EMERGENCY RESPONSE PLANNING FOR HEAVY RAIN RISKS

PART A - RECOMMENDATIONS AND MANUAL

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[1)] RIOCOM – Office for Water Management and Environmental Engineering

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Contents

Glossary

Action Plan	The plan where all the intervention measures are listed and described.
Basic Step	A part of the workflow, in particular the different columns of the flowchart.
Emergency Response Plan (ERP)	The final document where all the action plans, intervention maps and preliminary remarks are listed.
Exposed Objects	Any objects (in general: buildings) which are in danger to be destroyed during a heavy rainfall event.
Flood Modelling	The process of calculating and depicting flooded areas using computational software.
Flowpaths	Areas where a significant amount of water flows to a certain target.
Fluvial Flood	A flood event in connection with a river.
Hazard	The potential to cause harm to a vulnerable target.
Hazard Map	The map which shows the hazard situation in specific areas. For heavy rainfall events, mostly inundation areas are depicted.
Heavy Rainfall Event	A natural hazard event where significant amounts of rain fall within a short time period and damage on objects or subjects (buildings or persons) is caused.
Hydraulic Data	All data related to hydraulic phenomena (e.g. surface conditions, conditions of the fluid, …).
Hydrological Data	All data related to hydrological phenomena (e.g. precipitation, run-off, evaporation, infiltration, interception, …).

Intervention Map	The map showing the location of the intervention measures described in the action plan. This map is scenario specific.
Intervention Measures	Measures which are to be set during heavy rainfall events, in order to minimize risks.
Precipitation	Any product of the condensation of atmospheric water vapour that falls under gravity (e.g. rain, snow, drizzle, sleet, graupel, hail).
Process Step	The single question or task in the workflow.
Receptor	A vulnerable subject or object.
Risk	The combination of the hazard endangering an object and the vulnerability of the endangered object. The likelihood of a natural hazard event to happen is also considered in the risk.
Run-off	Water which flows on the ground and is not intercepted by vegetation or infiltrated by the soil.
Stakeholder	A person or group that has a legitimate interest in the course or outcome of a process or project.
Vulnerability	Describes qualitatively how a subject or object is prone to be harmed by a certain hazard.
Warning and Alarm Tool/System	A tool to assess the expected intensity of an event, following different parameters.
Workflow/Flowchart	The depiction of a process.
Workflow Phases	A part of the workflow, in particular the different rows of the flowchart.

PRELIMINARY REMARKS

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

I. Context and goals

a) Project context

Heavy rain events are a major environmental risk in Europe: they can hit any location with only very short warning time. Every year people die, thousands lose their homes, and environmental damages like water pollution occur. And the risks of heavy rain events are increasing all over Europe. In the project RAINMAN, partners from 6 countries have joined to develop and test innovative methods and tools for the integrated management of heavy rain risks by local, regional & national public authorities. These are included in the RAINMAN-Toolbox, a set of transferable tools and methods for municipalities and regional stakeholders.

This deliverable presents a toolkit for emergency response planning for heavy rain risks. It addresses local authorities who are in charge to set up plans to minimize risks caused by heavy rainfall events. With this toolkit the persons in charge get an overview about the necessary steps to develop such plans. This toolkit is closely related to the *"RAINMAN Tool Assessment and Mapping"*, which provides general information on how to generate hazard and risk maps for heavy rainfall events. Further information concerning the hazard and risk maps can be found in *"RAINMAN Tool Assessment and Mapping – Expert Corner"*, which is particularly addressed to experts in the field of hydrological and hydrodynamic analysis.

b) Goals

This toolkit aims to support those, who are in charge to develop emergency response plans for heavy rain risks. A flowchart shows the overall process of building up emergency response plans and a manual helps to work through the single process steps. Additionally, general recommendations for emergency response planning are given.

As this toolkit is considered to be a part of the RAINMAN Toolbox, frequent links to other RAINMAN deliverables are used, especially concerning the creation of hazard and risk maps, which is not part of this toolkit.

The process of generating emergency response plans is highly complex and often an expert assessment seems to be indispensable. Hence, certain process steps require a quite high own initiative and eventually further studying of relevant literature. Nevertheless, all the process steps are described in a way that also allows non-experts to apply the toolkit.

c) Structure

The toolkit consists of the following parts:

- Part A - Recommendations and Manual
  - Report: Recommendations and Manual
  - Supplement A1: Process Workflow - Flowchart
- Part B – Templates
  - Supplement B1: Templates Process Workflow (Forms B1.1 and B1.2)
  - Supplement B2: Templates Stakeholder Participation (Forms B2.1, B2.2, B2.3, B2.4 and B2.5)
  - Supplement B3: Template Risk Analysis (Form B3.1)
  - Supplement B4: Template Warning and Alarm Tool (Form B4.1)
  - Supplement B5: Checklist Process Workflow (Form B5.1)
  - Supplement B6: Template Emergency Response Plan – Text Document
  - Supplement B7 : Template Emergency Response Plan – Intervention Map

The first part of the toolkit's Part A provides important recommendations on emergency response planning, in particular for heavy rainfall risks. The second part contains the step-by-step manual for the process workflow. The process workflow flowchart is graphically shown in Supplement A1. In the annex a catalogue of example measures is presented.

Part B contains templates which should be used in the process of generating an emergency response plan.

II. Recommendations for Emergency Response Planning

The aim of emergency response planning is to avoid critical danger for human health and life, the environment, critical infrastructure or relevant valuable goods. In the sense of this, measures should be created in order to minimize the damage potential.

In general, emergency response plans (ERP) are set up to respond to a flood event in a way to help keeping the damage to a minimum. Heavy rainfall events tend to be natural hazards with only a short warning time and critical floods can develop within minutes. Hence, the few minutes between the first warning and the occurrence of flooding need to be used best. This is why a good planning process is essential.

In order to be well prepared for heavy rainfall events, a good knowledge about potential hazard scenarios and the areas where the highest damage potential is located is very important. Hence, this toolkit sets the focus not only on the detailed planning of emergency response measures, but also on a detailed review on the hazard and risk situation.

This chapter aims to give general recommendations for emergency response planning, in particular concerning heavy rainfall events. Regarding the following topics, short recommendations are proposed:

- Legal situation
- Crisis communication
- Goals and limits of emergency response plans for heavy rain risks
- Data
- Integration of existing systems (e.g. emergency response plans for fluvial floods)
- Action plans for different rainfall scenarios
- Regular training with the emergency response plan

a) Legal situation

The legal situation concerning the obligation to create emergency response plans might differ between countries. Further, the legal responsibility resulting from the existence of emergency response plans needs to be evaluated on the applicators country basis. Legislation might even differ between federal states of one country.

For example in Austria, municipalities are obliged to create emergency response plans for their regional specific hazards. Details on who is responsible for planning, adapting and applying of measures are legally regulated by the federal state's disaster protection laws.

Hence, legal situation settles the basis of all the developed emergency intervention measures and needs thus be clarified first. In addition it should be written down in the preliminary remarks of the final emergency response plan. This applies not only for heavy rainfall risks. Therefore it might already be put on record in existing emergency response plans.

b) Crisis communication

Heavy rainfall events are often characterised by short warning times. Communication during the events must thus be well organised. Crisis communication can be distinguished between the communications within operating organisations (e.g. the operational head advises to build up the planned road barriers) and the information to the affected public.

For communications within the operating organisation it must be clarified first who bears the legal responsibility and must thus be informed about every step. Communication itself must be direct and short. As communication channels, phone calls are to prefer against emails, because a direct receipt is given.

Regarding the information of the affected public, authorities should always keep the informational leadership. Hence, information needs to be given as soon as possible, in an easy-understandable way, describing the situation and planned further steps in a realistic manner. As communication channels both official websites and official social media accounts can be used.

c) Goals and limits

The overall goal of developing emergency response plans is to minimize risks. Most likely the affected region already dealt with risk caused by natural hazards. The aim is to create documents, which comprehensibly record what, by whom and when to do, even if those who have previously handled such emergency operations are not present. Things that are already common practice should be reflected in the emergency response plans.

Limiting are usually the non-existent short-term forecasts, which would allow setting detailed measures during the heavy rainfall events. Hence it makes sense to take into account medium to long term measures (spatial planning, structural changes, awareness raising, information of affected citizens, and self-provision of citizens).

d) Data

Data is the most important prerequisite for the generation of emergency response plans for heavy rainfall risk. Rainfall events can vary widely concerning the local spread and the intensity. Thus, maps showing certain heavy rainfall scenarios (hazard maps) can only depict one part of the potential hazard situation. Most likely a real rainfall event will not match exactly with the scenarios depicted in the hazard maps. It is therefore important to be aware of the inputs used to create the hazard maps.

Before an emergency intervention is started, measures should always be critically reviewed concerning the present event. Eventually, measures need to be applied or cancelled during the operation. In any case, all deviations from the emergency response plan need to be documented.

e) Integration of existing systems

The developed plans should reflect things that are already common practice. Thus, existing emergency response plans need to be evaluated and specific parts can be implemented in the documents for heavy rainfall risks. Especially plans for fluvial hazards contain important information and should be integrated in emergency response plans for heavy rainfall risks.

f) Action plans for different rainfall scenarios

Emergency intervention measures are always developed based on a specific hazard scenario. Hence, when the real event differs from the modelled scenarios, modifications during the emergency interventions are essential.

Heavy rainfall events are natural hazards which tend to differ locally and temporarily. Knowing this, one has to be aware that the scenarios depicted in any hazard map will most likely not exactly match any real event. Considering the fact that forecast data quality is often not precise enough to obtain a detailed knowledge which scenario is expected, this toolkit recommends to focus with the measure planning on a rather extreme rainfall event and cancel the inappropriate measures during the emergency intervention. If hazard and risk maps for different rainfall intensities are available, it is advisable to work out the differences in the area affected when developing measures. This will ensure that the available resources can be used optimally even during less intensive events. For the individual measures in the action plan, the expected event intensity at which the measures are to be set can then be specified.

Only if it is possible to clearly distinguish between different scenarios, like flash floods or long lasting heavy rainfall events, where the possible inundation areas differ largely, it might be useful to establish more than one critical scenario. If so, for each scenario a single action plan needs to be developed.

g) Regular training with the ERP

The work with emergency response plans need to be regularly trained to be well prepared when it comes to emergency interventions.

The first training should be carried out immediately after the ERP is finalised, in order to train those who are in charge to operate with the plan. After that the plan needs to be checked if all the information is still correct. Additionally this toolkit recommends yearly training with the documents.

This training is not meant to train how to set up measures in detail, but more to work through the documents, to know the responsibilities and how the alarm concept and further communications work.

III. How to read the manual?

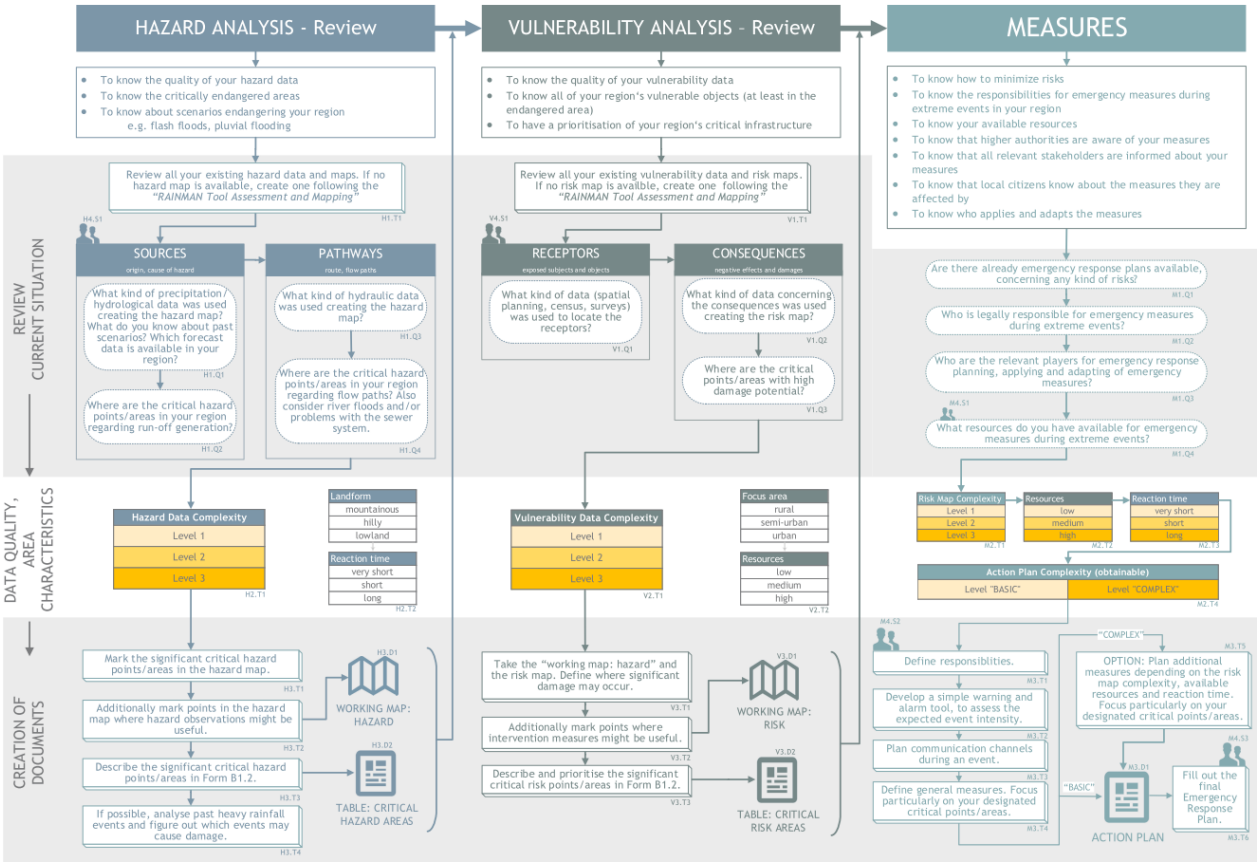


Figure 1: Process Workflow to build up an emergency response plan for heavy rainfall risks (Supplement A1)

a) General

This section aims to explain the manuals general structure, to summarize the single process steps and to give guidance for the application of the developed toolkit.

The toolkit is built up using the Source-Pathway-Receptor-Consequences (SPRC) concept, which is a conceptual model commonly adopted in flood risk assessment and suitable to create a better understanding of the elements of risk analysis and hazard, vulnerability and risk (Samuels and Gouldby 2009).

The overall process consists of **three basic steps**, which need to be worked off in order to build up an action plan:

- HAZARD ANALYSIS - Review
- VULNERABILITY ANALYSIS - Review
- MEASURES

These steps are further divided into **four workflow phases**, which show the minimum necessary steps in detail. These phases are:

> Review current situation
> Data quality and area characteristics
> Creation of documents
> Stakeholder

Within the workflow phases, firstly the **current situation** will be reviewed asking precise questions about the planning region. In the next workflow phase a filter is implemented based on the **quality** of available **data** and specific **area characteristics**. This is to filter out which areas should be considered in detail, concerning the application of intervention measures. Then the workflow will lead through detailed process steps in order to **create** the plan **documents** and finally the scenario specific action plans and the emergency response plan for heavy rain risks. **Stakeholder** implementation is considered within the whole process.

The basic steps are coded with different colours to facilitate the orientation in the process. This colour code is kept consistent within the manual.

To control if all steps are done, checklists for the overall process workflow are provided (B5.1).

b) Key Numbering

In order to facilitate the orientation in the process and provide a clear linkage between the flowchart (Supplement A1) and the manual, a key numbering system is introduced. The key numbering system is linked to the basic steps as well as to the workflow phases.

Basic Steps	
H	Hazard Analysis - Review
V	Vulnerability Analysis - Review
M	Measures

Workflow Phases	
1	Review current situation
2	Data quality and area characteristics
3	Creation of documents
4	Stakeholder

Process Step Types	
Q	Question
D	Document
T	Task
S	Stakeholder

In the toolkit, the used syntax looks like this:

X1.Y1

basic-step _ workflow-phase . type _ number

X = H (Hazard Analysis - Review) or V (Vulnerability Analysis - Review) or M (Measures)

Y = Q (Question) or D (Document) or T (Task) or S (Stakeholder)

e.g.: H3.T1 = hazard analysis - review, creation of documents, task 1

V1.Q3 = vulnerability analysis - review, review current situation, question 3

M4.S1 = measures, stakeholder, stakeholder 1

c) Example process step

All process steps are presented using the following layout:

Process Step **Question/Task/Document/Stakeholder XX.XX**

Additional information regarding the process steps and its applicability.

Detailed assignments to be carried out in the process step.

Input: *Description of the input (comes from: XX.XX)*

Output: *Description of the output ⇨ goes to XX.XX*

MANUAL

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

1. Hazard Analysis - Review

The hazard analysis is the first basic step in the emergency response planning process and forms the basis for further analysis and planning. This toolkit implies that hazard and risk maps are already available. Hence this process step aims to review existing hazard material (data and maps) focusing on the creation of an emergency response plan. If no hazard map is available, one should be created following the steps in *"RAINMAN Tool Assessment and Mapping"*.

The goals of reviewing the hazard analysis are to know about your region's endangered areas and about scenarios critically endangering your region. In addition the sources of forecast data (i.e. precipitation forecasts) shall be evaluated in order to build the basis for creating a warning and alarm system. Further, relevant stakeholders may be defined in an early process stage to be aware of who needs to be considered and to gain additional knowledge about the hazard situation. Therefore the user will be lead through different questions and tasks, concerning observed past events or any other available hazard data, eventually related to measuring or modelling approaches.

At the end of the hazard analysis, the user will:

- be aware of the data quality of the hazard data,
- know which areas are critically endangered,
- know which heavy rain scenarios are critically endangering the region and
- know where to obtain precipitation forecast data and of which quality this data is.

HAZARD ANALYSIS - Review				Template
Review current situation				
	Review all your existing hazard data and maps. If no hazard map is available, create one following the *"RAINMAN Tool Assessment and Mapping"*.	Task	H1.T1	B1.1
Sources				
	What kind of precipitation/hydrological data was used creating the hazard map? What do you know about past scenarios? Which forecast data is available in your region?	Question	H1.Q1	B1.1
	Where are the critical hazard points/areas in your region regarding run-off generation?	Question	H1.Q2	B1.2
Pathways				
	What kind of hydraulic data was used creating the hazard map?	Question	H1.Q3	B1.1
	Where are the critical hazard points/areas in your region regarding flowpaths? Also consider river floods and/or problems with the sewer system.	Question	H1.Q4	B1.2
Data quality and area characteristics				
	Evaluate the hazard data complexity.	Task	H2.T1	B1.1
	Evaluate your region's landform and reaction time.	Task	H2.T2	B1.1

HAZARD ANALYSIS - Review				Template
Creation of documents				
	Mark the significant critical hazard points/areas in the hazard map.	Task	H3.T1	-
	Additionally mark points in the hazard map where hazard observations might be useful.	Task	H3.T2	-
	Describe the significant critical hazard points/areas in Form B1.2.	Task	H3.T3	B1.2
	If possible, analyse past heavy rainfall events and figure out which events may cause damage.	Task	H3.T4	B1.1
	Working Map: Hazard	Map	H3.D1	-
	Table: Critical Hazard Areas	Document	H3.D2	-
Stakeholder				
	Stakeholder Workshop: Hazard	Stakeholder	H4.S1	B1.1 B2.1 B2.4 B2.5

1.1. Review current situation (H1)

In order to evaluate the data availability and quality of the hazard data, the current situation shall be reviewed. All available maps and data shall be re-analysed considering that this information will be used for the planning of measures.

As part of reviewing the current situation stakeholder involvements shall be planed from the beginning. In Chapter 1.4 you can find further details on the identification of relevant stakeholders and hosting a stakeholder workshop. It is important to think about the timing of your stakeholder involvement (not too early so detailed preparation is possible and knowledge about the data and the overall process is available but early enough for genuine participation).

Review all your existing hazard data and maps. If no hazard map is available, create one following the *"RAINMAN Tool Assessment and Mapping"* **Question H1.T1**

This toolkit implies that hazard maps are already available. Hence, the first process step is to review all the existing data and maps. All further tasks are based on the existing data and maps. If no hazard map is available, one should be created following advises in *"RAINMAN Tool Assessment and Mapping"*.

Evaluate which maps are available. Document or list your findings in Form B1.1.

Sources

Sources, in the context of this toolkit, can be described as the cause or origin of a hazard. Regarding flash floods or pluvial flooding, the source is a discrete rainfall event with very high amounts of precipitation per unit of time. The resulting run-off generation is also part of the sources (Sauer et al. 2019). The generation of run-off follows the topography (mountainous to lowland) as well as the hydrological conditions like infiltration (closely related to soil saturation) or interception (closely related to vegetation).

In this process workflow the current situation review regarding the sources, aims to evaluate the quality of precipitation and hydrological data. Additionally, past scenarios shall be reviewed focusing on how to

figure out which rainfall scenarios are most critical. In order to build up a warning and alarm concept in future process steps, it is important to be aware of the availability of forecast data for your region. Also the most critical hazard points or areas regarding run-off generation shall be evaluated.

In this very beginning of the process it might already be useful to include relevant stakeholders (see H4.S1).

What kind of precipitation/hydrological data was used creating the hazard map? What do you know about past scenarios? Which forecast data is available in your region? **Question H1.Q1**

Precipitation data is an important prerequisite not only to link the potential inundation areas with specific rainfall scenarios, but also to develop a warning and alarm system in order to apply certain risk reduction measures (M3.T2). Hence it is necessary to be aware of which data was used to depict the hazard in your hazard map, and be capable of linking these scenarios with past heavy rainfall events and values obtainable from forecast models.

Used data

Evaluate which data was used to create the hazard map. Data can be available in different levels of complexity. The following example table gives a hint on how the data can be classified. For detailed classification see the recommendation in "RAINMAN Tool Assessment and Mapping - Expert Corner". Use Form B1.1 for documentation.

	Level 1	*Level 2*	*Level 3*
Precipitation Data	*Station data (measured values)*	*Radar data (measured values)*	*Design values (statistically evaluated values)*
Hydrological Data	*observations*	*observations*	*Infiltration models*

Past scenarios

What do you know about past scenarios? Ask people with local knowledge about what they know about past heavy rainfall events. When did the last events happen? Do you see any increasing frequency of heavy rainfall events? Which amounts of rainfall where recorded in which time? Document all your findings, even if they rely only on observation and not on detailed measurements. Use Form B1.1 for documentation.

Forecast data

Which forecast data is available in your region? Is there any kind of meteorological service available, providing precipitation forecasts? Is a heavy rain warning service available? Eventually you can even obtain a detailed short term precipitation prognosis (now-casting). Heavy rain warnings or precipitation forecasts can be obtained by different organisations like meteorological or hydrographical services, but often these data is not free of charge. Eventually heavy rain warnings in your region are directed to regional governmental authorities, who are then informing the single municipalities. Use Form B1.1 for documentation.

Input:	*Hazard map (-)* *Local knowledge of stakeholders (H4.S1)*
Output:	*Summary and analysis of data used for hazard maps ⇨ H2.T1* *Past flood events ⇨ H3.T4, M2.T3* *Availability and quality of precipitation forecast ⇨ H3.T4, M2.T3*

Where are the critical hazard points/areas in your region regarding run-off generation? — Question H1.Q2

Run-off is generated where precipitation arrives on the soil more quickly than it can be absorbed, or when the soil is saturated or impermeable. The first situation most likely corresponds to what happens during flash flood scenarios, while the grade of soil saturation is critical during long lasting rainfall events. For each of the different possible hazard scenarios, different prerequisites apply. Hence, when thinking about critical hazard points regarding run-off generation, scenario specific parameters need to be considered as well.

Think about points or areas in your region where large amounts of water tend to start flowing on the surface during heavy rain events. Are there any differences during the year (vegetation period vs. winter months)? May ground sealing worsen the situation there? Document the points or areas that you consider important in Form B1.2.

Keep in mind these areas, when any structural changes are planned. Keep in mind that any structural changes not considering the process of run-off generation might worsen the hazard situation.

Input:	*Hazard map (-)* *Local knowledge of stakeholders (H4.S1)*
Output:	*Collection of hazard points/areas ⇨ H3.T1*

Pathways

The pathway describes the route of the rainwater from the point of impact on the surface towards a receptor (Sauer et al. 2019). Following this definition, the pathway is the linkage between precipitation and vulnerable object hence mitigation measures acting to reduce the hazard are most effective in the pathways (e.g. barriers, dams, retention basins).

Regarding the pathways, the workflow aims to classify the quality of the hydraulic data according to the three complexity levels. Furthermore, critical hazard points in the flowpaths shall be evaluated. Here, floods caused by high discharge in rivers need to be considered, as well as known problems with the sewer system.

What kind of hydraulic data was used creating the hazard map? — Question H1.Q3

Hydraulic data is important to know about potentially flooded areas. The data can only depict known scenarios.

Evaluate which data is available. Data can be available in different levels of complexity. The following example table gives a hint on how the data can be classified. For detailed classification see the recommendations in "RAINMAN Tool Assessment and Mapping - Expert Corner". Document your findings in Form B1.1.

	Level 1	*Level 2*	*Level 3*
Hydraulic Data	*Observations during events*	*GIS-based flow accumulation*	*Hydrodynamic modelling*

Input:	*Hazard map (-)*
Output:	*Summary and analysis of data used for hazard maps ⇨ H2.T1*

Where are the critical hazard points/areas in your region regarding flowpaths? Also, consider river floods and/or problems with sewer systems. — **Question H1.Q4**

As the pathway is crucial for a hazard to occur, it is important to know whether there are any hotspots or specific problems regarding flowpaths. Further, river floods may cause additional problems, as river floods may overlay with surface run-off after heavy rain events. Also, think about critical points in the sewer system.

Are there any culverts which, if blocked, critically redirect run-off? Are there any points in the sewer system where overflow occurs frequently? Are there any additional hazards concerning river floods? Document your findings in Form B1.2.

Input:	*Hazard map (-)* *Local knowledge of stakeholders (H4.S1)*
Output:	*Collection of hazard points/areas ⇨ H3.T1* *Information on related hazards (river floods, sewer system) ⇨ H3.T1*

1.2. Data Quality and Area Characteristics (H2)

After reviewing the current situation, this process step works like a filter, to filter out the relevant hazard points/areas. The existing and/or collected data have a certain quality/complexity. In order to be able to take further steps in the toolkit, it is essential to be able to classify the quality/complexity of the data situation in your region. In addition, the area characteristic plays an essential role in the planning of measures.

Evaluate the hazard data complexity — **Task H2.T1**

Reviewing the current situation (Chapter 1.1), data and information regarding the sources and the pathways of heavy rain-induced flooding were collected (H1.Q1, H1.Q3). In each previous step, the levels of complexity were assigned. Based on these principles, an expert assessment of the comprehensive complexity level has to be carried out.

Assess the complexity level of the hazard data. Use all previous classifications and information, which was assembled in the phase of reviewing the current situation. The classification should be done based on an expert assessment. Refer to the information shown in "RAINMAN Tool Assessment and Mapping - Expert Corner". If you vary between two levels, choose the lower level. Document the assumptions you made and the level you chose in Form B1.1.

	Level 1	*Level 2*	*Level 3*
Hazard Data Complexity			

Input:	*Summary and analysis of data used for hazard maps (data complexity H1.Q1, H1.Q3)*
Output:	*Overall hazard data complexity ⇨ M2.T1*

Evaluate your region's landform and reaction time — **Task H2.T2**

Based on the landform of your region a basic assumption of key processes can be made. This attribution gives a hint on the reaction time during a flood event. The reaction time is an important input parameter to plan adequate emergency measures.

Evaluate your region's landform. With this information and the following table you can estimate a landform specific reaction time. Note that this is only a basic estimation. Eventually refer to the information in "RAINMAN Tool Assessment and Mapping - Expert Corner". Document your assumptions and estimations in Form B1.1.

Landform		*Run-off and discharge dynamics*		*Reaction time*
mountainous	→	*very high*	→	*very short*
hilly	→	*high*	→	*short*
lowland	→	*low*	→	*long*

Input: *Landform (H2.T2)*

Output: *Estimated reaction time ⇨ M2.T3*

1.3. Creation of documents (H3)

After reviewing the existing hazard maps and necessary input data for setting up an emergency response plan, this process steps aim to prepare all the data and maps in a way to be implemented in the final plan. The quality of the existing data (H2.T1) needs to be considered throughout the whole process. All detailed process steps are carried out already giving thought to the following planning of measures.

Mark the significant critical hazard points/areas in the hazard map. — **Task H3.T1**

Hazards in the context of heavy rain induced flooding are typically described by parameters of the flood water in terms of (spatially differentiated/explicit) water level, inundation duration, flow velocity and direction as well as sediment load, flowing debris and released contaminants (Sauer et al. 2019).

Within these areas, specific points might be present where critical hazards exist. This could be culverts or bridges, where – if blocked – run-off could be redirected, or areas where a significant amount of run-off is generated. Also the sewer system needs to be considered here. Inlets can get blocked during heavy rain events, eventually certain points tend to overflow frequently.

Take the hazard map and mark all those points or areas where the hazard situation might get critical. Consider the quality/complexity of the data the hazard map was created with (with data complexity level 1, you might not be able to give a reliable assumption of certain critical hazard points). Also, consider the collection of hazard points you created in H1.Q1 and H1.Q4.

Input: *Hazard map (-)*
Collection of hazard points/areas (H1.Q2, H1.Q4)
Information on related hazards (river floods, sewer system) (H1.Q4)
Overall hazard data complexity (H2.T1)

Output: *Working map: hazard ⇨ H3.T4, V3.T1*

Additionally mark points in the hazard map where hazard observations might be useful. **Task H3.T2**

Observations during the hazard process are important not only to set adequate measures at the right time during the observed events, but also to gain knowledge for future events and the adaption of your emergency response plans. Observations can be carried out on points near the sources or flowpaths where the hazard is most likely visible.

Take the map you edited in step H3.T1 and add points where hazard observations might be useful. These points should mark locations for the observation of critical hazard points. They must not be endangered themselves in order to guarantee safety for the observers.

Input:	*Significant critical hazard points (Working map: hazard H3.D1)*
Output:	*Working map: hazard ⇨ H3.T4, V3.T1*

Describe the significant critical hazard points/areas in Form B1.2. **Task H3.T3**

In order to document all your findings of the previous steps (H3.T1 and H3.T2) a list should additionally be created where all the information is written down.

Take Form B1.2 from "Part B - Templates" and describe all your findings. This will help you to get a good overview about your critical hazard points/areas.

Input:	*Working map: hazard (H3.D1)*
Output:	*Table: critical hazard areas ⇨ H3.T4, V3.T1*

If possible, analyse past heavy rainfall events and figure out which events may cause damage. **Task H3.T4**

Heavy rain induced floods tend to be events with very little reaction time from the beginning of the rainfall until flooding happens. In future process steps you are asked to develop a warning and alarm tool which should help you assessing the expected events intensity. These intensity estimations are to facilitate the decision which measures need to be set. This warning and alarm tool will be based on different parameters affecting the intensity of a critical damage event. These parameters are:

- Rainfall intensity (mm/h)
- Ground sealing in the affected area
- Temperature (if snow is prevalent)
- Vegetation
- Current soil moisture content

According to your hazard maps and observed past events, analyse under which conditions a heavy rainfall event may become a critical damage event. Consider the parameter defined above.

Input:	*Working map: hazard (H3.D1)* *Table: critical hazard areas (H3.D2)* *Availability and quality of precipitation forecast (H1.Q1)* *Past flood events (H1.Q1)*
Output:	*Critical damage scenarios, parameter settings ⇨ M3.T2*

Working Map: Hazard	Map H3.D1

The output of Task H3.T1 and H3.T2 is the "Working Map: Hazard". If you know how to use GIS Software, you might digitize your results. Otherwise keeping your results on a paper map is sufficient.

Table: Critical Hazard Areas	Document H3.D2

The output of Task H3.T3 is the "Table: Critical Hazard Areas" with a detailed description of hazard points.

1.4. Stakeholder (H4)

Stakeholders are people who are relevant to be included in the process because they:

- *need to be included by legal reasons*
- *are vital for planning and applying of measures*
- *have additional knowledge (e.g. of the local situation)*
- *collaborated in similar projects*
- *can provide useful connections*
- *can enhance or block the process*
- *represent the public*
- *represent a particularly vulnerable part of the public (e.g. people with special needs, children)*

Often, relevant stakeholders are representatives of the public administration, politics or NGOs. Sometimes it might even be useful to include directly affected citizens.

The following table gives an overview about potential stakeholders for the hazard analysis.

Stakeholders	Function	Competences/Input	Level
Users of the emergency response plan			
Regional government	Head of operations	Regional knowledge, experiences	Regional
Local government, mayor	Head of operations	Local knowledge, experiences	Local
Local/Regional Crisis unit	Support of operational head	Local knowledge, experiences	Regional/Local
Emergency organisations	Fire brigade, police, rescue service	Local knowledge, experiences	Regional/Local
Technical input			
Water management	Technical Input	Local and regional knowledge, technical knowledge regarding hydrology, hydraulics, precipitation data	Regional
Local experts	Technical Input	Local knowledge, experiences, past/historical events	Local

Stakeholders	Function	Competences/Input	Level
Connections			
Emergency response units	Technical Input, Nationwide coordination	Knowledge of planning and applying of measures	Nationwide/Regional
Public			
Citizens, interested people, affected persons	Potentially affected, volunteers	self-provisioning, participation at exercises	Local

Another considerable group is the common public, which can also be included in the participation process. Nevertheless, the public needs to be at least informed about the results of your planning process (M4.S3).

A checklist on the stakeholder participation as part of the hazard analysis (Form B2.1 in "Part B – Templates") shall help you to consider all important process steps. In order to document the identification process of the relevant stakeholders, Form B2.4 from "Part B – Templates" can be used.

To make sure that all the relevant stakeholders were invited, it might be useful to evaluate the entry list after the first stakeholder meeting.

Further meetings with key stakeholders are possible as well.

Stakeholder Workshop: Hazard — **Stakeholder H4.S1**

In order to review the current hazard situation and all your available data and maps, local knowledge regarding the hazard processes is indispensable. Stakeholders should be included from the beginning. In order to be well prepared for the first workshop it is essential to deal with the existing hazard data as well as with the basic concept of this toolkit (i.e. what steps are planned to build up an emergency response plan, what is the structure of an emergency response plan), before the stakeholder workshop is held.

The following bullet points give information about how the stakeholder workshop can be organised:

- Inform

  In the first part of the workshop, the participants are informed about:

  - The purpose of the emergency plan
  - The planned steps to build up the emergency plan
  - Expectations on the participants (i.e. what should be worked out together)
  - Relevant hazard process depicted in the existing hazard map
  - Which scenarios are shown in the hazard map

- Discuss & Participate

  After the informational part, the stakeholders are invited to:

  - Bring in their knowledge following the questions concerning the current situation
  - Review the modelled scenarios in the existing hazard maps and identify critical hazard points/areas
  - Make suggestions on potential hazard observation points
  - Name persons who may have additional useful knowledge

Prepare the stakeholder workshop

Review all the existing material and make yourself confident with the planning process. Identify the entire relevant stakeholders using the table above and document the relevant stakeholders in Form B2.4. Use Form B2.1 as a checklist.

Host the stakeholder workshop

Host a meeting/workshop where stakeholders are informed about your planning process. Furthermore all the questions concerning the current situation as well as suggestions for potential hazard observation points shall be discussed. For the procedure of the workshop refer to the above list. All the feedback of the stakeholders shall be documented (Form B2.5 from "Part B - Templates").

Follow-up processing

After the workshop was held, sort out all the relevant feedback and document it in Form B1.1. Use Form B2.1 as a checklist. If it turns out that it might be useful to discuss additional topics within a smaller group, further meetings with key stakeholders are possible.

2. Vulnerability Analysis - Review

The vulnerability analysis is the second basic step in the emergency response planning process. In this review of the vulnerability analysis, the existing risk maps should be analysed.

Vulnerability in the sense of emergency planning means the vulnerability of an object or subject to a hazard. Vulnerability is a complex and dynamic characteristic of a receptor describing its susceptibility to the negative consequences of a hazard (Sauer et al. 2019). The vulnerability of an object, in combination with the hazard of flooding or the probability of occurrence of a hazard scenario, results in the risk.

The goals of reviewing the vulnerability analysis are to know if all the region's vulnerable objects have been evaluated, to determine a prioritisation of your region's critical infrastructure and to be able to classify the quality/complexity of the existing vulnerability data.

At the end of the vulnerability analysis, the user will:

- know the quality of the vulnerability data,
- know the project region's vulnerable objects,
- have a prioritisation of the region's critical infrastructure,
- know the region's critical risk points/areas.

VULNERABILITY ANALYSIS - Review				Template
Review current situation				
	Review all your existing vulnerability data and risk maps. If no risk map is available, create one following the *"RAINMAN Tool Assessment and Mapping"*.	Task	V1.T1	B1.1
Receptors				
	What kind of data (spatial planning, census, surveys) was used to locate the receptors?	Question	V1.Q1	B1.1
Consequences				
	What kind of data concerning the consequences was used creating the risk map?	Question	V1.Q2	B1.1
	Where are the critical points/areas with high damage potential?	Question	V1.Q3	B1.2
Data quality and area characteristics				
	Evaluate the vulnerability data complexity.	Task	V2.T1	B1.1
	Evaluate your region's focus area and resources.	Task	V2.T2	B1.1

VULNERABILITY ANALYSIS - Review				Template
Creation of documents				
	Take the "Working Map: Hazard" and the risk map. Define where significant damage may occur.	Task	V3.T1	-
	Additionally mark points where intervention measures might be useful.	Task	V3.T2	-
	Describe and prioritise the significant critical risk points/areas in Form B1.2.	Task	V3.T3	B1.2
	Working Map: Risk	Map	V3.D1	-
	Table: Critical Risk Areas	Document	V3.D2	-
Stakeholder				
	Stakeholder Workshop: Vulnerability	Stakeholder	V4.S1	B1.1 B2.2 B2.4 B2.5

2.1. Review current situation (V1)

In order to evaluate the data availability and quality of the vulnerability data, the current situation shall be reviewed. All available maps and data shall be re-analysed considering that this information will be used for the planning of measures.

Review all your existing vulnerability data and risk maps. If no risk map is available, create one following the "RAINMAN Tool Assessment and Mapping" — **Question V1.T1**

This toolkit implies that risk maps are already available. Hence, the first process step is to review all the existing data and maps. All further tasks are based on the existing data and maps. If no risk map is available, one should be created following advises in *"RAINMAN Tool Assessment and Mapping"*.

Evaluate which maps are available. Document or list your findings in Form B1.1.

Receptors

Receptors are the objects and subjects (e.g. people, property and environment) exposed to a hazard and potentially susceptible to damages and negative consequences. The vulnerability of a receptor can be modified by increasing its resilience to flooding.

This process step aims to verify the availability and quality of data, with which the receptors were displayed and located in existing risk maps.

What kind of data (spatial planning, census, surveys) was used to locate the receptors? — **Question V1.Q1**

To know about the vulnerable structures in your region it is important to consider all available data concerning the localisation of potentially exposed subjects or objects. The spatial planning data includes information about all plots in the area (location, extent, type of use). Further, census data might have been used as well as additional surveys.

Evaluate which data was used creating the risk map. The focus is on the localisation of the receptors. The following list should give you an idea of what data may be

available. For detailed classification see the recommendations in "RAINMAN Tool Assessment and Mapping - Expert Corner". Use Form B1.1 for documentation.

- Spatial planning data (zoning, cadastre, usage of buildings)
- Census data (information on the number of persons in the household, immobile persons)
- Data on traffic areas
- Additional surveys carried out as part of risk mapping

	Level 1	Level 2	Level 3
Receptors Data Complexity	*Analog data and local knowledge*	*-*	*Detailed digital data*

Input:	*Risk map (V1.T1)* *Local knowledge Stakeholders (V4.S1)*
Output:	*Summary and analysis of data used for risk maps ⇨ V2.T1*

Consequences

The term consequence comprises the negative effects such as economic (e.g. damaged property), social (e.g. loss of life, injuries, loss of cultural assets) or environmental (e.g. contamination of soil / water) damages that may result from the exposure of a receptor to a hazard (Samuels and Gouldby 2009). It can be expressed quantitatively (e.g. monetary value), by category (e.g. high medium, low) or descriptively.

Regarding the consequences, the current situation review aims to find out about damage related information and problems on infrastructural objects, people, agricultural and forestry land and the environment, in the endangered areas. Furthermore a prioritisation of the vulnerable objects shall be defined.

What kind of data concerning the consequences was used creating the risk map? **Question V1.Q2**

In addition to the knowledge about the receptors in your regions flood-prone areas (V1.Q1), further damage related information on the identified structures (e.g. object type, basements, underground car parking and hazardous goods) is of great interest. A minimal requirement for further planning is the knowledge on the object type (residential building, industrial and business buildings, outbuilding etc.) of the receptors.

Evaluate which data was used creating the risk map. Use the following example table to estimate what you already know about damage potential in your region and of which data complexity the existing information is. For detailed classification see the recommendations in "RAINMAN Tool Assessment and Mapping - Expert Corner". Use Form B1.1 for documentation.

	Level 1	Level 2	Level 3
Structure Data Complexity	*At least information on object type, no details on building construction and no information on water levels and flow velocity*	*Either some details on building construction or information on water levels and flow velocity*	*Details on building construction and information on water levels and flow velocity*

	Level 1	Level 2	Level 3
Damage assessment	*Description based on observations*	*Categories based on damage assessment with or without the use of water levels / flow velocities*	*Quantitative results by the use of damage functions based on water levels and flow velocities*

In case there is no available information on the object type of the identified structures, revise and adapt the risk map following the "RAINMAN Tool Assessment and Mapping" (process step V1.T1).

If the quality of the data, which was used for creating the risk map, is rather low, it could be improved by undertaking an additional risk survey. This seems particularly useful if the hazard data complexity is high (Level 3) and the vulnerability data complexity is low (Level1).

The following information can be collected as part of an additional risk survey (Use Form B3.1 from "Part B - Templates" to document the additional risk analysis):

- *Type of risk (e.g. to people, to property, functional failure, hazardous to water)*
- *Water entering the building (e.g. cellar window, floor height on the ground floor, backwater from the sewer, unsealed pipe outlets)*
- *People and equipment at risk of flooding (e.g. people in the basement or ground floor, electrical installations)*
- *Flood protection measures (e.g. object-specific operational plan, mobile flood protection, flood protection system, evacuation plan)*

Reasons why an additional survey makes sense:

- *Knowing, where the expected damage is the highest*
- *More details about which measures can be implemented*

Input:	*Risk map (V1.T1)* *Local knowledge Stakeholders (V4.S1)*
Output:	*Summary and analysis of data used for risk maps ⇨ V2.T1*

Where are the critical points/areas with high damage potential? **Question V1.Q3**

Damage can occur to infrastructural objects, to people, to agricultural and forestry land or to the environment. The negative effects and damages can vary widely depending on the detailed design of the objects. For example, a street underpass is probably not affected by an increased water level in its structure, but the presence of people can still lead to a critical risk situation. Hence, it is important to know, whether there are any specific problems regarding the vulnerable structures in your region.

Compile a list all of specific problems in your region regarding negative effects and damages. This may include, for example, basements, oil-fired heating, street underpasses, underground car parking, places with large crowds, etc. Document your findings in Form B1.2.

Input:	*Risk map (V1.T1)* *Local knowledge Stakeholders (V4.S1)*
Output:	*Collection of points/areas with negative effects ⇨ V3.T1*

2.2. Data quality and area characteristics (V2)

After reviewing the current situation, this process step works like a filter to filter out the relevant vulnerability points/areas. The existing and/or collected data have a certain quality/complexity. In order to be able to take further steps in the toolkit, it is essential to classify the quality/complexity of the data situation in your region. In addition, the area characteristic plays an essential role in the planning of measures.

Evaluate the vulnerability data complexity. **Task V2.T1**

In the previous steps, levels of complexity were assigned to the available data and information (V1.Q1, V1.Q2). In each previous step the levels of complexity was assigned. Based on these principles, an expert assessment of the comprehensive complexity level should be carried out.

Assess the complexity level of the vulnerability data. Use all previous classifications and information, which were assembled in the phase of reviewing the current situation. The classification should be done based on an expert assessment. Refer to the information shown in "RAINMAN Tool Assessment and Mapping - Expert Corner". If you vary between two levels, choose the lower level. Document the assumptions you made and the level you chose in Form B1.1.

	Level 1	*Level 2*	*Level 3*
Vulnerability Data Complexity			

Input: *Summary and analysis of data used for risk maps (Data complexity V1.Q1, V1.Q2)*

Output: *Overall vulnerability data complexity ⇨ M2.T1*

Evaluate your region's focus area and resources. **Task V2.T2**

The type of project area (rural, semi-urban and urban) often has a direct impact on the availability of resources for action during heavy rainfall events. However, other criteria may also limit or enhance the resource availability.

Arrange the availability of resources of your area - to set actions during heavy rainfall events - into a category. Document all the reasons you found limiting or enhancing your resources. This will be essential for further planning of detailed measures. Eventually refer to the information in "RAINMAN Tool Assessment and Mapping - Expert Corner". Document your assumptions and estimations in Form B1.1.

Focus area		*Resources*
rural	→	*low*
semi-urban	→	*medium*
urban	→	*high*

Input: *Focus area (V2.T2)*

Output: *Estimated resources availability ⇨ M1.Q4*

2.3. Creation of documents (V3)

After reviewing the existing risk maps and vulnerability data necessary for setting up an emergency response plan, this process steps aim to prepare all the data and maps in a way to be implemented in the final plan. The quality of the existing data (V2.T1) needs to be considered throughout the whole process. All detailed process steps are carried out, already giving thought to the following planning of measures.

Take the "Working Map: Hazard" and the risk map. Define where significant damage may occur. **Task V3.T1**

The vulnerability of an object in combination with the hazard of flooding or the probability of occurrence of a hazard scenario results in the risk. In Task H3.T1 critical hazard points/areas were evaluated. Within these areas, specific points might be present where significant damage may occur. This could be all areas with a high damage potential to people or the environment (schools, retirement homes, hospitals, buildings of public administration, infrastructure for communication and energy supply, train stations, etc.)

Take the risk map and mark all those points or areas where the risk situation might get critical. You can use the "Working Map: Hazard" for additional information on the hazard situation. Consider the quality/complexity of the data, the hazard map was created with (with data complexity level 1, you might not be able to give a reliable assumption of certain critical risk points).

Input:	*Working Map: Hazard (H3.D1)* *Risk map (V1.T1)* *Collection of points/areas with negative effects (V1.Q3)* *Overall hazard data complexity (H2.T1)* *Overall vulnerability data complexity (V2.T1)*
Output:	*Working Map: Risk ⇨ M3.T4, M3.T5*

Additionally mark points where intervention measures might be useful. **Task V3.T2**

After knowing the critical hazard scenarios and critical risk point/areas, the first intervention measures can be considered. In future process steps these ideas will be evaluated according to their practicability.

Take the map you edited in step V3.T1 and add points where intervention measures might be useful. In this early stage all potential places should be considered regardless of how likely you are capable of applying these measures.

Input:	*Points / areas with critical risk situation (Working Map: Risk V3.D1)*
Output:	*Working Map: Risk ⇨ M3.T4, M3.T5*

Describe and prioritise the significant critical risk points/areas in Form B1.2. **Task V3.T3**

In order to document all your findings of the previous steps (V3.T1 and V3.T2) a list should additionally be created where all the information is written down.

Heavy rain events are often events that are characterised by a short early warning time and can vary widely in local extension. In order to be able to set purposeful emergency measures during heavy rain events, it is important to prioritise the vulnerable object in your region.

Take Form B1.1 from "Part B - Templates" and describe all your findings. This will help you to get a good overview about your critical risk points/areas.

Make a priority list of the vulnerable objects in your region. Always consider the basic prioritisation:

1. *Human health and life*
2. *Environment*
3. *Cultural heritage*
4. *Economic activity*

Input:	*Working Map: risk (V3.D1)*
Output:	*Table: critical risk areas ⇨ M3.T4, M3.T5*

Working Map: Risk **Document V3.D1**

The output of Task V3.T1 and V3.T2 is the "Working Map: Risk". If you know how to use GIS Software, you might digitize your results. Otherwise keeping your results on a paper map is sufficient.

Table: Critical Risk Areas **Document V3.D2**

The output of Task V3.T3 is the "Table: Critical Risk Areas".

2.4. Stakeholder (V4)

Stakeholders are people who are relevant to be included in the process because they:

- *need to be included by legal reasons*
- *are vital for planning and applying of measures*
- *have additional knowledge (e.g. of the local situation)*
- *collaborated in similar projects*
- *can provide useful connections*
- *can enhance or block the process*
- *represent the public*
- *represent a particularly vulnerable part of the public (e.g. people with special needs, children)*

Often, relevant stakeholders are representatives of the public administration, politics or NGOs. Sometimes it might even be useful to include directly affected citizens.

The following table gives an overview about potential stakeholders for the vulnerability analysis.

Stakeholders	Function	Competences/Input	Level
Users of the emergency response plan			
Regional government	Head of operations	Regional knowledge, experiences	Regional
Local government, mayor	Head of operations	Local knowledge, experiences	Local
Local/Regional Crisis unit	Support of operational head	Local knowledge, experiences	Regional/Local
Emergency organisations	Fire brigade, police, rescue service	Local knowledge, experiences	Regional/Local

Stakeholders	Function	Competences/Input	Level
Technical input			
Operator of critical infrastructure	Technical Input	Local knowledge: electricity and gas supply, fresh water supply and waste water removal, road network, critical infrastructure	Regional/Local
Local experts	Technical Input	Local knowledge, experiences, past/historical events	Local
Connections			
Emergency response units	Technical Input, Nationwide coordination	Knowledge of planning and applying of measures	Nationwide/Regional
Public			
Citizens, interested people, affected persons	Potentially affected, volunteers	self-provisioning, participation at exercises	Local

Another considerable group is the common public, which can also be included in the participation process. Nevertheless the public needs to be at least informed about the results of your planning process (M4.S3).

A checklist on the stakeholder participation as part of the vulnerability analysis (Form B2.2 in "Part B – Templates") shall help you to consider all important process steps. In order to document the identification process of the relevant stakeholders, Form B2.4 from "Part B – Templates" can be used.

To make sure that all the relevant stakeholders were invited, it might be useful to evaluate the entry list after the first stakeholder meeting.

Further meetings with key stakeholders are also possible.

Stakeholder Workshop: Vulnerability **Stakeholder V4.S1**

In order to review the current vulnerability situation and all your available data and maps, local knowledge regarding the vulnerable objects and critical infrastructure is indispensable. Most of the stakeholders were already included in the Stakeholder Workshop: Hazard. Stakeholders who take part for the first time are operators of critical infrastructure and local experts concerning technical information on the vulnerability of exposed structures. In order to be well prepared for the workshop it is essential to deal with the existing vulnerability data as well as with the basic concept of this toolkit (i.e. what steps are planned to build up an emergency plan, what is the structure of an emergency plan), before the stakeholder workshop is held.

The following bullet points give information about how the stakeholder workshop can be organised.

- Inform

  In the first part of the workshop, the participants are informed about:

  - The purpose of the emergency plan
  - The planned steps to build up the emergency plan
  - Expectations on the participants (i.e. what should be worked out together)

- Relevant vulnerability data depicted in the existing risk map
- What kind of damage potential is shown in the existing risk map

- Discuss & Participate

  After the informational part, the stakeholders are invited to:

  - Bring in their knowledge following the questions concerning the current situation
  - Review the content of the existing risk maps and identify critical points/areas with high damage potential
  - Make suggestions where intervention measures might be useful
  - Name persons who may have additional useful knowledge

Prepare the stakeholder workshop

Review all the existing material and make yourself confident with the planning process. Identify the entire relevant stakeholders using the table above and document the relevant stakeholders in Form B2.4. Use Form B2.2 as a checklist.

Host the stakeholder workshop

Host a meeting/workshop where stakeholders are informed about your planning process. Furthermore all the questions concerning the current vulnerability situation as well as points/areas with high damage potential and suggestions on intervention measures shall be discussed. For the procedure of the workshop refer to the above list. All the feedback of the stakeholders shall be documented (Form B2.5 from "Part B – Templates").

Follow-up processing

After the workshop was held, sort out all the relevant feedback and document it in Form B1.1. Use Form B2.2 as a checklist. If it turns out that it might be useful to discuss additional topics within a smaller group, further meetings with key stakeholders are possible.

3. Measures

The third and last basic step in the emergency response planning process is the development of suitable measures. It is one of the overall goals of this toolkit to develop measures in order to minimize damages caused by heavy rainfall events. Damages can be reduced either by minimizing the vulnerability of the receptors or by altering the hazard process itself.

As floods caused by heavy rainfall tend to be events with a very short warning time, measures working during the event need to be accurately planned and well-coordinated. It might be difficult to fulfil all the prerequisites necessary to apply certain measures during heavy rainfall events (e.g. the quality of the forecast data is not good enough to install a highly sophisticated warning and alarm system in order to set up road barriers within a specific time). Hence the measure concept should also include measures concerning mid or long term structural changes or information and awareness raising for citizens.

The goal of the measure planning step is to develop a scenario specific action plan which will be part of the emergency response plan for heavy rain risks. In order to create such a plan, it is necessary to be aware of certain facts applying in your region, like legal responsibility or available resources for setting up measures. Additionally, it has to be considered that all relevant players need to be informed about what to do during flood events.

At the end of this step the user will:

- know how to minimize risks and damages, before, during or after a heavy rainfall event,
- know the responsibilities (legally and actively) for emergency measures during extreme events in your region,
- know the available resources for setting up emergency measures,
- know that higher authorities are aware of the measures,
- know that all relevant stakeholders are informed about the measures,
- know that local citizens are aware of the measures they are affected by and
- know who applies and adapts the measures.

MEASURES				Template
Review current situation				
?	Are there already emergency response plans available, concerning any kind of risks?	Question	M1.Q1	B1.1
?	Who is legally responsible for emergency measures during extreme events?	Question	M1.Q2	B1.1
?	Who are the relevant players for emergency response planning and applying and adapting of emergency measures?	Question	M1.Q3	B1.1
?	What resources do you have available for emergency measures during extreme events?	Question	M1.Q4	B1.1
Data quality and area characteristics				
✎	Evaluate the risk map complexity.	Task	M2.T1	B1.1
✎	Resources (estimated in V2.T2)	Task	M2.T2	B1.1
✎	Reaction time (estimated in H2.T2)	Task	M2.T3	B1.1
✎	Evaluate your obtainable action plan complexity.	Task	M2.T4	B1.1

MEASURES				Template
Creation of documents				
	Define responsibilities.	Task	M3.T1	B1.1 B6
	Develop a simple warning and alarm tool to assess the expected event intensity	Task	M3.T2	B4.1 B6
	Plan communication channels during an event.	Task	M3.T3	B1.1 B6
	Define general measures. Focus particularly on your designated critical points/areas.	Task	M3.T4	Chapter 5.1
	OPTION: Plan additional measures depending on risk map complexity, available resources and reaction time. Focus particularly on your designated critical points/areas.	Task	M3.T5	Chapter 5.1
	Action Plan	Document	M3.D1	Chapter 5.1 B6
	Fill out the final Emergency Response Plan	Task	M3.T6	B6 and B7
Stakeholder				
	Meeting Key Stakeholders: Resources (optional)	Stakeholder	M4.S1	B2.5
	Stakeholder Workshop: Measures	Stakeholder	M4.S2	B1.1 B2.3 B2.4 B2.5
	Present the finalised action plan/emergency response plan to citizens	Stakeholder	M4.S3	B2.3

3.1. Review current situation (M1)

Are there already emergency response plans available, concerning any kind of risks? **Question M1.Q1**

Already existing emergency response plans might help you get familiar with the most important basics for emergency response planning in your region. Eventually these documents already deal with legal responsibility for planning, applying and adapting of emergency response measures. It might also be already organised who sets up measures actively during a heavy rainfall event (e.g. fire brigade, operators of critical infrastructure, etc.). The most useful information will be found in emergency response plans concerning river floods. Depending on availability, other plans could be useful as well.

> *Evaluate which plans are already available and review them. Particularly focus on legal matters and legal responsibilities as well as how emergency operations are already organised. If plans concerning river floods are already available, you might also revise the detailed measures presented there. Document your findings in Form B1.1. You might again need that information when you are going to fill out the final emergency response plan (*M3.T6*).*

Who is legally responsible for emergency measures during extreme events? — Question M1.Q2

Often, it is regulated by law who is legally responsible for planning, applying and adapting emergency measures during extreme events. These responsible persons can be for instance the mayor, the regional government, local crisis units or sometimes even emergency organisations who are in charge for certain measures. Existing documents dealing with emergency response planning can give a hint on where to find these regulates.

In the end your emergency response plan should clearly state who bears the legal responsibility, who is the operational head of emergency operations and who sets specific measures. In "Part B – Templates" you find a template for an emergency response plan (Supplement B6).

> *Evaluate all documents available dealing with responsibilities for emergency operation during extreme natural hazards (existing emergency response plans, specific laws). Eventually you will need help by higher authorities (regional government, etc.). Use Form B1.1 for documentation.*

Who are the relevant players for emergency response planning and applying and adapting of emergency measures? — Question M1.Q3

Beside the legal facts, a number of other players are relevant for emergency response planning and applying and adapting of emergency measures. These can be – in addition to those legally responsible – emergency organisations (fire brigade, rescue service, police), local crisis units or operators of critical infrastructure. Sometimes – especially during flash flood events with very short warning time - it might be useful, that those players who are setting up measures during emergency operation can decide independently.

> *Identify the relevant players in your region for emergency response planning and applying and adapting of measures. Talk about what they can decide independently or what has to be advised by the operational head. Use Form B1.1 for documentation.*

What resources do you have available for emergency measures during extreme events? — Question M1.Q4

Based on the estimated resources availability (V2.T2) a detailed evaluation of the available resources should be carried out. Resources for emergency measures can be people or material necessary for setting up measures. It is further important to know where these resources are located in relation to potential emergency sites.

As already said before, heavy rainfall events tend to be events with very short warning time. Hence a good knowledge of the availability and the localisation of your resources is indispensable, to set up your measures in a well-coordinated manner. Local knowledge might be useful for this step.

> *Evaluate which resources you have available for emergency measures during extreme events. Document your findings in Form B1.1. Optionally you can host a meeting with key stakeholders (M4.S1).*

Input:	*Estimated resources availability hazard (V2.T2)* *Local knowledge (M4.S1)*
Output:	*Detailed knowledge of available resources ⇨ M2.T2*

3.2. Data quality and area characteristics (M2)

After reviewing the current situation, this process step works like a decision-making tool to find out which complexity of action plan is obtainable in your region. All the existing and/or collected data from previous steps (hazard analysis and vulnerability analysis) have a certain quality/complexity. The classification of quality/complexity of the data situation makes it possible to determine which complexity of action plan in reachable. In addition, the available resources and scenario specific reaction time have to be considered.

Evaluate the risk map complexity. **Task M2.T1**

The risk map is the combination of the hazard map and the vulnerability map. The risk of damage to certain receptors can be assessed with different criteria describing the hazard situation (e.g. water level and flow velocity) and the vulnerability of objects (e.g. prioritisation, damage potential). This toolkit implies that risk maps are already available. In previous process steps these existing maps where reviewed and the data complexity regarding the single documents was assessed. This process steps aims to finally assess the complexity of the risk map.

Assess the complexity level of the risk map. Use all previous classifications and information, which were assembled in the hazard analysis (H2.T1) and the vulnerability analysis (V2.T1). The classification should be done based on an expert assessment. Refer to the information shown in "RAINMAN Tool Assessment and Mapping - Expert Corner". If you vary between two levels, choose the lower level. Document the assumptions you made and the level you chose in Form B1.1.

	Level 1	*Level 2*	*Level 3*
Risk Map Complexity			

Input: *Overall hazard data complexity (H2.T1)*
Overall vulnerability data complexity (V2.T1)

Output: *Overall risk map complexity ⇨ M2.T4*

Resources (estimated in V2.T2) **Task M2.T2**

Setting up measures during natural hazard scenarios is also a matter of the available resources. The better your available resources, the better the chance to set up process related measures. If your resource availability is low, consider that measures working on mid or long term structural changes, information and awareness raising of citizens may be more suitable in your region's action plan.

Concerning the detailed knowledge of your resource availability (M1.Q4), try to assign your region to one of the following levels. Consider that this is only a basic assumption which will give you guidance to choose how detailed your action plan could be. Document the assumptions you made and the level you chose in Form B1.1.

Resources
low
medium
high

Input: *Detailed knowledge of available resources (M1.Q4)*

Output: *Level of resource availability ⇨ M2.T4, M3.T5*

Reaction time (estimated in H2.T2) — Task M2.T3

The scenario specific reaction time plays an important role to decide which measures are possible to implement during the heavy rain event. If the critical events in your region tend to have a very short warning time, it might not be possible to reach the emergency site in time. The warning time depends also on the quality of available precipitation forecast.

Based on the information you have on past scenarios, on the estimated reaction time in H2.T2 and the quality of the available precipitation forecast, try to assign your region to one of the following levels. Consider that this is only a basic assumption which will give you guidance to choose how detailed your action plan could be. Document the assumptions you made and the level you chose in Form B1.1.

Reaction time
very short
short
long

Input: *Past flood events (H1.Q1)*
Availability and quality of precipitation forecast (H1.Q1)
Estimated reaction time ⇨ M2.T3

Output: *Level of reaction time ⇨ M2.T4, M3.T5*

Evaluate your obtainable action plan complexity. — Task M2.T4

The previous analysis, concerning the risk map complexity (M2.T1), the resource availability (M2.T2) and the reaction time (M2.T3) shall now be brought together in order estimate the obtainable complexity of action plan in your region. The **complex version** requires a detailed knowledge of the hazard scenario, precise and early heavy rain warning and a good knowledge of the quantity and the localisation of resources. A **basic action plan** may be more feasible in some cases. It includes measures regarding mid or long term structural changes, observation, information and awareness raising. The basic action plan will also help you reduce risks caused by heavy rainfall events and provides you with a good foundation for emergency interventions.

Based on the information you worked out in the steps M2.T1, M2.T2 and M2.T3, try to assign your region to one of the following levels. Consider that this is only a basic assumption which will give you guidance to determine how detailed your action plan could be. Document the assumptions you made and the level you chose in Form B1.1.

	Level "BASIC"	*Level "COMPLEX"*
Action Plan Complexity (obtainable)		

Input: *Overall risk map complexity (M2.T1)*
Level of resource availability (M2.T2)
Level of reaction time (M2.T3)

Output: *Obtainable action plan complexity ⇨ M3.T4, M3.T5*

3.3. Creation of documents (M3)

After all the existing data was reviewed and analysed according to its quality/complexity, in this step the final action plans shall be created. Eventually you have different critical heavy rainfall scenarios defined in your hazard analysis (e.g. flash flood scenarios or long lasting pluvial flooding). If so, for each of these scenarios one action plan (basic or complex) needs to be developed, as intervention measures might differ between the scenarios. Also the intervention maps need to be created for each scenario. If only one heavy rainfall scenario is prevalent in your region, or the vast majority of problems is sufficiently depicted in a single scenario, one action plan (basic or complex) as well as one set of intervention maps is adequate.

Following which data is available, which resources you can rely on and the scenario specific reaction time, different complexity of action plans are possible.

In the last step the final emergency response plan should be filled out with all the information collected in previous steps.

Define responsibilities. **Task M3.T1**

The first part of preliminary remarks in the final emergency response plan deals with responsibilities. In addition, for every single measure a responsible person has to be determined. This is important, because during an emergency operation it has to be clear who gives instructions and who bears the legal responsibility.

> *In M1.Q2 and M1.Q3 you already worked out who bears the legal responsibility for emergency measures in your region and who are the relevant players for implementing the emergency measures. In step* M3.T6 *this information should be brought in the emergency plan document (see template emergency plan (Supplement* B6*) in "Part B-Templates"). Also define at least the operational head. Use Form B1.1 for documentation.*

Input:	*Legal responsibilities and relevant players in your region (M1.Q2, M1.Q3)*
Output:	*Emergency control ⇨ M3.T3* *Responsibilities in the emergency response plan ⇨ M3.T6*

Develop a simple warning and alarm tool, to assess the expected event intensity. **Task M3.T2**

In order to get an approximation, which measures make sense to be set during heavy rainfall events, a simple tool which helps you to assess the expected event intensity should be developed. The intensity of a heavy rainfall event is not only characterised by the amount of precipitation. Many other parameters must be taken into account as well. For example, a certain amount of precipitation may not always lead to the same run-off situation. During summer, when vegetation cover is high and the soil moisture content is low, a large fraction of precipitation can be stored on ground or in the soil and hence does not immediately contribute to run-off. Whilst in winter when snow is prevalent, additional precipitation in form of rain may enhance the snowmelt and therefore even worsen the run-off situation.

The suggested warning and alarm tool asks for different estimations concerning some of the most critical parameters which affect the run-off situation. It should be applied always, when a heavy rainfall event is predicted. In order to facilitate the estimation process, it might be useful to frequently collect data regarding the soil moisture content (fairly simple with a timeline of past rainfall events or more sophisticated using measurement data).

> *To develop such a tool, use the template table from PART B - Templates. Here especially the scale value for low and high rainfall intensity should be set accordingly. This is why you were asked to analyse the critical damage scenarios in your region (H3.T4).*

To estimate the magnitude of the event, after you received a heavy rain forecast, the following questions shall be answered:

1) What is the maximum predicted intensity of the event? (In mm/h)

2) What is the fraction of sealed surfaces in the area of the expected maximum precipitation?

3) In case of cold conditions/snow: What is the predicted temperature? Will there be additional run-off from snowmelt? Will the precipitation fall as snow and hence not contribute immediately to run-off?

4) What is the current vegetation cover, especially on agricultural land and in forests?

5) How would you assess the current soil moisture content? Have there been previous precipitation events?

Using the classification in the following example table, the expected magnitude of the event can thus be estimated. Blue letters show an example for those parts which need to be filled out for every predicted heavy rainfall event.

Parameter	Current value	Scale
Rainfall intensity	*40 mm/h*	low – medium – high
Ground sealing	*medium*	low – medium – high
Temperature (if snow is prevalent)	*no snow (to be dropped)*	low (precipitation in form of snow) – high (snowmelt)
Vegetation	*medium - hardly any (late autumn)*	much – hardly any
Soil saturation	*low - medium*	low – medium – high
Expected event intensity	*medium*	low – medium – high

If forecasts are not available, you can either develop an alternative warning and alarm concept (e.g. based on observers at critical points), or the measures in your action plan should be mainly focused on mid or long term structural changes, observations, information and awareness raising of citizens.

Input:	*Availability and quality of precipitation forecast (H1.Q1)* *Critical damage scenarios, parameter settings (H3.T4)* *Template B4.1 from PART B - Templates*
Output:	*Warning and alarm tool ⇨ M3.T4, M3.T5, M3.D1, M3.T6*

Plan communication channels during an event. — Task M3.T3

During heavy rainfall events, communication has to be direct and clear to ensure that the measures are set in a well-coordinated manner.

Define who informs whom and where all the information is gathered (i.e. the operational head). In step M3.T6 this information should be brought in the emergency plan document (Supplement B6). Use Form B1.1 for documentation.

Input:	*Emergency control (M3.T1)*
Output:	*Communication channels in the emergency response plan ⇨ M3.T6*

Define general measures. Focus particularly on your designated critical points/areas. — **Task M3.T4**

In this step general measures in order to reduce risks caused by heavy rainfall events should be developed. These measures focus mainly on mid or long term structural changes, observation, information and awareness raising of citizens. These measures are also possible to implement in the emergency response plan even if it was not possible to develop a detailed warning and alarm system.

Using the example-catalogue of measures (see chapter 5.1), plan "general measures" to reduce heavy rain risks. The suitability of measures in the example-catalogue of measures is assessed based on reaction time and resources. In step M3.T6 this information should be brought in the emergency plan document (Supplement B6). Use Form B1.1 for documentation.

Input:	*Working Map: Risk (V3.T1)* *Table: critical risk areas (V3.D2)* *Warning and alarm tool (M3.T2)* *Obtainable action plan complexity (M2.T4)*
Output:	*Action Plan ⇨ M3.D1*

OPTION: Plan additional measures depending on the risk map complexity, available resources and reaction time. Focus particularly on your designated critical points/areas. — **Task M3.T5**

Have you been able to develop a detailed warning and alarm system? Do you have detailed knowledge about the hazard process and the localisation and the characteristics of the endangered objects? Your resource and reaction time situation allows considering detailed measures? If this is the case, you can plan additional measures from the example-catalogue of measures. These measures are process related (e.g. road barriers or evacuation zones) and can refer to the individual expected magnitudes of the event and thus be set according to the result of the event's intensity estimation (warning and alarm tool).

Using the example-catalogue of measures (see chapter 5.1), plan "additional measures" to reduce heavy rain risks. The suitability of measures in the example-catalogue of measures is assessed based on reaction time and resources. In step M3.T6 this information should be brought in the emergency plan document (Supplement B6*). Use Form B1.1 for documentation.*

Input:	*Working Map: Risk (V3.D1)* *Table: critical risk areas (V3.D2)* *Warning and alarm tool (M3.T2)* *Obtainable action plan complexity (M2.T4)*
Output:	*Action Plan ⇨ M3.D1*

Action Plan — **Document M3.D1**

The output of Task M3.T4 or M3.T5 is the "Action Plan" (Supplement B6, Chapter Action Plan). One action plan consists of general measures and optionally additional measures. The measures are described in detailed tables and locally shown on intervention maps (Supplement B7). Hence, it is also necessary to create maps where your intervention measures are located. This can either be done by hand on a base map or by using GIS software. For the layout of the map, refer to Supplement B7.

In the action plan you can (if possible) note the expected event's magnitude for which the individual measures are to be set. This allows you to carry out a detailed selection of measures in individual cases based on precipitation forecasts and the expected event intensity (result of the warning and alarm tool).

If more than one heavy rain scenario is expected in your area that is fundamentally different from the others (e.g. flash floods and long-lasting continuous rain), further, separate action plans and emergency maps are required.

Fill out the final Emergency Response Plan **Task M3.T6**

The action plan(s) together with preliminary remarks (i.e. legal responsibility, description of the area, the potential scenarios, the hazard and vulnerable object), with your existing hazard and risk maps and the intervention maps forms your final emergency response plan (ERP). In the supplements (B6 and B7) you can see examples of how the different parts may look like.

The final emergency plan should consist at least of:

- Preliminary remarks (also possible with references to existing plans)
  - Purpose of the emergency response plan
  - Legal responsibility (M3.T1)
  - Geographical scope of the emergency response plan
  - Structure of the action plan
  - Communication channels (M3.T3)
  - Warning and alarm concept (M3.T2)
  - Description of the hazard situation, potential scenarios and vulnerable objects (H3.D1, H3.D2, V3.D1, V3.D2)
- The action plan itself (M3.D1)
- Maps showing the emergency measures (Intervention Maps, B7)
- Hazard maps
- Risk maps

All the information collected in previous steps (M2.T1, M2.T2, M2.T3) shall now be transferred to the final emergency response plan (Supplement B6*).*

3.4. Stakeholder (M4)

Stakeholders are people who are relevant to be included in the process because they:

- *need to be included by legal reasons*
- *are vital for planning and applying of measures*
- *have additional knowledge (e.g. of the local situation)*
- *collaborated in similar projects*
- *can provide useful connections*
- *can enhance or block the process*
- *represent the public*
- *represent a particularly vulnerable part of the public (e.g. people with special needs, children)*

Often, relevant stakeholders are representatives of the public administration, politics or NGOs. Sometimes it might even be useful to include directly affected citizens.

The following table gives an overview about potential stakeholders.

Stakeholders	Function	Competences/Input	Level
Users of the emergency response plan			
Regional government	Head of operations	Regional knowledge, experiences	Regional
Local government, mayor	Head of operations	Local knowledge, experiences	Local
Local/Regional Crisis unit	Support of operational head	Local knowledge, experiences	Regional/Local
Emergency organisations	Fire brigade, police, rescue service	Local knowledge, experiences	Regional/Local
Technical input			
Operator of critical infrastructure	Technical Input	Local knowledge: electricity and gas supply, fresh water supply and waste water removal, road network, critical infrastructure	Regional/Local
Local experts	Technical Input	Local knowledge, experiences, past/historical events	Local
Connections			
Emergency response units	Technical Input, Nationwide coordination	Knowledge of planning and applying of measures	Nationwide/Regional
Public			
Citizens, interested people, affected persons	Potentially affected, volunteers	self-provisioning, participation at exercises	Local

Another considerable group is the common public, which can also be included in the participation process. Nevertheless the public needs to be at least informed about the results of your planning process (M4.S3).

A checklist on the stakeholder participation as part of the planning of measures (Form B2.3 in "Part B – Templates") shall help you to consider all important process steps. In order to document the identification process of the relevant stakeholders, Form B2.4 from "Part B – Templates" can be used.

To make sure that all the relevant stakeholders were invited it might be useful to evaluate the entry list after the first stakeholder meeting.

Further meetings with key stakeholders are also possible.

Meeting Key Stakeholders: Resources (optional) — **Stakeholder M4.S1**

As resources are a highly interesting topic to implement certain measures and the knowledge concerning the quantity and the localisation of available resources might be spread through different organisations in your region, a meeting with key stakeholders can optionally be held.

> *Host a meeting with the key players for setting up emergency measures (e.g. emergency organisations, operators of critical infrastructure, local crisis units). Work*

through what they are capable to do in an emergency operation during a heavy rainfall event. A meeting protocol can be found in B2.5.

Stakeholder Workshop: Measures **Stakeholder M4.S2**

In order to properly develop an action plan which is coordinated between all the responsible persons, local knowledge is indispensable. All of the stakeholders were already included in the Stakeholder Workshop: Hazard or in the Stakeholder Workshop: Vulnerability.

The following bullet points give information about how the stakeholder workshop can be organised.

- Inform

  In the first part of the workshop, the participants are going to be informed about:

  - The purpose of the emergency plan
  - The planned steps to build up the emergency plan
  - Expectations on the participants (i.e. what should be worked out together)
  - The legal and operational responsibilities
  - The planned warning and alarm system
  - The planned measures

- Discuss & Participate

  After the informational part, the stakeholders are invited to:

  - Critically review the warning and alarm system
  - Critically review the planned measures
  - Make suggestions how the intervention measures shall be implemented
  - Name people who may have additional useful knowledge

Prepare the stakeholder workshop

Review all the existing material and make yourself confident with the planning process. Identify the entire relevant stakeholders using the table above and document the relevant stakeholders in Form B2.4. Use Form B2.3 as a checklist.

Host the stakeholder workshop

Host a meeting/workshop where stakeholders are informed about your planning process. Furthermore all the questions concerning the detailed measure planning shall be discussed. For the procedure of the workshop refer to the above list. All the feedback of the stakeholders shall be documented (Form B2.5 from "Part B - Templates").

Follow-up processing

After the workshop was held, sort out all the relevant feedback and document it in Form B1.1. Use Form B2.3 as a checklist. If it turns out that it might be useful to discuss additional topics within a smaller group, further meetings with key stakeholders are possible.

Present the finalised action plan/emergency response plan to citizens

Stakeholder M4.S3

After the emergency response plan is finalised, it should be presented to the public. This can be done with an informative event, where the whole local public is invited. The structure of this event can be similar to the information part in the stakeholder workshops.

The following bullet points can give guidance about what could be presented:

- The purpose and the aim of creating an emergency response plan
- A selection of relevant scenarios (start with scenarios showing a lower level of hazard, as extreme scenarios might seem unrealistic to the broad public)
- A selection of areas where significant damage may occur
- The measures you developed in order to reduce the risks for the areas shown before

Certain scenarios can also be shown in nature to a selected group of affected citizens.

Host an informative event where your finalised action plan / emergency response plan is presented to the interested public. Use Form B2.3 as checklist for the preparation.

4. References

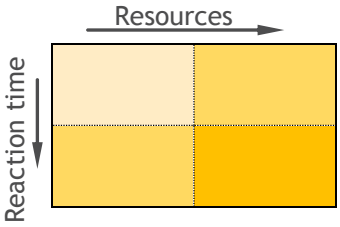
Samuels, P.; Gouldby, B. (2009): Language of Risk–Project Definitions. Edited by FloodSite Consortium (T32-04-01). Available online at http://www.floodsite.net/html/partner_area/project_docs/T32_04_01_FLOODsite_Language_of_Risk_D32_2_v5_2_P1.pdf.

Sauer, Axel; Olfert, Alfred; Körte, Lisa; Neubert, Marco; Ortlepp, Regine (2019): DT1.2.1 Joint Definitions and Analytical Framework. Edited by Interreg Project RAINMAN.

5. Annex

5.1. Example measures

In the following chapter a catalogue of example measures will be presented. Further, the purpose of all the measures is generally described. Each measure will be assessed according to its **suitability** for certain resources and reaction time conditions. Therefore the following matrix is applied. Each field in the matrix represents a certain combination of required resources and the scenario specific reaction time. Resources and reaction time are increasing from left to right and from top to bottom, meaning the lower right field indicates a high resource demand and a long reaction time.



The suitability of each measure for all the resources/reaction time combinations is then assessed using the following signs.

◦◦◦◦	Very suitable
◦◦◦	Suitable
◦◦	Little suitable
◦	Poorly suitable

In addition, next to the **general** and the **additional measures** a triggering state is given. This provides a recommendation when certain measures should be applied following the expected event intensity of your warning and alarm tool, developed in M3.T2. For example, measure *"G1"* should be applied every time you receive any kind of heavy rain warning, irrelevant of the expected event intensity. The other **general measures** are mainly to be triggered if at least a medium intensity event is expected (indicated by the brown colour). The **additional measures** may only to be triggered if a rather extreme event is predicted (indicated by the red colour). Detailed triggering states may vary depending on local conditions. Hence, a further check depending on your region's characteristics is necessary.

> Example:
>
> You want to implement the measure *"G2 Establish the operation control"* in your action plan. First, consider the reaction time of your rainfall scenarios on which this measure shall work on. If the scenario specific reaction time is long, this measure is suitable or very suitable, if the scenario specific reaction time is rather short, this measure is little or poorly suitable. In combination with your available resources to implement this measure, you will get a hint on the overall suitability of it. If your resource availability is high and the scenario specific reaction time is long, the measure *"G2 Establish the operation control"* is very suitable for your action plan. The triggering state states that this measure should be executed if at least a medium intensity event is expected.

Note:

Keep in mind that these measure assessments only provide a basic estimation which measures are suitable in which cases and when to trigger them.

No.	Category	Measure	Triggering state	Suitability
PREVENTIONAL MEASURES (P)				
P1		Consider areas where changes in building structure may improve/worsen the run-off situation		○○○○ ○○○○ ○○○○ ○○○○
P2		Information and awareness raising events for affected citizens		○○○○ ○○○○ ○○○○ ○○○○
P3		Support for self-provisioning of affected citizens		○○○○ ○○○○ ○○○○ ○○○○
P4		Training for the citizen observatory concept		○○○ ○○○○ ○○○ ○○○○
P5		Regularly check your resources and your material necessary for your measures		○○ ○○○○ ○○○ ○○○○
GENERAL MEASURES (G)				**PLAN 1**
G1		Receive and assess the heavy rain forecast/warning		○○○○ ○○○○ ○○○○ ○○○○
G2		Establish the operation control		○ ○○ ○○○ ○○○○
G3		Inform relevant persons in charge		○○ ○○○ ○○○ ○○○○
G4		Inform affected citizens		○○○ ○○○ ○○○○ ○○○○
G5		Hazard Observation / Citizen observatory		○○○ ○○○ ○○○○ ○○○○
G6		Check the available/needed resources for an emergency intervention		○○ ○○○ ○○○○ ○○○○
ADDITIONAL MEASURES (A)				**PLAN 2**
A1		Set up road/pathway barriers		○ ○○ ○○○ ○○○○

No.	Category	Measure	Triggering state	Suitability	
A2		Evacuate the endangered area		○	○
				○○○	○○○
A3		Traffic management		○	○
				○○○	○○○○
A4		Protect endangered objects		○○	○○○
				○○○	○○○○
A5		Remove hazardous/vulnerable goods		○○	○○○
				○○○	○○○○
A6		Remove hazardous situations		○○	○○○
				○○○	○○○○

Legend:

 Preparation / Mitigation

 Organisation

 Observation

 Information

 Closure

 Evacuation

 Protect objects

 Remove goods

 Remove hazard

P1	PREVENTIONAL MEASURES	

CONSIDER AREAS WHERE CHANGES IN BUILDING STRUCTURE MAY IMPROVE/WORSEN THE RUN-OFF SITUATION

Responsible for the measure (recommendation): *Local authorities*

Structural changes can improve or worsen the run-off situation. Hence it is useful that areas where the run-off situation can be positively or negatively affected are kept in mind for all future planning processes. A map or database of these areas might be useful.

P2	PREVENTIONAL MEASURES	

INFORMATION AND AWARENESS RAISING EVENTS FOR AFFECTED CITIZENS

Responsible for the measure (recommendation): *Local authorities*

As heavy rainfall events tend to be events with only a short warning time, it is highly important that affected citizens are aware of how their property is endangered. This measure can include regular informational events, where modelled hazard scenarios are presented.

P3	PREVENTIONAL MEASURES	

SUPPORT FOR SELF-PROVISIONING OF AFFECTED CITIZENS

Responsible for the measure (recommendation): *Local authorities*

Like Example Measure P2, this measure shall prepare the affected citizens for to heavy rainfall events. Here you could plan measures, where affected citizens are directly informed by experts about what they can do in detail to minimize risks for their property.

P4	PREVENTIONAL MEASURES	

TRAINING FOR THE CITIZEN OBSERVATORY CONCEPT

Responsible for the measure (recommendation): *Local authorities*

Following a definition by the European Commission, citizen observatory describes a community-based environmental monitoring, data collection, interpretation and information delivery system, generally based on mobile devices (smartphones, tablets, etc.). Communities should be empowered with the capability to monitor and report on their environment and enabled to access the information they need to make decisions in an understandable and readily usable form.

To implement a citizen observatory system in your region, any form of web-based application needs to be provided. In order to guarantee that the information you obtain by citizens is reliable, training for a specific peer group should be planned.

P5	PREVENTIONAL MEASURES	

REGULARLY CHECK YOUR RESOURCES AND YOUR MATERIAL NECESSARY FOR YOUR MEASURES

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

All the resources needed for emergency interventions need to be checked on a regular basis. They need to be checked not only for availability but also for functionality. The resources to be checked can be mobile flood protection barriers, pumps, road or pathway barriers, etc.

Here you can list what needs to be checked, by whom, when, and where to document it. An additional overview map of all the locations where material is stored, as well as detailed photographs of the exact position might be useful.

A	*Describe here which material needs to be checked (Location A).*
B	*Describe here which material needs to be checked (Location B).*

G1	GENERAL MEASURES	
	RECEIVE AND ASSESS THE HEAVY RAIN FORECAST/WARNING	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
Depending on the developed warning and alarm system and the available forecast data, any information about an upcoming heavy rainfall event will be delivered. This will trigger the detailed action plan and has thus to be documented.		

G2	GENERAL MEASURES	
	ESTABLISH THE OPERATION CONTROL	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
When a heavy rainfall event, reaching a certain triggering state, is forecasted, an operation control should be built-up. *The head of the operation control gives instructions about when and where the measures need to be set. He or she needs to be informed about every step. Consider the legal responsibilities when the operational head is established.*		
A	*Name the operational head (e.g. mayor).*	
B	*List further persons who should be members of the operation control.*	

G3	GENERAL MEASURES	
	INFORM RELEVANT PERSONS IN CHARGE	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
After a heavy rain warning was received, persons who are relevant for further actions need to be immediately informed. All the communications must be documented accordingly.		
A	*Describe here who needs to be informed (Person A).*	
B	*Describe here who needs to be informed (Person B).*	

G4	GENERAL MEASURES	

INFORM AFFECTED CITIZENS

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

After a heavy rain warning was received, affected citizens need to be informed. It is important to point out an impending flood and the resulting preparatory measures.

- *Information on the size of the expected scenario (based on the meteorological forecasts)*
- *Information about imminent restrictions (road or pathway barriers, etc.)*
- *More information as needed*

All communication has to be documented accordingly.

G5	GENERAL MEASURES	

HAZARD OBSERVATION / CITIZEN OBSERVATORY

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

Hazard observations are not only important for the ongoing emergency interventions but also to properly document the event. This can deliver important data for adapting your emergency response plan. Observation can be carried out by inspectional trips to the observation points developed in H3.T2.

Further, the citizen observatory concept can be used here. If you provided any kind of web based application and trained a specific peer-group accordingly, this can deliver useful information for future adaption of measures.

In the following list you can describe the observation points. Also provide an overview map where to find them. All inspections and observation need to be documented accordingly. Form B1.1 can be used here.

A	*Describe the relevant observation points here (Point A).*
B	*Describe the relevant observation points here (Point B).*

G6	GENERAL MEASURES	

CHECK THE AVAILABLE/NEEDED RESOURCES FOR AN EMERGENCY INTERVENTION

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

If additional measures with high resource requirements have been planned, it might be useful to quickly check if all the resources are available. Anyway, if you followed the preparative measures, this should have been done prior to a heavy rainfall event.

A1	ADDITIONAL MEASURES	
	SET UP ROAD/PATHWAY BARRIERS	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
It may be useful to install barriers on specific streets or pathways, in order to avoid people entering the endangered area. *List the points were barriers are to be set up and by whom. Additionally provide a map where the road/pathway barriers are located.*		
A	*Describe the road /pathway barriers (Location A)*	
B	*Describe the road /pathway barriers (Location B)*	

A2	ADDITIONAL MEASURES	
	EVACUATE THE ENDANGERED AREA	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
If inundation lasts longer than just a few hours or affects objects with highly vulnerable persons, evacuation may be useful. *List the evacuation zones by priority. Additionally provide an estimated number of persons to be evacuated. Evacuation zones should be additionally shown in the intervention map.*		
A	*Evacuation zone A (No. of persons (mobile/immobile))*	
B	*Evacuation zone B (No. of persons(mobile/immobile))*	

A3	ADDITIONAL MEASURES	
	TRAFFIC MANAGEMENT	
Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*		
During flash flood events, significant amounts of water can run-off above roads. Although they may still seem safe to pass, dangerous situations might develop rapidly. Hence, traffic management measures in order to regulate the traffic on certain roads might be useful. *List here the locations where traffic management is useful. Additionally provide an overview map.*		
A	*Location for traffic management A*	
B	*Location for traffic management B*	

A4	ADDITIONAL MEASURES	

PROTECT ENDANGERED OBJECTS

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

For certain objects, specific object related protection measures shall be built up. Describe in this measures where, when and by whom these measures are set.

List all locations where object related protection measures shall be built up. Prioritise them if your resources are limited. Additionally provide an overview map of the locations.

A	*Object related protection measure A*
B	*Object related protection measure B*

A5	ADDITIONAL MEASURES	

REMOVE HAZARDOUS/VULNERABLE GOODS

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

In some objects, hazardous or highly vulnerable goods may be stored. This measure is to plan the removal of such goods.

List all locations where hazardous or vulnerable goods shall be removed. Prioritise them if your resources are limited. Additionally provide an overview map of the locations.

A	*Describe location of hazardous/vulnerable good A*
B	*Describe location of hazardous/vulnerable good B*

A6	ADDITIONAL MEASURES	

REMOVE HAZARDOUS SITUATIONS

Responsible for the measure (recommendation): *Local authorities or emergency organisations or crisis units*

In some areas critical hazardous situations (like log jams) may develop during a heavy rainfall event. In order to avoid the occurrence of backwater above log jams, this measure can be planned. This shall only be carried out using appropriate devices and only if safety for the operator is guaranteed.

List here where critical log jams may occur. Inspect those points frequently during an emergency operation. Additionally provide an overview map.

A	*Critical log jam A*
B	*Critical log jam B*

EMERGENCY RESPONSE PLANNING FOR HEAVY RAIN RISKS

PART A – RECOMMENDATIONS AND MANUAL

Supplement A1: Process Workflow - Flowchart

HAZARD ANALYSIS - Review

- To know the quality of your hazard data
- To know the critically endangered areas
- To know about scenarios endangering your region
  e.g. flash floods, pluvial flooding

Review all your existing hazard data and maps. If no hazard map is available, create one following the *"RAINMAN Tool Assessment and Mapping"*

H1.T1

H4.S1

SOURCES
origin, cause of hazard

What kind of precipitation/ hydrological data was used creating the hazard map? What do you know about past scenarios? Which forecast data is available in your region?

H1.Q1

Where are the critical hazard points/areas in your region regarding run-off generation?

H1.Q2

PATHWAYS
route, flow paths

What kind of hydraulic data was used creating the hazard map?

H1.Q3

Where are the critical hazard points/areas in your region regarding flow paths? Also consider river floods and/or problems with the sewer system.

H1.Q4

REVIEW CURRENT SITUATION

DATA QUALITY, AREA CHARACTERISTICS

Hazard Data Complexity

Level 1
Level 2
Level 3

H2.T1

Landform
mountainous
hilly
lowland

Reaction time
very short
short
long

H2.T2

CREATION OF DOCUMENTS

Mark the significant critical hazard points/areas in the hazard map.

H3.T1

Additionally mark points in the hazard map where hazard observations might be useful.

H3.T2

H3.D1

WORKING MAP: HAZARD

Describe the significant critical hazard points/areas in Form B1.2.

H3.T3

H3.D2

TABLE: CRITICAL HAZARD AREAS

If possible, analyse past heavy rainfall events and figure out which events may cause damage.

H3.T4

VULNERABILITY ANALYSIS – Review

- To know the quality of your vulnerability data
- To know all of your region's vulnerable objects (at least in the endangered area)
- To have a prioritisation of your region's critical infrastructure

Review all your existing vulnerability data and risk maps. If no risk map is availble, create one following the *"RAINMAN Tool Assessment and Mapping"*

V1.T1

V4.S1

RECEPTORS
exposed subjects and objects

What kind of data (spatial planning, census, surveys) was used to locate the receptors?

V1.Q1

CONSEQUENCES
negative effects and damages

What kind of data concerning the consequences was used creating the risk map?

V1.Q2

Where are the critical points/areas with high damage potential?

V1.Q3

Vulnerability Data Complexity

Level 1
Level 2
Level 3

V2.T1

Focus area
rural
semi-urban
urban

Resources
low
medium
high

V2.T2

Take the "working map: hazard" and the risk map. Define where significant damage may occur.

V3.T1

Additionally mark points where intervention measures might be useful.

V3.T2

V3.D1

WORKING MAP: RISK

Describe and prioritise the significant critical risk points/areas in Form B1.2.

V3.T3

V3.D2

TABLE: CRITICAL RISK AREAS

MEASURES

- To know how to minimize risks
- To know the responsibilities for emergency measures during extreme events in your region
- To know your available resources
- To know that higher authorities are aware of your measures
- To know that all relevant stakeholders are informed about your measures
- To know that local citizens know about the measures they are affected by
- To know who applies and adapts the measures

Are there already emergency response plans available, concerning any kind of risks?

M1.Q1

Who is legally responsible for emergency measures during extreme events?

M1.Q2

Who are the relevant players for emergency response planning, applying and adapting of emergency measures?

M1.Q3

M4.S1

What resources do you have available for emergency measures during extreme events?

M1.Q4

Risk Map Complexity	Resources	Reaction time
Level 1	low	very short
Level 2	medium	short
Level 3	high	long

M2.T1 M2.T2 M2.T3

Action Plan Complexity (obtainable)

Level "BASIC" | Level "COMPLEX"

M2.T4

M4.S2

Define responsiblities.

M3.T1

Develop a simple warning and alarm tool, to assess the expected event intensity.

M3.T2

Plan communication channels during an event.

M3.T3

Define general measures. Focus particularly on your designated critical points/areas.

M3.T4

"COMPLEX"

OPTION: Plan additional measures depending on the risk map complexity, available resources and reaction time. Focus particularly on your designated critical points/areas.

M3.T5

"BASIC"

M3.D1

ACTION PLAN

M4.S3

Fill out the final Emergency Response Plan.

M3.T6

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RAINMAN
European Union
European Regional Development Fund

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