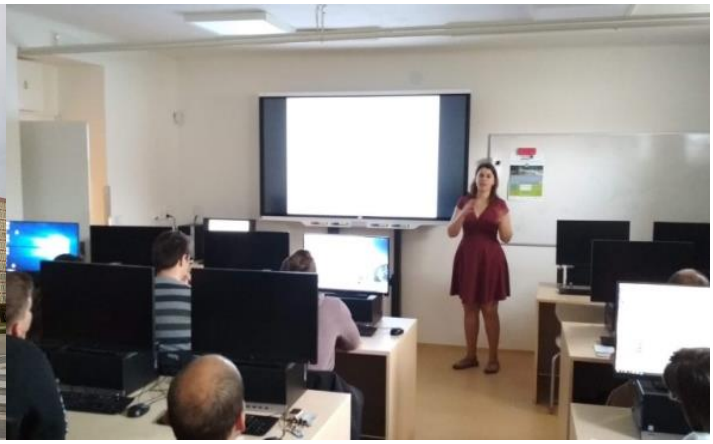
Name	Strakonice
AREA (km²)	15
INCLUDED MUNICIPALITIES	8

7. Activities and good practices in other RAINMAN Pilot Areas

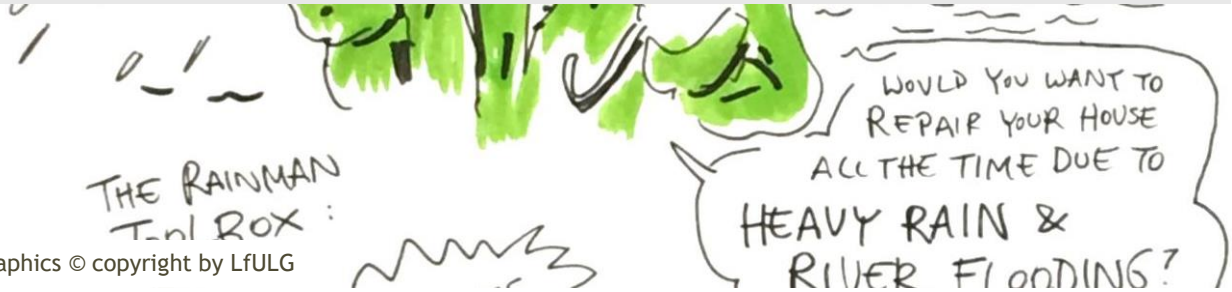
7.2 TOOL RISK COMMUNICATION

Lecture at the University of South Bohemia (PA 2: South Bohemia, Czech Republic; contact: The Region of South Bohemia, The Department of Regional Development, Spatial planning and Building Regulation).
The South Bohemian Region organized one lecture at University of South Bohemia. This meeting was organized for students of the fourth year of the study field "Ground Consolidation" and was held as part of the "Hydrology" course.
During this lecture, the RAINMAN project was presented to future experts in the field of water management activities. The first part of the meeting was devoted to basic information about the project. The project's contents, objective, involved organisations, duration and the main output "RAINMAN-Toolbox" were presented. In the second part the general principle of spatial planning in the legal framework of the Czech Republic was introduced. This introduction was essential for the final discussion, because the main output of the RAINMAN project partner "The Region of South Bohemia" aims at linking professional water management outputs with land-use planning documentation. The next part of the meeting was focused on one of the pilot sites – Lipí. In this part of the meeting a comparison of a proposal developed by RAINMAN project partner "T. G. Masaryk Water research institute, p.r.i." (professional water management solution designed based on the critical point method) with the applicable land use plans was presented.
The discussion with students was the last part of meetings. The aim was to spread awareness of the project and the issue of flooding caused by torrential rains among students who will be dealing with this topic in their future professional practice.

University Campus;
Source: South Bohemia Region



Source: South Bohemia Region



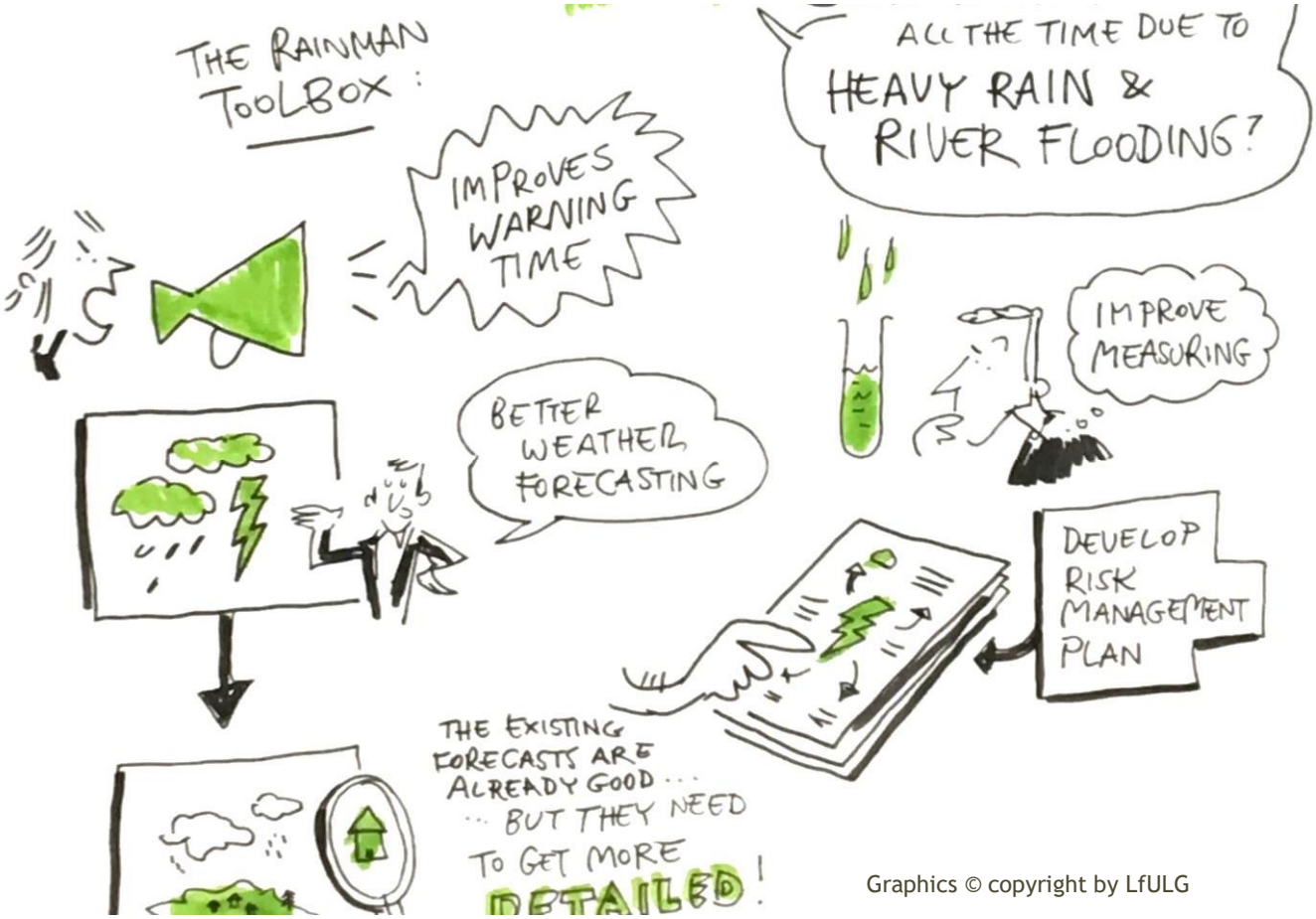
7. Activities and good practices in other RAINMAN Pilot Areas

7.2 TOOL RISK COMMUNICATION

Source: Land Steiermark, Lebensressort/free of charge

Heavy Rain Risk Check Graz (PA 3: Graz, Styria, Austria; contact: Office of the Styrian Government, Department 14 Water Management, Resources and Sustainability, Cornelia Jöbstl, cornelia.joebstl@stmk.gv.at). A two-day workshop was conducted to elaborate the status of heavy rain risk management in the City of Graz. Together with external experts, all concerned departments on the regional and local level, as well as SME, analyzed 35 indicators regarding land use, building, information, behavior, risk precautions, natural water retention and emergency response.

Wide-ranging and lively discussion arose amongst the participants about the current preparation status and possibilities for improvements. The auditors gave valuable inputs and examples from other city how to deal with pluvial flood risk. As a result, a protocol informs, amongst others, about the assessment in the four sectors "area effect precaution, building precaution, behavioral precaution and risk precaution". The assessment was done for different scenarios, e.g. in case all scheduled initiatives are implemented or none at all. Beyond that, political representatives held a press conference to inform the public about the project activities.



7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Detention basin - Korbitzer Schanzen, Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: stadtbauamt@stadt-meissen.de). At the end of a discharge path on an agricultural area, above the spring of the brook "Kirchsteigbach", a detention basin with a retention volume of about 4500 m³ was built. The City of Meissen built and funded the measure on a partially private land parcel (legally protected and with building permission) from their own financial resources. The maximum detention volume is approx. 5600 m³. The dam has a length of 81 m and is 6 m high. The throttle discharge amounts to 450 - 600 l/s. The basin retains water of an area of 28.7 ha.

Source: Sabine Scharfe LfULG

Besides its function as a detention area, it reduces flow rate and water velocity of the running surface water. Subsequently it slows down the inflow into the brook and reduces sediment transport. Interference of runoffs peaks with tributaries of the "Kirchsteigbach" are avoided. Ecologic valuable utilization of debris in the basin's construction involved the recycling of 4.500 m³ sediment which was washed out during the heavy rain event. The measure receives very high acceptance by the local residents who were asking for more flood protection. The detention basin has been regarded as well-fitting into the landscape. The measure belongs to a bundle of risk reduction measures (see other 7 examples of Meissen below).

Appropriate design of unsealed roads and stream crossing in forests - Korbitzer Schanzen, Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: stadtbauamt@stadt-meissen.de). Two bridges destroyed by a heavy rain event were rebuilt to reconnect the existing forest track network in the "Stadtwald" area. The use of glass fibre as construction material improves the resilience of the bridges and reduces upkeep in contrast to a wooden design. Destroyed culverts and bridges in nearby areas were replaced by fordings. Recovery and reconnection of the forest track network by fordings (instead of bridges) prevent from log and debris jams and contribute hence to a controlled water runoff. Fordings simplify forest management as they need a much lower upkeep.

Source: P. Voigt

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Renewing of a pipe and inlet structure - Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: stadtbauamt@stadt-meissen.de**).** With entry into the settlement area, the stream "Kirchsteigbach" is piped. After a heavy rain event, the intake became clogged and could not catch the water masses, which then flowed off as a flash flood.

As a risk reduction measure the destroyed stream pipe was enlarged (from 1.00 m to 1.40 m in diameter) and replaced by a new, reinforced concrete pipe. The inlet was equipped with a rake for sediment and debris retention. The enlarged pipe enhances runoff and discharge capacity was almost doubled. The inlet rake prevents from pipe blockage due to deposited debris. Such massive constructions to improve discharge are especially reasonable in immediately surrounding settlement areas to protect and reduce risk in lower settlement areas. Those measures should by accompanied by other retention measures in the upper area of the catchment.

Source: Sabine Scharfe, LfULG

Repair of a mill ditch system and a quarry lake - Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: stadtbauamt@stadt-meissen.de**).** The old and unused mill ditch system "Mühlgraben" fortunately collected and redirected much water, mud and sludge during a heavy rain event and protected the residential area from damages. The functional benefits of the existing system of drainage ditches for controlled surface runoff and for increasing the retention capacity of existing channels and floodplains was recognised and the ditches were restored immediately after the heavy rain event.

Source: Sabine Scharfe, LfULG

Additionally, the quarry lake "Kleiner Königssee", located at the slope of a stone quarry, was connected to the "Mühlgraben" by intense erosion processes during the heavy rain event, which created a canyon-like situation. This canyon was kept, partially expanded and is designated to be considered for controlled surface water runoff from the stone quarry area. In contrast to a totally new investment, restoring of the existing drainage system might be less costly and is hence regarded as a reasonable decision by inhabitants. Little effort, high effect.

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Source: Sabine Scharfe, LfULG

Afforestation on hillslopes of former arable land - Korbitzer Schanzen, Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: Stadt Meissen bauverwaltung@stadt-meissen.de). After a heavy rain event, 7.9 hectare of arable land at the border between farmland and existing slope forests have been turned into forest areas. Suitable, valuable native broad-leaved trees have been planted. These areas were protected by game fences to avoid damage due to excessive browsing by game. Trees increase infiltration into the ground whilst reducing runoff and sediment transport. Damages are reduced by establishing a suitable land use type with lower damage potential.

Afforestation is regarded as an ecological measure as well. The new developing forest improves the recreational value and offers a new habitat for insects, small animals and birds.

Source: M. Sura, Hoch- und Tiefbau GmbH

Stopping inflow structure from being clogged - Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: stadtbauamt@stadt-meissen.de**).** In the course of the stream "Kirchsteigbach", vertical wooden racks have been installed in the streambed. They act as a barrier to stop carried trees and branches. Otherwise their size, shape and floating energy could not only clog, but also damage and destroy the inflow structure at the lower parts of the brook. At the lower part of the brook "Kirchsteigbach", a gravel trap basin with overflow has been constructed. It acts as a detention basin, catches smaller debris and reduces the peak discharge. Its best performance was determined by terrain modelling.

A traffic-oriented access is important in the decision-making process for debris barriers. Accessibility for crafts must be given. The idea is very simple and expense for required construction material was very limited.

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Source: Sabine Scharfe, LfULG

Planting and maintenance of a buffer strip - Korbitzer Straße, Kanonenweg, Korbitzbach (PA 1: City of Meissen, Saxony, Germany; contact: City of Meissen stadtbauamt@stadt-meissen.de). After a heavy rain event, a flat depression (still arable land) and a dam have been built (tree and bush planting area). Some results of terrain modelling were implemented to find a suitable spot for collecting runoff, mud and sludge from the field before it flows over the street into private building properties. A 5 m wide retention hollow combined with a drainage system ensure that the building area is now protected from flooding. The planted buffer stripe strengthens and stabilises the soil surface. The developing humus layer functions as a water reservoir. Runoff water is collected and controlled drain off is enhanced, whilst water and mud runoff through the residential area is being stopped.

The combination of different measures allows for an optimal setup for protecting the nearby infrastructure and especially private buildings. The planted buffer stripe improves microclimate, acts as a windbreaker, avoids snowdrift and offers a habitat for many species. This measure fulfills its function properly and is recommendable for other locations. Large detention areas can be created without a huge loss of agricultural land. Besides advantages of detention, the decision-making process and its cost-benefit calculation should also consider related synergy effects: reduction of soil erosion, revegetation, improvement of landscape quality as well as protection of nearby infrastructure.

7. Activities and good practices in other RAINMAN Pilot Areas

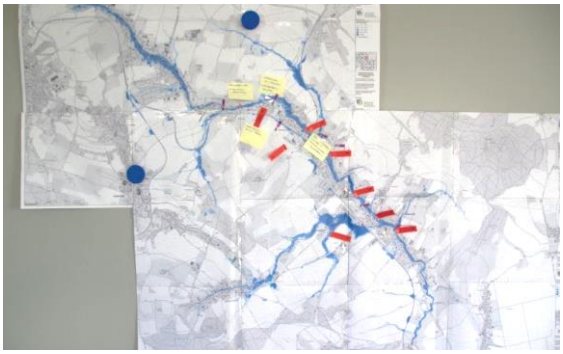
7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Bank reinforcement for the course of the brook - Kirchsteigbachtal (PA 1: City of Meissen, Saxony, Germany; contact: City of Meissen stadtbauamt@stadt-meissen.de). A heavy rain event caused severe damage in the area of the water body of the brook "Kirchsteigbach" itself as well as of the hiking trail running directly next to it. A near-natural bank reinforcement maintains the course of the stream. Embankments in the bump curves (undercut banks) of the brook course prevent the river from overflowing its banks and uncontrolled water runoff, coming along with mud and sediment deposit.

Source: P. Voigt

Terrain modelling was carried out in the lower area to create additional retention space and at the same time protect the banks from erosion. The measure requires just few time for planning and realisation as well as material, machines and manpower. If there is enough space, river streams should always follow their natural habitus and course. Just small investments are necessary to protect the natural stream course and their adjacent road and track structures on a long-term perspective.

Improving emergency response in Leutersdorf and Oderwitz with the RAINMAN toolkit (PA 1: Municipalities Leutersdorf and Oderwitz, Saxony, Germany; contact: Municipality of Oderwitz gemeinde@oderwitz.de, Municipality of Leutersdorf kommunalwesen@gv-leutersdorf.de). Both municipalities tested the RAINMAN project product "Emergency Response Planning - Toolkit for heavy rain events". As a result of the work process, the municipalities agreed on numerous measures to improve hazard prevention. These covered two main areas of action: the improvement of communication in the event of a crisis and an information event for citizens.

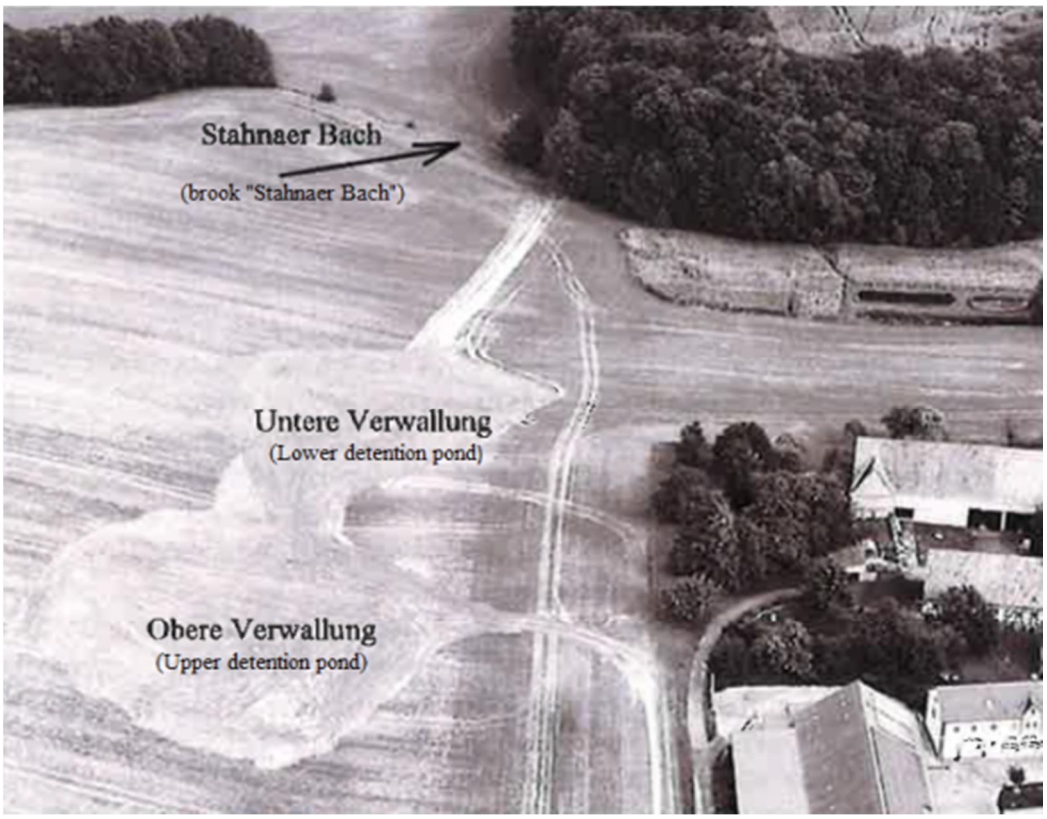


Source: Sabine Scharfe, LfULG

The direct dialogue with potentially affected citizens provides information about the risk and the limited possibilities of hazard prevention and encourages for private self-provision (property protection measures and behavioural precautions). The work was carried out on site with great personal commitment and was supported by the mayors. The treatment of the topic took place in close exchange between municipalities (exchange of experience, knowledge, agreements. Existing, valuable knowledge about proper action in an emergency is written down, thus making it more independent of people and more future-proof. Working with the toolkit provides security and orientation, thus increasing the courage to make a step towards interest groups (e.g. residents).

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES



Source: S. Peschke, LfULG

Implementation of a little detention pond integrated into the agricultural management – Pröda (PA 1: City of Nossen, Saxony, Germany; contact: District Administration of Meissen KVmA.Flurneuordnung@kreis-meissen.de). During several heavy rain events, agricultural land around Pröda was repeatedly affected by severe erosion processes. Two ramparts, including two shallow depressions were modelled to reduce soil erosion and massive sediment input into the close brook in the future. The upper system has a storage capacity of 500 m^3, whereas the lower one can retain around 200 m^3 of water.

The water drains off throttled via a seepage drain. Ramparts create additional storage volume, delay and reduce the discharge volume. They support groundwater recharge and retain sediment - i.e. they protect the underlying water body from substance inputs. The slopes of the implemented measures are so flat that the entire area can continue to be cultivated as farmland without restriction. The plant is integrated into the farmland management system and almost invisible in the landscape. In combination with erosion-avoiding soil tillage methods, the measure has proven to be an inexpensive, effective and sustainable measure for decentralised flood protection, for the protection of the soil against erosion and for the protection of a water body against discharges.

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Source: Sabine Scharfe, LfULG

Implementation of risk reduction measures through land consolidation in Sora (Municipality of Klipphausen (district Sora, Lotzen, Lampersdorf), PA 1: Saxony, Germany; contact: District Administration of Meissen KVmA.Flurneuordnung@kreis-meissen.de). In the past, flooding as well as problems caused by silt deposits have occurred several times in the local areas and on agricultural land. Within the framework of a land consolidation process, the affected owners form a community of participants under the direction of the responsible authorities and with the participation of the municipality. The joint identification, determination and implementation of measures is an essential part of the current procedure. These measures aim at:

- Improvement of flood protection (e.g. linear protection measures, increasing the retention capacity of existing channels and floodplains by restoration, property protection measures)
- Mitigate erosion (e.g. stabilisation of runoff pathways, conservating tillage)
- Delay runoff and improve water retention (e.g. small elevation oriented dikes).

In order to analyse the actual state in the planning area and to be able to assess the effectiveness of potential measures, problems and their causes were identified in a catchment area-related study and numerous measures were proposed to the community of participants. The method of land consolidation should also be used at other locations to tackle existing problems caused by heavy rain. Affected citizens, experts and public administration should work together to solve their problems bottom-up.

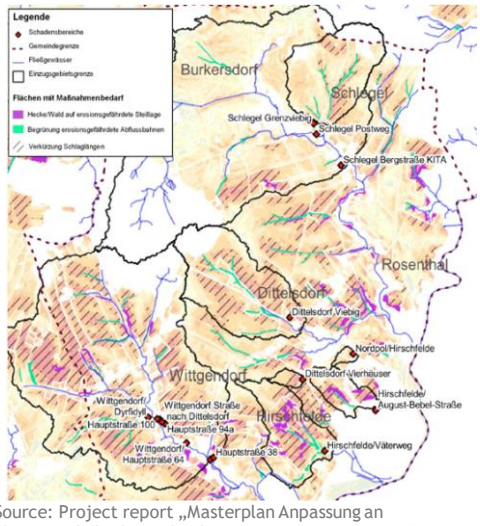
Participative development of a concept for heavy rain risk reduction and sustainable soil management - Freital (PA 1: Freital (district Niederhäslich), Saxony, Germany; contact: 2bm@freital.de). Several heavy rainfall events caused soil erosion on arable land above the settlement area. Mudslides led to massive sediment input into the nearby brook and to damage on inhabited property. Conflicts arose between the owners of the agricultural land and the residents affected.

Source:
D. Winderlich, Niederhäslich

In an informal planning and interactive communication and participation process, a concept for improving water retention and better drainage of surface water runoff and proposals for measures on private properties was developed. The process was characterised by a continuous and comprehensive, multi-level participation of all stakeholders, in particular by the intensive involvement of flood-affected residents, the municipality and farmers. The intensive participation of affected residents and the public served to develop a strategy for measures that can be supported and implemented by all those involved. In addition, the concept of measures also contributes to risk communication and promotes self-provision.

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES



Source: Project report „Masterplan Anpassung an klimawandelbedingte Starkregenereignisse in Zittau“, GFI Grundwasser-Consulting-Institut GmbH Dresden

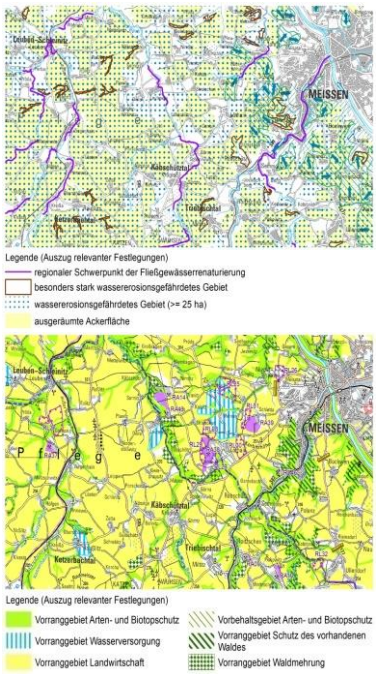
Participative development of a concept for risk reduction and sustainable soil management - Zittau (PA 1: Zittau, Saxony, Germany; contact: City Administration of Zittau energie@zittau.de). The City of Zittau initiated a master plan to adapt to heavy rainfall events. It is an informal planning and interactive communication and participation process. Early involvement of stakeholders and the public at all stages of the work is the key to success. Decision-makers and the general public were involved at an early stage in all steps of the process of identifying, evaluating and selecting measures. This took place in addition to calls for active participation within the framework of public information events with the possibility for discussion and exchange every 1-2 months. Ways to reduce the risk were shown, e.g. how adaptation measures can be implemented by means of subsidies or how measures can be implemented in the case of difficult property rights conditions (e.g. through mediation). The dialogue with affected citizens and stakeholders interested in climate protection leads to a transfer of knowledge and promotes the awareness of problems and responsibility in the public.

Incorporating and training volunteers for hazard observation and increase of emergency response - Glashütte (PA1: Glashütte, Saxony, Germany; contact: TU Dresden, CIMMT - Centre of Production Engineering and Management cimtt@mailbox.tu-dresden.de). Especially in rural, hilly areas, emergency responders have to cover quite long distances until they reach their place of emergency. The measure aims at the strengthening of local, voluntary emergency responders in rural areas. Hereby, the realisation of a one-day-event, a so-called “flood provision day” is a core element of recruitment. This event informs participants about problems and losses caused by uncontrolled surface water runoff and sensitises to feel responsible for self-provision and to take actions to help and protect others. In sum, four flood provision days had been taken place. Supported by further public-oriented measures and activities, a pool of volunteers was consolidated. Recurring volunteer trainings have become an integral part of the municipality and take place at least once a year. Professional emergency personnel was trained on teaching uncommitted volunteers in handling sandbags.


Source: Judith Schache, TU Dresden

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

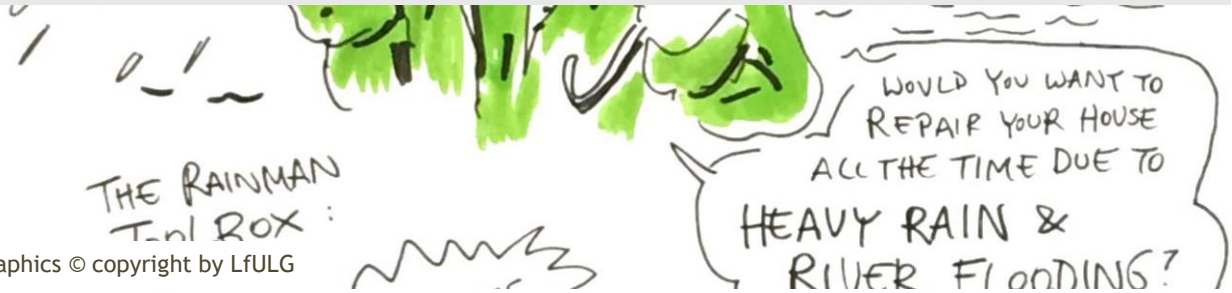


Source: 2nd overall update of the Upper Elbe Valley/Eastern Ore Mountains Regional Plan (draft statutes not yet approved), https://rpv-elbtalosterz.de

Land use and objectives for agricultural use considering the consequences of climate change in the Upper Elbe Valley/Eastern Ore Mountains Regional Plan (PA 1: Planning region Upper Elbe Valley/ Eastern Ore Mountains, Saxony, Germany; contact: Regional Planning Association Upper Elbe Valley/Eastern Ore Mountains post@rpv-oeoe.de). The task of regional planning in Germany is to regulate land use at regional level. On maps, they define so-called priority and reserved areas for certain uses and functions and formulate justified objectives and principles for spatial uses. One of the problems is the increased risk potential for agriculture with regard to the loss of fertile arable land through water erosion due to heavy precipitation, especially after dry periods. For this reason, the consideration of runoff paths and steep slopes is also gaining importance. Farming methods need to be adapted, e.g. by conservation tillage or mulch sowing/direct seeding. In areas with a particularly high risk of water erosion (run-off areas and steep slopes), in particular when these are simultaneously overlaid with priority or reserved areas for species and biotope protection and/or with areas for improving water retention, efforts must be made to ensure that agricultural use is converted to permanent greening. This can be achieved by planting flowering areas, field grass or grassland, hedge structures and strips of woodland, as well as by afforestation. In cooperation with specialist authorities and scientific institutions, regional planning can establish a framework for effective measures to reduce water erosion.

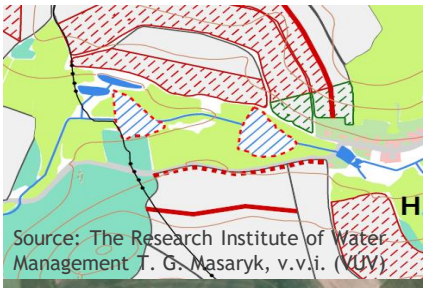
Building the baulk near the village Kuřimany (Pilot area Strakonice) Village Kuřimany, District Strakonice (PA 2: South Bohemia, Czech Republic). The site is located on a sloping terrain. During a heavy rain event there was an erosive wash from the higher-lying neighbouring plot to the owner's plot. This owner therefore built a baulk at the edge of the farmland, which reduces surface runoff and prevents erosion of the washes, thus helping to safely drain the runoff during increased rainfall events. Moreover, this risk reduction measure has been enriched by appropriate planting, where trees help to increase the ecological stability of the landscape. It also serves as a measure against wind erosion and divides the soil block according to its land use (respectively according to land owners).

Source: The Region of South Bohemia, The Section of Territorial Planning



7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES



Source: The Research Institute of Water Management T. G. Masaryk, v.v.i. (VÚV)


Source: Mapy.cz

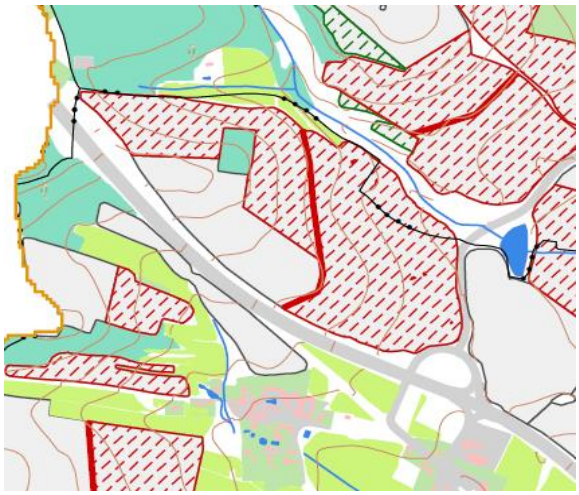
Design of water reservoirs in Horní Olešná (Pilot area Popelín) Village Popelín, District Jindřichův Hradec (PA 2: South Bohemia, Czech Republic; Contact list: https://www.kraj-jihocesky.cz/ku_tseznam/os?id_os=94). The locality consists of a grassy land through which the Olešná stream flows. The proposed measure aims to increase the retention capacity of the area in order to slow down runoff during torrential rains and increase the ecological stability of the landscape. The Research Institute of Water Management T. G. Masaryk, v.v.i. (VÚV) assessed the original spatial plan that includes the location of water reservoirs and confirmed the suitability of this proposal. The current spatial plan of the municipality of Popelín (Horní Olešná is part of this administrative territory), proposes a revitalization of the Olešná watercourse in this locality, where these water reservoirs are also planned to be built. Also a study of the applicability of flood control measures into land use plans evaluated the planned location of the water reservoirs. The study showed for one of the reservoirs a collision with a conceptual solution in spatial plan. The study recommends examining this collision in the spatial plan so that the reservoir can be subsequently realized.

Realization of the culvert in the municipality of Lipí (Pilot area Lipí) Village Lipí, District České Budějovice (PA 2: South Bohemia, Czech Republic; contact: The Region of South Bohemia, The Section of Territorial Planning www.kraj-jihocesky.cz, Contact list: https://www.kraj-jihocesky.cz/ku_tseznam/os?id_os=94). The need to regulate the Dehtářský brookis mentioned in the spatial plan of the municipality of Lipí, more precisely in the section between the football field and the proposed capacity increase of the culvert on the Dehtářský creek on the road III/14319 on the western edge of the Lipí settlement. The solution is based on the construction of a tubed bypass channel located behind the culvert, because increasing the capacity of the culvert itself would mean building a new bridge including the technical infrastructure. In case of heavy rainfall, the bypass channel helps to partially transfer the excess water, thus relieving the bed of the Dehtářský brook in this section. The bypass channel is again connected to the stream, but at a point where the stream can take larger discharges. In connection with this measure, the bed of the Dehtářský brook was modified and small barrages were built in the section from the culvert to the football field.


Source: Mapy.cz

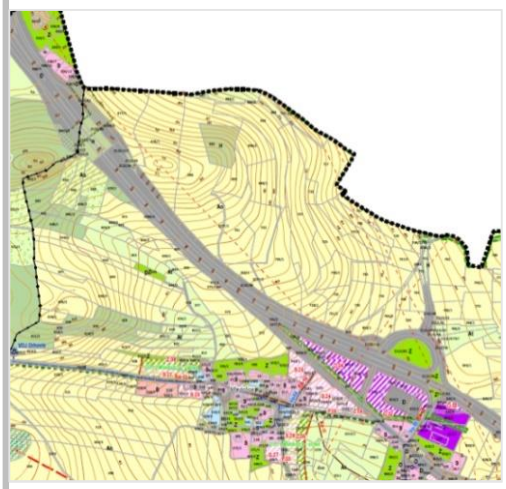
7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES



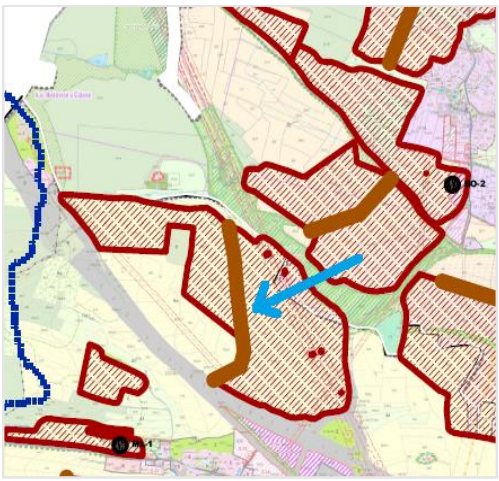
Source: Výzkumný ústav vodohospodářský T. G. Masyryka

Proposal of the interaction element - Baulk near Drhovle (Pilot area Písek) Village Drhovle, District Písek (PA 2: South Bohemia, Czech Republic). The site is a large block of farmland where heavy rainfall can cause erosion washes. These can then cause damage to the drainage system of the road or flood the road itself. On this piece of land the Research Institute of Water Management T. G. Masaryk, v.v.i. (VÚV) has designed a baulk as a flood protection measure. The baulk limits the soil block and thus helps to increase ecological stability. Furthermore, VÚV proposed a protective soil management (especially sowing into a protective crop, stubble, mulch or post-harvest residues). This often accompanied by limited tillage. The roughened surface of agricultural land slows down surface runoff and improves the conditions for infiltration of precipitation. For the implementation of anti-erosion agricultural technologies, it is recommended to use post-harvest or intermediate crops, which are partially incorporated by soil cultivators.



Section of the Spatial plan Drhovle
Source: The Region of South Bohemia, The Section of Territorial Planning

Ortophoto location
Source: Mapy.cz



Proposal of the baulk designed in Study of the applicability of flood control measures into spatial plans
Source: Architectural Studio Štěpán

7. Activities and good practices in other RAINMAN Pilot Areas

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HEAVY RAIN RISK REDUCTION MEASURES

Flood protection measures Strunkovice nad Blanicí (Strunkovice nad Blanicí - PA 2: South Bohemia Region, Czech Republic). The subject of the project is the realization of a part of the common facilities, namely the construction of weirs, the reduction of the leveling of the terrain and the bypass channel. Everything is in accordance with the approved design of comprehensive land consolidation in the cadastral area of Strunkovice nad Blanicí. The project is divided into the following buildings: Building SO 01 - landscaping of the Blanice riverbed by forming a composite profile with a take for slowing the velocities in the flow profile and reducing the dynamic effect of the water stream on the left bank. Building object SO 02 and 04 - landscaping of the Blanice riverbed by creating a composite profile with a berm and holes to increase the capacity of the profile with a connected bypass sewer (SO 03 - separate documentation) to approx. Q20. Part of the modification is the replacement of the sewer under the passage, the reduction of the paved access and the relocation of the water supply level under the lower berm. Building SO 03 - extension of the bypass sewer was performed with the creation of lower gaps in the upper and lower part for the capacity increase of the profile with the consequent landscaping of the Blanice channel by creating a composite profile with a berm and punchings so that the capacity of the troughs in the solution section can be achieved at approximately Q20.

Source: South Bohemia Region

Source: South Bohemia Region

Establishment of principles and regulations in the spatial plan of the municipality Nová Ves, nearby České Budějovice (PA 2: South Bohemia Region, Czech Republic). There are two specific measures defined in the graphical part of the spatial plan: planting of a vegetation belt (relocation of the local biocorridor due to the road bypass) and the implementation of a water channel (partly open, partly piped). The text part of the spatial plan contains a separate chapter defining heavy rain risk reduction measures: preservation of existing watercourses, including an 8 m wide access strip, maintenance of existing vegetation along watercourses and increasing the natural retention capacity of the area (for example sowing suitable grass cultivars).

7. Activities and good practices in other RAINMAN Pilot Areas

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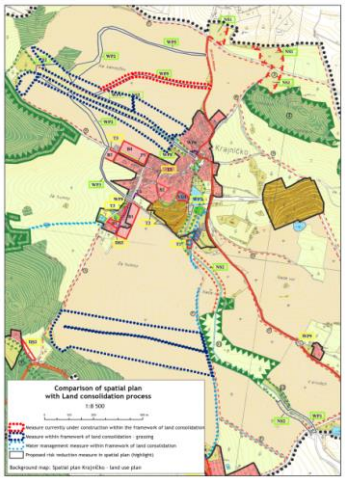
HEAVY RAIN RISK REDUCTION MEASURES

Flood protection and erosion control measures Krajníčko (PA 2: South Bohemia Region, Czech Republic). In 2009, the spatial plan of Krajníčko was approved, which proposes flood protection measures. The spatial plan locates a retention area, a ditch, an erosion control wall and the revitalization od the watercourses. In urban area, the spatial plan proposes a barrage to increase the capacity of the watercourse and culvert, and the partial demolition of one building. On the outskirts of the village, the spatial plan suggests to build an overflow on the existing pond. All the proposed measures are defined as public benefit buildings or public benefit measures. This means, that the rights to property and buildings can be expropriated in order to realise the proposed measures. The spatial plan with the proposed flood protection measures was the basis for planning the land consolidation project. The selected measures were subsequently included in the plan of joint facilities (a part of land consolidation project) in 2012 (approved in 2014). One of the proposed measures – WP5, erosion control wall - began to be realized in 2019. This measure was realized together with one dirt road. The total costs of both constructions were 9,909,220 Kč including VAT. The investor was the State Land Office.



Source: South Bohemia Region

Flood protection measures in Libín - furrow (PA 2: South Bohemia Region, Czech Republic). The flood protection measures of the village Libín consists of a bypass channel built as a furrow with a slight side slope. The furrow is dimensioned for a 100-year event. The length of the furrow is 625 m and it is followed by a watercourse in fiberglass pipes. The diameter of the pipes is 900 mm, the length is 155 m and the capacity corresponds to a 50-year event. The pipe outlet flows into a nameless watercourse which flows into the Spolský stream. As part of the realized construction the pressure under road had to be considered, a water pipe was relocated and other technical infrastructures were built.

Flood protection measures Přední Ptákovice - Strakonice, district Přední Ptákovice (PA 2: South Bohemia Region, Czech Republic). A study was carried out for the endangered area. However, this study was not successfully discussed with landowners, and despite the efforts of the municipality, it failed to buy enough land. Due to this failure, a second study with the same task was carried in 2016. The resulting concept proposed a set of infiltration furrows with total length 500 m and potential capacity 1920 m^3 of water. The furrows are proposed parallel to the contour lines and have a zero gradient. Rainwater is not drained but absorbed. Total depth of the furrow is 1 meter. The overflows of furrows were built as lowered stone barrage. This way the water will overflow from one furrow to the next during heavy rain event.

7. Activities and good practices in other RAINMAN Pilot Areas

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HEAVY RAIN RISK REDUCTION MEASURES

Source: South Bohemia Region

Flood protection measures Ledenice - furrow and bypass channel. Ledenice (PA 2: South Bohemia Region, Czech Republic). The subject of the project is the realization of part of measures which were defineted in the Study of Flood Protection Ledenice, ing. Daniel Vaclík, 1997. A comprehensive solution to the flood protection of the area included the restoration of the Kačerovec pond, the construction of a safety spillway at the Slavíček pond, mud removal and repair of the Lazny pond dam, the safety spillway at the Parčáček pond and and drainage trough on the square, watercourse treatment from Růžov, modification of the dam of the Dolní Hradský pond and construction of a bypass channel.

Flood protection measures Ledenice - other measures (PA 2: South Bohemia Region, Czech Republic). The following general measures have been proposed in addition to the bypass channel to reduce flood risk: increasing the natural retention capacity of the landscape, the use of valley morphology for the realization of a retention reservoir, increase in flow capacity of watercourses, replacement of non-capacity functional objects of water management works. the restoration of the Kačerovec dam is essential of this measures (single examples of other measures are in the first paragraph). The original flood dam was ruptured in 1925 and caused a flood in the entire catchment area of the Spolský stream, including damage to the dam of the Svět pond in Třeboň. Kačerovec dam was realized as retention reservoir with low water level - in periods without precipitation it can be dried.

Source: South Bohemia Region

Land consolidation and furrow in Branná. Village Branná, City Třeboň (PA 2: South Bohemia Region, Czech Republic). The study of the runoff conditions proposed the clean-up of the existing watercourses (except for the channel Opatovická), the realization of new channels and technical measures to reduce the risk of erosion and the reconstruction of a bridge with culvert. It was proposed that the watercourses should be cleaned only at their original level of the channel bed. The total length of the channels is 6,300 meters. The study of the runoff conditions proposed channels and furrows with accompanying vegetation in suitable locations. New channels and watercourses (total length 2,100 meters), furrows (total length 600 meters) and accompanying vegetation (total length 2,000 meters) were proposed.

7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Setting conditions for certain risk areas in spatial plan of municipality Ratiboř (PA 2: near Jindřichův Hradec, South Bohemia Region, Czech Republic). Planner proposed possible risk reduction measures in spatial plan. The municipality doesn't have adequate resources and has a limited budget. Therefore, only a drainage channel was proposed in the spatial plan and regulations for a certain area were set.

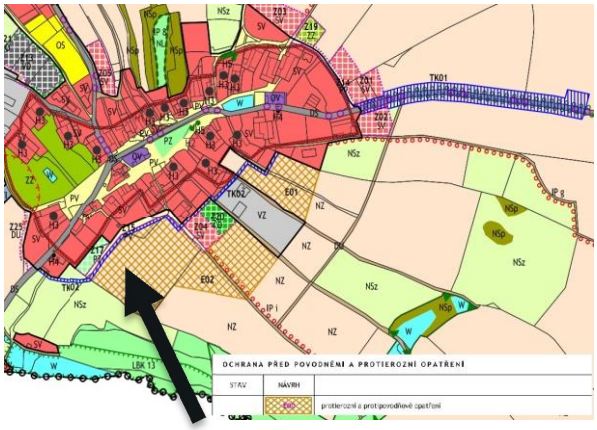
Extract from spatial plan Krajníčko – regulations for land use

Admissible land use: buildings, installations or other measures for risk reduction of ecological and natural disasters; measures and structures used to drain or retention water in heavy rain events (for example: dry retention reservoirs, small dikes, ditches, furrows; activities, measures and uses which can be considered as risk reduction of water erosion and which increase the retention capacity of the landscape (for example grassing, cultivation across the slope, baulks, furrows, infiltration belts realization, small dikes, crop rotation and other agro technical and technical measures); technical and transport infrastructure.

Conditionally admissible land use: intersection with transport and technical infrastructure provided that it does not prevent the realization of the measure for which this area is protected.

Inadmissible land use: to permit structures (including temporary structures) and except measures and related structures for which this area is protected; land use that would make it impossible to realize the proposed measures; measures and land use that would accelerate the runoff conditions or could lead to this being secondary.

Source: South Bohemia Region



Source: South Bohemia Region

Erosion and flood risk reduction measures, measures for water retencion in the landscape, construction and revitalization of water area and streams are made possible by land use conditions in the whole investigated area.

7. Activities and good practices in other RAINMAN Pilot Areas

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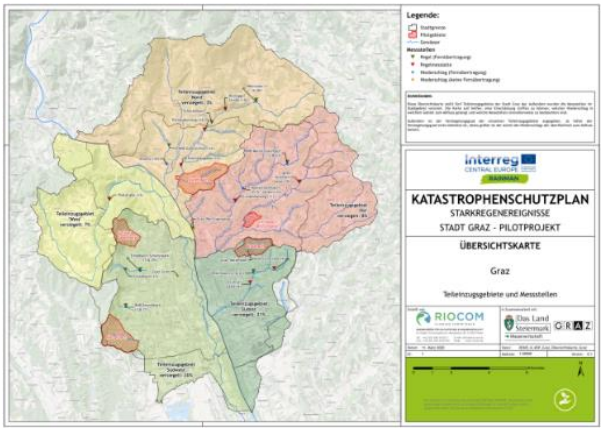
HEAVY RAIN RISK REDUCTION MEASURES



Source: RIOCOM – Engineering office for environmental engineering and water management

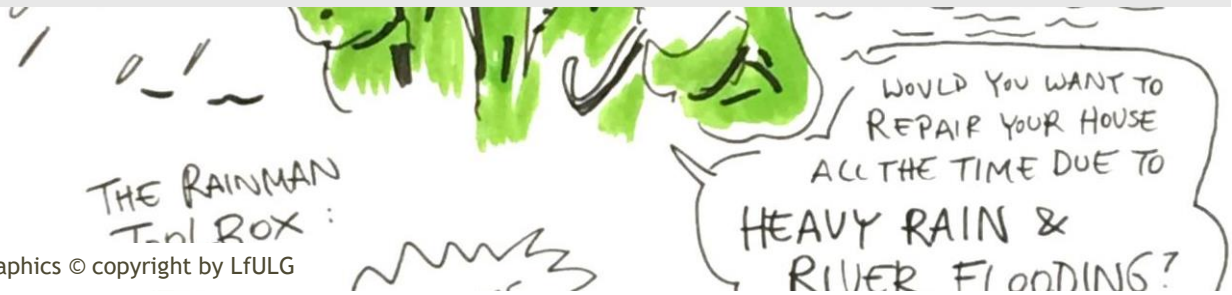
Emergency Response Plans for Graz (PA 3: City of Graz, Styria, Austria; contact: Office of the Styrian Government, Department 14 Water Management, Resources and Sustainability, Cornelia Jöbstl, cornelia.joebstl@stmk.gv.at).

In 2005, 2009 and 2013 severe fluvial floods have hit the City of Graz. Before 2005, the preparation status of the emergency response units regarding floods was low. Over the years, responsible authorities have built up a lot of knowledge, data, and experience in dealing with fluvial floods. As pluvial flooding differs from known fluvial events, new strategies are needed to protect Graz. Emergency response plans for pluvial floods for 5 study areas (Annabach, Schloss Eggenberg, Katzlbach, Stufenbach, Stiftingbach) were created.

All works are based on the developed hazard and risk maps, as well as on the emergency response toolkit in the RAINMAN project. The plans support those responsible to conduct operations and to set measures to minimize risk, in a structured, coordinated and targeted manner. At first, a review of the existing hazard analysis was done, followed by a review of the existing vulnerability analysis. A workshop with all affected and responsible institutions was held to discuss the results. In close cooperation with the professional fire brigade, applicable measures were defined. Special focus was set on the improvement of precipitations forecasts for small catchments, as initial point for the start of operations. The legal framework, existing documents and systems were considered in the emergency response plan.

Source: MTDWD

Optimise rain water storage at Kakat Pond (PA 4: Hungary, Kunhegyes; contact: Middle Tisza District Water Directorate titkarsag@kotivizig.hu). The retention basin was created to mitigate the negative effects of heavy rain in the catchment area. This type of water management facility is a side storage, i. e. the storage area is parallel to the main canal. The main purpose of this storage is to cover the whole discharge coming from the territory of Kunhegyes. The capacity of the storage area is almost 12.000 m^3, its length is 550 meters. The depth of the water in the storage area can reach 2 meters. The storage has two structures with which the water level is controlled. So with the optimisation of the water storagey, the effects of heavy rains (pluvial floods) can be reduced and controlled more accurately and safely.



7. Activities and good practices in other RAINMAN Pilot Areas

7.3 TOOL
HEAVY RAIN RISK REDUCTION MEASURES

Source: Screenshot from VIZ24 mobile application

VIZ24 mobile application for support the protection against the pluvial flood (PA 4: Territory of MTDWD (KÖTIVIZIG) Hungary; contact: Middle Tisza District Water Directorate Gábor Harsányi Head of Karcag Department harsanyi.gabor@kotivizig.hu). Our aim was to create an application for mobiles and tablets for different systems (Android, iOS), which contains every important data for risk reduction in case of pluvial flood, and to make the defense works more smooth for people who are involved in such a situation. The application has a high quality graphic design and user interface. The users can reach the water management plans of municipalities, variable maps (GIS, picture format), phonebook, and can reach weather and rain forecasts as well. The VIZ24 mobile application contains water management plans, maps and contact lists for more than 100 settlements in the Middle Tisza District. The application is available on Google Play and App Store at the moment.

Management of pluvial floods in Upper Austria – "Hangwasserkatalog" (PA 7: Upper Austria, Austria; contact: Amt der Oberösterreichischen Landesregierung Abt. Wasserwirtschaft, Gruppe Schutzwasserwirtschaft Mag. Felix Weingraber). The catalogue of measures contains all in Upper Austria known measures which are principally able to reduce the heavy rain risk in and around settlement areas. The catalogue illustrates the collected measures in a systematic way. First, an illustration or a photo is provided together with a basic description of the measure. Next, the basic effect of the measure is given, including the temporal and spatial effect of the measure. This is finally concluded by the specific costs of the measure and by additional recommendations for an effective implementation of the measure.

Source: Land Oberösterreich

The measures are grouped very clearly in three distinctive classes:

- Object-related measures (at a building)
- Property-related measures (on the parcel / property)
- Catchment-related measures (in the catchment area)

In this respect, it is essential to differentiate if measures are to be implemented for already existing objects or for future objects.

The aim of the catalogue is to give affected stakeholders like property owners or farmers an easy-understandable selection list or "menu" for good and effective surface water management measures, in order to improve prevention and protection against heavy rain events.

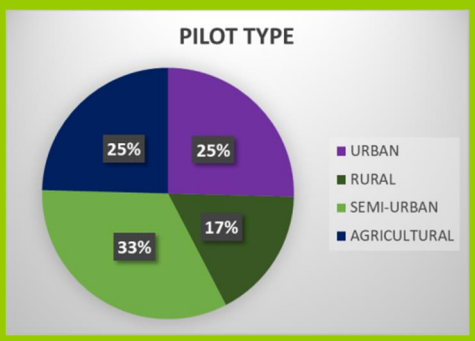
8. Summary

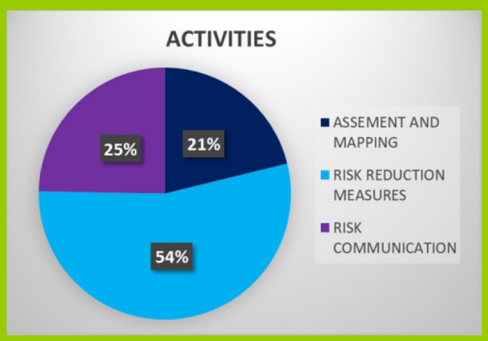
Currently, there are no comprehensive solutions for the local community regarding activities in the field of heavy rain. The presented catalogue brings the issue of practical activities carried out in seven pilot areas. It provides the basis for further steps to improve safety in an area characterized by potential risk of heavy rain.

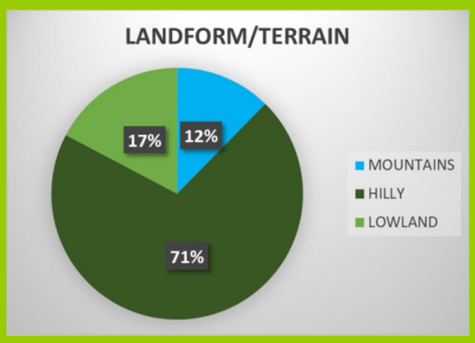
As part of the RAINMAN project, activities for urban (25%), agricultural (24%), rural (17%) and semi-urban (32%) areas were presented and tested.

The pilot areas included areas with varied physical-geographical conditions, including: mountains (12%), hills (71%) and lowlands (17%). In the pilot areas, the focus was on the presentation of good practices in the field of:

- mapping areas potentially exposed to heavy rain (21%),
- risk communication (25%),
- implementation of specific measures to reduce the effects of heavy rain (54%).







Source: IMGW-PIB

In the Polish pilot area, the activities were focused on mapping potential areas exposed to heavy rain, because such a map has not yet been developed for the whole country. Mapping potentially threatened areas is important in the context of actions undertaken by local authorities. It can also be reflected in contents of acts concerning spatial planning and other local or regional policies in Poland.

Furthermore, the activities in the pilot area in Lower Silesia also included non-technical measures related to increasing awareness concerning knowledge about heavy rain. It also included school packages.

Additionally, numerous presentations were carried out. They inform about the hazards caused by heavy rain with recommendations concerning prevention against their potential effects. Numerous examples of measures, that already had been applied in Poland, were also presented.

The catalogue is a collection of practical solutions used in Central Europe in the field of measures to prevent the potential effects of heavy rain. It is complementary to the RAINMAN project toolbox. Toolbox contains a full range of activities necessary to prevent the risk of heavy rain. We hope that the developed catalogue will encourage local communities to practical implementation of the developed suggestions in reducing the risk of heavy rain.

For details on activities
visit the RAINMAN toolbox
http://rainman-toolbox.eu/

Rainman

for details visit:

http://rainman-toolbox.eu/