

D1.1 – Real World Labs description and setup

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Report overview

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Executive summary

This deliverable provides an overview of the Real-World Labs (RWLs) established in different European regions for disaster risk management (DRM) and climate change adaptation (CCA), with focus on the stakeholder landscape, CCA and DRM challenges and setup process.

Each RWL aims to address different challenges posed by climate change in its specific context and enhance resilience in the Study Area here identified and described.

The report begins with an introduction, providing the background and context of the RWLs. It outlines the significance of DRM and CCA in mitigating climate-related risks and improving disaster preparedness.

The RWL setup section is the core of the report and presents detailed information about each RWL. It covers four regions: the Capital Region of Denmark, Emilia-Romagna Region in Italy, the Danube Region (including Vienna, Austria; Budapest, Zala County, Hungary; Zala Region, Hungary; and Belgrade, Serbia), and the Rhine-Erft Region in Germany, and is structured in the following sections.

For each RWL, the Study Area Definition and Stakeholder Landscape Analysis sections describe the geographical boundaries and characteristics (e.g., soil use and climatic conditions etc.), and involved stakeholders (including roles, responsibilities/influence in hazard governance and relations between them). The framing of CCA and DRM in each RWL section highlights observed climate change impacts and extreme events. It describes climate-related hazards in the study areas and identifies past recent events/experiences in CCA and DRR, furthermore it outlines the challenges faced in adapting to climate change impacts and reducing disaster risks and summarizes stakeholder expectations and improvements over the status quo.

The RWL setup Process sections discuss the steps taken to initiate the RWLs, engage stakeholders (formally and informally to accommodate the heterogeneous landscape of organization involved), and analyses achievements and gaps in DRM and CCA. These processes are essential for improving communication, understanding among stakeholders, and enhancing existing governance structures.

Finally, RWL's Next Steps section outlines the plans for future actions, including summarizing results from stakeholder meetings, developing guidelines, conducting training sessions, and improving stakeholder's panel.

A recap of the key findings from this RWL setup activities is provided in the conclusions, together with a brief overview of the incoming activities that ground on this setup phase.

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List of Abbreviations

ACRONYM	DEFINITION
CCA	CLIMATE CHANGE ADAPTATION
DMP	DATA MANAGEMENT PLAN
DRM	DISASTER RISK MANAGEMENT
DRR	DISASTER RISK REDUCTION
FAIR	FINDABLE, ACCESSIBLE, INTEROPERABLE AND REUSABLE
FPC	FLOOD PROTECTION CORPORATION
RWL	REAL WORLD LAB
WP	WORK PACKAGE
DTU	DANMARKS TEKNISKE UNIVERSITET
REGIONH	THE CAPITAL REGION OF DENMARK
DRB	DANUBE RIVER BASIN
VVÖ	ASSOCIATION OF INSURANCE COMPANIES
FPC	INTER MUNICIPAL FLOOD PROTECTION CORPORATION

1. Introduction

1.1 Background and context of the RWLs

Real World Labs (RWLs) play a crucial role in the implementation and assessment of the multi-risk governance mechanisms proposed by the DIRECTED project. These labs serve as focal points for the expected impacts of the project and for monitoring the effectiveness of the proposed multi-risk governance mechanisms. The aim of RWLs setup is to create the collaborative environment for learning and innovation where DIRECTED will deploy and review its co-development process with engaged stakeholders. The aim is to shift perceptions from single risk to multi-risk thinking across the disaster risk management (DRM), disaster risk reduction (DRR), and climate change adaptation (CCA) cycle. By exploring synergies and trade-offs, the RWLs will improve strategic decision-making at various timescales and geographic resolutions.

The four RWLs represent different European regions and climate change hotspots, address real-life cases, and cater to the needs of first and second responders, including authorities, citizens, volunteers, and business sectors. Each RWL is led by an accountable practice partner who acts as the lab manager and is a stakeholder.

Hereafter, we provide a summary of each RWL background, the involved stakeholders and the challenges to face and a general overview map to localize them.

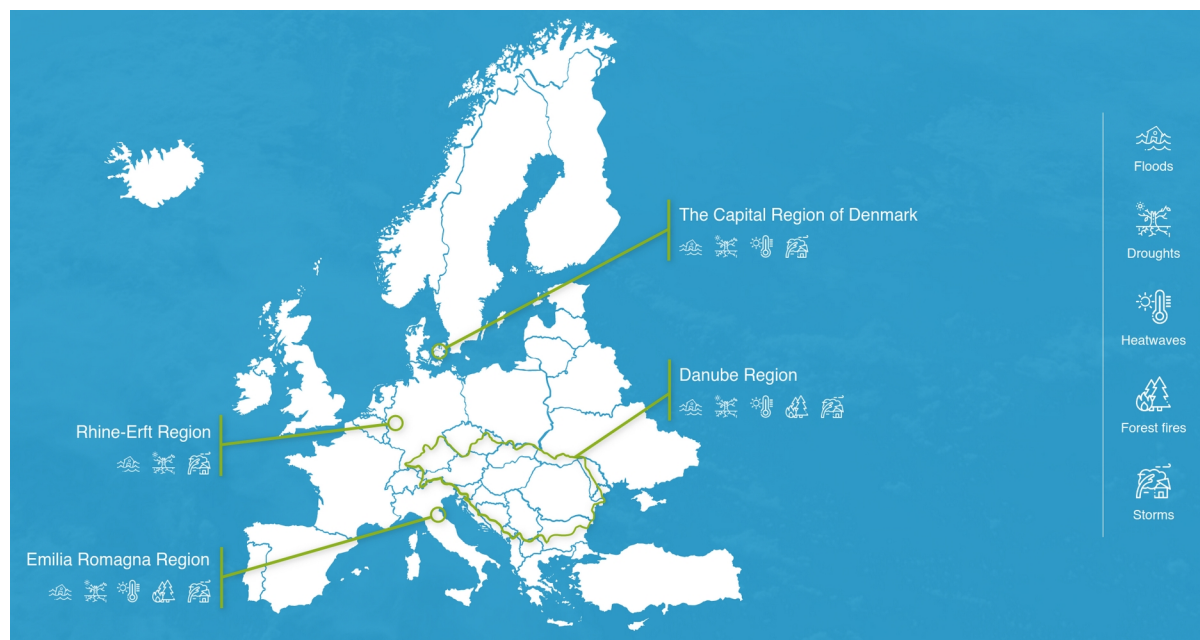


Figure 1: Overview map of the DIRECTED Real World Labs

RWL1 – The Capital Region of Denmark faces significant flood damage potential due to climate change, characterized by modified rainfall patterns and increased cloudbursts. Challenges include governance and policy integration, coordination across municipal boundaries, and varying levels of risk governance and preparedness. The RWL aims to co-innovate governance strategies and decision-support methodologies for integrated risk reduction and climate adaptation. A particular focus of RWL1 lies on the catchment of Værebros River and Roskilde Fjord in Denmark, relevant for their coastal and river coverage, experience with flooding, and governance perspective. The Værebros River catchment poses significant fluvial flooding problems for residents and farmers, while Roskilde Fjord coastal cities are susceptible to storm surges and increased pluvial flooding. The stakeholders involved include municipalities, emergency managements, national agencies, and the regional government with identified challenges to work on initially ranging from data alignment and lack of knowledge of risk awareness and citizens communication, to ‘retreat’ considerations, timeliness, and event impacts.

RWL2 – The Emilia-Romagna Region deals with multiple natural hazards, including extreme rainfall events, coastal flooding and erosion, and wildfires.

The RWL led by the Civil Protection of the Emilia-Romagna Region (ARSTPC-ER) and the regional environmental agency ARPAE, focuses on two study areas along the Rimini Province coastline and the municipalities of Comacchio e Mesola (province of Ferrara). The Rimini coast is densely urbanized, with a strong tourist presence and vulnerability to marine ingress, erosion, windstorms, and heavy rains. Comacchio and Mesola, located in the Po Delta, face wildfire risks due to a forest area (Bosco Mesola) located nearby a high density residential and touristic location and road traffic area. Stakeholders include regional and municipal governments, protected areas, and essential service providers (multi-utility company), with interests and responsibilities in CCA and DRR at various levels.

Challenges include improving coordination between various first responders, enhancing early warning systems based on forecasts, and pre-emptive damage assessment tools. The RWL aims to develop and improve DRR and CCA tools and models, raise awareness about the importance of interoperability, and support medium and long-term prevention measures.

RWL3 – The Danube Region: The Danube River Basin covers more than 800,000 square kilometres—10% of mainland Europe—and extends over the territory of 19 countries. This makes it the most international river basin in the world. About 79 million people live in this basin, many of whom depend on the Danube as a source of drinking water, energy production, agriculture, and transportation. Its ecological diversity, from plant and animal species to critical habitats, is also highly valued. Floods and droughts are natural phenomena. They shape natural landscapes, create new habitats and are impossible to prevent entirely, although measures may be taken to reduce their frequency and the damage they cause. Through the centuries, the Danube countries suffered from many disastrous flood events. The most significant among these is the 1501 flood on the upper Danube, considered to be the largest summer flood of the last millennium, causing extensive devastation down to Vienna.

Changing land use in rural and urban areas can also exacerbate the effects of flooding. It is desirable to reduce the adverse impacts of flooding, particularly on human health and life, the environment, cultural heritage, economic activity, and infrastructure. In addition to these human-induced interventions, climate change has a significant impact on the peak discharge of the Danube and its tributaries. The distribution of heavy rainfall events and droughts no longer follows long-term patterns but is becoming more uneven distributed and extreme. The impacts are most severe where natural floodplains are forced into artificial levees and where houses and industrial facilities have been built in areas that are naturally floodplains. However, flood and drought risk reduction measures should be coordinated not only in areas where riverbeds and courses are being reconfigured, but throughout the river basin to create synergies among institutions that can affect water flow and thus influence not only the severity of floods, but also of droughts.

Due to the sheer size of the Danube River Basin and the associated very heterogeneous stages of development with respect to CCA and DRM, Vienna was identified as a region with the most advanced CCA and DRM due to its long history of active disaster management and was chosen as the main test site for detailed investigation within the DIRECTED Project.

Other test sites that will help to reflect the heterogeneity within the DRB are the Zala Region in Hungary and Belgrade in Serbia.

RWL4 – The Rhine-Erft Region

Is in North Rhine-Westphalia, Germany. Currently, the focus is on the districts of Euskirchen and Rhein-Erft, comprising 21 municipalities. The RWL area can be divided into the northern part, which is characterized by agriculture and lignite mining and the forested and agricultural southern part, all part of the ~1,900 km² Erft river catchment.

Currently, the stakeholders comprise different departments on district level, responsible for DRM and CCA (e.g., department of rescue, fire and civil protection and technical environment protection). Further, experts on flood risk management strategies and technical flood protection are part of the group of stakeholders in RWL4. Due to the responsibilities defined in German law, the districts were contacted first and the expansion to the municipal level is due to/will follow/is in progress.

Challenges encompass climate change impacts, with rising temperatures and more frequent and extreme heavy rain events, which can cause devastating floods as in 2021. But drought will also be a significant risk in the future. Integrating climate projections into flood risk management is essential. Risk awareness and communication also require improvement from stakeholder side to e.g., better warn and inform the population and coordinate responses.

To address these challenges, RWL4 aims to create an integrated risk management strategy, enhance understanding of climate change's impact on extreme events as floods, foster communication among stakeholders, and identify concrete measures for hazard prevention and resilience building. A comprehensive approach with involvement from diverse stakeholders, experts, and organizations is sought to tackle the complex CAA and DRM challenges in this region.

2. The RWL Setup

2.1 RWL1 – The Capital

Region of Denmark

RWL1 is led by The Capital Region of Denmark (REGIONH) which is a regional public institution together with Technical University Denmark (DTU) who is a research partner in DIRECTED.

2.1.1 RWL Study Area Definition and Stakeholder Landscape Analysis

RWL1 has defined two primary study areas which are the catchment of Værebros River and Roskilde Fjord. The two areas have been chosen due to several factors; firstly, because they cover both coast and river, and because they have experienced significant flooding events. In these areas the emergency management agencies cover either one or several municipalities which makes this context quite interesting from a governance perspective.

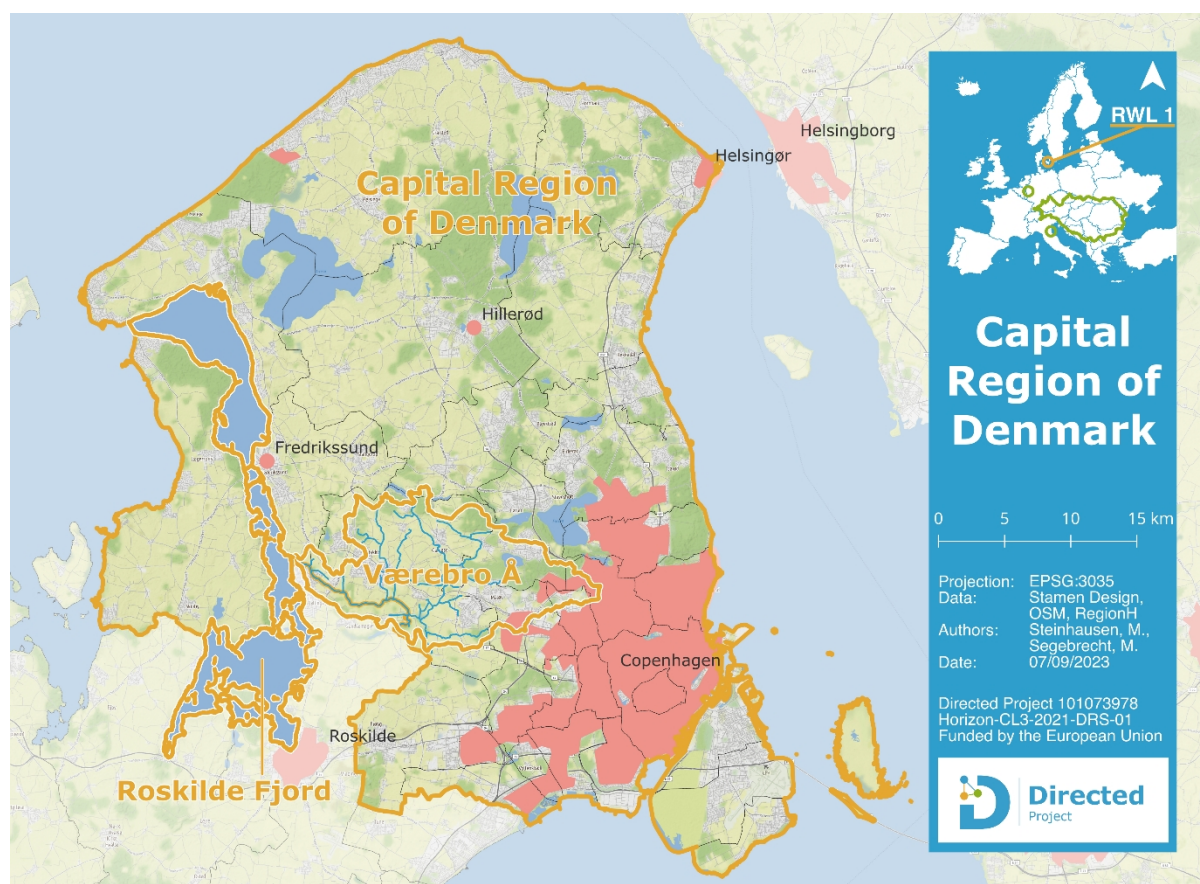


Figure 2: Overview map of the Real World Lab 1 – The Capital Region of Denmark

Værebros Å (river): The catchment of Værebros Å covers an area of 153 km² and the mainstream is 35 km long, making it one of the longest rivers in the Capital Region of Denmark. The river system consists of 37 streams which run through eight municipalities and three utility companies from the east at Smørmosen in Herlev to the west in Frederikssund and Roskilde municipalities, where the mainstream flows into Roskilde Fjord. The catchment of Værebros Å is primarily located in rural areas. Approx. 20% of the catchment is in urban areas, and approx. 5% of the area is estimated to be fortified. Upstream the surrounding areas are characterized by a bog rich in biodiversity, from where the river passes through mixed land use with small and medium-sized villages, including small and larger farms and agriculture. Especially in the lowest-lying areas in Egedal and Roskilde Municipalities, river floods cause major problems for residents and farmers in relation with major rain events.

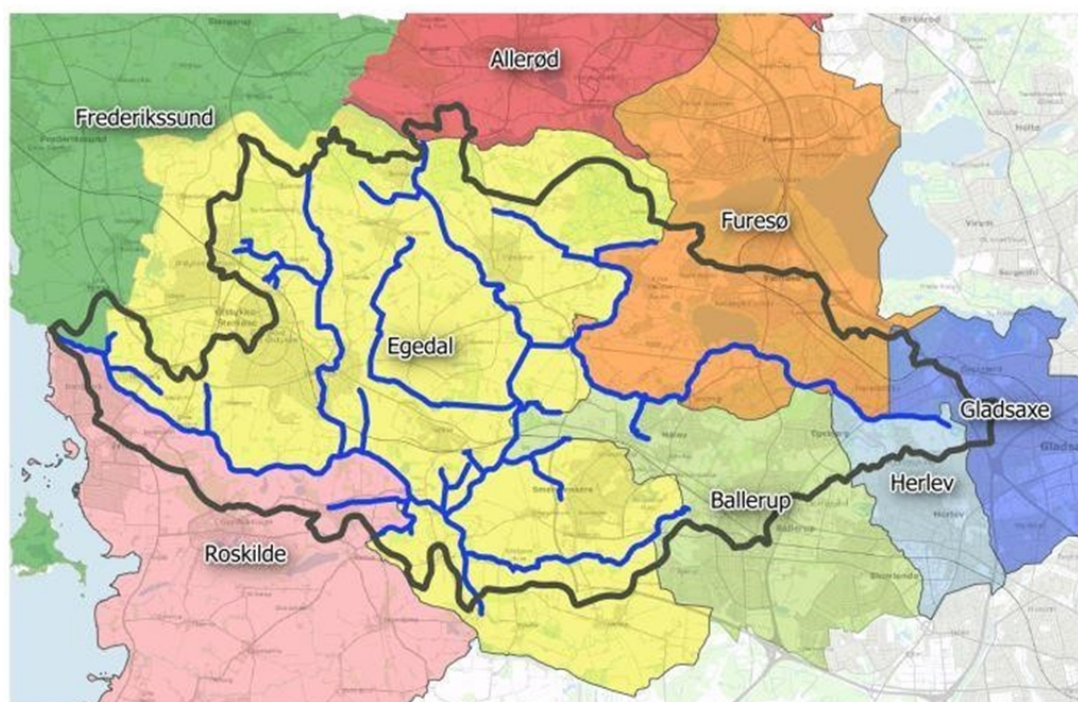


Figure 3: The catchment area of Værebros Å

Roskilde Fjord: Roskilde Fjord features one of Denmark's most beautiful and diverse landscapes. The narrow inlet, which extends 40 km into the Zealand landscape, is dotted with around 30 small islands and islets, home to rich and largely undisturbed flora and fauna. Roskilde Fjord is an EU bird protection area and EU habitat area. The coastline extends over three municipalities. The cities of Roskilde, Jyllinge, Frederikssund and Frederiksværk are especially vulnerable to flooding from storm surges (and increased fluvial flooding from Værebros Å which runs out into the fjord).

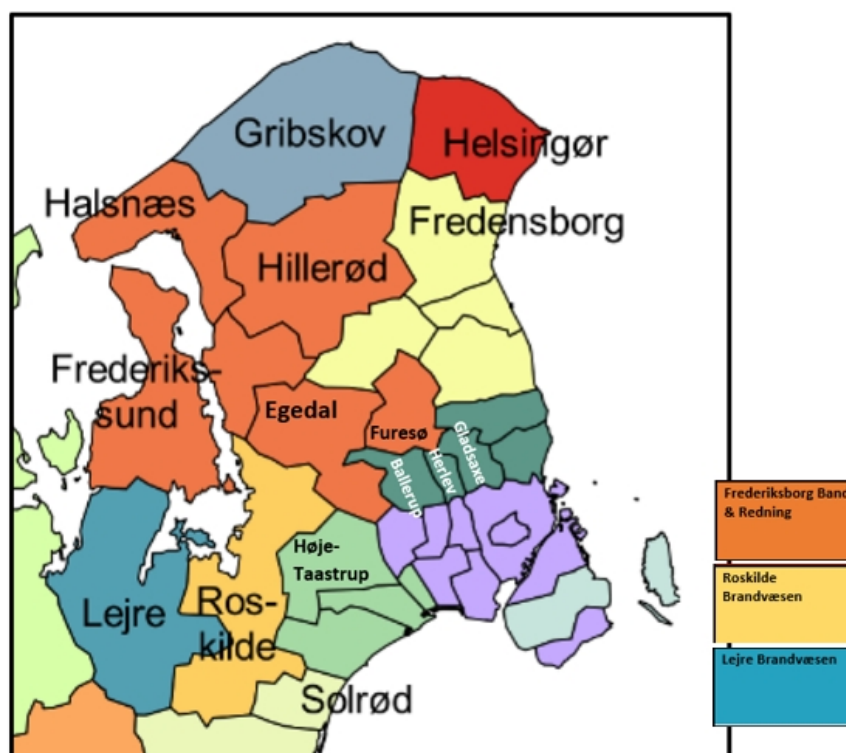


Figure 4: Map of municipalities and emergency management agencies around Værebros Å and Roskilde Fjord

In Denmark, the primary responsibility for hazard governance lies within the municipalities and the emergency management agencies. To support their work—and in case of major disasters - there are the national emergency management as well as national governmental authorities who also enact laws and regulations. The regions (like Region Hovedstaden/the Capital Region of Denmark) are responsible for the health care sector in Denmark but do not have any other direct authority on CCA and DRR. However, the regions work with these matters through facilitation, coordination, and funding in regional development projects. There are also other stakeholders related to hazard governance which we elaborate on in section 2.1.4.

Apart from the two partners – The Capital Region of Denmark and DTU—The following table points out the roles and responsibilities of each of the central stakeholders that have been involved in RWL1 to date (as well as their primary interest in CCA or DRR). The subsequent flow chart in Figure 4 shows the relationships and interactions among all the stakeholders identified so far. As stakeholder engagement is an ongoing process the number of stakeholders will likely change during the project.

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD	COMMENTS
Halsnæs Municipality	Municipality	CCA authority	Sea-level rise, storm surges, pluvial flooding, heat/drought.	Covers part of the coast towards Roskilde Fjord
Frederikssund Municipality	Municipality	CCA authority	Sea-level rise, storm surges, pluvial flooding, heat/drought.	Covers part of the coast towards Roskilde Fjord
Roskilde Municipality	Municipality	CCA authority	Sea-level rise, storm surges, pluvial flooding, heat/drought.	Covers part of the coast towards Roskilde Fjord
Lejre Municipality	Municipality	CCA authority	Sea-level rise, storm surges, pluvial flooding, heat/drought.	Covers part of the coast towards Roskilde Fjord
Egedal Municipality	Municipality	CCA authority	Pluvial flooding, fluvial flooding, heat/drought, storm surges.	Downstream of Værebros Å, no coast but can be affected by storm surges from Roskilde Fjord
Frederiksborg Brand og Redning	Emergency Management/Fire Department	First responders in DRM locally	Floods and fire	Covers five municipalities including Halsnæs, Frederikssund and Egedal.
Roskilde Brand	Emergency Management/Fire Department	First responders in DRM locally	Floods and fire	Covers only Roskilde Municipality
Lejre Brandvæsen	Emergency Management/Fire Department	First responders in DRM locally	Floods and fire	Covers only Lejre Municipality
The Danish Emergency Management Agency	National emergency management agency	Responsible for DRR and DRM nationally	"Disasters"	
Danish Meteorological Institute	National weather and climate agency	Meteorological knowledge, data and warnings on weather, climate, and sea. Both used in CCA/ DRM.	All	Is currently developing a new warning system for floods
The Danish Coastal Authority	National government agency for the coastal zone	Regulation of the coastal zone in CCA	Coast-related hazards	
Region Zealand	Regional government	No official role in CCA or DRM except for involvement of the health sector in DRM	All	Part of Roskilde Fjord and the municipalities are in Region Zealand. See flowchart below

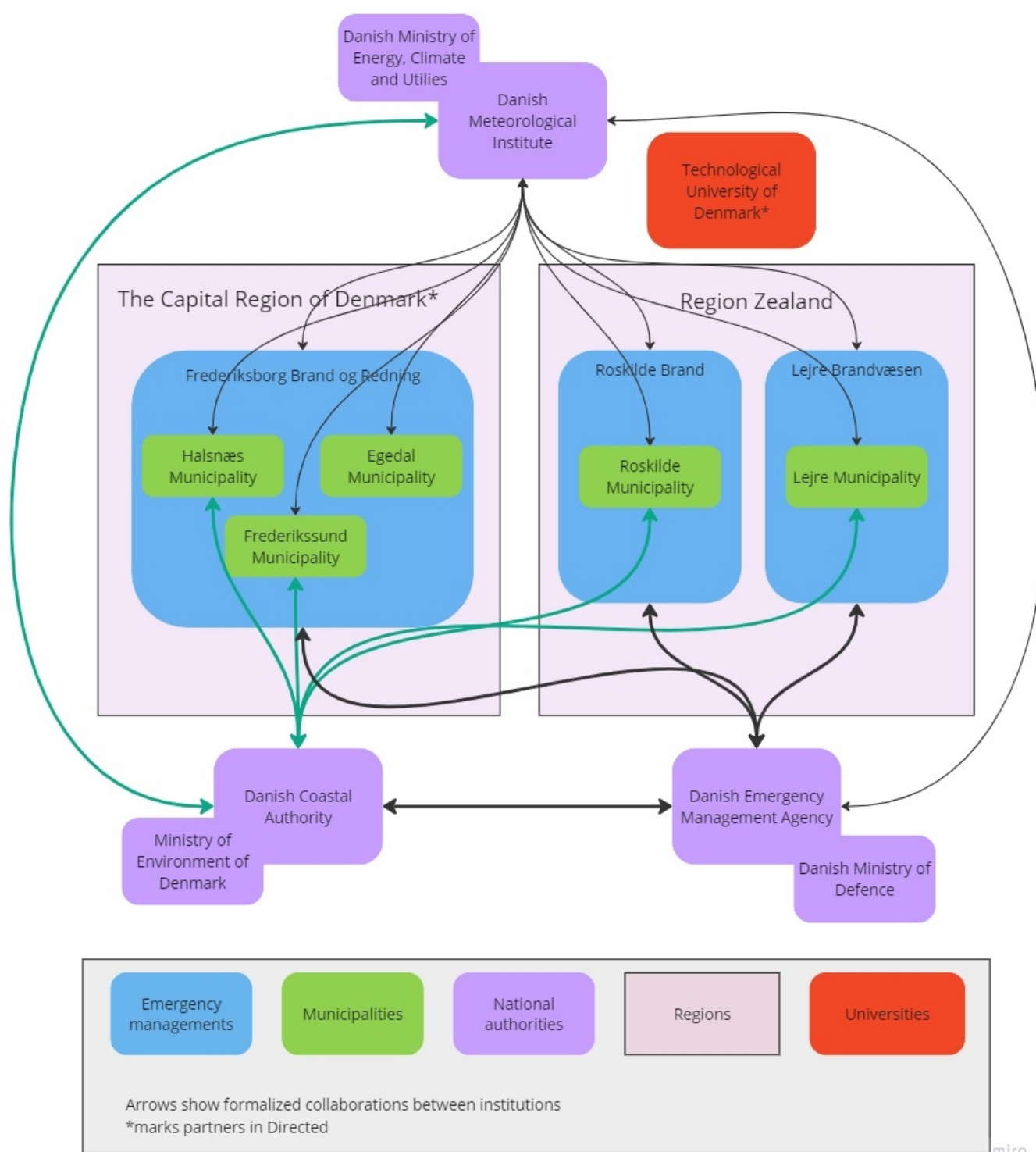


Table 1: Stakeholders involved organizations in the RWL 1

2.1.2 Framing CCA and DRR in the RWL

Climate related hazards and past events in the RWL

Copenhagen and the surrounding Capital Region of Denmark are estimated to hold some of the highest flood damage risks amongst countries bordering the Baltic Sea. Due to climate change, changed rainfall patterns combined with a heightened frequency and intensity of cloudbursts are increasingly leading to overflows from streams and sewer systems, impacting densely populated and rural areas in the region. This was the case of the 2011 cloudburst event that caused insured losses of €655m in Copenhagen. Recently drought has emerged as another critical factor to consider (e.g., 2018) which CCA and DRR actors only have little experience with. The large and compound diversity of climate-related hazards combined with the exceptionally high concentration of people, valuable assets and critical infrastructure in the Capital Region of Denmark makes the challenges even greater.

In 2013, storm Bodil (also known as storm Xavier, Sinterklaasstorm and Sven) caused the highest wind gusts ever recorded in Denmark hitting 135-153 km/h on the North Atlantic Coast and killing one person in Denmark and 19 people across Europe. It caused severe damage across the region due to winds, severe flooding, and coastal storm surges. The effect of Bodil was the strongest storm around Roskilde Fjord and the event required collaborations between many different actors. The event revealed several challenges, making a robust and adequate response harder to achieve. Some of the key points that challenged the emergency managements included uncertainty in data, dikes breaching, fires in flooded basements and communication barriers.

The city of Roskilde experienced multiple cloud bursts in the summer of 2021 and 2022. The main challenges during these events included the lack of knowledge citizens have regarding who to contact in these types of situations. Both, the emergency management, Roskilde Brand, and Roskilde Municipality were getting a massive amount of phone calls from worried citizens, when in fact the right procedure would have been to phone the police. In both 2021 and 2022 the cloud bursts caused 100-year flood events, and hence it can be really challenging to explain to citizens how this type of event can happen two years in a row.

As mentioned earlier the municipalities located downstream of Værebros Å have experienced floods from the river several times. One instance was in 2017 where the river had exceeded the riverbanks. This affected the local golf club and many landowners' fields along the river. This had been a recurrent issue in the last ten or more years.

Challenges in CCA and DRR in the RWL

Through ongoing dialogue with the stakeholders and their participation in workshops, REGIONH and DTU have gathered initial inputs related to challenges regarding CCA and DRR in RWL1.:

- In general, there is a need to enhance the alignment of data between the municipalities, including accessibility to each other's measuring systems, preferably through one shared platform
- Need for more precise prognoses/forecasts and warnings and including waves in such modelling

Other gaps and needs identified include:

- The lack of knowledge regarding risk areas in cities
- More political and public awareness is needed on CCA and DRM/DRR as the attention and memories from past events is quickly lost.
- Gap in communication directed towards the citizens regarding their own responsibility during an extreme event as well as how to best prepare before a storm hits.
- Limited focus on managed retreat as an option in CCA
- Insufficient access to timely and precise data to support effective preparedness and response (e.g., vaccines of first responders, water-tubes being rolled out etc.)
- Need from both municipalities and emergency management agencies to have resources allocated to do (joint) preparedness drills.

Summary of stakeholder expectations:

The stakeholders have shown interest in several digital solutions that could enhance their work during extreme events. Both a common platform for data sharing and communication were among their wishes. But also, more locally specific, and precise data on forecasting would be beneficial according to the stakeholders. These are all factors DTU and REGIONH – in collaboration with the rest of the DIRECTED consortium – will continue to be in dialogue with the stakeholders about.

An agreement was reached at the workshop on the 3rd of March on capacity building being essential. Hence, the idea of simulating an extreme weather event came up. All stakeholders have different levels of experience with emergency management and therefore being able to try it out in practice was highly praised. This is an idea that DTU and REGIONH will develop further, to strengthen local disaster resilience.

2.1.3 RWL Setup process, Achievements, and Gaps

Hereafter a summary of the engagement process, encountered gaps, difficulties and first lessons learned is provided through short descriptions and bullet points.

Stakeholder engagements

Most of the engaged stakeholders were at first approached by email with a short description of the DIRECTED Project and why it was important for our work in RWL1 to have them on board. In the same email stakeholders were invited to attend a short bilateral meeting. At these meetings REGIONH met up (online) with each individual stakeholder to give a more in-depth description of the project and what they could expect from the participation in the project. It was also at these bilateral meetings that the stakeholders were invited to the first official workshop in RWL1.

On the 3rd of March 2023 all stakeholders were invited to participate in a workshop held at the regional office of The Capital Region of Denmark. REGIONH facilitated the workshop together with DTU and supported by WP3 and WP4, focusing on mapping barriers and challenges in data/models, governance, and communication in both CCA and DRM. Other stakeholders to involve going forward were also mapped – see the flowchart above (Figure 4). After the workshop we sent out an email with meeting notes and letters of engagement for the stakeholders to sign. The letters are attached in Annex 1.

As not all stakeholders were able to participate on the 3rd of March, we held a mini version of the workshop together with Roskilde Municipality and Roskilde Brand in May 2023 to be able to get their input as well.

MEETING	LOCATION/ ONLINE	DATE (DD/MM/YY)	PARTICIPANTS	COMMENTS
Bilateral introduction meetings with stakeholders	Online	05/01/23 - 20/01/23	The Danish Emergency Management Agency, Egedal Municipality, Frederikssund Municipality, Roskilde Brand, Halsnæs Municipality, Frederiksborg Brand og Redning, REGIONH	
RWL workshop	Hillerød, Denmark (in person)	03/03/23	Egedal Municipality, Frederiksborg Brand og Redning, The Danish Emergency Management Agency, Frederikssund Municipality, Halsnæs Municipality, Region Zealand, Lejre Brandvæsen, REGIONH, DTU	17 participants in total
Mini workshop	Roskilde (in person)	02/05/23	Roskilde Brand, Roskilde Municipality, REGIONH, DTU	

Table 2: Meetings calendar for RWL1

Gaps and Difficulties

Scope of stakeholder engagement: When working in RWL1 some gaps and difficulties have emerged, which we will have to address going forward. One of the dilemmas is the scope of stakeholder involvement. DRM and CCA are complex matters when it comes to who is involved. As mentioned earlier, we have engaged a variety of relevant actors and have also mapped out at least 16 more actors that could be relevant to include. The dilemma is how we make sure to include and invite all relevant stakeholders on board, while not making the scope way too big for the RWL. One approach is to keep the key stakeholders closely engaged while the more peripheral stakeholders will only be informed when relevant. We will also get support from WP3 partners to guide us in limiting the broad stakeholder landscape within CCA and DRM in RWL1.

Time commitment from stakeholders: Another issue we are finding difficult is how much time we can ask for the stakeholders to put into the RWL1 work. As they are not being financially supported and have other competing priorities. It is important that we find a good balance when it comes to the amount of work the stakeholders should put into this project. One way we have already addressed this, is by having a survey at the first RWL1 workshop, where we asked about the desired or realistic level of participation. This gives us an idea about how much time we can plan for the stakeholders to engage.

Translating between complex project and practice: Lastly, REGIONH wants to highlight the difficulty of being a non-technical practice orientated partner in a technical complex multidisciplinary project. This can be an issue when engaging with stakeholders, workshop facilitation and communication of the progress in RWL1. To address this, ongoing “translation” is needed between the DIRECTED partners, so what is communicated to the stakeholders is aligned with what is possible within DIRECTED.

Lessons learned

Some of the lessons we have learned so far and will make sure to incorporate going forward is to be open to future role play/scenario-based exercises for the next in-person workshop as well as be open to short online meetings (e.g., review stakeholder mapping, review models/data/tools) where we could use interactive platforms such as Miro ¹ and Menti². We also want to make sure to give space or probe participants who have no direct experience

1

2

with emergency management, time to contribute and share at the workshops as they have the most to benefit/ learn from the process. It also important to be more precise about the relationship between extreme weather events and more longer-term CCA as some CCA stakeholders at the workshop were a bit unsure or hesitant to give input whenever the focus was high on extreme weather events. But this also reflects the value or importance of DIRECTED. We want to continue to promote that different stakeholders who would rarely be in the same room can have a space to interact and exchange knowledge at the RWL meetings. This is something we received positive feedback on at the first RWL1 workshop.

2.1.4 RWL Next Steps

In the coming months until the end of the year we have several activities planned. We would like to make a more detailed stakeholder mapping, likely with support from WP3 and WP4.

Another activity is to initiate stakeholder engagement with those we have yet to involve in the project. This will be based on the mapping exercise.

We will also conduct a second RWL1 workshop with stakeholders during the fall 2023. The aim is to zoom in further on what type of digital solution could be beneficial for the stakeholders as well as get more details about what a possible extreme weather event simulation should entail. This workshop will take place around November 2023.

Regarding types of engagement going forward, the main wish from the participants is to participate in workshops twice a year (in person). On top of this they are open to online meetings/webinars in between and the possibility of bilateral meetings with REGIONH and DTU when needed.

2.2 RWL2 – The Emilia-Romagna Region

The Real-World Lab in Emilia-Romagna is led by the Civil Protection of the Emilia-Romagna Region (ARSTPC-ER) together with the ARPAE Hydrometeo Service Civil Protection Functional Centre, which are responsible for Disaster Risk Reduction (DRR) related to climate risks. This includes early warning, Disaster Risk Management (DRM) systems and Climate Change Adaptation (CCA) planning.

2.2.1 RWL Study Area Definition and Stakeholder Landscape Analysis

Two areas have been chosen: for Marine ingression and windstorm risk the Real-World Lab area of Rimini coastline, which covers the coastal strip of the province of Rimini, including the municipalities of Bellaria-Igea marina, Rimini, Riccione, Misano Adriatico and Cattolica.

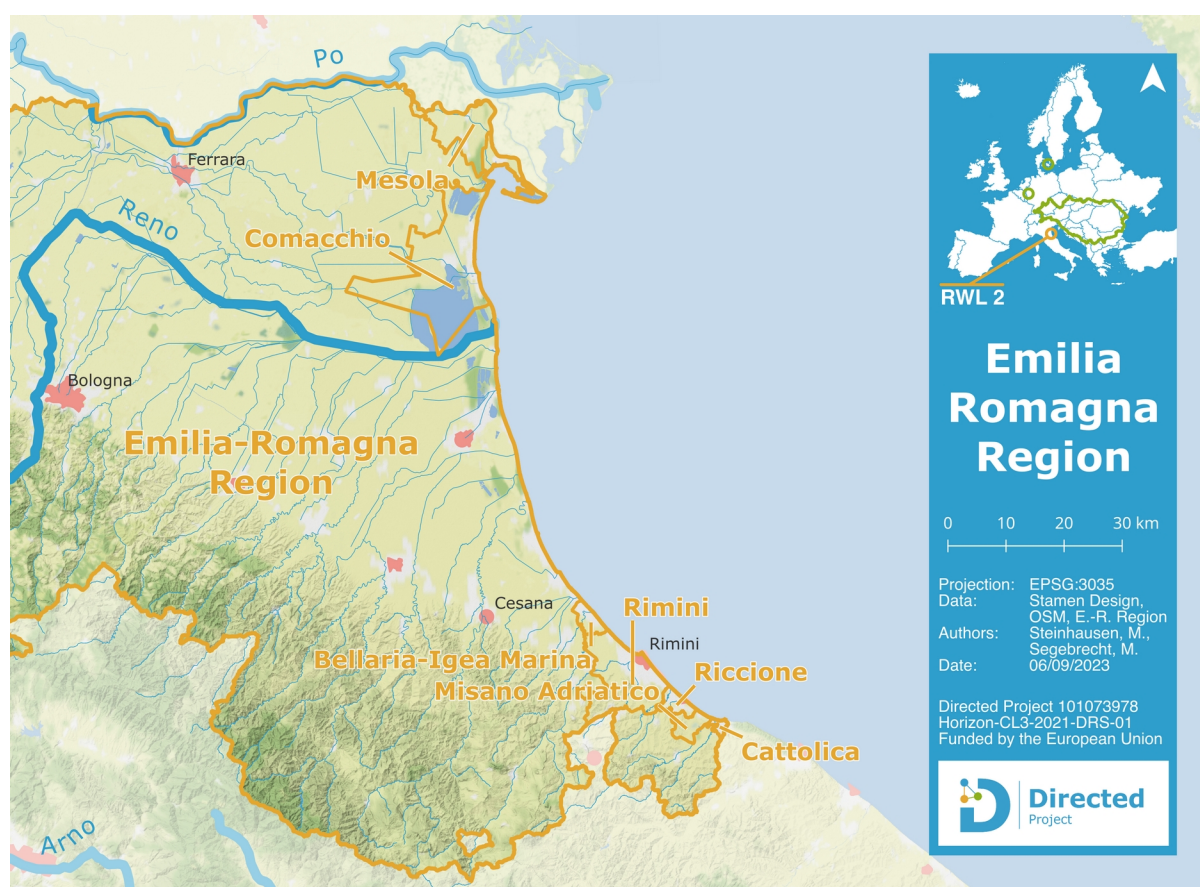


Figure 6: Overview map of the Real World Lab 2 – Emilia-Romagna Region

For Wildfire risk the Real-World Lab area of Comacchio e Mesola, two municipalities of the Ferrara Province, located on the coast of Ferrara province. Hereafter we provide a brief description of the two areas.

RWL Rimini coastline

The coastal strip of Rimini is a densely urbanized territory, that comprises centers that have developed near the coast to compose a real "linear city" about 30 km long, which includes the territories of Bellaria-Igea Marina, Rimini, Riccione, Misano Adriatic and Cattolica Municipalities.

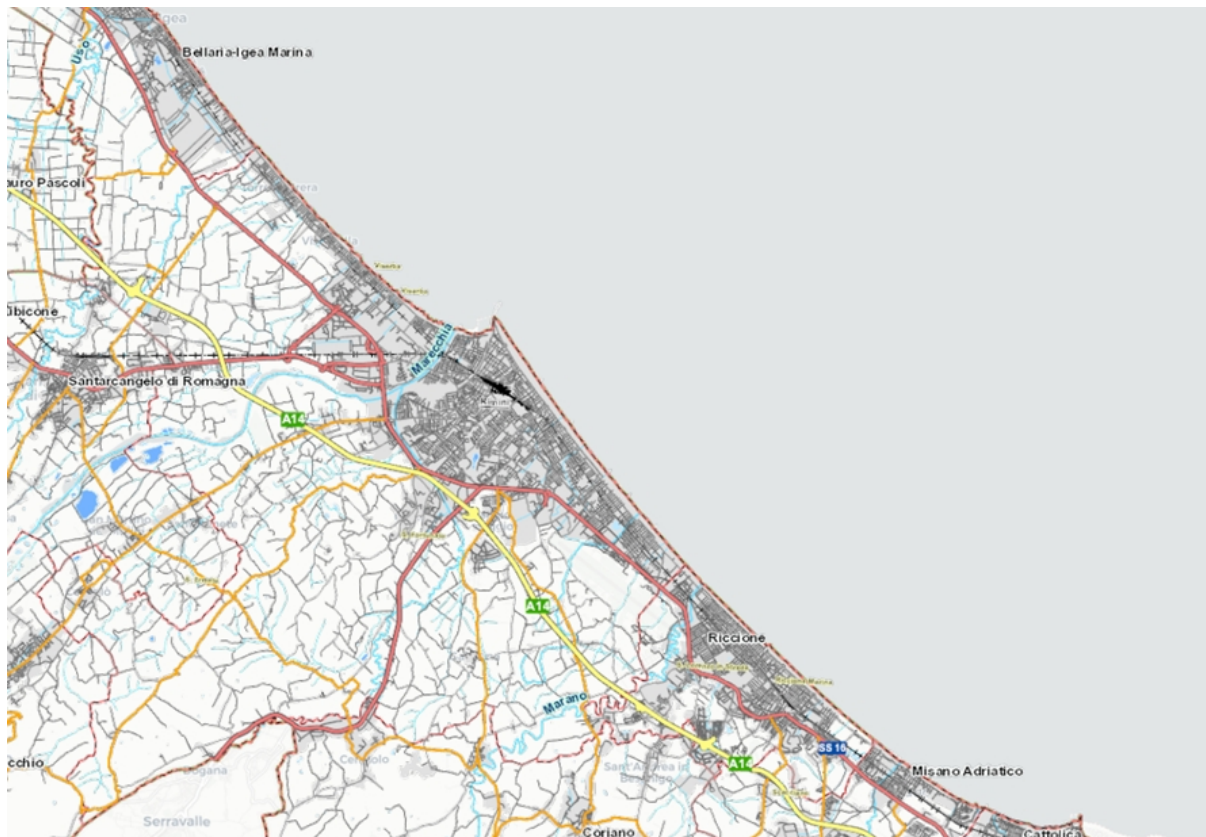


Figure 7: Map of the Rimini coastline, showing the "linear city"

The whole territory has a strong tourist vocation linked to the seaside sector and to the use of the low sandy beaches that characterize the entire regional coast. The population of the municipalities along the coast changes from around 200.000 inhabitants in winter to over 800.000 in the summer. In this context, there are various types of weather events that can have a very negative impact on the coastal sector by causing significant damage, for example, destruction of beaches due to marine ingression, erosion, and windstorms.



Figure 8: Shoreline setup during summer season



Figure 9: Sea storm during tourist season along coastline

The vulnerability of the beaches, exposed elements (coastal cities and bathing facilities) and intangible assets (use of the beaches) determine a significant risk for the economy of the entire Rimini coastal area.

The territory is also exposed to several other hazards linked to particularly severe weather events such as heavy rains (water bombs) which can overload the urban drainage system but also the main network, causing widespread flooding above all in conjunction with high sea levels and storm surges.



Figure 10: Fallen tree, during a summer storm event in Rimini in 2022

In the area of interest, various watercourses flow into the sea in addition to the urban drainage network; on heavy rain events concomitant with high tide values (recently up to + 115 cm a.s.l.) flooding of urban areas occurs because the regular discharge of the water into the sea does not work.

RWL Comacchio and Mesola

Comacchio Municipality

Comacchio municipality is in the eastern part of Ferrara Province, bordering to the south the municipality of Ravenna, and to the east with the Adriatic Sea. It has an area of 283 square kilometres and the main economic sources of income are currently related to tourism, commercial fishing, valley farming.

The municipal territory of Comacchio is also known for its seven beaches, distributed along the coast; from north to south are: Lido di Volano, Lido delle Nazioni, Lido di Pomposa, Lido degli Scacchi, Porto Garibaldi, Lido degli Estensi and Lido di Spina.

These areas are particularly well-visited during the spring and summer period, while in autumn and in winter the population decreases and only residents remain.

There are also large areas of mixed forests, such as the Po di Volano Nature Reserve, located along the northern part of the coast between Volano and Lido di Volano. The forests mainly consist of coniferous woods such as the one next to Lido delle Nazioni and of deciduous woods such the one present west of the town of San Giuseppe.

Mesola

The Municipality of Mesola has an area of 84,31 square kilometres; is situated in the Po Delta, in the southern part of the branch called Po di Goro that represents both the municipal and regional border between Veneto and Emilia-Romagna.

The entirely flat territory is mostly below sea level, but the lines of the dunes that represent the ancient coast are still visible. In Massenzatica there is a reserve of about 0,5 km² of ancient fossil dunes. In many of these areas various reclamation interventions have been carried out.

Widespread human presence and high road density are factors that increase the risk of fire, especially when persistent drought is accompanied with strong winds.

Considering that wooded areas are mainly located in the coastal zone, this problem is certainly more accentuated in the summer period during which the low rainfall and high

attendance of tourists in these areas increase the likelihood of a fire. This is supported by statistical data, which shows that:

- Most forest fires occur in the months with the greatest tourist occupancy
- Most forest fires are triggered in the early afternoon by people not properly extinguishing their bonfires after having lunch
- The triggers for most of the forest fires cannot be determined
- Frequently the fire affects both wooded and non-wooded areas. In our province many fires have affected bushes and/or shrubs that border the ways of communication further east of the territory



Figure 11: Wildfire spreading nearby a region frequented by tourists in summer 2022

There is a need to improve the coordination between the various first responders (public bodies, service managers, volunteers) in case of extreme events to support actions in the emergency phase that are based on an effective and coordinated analysis of a large diversity of data from monitoring networks including: wind, temperature and rain gauges, hydrometers, wave meters, tide gauges. In addition, modelling tools for real time data integration and forecasting need to be analysed. Similarly, there is a need for pre-emptive damage assessment tools to support public administrations in choosing medium and long-term prevention measures, fostering adaptation to changing risks of floods and wildfires, particularly regarding climate change.

The following table points out the roles and responsibilities of each of the central stakeholder that we have involved in DIRECTED (as well as their primary task of either CCA or DRR) whereas the subsequent flow chart shows the relationships and interactions among all the stakeholders identified so far.

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD	COMMENTS
Regional Protected Areas, Forests, and mountain areas development sector	Regional Government	CCA	Forest Fire	
Regional Soil Defence Sector - Geology, Soils and Seismic Area	Regional Government	DRR	Coastal Risk, hydrogeological Risk	Covers the entire regional territory, uses data and models to support knowledge of hydrogeological risk and coastal risk
Po Delta Parks and biodiversity management body	National Government	CCA	Forest Fire	
Ferrara provincial civil protection voluntary coordination	Provincial Government	DRM	ALL	Supports emergency management in the province of Ferrara
Rimini provincial civil protection voluntary coordination	Provincial Government	DRM	ALL	Supports emergency management in the province of Rimini
Comacchio Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Mesola Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Riccione Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Rimini Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Bellaria Igea Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD	COMMENTS
Misano Adriatic Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Cattolica Municipality	Municipal Government	DRR/CCA	ALL	Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
HERA SPA	Essential services Provider			Municipal competent authority, is the first entity that responds to emergencies in competence and is responsible for the implementation of the municipal civil protection plan, uses data and models
Biodiversity Police	National Government	DRR/CCA	Forest Fire	
Romagna Reclamation consortium		DRR/CCA	Hydraulic Risk	Manages the minor artificial hydraulic network of the plain in the Romagna area, supports emergency management, uses data and models
Riviera del Conca Civil Protection operative centre	Municipal Government	DRM	ALL	Inter-municipal civil protection operations centre for the municipalities of Cattolica, Coriano, Misano Adriatico, Riccione, San Giovanni in Marignano

Table 3: Stakeholders involved organizations in the RWL 2

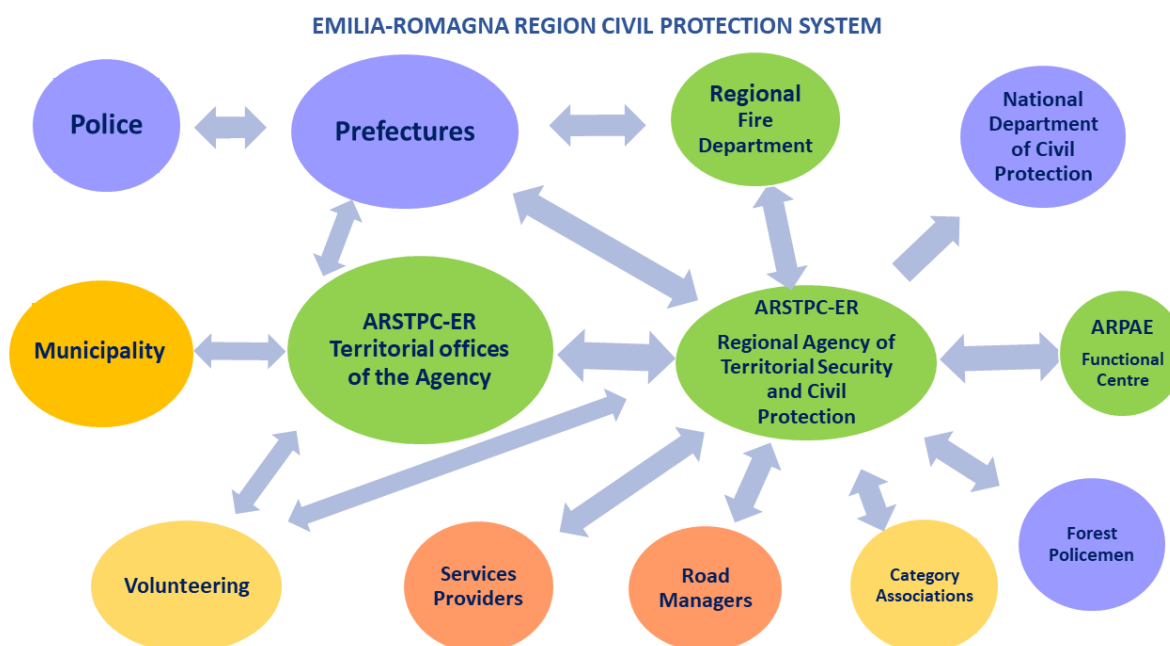


Figure 12: Relations between the involved stakeholders

2.2.2 Framing CCA and DRR in the RWL

The region is susceptible to a multitude of natural hazards including extreme rainfall events, marine ingressions, coastal erosion and wildfires. The dominant erosive phenomena and the morphological structure of the territory make a large part of the coastline prone to marine ingression, which is exacerbated by the rising sea levels and increasing frequency and intensity of extremes. The risk of flooding is widespread and particularly high during compound events and extreme marine-weather events. It is aggravated by the inefficiency and/or inadequacy of urban drainage systems in some places. Some data, in detail:

- FLOOD RISK: 45.7% areas with average danger of the regional total
- COASTAL RISK: 135 km of coastline, 77 km of coastline protected by banks, works in progress

Likewise, the risk of wildfires is particularly high during summer as forests and densely populated residential areas are highly co-located along the coastline, 25% of the regional territory is covered by forests. About 95% of the forest areas of Emilia-Romagna are hilly and mountainous and are potentially at risk of forest fires.

Looking at past recent events/experiences in CCA and DRR a short summary of relevant events identified with stakeholders is provided hereafter (Marine weather reference events related to marine ingression):

Meteo-marine events

- February 2015, the entire coastline of the region was affected
- September 17, 2022, the entire coastline of the region was affected
- November 22, 2022, Provinces of Ferrara, Ravenna, and Forlì-Cesena
- 20-21 January 2023, the entire coastline of the region was affected

Particularly intense phenomena, some of which were prolonged events, caused critical conditions and damages on a large part of the regional coastal territory. These were events characterized by high water conditions with particularly significant values which caused damage to bathing facilities and flooding of the urban coastal strip.

Windstorms

- 2 August 2019 and 17 September 2022, the entire coastline of the region was affected

They seasonally frequent events, reoccurring with distinct spatial and temporal patterns; they are phenomena that develop above all in the summer season and have caused various damages especially to the bathing facilities.

Thunderstorms/heavy rainfall

- June 24, 2013, several municipalities in the province of Rimini and in particular the city of Rimini

The June 24, 2013 storm caused rainfall of over 120 mm in one hour and over 90 mm in half an hour with various damages in most of the City of Rimini, flooding canals and the sewage system. Several challenges are faced in adapting to climate change impacts and reducing disaster risks. For all events associated with weather phenomena such activity is assessed daily. In collaboration with the functional centre of Arpa, the portal ALLERTAMETEO <https://allertameteo.regione.emilia-romagna.it/> is guaranteed to operate 24 hours a day. It contains information on alerts and weather reports, real-time updates on the evolution of events, forecasts, data, and advice in case of risks. The campaigns against forest fires is planned and managed between the regional system (ARSTPC, Fire brigades, Law enforcement, Volunteers, ARPAE).

A challenge for local governance of disaster risks is the limited ability to coordinate and support multiple stakeholders in both early warning and when planning climate change mitigation and adaptation. The lack of capacity building and cultural awareness among multiple stakeholders concerning climate change threats, currently seems to be a critical barrier in implementing integrated DRR and CCA strategies.

Involved stakeholder expectations, as captured so far include:

- There is great interest in updating the Civil Protection Plan where benefits from the DIRECTED activities and data, models and tools may be useful
- Providing interconnected observed data in real time, which is currently missing
- Potential exploitation and integration of HERA Spa monitoring system (Rada and Sea Level station)

To Strengthen emergency coordination a few potential actions have been identified:

- Share, among the various actors involved in the project (Hera, Reclamation Consortium, Municipalities), the gauging stations monitoring network and the forecast modelling network to evaluate them and possibly integrate them with the current forecasting and regional emergency management system
- Develop platforms and tools for data acquisition. Being able to identify a protocol of actions that return information/data, through an automated tool or an App, a website by implementing Citizen Science actions, involving, for example, citizens and schools
- Greater information, training and dissemination on the danger associated with risks through billboards also in bathing establishments. Prefer presence mode information and training activities
- Organize exercises for coastal risk management

2.2.3 RWL setup Process, achievements, and gaps

The first activity made to set up the RWL2 Emilia-Romagna was an initial stakeholder mapping carried out together with the civil protection offices present in the provincial territories. Subsequently, direct contacts were made and after acquiring their affirmative answers we proceeded with the formal sending of a request to participate in the project.

Following this first email exchange, we received formal acceptance of participation in the project and the engagement letter from the entities contacted, which we then forwarded to the project coordinator.

We invited the stakeholders engaged to the first RWL2 Meeting, organized in Bologna on 21 March 2023, with roughly 40 participants in presence online.

In this context the Project was presented, introducing it to stakeholders thanks to the partners involved in the lab. We gained preliminary feedback on actual data, tools, policies, and models for DRR and CCA. In addition, we gained a first insight into users' practical interests in the project, in a roundtable discussion.

After this first introductory activity a second, in-person meeting with stakeholders has been organized after the summer break, to focus on both governance processes and available data, networks, models, and tools. Ongoing, we will take care to address guiding questions around governance assessment provided by WP 3.

MEETING	LOCATION/ ONLINE	DATE (DD/MM/YY)	PARTICIPANTS	COMMENTS
RWL2 Meeting	Bologna	21/03/2023	Civil Protection Agency Emilia-Romagna Region, Environmental Agency Emilia-Romagna Region, Comacchio Municipality, Mesola Municipality, Ferrara provincial civil protection voluntary coordination, Po Delta Parks and biodiversity management body, Regional Protected Areas, Forests and mountain areas development sector, Riccione Municipality, Rimini Municipality, Bellaria Igea Municipality, Misano adriatico Municipality, Rimini provincial civil protection voluntary coordination, HERA SPA - Provider of essential services, Regional Soil Defence Sector - Geology, Soils and Seismic Area	
RWL 2, 2° Meeting	September 2023	September 2023	Civil Protection Agency Emilia-Romagna Region, Environmental Agency Emilia-Romagna Region, Comacchio Municipality, Mesola Municipality, Ferrara provincial civil protection voluntary coordination, Po Delta Parks and biodiversity management body, Regional Protected Areas, Forests and mountain areas development sector, Riccione Municipality, Rimini Municipality, Bellaria Igea Municipality, Misano adriatico Municipality, Rimini provincial civil protection voluntary coordination, HERA SPA - Provider of essential services, Regional Soil Defence Sector - Geology, Soils and Seismic Area	Initially scheduled for May, postponed due to the tragic events that hit the Region in May.

Table 4: Meetings calendar for RWL 2



Figure 13: First RWL 2 meeting in Bologna the 21st of March 2023

The first meeting outlined some key aspects related to emergency management in Emilia-Romagna, focusing on specific case studies, forecasting models, and identified challenges. For Case Study 1- Rimini Coast, attention was placed on emergency management identifying hazards (pluvial and coastal flooding), and how current masterplans map this hazard. For Case Study 2: Ferrara Coast - Comacchio and Mesola Municipalities –stress was put on the (wildfire) hazard characterization and prevention/information (to be enhanced) measures, outlining actual resources devoted to this activity and on existing datasets of past events.

Discussion touched the actual availability of public datasets, forecasting tools, and models behind for weather and climate variables of potential interest publicly available. Pre-alarm, and alarm phases were discussed, also outlining the actions and resources involved in each phase. Before the roundtable, an overview was provided to participants on the variety of tools and models that the DIRECTED project can provide (e.g., SaferPlaces, RIMurban, CAIMAN, CLIMADA) and that are available for upstream services (e.g., Copernicus Climate Data Store).

The roundtable identified the need to increase prevention activities for forest fires, integrating monitoring networks, and creating platforms for data acquisition. The importance of information and education for the population was emphasized. Interest raised for possible usage of innovative tools in the incoming Civil Protection Plan and for local activities across the emergency (see for example box 1).

All in all, this meeting provided an in-depth look at emergency management related to coastal risks and forest fires in Emilia-Romagna. Discussions highlighted the importance of forecasting models, the need for integrated monitoring networks, and the urgency of information and education for an effective response to emergencies. Interesting proposals were also presented to address the challenges identified in the emergency management process.

Hereafter a summary of *gaps and difficulties* and *first lessons learned* during the setup phase. Concerning *gaps and difficulties*, the setup phase was slower than expected given the high number of organizations involved, and some of them have not been involved so far. Particularly, now, it has not been possible to involve the Firefighters and Prefectures in the RWL for reasons related to priority activities that require the involvement of all their resources.

During the first meeting a few practical challenges were raised such as difficulty in reaching the "last mile" in forecasting plans, delays in observed data during events, and a lack of data along the coast. Issues with instrument placement and data timing were also raised.

Moreover, after the first meeting an extreme flood occurred in the Region (in May 2023) stopping *de facto* for months all the activities of the lab as most participants were involved in emergency and post event recovery actions.

This delay of planned activities led to rescheduling the second meeting (initially planned before summer) to the end of September. By the time of this report a preliminary agenda and a place for physical meeting have been rearranged and invitation have been sent to the stakeholders.

Besides that, the event offered a unique opportunity to test the SaferPlaces' platform, one of the tools offered by DIRECTED for supporting real-time emergency management and post event operation of the Civil Protection Agency, further explained in box 1.

Some lessons **have been learned** from this first round of interaction with stakeholders, despite mentioned difficulties and delays. The following key messages were identified for the incoming work in the RWL, both for local and regional level stakeholders:

Local Stakeholders

- Support to Municipal Emergency Planning
- Improve the timing of data availability for real-time risk scenarios.
- Importance of informing and training citizens – more effective in presence

- Importance of constant dialogue between all actors of the civil protection system
- Importance of good communication in early warning

Regional Stakeholders

- Interest in SaferPlaces real-time scenarios tool, need to use suitable input data
- Importance of the historical event analysis, collection of information related to the events occurred from the various involved parties is fundamental, the need to improve the collection method

Concerning the practical engagement process this setup phase made lot of use of on-line tools like Miro Board to coherently collect and organize the activities, resume outputs, and try to link and get input from other WPs. Such interactive tools look promising also from the continuation of the activities where input from other WPs need to be integrated with activities carried out with stakeholders.

Box 1 – Supporting flood emergency in May 2023 in Emilia Romagna with SaferPlaces Platform

Between the 16th and 18th of May 2023, six months' worth of rain fell within 36 hours across Emilia-Romagna, one of Italy's most important agricultural regions. As Prof. Attilio Castellarin from UNIBO explained in this [video](#), the intense rainfall originated an historic event, unprecedented in the entire country, in terms of the type of phenomena between landslides and floods. 350 million cubic meters of water fell in the most affected area (800 sq. km. of territory), causing 23 rivers to overflow and thousands of landslides (more than 400), which in turn affected 100 municipalities and damaged hundreds of roads and infrastructures.

Immediately before and during the flood event (16-20 May 2023) the SaferPlaces platform (www.saferplaces.co), a formal tool made available by DIRECTED project, has been exploited to support the ER Civil Protection in Rapid Flood Mapping and related early warning and displacement of people. Using the SaferPlaces' platform, the Civil Protection activated more than 20 areas across the region, to monitor the situation in real-time (Figure 14).

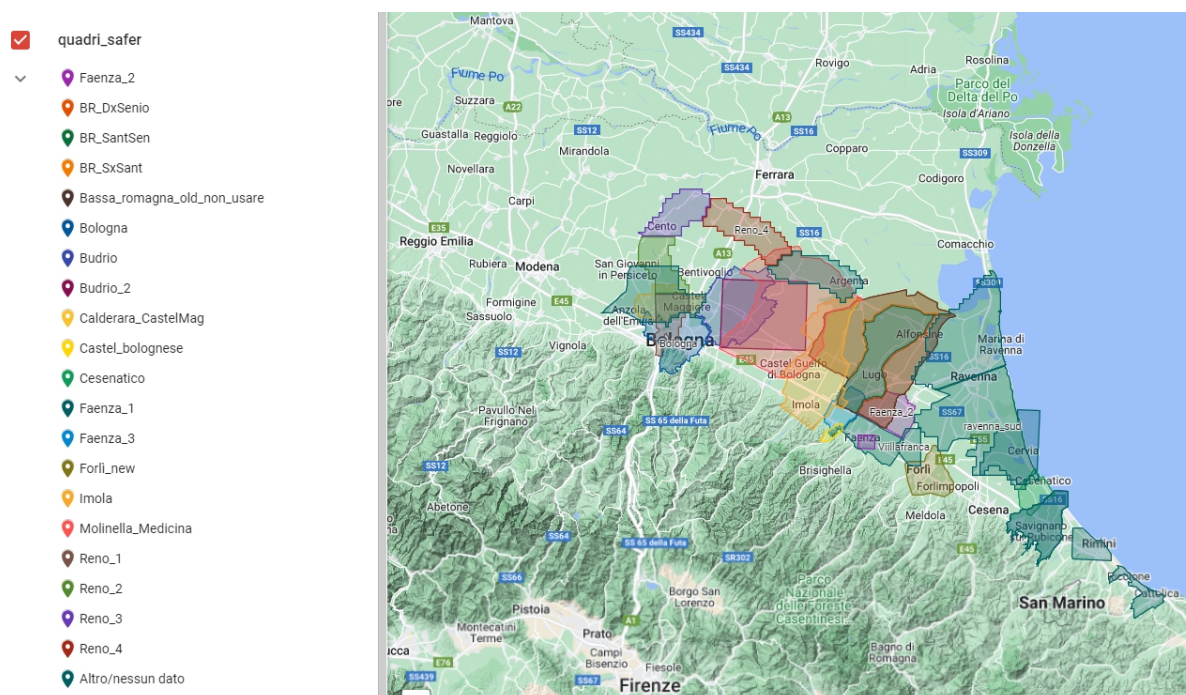


Figure 14: Areas monitored by the Emilia-Romagna Civil Protection, activated on the SaferPlaces' platform.

During and after the event the flood hazard maps generated by the Digital Twin Cloud-based solution has been validated and compared with real picture resulting a very positive accuracy of the predicted maps compared with real flood extension and water depth.

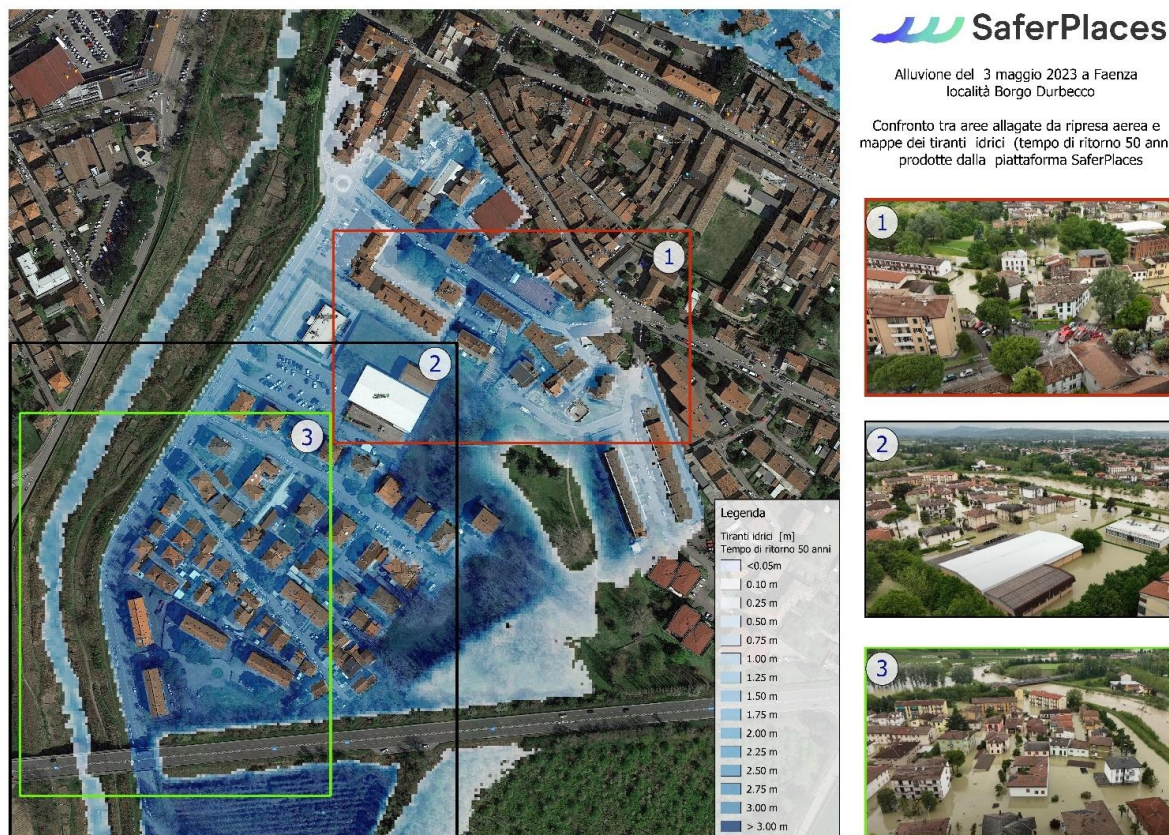
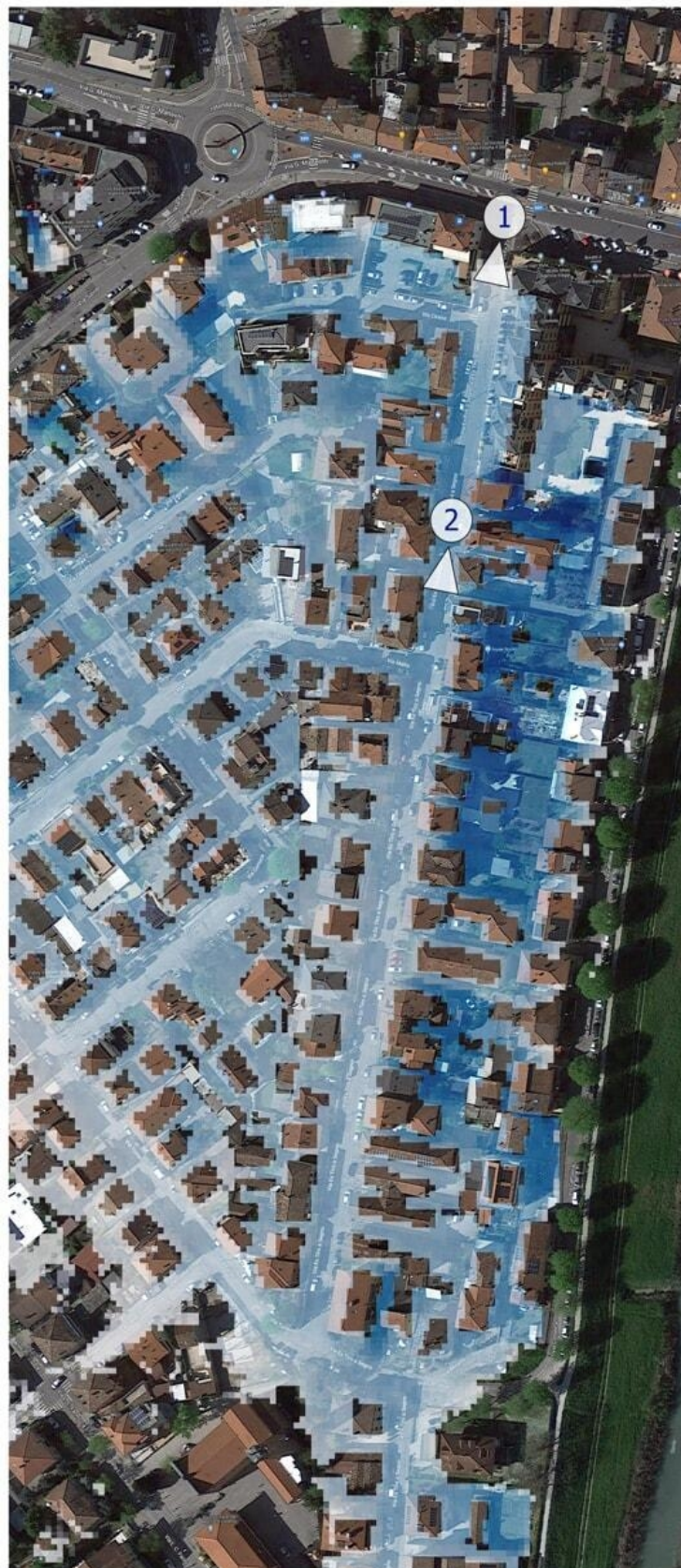


Figure 15: Comparison between SaferPlaces simulation of high probability flooding areas and actual flooded areas in the "Borgo Durbecco" neighbourhood, Faenza.

Full report on carried on activity can be found [HERE](#).

In the months between June and August 2023 the activities of RLW2 have been mainly focused on Post Event Analysis with particular emphasis in supporting the Emilia Romagna Civil Protection in quantifying the total economic losses. The SaferPlaces platform made available by DIRECTED partner GECOSistema has been exploited to quantify economic losses and damages exploiting satellite data as featured here by ESA.



SaferPlaces

Alluvione del 16-17 maggio 2023 a Cesena
Quartiere Oltresavio

Ricostruzione speditiva post evento

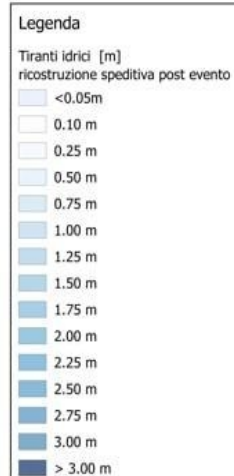


Figure 16: Comparison between SaferPlaces simulation of high probability flooding areas and actual flooded areas in the "Oltresavio" neighbourhood, Cesena.



Figure 17: Example of damage assessment through SaferPlaces platform

2.2.4 RWL Next Steps

The incoming step forward is the organization of the second RWL meeting which will be held at the end of September, realigning activities after the unexpected flooding emergency. The meeting will have the objective of consolidating the constitution of the RWL and deepening the needs of stakeholders, highlighting critical issues and proposals to plan the future activities to improve governance and data usage.

Particularly it will focus on each of the two areas (Rimini coast and Mesola municipality) highlighting risk governance processes in DRR and CAA for floods and wildfires.

In the second part of the meeting, we expect to have deeper discussions on available data, tools, models, and available monitoring networks and how they can integrate with upstream services like Copernicus.

2.3 RWL3 – Danube Region

RWL3 is led by Genillard & Co, a consulting company and reinsurance broker from Munich with a focus on developing and implementing risk management strategies for specialty insurance markets, together with Fred Hattermann and Tobias Conradt from the Potsdam Institute for Climate Impact Research (PIK) and Levente Huszti from Zala Special Rescue, the Hungarian partner of UN INSARAG, a first responder organisation of civilian volunteers with a nationwide coverage, and the regional lead organisation of Zala County.

In addition to the common types of risk reduction – risk avoidance, risk reduction and risk acceptance – risk transfer is a popular method in the field of natural disasters. Here, the insurance industry plays an important role, as they take on a pre-defined risk, such as the possibility of suffering damage from a flood, drought, or storm, in exchange for a premium payment. Since it is necessary to understand and measure the risk to determine the premium for a particular insurance benefit, the insurance industry as a stakeholder has a wealth of experience that can be accessed during the project.



Figure 18: Overview map of the Real World Lab 3 – Danube Region

2.3.1 RWL Study Area Definition and Stakeholder Landscape Analysis

Due to the sheer size of the Danube River Basin, three test sites were selected to be analysed during DIRECTED for their disaster preparedness and measures to avert adverse climate change impacts. The focus is on the city of Vienna in Austria, the Zala region in Hungary and Belgrade in Serbia.

2.3.1.1 Vienna, Austria

Vienna, which covers an area of 415 km² in total, is traversed by the Danube River, the second largest river system in Europe. Climate change projections indicate an increase in temperature as well as shifts in precipitation patterns, with an increased risk of extreme weather events in the future.

The City of Vienna lies on the banks of the Danube River and overlaps the downstream part of the Vienna River Basin, which contributes to the potential for significant water accumulation and run-off. Rapid snow melt or heavy rainfall events in the upstream mountainous region, mostly in spring or early summer, regularly cause a rise in water levels, potentially resulting in localized or even widespread flooding but are well controlled by dikes, retention basins as well as the Danube Channel to mitigate damage by flooding.

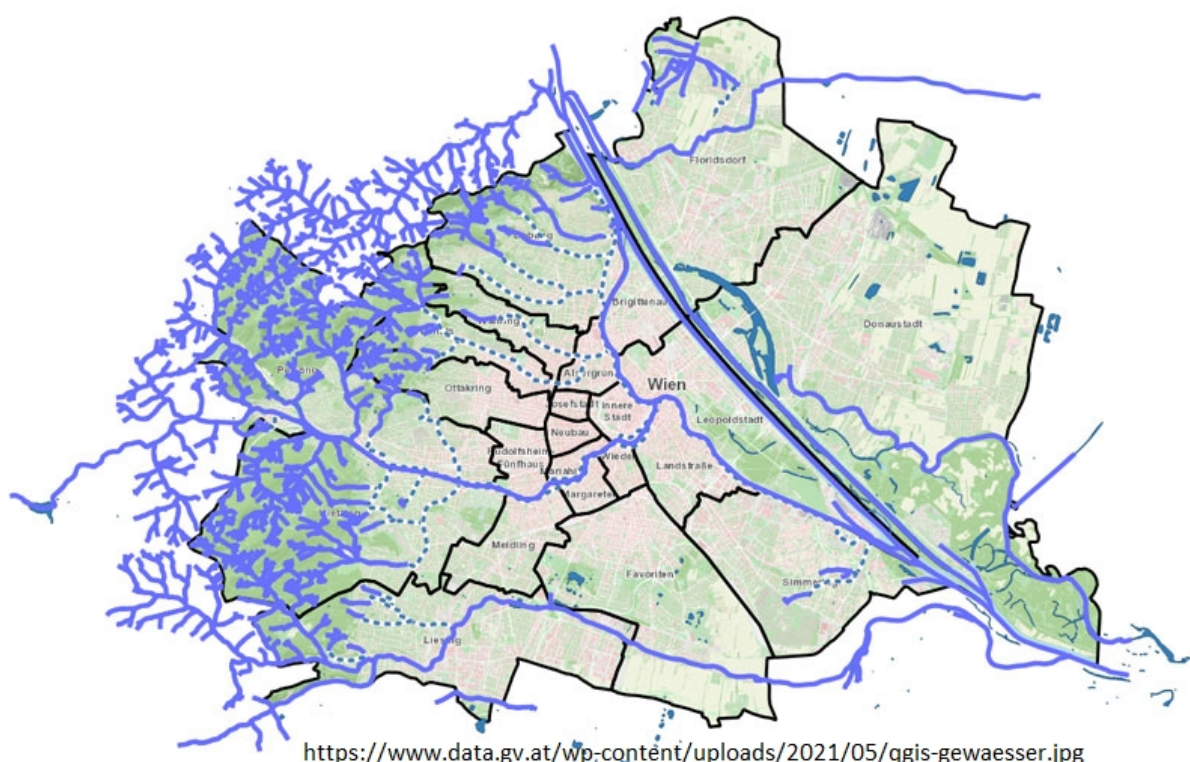


Figure 19: Rivers flowing to and through Vienna

In addition to flood risk, Vienna is vulnerable to droughts. The region regularly experiences periods of reduced precipitation as well as increased evaporation, which causes the levels of the Danube and tributaries to sink and potentially affect agriculture more strongly than fluvial and pluvial flooding.

Vienna's flood and drought risk management landscape is a diverse network of both public authorities and private institutions and organizations active at national, regional, and local levels. The government of Vienna is responsible for developing and implementing protection policies and infrastructure projects. Environmental agencies and water management authorities also collaborate closely to monitor water levels and implement warning systems. On a national level, various authorities such as the Ministry of Agriculture, Forestry, Regions and Water Management, the Ministry of the Interior and the Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology are involved in the development of comprehensive protection plans.

Civil Protection management structure of Austria

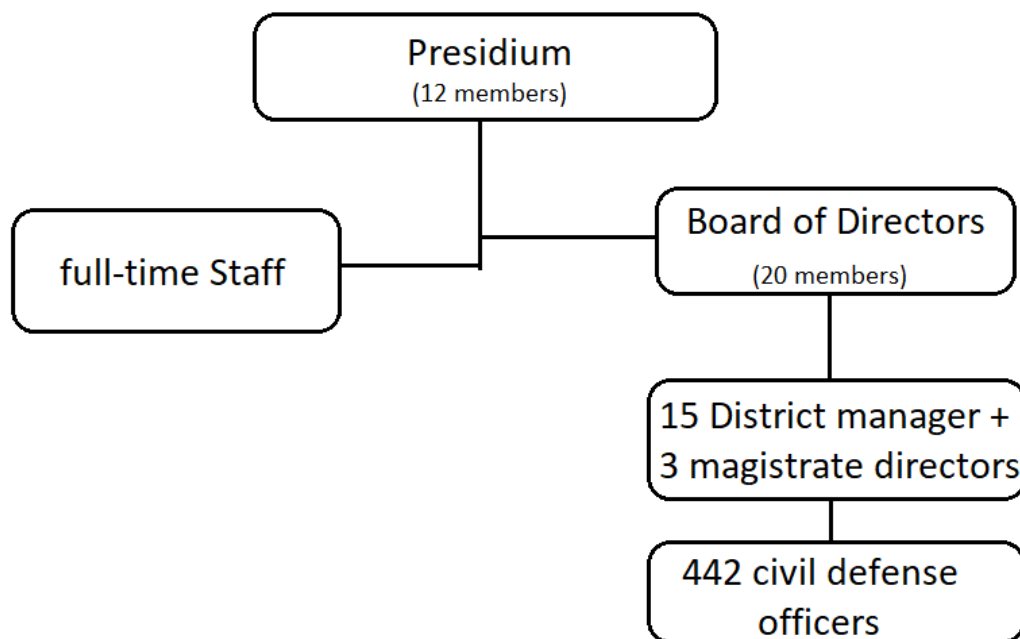


Figure 20: Main actors in the Austrian civil protection structure

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD
Viadonau.org	Regional	DRM	Flood
Red Cross Austria	National	DRM/CCA	Flood, Drought, Storm, Earthquake
Disaster Risk Management - Salzburg	Regional	DRM	Flood, Drought, Storm, Earthquake
VVÖ – Insurance Association Austria	National	DRM/CCA	Flood, Drought, Storm, Earthquake, Hail
Uniq – Insurance	National	DRM/CCA	Flood, Drought, Storm, Earthquake, Hail
VIG - Insurance	International	DRM/CCA	Flood, Drought, Storm, Earthquake, Hail
Generali-Insurance	International	DRM/CCA	Flood, Drought, Storm, Earthquake, Hail
University of Natural Resources and Life Sciences-BOKU	National	DRM/CCA	Flood, Drought
European Commission/ JRC	International	DRM/CCA	Flood, Drought, Storm, Earthquake, Hail
Central Institute for Meteorology and Geothermal Energy (ZAMG)	National	DRM	Flood, Drought, Storm, Earthquake, Hail
Federal Ministry of Agriculture, Forestry, Regions, and Water Management	National	CCA	Drought, Flood, Hail, Storm

Table 5: Stakeholder overview Vienna

2.3.1.2 Zala County, Hungary

Zala County, situated in the southwestern region of Hungary, exhibits a diverse and intriguing geographical composition. The terrain is characterized by undulating hills and low mountains, creating a visually captivating landscape. The topography is a result of tectonic and erosional processes over geological time scales, shaping the county's distinct features. The county has very significant agricultural cropping and production. The road network is of average quality. The region has a very scattered village structure: Zala County has one of the highest proportions of settlements in terms of territory: it is made up of a fragmented number of small villages, with a few towns that have been established as major regional hubs. There are almost 300 settlements in the county. Many of the small settlements are spread over a large area of intensively farmed land with varied topography. This is where extreme rainfall caused by climate change has hit: in recent years, unprecedented mudslides have developed in the county: floods wash muddy soil from agricultural land into the public areas, residential yards, and road networks of small, populated settlements, causing significant erosion of agricultural land and a constant challenge for water and disaster management professionals involved in the cleaning up and remediation of damage. The mud blocks drains, floods ditches and damages paving and asphalt roads. The water authority's staff have not yet devised a permanent solution to this new type of threat: it is likely that protective structures and changes in cultivation methods will have to be introduced in several areas of the county to reinforce natural water retention and thus slow down the speed and flow of the water, and to divert floodwater away from populated areas.



Figure 21: Mudslides effect along roadways in the Zala Region. Photo courtesy of Zala Special Rescue Team



Figure 22: Overview map of Zala County in Hungary. Depicting the regions river network and Lake Balaton.

To the southwestern edge of Zala County lies the renowned Lake Balaton, a large freshwater lake formed during the Quaternary period. The presence of Lake Balaton has a significant influence on the local climate, creating a moderating effect on temperature and fostering unique ecological conditions in the surrounding areas.

The county is traversed by the meandering Zala River, which has played a vital role in shaping the fluvial landscape of the region. The river's hydrological dynamics have contributed to the formation of fertile floodplains and wetland habitats, supporting diverse flora and fauna.

Kis-Balaton, an expansive wetland area, is situated to the south of Lake Balaton, designated as a protected nature reserve of high ecological importance. This wetland ecosystem provides a sanctuary for various bird species, making it a site of interest for ornithologists and conservationists.

The county's thermal springs and geothermal activity can be attributed to its location within the Pannonian Basin, known for its geological subsidence and heat flow. These natural hot springs have led to the development of numerous thermal spas, making Zala County a popular destination for wellness tourism.

Lake Balaton, situated in the western part of Hungary, is a large shallow lake with a surface area of 605 km² (official data) and an average depth of 3.6 m. The shape of the lake is slender with a length of 77.8 km and a width of 7.7 km on average. The narrowest point is the Tihany Strait. Here the accelerated lake current erodes the bottom sediment to more than 10 m depth. The catchment area of the lake is 5,188 km² excluding the surface of the

lake itself. Out of the many water courses that enter the lake River Zala is the most significant, contributing 45 % of the catchment area.

The southern shore is characterised by a gently deepening, velvety quicksand due to its lotic conditions. Reed belts cover major parts of the southern shore and the area around Keszthely Bay. Due to its shallow waters the lake responds quickly to changes in air temperature and solar radiation. During the summer it is not rare that the water temperature exceeds 25° C, while in winter the lake freezes. For management purposes the lake is usually subdivided into four basins, namely Keszthely-, Szigliget-, Szemes- and Siófok, from west to east.

The Sió or Sió-csatorna (Sió-Channel) is a fully regulated river in midwest Hungary. It is the eastward outlet of Lake Balaton at Siófok. It flows into the river Danube near the city of Szekszárd. Sió flows through the Hungarian counties Somogy, Fejér and Tolna, its main tributaries are Kapos from the right and Sárvíz from the left. It is 124 km long and its basin size is 14,693 km². The drainage basin of Sió (including Balaton) covers more than a third of Transdanubia. Its average discharge at the mouth is 39 m³/s (1,400 cu ft/s).

Two major areas can be distinguished in terms of the importance and the tasks of the RWL: the intensification of excessive water and flooding, storms, and the more prolonged drought in winter, spring and summer, the lack of water and the resulting forest and bush fires.

Zala County, located in southwestern Hungary, possesses diverse and fascinating hydrogeographical features. The county is traversed by several important rivers, with the Zala River being the most significant. This river is a tributary of the Danube and plays a crucial role in the regional hydrological system. Additionally, smaller streams and creeks crisscross the county, contributing to the overall drainage network.

Wetlands and Lakes: The region is home to various wetlands and shallow lakes, which support a rich diversity of plant and animal species. These wetlands act as essential habitats for migratory birds and other wildlife, making Zala County a significant ecological hotspot. **Karst Landscapes:** In some parts of the county, karst landscapes are prevalent. Karst refers to a topography formed by the dissolution of soluble rocks, such as limestone, resulting in unique landforms like sinkholes, caves, and underground rivers.

Groundwater Resources: Zala County's hydrogeological conditions are favourable for groundwater accumulation. As a result, groundwater plays a crucial role in supplying water for various human activities, including agriculture and public consumption.

Monitoring and addressing the impacts of drought and flood events in Zala County require a combination of sustainable water management practices, climate change adaptation strategies, and community awareness. Local authorities and stakeholders need to work together under the umbrella cooperation of the RWL to develop resilience against these natural hazards and protect the well-being of the region's inhabitants and ecosystems.

The development of a county climate strategy, and even more so its implementation, requires a broad county-wide cooperation, which is primarily due to two reasons. Firstly, climate change affects almost the whole of the county's society, economy, natural environment, and infrastructure, thus requiring the involvement of representatives of the institutions concerned, and secondly, the Zala Regional Council, as the developer and adopter of the climate strategy, does not have the powers to fully implement the planned measures. Action and adaptation to climate change must therefore be a shared concern of the people, farmers, entrepreneurs, and workers in the county. It cannot be denied that the tasks relating to climate change, their content, and the order of priority between them may be perceived differently by the various stakeholders, institutions, and organisations in the county. This fact underlines the importance of dialogue and professional debate, which is one of the key challenges for the future.

In 2017, the Zala County Climate Change Platform was established as a forum for county-level discussions and debates on climate change. The Platform was a result of previous grant funding that has already addressed climate change at county level through a short-lived collaboration. Based on the minutes that have been preserved, it is envisaged that we will re-contact the partners that were previously involved in the Climate Change Platform because they initiated a dialogue that could not go further due to the level of expertise

available, beyond the production of a written document. As a result, the meetings and the professional forum ceased.

At the end of the paragraph a list of higher education and public administration institutions, scientific, advocacy and civil society organisations represented is provided.

Furthermore, as climate change is a wider issue, more organisations have been consulted in addition to the members of the Climate Change Platform in the development of the climate strategy (full list at the end of the paragraph).

Current flood protection measures

A total of six protection depots are maintained and operated on the territory of the Directorate. A yearly revision of security stocks and security equipment is carried out. The materials and equipment stored in the warehouse are available in the quantities required for flood protection in the protection sections. In total, around 238,000 bags are stored in emergency warehouses and 11 large and 22 small mobile pumps with generators are available in case of flood events.

A group of 56 dam guards, 13 machine operators and 30 technical managers are involved in the protection.

In the event of major floods, the Directorate cannot deploy enough of its own staff to deal with the major protection works in its area of operation, and may therefore need to call on external resources, technical equipment, and transport vehicles. The availability of external forces and equipment will be ensured through cooperation agreements.

Due to the topography of the area in which it operates, flood events occur quickly, so mainly partners, civil engineering companies and transport companies operating in the region are expected to help with the protection work, which is made possible by cooperation agreements.

List of consulted organizations

The following higher education and public administration institutions, scientific, advocacy and civil society organisations represented:

University of Pannonia Nagykanizsa Campus; Pannon University Mechatronics Training and Research Institute, Zalaegerszeg; Budapest University of Economics, Faculty of Business Administration, Zalaegerszeg; University of Pécs, Faculty of Health Sciences; Hungarian Academy of Sciences, Research Centre for Economics and Regional Sciences (MTA KRTK), Institute of Regional Studies, West-Hungary Department, Győr; Social and Child Protection Directorate General, Zala County Branch; National Chamber of Agriculture, Zala County Directorate; Zala County Chamber of Commerce and Industry; Hungarian Agri-Environmental Association; Green Zala Nature Protection Association; Kaán Károly Environmental Protection Association; Alternatíva Naturbarát Egyesület;

IMRO-DDKK Nonprofit Ltd. Keszthely Environmental Protection Association; Association of Climate Friendly Settlements.

Organisations consulted in addition to the members of the Climate Change Platform in the development of the climate strategy:

Balaton-Highlands National Park Directorate; Balaton Integration Ltd.; Délzalai Víz- és Csatornamű Zrt.; Hévíz Spa and Szent András Rheumatology Hospital; Lenti Gyógyfürdő Kft.; Nyugat-Dunántúli Vízügyi igazgatóság; National Hungarian Hunting Association of Zala County; Ernő Soós Water Technology Research and Development Centre; Zalaerdő Zrt.; Zala County Care Unified Social Institution; Zala County Disaster Management Directorate; Zala County Government Office, Public Health Department; Zala County St. Rafael Hospital; Zalavíz Zrt.

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD
West Transdanubia Water Directorate	water treatment and management	DRM/CCA	Flood, Drought
Association of Volunteer Firefighters	Fire prevention, fire rescue, etc. – Regional	DRM/CCA	Flood, Drought, Storm, Hail
Zala County Territorial Protection Committee	Territorial protection and administration – Regional	DRM/CCA	Flood, Drought, Storm
MouldTech Systems	Tech-company – Regional	DRM/CCA	Flood, Drought
City of Nagykanizsa	Local municipality – Regional	DRM	Flood, Drought, Storm, Hail
Municipality of Zala County	County municipality – Regional	DRM	Flood, Drought, Storm, Hail
Hungarian Road Department	Road Operator – Regional	DRM	Flood, Drought, Storm, Hail
City of Zalaegerszeg	Local municipality - Regional	DRM	Flood, Drought, Storm, Hail
Zalaerdő PLc.	Forest Management, Woodwork – Regional	DRM/CCA	Drought
National Association for Radio Emergency and Info communications	professional activity - related to the enhancement of road traffic and water safety – National	DRM	Flood, Drought, Storm, Hail
EDER STT Special Tank Transport	hazardous material transfer, ADR – National	DRM	Flood, Drought, Storm
Zala County Disaster Management Directorate	Disaster management – National	DRM/CCA	Flood, Drought, Storm, Hail
Town of Keszthely	Local Municipality – Regional	DRM	Flood, Drought, Storm

Table 6: Stakeholder overview Zala County

2.3.1.3 Belgrade, Serbia

Serbia is in the border area between Central and Southeastern Europe and includes not only the central Balkans but also the southernmost foothills of the Pannonian Plain. It borders Bosnia-Herzegovina, Bulgaria, Croatia, Hungary, northern Macedonia, Montenegro, Romania, and Albania. Serbia is a landlocked country, but it has access to the Adriatic Sea via Montenegro and direct access to inland Europe and the Black Sea via the Danube.

Serbia's relief is varied, ranging from agriculturally productive locations such as the Pannonian Plain in the autonomous province of Vojvodina to the north, to hilly terrain in Sumadija in central Serbia, to mountainous terrain such as the Balkan Mountains in the far southeast of the country with peaks over 2,500 meters high. The mountains of Serbia are crisscrossed by a multitude of gorges. One of the most famous gorges is the Iron Gate on the Danube River, which separates the southern Balkan Mountains from the Carpathian Mountains.

The rivers of Serbia belong to three basins and flow respectively into the Black Sea, the Adriatic Sea, and the Aegean Sea. On the Crnoljeva mountain range is the hydrographic border between the drainage areas of the Adriatic, Aegean, and Black Seas. From the highest point of Drmanska glava (1,367 m), the rivers run via the White Drim into the Adriatic, via the Sitnica and Ibar into the Black Sea, and via the tributaries of the Lepenac to the Vardar and the Aegean. Due to a hydrographic peculiarity, the Nerodimka in the Sitnica drainage system in Kosovo even drains into two seas through a bifurcation.

The lowland of Vojvodina represents the largest hydrographic node in Europe. Here rivers from the Alps, Central Europe, the Dinarides and Carpathians coincide. With the Drava (on the Croatian side), the Tisza, the Sava and the Danube, all navigable rivers of Southeastern Europe meet in Vojvodina. The region, which used to be at high risk of flooding, is no longer endangered today due to the large-scale project of the Danube-Tisza-Danube Canal and the lowering of the groundwater level.

The capital region of Belgrade is affected by floods at irregular intervals. This year, 56 municipalities and cities were affected because of 14 days of rainfall.

During this period, various parts of the Republic of Serbia experienced persistent heavy rains with an intensity of 30 to 80 litres per square meter within 12 hours.

They caused landslides in some municipalities and severely damaged important infrastructure such as roads and bridges, agricultural land, and residential houses. Affected households suffered significant damage to homes, infrastructure necessary for daily life, and livelihoods of the local population. Households in rural areas and villages suffered major damage to agricultural land. According to the Red Cross 15.432.



Figure 23: Map of Belgrade, Serbia

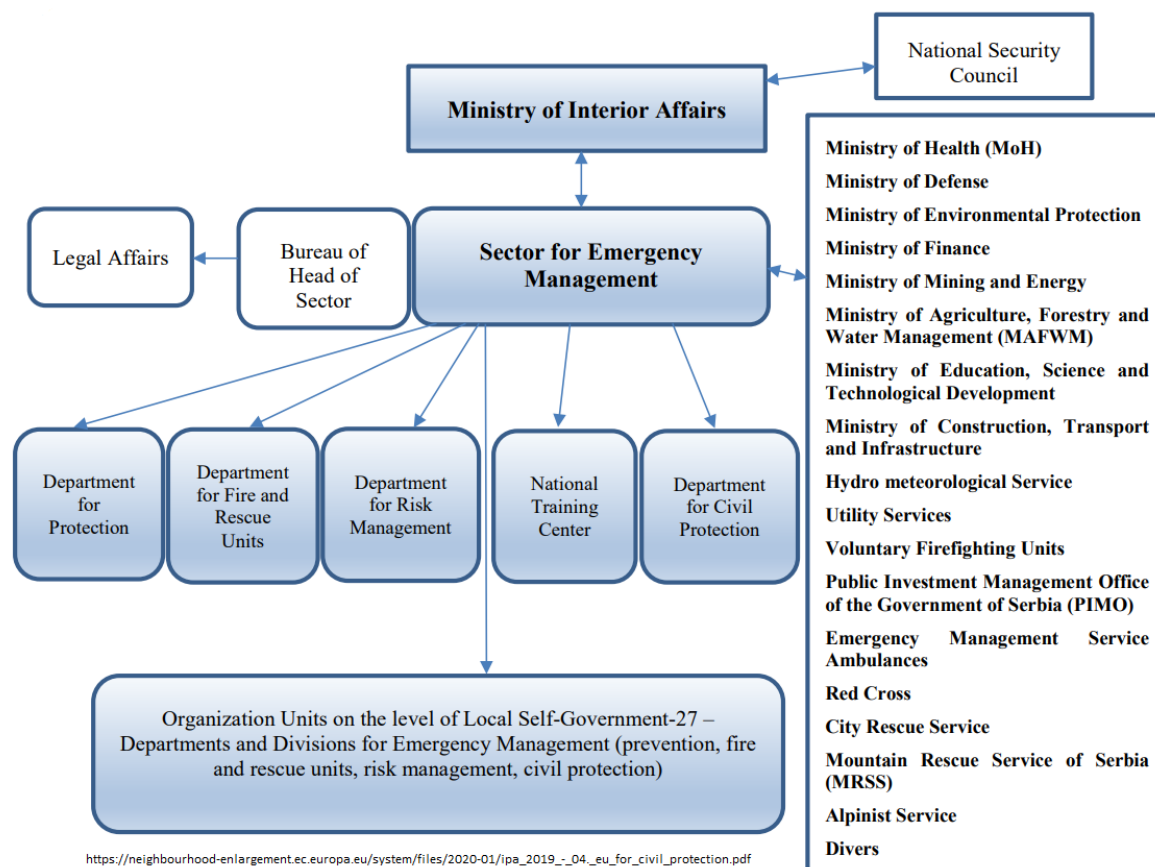


Figure 24: Overview of Stakeholders involved in the Sector for Emergency Management in Serbia

Serbia joined the EU Civil Protection Mechanism in 2015 to get support in preparedness and prevention, monitoring and best practice sharing of disaster risk management strategies.

Within the Ministry of Interior, the Sector for Emergency Management (SEM) is the leading departmental entity which is organized along four key areas: prevention, fire and rescue, risk management, and civil protection. In 2009, with the introduction of the Law on Emergency Situations, SEM was recognized as a single body within the Ministry of Interior where all emergency services from MOI, Ministry of Defence and Ministry of Environment are integrated. Since 2011, the Ministry of Interior is leading the National Emergency Management Headquarters (NEMH). Their role is to coordinate activities and measures included in the Serbian National Strategy for Protection and Rescue in Emergencies. SEM led the preparation of the National Risk Assessment and approved all the local risk assessment documentation. They have national and regional Information Centres (RCO) which are responsible to communicate all information to ministries and other actors. They prepare a bulletin including data from RHMSS. SEM has regional representation which support monitoring of the Local or City Emergency Management Headquarters activities and department of Civil Protection, City Administration.

National: The Ministry of Defence and the Ministry of the Interior are responsible for:

- The overall legislation (Law on Emergency Situations)
- Development and implementation of policy (e.g., National Security Policy)
- Providing information
- Disaster Risk Prevention
- Monitoring and coordinating implementation of measures envisaged in the National Strategy for Protection and Rescue emergency

Regional autonomous provincial authorities are responsible for:

- Providing relevant risk information
- Organizing the functioning of civil protection in its territory
- Planning and development of a protection system
- Determining the fund resources for performing the tasks of civil protection program
- Development and implementation of civil protection measures
- Forming headquarters for emergency situations
- Cooperation and coordination with other levels or institutions involved in DRM and CCA
- Preparation risk assessment and plan of protection and rescue in emergency situations

Local municipal authorities are responsible for:

- Providing relevant risk information to the population
- Using the State police or army for civil protection
- Organizing a functioning civil protection and ensuring its implementation
- Creating a plan and program to development a protection and rescue system
- Planning and identifying fund sources

- Training staff for emergencies
- Direct cooperation with relevant departments, other governmental agencies, companies, and other legal entities
- The preparation of risk assessment and protection and rescue in emergency situations

Since 2003, the core responsibility for observations, forecasts, and warnings of extreme meteorological and hydrological events resides with the Republic Hydro-meteorological Service of Serbia (RMHSS). They are a national institute not part of any Ministry. They produce information for 1st level rivers on the current water levels and forecasts with 2 days lead time for the Sava and Danube. For 2nd level rivers they produce information on the water level trend – going up or down. They have 50 automatic rain gauges and 198 water level gauges (120 automatic). Their forecasts are produced for regions. It does indicate a warning level based on the response plan – yellow, orange, or green (based on MeteoAlarm).

The Directorate for Water (DW) under the Ministry of Agriculture, Forestry and Water combines the responsibility for water resource management and floods protection on first level water courses, drainage, water supply and sanitation services. Under the Water Law, the water directorate is responsible for the three steps of flood analysis: Preliminary flood risk assessment for each river basin; Flood mapping including flood hazard maps and flood risk maps; Floods risk management plans, to be completed by 2015.

The water directorate is also responsible for the flood risk assessment and for preparation of the national plan for floods protection (each 5 years), as well as the annual plans in collaboration with other stakeholders.

However, they are not involved in any implementation or operational activities, all of which is done by the Public Water Companies.

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD
Republic Hydrometeorological Service of Serbia	Hydrometeorological early warning system - National	CCA	Drought, Flood, Storm, Hail
Vode Vojvodine	Public Water Management Company, Novi Sad - Regional	DRM/CCA	Drought, Flood
Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences,	University of Novi Sad - Regional/National	DRM/CCA	Drought, Flood, Storm, Hail
UOS Insurance Association	Belgrade - Regional	DRM/CCA	Drought, Flood, Storm, Hail

Table 7: Stakeholder overview Belgrade

2.3.2 Framing CCA and DRR in the RWL

The effects of climate change in Austria, as in most areas of the Danube River Basin are reflected in an increased yearly average temperature (approx. 2°C in the last 40 years in Vienna). Also heat waves, heavy rainfall events and dry periods have increased. Studies predict a further warming of up to four degrees Celsius by the year 2100 and a particularly significant increase of days with temperatures above 30 degrees Celsius.

Soil sealing, lack of green spaces, the heat storage capacity of building materials and heat sources from residential, commercial, and industrial areas contribute significantly to the heat island effect in urban areas.

In addition, precipitation patterns are also changing. When long periods of drought are followed by heavy rainfall events, the desiccated soils are significantly less able to absorb moisture, which in turn increases fluvial and pluvial flooding whereby the dried-out soils can only absorb a small amount of the incoming rain. As a result, agricultural areas as well as trees in urban areas suffer more frequently from pluvial runoff and drought stress. Increased damage to infrastructure and structural facilities due to weather extremes is also to be expected, such as localised flooding, the melting of asphalt or the heat-induced expansion of tracks. Just recently in August 2023, during a long-lasting heavy rainfall event, communities in two-thirds of the Slovenian territory were affected by heavy flooding. Because a dam broke on 5th of August in the east of the country it was necessary to hurriedly bring 500 people to safety from the village of Dolnja Bistrica in the east of the country. The total damage caused by the floods in Slovenia alone is estimated at over 500 million Euros.

The Austrian provinces of Carinthia and Styria were also significantly affected by the same prolonged precipitation that hit Slovenia and caused severe flooding and landslides. The damage is estimated at several tens of millions of euros. According to the Austrian Association of Insurance Companies (VVO), losses of €1 billion are incurred in Austria each year because of such natural disasters.

In addition to technical modeling and making the results available to the public, however, the importance of a well-coordinated civil defence system that can intervene quickly and in a targeted manner to keep personal injury and property damage to a minimum is also emphasized.

DRM events in Zala County

Zala County was hit by heavy rainfall and floods several times. The overflowing rivers caused significant damage to infrastructure, homes, and agricultural fields.

2013 Danube Floods: While not directly impacting Zala County, the 2013 Danube floods had downstream effects, with water levels rising in the Danube tributaries, including the Zala River. The flood alerts and potential for further inundation required vigilance, alert, and preparedness in the region.

The Western Transdanubian Water Management Directorate manages 48 km of the Mura River in Zala County, 1628 km of watercourses, ditches and inland water channels, 128 km of flood protection embankments (43 km Mura, 34 km Zala, 51 km Kis-Balaton), 2 flood reservoirs (Kerka reservoir, Kebele reservoir), 2 storm water reservoirs (Kozmadombi stream in Zalatárnok and Rátka stream in Murarátka), 9 inland water pumping stations and the Kis-Balaton Water Protection System.

In accordance with Decree 10/1997 of the Ministry of Water Management (Western Transdanubia Water Directorate -NYUDUVIZIG) reviewed the water and facilities under its management in September-October 2022, and an evaluation meeting was held on 15 November 2022.

The annual maintenance and upkeep of the flood protection embankments has been fully carried out and the embankments are in good condition. However, they are not up to standard, except for the entire Murakeresztur floodplain and a small part of the Letenye floodplain.

Zala County, like many other regions in Hungary, experienced a severe drought during in recent years. The lack of precipitation and high temperatures led to a significant water deficit, affecting agricultural productivity, and causing water shortages.

In 2020, Hungary faced a major drought event, and Zala County was not exempt from its impacts. The prolonged dry period affected crop yields, led to decreased water levels in rivers and lakes, and posed challenges for water supply and irrigation.

From the point of view of outdoor fires, the dry spring period due to the current extreme, shifting rainfall patterns is the most dangerous time, as more and more people choose outdoor activities or start gardening in good weather, while undergrowth is extremely dry due to the lack of rain. The main danger is from dry ground vegetation and undergrowth, where fires can spread quickly and easily. Apart from a few exceptions, fires in the open air are caused by human negligence, even though residents and operators are constantly informed about how to prevent fires in the open air (indoors and outdoors), and the rules and regulations, by telephone, by letter, e-mail, via the local disaster management authority's website and the local media.

In 2022, 240 outdoor fires occurred in the Zala County Disaster Management Directorate's area of responsibility, and 50 fires occurred between 01.02.2023 and 31.03.2023. These incidents covered an area of 6,659,606 m² in 2022 and 487,148 m² in the first quarter of 2023. The most affected area (7,124,808 m² in total) was forest and vegetation. Still, there were also fires in public places, on land used for livestock, and open burning of waste and rubbish, which required fire brigade intervention.

It is clear, however, that in addition to the organizations listed above, the successful implementation of the climate strategy will require the cooperation of other institutions (e.g., schools, kindergartens – early education, training for the youths). The long-term cooperation framework and partnership plan will be discussed at a later stage of the project.

There is a consensus among stakeholders that water damage mitigation could be a focus for cooperation.

The expected increase in high intensity rainfall due to climate change, coupled with the topography of the Zala landscape, will create ideal conditions for flash floods. However, flood risks are also expected to increase along the larger watercourses, such as the River Zala, River Kerka, and the River Mura, which have higher discharges. The objective is to reduce water damage to buildings and agricultural land by encouraging the construction and expansion of reservoirs to protect against flash floods, the use of municipality' drainage systems designed to retain water, the application of agrotechnical measures to reduce run-off, the installation of agroforestry systems and the development of flood protection works along major rivers.

The partners involved would like the project to result in a risk analysis that is based on scientific findings and takes maximum account of local conditions. In other words, they do not expect a general risk assessment at national level, but to show the authorities and the population, in a regional-district, or micro-regional breakdown, what is to be expected, and what adaptation strategy should be followed at municipal-regional level. This could be a scientific assessment, but it would help communication if the organizations involved in the DIRECTED partnership could also present or support the characterization of risks in line with the project objectives with infographics, tables, visual assessments, on a map. The production of a climate risk map of the county would fill a gap, as neither the municipalities nor the authorities have the resources to do this, and everyone has only partial information or knowledge. Local actors cannot easily evaluate and judge accuracy and effectiveness of the various climate projections, as such kind information is too far from their area of expertise. DIRECTED can help by providing a high-resolution, localized risk assessment and proposal based on the available information.

2.3.3 RWL setup Process, achievements and gaps

The development of the RWL Danube Region started with a basic analysis of the structures of disaster management dealing with potential consequences of climate change on the national level of the country. Here, major differences between the Danube riparian states were identified. Stakeholders were primarily contacted by phone and email and then informed about DIRECTED whenever possible in person or by video call.

The focus regions of the analysis regarding the level of disaster management and adaptation for adequate climate change management are Vienna, Austria, the Zala region near Budapest and Belgrad in Serbia. Stakeholder engagement in Serbia is at this stage of the project still behind progress in Austria and Hungary. However, all countries located in the Danube basin shall be analysed within the next months that a basic understanding of their preparedness for the consequences of climate change and disaster risk management can be given. The Future Danube Model³ will serve as central tool for the analysis and communication of climate change impact on hydrological extremes in the region.

The main difficulty in stakeholder recruitment was and is the language barrier, as speaking English as a second language is not as common in the Eastern European countries of the Danube River Basin as it is in the Western European countries. This results in the need to either obtain the necessary information via an external native speaker in each country or to work with an interpreter. Both options are time-consuming and costly compared to communication in English. Since our project partner Levente Huszti is a native Hungarian, it was natural to analyse disaster management in Hungary in more detail. Likewise, our existing contacts in the research and insurance industry in Serbia were used to gain insights into the management situation there. Despite these locally, regionally, and nationally well-connected contacts, it turned out to be more difficult than expected to get the requested information in the desired time frame. On the one hand, we were told that the time it takes to receive a response from state institutions in Eastern European countries such as Bulgaria, Moldova, Serbia, and Romania are sometimes weeks and that patience, and a lot of time are necessary. On the other hand, the public and political awareness of the necessity to deal with climate change and its consequences tends according to initial research to not be as distinctive as in more western countries like Germany, Austria, Slovakia, Croatia, and Hungary.

In the western Danube riparian countries there is high awareness of the need to understand climate change and to preventively combat negative consequences, pronounced and promoted by a variety of EU initiatives. The awareness and access to financial resources provided by the countries for these measures decreases steadily, the further one analyses the Danube states towards the east. As such, experiences of managing risk can be exchanged between eastern and western Danube countries. According to initial research, reasons for this fundamentally different perception of climate change may also be related to the level of technological development, political system, and general level of education of the population. This divergence will enable learning through exchange of knowledge around models/ tools, governance, and communication processes to develop contextually appropriate DRR/ CCA solutions.

Lessons learned

- The awareness of DRM and CCA is very heterogeneous in the different countries of the Danube River Basin, which can be explained by cultural, social, political, and technological aspects. The stakeholder engagement approach should be individually adapted to the needs of each entity in the country to increase the chance for fruitful cooperation
- Start actively engaging stakeholders, ask for concrete contributions as soon as possible because response periods may be significantly longer than anticipated

³Hattermann, F. F., Wortmann, M., Liersch, S., Toumi, R., Sparks, N., Genillard, C., Schröter, K., Steinhausen, M., Gyalai-Korpos, M., Máté, K., Hayes, B., del Rocio Rivas López, M., Rácz, T., Nielsen, M. R., Kaspersen, P. S., & Drews, M. (2018). Simulation of flood hazard and risk in the Danube basin with the Future Danube Model. *Climate Services*, 12, 14–26. <https://doi.org/10.1016/j.cliser.2018.07.001>

- Patience and perseverance in explaining benefits to stakeholders is very important, especially in the eastern countries of the Danube River Basin
- Target the benefits that can accrue to stakeholders based on their individual needs. Benefits that are attractive to one stakeholder group may be unattractive to another stakeholder group

2.3.4 RWL Next Steps

- Completion of the test sites Vienna, Zala County and Belgrade by collecting formal letters of support.
- Planning (in October 2023) a workshop for the Vienna and Belgrade test site at the beginning of November in Vienna (or online).
- Presentation of the DIRECTED project at the Danube Flood Forecasting Forum (DAFF) in Budapest from 10-12.10.2023 for evaluation of the status of the DRM and CCA in the Danube River Basin and continued selective stakeholder recruitment in further Danube riparian countries.

2.4 RWL4 – The Rhine-Erft Region

2.4.1 RWL Study Area Definition and Stakeholder Landscape Analysis

The Real World Lab (RWL) Rhine-Erft Region is in the federal state of North Rhine-Westphalia, Germany. At the present time the RWL includes the districts of Euskirchen and Rhein-Erft, comprising 21 municipalities in total. The RWL area can be divided into the northern and the southern part. The northern part is characterized by a less pronounced relief, which belongs to the North German Lowlands [4] [5]. The land use of the northern area is predominantly shaped by agriculture and open-pit lignite mining [6]. There are minor scattered forested areas as well as oxbow lakes [8]. Besides visible mining-pits, the mining activities have caused a lowering of the groundwater table, due to dewatering activities of up to 509 million m³ per year. Around 270 million m³ per year are discharged into the river system. Accordingly, the rivers of the northern basin have been steadily adapted over the past decades, being relocated, straightened, and expanded for higher capacity. With the planned termination of lignite mining activities soon and thus, reduced dewatering activities, the hydrological situation in the northern part will again change [9]. By comparison, the southern part comprises the Middle Mountain Range Eifel with a more pronounced relief and steep valleys around rivers and creeks [8]. The Eifel is part of the Central European Uplands [7] and is characterized by both forests and agricultural land. In the west, the study area also includes a slightly hilly heath landscape [8]. Almost the entire area of the Rhine-Erft RWL is part of the ~1.900 km² large Erft river catchment. The Erft rises south of Bad Münstereifel, has a length of about 100 km and flows into the Rhine in Neuss, near Düsseldorf [7].

In the German federal system, the civil protection is divided into civil defence and disaster control. The task of civil defence, which is the defence of the population against water related hazards, lies with the federal government. The districts within the counties are responsible for disaster control [8]. After defining the spatial distribution of the RWL area, the first step for the setup of the Rhine-Erft Region RWL was to involve the districts within the study area (district of Euskirchen and Rhein-Erft). Those are organized in different departments such as water authority and hazard prevention. For the bottom-up principal of the DIRECTED-project, the municipalities, which organize e.g., first responders in case of extreme events, also need to be involved. This will be carried out by involving the inter municipal flood protection corporation (FPC) the Erftverband has initialized after the flood in western Germany in 2021 [9]. The aim of the FPC is to support the municipalities in the creation of protection concepts and to coordinate those concepts across municipal borders. The DIRECTED project was already presented to the members of the FPC, but the engagement process is still ongoing.

⁴Federal Agency for Nature Conservation Germany (2023): Biogeografische Regionen und naturräumliche Haupteinheiten Deutschlands. <https://www.bfn.de/daten-und-fakten/biogeografische-regionen-und-naturraeumliche-haupteinheiten-deutschlands> (05/2023)

⁵ Federal Agency for Nature Conservation Germany (2015): Landschaften in Deutschland. <https://geodienste.bfn.de/landschaften?lang=de> (05/2023)

⁶Erftverband (2014): Der Erftverband stellt sich vor. https://www.erftverband.de/wp-content/uploads/2021/06/erft_imagebrosch-2014_web.pdf (05/2023)

⁷Erftverband (2021): Die Erft. <https://www.erftverband.de/die-erft/> (05/2023)

⁸Federal Office for Civil Protection (2023): Zivilschutz versus Bevölkerungsschutz. https://www.bbk.bund.de/DE/Infothek/Presse/Pressedossiers/_documents/pressedossier-artikel_zivil-bevoelkerungsschutz.html (07/2023)

⁹Erftverband (2023): Hochwasserschutz Kooperation Erft. <https://hws-kooperation.erftverband.de/> (07/2023)

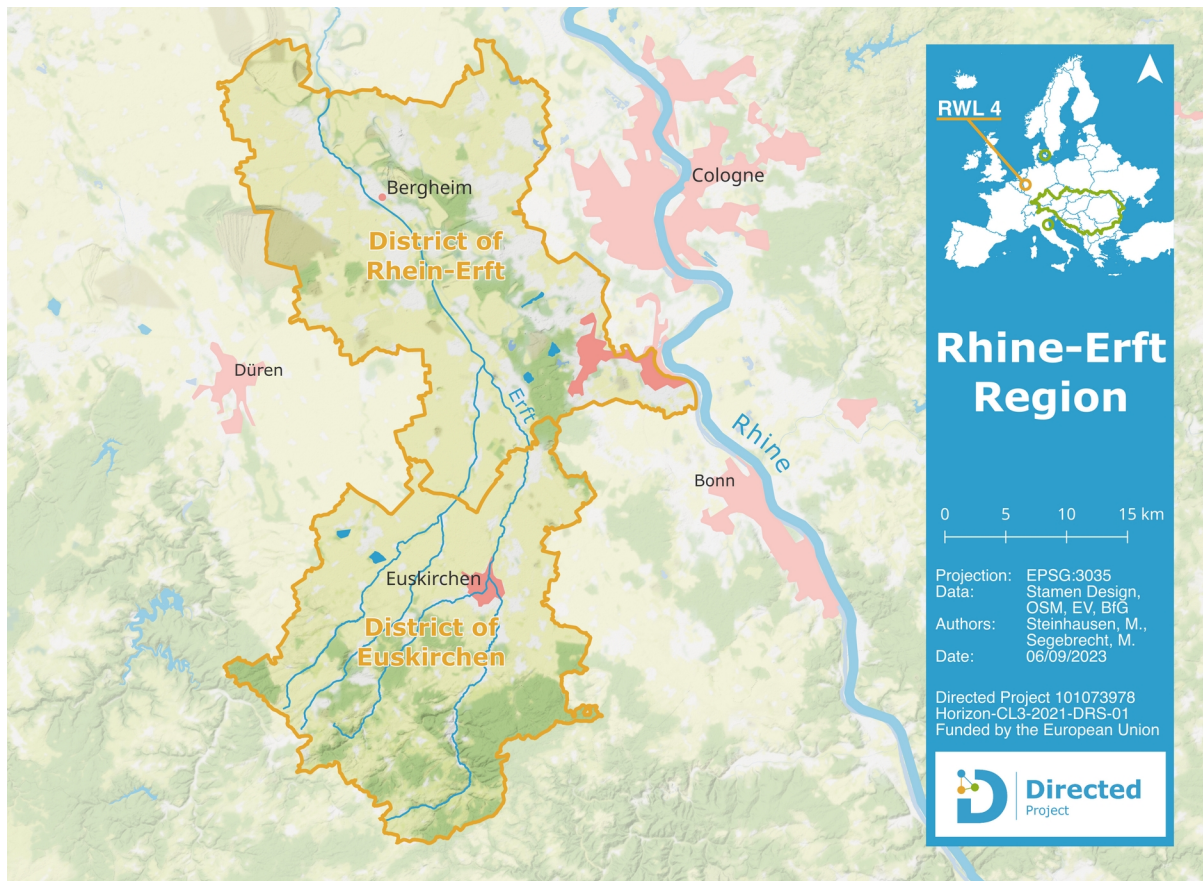


Figure 25: Overview map of the Real World Lab – Rhine-Erft Region

The district of Euskirchen is part of a project funded by the federal Ministry of Interior and Home Affairs with the topic of the protection of critical infrastructures through resilience governance. This project, called KRITIS, is also involved as stakeholder in RWL 4.

To benefit from knowledge and previous analysis of the situation in the study area, first exchanges with an insurance company, also providing e.g., workshops on the assessment of organization and risk management strategies for flood events, as well as with a scientific working group specialized in the field of hydraulic engineering, water management, and operative flood protection has taken place. The latter focuses on resilience in flood risk management, evaluation of extreme scenarios (e.g., dam-failure), and the development and improvement of trainings for e.g., first responders.

The inclusion of other districts, lying within the catchment area of the Erft, is also planned for the further development of the RWL (district of Rhein-Sieg, district of Düren and district of Rhein-Neuss).

The following flowchart gives an overview of the already obtained and contacted stakeholders within RWL 4. By now, between the districts of Euskirchen and Rhein-Erft there are only few communication patterns and defined communication pathways. The stakeholders outside the districts have had no contact with each other or the districts yet.

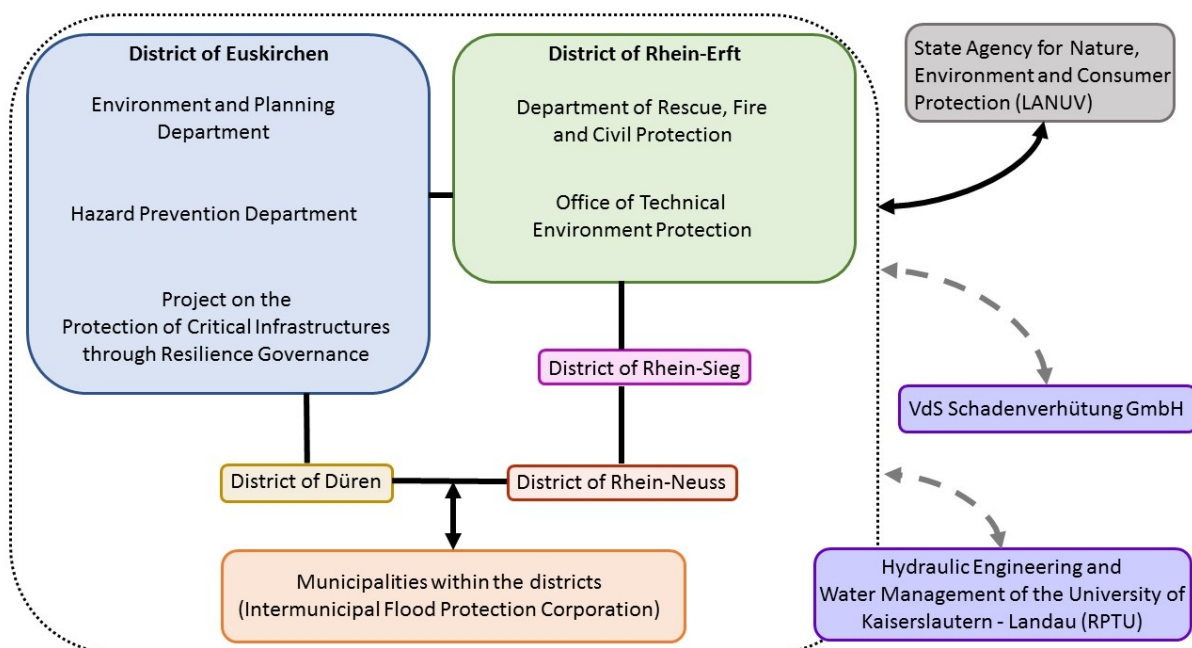


Figure 26: Flowchart showing the relationships between the involved and contacted stakeholders.

ORGANIZATION	GROUP	PHASE OF DRM/CCA	HAZARD	COMMENTS
Environment and Planning Department	District of Euskirchen	Responsible for DRR, DRM and CCA regionally	All	-
Civil Protection	District of Euskirchen	Responsible for DRR, DRM and CCA regionally	All	-
Department of Rescue, Fire and Civil Protection	District of Rhine-Erft	Responsible for DRR, DRM and CCA regionally	All	-
Department for Technical Environment Protection	District of Rhine-Erft	Responsible for DRR, DRM and CCA regionally	All	-
District of Rhein-Sieg	District	Responsible for DRR, DRM and CCA regionally	All	has shown interest in participating in DIRECTED, but no signed letter of engagement yet
District of Rhein-Neuss	District	Responsible for DRR, DRM and CCA regionally	All	has shown interest in participating in DIRECTED, but no signed letter of engagement yet
District of Düren	District	Responsible for	All	has shown interest

		DRR, DRM and CCA regionally		in participating in DIRECTED, but no signed letter of engagement yet
Municipalities of the district of Euskirchen (Bad Münstereifel, Blankenheim, Dahlem, Euskirchen, Hellenthal, Kall, Mechernich, Nettersheim, Schleiden, Weilerswist and Zulpich)	Municipalities	Responsible for DRR, DRM and CCA locally	All	have shown interest in participating in DIRECTED, but no signed letter of engagement yet
Municipalities of the district of Rhein-Erft (Bedburg, Bergheim, Brühl, Elsdorf, Erftstadt, Frechen, Hürth, Kerpen, Pulheim and Wesseling)	Municipalities	Responsible for DRR, DRM and CCA locally	All	have shown interest in participating in DIRECTED, but no signed letter of engagement yet
Municipalities of the district of Rhein-Sieg (Alfter, Bad Honnef, Bornheim, Eitorf, Hennef, Königswinter, Lohmar, Meckenheim, Much, Neunkirchen Seelscheid, Niederkassel, Rheinbach, Ruppichteroth, Sankt Augustin, Siegburg, Swisttal, Troisdorf, Wachtberg, Windeck)	Municipalities	Responsible for DRR, DRM and CCA locally	All	have shown interest in participating in DIRECTED, but no signed letter of engagement yet
Municipalities of the district of Düren (Aldenhoven, Düren, Heimbach, Hürtgenwald, Inden, Jülich Kreuzau, Langerwehe, Linnich, Merzenich, Nideggen, Niederzier, Nörvenich, Titz, Vettweiß) interest in participating in DIRECTED, but no signed letter of engagement yet	Municipalities	Responsible for DRR, DRM and CCA locally	All	have shown interest in participating in DIRECTED, but no signed letter of engagement yet
State Agency for Nature, Environment and Consumer Protection (LANUV)	State Agency	DRR, DRM and CCA	All	has shown interest in participating in DIRECTED, but no signed letter of engagement yet
VdS Schadenverhütung GmbH	Insurance company	Prevention, Preparedness	Flooding	has shown interest in participating in DIRECTED, but no signed letter of engagement yet
Hydraulic Engineering and Water Management	University of Kaiserslautern - Landau (RPTU)	Prevention, Preparedness	Flooding	has shown interest in participating in DIRECTED, but no signed letter of engagement yet

Table 8: Stakeholders involved and addressed in the RWL 4 Rhine-Erft Region

2.4.2 Framing CCA and DRR in the RWL

In North Rhine-Westphalia the recent climate observations show that air temperature as well as precipitation patterns have already started to change. Several years in the recent past were warmer and drier compared to past recordings. Also, heavy rain events have tended to increase leading to devastating events such as the flooding in 2021 [10].

The air temperature trend is significantly increasing, compared to previous records. In terms of precipitation, the pattern is more complex. Fluctuations tend to be more pronounced, thus, both increases and decreases in precipitation are observable. However, the past 30 years show a decrease in the annual amount of precipitation, but simultaneously a more frequent occurrence of heavy rain events especially during summer. The climatic extremes already observed in the region are droughts, pluvial and fluvial floods, as well as storms [13].

The impacts of climate change are already visible and noticeable as the heavy rain, has caused extreme flooding in Luxemburg, Belgium, the Netherlands, and western Germany, has shown in July 2021 [11]. The extent and the tremendous damages of this event showed that there is a major need of optimization of communication and disaster risk management processes. There were difficulties in e.g., warning and communication as well as in the awareness of the population observed [12]. Thus, a detailed consideration of the existing structures is required. Besides flood events the preparedness for other extreme climate events seems insufficient, too.



Figure 27: Flood retention basin Horschheim before the flood in 2021

¹⁰State Agency for Nature, Environment and Consumer Protection (LANUV) (2022): Klimabericht 2021 NRW. https://www.lanuv.nrw.de/fileadmin/lanuvpubl/3_fachberichte/Screen_Klimabericht_2021_2200214.pdf (07/2023)

¹¹German Weather Service (2021): Hydro-klimatologische Einordnung der Stark- und Dauerniederschläge in Teilen Deutschlands im Zusammenhang mit dem Tiefdruckgebiet „Bernd“ vom 12. bis 19. Juli 2021. https://www.dwd.de/DE/leistungen/besondereereignisse/niederschlag/20210721_bericht_starkniederschlaege_tief_bernd.pdf;jsessionid=3A9EF431EC9EC3251EB5A1137CDE4873.live21061?__blob=publicationFile&v=10 (07/2023)

¹²Bung, Daniel B. (2021): Extreme flooding in Western Germany: Some thoughts on hazards, return periods and risk. In: Hydrolink 2021/4. Madrid: International Association for Hydro-Environment Engineering and Research (IAHR). S. 108-113. <https://www.iahr.org/library/hydrolink?hid=412>.



Figure 28: Flood retention basin Horchheim during the flood in 2021



Figure 29: The Erft region during the flood in 2021

The stakeholders expect to improve the communication and the understanding among different actors in disaster risk management and climate change adaptation. Further, they would like to develop concrete results and measures that can be used in hazard prevention and lead to improved resilience to extreme climate events. They also pointed out the need to analyze and improve existing (governance) structures.

2.4.3 RWL setup Process, Achievements, and Gaps

The first step for the RWL 4 setup was to get in contact with the districts. Thus, an online meeting was organized where DIRECTED was presented and a first discussion was carried out. Afterwards, the representatives of the districts received a short questionnaire which focused on their experience during and after the flood in 2021, their expectations concerning DIRECTED as well as concrete ideas for the improvement of disaster risk management (DRM). The answers were analysed and discussed in a second meeting, which led among other things to the first concrete obstacles within the communication in the case of natural hazards that we can work on overcoming. Furthermore, to follow the bottom-up principle of DIRECTED, the project was presented during a steering committee meeting of the FPC and was met with a great response.

Hence, one of the next steps is to identify a contact person in each municipality. As we also strive to benefit from other expertise in the field of disaster risk management, we did present the DIRECTED-project to the Hydraulic Engineering and Water Management of the University of Kaiserslautern – Landau (RPTU) as well as to an expert on workshops on the assessment of organization and risk management strategies for flood events. The districts of Rhein-Erft and Euskirchen each signed the letter of engagement (Annex).

MEETING	LOCATION/ ONLINE	DATE (DD/MM/YY)	PARTICIPANTS	COMMENTS
First meeting with stakeholders	online	19/04/23	Jana Löhrllein (DIRECTED-project, Erftverband - EV), Dr. Julian Struck (project manager of the intermunicipal flood protection corporation, Erftverband), Dr. Daniel Bittner (head of department of river basin management, Erftverband), Marcel Schneider (team leader - water & soil conservation; district of Euskirchen), Martin Fehrmann (head of department of civil protection; district of Euskirchen), Peter Jonas (employee department of civil protection; district of Euskirchen), Sarah Nolting (reconstruction unit, leader of the project KRITIS-Dialog; district of Euskirchen), Christine Bernt (head of department of technical environmental protection; district of Rhine-Erft), Thomas Weiler (head of department of rescue, fire and civil protection; district of Rhine-Erft)	-
Second stakeholder meeting	Bergheim (in person)	29/06/23	Jana Löhrllein (DIRECTED-project, Erftverband), Dr. Julian Struck (project manager of the intermunicipal flood protection corporation, Erftverband), Dr. Dietmar Jansen (head of division surface waters, Erftverband), Per Seeliger (lawyer, Erftverband), Dr. Daniel Bittner (head of department of river basin management, Erftverband), Ulrich Muris (head of department river maintenance water operations, Erftverband), Dr.	-

MEETING	LOCATION/ ONLINE	DATE (DD/MM/YY)	PARTICIPANTS	COMMENTS
			Tilo Keller (team leader hydrology measurements and data management, Erftverband), Timo Schneider (project manager in the department of surface waters, Erftverband), Marcel Schneider (team leader - water & soil conservation; district of Euskirchen), Hartwig Kaven (employee water & soil conservation, district of Euskirchen), Peter Jonas (employee department of civil protection; district of Euskirchen), Sarah Nolting (reconstruction unit, leader of the project KRITIS-Dialog; district of Euskirchen), Christine Bernt (head of department of technical environmental protection; district of Rhine-Erft), Thomas Weiler (head of department of rescue, fire and civil protection; district of Rhine-Erft)	
First contact and introduction DIRECTED - VdS Schadenverhütung GmbH	Bergheim (in person)	30/06/23	Jana Löhrllein (DIRECTED project, Erftverband), Dr. Julian Struck (project manager of the intermunicipal flood protection corporation, Erftverband), Bettina Falkenhagen (VdS Schadenverhütung GmbH)	Showed interest in participating in DIRECTED (no signed letter of engagement yet)
First contact and introduction DIRECTED - department of hydraulic engineering and water management RPTU Kaiserslautern - Landau	Online	04/07/23	Jana Löhrllein (DIRECTED-project, Erftverband), Dr. Julian Struck (project manager of the intermunicipal flood protection corporation, Erftverband), Prof. Dr. Robert Jüpner (head of department of hydraulic engineering and water management RPTU Kaiserslautern - Landau), Dr.-Ing. Martin Fabisch (head of the department of surveying and geoinformation), Dr.-Ing. Hellen Hammoudi (research associate in the department of hydraulic engineering and water management), Selina Schaum (research associate in the department of hydraulic engineering and water management), Luzie Kretschmer (research associate in the department of hydraulic engineering and water management)	Showed interest in participating in DIRECTED (no signed letter of engagement yet)

Table 9: Meetings RWL 4 Rhine-Erft Region

During the setup of the RWL some difficulties were discovered that include the identification of the important actors in DRM and CCA. This issue could be solved by starting to contact and communicate stakeholders that shared their experiences and suggestions on who to involve. Thus, the option of expanding the list of stakeholders during the project simplifies the setup process. Further, the stakeholders seek for the definition of concrete aims and results in the end of the project, which can be difficult in the beginning. Hence, an explanation on the approach of the project being a process, as well as the opportunity and advantage that not to be fixed offers, was necessary. Also, the exchange within the project is important and the resources we have are valuable.

2.4.4 RWL Next Steps

The next steps in RWL4 include the analysis of the results from the second stakeholder meeting. Subsequently, a guideline for the implementation of the discussion results as well as the further procedure will be created. After the coordination of the guideline with the stakeholders, concrete measures such as the training of assessing situations in terms of weather and discharge forecasts will be conducted. Further, the collaboration with the already contacted and interested potential stakeholders will be developed. To serve the bottom-up principle, contact persons in each municipality will be identified.

3. Conclusions

This report comprehensively explores the Real World Labs (RWL) established in 4 different regions, focusing on the setup process and the actions taken to establish the labs, and engaging with stakeholders.

These labs are a collaborative environment to start working, in a bottom-up approach, with the involved key actors in disaster risk management (DRM) and climate change adaptation (CCA) chains. The RWL activities form the foundation for stakeholder engagement and inclusive risk governance that will be amplified through the knowledge co-production processes and application of the Risk-Tandem framework. Each RWL, namely the Capital Region of Denmark, Emilia-Romagna Region, the Danube Region (encompassing Vienna, Austria; Budapest, Zala County, Hungary; Zala Region, Hungary; and Belgrade, Serbia), and Germany's Rhine-Erft Region, faces distinct DRM and CCA challenges in their respective Study Areas, outlining vulnerabilities and areas for improvement.

Through the Study Area Definition and preliminary stakeholder landscape analysis, we gained insights into the peculiar geographical features and stakeholder dynamics, roles, and responsibilities in each RWL. Stakeholders from diverse organizations such as municipalities, civil protection agencies, and research institutions have been indeed involved in the Labs to start a collaborative journey towards more effective, synergic, and multi risk-based governance DRM and CCA.

Challenges such as increasing temperatures, extremes (e.g., heavy rain) events, and evolving hydrological conditions are common across RWLs, as well as some stakeholder expectations to improve communication pathways, enhance risk awareness and stakeholder involvement, and facilitate flexible governance models to tackle the urgency of climate adaptation and disaster preparedness. Furthermore, the significance of transdisciplinary collaboration between governmental bodies, research institutions, municipalities, and civil protection agencies emerged a common key message.

The established labs serve as foundation for incoming activities, to be carried on interacting with the different work packages. Particularly Work Packages (WP) 3 and 4 have already begun implementing the Risk-Tandem framework and associated knowledge co-production process in the RWLs, to enable and guide transdisciplinary and co-produced risk governance throughout DIRECTED. WP4 will train hosts (Trainers) of the RWLs on the principles of co-production and their application to risk governance, to support stakeholder activities required to operationalise RWLs (e.g., workshops, stakeholder mapping, analysis, or risk scoping). This work is further informed by the iterative capacity development strategy for Training of Trainers (D1.2) under development, complementary learning modules and training activities aligned with the Risk-Tandem. The training remains adaptive and responsive to emerging needs, with a focus on supporting hosts of RWLs to address their risk management challenges in a contextually appropriate manner. Learning activities and modules are thus developed through continuous consultations and annual capacity needs assessments with RWLs, first of which will be implemented toward the end of 2023 to inform the development of training activities in 2024. Finally, Task 1.3 will involve evaluating the impact of the implementation of the Risk-Tandem framework and related governance mechanisms in the RWL, which will happen at a later phase in project.

Partners

