COVALEX

Funded by the European Union

NALAS TRAINING

EFFECTIVE APPLICATION OF DRR IT TOOLS FOR HYDROMETEOROLOGICAL HAZARDS AT A LOCAL LEVEL

Participants' Guide

PARTNERSHIP

NALAS

cima RESEARCH FOUNDATION

HELLENIC REPUBLIC
Ministry for Climate Crisis and Civil Protection

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DCNAustria
Disaster Competence Network Austria

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This publication is prepared within the European Union-funded project COVALEX (Community of Valued Experts in Hydrometeorological and Technological Multi-Hazards).

The project is implemented by NALAS in a consortium with the University of A Coruna (Lead partner), CIMA Foundation, Italian Red Cross, Greek General Secretariat for Civil Protection and Disaster Competence Network Austria.

Content

Acronyms

5G	The fifth generation of wireless cellular technology
AAL	Average annual loss
AR	Augmented Reality
AR6	Sixth Assessment Report
BIH	Bosnia and Herzegovina
CC	Climate change
CCA	Climate change adaptation
CRED	Centre for Research on the Epidemiology of Disasters
DCNA	Disaster Competence Network Austria
DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
DRM	Disaster risk management
DRMKC	Disaster Risk Management Knowledge Centre
DRR	Disaster risk reduction
DW	Deutsche Welle
ECMWF	European Centre for Medium-Range Weather Forecasts
Eco	DRR – Eco-Disaster risk reduction
EENA	European Emergency Number Association
EFAS	European Flood Awareness System
EFFIS	European Forest Fire Information System
EWS	Early Warning Systems
EC	European Commission
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FEMA	Federal Emergency Management Agency
GAR	Global Assessment Report
GDACS	Global Disaster Alert and Coordination System
GeoIKP	Geospatial Information Knowledge Platform
GIS	Geoinformation Systems
GIZ	German Agency for International Cooperation
GNSS	EU´s Global Navigation Satellite System
ICT	Information and communication technology
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standardization Organization
IT	Information technology
IUCN	International Union for Conservation of Nature
JRC	Joint Research Center
LG	Local governments
MKFFIS	Macedonian Forest Fire Information System
NALAS	Network of Associations of Local Authorities of South-East Europe
NDRA	National Disaster Risk Assessment
NGOs	Non-governmental Organizations
NUA	New Urban Agenda
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
OECD	Organization of economic cooperation and development
OPENDRI	Open Data for Resilience Initiative
OSOCC	On-Site Operations Coordination Centres
PDNA	Post-disaster Needs Assessment
RVAs	Risk and vulnerability assessments
SAR	Search and Rescue
SDG	Sustainable Development Goal
SDGs	Sustainable Development Goals
SEEDS	Sustainable Environment and Ecological Development Society
SFDRR	Sendai Framework for Disaster Risk Reduction 2015 – 2030
SMDRM	Social media-driven disaster risk management
SMS	Short message service
UAVs	Unmanned Aerial Vehicles
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNICEF	The United Nations International Children's Emergency Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USA	United States of America
VR	Virtual Reality
WMO	World Meteorological Organization

Foreword

This publication was developed by the Network of Associations of Local Authorities of South- East Europe (NALAS) within the European Union-funded project COVALEX (Community of Valued Experts in Hydrometeorological and Technological Multi-Hazards).

COVALEX aims to strengthen cooperation and risk management in the face of hydrometeorological events and hydrometeorological multi-hazard events with the goal to bridge the gap between first responders (practitioners), civil protection authorities, municipalities and scientific institutions and to foster their collaboration through integrated and coordinated approaches to mitigate vulnerabilities.

The project is implemented by NALAS in a consortium with the University of A Coruna (Lead partner), CIMA Foundation, Italian Red Cross, Greek General Secretariat for Civil Protection and Disaster Competence Network Austria.

NALAS, which brings together 13 local government associations (LGAs) that represent roughly 7000 local authorities in the region of South-East Europe (SEE), is working on supporting LGAs and its members in becoming more resilient. NALAS serves as a hub for knowledge sharing, experiences, and providing training for local government authorities. Our geographical coverage includes areas affected by climate change impacts, and local governments are always on the frontline of action. Their preparedness in assessing vulnerability and implementing climate adaptation measures is highly needed.

With the development of the training on *Effective Application of DRR IT Tools for Hydrometeorological Hazards at a Local Level*, NALAS contributes to the enrichment of the disaster risk reduction capacity development measures available and at disposal to LGs.

The development of risk and vulnerability assessments is vital in creating robust adaptation plans and measures. These assessments allow us to identify the people, infrastructure, and systems that are particularly at risk or highly vulnerable, thereby enabling us to prioritize actions effectively. Local governments, being closest to the citizens, have a profound understanding of the local context, infrastructure, and communities. This unique position allows them to best identify vulnerabilities and, consequently, the risks involved.

One of the key factors in managing these risks is the utilization of digital solutions. Evidence-based decision-making, analysis, and planning supported by digital tools and locally-generated data are essential for delivering more informed, innovative, resilient, and high-quality infrastructure and services. These solutions include resilient infrastructure planning and construction, smart urban mobility, energy efficiency, sustainable urban planning, and digital public services.

For the local level, which is our primary focus, we are aware of the limited capacity and resources. There is often an expectation that solutions will be provided from the central level, while implementation is carried out locally. However, local data are crucial for an adequate response and to develop preparedness plans. Moreover, this local data is essential for modelling, training, and preparing for various actions.

This training covers critical topics such as risk assessment, resilience building, and the use of international frameworks and EU mechanisms.

Your engagement in this training is a testament to your commitment to enhancing your community's resilience. Together, we can leverage our collective knowledge, innovative spirit, and shared experiences to build a safer, more resilient future.

01

INTRODUCTION

1.1 Background

Europe faces growing disaster risk across its vast territory of more than 10 million km^2 and its 745 million population. The region has encountered a diverse range of natural and human-made hazards, with recent decades witnessing a surge in occurrence and cost. *Hydrometeorological hazards* i.e. floods and flash floods, storms, heatwaves, droughts, etc. are dominating the hazard profile with an increase in frequency, intensity and magnitude of consequences. These events have caused great trauma across the region, as seen from the prolonged heatwaves in 2003, devastating floods in Croatia, Bosnia and Herzegovina in May 2014, North Macedonia floods in 2015 and 2016, severe drought across the EU in 2018 and 2022, as well as unprecedented floods in Belgium, Germany and the Netherlands in 2021.

"Extreme weather events like storms, heatwaves and flooding accounted for 85,000 to 145,000 human fatalities across Europe, over the past 40 years. Over 85% of those fatalities were due to heatwaves. Economic losses from weather and climate-related extremes in Europe reached around half a trillion euros over the same period."[1] These disasters have often transboundary impacts eroding the resilience texture of the societies and communities and deepening the existing and creating new vulnerabilities and social inequalities. Moreover, the region faces significant climate vulnerability, labelled as the fastest-warming continent in the world. Europe is expected to get warmer, some regions getting drier, while others wetter. In that sense, the Sixth Assessment Report of the IPCC (AR6) completed in 2022 in Chapter 13 identifies key risks that will mark the climate uncertain future in Europe with floods being one of them i.e. heat, agriculture loss and water scarcity.

These consequences of the hydrometeorological hazards and changing climate are additionally worsened by the changing and systemic nature of risk, diverse governance structures and mechanisms, urbanization, environmental degradation, cascading impacts of other crises, etc. Therefore, effective prevention, preparedness and response to these types of hazards require multi-sectoral collaboration and a societal approach with action taken by all traditional and non-traditional actors within the resilience-building domain.

In that sense, a survey conducted among COVALEX stakeholders revealed that public authorities are the most prominent actors in the network at the moment. Their main concerns are floods, torrential rain, and storms. Risk perception is an important factor in disaster governance[2]. The participants expect a shift in relevance towards risks such as heat waves, droughts, and wildfires in the next 10 years. In terms of requirements for the COVALEX network, the participants expressed interest in the exchange of best practices and experiences, learning about different disaster governance strategies, and collaboration and education.

Within these efforts, the local-level governments and stakeholders are key to preventing and responding to the adverse consequences of the hydrometeorological hazards. Collaboration between communities, experts, and authorities is essential to develop effective strategies that safeguard lives and property from the unpredictable nature of weather-related disasters. Consequently, an online training program on "Effective application of DRR IT tools for hydrometeorological hazards at the local level" was designed to empower the key local level stakeholders in the project beneficiary countries and beyond.

1.2 Purpose of the Participants' Guide

This *Participants' Guide* aims to offer thorough insights and practical guidance for understanding and effectively managing hydrometeorological hazards. It equips participants with knowledge of innovative solutions aligned with global and regional sustainable development frameworks, fostering resilience.

The guide provides relevant background information and subject matter material, offering an extensive overview of contemporary trends, technologies, and collaborative strategies in this domain. These resources empower training participants and practitioners to deepen their understanding of the thematic area and contribute to the formulation of better policies and actions to respond to hydrometeorological hazards, utilizing innovative solutions and tools.

[1] European Environment Agency. "*Climate change impacts, risks and adaptation*". 03 May 2024. Online. Accessed at: https://tinyurl.com/2t3hnd6m

[2] Jasmina Schmidt, DCNA. "https://udcgal-my.sharepoint.com/personal/marta_moreno_udc_es/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fmarta%5Fmoreno%5Fudc%5Fes%2FDocuments%2FEscritorio%2FCovalex%2FDERIBABLES%2FD2%2E1%20%E2%80%93%20One%20Background%20Study%20on%20actors%20%2Epdf&parent=%2Fpersonal%2Fmarta%5Fmoreno%5Fudc%5Fes%2FDocuments%2FEscritorio%2FCovalex%2FDERIBABLES&ga=1"*Study on Risk Governance in Europe: Challenges, Key Actors, and Future Needs and Requirements*". 28.06.2023

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TRAINING OBJECTIVE AND AUDIENCE

2.1 Overall learning objective

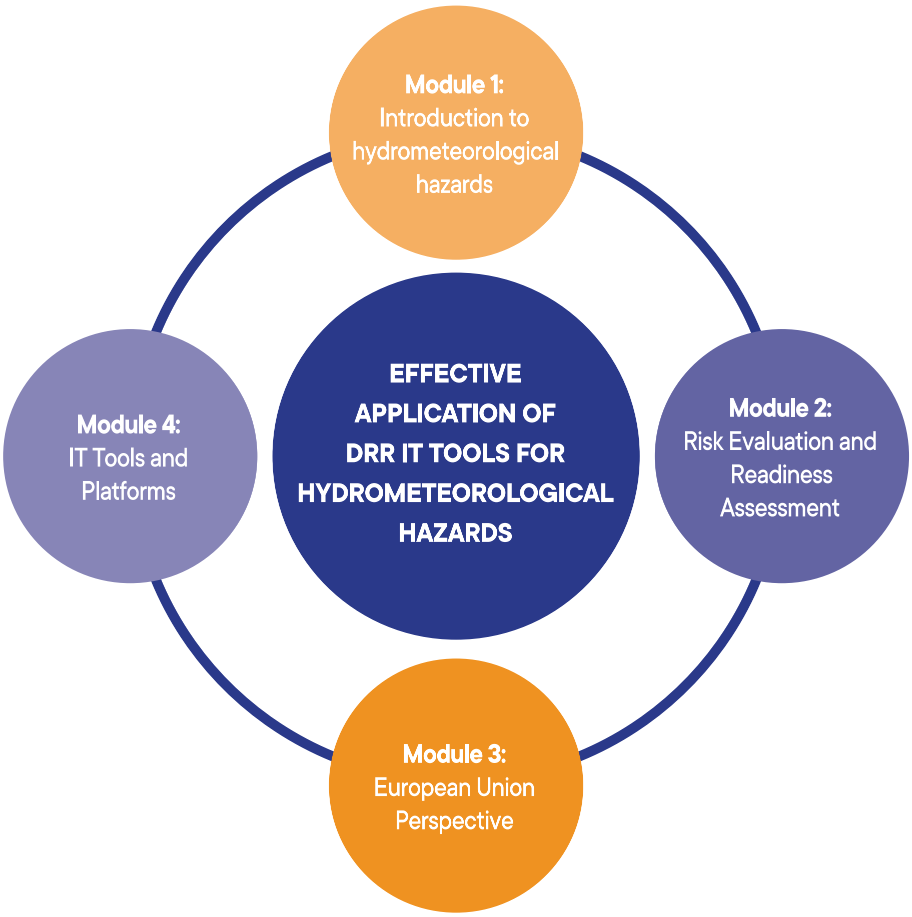
The participants are equipped with the knowledge and tools necessary to address critical challenges faced by local governments in managing hydrometeorological hazards. They transition from first responders to first preventers, understanding global, EU, and regional/national disaster risk reduction concepts, risk assessment phases, and innovative solutions for prevention, preparedness, response, and recovery. Additionally, they grasp considerations for gender and disability mainstreaming in local resilience-building.

2.2 Specific learning outcomes

- Participants are acquainted with the hydrometeorological hazards and understand the process of risk assessment and the need for resilience building.
- Participants are informed about the European Union's perspective and coordination mechanisms in hydrometeorological hazard management.
- Participants are informed about the existing IT tools and platforms for hydrometeorological hazards' risk assessment and management and their applicability at a local level by the local governments.
- Participants are informed about innovative solutions and best practices for hydrometeorological hazards' risk assessment and management.

2.3 Key areas to be covered

Figure 1 - Key areas to be covered with the training



2.4 Who is the target audience?

The online training on the "Effective application of DRR IT tools for hydrometeorological hazards at the local level" is primarily intended for a variety of key stakeholders and practitioners as presented in the table below.

Table 1 – Training designs, audience and required knowledge of participants

Training designs	Target audience	Level of required knowledge
One-day training webinar for awareness-raising	Practitioners from the digital innovation hubs and teams for innovations at local governments	Basic understanding of the management of hydro-meteorological hazards, DRR concepts and experience in innovation practices
Two-day training for local governments	Practitioners from the local governments and members of the local headquarters for protection and rescue/civil protection	Medium understanding of the management of hydrometeorological hazards and disaster risk reduction
One-day training webinar for senior civil protection practitioners	Senior practitioners and managers from civil protection entities e.g. the General Secretariat for Civil Protection	Good understanding of the management of hydrometeorological hazards and disaster risk reduction

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TRAINING MODULES

3.1 MODULE 1: INTRODUCTION TO HYDROMETEOROLOGICAL HAZARDS

3.1.1 Introduction

This module opens the training and sets the stage for dynamic engagement and knowledge exchange on the management of hydrometeorological hazards and the application of innovative solutions across the disaster risk reduction cycle. Participants will gain valuable insights into the essentials of the hydrometeorological hazards, historical events and trends, future climate uncertainty projections, an overview of current global and regional sustainable and resilient development framework, as well as knowledge foundations for better understanding the management of hydrometeorological risks, climate change adaptation, and resilience-building nexus that is crucial in addressing the complex challenges posed by changing weather patterns and environmental conditions. By exploring the interconnectedness of these factors, participants can develop holistic approaches to mitigate risks, adapt to climate change impacts, and build resilience within communities and ecosystems.

Understanding what it means to "*build resilience*" and why it is crucial as many local governments may lack comprehensive knowledge in this area. In many countries, LGs are weakly prepared to build resilience, and the lack of knowledge and understanding of what it involves prevails. This introductory part covers the glossary and terms and discusses the involvement of government, and stakeholders to anticipate, prepare for, respond to, and recover from the adverse impacts of hydrometeorological hazards. The introductory part emphasizes the vital importance of risk reduction, a range of measures to minimize the likelihood and impact of disasters on communities such as infrastructure development, early warning systems, land-use planning, community engagement, and policy implementation, but also inter-governmental cooperation and cooperation with EU agencies. Without a clear understanding of these concepts, local governments may struggle to formulate effective strategies to enhance their community's ability to withstand and recover from disasters. The lack of knowledge in this area may result in inadequate planning, leading to increased vulnerability and prolonged recovery periods after hydrometeorological events.

> ***Resilience*** is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.
>
> ***Source: UNDRR, 2019***
>
> https://tinyurl.com/3ej4yveh

Furthermore, this module aims to provide a comprehensive understanding of the evolving trends and challenges in managing hydrometeorological risks. This session delves into the key challenges and impacts on local governments. Additionally, it explores potential forward-looking strategies for building resilience, emphasizing the role of innovative solutions such as advanced forecasting technologies, sustainable infrastructure, and community-based approaches. It is designed to facilitate a smooth transition towards innovative, proactive and adaptive risk management practices.

Note #1: During the introductory part of the training, ***a quiz*** is considered an ice-breaker and a transition from the opening part to the first session. The intention is not to test the knowledge of the participants, but rather to initiate the training in a relaxed manner. Six quiz questions are formulated as follows and the correct answers are given in Annex II.

Table 2 – Note #1: Quiz

#1: Which of the following is not a hydrometeorological hazard? a) Flood b) Storm surge c) Earthquake d) Typhoon
#2: What is the most frequent and costly hydrometeorological hazard? a) Avalanche b) Flood c) Drought d) Tsunami
#3: According to the United Nations High Commissioner for Refugees, how many people have migrated because of weather-related disasters like droughts, floods, etc.? a) 2 million b) 5.5 million c) 15.5 million d) 21.5 million

#4: FEMA estimates that 13 million Americans live within one. Another study in an environmental journal estimates that as many as 41 million Americans live within one. What is it?
a) 100-year flood zone
b) Mudslide zone
c) Nuclear power plant fallout zone
d) Coastal flooding zone

#5: Which is the deadliest flooding event in Europe during the period 1950 – 2021?
a) 2021 floods in Germany and Belgium
b) 1973 flash floods in Spain
c) 1970 Tisza River floods in Hungary
d) 1953 North Sea flooding in Netherlands and Belgium

#6: What is the average annual loss (AAL) due to flooding in Europe during the period 1980 and 2020?
a) 12 billion Euro
b) 10 billion Euro
c) 15 billion Euro
d) 8 billion Euro

Note #2: In addition, for the training of local government practitioners, ***a pre-training assessment test*** is formulated to check participants' knowledge before attending the training course and after the finalization of the course. This will not be graded but should offer an opportunity for self-evaluation of their current and gained knowledge.

Table 3 – Note #2: Pre-training Assessment Test

#1 Hydrometeorological hazard is a process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage
a) True
b) False

#2 What is the main goal of disaster risk reduction?
a) Eliminate all disasters
b) Reduce the impacts of all disasters
c) Predict the occurrence of disasters
d) Decrease the frequency of disasters

#3 What are the main components of disaster risk management?
a) Prevention/mitigation, preparedness, response, recovery
b) Prevention, early warning, preparedness, response, recovery
c) Prevention, preparedness, response
d) Mitigation, preparedness, and response

***#4 What type of disaster risk management is explained in the following case*? It promotes the involvement of potentially affected communities in DRM at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local DRR action.**
a) Prospective disaster risk management
b) Local and Indigenous peoples' approach to disaster risk management
c) Community-based disaster risk management
d) Corrective disaster risk management

#5 Which notion describes resilience?
a) Preserving the safety of the critical infrastructure
b) Continual action being taken to reduce or eliminate the medium- and long-term risk
c) The ability to adapt, transform and recover from the effects of a hazard
d) The capability to equitably meet vital human needs.

#6 What is the purpose of conducting risk assessment in disaster risk management?
a) To predict the exact time and location of a disaster
b) To determine the financial cost of a disaster
c) To identify and analyze potential hazards and their impacts
d) To allocate resources for disaster response

#7 Risk and hazard assessment include:
a) Only qualitative methods since there is no need for quantitative data collection.
b) Only quantitative information since qualitative information is not reliable.
c) Both qualitative and quantitative data and information to fully understand the context.
d) None of the above, the assessment consists of an analysis of affected sectors and environment.

#8 Which of the following is the first step in the risk assessment process?
a) Risk evaluation
b) Hazard identification
c) Risk mitigation
d) Risk communication

#9 What is the limitation of the following definition? Definition: Innovation means doing things in a new way, or creating new things.
a) There is no limitation.
b) It includes creative actions that, in isolation, are not strictly innovation.
c) It does not mention science or invention.
d) Creativity and innovation are the same thing.

#10 Which of the following technologies is most commonly used to improve disaster resilience through early warning systems?
a) Blockchain technology
b) Artificial Intelligence
c) 3D printing
d) Geoinformation Systems (GIS)

3.1.2 Essentials of the hydrometeorological hazards

Hydrometeorological hazard is defined as "*a process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage*". Hydrometeorological hazards are of atmospheric, hydrological or oceanographic origin. Examples are tropical cyclones (also known as typhoons and hurricanes); floods, including flash floods; drought; heatwaves and cold spells; and coastal storm surges[3]. Hydrometeorological conditions may also be a factor in other hazards such as landslides, wildland fires, locust plagues, epidemics and in the transport and dispersal of toxic substances and volcanic eruption material.[4] These hazards are often influenced by climatic factors such as temperature variations, atmospheric pressure changes, and moisture levels. Human activities, such as deforestation and urbanization, can exacerbate their frequency and intensity. Impacts of hydrometeorological hazards can be classified as *human impacts* (loss of life, injuries), *economic impacts* (property damage, infrastructure loss) or *environmental impacts* (habitat destruction, ecosystem disruption). The impact of these hazards is heightened in regions with high population density, poor infrastructure, and inadequate preparedness measures. Vulnerable groups include low-income communities, the elderly, and those with limited access to resources.

3.1.3 Historical events, impacts of hydrometeorological hazards and climate future

The initial point in understanding the historical profile and hydrometeorological events and their impacts is understanding the trend throughout the recent decades. In that sense, comparisons are made between the periods 1980 – 1999 and 2000 – 2019 (Human costs of disasters 2000 – 2019). So, "in the period 2000 to 2019, 7,348 major recorded disaster events claimed 1.23 million lives, affecting 4.2 billion people (many on more than one occasion) resulting in approximately US$2.97 trillion in global economic losses. This is a sharp increase over the previous twenty years. Between 1980 and 1999, 4,212 disasters were linked to natural hazards worldwide claiming approximately 1.19 million lives and affecting 3.25 billion people resulting in approximately US$1.63 trillion in economic losses. The second twenty years have seen the number of major floods more than double, from 1,389 to 3,254, while the incidence of storms grew from 1,457 to 2,034. Floods and storms were the most prevalent events. Also, there is a major increase in other categories including drought, wildfires, and extreme temperature events. Much of the difference is explained by a rise in climate-related disasters including extreme weather events: from 3,656 climate-related events (1980-1999) to 6,681 climate-related disasters in the period 2000-2019."[5] Given the rate of climate change and its consequences, it can be said that these numbers can be doubled during the next twenty years.

[3] Definitions of each hydrometeorological hazard are given in Annex I.

[4] UNDRR. *Terminology*. 2019. Online. Available at: https://tinyurl.com/2h4244mb

[5] UNDRR. *The human cost of disasters: an overview of the last 20 years (2000–2019)*. 2020. Online. Available at: https://tinyurl.com/c5x-9e4tb

Europe is highly exposed and vulnerable to the impacts of hydrometeorological hazards with floods, flash floods and storms leading to the past disaster profile, followed by droughts and extreme temperatures i.e. heatwaves which are increasing in frequency and magnitude of consequences during the recent years. Consequently, the following events were marked as significant for the region and the project partner countries i.e. European Heatwave in 2003 which brought record high temperatures and resulted in at least 30,000 deaths; unprecedented May 2014 floods in Bosnia and Herzegovina, Croatia and Serbia caused the greatest damages ever recorded i.e. more than 3.5 billion EUR only in Serbia and Bosnia and Herzegovina and claiming 83 lives in these countries; North Macedonia Flash Floods in 2015 and 2016 with a price tag of more than 125 million EUR and the latter one with the highest death toll (22) after the Skopje Earthquake in 1963; severe drought in EU in 2018 with the largest area ever affected; 2021 European Floods that caused widespread destruction in Belgium, Germany and Netherlands or droughts from July 2022.

Following this trend, the 2023 year is marked as one of the most specific disaster years. In total "*399 disasters resulted in 86,473 fatalities and impacted 93.1 million people. Economic losses soared to an estimated US$202.7 billion, underlining the profound socioeconomic repercussions of these events.*"[6] Munich Re – the world's largest reinsurer – has released its global disaster loss calculation for 2023, coming in at a total of US $250 billion. This roughly equals the entire GDP of New Zealand or Portugal. It is also slightly lower than the previous estimate for 2022, which originally came in at US $270 billion. Europe has the third place globally in terms of number of events. Floods and storms are dominating the annual disaster profile. Chronologically, several disaster events marked the year alongside the devastating earthquake in Türkiye i.e. in May 2023 parts of northern Italy's Emilia-Romagna region received half their average annual rainfall in just 36 hours affecting 20,000 people, 13 human lives and submerging thousands of hectares; summer 2023 was hottest on record; supercell storms in Slovenia, Serbia and Croatia during the summer months (a historic long-lived supercell storm with giant 14 cm hailstones tracks for more than 1200 km across five European countries leaves severe wind and hail damage along its path); extreme floods in August in Slovenia (during 48 hrs up to 275 mm rain fell, seven human lives were lost, up to 15,000 households damaged with 5 billion USD in damages); in September extreme rainfall from a storm system called Storm Daniel has hit parts of the central and eastern Mediterranean, leading to devastating flooding and massive loss of life in Libya, the worst affected country, as well as in Greece, Türkiye and Bulgaria (in Central Greece record rainfall fell during 18 hours e.g. in the village of Zagora, a record-breaking 754 mm of rain fell in just 18 hours and to put this in perspective, London gets about 585mm of rain over the course of a year while Thessaly gets 495mm, meaning that, about 1.5 years' worth of rain fell in 18 hours). The 2024 year follows the previous one and its first half was marked with similar events i.e. a series of storms during the first months of the year bringing storms and floods, and an unprecedented spring heatwave in April. On the other side, the "apocalyptic" Dubai floods from April caused '$1 billion worth of damage' in a DAY after the drowned city was hit by the worst storm in 75 years.

Climate change due to human activities is now undeniably responsible for an increase in extreme weather events in Europe. Climate impacts are rapidly intensifying and expanding and storms, floods, droughts, extreme temperatures and wildfires are increasingly claiming the largest economic losses globally i.e. during the period 1990 – 2022 storms are dominating the hazard profile followed by floods and droughts[7]. In that sense, in the EU Member states "between 1980 and 2022, weather- and climate-related extremes caused economic losses of assets estimated at EUR 650 billion in the EU Member States, of which EUR 59.4 billion in 2021 and EUR 52.3 billion in 2022".[8] In 2022, heatwaves dominated the annual hazard profile, followed by storms and floods and the 30-year moving average was the highest.

The Sixth Assessment Report of the IPCC (AR6) (2022) identifies four key risks for the future climate i.e. *heat* (mortality and morbidity of people and ecosystems disruptions due to heat will increase), *agriculture loss* due to combined heat and drought, *water scarcity* across sectors and *floods* impacting the people, economies and infrastructure. Europe is expected to get warmer, some regions getting drier, while others wetter. Europe's changing climate hazards report echoes the findings of the IPCC that climate change is undeniably responsible for an increase in extreme weather events but provides more detailed information for Europe. Projected changes include that mean temperatures will continue rising across Europe and hot extremes are expected to increase even faster. Europeans need to prepare for more days with extreme heat and for more extreme precipitation events, the report states:

- Southern Europe should prepare for hotter summers, more frequent droughts and an increased fire hazard.
- In Northern Europe, annual precipitation and heavy rainfall are likely to increase.
- Central Europe is likely to experience lower summer rainfall, but also more frequent and stronger weather extremes, including heavy precipitation, river floods, droughts and fire hazards.

[6] CRED. *2023: Disasters in Numbers.* Brussels: CRED, 2024. Online. Available at: https://tinyurl.com/chj8ad3p

[7] OECD. *Climate Action Monitor.* 2023. Online. Available at: https://tinyurl.com/2a63xdk5

[8] European Environment Agency. *Economic losses from weather- and climate-related extremes in Europe.* 06 October 2023. Online. Available at: https://tinyurl.com/58fsyn6m

- Sea surface temperature, marine heatwaves and water acidity are projected to increase in all European regional seas.
- Sea level rise is accelerating across all European coasts, except for the Northern Baltic Sea.[9]

In Europe, the lack of adaptation actions could result in 96,000 fatalities per year from extreme heat, compared with 2,750 annual deaths at present. The chart shows that extreme heat is the most reported hazard in risk and vulnerability assessments (RVAs) in Europe (93%) followed by heavy precipitation and droughts & water scarcity (89%), floods & sea level rise (85%), and wildfires (71%). All other hazards (e.g., extreme cold, storms, mass movement) are reported in less than 55% of the RVAs. The bottom chart digs into extreme heat and demonstrates that the current probability and impact are most commonly rated as medium/high (76% and 73% of the RVAs, respectively), while, in the future, cities foresee an increase in both intensity (92%) and frequency (93%).[10]

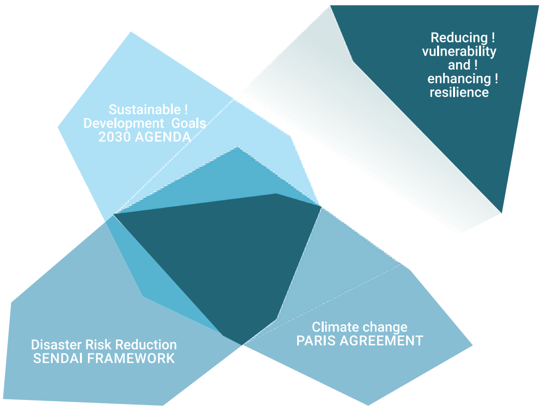
Finally, When we are considering climate and disaster future uncertainties, it is important to emphasize that we are very often facing so-called "black swan" events that are rare and unlikely and unpredictable events that are beyond what is normally expected of a situation and have potentially severe consequences i.e. they are hugely impactful events. Black swan events are characterized by their extreme rarity, severe impact, and the widespread insistence that they were obvious in hindsight. Some examples include the Great Recession, the winter storm "Uri" in Texas, USA or the COVID-19 pandemic crisis. "While the probability of them emerging and wreaking havoc is low, their impact would be catastrophic, so they should be considered in future climate scenarios."[11]

3.1.4 Building resilience and sustainable and resilient framework

3.1.4.1 Introduction

Considering all of this, we must think of not only how to prepare and mitigate disasters that are presently occurring, but also about driving factors that affect the frequency and impact of future disasters. As mentioned above, resilience is the adaptive capacity for maintaining the function of the system for response and smart and sustainable recovery. Resilience matters because we frequently face risk, risks are changing with an increasingly systemic and complex nature, cascading throughout sectors, and becoming more and more unpredictable. Understanding the contemporary DRR frameworks that shape the approach to sustainable and resilient development is essential for effectively managing hydrometeorological risks, adapting to climate change, and building resilient communities. These frameworks provide the foundation for coordinated actions and policies that drive sustainable development on both global and regional scales. Furthermore, innovation is recognized as an enabler for building resilience and its solutions and tools support the overall risk reduction policies and actions. Consequently, the most important aspects will be presented in the section below.

Figure 2 – Relation between global framework and resilience-building[12]



[9] EEA. *Climate hazards are increasing in frequency and severity across Europe; new regional overview published.* 17.11.2021. Online. Available at: https://tinyurl.com/3rshdnmx

[10] Giulia Ulpiani, Aldo Treville, Paolo Bertoldi, Nadja Vetters, Paulo Barbosa, Luc Feyen, Gustavo Naumann and Mat Santamouri. *Are cities taking action against urban overheating? Insights from over 7,500 local climate actions.* One Earth 7, 848–866, May 17, 2024. Online. Available at: https://tinyurl.com/3he67d84

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[12] UNDRR. *Europe's opportunity to manage risk and build resilience. Recommendations to the European Green Deal.* Online. Available at: https://tinyurl.com/48e2xwd5

3.1.4.2 Sendai Framework for Disaster Risk Reduction 2015 – 2030

The *Sendai Framework for DRR 2015-2030 (SFDRR)* was adopted at the Third World Conference for Disaster Reduction that was held in Japan in March 2015. The Sendai Framework works hand in hand with the other 2030 Agenda agreements, including The Paris Agreement on Climate Change, the New Urban Agenda, and ultimately the Sustainable Development Goals. The Sendai Framework, a contemporary approach to global disaster resilience, shifts from disaster management to proactive risk reduction. It advocates for *the substantial reduction of disaster risk and losses in lives, livelihoods and health and the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.* It has seven objectives and four priorities as follows. The present framework applies to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks. It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors.

> ***GAR 2019***
> "The Sendai Framework thus has the potential to simultaneously transform the risk landscape and facilitate accelerated achievement of the goals and targets of the climate change and SDG agendas."
>
> ***Source:***
>
> *https://tinyurl.com/yckwpc9e*

Figure 3 – Seven targets of the Sendai Framework for DRR 2015 – 2030

Figure 4 – 13 Guiding Principles of the Sendai Framework for DRR 2015 - 2030

Table 4 – Four priorities of the Sendai Framework

Priority 1: Understanding disaster risk	Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. This knowledge can be leveraged for pre-disaster risk assessment, prevention and mitigation actions followed by adequate preparedness and timely, effective responses thereby safeguarding the main principles of national and local sustainable development.
Priority 2: Strengthening disaster risk governance to manage disaster risk	Disaster risk governance at the national, regional and global levels is vital to the management of disaster risk reduction in all sectors and ensuring the coherence of national and local frameworks of laws, regulations and public policies that, by defining roles and responsibilities, guide, encourage and incentivize the public and private sectors to take action and address disaster risk.
Priority 3: Investing in DRR for resilience	Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental in saving lives, preventing and reducing losses and ensuring effective recovery and rehabilitation.
Priority 4: Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction	Integration of DRR into disaster preparedness, post-disaster recovery and rehabilitation of the sustainable development of affected areas. Experience indicates that disaster preparedness needs to be strengthened for a more effective response and to ensure capacities are in place for effective recovery. Disasters have also demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of the disaster, is an opportunity to «Build Back Better» through integrating disaster risk reduction measures. Women and persons with disabilities should publicly lead and promote gender-equitable and universally accessible approaches during the response and reconstruction phases.

The Sendai Framework for Disaster Risk Reduction 2015-2030 calls for the "*use and expansion of thematic platforms of cooperation, such as global technology pools and global systems to share know-how, innovation and research and ensure access to technology and information on disaster risk reduction*". Commitments to enhanced access to innovations in science and technology, exchange of disaster risk reduction information, and improved innovations in integrating local knowledge into DRR decision-making are essential to addressing the challenge of an all-hazards approach that incorporates natural and man-made hazards (including technological hazards that can have cascading effects).[13] A combination of innovative ideas and unity is the key to unlocking a transformational response to escalating climate and disaster risk. Therefore, innovation is widely elaborated in the text. *For a better understanding of the risk*, national and local levels shall promote real-time access to reliable data, make use of space and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data (24 f), promote investments in innovation and technology development in long-term, multi-hazard and solution-driven research in disaster risk management to address gaps, obstacles, interdependencies and social, economic, educational and environmental challenges and disaster risks (24k), whether on global level enhance access to and support for innovation and technology, as well as in long-term, multi-hazard and solution-driven research and development in the field of disaster risk management is needed (25i). Public and private investment in disaster risk prevention and reduction through structural and non-structural measures can be drivers of innovation, growth and job creation (29). Business and private sector entities should engage in and support research and innovation, as well as technological development for disaster risk management (36c).

[13] UNISDR. *Sharing Innovations to Improve Implementation and Reporting of the Sendai Framework for Disaster Risk Reduction 2015–2030.* 2016. Online. Available at: https://tinyurl.com/2kn5svmr

The Mid-term Review of the Sendai Framework Report (2023) summarizes the learning and recommendations of an extensive review by states and stakeholders pursuing the expected outcome and goal of the Framework and thus risk-informed sustainable development. Consequently, recommended activities encompass all sectors of society and levels of government, connecting diverse areas with the Sendai Framework seen as an opportunity to promote convergence, enhance inclusion and create equitable outcomes across societies.[14] Some of the recommended activities relevant to this area can be summarized as follows:

- *Priority 1: Understanding disaster risk* - improve the standard of risk data and broaden the application of the risk assessments, with advances in computing power, data availability and use of artificial intelligence to ensure circulation and interoperability of data and risk information across systems, comprehensive training and education for data collection and analysis at the local level, investments in data-sharing infrastructure in the information technology sector, improvement of disaster loss databases and disaster risk mapping, strengthening disaggregated data collection and analysis, ensuring that disaster risk data and information are systematically used to inform decision-making, developing comprehensive risk assessments and making better use of emerging technologies and scenario-planning activities, etc.

- *Priority 2: Strengthening disaster risk governance to manage disaster risk* – treating disaster risk reduction as an outcome, not as a sector, pursuing adaptive, vertically and horizontally integrated risk governance, developing institutional architecture to mobilize and engage knowledge and expertise, ensuring that local-level risk governance structures are supported with the authority and resources, considering strategic foresight activities, etc.

- *Priority 3: Investing in disaster risk reduction for resilience* – making supporting disaster risk reduction a core duty in investments, incentivizing investments in risk reduction and resilience, greater public and mobilizing private sector investments, etc.

- *Priority 4: Enhancing disaster preparedness for effective response and to Build back better in recovery, rehabilitation and reconstruction* - continue to mobilize resources, technology and capacity to implement and extend the reach of multi-hazard early warning systems, closer work with communities to ensure last mile communication during early warning, placing resilience into the core of infrastructure development, etc.

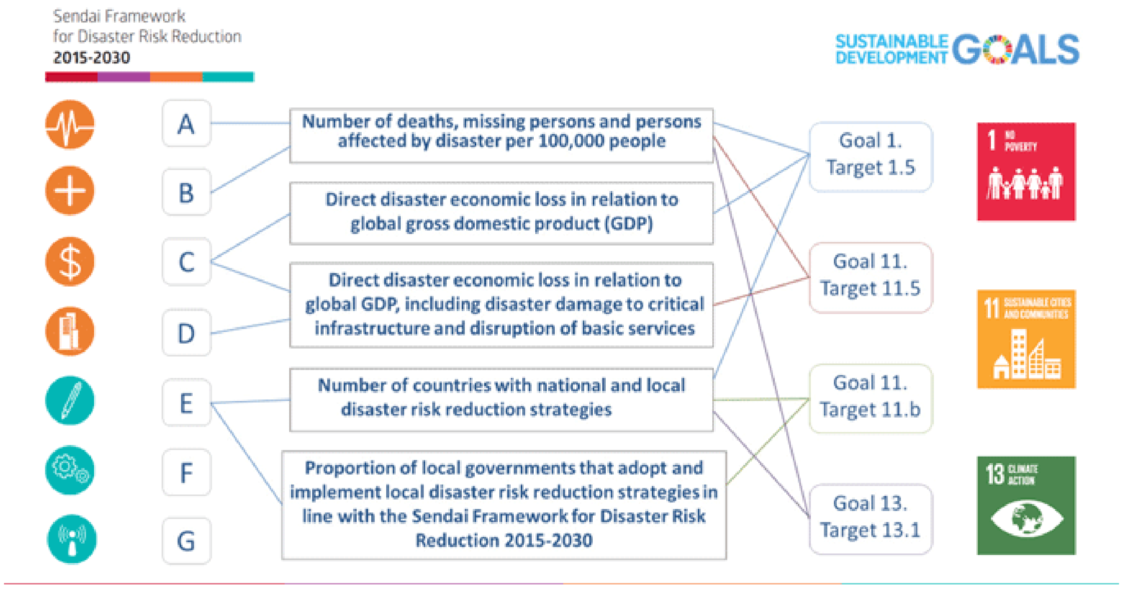
3.1.4.3 Sustainable Development Goals

The 2030 Agenda for Sustainable Development adopted in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the *17 Sustainable Development Goals (SDGs),* which are an urgent call for action by all countries in a global partnership to make the world and its future more sustainable and resilient to existing and new development challenges and risks. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and support economic growth, innovation and the sustainability of cities and communities – all while tackling climate change and working to preserve forests. Concerning disaster risk reduction, there is no dedicated goal, but it recognizes and reaffirms the urgent need to reduce the risk of disasters through direct references to the Sendai Framework as well as the specific opportunities to achieve the SDGs through reducing disaster risk. For example, by reducing the exposure and vulnerability of the poor to disasters or building resilient infrastructure. DRR and resilience are integrated within the SDG's structure and the achievement of related goals and targets provides opportunities for systematic and comprehensive DRR mainstreaming across the sectors and areas, with the involvement of all DRR actors. "The focus on implementation provides an opportunity to encourage increased political commitment and economic investment to reduce risks and take development action that considers disaster resilience as critical to poverty reduction and as a key enabler of sustainable development."[15] Several goals and targets can contribute to reducing disaster risk and building resilience, even where disaster risk reduction language is not explicit. These include targets related to promoting education for sustainable development, building and upgrading education facilities and ensuring healthy lives among others. Nevertheless, at the core of disaster resilience are SDG 1 – No Poverty, SDG 11 – Sustainable Cities and Communities and SDG 13 – Climate Action. On the other side, innovation is emphasized in SDG 9 – Industry, Innovation and Infrastructure where building resilient infrastructure, promote inclusive and sustainable industrialization and fosters innovation.

[14] United Nations. General Assembly. *Main findings and recommendations of the midterm review of the implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030.* A/77/640. 31 January 2023. Online. Available at: https://tinyurl.com/rd6e5zb6

[15] UNISDR, *Think Piece National Disaster Risk Reduction Strategy Requirements (Draft).* 2017, Online. Available at: https://tinyurl.com/y5b-kmzh3

Figure 5 - Interlinkage between SFDRR and the SDGs



3.1.4.4 Paris Agreement

The ***Paris Agreement*** is a legally binding international treaty on climate change that was adopted in 2015 to limit global to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. The Paris Agreement seeks to significantly scale up climate actions and deal more comprehensively with climate change impacts to safeguard development and eliminate poverty through *significant reduction of the risks and impacts of climate change and fostering climate resilience*. In particular, it relates to Article 7 on adaptation, and Article 8 on averting, minimizing, and addressing loss and damage. These areas of cooperation and facilitation correlate with the Sendai Framework priorities and SDGs goals and targets. Its relation with DRR is in the interlinkage with the SFDRR as well as through "recognizing the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damages. Areas of cooperation and facilitation to enhance understanding, action and support may include (a) Early warning systems; (b) Emergency preparedness; (c) Slow onset events; (d) Events that may involve irreversible and permanent loss and damage; (e) Comprehensive risk assessment and management; (f) Risk insurance facilities, climate risk pooling and other insurance solutions; (g) Non-economic losses; and (h) Resilience of communities, livelihoods and ecosystems. (Article 8)." Innovation is one of the enablers of achieving Paris Agreement goals. Consequently, the relation between SFDRR, SDGs and the Paris Agreement is presented below.

Table 5 - Correlation of the Article VIII areas of cooperation and facilitation with the SFDRR priorities and the SDGs goals and targets (the Author)

Paris Agreement Article VIII	Sendai Framework	SDGs
Early warning systems/Emergency Preparedness	Priority 4	3, 11, 13
Slow onset events/Events that may involve irreversible and permanent loss and damage	All priorities	1, 2, 13, 15
Comprehensive risk assessment and management	Priority 1	11, 13, 15
Risk insurance facilities, climate risk pooling and other insurance solutions	Priority 3	
Non-economic losses	Priority 3	1, 2, 11, 13, 14, 15
Resilience of communities, livelihoods and ecosystems	All priorities	All SDGs

3.1.4.5 European Forum for Disaster Risk Reduction (EFDRR)

The Roadmap 2021-2030 for a climate and disaster-resilient Europe and Central Asia marks a new phase in the advancement of disaster risk reduction in Europe. Accordingly, innovation from all sectors of society is beneficial and technological innovation has a distinctive value for building the resilience of the society and communities.

3.1.4.6 Union disaster resilience goals

The European Commission adopted a Recommendation and a Communication to establish five common goals as follows: *anticipate* – to improve risk assessment, anticipation, and disaster risk management planning, *prepare* - to increase risk awareness and preparedness of the population, *alert* - to enhance early warning, *respond* – to enhance the Union Civil Protection Mechanism response capacity and *secure* - to ensure a robust civil protection system. A solid understanding of disaster risks, including the economic, environmental and social impacts of disasters will be supported by research and innovation.

3.1.4.7 EU strategy for adaptation to climate change

The EU strategy for adaptation to climate change sets out how the European Union can adapt to the unavoidable impacts of climate change and become climate resilient by 2050. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change. The importance of adaptation is increasingly recognized globally and innovation is recognized as one of the "*triple dividends of adaptation*" resulting in multiple co-benefits for nature-based solutions and disaster risk prevention. In addition, dialogue and innovation can greatly increase the climate resilience potential of insurance regimes.

3.1.4.8 EU Green Deal

The EU Green Deal is a package of policy initiatives, which aims to set the EU on the path to a green transition, with the ultimate goal of reaching climate neutrality by 2050. It supports the transformation of the EU into a fair and prosperous society with a modern and competitive economy.

3.1.4.9 Importance of resilience-building to hydrometeorological hazards

Resilience-building to hydrometeorological hazards is of paramount importance as it enables communities, infrastructure, and ecosystems to withstand, adapt to, and recover from adverse weather events and climatic conditions. In general, by investing in resilience, the capacity to mitigate the impacts of floods, droughts, and other hydrometeorological hazards is enhanced, resulting in reduced economic damages and losses, safeguarding lives, and protecting livelihoods. Resilient systems are better equipped to respond to hydrometeorological emergencies, while maintaining functionality during disruptions, and quickly restoring normalcy post-crisis. Furthermore, the importance of resilience is widespread for societies and communities in the context of hydrometeorological hazards i.e.

- *Supports sustainable development* - Building resilience to hydrometeorological hazards supports sustainable development by safeguarding development gains from disasters, ensuring long-term economic and social stability. Resilient societies and communities are better equipped to withstand and recover from adverse events, protecting infrastructure, livelihoods, and well-being. This proactive approach minimizes disruptions, reduces economic losses, and preserves progress made towards development goals, fostering a stable and prosperous future.

- *Enhancing adaptive capacity* through fostering resilience enables communities and ecosystems to better adapt to changing climatic conditions, mitigating the impact of future hydrometeorological events. By building this adaptive capacity, it can be ensured that both human and natural systems can adjust to and thrive despite evolving environmental challenges, reducing vulnerability and promoting sustainable and resilient development.

- *Promoting efficient resource management*, resilient approaches optimize resource use in disaster risk management, ensuring the effective and sustainable use of resources. By implementing strategies that prioritize resilience, communities can better allocate and utilize resources to prepare for, respond to, and recover from hydrometeorological hazards, ultimately enhancing overall sustainability and reducing waste.

- *Economic stability* is bolstered by resilient communities, which maintain productivity and prosperity even in the face of hydrometeorological hazards. By investing in resilience, these communities can quickly recover from disruptions, minimize economic losses, and sustain growth, ensuring long-term economic health and stability.

- *Safeguarding livelihoods* is a critical aspect of resilience measures, as they help protect households and communities from the damage caused by hydrometeorological hazards. By implementing strategies that reduce vulnerability and enhance preparedness, resilience efforts ensure that people's incomes, assets, and overall well-being are preserved, contributing to stronger, more secure communities.

- *Minimizing impact on communities* is a key benefit of building resilience, as it helps communities withstand and quickly recover from the adverse effects of hydrometeorological hazards. By enhancing resilience, we reduce loss of life, property damage, and disruptions to daily life, ensuring that communities can bounce back more swiftly and effectively after disasters.

- Furthermore, *building resilience to hydrometeorological hazards* requires a multifaceted approach throughout the disaster risk reduction cycle with the implementation of a palette of structural and non-structural measures which include innovative and sustainable practices as presented:

- *Prevention (improvements towards reducing the adverse impacts of existing and emerging risks)* - Conduct risk and hazard assessments and implementation of mitigation measures to reduce vulnerability to hydrometeorological hazards, advance risk governance frameworks, strengthen critical infrastructure, implement Eco-DRR[16] and Nature-based Solutions[17] approaches, etc.

- *Preparedness (Getting ready to respond to disasters)* - Building a culture of resilience, awareness raising and education, professional training, developing people-centred early warning systems, risk transfer instruments incl. Insurance, creating comprehensive and inclusive preparedness plans to ensure disaster readiness, etc.

- *Response (timely, efficient and effective in life and property-saving measures) and Recovery (restoring or improving conditions following disasters)* - Coordination of the immediate response efforts and focus on resilient restoration and reconstruction, applying the "Build Back Better"[18] principle, while learning from past events to improve future resilience.

Building resilience to hydrometeorological hazards is a continuous and dynamic process requiring collaboration across various sectors and scales. By implementing comprehensive strategies that combine infrastructure improvements, technological advancements, community engagement, and sustainable practices, societies can better prepare for, respond to, and recover from these hazards, ultimately reducing their impact on lives and livelihoods.

16 "*Ecosystem-based disaster risk reduction (Eco-DRR)* entails combining natural resources management approaches, or the sustainable management of ecosystems, with disaster risk reduction methods, in order to have more effective disaster prevention, reduce the impact of disasters on people and communities, and support disaster recovery (Sudmeier-Rieux et al., 2019). Eco-DRR also aims to produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation." – UNDRR. *Ecosystem-based Disaster Risk Reduction. Implementing Nature-based Solutions for Resilience.* 2020. p.9. Online. Available at: https://www.undrr.org/media/48333/download?startDownload=20240908

17 "*Nature-based Solutions* address societal challenges through actions to protect, sustainably manage, and restore natural and modified ecosystems, benefiting people and nature at the same time." IUCN. *Nature-based Solutions.* Online. Available at: https://tinyurl.com/3y5e887k

18 During the negotiation period for the Sendai Framework, the concept of "Build Back Better" was proposed by the Japanese delegation as a holistic concept which states: "The principle of 'Build Back Better' is generally understood to use the disaster as a trigger to create more resilient nations and societies than before. Online. Available at: https://tinyurl.com/5dj42fyd

3.1.4.10 Understanding challenges and emerging trends in hydrometeorological risk management

Hydrometeorological risks are a major threat to societies, communities and infrastructure worldwide. They are caused by the interaction of weather and climate with the Earth's surface, such as floods, droughts, storms, and heat waves. Disaster impact is most acutely felt at the local level because communities directly experience the immediate physical destruction, loss of lives, and disruption to daily life. Local economies often suffer significantly, as businesses are destroyed, jobs are lost, and infrastructure like roads, schools, and hospitals are damaged, affecting recovery and growth. Additionally, social and psychological impacts are profound, as individuals and families deal with trauma, displacement, and the loss of community support systems. Vulnerable groups of citizens are the most affected, their voices are least heard and recognized and their needs could be underestimated. Climate change impacts will make the magnitude of these events even greater. Therefore, understanding these risks and building resilience is crucial for protecting lives, livelihoods, and infrastructure. Accordingly, the focus is on understanding these trends and processes that are important in enabling local governments to make informed decisions and implement targeted interventions that enhance their community's resilience to hydrometeorological hazards.

Hydrometeorological risk management involves addressing challenges associated with managing risks related to water and weather phenomena, such as floods, droughts, storms, and other extreme weather events. These challenges are multifaceted and can be categorized into several key areas:

- *Increased number of disaster events following the consequences of the changing climate* – As the climate crisis intensifies, there is no question that the intensity and frequency of extreme weather—often resulting in disasters—is increasing. According to the IPCC's Sixth Assessment Report, disasters fueled by the climate crisis are already worse than scientists originally predicted.

- *Increased number of the population exposed and affected by these risks* - Weather-related disasters have increased over the past 50 years and they affect more populations with greater damages and losses, but fewer deaths. Population growth and density, rapid urbanization and degradation of the environment, coupled with rising consumption, exacerbate climate change by increasing greenhouse gas emissions, straining resources, and exposing more people to climate-related risks.

- *Increased vulnerability of the population given the "poly-crisis" and cascading impacts of interconnected global challenges i.e. pandemics, economic instability, environmental degradation, political unrest, migration movements, etc.* - These interconnected issues exacerbate each other, creating a vicious cycle that intensifies the population's vulnerability to hydrometeorological hazards. For example, economic downturns increase poverty and inequality, limiting access to resilient resources, while ecosystem destruction, like deforestation, removes natural barriers against extreme weather, heightening community vulnerability.

- *Increased losses and damages gave the number of events and values of assets* - During 2023, in the USA there were 28 separate billion-dollar weather and climate disaster events. This historic number of events exceeds the prior annual record number of inflation-adjusted billion-dollar disaster events (i.e., 22 events in 2020). The total cost of these 28 events was $92.9 billion. The number and cost of disasters are increasing over time due to a combination of increased exposure (i.e., values at risk of possible loss), vulnerability (i.e., how much damage the intensity (wind speed, flood depth) at a location causes) and that climate change is increasing the frequency of some types of extremes that lead to billion-dollar disasters.

- *The complexity of predicting extreme weather events* with accuracy due to inherent variability and chaotic nature of the atmosphere, limitations of the current technology and data i.e. for flash floods, new climate uncertainties and weather patterns due to climate change, availability of resources, etc.

- *Inadequate infrastructure and resources for early warning systems* - Fragmentation of the early warning system value chain, neglecting disaster risk knowledge, monitoring and forecasting, and warning dissemination and communication, is exacerbated by limited funding for observation and forecasting, lack of streamlined capacity development, and insufficient automation and digitalization of processes.

- *Limited access to data and information in vulnerable regions* exacerbates the challenges of managing risks associated with hydrometeorological hazards e.g. inadequate data collection and analysis infrastructure, data scarcity and quality, data integration, data modelling and scenario development, knowledge and awareness of the at-risk communities, etc. These challenges prevent risk-informed and timely decision-making and proactive measures, leaving local governments and communities more exposed to the impacts of hydrometeorological hazards and reducing their capacity to implement resilience-building strategies.

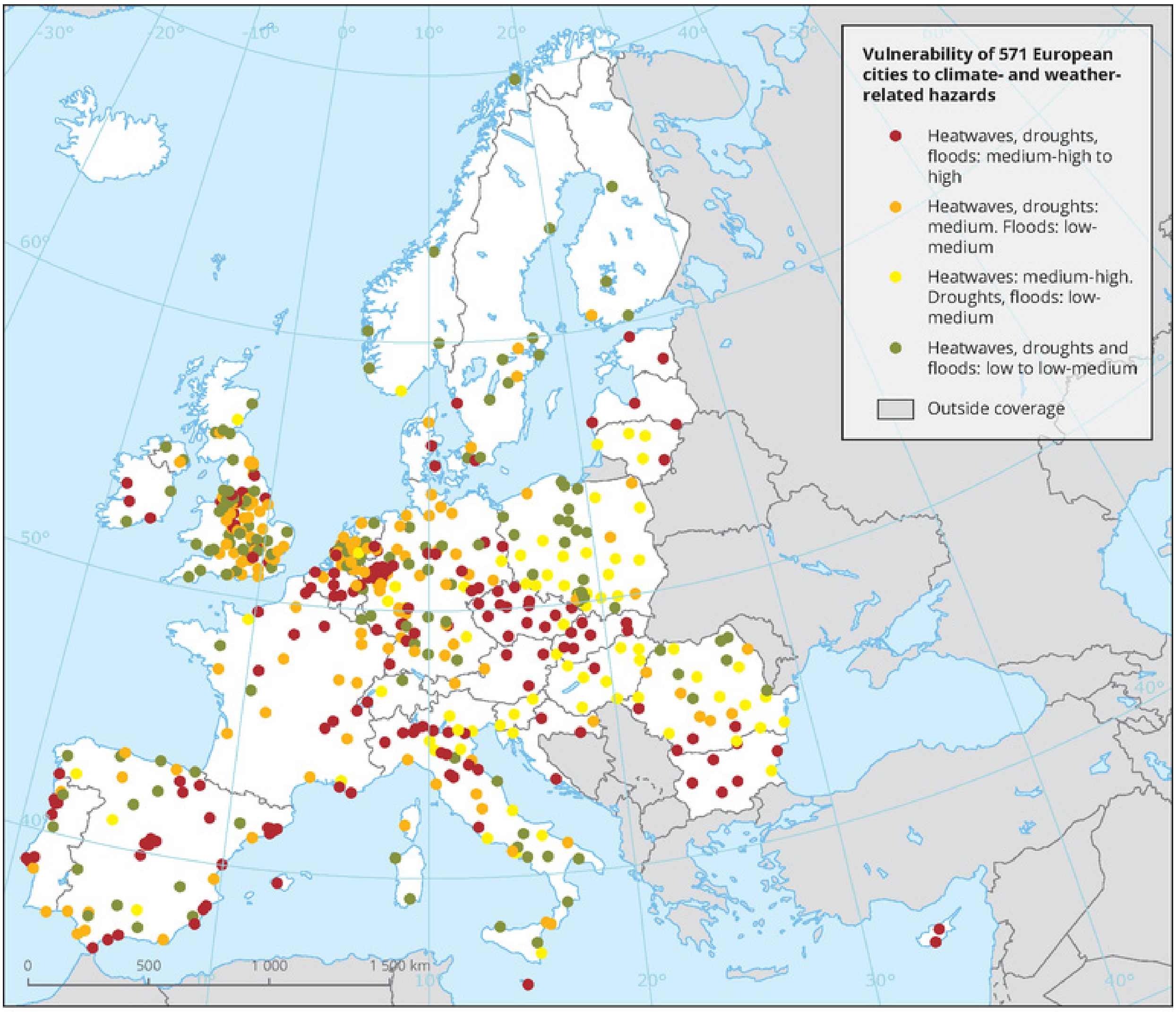
- *Difficulties in coordinating response efforts across multiple stakeholders and sectors for hydrometeorological hazards* might arise from the diverse priorities, resources, and operational protocols of different organizations involved. Communication barriers and lack of standardized procedures cause delays and inefficiencies in disaster response. Additionally, overlapping jurisdictions and conflicting interests among governmental, non-governmental, and private entities further hinder strategy alignment, undermining overall disaster management and mitigation effectiveness.

- *The ongoing struggle to integrate climate change adaptation strategies into existing risk management frameworks for hydrometeorological hazards* is characterised by several challenges i.e. lack of anticipatory approach to risk assessment, insufficient foresight and predictive tools, as well as CC projections and models, lack of political will and Budget support or poor multidisciplinary approach to climate change adaptation and resilience-building.

Emerging trends in the management of hydrometeorological risks reflect advancements in technology, enhanced collaboration, and a greater emphasis on resilience and adaptation. Some of the examples include multi-sector, stakeholder engagement collaborative strategies, data-driven approaches and innovative technologies e.g. remote sensing, sensor networks, big-data analytics, etc., advancements in climate modelling and forecasting, integrated multi-risk, multi-hazard and multi-sector assessments, people-centred early warning systems, building resilience of the critical infrastructure, etc.

Local governments encounter *substantial challenges* in preparing for and responding to hydrometeorological hazards such as flooding, extreme storms, drought, and heat waves i.e. reactive risk management, policy and regulatory barriers and institutional architecture, risk and hazard assessments mainstreaming, data and information deficits, climate change adaptation integration, risk-informed development, vulnerable population and ageing infrastructure, coordination and cooperation, warning dissemination and risk communication, inequality, discrimination and marginalization of population groups, private sector involvement in resilience-building efforts, etc. Furthermore, *the civil protection authorities encounter significant challenges* in preparing for and responding to hydrometeorological hazards i.e. reactive risk management, insufficient integration of civil protection in the DRM area (the civil protection operations are still considered short-term operations), policy and regulatory barriers and institutional architecture (incomplete or outdated policies and regulations related to disaster risk management, lack of enforcement and compliance with existing regulations and complex institutional framework), *challenges in cooperation, coordination and communication* among multiple agencies, organizations and stakeholders e.g. siloed operations, overlapping responsibilities, lack of interoperability, Insufficient joint training, etc., limited risk and hazard assessment mainstreaming, *gaps in data collection, analysis and information sharing i.e. data and information deficits* (data collection systems are often fragmented or incomplete, hindering the accurate assessment of risk factors and the development of effective mitigation strategies), insufficient data analysis (the lack of capacity to analyze and interpret large volumes of data collected on meteorological events and potential impacts is a significant challenge) or inadequate information sharing (effective coordination between agencies and stakeholders is crucial for sharing data and insights, but communication channels are often lacking or inefficient), *incomplete EWS value chain* (EWS is fragmented with focus on monitoring and forecasting not including other interconnected key elements such as the disaster risk knowledge, warning dissemination and communication and preparedness and response capabilities), *insufficient public awareness and community engagement* i.e. low levels of public awareness and preparedness for hydrometeorological risks where many individuals and communities are unaware of the hydrometeorological risk and how to respond, limited or inadequate engagement and challenges in disseminating timely and accurate information to the public, *outdated emergency response plans and protocols, funding and resource constraints for mitigation and preparedness* i.e. budget limitations, reactive budgeting, insufficient funding and resources to prepare for and respond to large-scale events, limited availability of specialized equipment and trained personnel, climate change adaptation integration, risk-informed development, vulnerable population and ageing infrastructure, private sector involvement in resilience-building efforts, etc.

Figure 6 – Vulnerability of 571 European cities to climate- and weather-related hazards[19]



Reference data: ©ESRI

The way forward pathway leads through a paradigm shift in resilience building i.e. proactive risk management, prevention and mitigation rather than response, where the local governments will be first preventers, rather than first responders to disasters. Better understanding of the hydrometeorological and anticipation of risks, utilization of data-driven approaches and technologies, as well as fostering collaborative solutions for building resilience. Consequently, *the modus operandi* to achieve this is based on the following aspects:

[19] European Environment Agency. *Vulnerability of 571 European cities to climate- and weather-related hazards.* 2020. Online. Available at: https://tinyurl.com/5b63zps5

Table 6 – Modus operandi to build resilience at a local level

Action	Sendai Framework
Understanding local risks i.e. vulnerability, exposure, capacities	Priority 1
Inclusive and participatory risk assessment	Priority 1
Design of effective and efficient mitigation and adaptation plans	Priority 1 & 2
Long-term transformative risk governance solutions	Priority 2
Design and application of digital solutions for evidence-based and risk-informed decision-making and planning	All priorities
Impact-based warning/forecasting	Priority 3
Building inclusive adaptive capacity i.e. capacity development, learning, awareness, infrastructure upgrading, ecosystem restoration	Priority 3 & 4

Table 7 – Fostering multi-stakeholder collaboration

Key stakeholders	Actions
Governments	Develop policies, regulations, and funding mechanisms to support resilience initiatives.
Private sector	Invest in resilience measures and technological innovations to ensure business continuity and robust supply chains.
Academia/Research and Development entities	Conduct research and analysis, provide technical expertise, and develop new methodologies including innovative solutions.
Non-governmental institutions	Mobilize community resources, advocate for inclusive resilience strategies, and focus on outreach and education for vulnerable populations.
Communities at-risk	Establish grassroots initiatives and social safety nets, application of local and traditional knowledge. Participation in planning and decision-making processes.

Best practices in building resilience to hydrometeorological hazards at the local levels could be the following: establishing an adaptation coordination group in Apulia, Italy; Greening urban areas in Ampelokipoi-Menemeni, Greece; flood control measures along the river Tanaro in Asti, Italy; climate change adaptation pilots in Asturias, Spain, flood model of the City of Skopje, North Macedonia, etc.

The case studies below offer an overview of experience and lessons learned on disaster risk reduction and resilience-building for hydrometeorological hazard interventions in building long-term resilience to changing climate. In this way, they aim to enhance understanding within the broader DRR community and practitioners by generating and sharing knowledge about different project approaches. This effort fosters greater awareness and collaboration among stakeholders, facilitating the exchange of best practices and innovative strategies for effective adaptation. By disseminating these insights, it supports the continuous improvement and scaling of successful risk reduction and climate change adaptation efforts.

Case Study #1 ***Albania, North Macedonia, Montenegro: Integrated climate-resilient transboundary flood risk management in the Drin River Basin in the western Balkans*** ***(2019 – 2024), Adaptation Fund/UNDP***

Background - The Project assists the Drin River riparian states in the implementation of an integrated climate-resilient basin-wide flood risk management approach aiming to improve their capacities to manage flood risk at regional, national and local levels and to enhance the resilience of vulnerable communities to climate-induced floods.

Objectives - improved climate and risk-informed decision-making, availability and use of climate risk information; improved institutional arrangements, legislative and policy framework for climate resilient FRM and strengthened community resilience through improved flood management.

Major achievements:

- Optimized hydrometeorological monitoring network incl. 20 fully automated hydrological and 13 meteorological stations;
- Hi-res Digital Elevation Models and topographic data sets were acquired, and a basin-wide hydrological model was developed to simulate scenarios and calculate hydrographs for studies of the Areas of Potentially Significant Flood Risk;
- A detailed hydraulic model was developed for the Crni/Black Drim sub-basin in North Macedonia and targeted APSFRs in Albania, alongside a 1D model of the entire basin;
- Methodology and tools developed for vulnerability assessment and prioritization of communities at risk;
- A tailored GIS-based flood risk model was developed, integrating various spatial socio-economic data with the flood hazard maps, performing vulnerability assessments and producing vulnerability maps that include damage and loss assessments;
- Tailor-made trainings on flood risk management delivered to practitioners, national and local level decision-makers and communities;
- Design of the (non)structural local flood protection measures undertaken across the prioritized communities;
- Structural risk reduction measures constructed/ underway in prioritized areas;
- Community resilience strengthened through participatory design and implementation of non-structural measures;
- Development of the basin flood risk management strategy and plan and sectoral policies underway.

Approaches and lessons:

- *Basin-wide flood risk management* – The project united countries across the entire basin to develop an integrated transboundary approach, building on EU flood management recommendations and yielding three key lessons. First, basin-wide models and flood risk maps enhanced comprehensive long-term planning. Second, efficient use of technical and financial resources led to significant cost savings. Third, it facilitated learning and information exchange across countries, building capacity to address current and future flood risks. However, a long-term framework and formal institutions are needed to support ongoing basin-wide planning beyond the project's scope.
- *Risk management tools, technologies and systems* – The development of climate risk information tools, including improved early warning systems, has led to more evidence-based decision-making in the basin. North Macedonia and Montenegro now have new automatic hydrological and meteorological monitoring stations, and existing systems in North Macedonia have been upgraded, enhancing flood forecasting and early warning capabilities. Basin-wide hydrological models and flood risk maps have informed spatial planning, construction zoning, and flood protection infrastructure design, leading to more resilient flood risk planning. The project overcame data challenges by developing national partnerships, building capacity, and using satellite imagery to fill information gaps, creating a replicable approach for other regions. Additionally, a flood risk modelling and mapping technical guidance document was developed to share lessons with other jurisdictions.
- *Learning, capacity-building and information sharing* – Coordination and effective partnerships were essential for supporting learning and information exchange across sectors at both national and regional scales throughout the project. This included engaging with the regional coordination mechanism, National Hydrometeorological Service, National Water Administrations, relevant ministries, and basin-wide technical working groups. Learning and training programs for national and regional stakeholders, along with hands-on training for Hydromet services staff, ensured effective infrastructure investments and supported long-term resilience, while alignment with other initiatives like GIZ improved resource efficiency and built on existing frameworks.

Case Study #2 Improving resilience to floods in Polog Region (2017 – 2024), Swiss Development Cooperation/UNDP

Background: Following the deadly flash floods in 2015 and 2016, the project's ambitious goal is to instigate transformational change in managing flood risk in the Polog region, accelerating the shift from purely reactive responses to floods to integrated systems to manage hazards, vulnerabilities and exposure of communities and assets to prevent/mitigate losses and alleviate the impact of future floods.

Objectives - The project aims to substantively support achieving: a) improved knowledge of the region's flood risk, causes and appropriate responses among authorities and other stakeholders; b) an inclusive approach to flood risk management planning in line with EU legislation that is sensitive to the specific needs of different vulnerable social groups; c) a better preparedness for flood risks and strengthened recovery capacity thanks to improved governance; d) progress toward flood risk-based urban and economic development; e) a reduction in the adverse consequences of future floods in high-risk areas through the repair or construction, as demonstration projects, of flood control infrastructure in line with contemporary approaches and techniques; f) creation of a flash-flood early warning and public-alert system; and g) progress in the adoption of the objectives and principles of the EU Floods Directive and the Sendai Framework for Disaster Risk Reduction.

Major achievements:

- Flood Risk Management Plan for the Upper Vardar River Basin;
- High-resolution digital terrain for more accurate assessment and risk-informed development planning (by using LiDAR methodology);
- Updated erosion map and landslide risk and hazard mapping;
- Mainstreaming DRR into local urban planning in the municipalities of Tetovo and Bogovinje;
- Inter-municipal cooperation is created as a mechanism for improved disaster risk management at a local level (Resilient Polog network);
- Enhancement of the risk and hazard assessment and planning by updating the by-law on the risk and hazard assessment methodology and development of municipal flood defence plans.
- Optimized hydrometeorological network i.e. automatic hydrological and meteorological stations and enhancement of the regional flood early warning system;
- Conducting a nation-wide public awareness campaign on flood risk management, flood preparedness and early warning systems;
- Community capacity-building on flood preparedness, response and early-warning system for the Polog Region;
- Prioritization of the flood risk mitigation measures by feasibility assessment of technical solutions, preparation of technical documentation and implementation of Eco-DRR and NbS solutions for flood protection.
- Urban runoff studies for Tetovo and Gostivar.
- Design and implementation of floodproofing options and green roofs for selected sets of public buildings in different municipalities, including the construction of a green roof in the kindergarten "Mladost" in Tetovo and Gostivar elementary schools.
- Improvement of the national legal and regulatory framework for disaster risk reduction in line with the Sendai Framework and the EU Floods Directive and conceptualization of the risk financing and risk transfer mechanisms.
- Public awareness campaign and development of knowledge products for citizens.
- Project knowledge, lessons learnt, and best practices are systematized and shared nationally and internationally
- Fostering knowledge exchange between Macedonian and Swiss DRR specialists and universities
- Gender and disability inclusion is mainstreamed at the local level through awareness raising and education.

Approaches and lessons:

- Authorities and communities have an improved understanding of flood risks and the capacity to manage them effectively in an informed manner. Emphasis was placed on creating incentives for transforming the current ad-hoc responses and reactive approaches to flood events applied by individual municipalities to a collaborative, basin-scale system of flood risk governance. The assessment and planning were carried out in a highly participatory environment through the involvement of multiple stakeholders including the most vulnerable communities and social groups. It provided detailed flood risk assessments and maps, enabling informed decision-making. Additionally, local stakeholders received training to support long-term resilience and effective flood management.
- The project enhanced disaster preparedness in the Polog region, equipping institutions and communities for effective response, recovery, rehabilitation, and reconstruction. It strengthened local capacities through training and resource allocation. As a result, the region is better prepared to timely manage and efficiently recover from disasters.
- The project implemented priority flood risk mitigation measures in the Polog region, guided by international best practices to effectively reduce future risks. These measures were designed to protect vulnerable areas and enhance community resilience. As a result, the region is better equipped to handle potential flood events.
- The project improved the national legal and regulatory framework for disaster risk reduction, aligning it with the Sendai Framework and the EU Floods Directive. It also conceptualized risk financing and risk transfer mechanisms to enhance resilience. These updates ensure a more robust and proactive approach to managing disaster risks.

3.2 MODULE 2: RISK EVALUATION AND READINESS ASSESSMENT

3.2.1 Introduction

This module aims to provide a comprehensive understanding of the risk evaluation and readiness assessment i.e. understanding of the elements of risk, assessments of risk and hazards as well as key challenges and gaps in the management of hydrometeorological hazards at the local level and international framework and indicators to support these processes. The Evaluation Process is important as it equips cities and municipalities with a systematic and practical guide to assess their risks and readiness for hydrometeorological hazards. This guidance facilitates a structured approach, allowing local governments to start their analysis and identify vulnerabilities and capacities within their communities. Utilizing international indicators in the evaluation process will ensure that assessments are comprehensive, standardized, and comparable globally. With this module, local decision-makers are empowered with the knowledge of the importance of measurements and evaluations to prioritize actions, allocate resources effectively, and tailor their strategies based on the specific needs identified through the evaluation process. The module's focus is on understanding that the evaluation process is important in enabling local governments to make informed decisions and implement targeted interventions that enhance their community's resilience to hydrometeorological hazards. Understanding international frameworks and indicators is vital for local governments because it provides a standardized and globally recognized approach to assessing and addressing hydrometeorological hazards. By exploring these frameworks, local governments gain insights into globally acknowledged indicators and benchmarks, enabling them to align their strategies with international best practices. This ensures that their risk assessments and resilience-building efforts are not only effective locally but also contribute to broader global objectives.

3.2.2 Essentials of risk assessment

The most common formula for understanding the risk is the following: ***Risk = (p*E*V/C)*** where ***p*** is the ***hazard*** (a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation), ***E*** is the ***exposure*** (the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas), ***V*** is the ***vulnerability*** (the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards) and ***C*** is the ***capacity*** (the combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience).

Figure 7 – Disaster risk formula

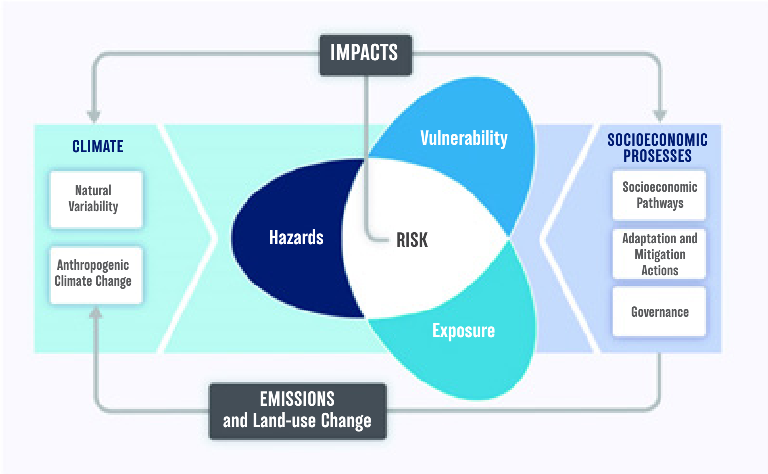
$$Risk = Hazard \times Exposure \times Vulnerability / Capacity$$

In other terms, ***the disaster risk*** is the likelihood of harmful consequences of losses (deaths, injuries, destroyed properties, disrupted economic activities or consequences to the environment) as a result of the interactions between the hazards, exposures and vulnerabilities. Disaster risk has its characteristics such are the following:

- *Forward-looking:* the likelihood of loss of life, destruction and damage in a certain period;
- *Dynamic*: it can increase or decrease according to our ability to reduce vulnerability;
- *Invisible*: it is comprised of not only the threat of high-impact events but also the frequent, low-impact events that are often hidden;
- *Unevenly distributed around the earth*: hazards affect different areas, but the pattern of disaster risk reflects the social construction of exposure and vulnerability in different countries;
- *Emergent and complex*: many processes, including climate change and globalized economic development, are creating new, interconnected risks.

Furthermore, the IPCC framed the relationship between climate change adaptation and disaster risk reduction. Exposure and vulnerability to weather and climate events, combined with the impacts of the events themselves, are understood as the key factors in disaster risk. Thus, reducing this exposure and vulnerability is a core goal of both DRR and adaptation. Importantly, both adaptation and DRR have to be understood in the context of wider social and economic development. Development can exacerbate disaster risks, both in the long run – by increasing greenhouse gas emissions that drive climate change – and in the near term, by creating or worsening hazards (e.g. in coastal areas where natural storm-surge protection is removed in favour of beachfront property development). At the same time, development is a key factor in reducing vulnerability (e.g. by improving basic infrastructure, or increasing literacy so people can read evacuation instructions). Disaster impacts can also interfere with development pathways and outcomes.

Figure 8 - A framework for understanding disaster risk, adaptation and development. Source: IPCC, 2012[20]



Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend. Disaster risk assessment is essential for hydrometeorological risk management as it offers a systematic method to identify, analyze, and evaluate potential hazards such as floods, hurricanes, and droughts. This process allows authorities to comprehend the likelihood and impact of these events, thereby enabling the development of effective mitigation strategies and preparedness plans. By assessing vulnerabilities and exposure levels, decision-makers can prioritize resources and implement measures that enhance community resilience, reduce economic losses, and save lives. Moreover, comprehensive risk assessments support informed policy-making and foster collaboration among various stakeholders, ensuring a coordinated and proactive response to hydrometeorological threats.

As per UNDRR[21], ten elements that enable the success of a risk assessment are organized under three stages. The elements are interlinked and have some level of flexibility in sequencing and timing:

- *Stage I Preparing and scoping* - This stage considers what needs to be done before embarking on a National Disaster Risk Assessment (NDRA) process, ensuring that outputs are fit for purpose. It explains the importance of identifying the key stakeholders and shaping viable governance mechanisms for NDRA, including roles and responsibilities, defining the thematic scope of the assessment, agreeing on a data management plan, and assessing the technical capacities necessary for the successful implementation of the NDRA and, if necessary, developing those capacities. The final product of this preparatory stage is the terms of reference to initiate the assessment process.
- *Stage II Conducting risk analysis* - Risk analysis is performed by the technical team, based on the terms of reference developed at the end of the scoping and preparation stage. The process provides the tools for decision-making and engaging stakeholders in disaster risk management. It involves agreeing on a set of methodologies for analysing risk from various hazards and for merging the outputs into a common format for evaluating and comparing risks and communicating the results.
- *Stage III Using NDRA results* for disaster risk management and development ensures risk-informed decisions and the long-term sustainability of the NDRA system.

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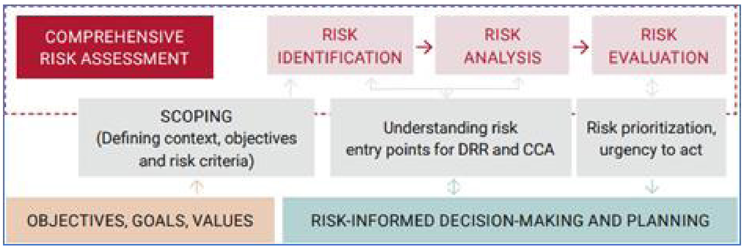
[20] IPCC. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* 2012. p.4. Online. Available at: https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/

[21] UNDRR. *Words into Action guidelines: National disaster risk assessment.* 2017. Online. Available at: https://www.undrr.org/publication/words-action-guidelines-national-disaster-risk-assessment

Figure 9 – National Disaster Risk Assessment Process (source: UNDRR, 2017)

On the other side, a *Comprehensive Risk Assessment*[22] addresses the complexity and deals with the uncertainty related to a comprehensive risk perspective. It applies a mix of quantitative, semi-quantitative and qualitative approaches. It is case-specific and action-oriented, with a significant participative element. The ISO 31000 workflow proposes the following phases of a risk assessment: scoping (to prepare the risk assessment), risk identification, risk analysis and risk evaluation. The risk assessment finally prepares the phase of risk treatment, which refers to selecting and implementing options for addressing and reducing risk. Risk communication and consultation are conducted throughout the whole process. The recommendations in this guidance are structured along the usual steps of any risk assessment.

Figure 10 - Phases of a risk assessment according to ISO 31000 and the relationship with risk-informed decision-making and planning (Source: UNDRR, 2022)



Scoping means to design a risk assessment in such a way that it can support decision-making and planning by taking into account existing objectives, goals and values and the existing policy and planning framework. In this phase, the risk assessment is linked to the context and the set-up is defined. *Risk identification* aims to identify relevant risks starting from existing knowledge and expert input. In addition, key affected sectors and geographic regions where an in-depth analysis is selected, an initial list of suitable data sources is created and potential future changes are determined. Risk identification starts with a first identification of the relevant risk(s) with a wider focus based on existing knowledge, such as reports, event databases and expert knowledge. It ends with a selection of hazards, impacts and risks that will be considered in the risk analysis phase. Risk identification can be organized in a desktop-based format and should always include a workshop with the stakeholders identified in the scoping phase. *Risk analysis* is about analysing the risk components (hazards, exposure and vulnerabilities), understanding their interrelationships as well as the resulting cascading impacts, describing the potential for adverse consequences for selected human or ecological systems and assigning risk levels (e.g. from very low to very high). For a “comprehensive” risk analysis of complex risks, a clear conceptualization of risks with so-called “impact chains” is recommended. Risk analysis analyses each selected risk, the underlying and interrelated risk factors (hazards, exposure factors and vulnerabilities) and assesses the resulting risk with data-driven, semi-quantitative and qualitative methods. The final step of “risk analysis” is to assess the risk, by assigning it to risk levels (e.g. from very low to very high), based on the description of adverse consequences and, if possible, their likelihood. This assessment is a value-based process that needs an agreed and value-based target system that should have been

[22] UNDRR (2022) *“Technical Guidance on Comprehensive Risk Assessment and Planning in the Context of Climate Change”*, United Nations Office for Disaster Risk Reduction. Online. Available at: https://www.undrr.org/media/79566/download?startDownload=20240622

defined already in the scoping phase. *Risk evaluation* means concluding out of the risk assessment concerning the demand for risk reduction measures. Risk evaluation involves comparing the results of the risk analysis with the risk criteria established in the scoping phase to determine where additional action is required.[23]

Finally, there is a set of good practices in the utilization of international indicators frameworks that can be applied to leverage resilience-building at the local level.

- With the adoption of the New Urban Agenda, Member States made transformative commitments which are grouped into the following three integrated and indivisible dimensions of sustainable development (NUA §24): (i) sustainable urban development for social inclusion and ending poverty; (ii) sustainable and inclusive urban prosperity for all; and (iii) environmentally sustainable and resilient development. To track the progress of its implementation a Monitoring Framework was developed for indicators for each dimension. Accordingly, for the environment's sustainable and resilient development, some of the indicators refer to the topic e.g. percentage of local governments that adopt and implement local disaster risk reduction strategies in line with national strategies; the percentage of subnational/local governments with budgets dedicated to climate change mitigation and adaptation actions; percentage of cities with multi-hazard mapping; does the country have a multi-hazard monitoring and forecasting system?; the number of cities that have / percentage of urban population that is covered by multi-hazard EWS; percentage of cities with multi-hazard mapping. Furthermore, there are indicators for innovation in other dimensions i.e. the percentage of cities utilizing e-governance and citizen-centric digital governance tools and the percentage of cities utilizing geospatial information systems.

- Disaster Resilience Scorecard for Cities provides a set of assessments that allow local governments to assess their disaster resilience, structuring around UNDRR's Ten Essentials for Making Cities Resilient. It also helps to monitor and review progress and challenges in the implementation of the Sendai Framework for Disaster Risk Reduction: 2015-2030 and supports the baseline analysis for preparation of the disaster risk reduction and resilience strategies. The Scorecard supports the identification of the "most probable" and "most severe" risk scenarios for each of the identified city hazards or a potential multi-hazard event. The Quick Risk Estimation tool developed by UNDRR and Deloitte supports the risk consideration since it has been designed to identify and understand current and future risks/stress/shocks and exposure threats to both human and physical assets. This tool is not a full-scale risk assessment, but rather a multi-stakeholder engagement process to establish a common understanding. Taking into account the actions or corrective measures already undertaken, the Quick Risk Estimation Tool will produce a dashboard-style risk assessment advising the risks and hazards to human and physical assets, impacts of identified main risks and associated perils on the specified location and/or particular asset. Furthermore, in 2023 the Quick Risk Estimation Tool for Integrated Climate and Disaster Risks (Climate QRE) was launched as an instrument to support cities and municipalities in making informed decisions about risk. In this context, the tool is built on processes that involve qualitatively assessing and considering risks, as an integral part of the sustainable and resilient management of these urban environments.

- ThinkHazard! provides a general view of the hazards, for a given location, that should be considered in project design and implementation to promote disaster and climate resilience. The tool highlights the likelihood of different natural hazards affecting project areas (very low, low, medium and high), guides how to reduce the impact of these hazards, and where to find more information. The hazard levels provided are based on published hazard data, provided by a range of private, academic and public organizations.

- Making Cities Resilient 2030 (MCR2030) is a unique cross-stakeholder initiative for improving local resilience through advocacy, sharing knowledge and experiences, establishing mutually reinforcing city-to-city learning networks, injecting technical expertise, connecting multiple layers of government and building partnerships. Through delivering a clear 3-stage roadmap to urban resilience, providing tools, access to knowledge and monitoring and reporting tools, MCR2030 supports cities on their journey to reduce risk and build resilience. Stage A: Cities Know Better focuses on enhancing cities' understanding of risk reduction and resilience. Stage A cities are committed to moving along the resilience pathway to develop and implement DRR and resilience strategy by firstly raising awareness around DRR and resilience and bringing relevant city actors and the public on board with the city's plans for DRR and resilience. The thematic area for this stage cities is raising awareness through accessing the suite of MCR2030 advocacy tools, guidance, and communication assets to build awareness and common understanding across their cities and amongst citizens about resilience and the city's intent to build a resilient city. The tools and assets will be relevant to a range of audiences, from the public sector to the private sector (at multiple scales), media, civil society, interested citizen groups, schools, etc. Specifically, communication assets will outline the Ten Essentials for Making Cities Resilient, thus providing a broad-based understanding of how cities reduce risk and build resilience. Stage B: Cities Plan Better cities will initially focus on improving assessment and diagnostic skills, increasing alignment between local strategies with national and regional strategies, and improving early-stage strategies and policies. Stage B cities may have had some early successes and momentum towards achieving DRR, sustainability and

[23] UNDRR (2022) *"Technical Guidance on Comprehensive Risk Assessment and Planning in the Context of Climate Change"*, United Nations Office for Disaster Risk Reduction. Online. Available at: https://www.undrr.org/media/79566/download?startDownload=20240622

resilience improvements, and have some form of strategy to address disasters but may not yet incorporate risk reduction or preventive measures. The cities must demonstrate the commitment to move towards the development or refinement of a DRR and resilience strategy and ensure development plans are risk-informed. Thematic areas for Stage B cities are improving risk analysis (Cities need to start understanding the concrete and specific nature of localized risks and resilience gaps. All stakeholders must be made aware and informed of localized risks to encourage better prevention, preparedness, and response. Importantly, cities need to access risk analysis tools to improve the analysis), and diagnostic skills for planning (Without a proper assessment of a city's historic losses and potential future risks nor understanding the baseline resilience progress, it is not possible to develop a specific evidence-based DRR, resilience and risk-informed development strategies and activities that reflect the actual needs and priorities of the cities. At this stage, cities will need diagnostic tools such as the City Resilient Profiling Tool, Disaster Resilience Scorecard for Cities, City Scan Tool, City Resilience Framework, Empowering Cities with Data, City Resilience Perceptions Assessment, City Resilience Actions Inventory, City Resilience Actions Inventory, etc. Pairing one city with another, combined with supporting cities to undertake a proper resilience assessment will help cities understand the broader implications of risks and vulnerabilities that are likely to affect them and ensure that DRR and resilience strategies address their specific vulnerabilities, exposures and other variables) and improving strategies and plans. Stage C of the resilience roadmap focuses on supporting cities in the implementation of risk reduction and resilience actions. Thematic areas for this stage cities are the following: increased access to finance, resilient infrastructure, Nature-based Solutions, climate risk integration and inclusion.

- Comprehensive risk assessment and planning in the context of climate change acknowledges that risks in the context of climate change are complex and systemic due to non-linear interactions among system components and the need for improved risk governance. The guidance can be contextualized to national and local needs.

Note #3: For the training for local government practitioners a structured practical exercise is planned following the completion of the second module. The aim is to practically apply the newly gained information and knowledge on the thematic areas of risk assessment and innovation. The structured practical exercise is enclosed as Annex III.

Case Study #3 IPA DRAM – Programme for Disaster Risk Assessment and Mapping in the Western Balkans and Turkey (2016 – 2019), EU

Background – IPA DRAM further contributed to enhancing the capabilities of the partner countries to strengthen disaster risk management by creating an open platform for the development and improvement of national disaster loss databases, enhancing the coherence among the national systems and methodologies, and consistency with existing EU regulations, guidelines and good practices.

Objectives - To improve effective, coherent and EU-oriented national systems for disaster loss data collection, risk assessment and mapping, and alignment and integration into the Union Civil Protection Mechanism and to increase beneficiaries' capabilities to ensure proper disaster risk management at national, regional and EU levels.

Results - Further developed and improved national systems for disaster loss data collection based on the EU guidelines and good practices; linkages to European or global disaster loss databases, further developed and improved national risk assessments following EU guidelines and good practices, in particular including the identification of risks of cross-border and regional aspects and further developed and improved national and regional risk mapping, and establishment of the Electronic Regional Risk Atlas (ERRA).

Case Study #4: Civil Protection of the City of Kraljevo

Background - The City of Kraljevo is highly vulnerable to disasters, particularly floods, landslides, and earthquakes. The risk of floods is specifically high due to degraded forests and erosion, harming the community's livelihood, especially for women and vulnerable groups. Following the 2010 Earthquake and 2014 Floods, the city of Kraljevo established a new disaster risk reduction framework, under the motto: Observe to predict, predict to prevent (something Galileo said a long time ago). The new approach called for the local community to take a more active role, with new forms of cooperation and communication. The city developed an extensive process for disaster risk assessments, protection and rescue plans, and disaster risk reduction plans. The first regional centre for Civil Protection training was established in Rudno, near Kraljevo and the City joined the Agreement on cooperation in the area of disaster risk reduction and civil protection development activities in the West Morava Basin. The Agreement also establishes a new joint civil protection service between the municipalities of the Western Morava River Basin to improve prevention and preparedness in the event of disasters. This area, populated by about 800,000 people, is particularly at risk of earthquakes, floods, and landslides.

3.3 MODULE 3: EUROPEAN UNION PERSPECTIVE

3.3.1 Introduction

The European Union Perspective session is critical for local governments as they lack knowledge and a comprehensive understanding of the EU's role in hydrometeorological hazard management. The overview of EU institutions involved in hazard management ensures that local authorities are aware of the diverse agencies and bodies contributing to the region's resilience. This knowledge is important in fostering collaboration, both nationally and internationally, as local governments can leverage the expertise and resources offered by EU institutions. Describing the role of the Joint Research Centre (JRC) emphasizes the importance of research and data analysis in informed decision-making. Local governments can benefit from JRC's contributions to scientific understanding and its role in providing data that informs effective hazard management strategies. The look at the EU Civil Protection Mechanism further enhances the training's significance by outlining the structure and elements of a collaborative approach to disaster response. Understanding the mechanism's definition and elements enables local governments to tap into EU-wide assistance during emergencies. This not only enhances the efficiency of emergency responses but also fosters a cooperative and coordinated response to hydrometeorological events and a sense of solidarity among European nations. Finally, the examination of the Emergency Response Coordination Centre (ERCC) underscores the importance of centralized coordination in responding to crises.

3.3.2 EU Institutions

The European Union has several institutions and bodies that play pivotal roles in managing hydrometeorological hazards, ensuring coordinated efforts across member states. These institutions are involved in risk assessment, emergency response, research, policy development, and funding to enhance resilience against such hazards. These EU institutions work collaboratively to address hydrometeorological hazards through a combination of policy-making, research, funding, and direct response efforts. By leveraging their respective expertise and resources, they enhance the EU's overall capacity to manage and mitigate the risks associated with extreme weather events and climate-related disasters. Their integrated approach ensures a comprehensive and coordinated response, facilitating the rapid deployment of resources and expertise where needed most. Additionally, continuous investment in research and innovation helps to improve predictive models and early warning systems, further strengthening the EU's resilience. Through these concerted efforts, the EU not only protects its citizens but also sets a global standard for disaster risk management and climate adaptation. Here is an overview of the key EU institutions involved:

- ***European Commission*** through the following directorates: *Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO)* manages the EU Civil Protection Mechanisms facilitating the cooperation among national civil protection authorities and is responsible for the coordination of the EU disaster response and providing humanitarian aid; *Directorate-General for Climate Action (DG CLIMA)* develops and implements policies to combat climate change, which is closely linked to the frequency and intensity of hydrometeorological hazards and supports adaptation strategies to mitigate the impacts of climate change on member States, as well as *the Directorate-General for the Environment (DG ENV)* which focuses on environmental protection, which includes managing natural resources and mitigating environmental hazards and implements the EU Floods Directive, which requires member states to assess and manage flood risks.

- ***European Environment Agency (EEA)*** provides independent information on the environment, including data on hydrometeorological hazards, supports EU institutions and member states in making informed decisions related to environmental policy and risk management, publishes reports and assessments on climate change, water management, and disaster risk reduction, etc.

- ***The European Centre for Medium-Range Weather Forecasts (ECMWF)*** is an independent intergovernmental organization supported by the EU, that provides weather forecasts and climate data, operates the Copernicus Climate Change Service (C3S) and the Copernicus Atmosphere Monitoring Service (CAMS), which offers critical information for managing hydrometeorological risks, provides advanced weather predictions and early warnings, aiding in proactive disaster preparedness, etc.

- ***European Union Agency for the Space Programme (EUSPA)*** manages the EU's space program, including the Copernicus Earth Observation Program, provides satellite data that is crucial for monitoring and assessing hydrometeorological hazards, such as floods, storms, and droughts, supports disaster management through real-time satellite imagery and geospatial information, etc.

- ***European Civil Protection Pool (ECPP)*** is a reserve of pre-committed resources from EU member states and participating countries, which enables a faster, better-coordinated, and more effective European response to human-induced disasters and natural hazards. Resources from 27 Member States and 10 participating States can be rapidly deployed in response to emergencies and each of these resources combine specialized staff and equipment necessary to respond to disasters. As of March 2024 - 130 specialized response capacities to the European Civil Protection Pool. In addition, it enhances the EU's collective capacity to manage large-scale disasters, including hydrometeorological events, facilitates mutual assistance and resource sharing among member States, etc. Notable field deployments in the recent period are the following i.e. forest fires in Chile in 2023, Italy floods in 2023, Canada forest fires in 2023, Libya floods in 2023, Germany floods in 2023, Slovenia floods in 2023, etc.

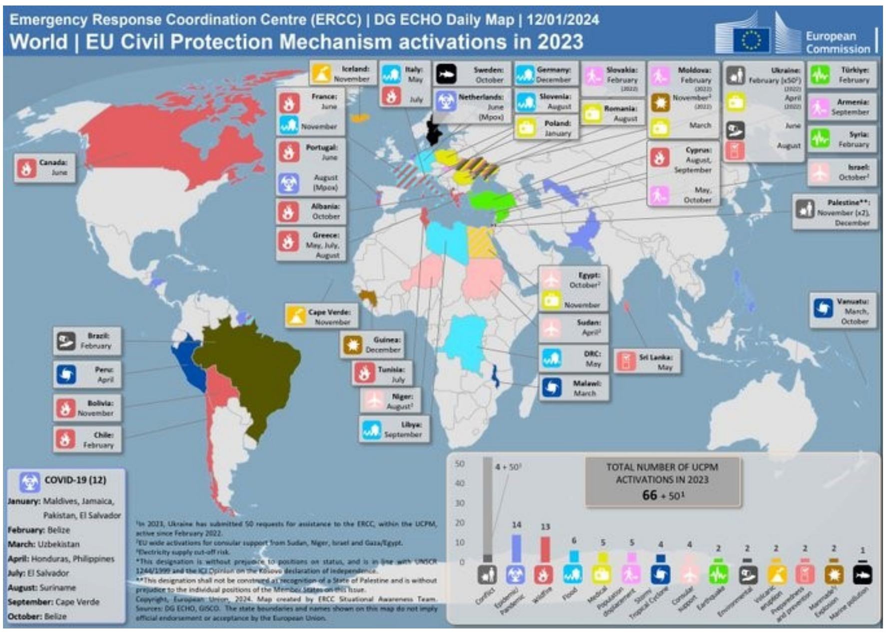
- ***European Union Solidarity Fund (EUSF)*** provides financial aid to EU member states and accession countries in the aftermath of major natural disasters, including hydrometeorological events and supports disaster recovery and rebuilding efforts, helping affected regions to restore normal living conditions quickly.

- ***The European Investment Bank (EIB)*** as a financial institution provides funding for projects aimed at disaster risk reduction and climate resilience, supports investments in infrastructure improvements, flood defences, and other measures to mitigate the impact of hydrometeorological hazards and works in conjunction with EU policies to promote sustainable development and resilience. ***Joint Research Centre (JRC)*** is the European Commission's science and knowledge service, which conducts research and provides technical support for EU policies, develops tools and methodologies for disaster risk assessment and management, offers expertise in flood forecasting, climate modelling, and risk analysis to enhance the EU's capacity to respond to hydrometeorological hazards. JRC provides independent, evidence-based knowledge and science supporting EU policies to positively impact society. Its strengths are anticipation, integration and a broad impact. Its science and knowledge activities support the six Communities' priorities for 2019 – 2024 through 33 portfolios including crisis management, cyber security, earth observation, Galileo, risks and opportunities of the future, trustworthy AI, etc. Local government benefit a lot from the JRC work through various research and development activities, such as education for climate action, localization of SDG monitoring, urban risk data platforms, etc.

3.3.2 EU Civil Protection Mechanism

The EU Civil Protection Mechanism (EUCPM) is a framework designed to enhance cooperation among EU Member States and ten participating countries (Albania, Bosnia and Herzegovina, Iceland, Moldova, Montenegro, North Macedonia, Norway, Serbia, Türkiye, and Ukraine) in the field of civil protection, to improve disaster prevention, preparedness, and response. When an emergency hits, any country can request assistance via the EU Civil Protection Mechanism. The Commission plays a key role in coordinating disaster response worldwide, contributing to at least 75% of the transport and/or operational costs of deployments. It is a joint approach that further helps pool the expertise and capacities of first responders, avoids duplication of relief efforts, and ensures that assistance meets the needs of those affected. Since its inception in 2001, the EU Civil Protection Mechanism has responded to over 700 requests for assistance inside and outside the EU. The Mechanism also helps coordinate disaster preparedness and prevention activities of national authorities and contributes to the exchange of best practices. During 2023 in total 116 activations were initiated i.e. 66 activations on the global level plus 50 activations in Ukraine.

Figure 11 – EUCPM activations in 2023



Some key points considering the EUCPM could be summarized as follows: the EUCPM coordinates disaster response efforts across Europe and beyond, assisting when a disaster overwhelms a country's ability to cope and it helps to ensure a swift and efficient response by pooling resources and expertise from participating States; the mechanism provides training programs and conducts simulation exercises to enhance the capabilities and preparedness of national civil protection authorities and these activities help build a strong network of well-trained professionals ready to respond to disasters; the EUCPM promotes disaster risk reduction by supporting prevention and preparedness measures and encourages the sharing of best practices, knowledge, and resources to mitigate the impact of disasters; through the EUCPM, countries can receive financial support for disaster response and recovery and this includes co-funding for the transportation of relief items and deployment of experts, as well as funding for prevention and preparedness projects; and by leveraging collective resources and expertise, the EU Civil Protection Mechanism significantly enhances Europe's ability to prevent, prepare for, and respond to disasters, ultimately safeguarding lives, property, and the environment.

rescEU was established as a reserve of European capacities, fully funded by the EU. It includes a fleet of firefighting planes and helicopters, a medical evacuation plane, and a stockpile of medical items and field hospitals that can respond to health emergencies. The rescEU reserve also includes shelters, transport and logistics assets and energy supply items. Reserves are also being developed to respond to chemical, biological, radiological, and nuclear (CBRN) risks. These include decontamination and detection, as well as reserves of CBRN medical countermeasures.

3.3.3 Emergency Response Coordination Centre (ERRC)

The Emergency Response Coordination Centre (ERCC) is a crucial component of the European Union's civil protection and humanitarian aid operations and it is the operational hub of the EU Civil Protection Mechanism. It plays a central role in coordinating and facilitating disaster response efforts within and outside the EU i.e. delivery of assistance to disaster-stricken countries, such as relief items, expertise, civil protection teams and specialized equipment. Its competencies can be summarized as the following:

- ***24/7 Monitoring and Situational Awareness*** - The ERCC operates around the clock, continuously monitoring potential and ongoing disasters globally. It gathers and analyzes information from various sources, including satellite imagery, weather forecasts, and reports from national authorities and international organizations, to maintain a comprehensive and up-to-date situational picture.

- ***Coordination of Disaster Response*** - When a disaster strikes, the ERCC acts as the central coordination hub for mobilizing and deploying assistance from EU Member States and other participating countries. It facilitates the rapid deployment of expert teams, equipment, and relief supplies to affected areas, ensuring that aid reaches those in need quickly and efficiently.

- ***Resource Management and Deployment*** - The ERCC manages a pool of resources, including emergency response teams, medical units, and specialized equipment, that can be deployed to disaster zones. Through the RescEU reserve, the ERCC has additional capacities, such as firefighting planes and medical evacuation units, to address large-scale emergencies.

- ***Information Sharing and Communication*** - The ERCC serves as a communication hub, disseminating critical information to relevant stakeholders, including national authorities, EU institutions, and international partners. It ensures that all parties involved in the disaster response are informed and can coordinate their actions effectively.

- ***Training and Exercises*** - The ERCC organizes training programs and simulation exercises to enhance the preparedness and response capabilities of civil protection authorities across Europe. These activities help build a cohesive and well-prepared network of responders who can work together seamlessly during actual emergencies.

- ***Support for Prevention and Preparedness*** - Beyond immediate response, the ERCC supports initiatives aimed at disaster prevention and preparedness. It promotes the sharing of best practices, risk assessments, and early warning systems to mitigate the impact of future disasters.

- ***International Cooperation*** - The ERCC collaborates with international organizations, non-EU countries, and humanitarian partners to address global disaster challenges. It coordinates EU assistance to countries outside the EU, reinforcing solidarity and cooperation in the face of humanitarian crises.

- ***Technological Integration*** - The ERCC utilizes advanced technologies and tools, such as the Common Emergency Communication and Information System (CECIS), to enhance coordination and information exchange during emergencies. These technological solutions ensure efficient management of resources and facilitate real-time communication among stakeholders.

***Case Study #5** [Joint Research Center's Risk Data Hub (RDH), European Union]*

Background:

This GIS web platform is managed by the European Commission's Disaster Risk Management

Knowledge Centre - DG Joint Research Center - Directorate for Space, Security and Migration. The Risk Data Hub is designed as a point of reference for curated EU-wide risk and disaster data, either through hosting relevant datasets or through linking to national datasets. Developed as a decision support system that integrates spatial data along with statistical analysis, it helps decision makers have an indication for time and spatial coverage of economic damages and human losses across Europe from hazardous events, upon which consistent decisions can be made.

Highlights:

It comprises three main analytical tools for risk analysis: damage and losses; facts and figures with EU region aggregates of values for the indicators of the seven Sendai Global targets; and a cross-hazard comparative view of both past and future hazards.

One feature under development is the visualization of the potential losses due to climate change under three scenarios (temperature increases of 1.5°C, 2°C or 3°C). This feature will allow end-users to better understand climate change as a risk driver. While currently, the risk analysis module contains mostly exposure and hazard information, RDH is expected to develop a vulnerability frame which will include social, political, economic, physical and environmental dimensions, which will be combined with the empirical vulnerability extracted from the past losses and damages suffered in the area.[24]

3.4 MODULE 4: IT TOOLS AND PLATFORMS

3.4.1 Introduction

This module aims to provide a comprehensive overview of the innovation for building the resilience of societies and communities to hydrometeorological hazards for practitioners from the digital innovation hubs and teams for innovations at local governments. It introduces and raises awareness about key technologies for disaster management, showcasing their common applications and outlining the main challenges and key considerations associated with them. The goal is to promote the use of technology to foster resilience. Extensive research, expert insights, and real-world implementations have demonstrated that these technologies are essential for enhancing catastrophe resilience, reducing casualties, preserving livelihoods, and improving disaster preparedness, response, and recovery. The overview of ICT solutions and tools introduces innovation practitioners and local authorities to technologies specifically designed for disaster response and risk reduction. Understanding these tools is essential for optimizing decision-making processes during emergencies and by demonstrations, their functionalities will empower local officials to use the full potential of these tools, ensuring efficient data analysis, communication, and coordination in the face of hydrometeorological hazards. In times when technology plays a pivotal role in disaster management, this module provides local governments with the skills and knowledge necessary to leverage ICT for effective response and resilience building.

3.4.2 Importance of innovation for resilience

Innovation for disaster resilience refers to the development and implementation of new ideas, technologies, and strategies that enhance the ability of individuals, communities, and systems to withstand, adapt to, and recover from the impacts of disasters. Combining innovative ideas with unity among stakeholders is essential to unlock a transformational response to the escalating challenges of climate change and disaster risk. Innovative ideas drive the development of new technologies, approaches, and solutions that can effectively address complex and evolving risks. By working together across levels of government, sectors and borders, harnessing diverse perspectives and expertise, and leveraging the power of innovation, communities can build resilience, adapt to changing conditions, and mitigate the impacts of climate-related disasters more effectively. This combination forms the cornerstone of a holistic and transformative approach to addressing the interconnected challenges of climate change and disaster risk.

Principles of innovation for building resilience could be summarized as follows. By adhering to these principles, innovation for resilience can catalyze transformative change, empower communities, and build adaptive capacity to withstand and thrive in the face of growing environmental and societal challenges.

- *Engaging innovator communities* fosters creativity, collaboration, and impactful solutions by tapping into diverse expertise and perspectives, stimulating cross-disciplinary collaboration, and accelerating the co-creation of innovative responses to complex challenges like climate change and disaster resilience.

[24] Capacity for Disaster Reduction Initiative (CADRI) Partnership. Compendium of Good Practices on Integrated Risk Information Systems. 2020. p.5–6. Online. Available at: https://tinyurl.com/mshvk5kz

- *Collaboration and Co-creation* - Foster collaboration among diverse stakeholders, including governments, communities, academia, the private sector, and NGOs, to co-create solutions that reflect local needs and contexts.
- *Anticipation and Adaptation* - Innovations should anticipate future challenges and adapt to changing circumstances, enabling communities to proactively address emerging risks and vulnerabilities.
- *The use of technology* aims to integrate the newest and most accessible solutions.
- *Data-driven decision-making* - Innovation efforts should be based on robust risk assessments and data-driven analysis to prioritize interventions and investments that yield the greatest resilience benefits.
- *Scalability and flexibility* - Successful approaches can be replicated and expanded to benefit larger populations and endure over time.
- *Inclusion and equity* ensure that innovation processes are inclusive and equitable, considering the needs and perspectives of all stakeholders, and at-risk communities, particularly marginalized and vulnerable groups.
- *Policy and governance frameworks* should enable to address of resilience holistically, considering interconnected systems such as infrastructure, ecosystems, governance, and social networks, to build comprehensive and integrated solutions.

3.4.3 Available IT Tools and Platforms

This module primarily addresses frontier technologies i.e. GIS platforms, earth observation/remote sensing, cloud (computing) technology, big data/open data analytics, cellular networks and 5G, crowdsourcing and crowdfunding, UAVs, augmented reality and virtual reality, social media, 3D printing, Internet of Things, blockchain/cryptocurrency, artificial Intelligence, hackathons/Gamification.

3.4.3.1 Geoinformation Systems - GIS

Geoinformation Systems - GIS captures, stores, analyses, manages and presents various types of geographic data and can be used to locate high-risk and disaster-prone areas for flood disaster prevention and preparedness efforts. GIS use multilayered maps to display spatial information such as elevation, meteorological data, resources, man-made structures, mass migration and demographic data. These systems combine computer science, geodesy, geomatics, geography, statistics and ML Their applications include modelling how flood disasters will spread and creating evacuation routes and local response protocols. During the response and recovery cycles, GIS can be used to create up-to-date area maps, support damage assessments, identify high-need areas, provide immediate relief, flag obstacles and contribute to Build Back Better after floods. The main challenge is the availability and quality of the data needed to create these systems e.g. cloudy sky[25] or lack of data in digital format. Some of the *best practices* include the following:

- E-Assessment Platform (North Macedonia) is a web-based platform for risk and hazard assessment operated by the National Crisis Management Centre. The E-assessment contains the hazard profile and the level of risk for the country and the 81 local self-government units (80 municipalities and the City of Skopje). The existing risk assessment process is collaborative, cross-disciplinary and cross-sectoral, both at the national and local levels, involving the key stakeholders at these levels. This GIS Platform consists of several components i.e. risk and hazard assessments component, registry of critical infrastructure, registry of resources, population data, historical events, Eco-DRR/Nature-based Solutions, and National Disaster Database (damages/losses). It is part of the National Spatial Data Infrastructure.
- Disaster Risk Analysis System (DRAS) (Bosnia and Herzegovina) is an online platform which allows free access to scientific flood, landslide and earthquake hazard data to decision-makers and citizens to increase disaster risk awareness for specific localities. Module 1 displays floods, landslides and earthquake hazard maps on Google Maps. Module 2 allows local governance authorities to view information on individuals that are considered vulnerable categories of the population, enabling better inclusion of vulnerable categories into DRR planning. Module 3 allows fast computer analysis and creation of spatial risk assessments for local authorities combining scientific hazard, land use and vulnerability data following the EU Floods Directive.
- Disaster Risk Registry (Serbia) is an interactive, electronic, geographic, and information database for the territory of the Republic of Serbia run by the Ministry of Interior Affairs in cooperation with the competent state administration bodies, other state bodies and public authority holders. The Risk Registry contains data of importance for risk management which includes

[25] OCHA. UNDP. *Innovation in Disaster Management. Leveraging Technology to Save More Lives.* 2023. p.34. Online. Available at: https://tinyurl.com/yn7y3ckx

physical and geographical data on the area affected by the risk; data on the number and structure, as well as the exposure and vulnerability of the population, that may be affected by the disaster; data on residential buildings and buildings for other purposes, infrastructure and other facilities, their exposure and vulnerability; information on past disasters and their consequences; description and characteristics of the hazard; data significant for risk reduction. The Risk Registry is public, except in the case of data that are protected under special regulations.

- European Flood Awareness System (EFAS) is developed to produce European overviews on ongoing and forecasted floods up to 10 days in advance, contributing to better protection of the European citizens, the environment, property and cultural heritage. EFAS also represents the first operational hydrological network in Europe. The principal aims of EFAS are to provide added value early flood forecasting products to hydrological services and to provide unique overview products of ongoing and forecasted floods in Europe more than three days in advance.

- EU Flood Risk Areas Viewer - Over 14,000 areas in the EU are at significant risk of flooding, according to a new online viewer. The viewer presents for the first time on one map the areas in the European Union which, according to the national authorities, carry a potentially significant flood risk. The flood risk information presented in the viewer is provided by EU Member States with support from the Commission and the European Environment Agency. This useful and user-friendly awareness tool is the result of the obligations under the EU Floods Directive that establishes the steps in the process of managing flood risk. The viewer shows the areas of potential significant flood risk, along with additional information and web links. It provides a single gateway to all Member States' preliminary flood risk assessments, flood hazard and risk maps, and flood risk management plans in the national language/s.

- European Forest Fire Information System (EFFIS) supports the services in charge of the protection of forests against fires in the EU and neighbouring countries and provides the European Commission services and the European Parliament with updated and reliable information on wildfires in Europe. EFFIS consists of a modular web geographic information system that provides near real-time and historical information on forest fires and forest fire regimes in the European, Middle Eastern and North African regions. Fire monitoring in EFFIS comprises the full fire cycle, providing information on the pre-fire conditions and assessing post-fire damages. It has several technical modules i.e. Fire Danger Forecast, Active Fire Detection, Rapid Damage Assessment, Fire Damage Assessment, Fire Emissions, Wildfire Risk Assessment, Seasonal Forecast, Monthly Forecast, European Fire Database, Fuels, etc., as well as applications i.e. current situation viewer, the current statistics portal, fire news, long-term fire weather forecast, wildfire risk viewer, data Request form and data and services.

- The Macedonian Forest Fire Information System (MKFFIS) is an integrated system for prevention, early warning and responding to disasters, especially forest fires. On the website, it is possible to visualise hotspots of forest fires and get an overview of the spatial distribution of forest fire risk. The service also provides the opportunity to visualise single parameters, such as vegetation dryness or damaged forest. The MKFFIS integrates, also, web applications and databases relating to critical infrastructure, population, a registry of available resources, and the emergency management grid. With its comprehensive capabilities, the system now makes significant contributions to assessments of risks, hazards, and response.

- Global Disaster Alert and Coordination System (GDACS) is a cooperation framework between the United Nations and the European Commission. It includes disaster managers and disaster information systems worldwide and aims at filling the information and coordination gaps in the first phase after major disasters. GDACS provides real-time access to web-based disaster information systems and related coordination tools. The integrated GDACS website offers the following disaster information systems and online coordination tools: GDACS Disaster Alerts (which are issued and disseminated to some 25,000 subscribers immediately following sudden-onset disasters and automatically estimates damages and analyse risks), the Virtual OSOOC (a restricted online platform for real-time information exchange and cooperation among all actors in the first phase of the disaster where information updates from the affected country and international responders are moderated by a dedicated team) and maps and satellite imagery (from various providers are shared on the Virtual OSOCC trough the GDACS Satellite Mapping and Coordination System which provides a communication and coordination platform where organisations may monitor and inform stakeholders of their completed, current and future mapping activities during emergencies).

- The INFORM Risk Index is a global, open-source risk assessment for humanitarian crises and disasters. It can support decisions about prevention, preparedness and response. INFORM Climate Change Risk Index is an upgrade of the INFORM Risk Index. It includes climate and socio-economic projections. The results are intended to inform policy choices across climate mitigation, climate adaptation, disaster risk reduction, sustainable development and humanitarian assistance.

- DisasterAWARE is a multi-hazard early warning, hazard monitoring, and risk intelligence platform. It provides specialized situational analysis reports for use by disaster management practitioners. Some of these are generated automatically with every advisory, while others are custom-created by PDC as needed to support hazard response.

- KAJO is the main technical partner behind the development of GeoIKP, an open-access platform, to gather and share knowledge about solutions to reduce risks of natural disasters inspired by nature – Nature-based Solutions.

- myDEWETRA is a fully integrated system for the analysis and projection of hazard-related events in multiple space and time scales, while also providing calculated impact-oriented scenarios. myDEWETRA works as a single point of access to international heritage data, previously identified, collected and systemized within a single platform. Upon formal agreement, authorized users can also integrate their data, allowing for a wider interconnectedness among information from different sources. This is expected to facilitate disaster risk managers' monitoring capacities and to foster effective disaster risk responses at any scale.

- Desinventar Sendai is a computer-based information management system that helps with the systematic collection, documentation and analysis of data about damage and losses caused by disasters associated with natural hazards. The DesInventar system supports historical data collection over long periods by using a standardized disaster data registration template. The software also provides data analysis support through the integrated DesInventar software package (database query, statistics, reporting and mapping capabilities).

3.4.3.2 Earth observation/remote sensing

Earth observation/remote sensing is collecting data from a distance, often by measuring reflected and emitted radiation. It can be used to track hazards e.g. storms and predict weather. Remote sensing can also be used to predict floods and assess vulnerability before a disaster happens by creating land elevation maps. This can be applied to disaster preparedness. Remote sensing can also be used in the recovery phase to assess flood, fire and infrastructure damage and monitor recovery efforts. One advantage of the method is that it can be used in both urban and rural locations. There are a lot of challenges i.e. cloudiness of the sky, satellite path, speed of data collection, etc.[26] *Best practices* include the following:

- Copernicus is an EU programme aimed at developing European information services based on satellite Earth Observation and in situ data. The objective of Copernicus is to monitor and forecast the state of the environment on land, sea and in the atmosphere, to support climate change mitigation and adaptation strategies, the efficient management of emergencies and the improvement of the security of every citizen. Information provided by Copernicus improves people's safety, e.g. by providing information on natural hazards such as forest fires or floods, and thus helps to prevent the loss of lives and property and damage to the environment.

- Galileo, the EU´s Global Navigation Satellite System (GNSS), provides improved navigation, positioning and timing information. Unlike other global satellite navigation systems, Galileo is a civilian system – it was conceived with secure service provision to end users at its core. Galileo offers many high-performance services worldwide including Search and rescue services to lifesaving missions by swiftly relaying radio beacon distress signals to relevant SAR crews utilizing dedicated payloads on board Galileo satellites, which are supported by three ground stations strategically deployed across Europe, and the newly planned service Galileo Emergency Warning Satellite Service which swiftly shall broadcasts alerts globally, allowing national civil protection authorities to directly transmit to smartphones (or any Galileo-enabled devices) for enhanced emergency response and resilient risk management.

3.4.3.3 Cloud computing

Cloud computing is a broad concept that can be roughly described as the remote delivery of computing services over the Internet. In other words, the machine processing the services does not need to be on-site. It can be applied before and after disasters i.e. for data collection, analysis and storage or to enable business continuity from alternate locations after hydrometeorological disasters. Challenges can be identified in the aspects of data security and privacy, reduced visibility and control, complexity and opacity and cloud migration issues.[27] Some of the good examples include the following:

- The European Weather Cloud is a community cloud computing platform jointly operated by ECMWF and EUMETSAT on behalf of their Member and cooperating tates that provides improved processing capabilities for large and complex datasets. It aims to maximise the value generated by Member States' investments, make data access easier, improve data processing capability, and foster new forms of collaboration among national meteorological and hydrological services and researchers

- SmartFLOOD is an innovative Artificial Intelligence Cloud-Web platform developed to drastically reduce cost and processing time in mapping Fluvial Flood Hazards at large scales and high resolution anywhere in the world. SmartFLOOD generates in real-time comprehensive flood hazard map for every place in Europe (at 25 m resolution) and for the entire planet (at 90 m resolution).

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[26] OCHA. UNDP. *Innovation in Disaster Management. Leveraging Technology to Save More Lives.* 2023. p.38–39. Online. Available at: https://tinyurl.com/yn7y3ckx

[27] Ibid p.22–23.

3.4.3.4 Big data/Open data

Big data/open data analytics play a crucial role in enhancing our understanding of hydrometeorological hazards and improving our ability to mitigate, respond to, and recover from such events. Nowadays data generation is currently skyrocketing with approximately 328.77 million terabytes of data being created each day in 2023 and it is estimated that 90% of the world's data was generated in the last two years alone. And by 2025, this figure is expected to skyrocket to a staggering 181 zettabytes. As an example, a single TB could hold 1,000 copies of the Encyclopedia Brittanica and 10 Terabytes could hold the entire printed collection of the U.S. Library of Congress. In that context, big data are large amounts of digital data continuously generated by the global population and open data are the data that can be freely used, re-used and redistributed by anyone. Big data and open data analytics offer valuable insights, tools, and resources for improving our understanding of hydrometeorological hazards and enhancing our resilience to such events. By harnessing the power of data and promoting open access to information, we can better prepare for, respond to, and recover from the impacts of extreme weather and climate-related disasters. They contribute to comprehensive risk assessment and planning, enhanced prediction and forecasting, improved early warning, as well as timely and effective response and recovery. Some of the *best practices* include the following:

- Big Data and analytics to support effective decision-making.
- Open Data for Resilience Initiative applies the concepts of the global open data movement to the challenges of reducing vulnerability to natural hazards and the impacts of climate change and engages with client governments in three main areas: sharing data, collecting data and using data. The OpenDRI team, in partnership with international and national agencies, has developed this suite of complementary tools to improve risk information through better access to data. These tools have global developer and user communities, all of whom contribute to the ongoing use and development of the tools – all of which are aimed at providing better information for decision-makers at all levels to take action to reduce, prepare for, and recover from disaster risks. While engaging with the government to leverage the usage of these tools, the OpenDRI also strive to create local communities of users and developers involving government agencies, universities, NGOs, and innovation hubs to create sustainable capacity.
- Virginia Flood Risk Information System (USA) is an Open Data Hub and helps communities, real estate agents, property buyers and property owners discern an area's flood risk. It allows users to quickly locate and see if the property is within the Special Flood Hazard Area. Virginia Coastal Resilience Master Plan, Open Data Portal provides datasets relevant to coastal flooding.
- OPERANDUM delivered the tools and methods for the validation of Nature-Based Solutions to enhance resilience in European rural and natural territories by reducing hydro-meteorological risks.
- GeoNODE is an open-source Geospatial content management system. It is a web-based application and platform for developing geospatial information systems and for deploying spatial data infrastructures.
- The Open Geospatial Consortium (OGC) is an international consortium of more than 500 companies, government agencies, research organizations, and universities participating in a consensus process to develop publicly available geospatial standards. OGC standards support interoperable solutions that "geo-enable" the web, wireless and location-based services, and mainstream IT.

3.4.3.5 Cellular Networks and 5G

Cellular Networks and 5G play a critical role in enhancing communication, data exchange, and disaster response capabilities in the face of hydrometeorological hazards. They enhance hydrometeorological hazard management by enabling real-time data collection, faster communication, and improved response coordination. Challenges can include infrastructure gaps and universal coverage, costs and infrastructure expansion, private sector innovation, government support and regulatory policies, etc. Some of the *best practices* include the following:

- When communication networks become unavailable, solutions such as THOR mobile can be used, bringing ultra-wideband 5G in a response vehicle to any location. THOR can be used to create a mobile network, a control centre for drones and other computing solutions.
- An alternative example is Starlink, which provides a satellite-based Internet connection that does not require on-the-ground infrastructure
- Télécoms Sans Frontières restored communication during floods in Germany in 2021 by deployment of various solutions i.e. establishment of portable networks and provision of satellite communications and connections for the emergency responders e.g. local firefighters, Red Cross, the Federal Agency for Technical Relief, etc.

- The 5G-EPICENTRE project develops an ecosystem of tools and systems to demonstrate the benefits of 5G-connected solutions to civil protection. 5G is considered to be the next decade's mainstream broadband wireless technology and can leverage the efficiency and effectiveness of everyday high-demanding operations such as Public Protection and Disaster Relief.

3.4.3.6 Crowdsourcing and Crowdfunding

Crowdsourcing/funding brings together the collective intelligence and resources of multiple actors to serve a common goal, usually through online platforms. The aim is to get a group of people to contribute towards a cause in some way, often to achieve social good. Crowdsourcing/funding projects typically involve profit sourcing, online communities, large group participation, knowledge-sharing and self-governance. Crowdsourcing is used for geotechnology (collecting geographic information), mobile communication, digital crisis information (gathering, sharing and using crisis-related information), digital volunteering, collective intelligence, multi-directional communication and situational awareness. Crowdsourcing is fundamental to humanitarian fundraising. Challenges can be identified in the access to platforms, data privacy and management.[28] Some of the *best practices* include the following:

- Crowdsourcing via social media and mobile SMS can help spread information and establish communication.
- Google Crisis Response helps people access trusted information and resources in critical moments.
- For disaster recovery, victims can crowdsource data and images of their losses to help illustrate the extent of the damage.
- PetaBencana.id provides residents, government agencies, and first responders with a real-time disaster information-sharing system at an unprecedented scale. It is the first platform of its kind to harness the power of crowdsourcing through social media to aid humanitarian response and recovery. Posts tagging the PetaBencana initiative with a reference to the disaster will prompt a chatbot to appear with a link to the PetaBencana platform. Users can then share their location, photos of any visible damage, and details like flood depth. Indonesian government agencies then validate these crowdsourced situation reports, using the data to coordinate emergency response measures. Residents can also consult the resulting collaborative map in real-time to make informed decisions about their safety and security.
- Global Adaptation Mapping Initiative is a collaborative network for mapping global evidence on climate change adaptation. It reviewed thousands of peer-reviewed articles to develop the first systematic global assessment of empirical evidence on adaptation progress. This initiative was developed to provide synthesis results to inform the ongoing Intergovernmental Panel on Climate Change 6th Assessment Report (AR6), seeking to answer the question: Are we adapting?
- Crowdfunding is possible with GoFundMe, Better World and similar platforms.

3.4.3.7 Unmanned Aircraft Systems

An unmanned aerial vehicle (UAV), also referred to as a drone is defined as a "powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload". There are three main types of UAV: fixed wing (manoeuvring like planes); rotary (manoeuvring like helicopters); or hybrid (a combination of the two). Drones can be equipped with cameras, meteorological or infrared sensors or deliverable goods, meaning that they can be used in a wide range of sectors. They can be used in a variety of ways in disaster contexts and below are some good examples:

- Drones-carrying cameras can be used to create highly detailed maps of areas vulnerable to meteorological hazards or to identify faulty infrastructure.
- Risk assessment, mapping of exposed areas, vulnerable populations and the built environment.
- Aerial surveying, damage assessment, livelihood and services restoration, insurance (handling insurance claims).
- UNICEF established UAV corridors for emergency management and response.
- FLOAT uses drones to capture location-specific elevation data.

[28] OCHA. UNDP. *Innovation in Disaster Management. Leveraging Technology to Save More Lives.* 2023. p.28–29. Online. Available at: https://tinyurl.com/yn7y3ckx

- Copernicus Emergency Management Service drone mapping aims to establish an EU-wide drone operators' network, with a dedicated GIS tool for quick deployment, able to collect drone data after activation and provide processed data within 48 hours.
- Mount Everest received its first-ever drone delivery at 6,100 m in a proof-of-concept test conducted in April this year. The incredible achievement was a first-of-its-kind mission to use drones to deliver supplies to mountaineers at such an altitude.

3.4.3.8 Augmented and virtual reality

Augmented Reality (AR)/Virtual Reality (VR) are interactive technologies that seamlessly blend the digital with the real world. AR combines the real and digital and VR creates fully immersive digital environments. A prominent example of these technologies is the metaverse, an evolving 3D-enabled digital realm that leverages VR, AR and cutting-edge Internet and semiconductor technologies. It aims to enable individuals to participate in immersive personal and business interactions online that are similar to real-life experiences. Some of the challenges include high implementation costs, suboptimal device performance with AR applications, shortfalls in safeguarding user privacy and potential security breaches.[29] Some of the *best practices* applications are like the following ones:

- Augmented Reality Crowd-Mapping System for Civil Protection and Emergency Management.
- Inond'Action, a VR experience on flood prevention and anticipation. Its purpose is to raise awareness among the general public about flooding risks, to the importance of preparation and to create a desire for citizens to be informed, and to go further. The scenario lasts about 15 minutes during which participants virtually travel between different spaces and answer some challenges. The person will have only some minutes to take all useful actions, get out of the house and save their loved ones.
- Creation of an augmented flood map identifying safe evacuation routes and infrastructure damages.
- Immersed: a VR experience about flood and resilience. Immersed is specifically targeted at community officials because they are the people who decide funding levels and drive action across the countries to combat flood risk. VR was chosen as a medium for this message delivery to create a more visceral reaction and emotional connection to the issues linked to flooding. Flood risk is difficult to visualise and understand, and Immersed allows the user to experience a major flood event in a real, personal way.
- Managing flood operations through forecast-based financing downstream of a dam.
- Japan is using Augmented Reality to teach children about the dangers of flash floods. Primary schools are running workshops using this technology. Tablets are used to simulate flash floods and show children how quickly water can rise.

3.4.3.9 Social media

Social media is any technology that connects people's ideas and information through the Internet. It is an inherently casual social environment that is online. Social media platforms play a pivotal role in facilitating information-sharing during crisis management. The applications of social media in disaster management include information gathering, semi-journalistic verification and crowdfunding. Social media has become a vital tool for gathering information by enabling anyone to share messages, photos and videos across the globe instantly. Social media allows organizations to receive the latest news from media and individuals, allowing anyone to voice a problem to the World. Some of the *best practices* are like the following:

- A vital tool for gathering information by enabling anyone to share messages, photos and videos across the globe instantly.
- X's disaster alerts have made the platform useful for emergency communication.
- Facebook has a safety check feature.
- JRC is open-source software that decrypts social media messages to help manage risks and disasters

[29] OCHA. UNDP. *Innovation in Disaster Management. Leveraging Technology to Save More Lives.* 2023. p.18–19. Online. Available at: https://tinyurl.com/yn7y3ckx

- Telegram provides channels for sharing disaster information i.e. @Disaster News and Chatbot.
- DRMKC established the SMDRM Task Force to identify, understand, and address the challenges for improving the adoption of non-traditional social media data for disaster management by taking a collaborative approach between researchers and practitioners in disaster management to co-design solutions.

3.4.3.10 3D printing

3D printing, also known as additive manufacturing, is a way of producing three-dimensional objects from a digital model by depositing or joining layers of a given material. 3D printing is a bespoke service that shortens production time for parts with minimal resources. 3D-printed models of the terrain are used to determine exposed and vulnerable communities and create response plans. Challenges still exist due to the need for specific materials, hardware and technological knowledge. Some of the best practices examples include the following:

- Application of 3D-printed Automatic Weather Stations for improvement of the monitoring and forecasting part of the EWS value chain.
- 3D Printing can create tools, shelters and solutions for any emergency i.e. floods or personal protective equipment for rescuers, as well as housing and social infrastructure units during a disaster recovery phase.

3.4.3.11 The Internet of Things (IoT)

The Internet of Things (IoT) is an interconnected network of devices and sensors that uses technology to integrate systems, environments and contexts better. IoT technology can support every stage in the disaster management cycle.

- IoT is a flood mitigation game-changer with the application of IoT sensors allows for accurate flood forecasts and near-real-time data analysis.
- IoT enables EWS for disaster resilience by collecting real-time data and connecting data sources/sensors for informed decision-making.
- Critical infrastructure can be protected through predictive maintenance.

3.4.3.12 Blockchain and Cryptocurrencies

Blockchain/cryptocurrency is still mainly used in disaster risk management settings for response and recovery. It can be used for supply chain management, pre-project donor funding processes, cash programming, crowdfunding and the creation of digital IDs for affected citizens. Some key challenges are the following: certain blockchain types require significant technology investments, transaction throughput is limited, and blockchain has a track record of being used for illegal activities, such as on the dark Web, the regulatory landscape is uncertain and varies across jurisdictions and there are limitations relating to data storage capacity. Some of the best practices are listed below:

- Habitat for Humanity uses the cryptocurrency Ethereum for Disaster Relief.
- UNICEF uses Ethereum for smart contracts.
- FEMA looks at Blockchain to streamline disaster insurance payouts, as well as speed up its response to disasters.

3.4.3.13 Artificial Inteligence

Artificial Intelligence (AI) is the automation of activities that we associate with human thinking, activities such as decision-making, problem-solving, and learning. AI can be subdivided into three categories: artificial narrow intelligence (ANI), artificial general intelligence (AGI) and artificial super intelligence (ASI). AI is seamlessly integrated into diverse technological domains and the following applications can be listed: automation, machine learning, natural language processing, self-driving cars or text, image and audio generation. Good practices are identified as follows:

- SEEDS AI system developed by SEEDS, Microsoft and Gramener predicts natural disaster risks based on local conditions, enhancing preparedness and creating tailored response plans.
- Use of machine learning in hydrometeorological hazards modelling.
- Natural language processing applications for hydrometeorological hazards assessment
- TEMA project - designing and development of an AI-enabled Natural Disaster Management platform.
- Earth Care Climate is a one-stop-shop platform for easy data access and analytics of climate & severe weather. It has access to over 25 climate, environmental and severe weather data types globally. Data is combined from satellites, radar systems, national agencies and IoT devices.

3.4.3.14 Collaborative solutions and gamification

Hackathons are social coding events and the application of ***gamification***[30] tools for improving or building new solutions for resilience. They are beneficial since they include traditional and non-traditional actors in risk reduction i.e. youth, data scientists or gamers. Mainly are used for designing solutions to some identified resilience-related problems, to test certain approaches or to contribute to strategic development and understanding of the complex and uncertain future. Some of the examples are listed below:

- HackZurich 2021 - hackathon coders enhance relief efforts during dangerous floods
- EU Sparks for Climate: Citizens Hackathon Championship
- Resilient Skopje Foresight for identification of vulnerable sectors to climate change i.e. water, health and disaster risk reduction.
- Floodwatch - A tool that helps evacuate zones prone to flooding and save lives.
- Urban resilience and climate change adaptation challenges.
- Water for Life - to generate insights and data on the key challenges and opportunities surrounding the Strumica region including water and flood management.

3.4.4 Challenges and lessons learnt in implementation of innovations for DRR

Challenges with the implementation of innovation projects for building resilience to disasters can be summarized as follows:

- Technical limitations: lack of technical knowledge, resources or infrastructure, restrictive technical environment and integration, interoperability;
- Data requirements: availability and access, quality, timeliness and relevance;
- Data Ownership & integrity: accountability, equity and inclusivity, privacy, ethics and integrity concerns;
- Practical considerations: scalability, high-tech vs. low-tech solutions, funding, awareness and education, policy and regulatory framework, institutional architecture, capacity development, political, cultural and environmental challenges

Lessons learned from the application of the innovation solutions are as follows:

- Empowering innovators through support, capacity building, resources, and partnerships with local governments and the private sector;
- Innovative approaches are needed to develop disaster and climate-resilient systems and communities;

[30] Gamification is using gaming elements in non-gaming contexts.

- Innovative technologies and solutions are touted as a potential contributor to building resilience.
- Reliable data and advanced analytics are essential for informed decision-making and proactive;
- Integration of technologies and traditional knowledge enhances the effectiveness;
- Scalability and flexibility of innovations to different sizes and types of hazards

EU Framework Programmes for Research and Innovation are the main instruments for the implementation of the common scientific and innovation policy. Horizon Europe, through Cluster 3 – Civil Security for Society, continues in 2024 to support the most innovative and ambitious European institutions, as well as researchers and economic actors, in their efforts to respond to challenges posed by threats such as natural disasters, cybercrime, and terrorism.

Case Study #6 ***Copernicus Emergency Management Service Mapping***

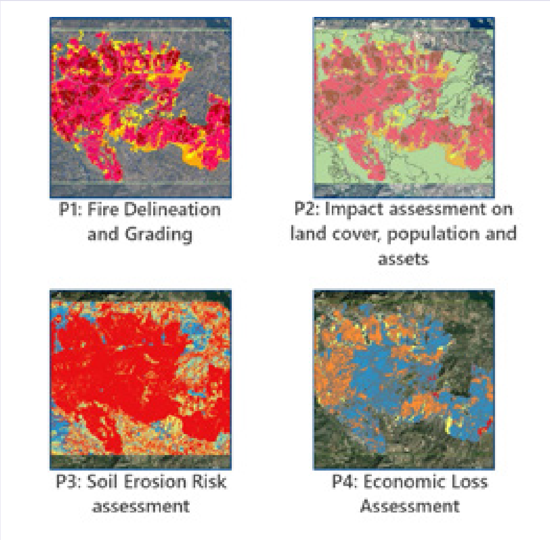
Background:

The Copernicus Emergency Management Service (CEMS) with more than 12 years of experience and 900+ activations support all actors in managing natural and human-made hazards across all disaster management phases i.e. prevention (risk assessment and reduction), preparedness (early warning systems and near real-time monitoring), response (rapid maps and monitoring of events) and recovery (post-disaster analysis). It offers, on-demand, timely and accurate geospatial information derived from satellite images and supplemented by available (in situ) data sources. Service at no cost to users with global coverage and studies on national, regional and local scales. It supports various agents (mainly civil protection authorities, and humanitarian aid agencies).

Case Study – Forest Fires

User: Ministry of Interior/D.G. Guardia Civil/Jefatura del Seprona, Spain

- Objective: support police investigation and delineation and impact assessment of a forest fire
- AOI: >100 km2
- Products: fire delineation and grading to determine its extent and spatial effects, impact on landcover and ecosystems: most affected types of natural and man-made capital changes in soil erosion risk to identify erosion-prone areas and economic loss assessment: direct losses - an estimate of the monetary cost of restoration and indirect losses – affected ecosystem services.



Case Study – Aerial component

- Aerial imagery by planes (optical data acquisition and LiDAR data) and UAVs (EU-wide drone network with more than 160 operators and data processing after image collection within 48 hours), and
- Satellite VHR1.

3.4.5 Leadership and decision-making for resilience-building

Leadership and Decision-making - This session covers contemporary aspects of leadership and decision-making in disaster risk management that are important for senior practitioners and managers in civil protection agencies. Effective leadership is crucial during emergencies and disasters, as these situations demand rapid decision-making, clear communication, and the ability to motivate and coordinate teams under pressure. This section delves into the essential qualities and strategies that enable leaders to effectively manage the complexities and uncertainties inherent in emergencies beyond the hydrometeorological hazards. There are several theoretical concepts and schools about the origin of the concept of leadership, its components, applicability in different fields and scientific disciplines, etc. On this occasion, we will not elaborate on the concepts for the construction of the notion of leadership but simply determine the terminological framework that is closest to the thematic area and set the basic principles, characteristics and skills of leadership in crisis management. So for example, leadership is understood as "*a relationship through which a person influences the behaviour or actions of other people*"[31] or "a function of knowing oneself, having a vision that is well shared and that builds trust among *colleagues and taking effective action to realize one's leadership potential*".[32]

Contemporary challenges in emergency management could be summarized as the following:

- *Leadership challenges* - Effective emergency management requires clear leadership, defined chains of command, and seamless communication among multiple response teams and agencies. Traditional command and control systems often lack a real-time common operating picture and the ability to share vital information instantly, hindering coordination and response efficiency.

- *Ineffective communications* often undermine emergency management operations due to the need to coordinate with various stakeholders, including response teams, third-party services, and the public.

- *Dynamic and widespread emergencies and incidents* - Routine approaches to small-scale incidents are insufficient for managing major disruptions. Organizations that lack systematic and well-rehearsed operating procedures struggle during critical incidents, risking business operations, stakeholder relationships, and long-term reputation.

- *Complexity and uncertainty* – Disaster risk management inherently involves dealing with complex and uncertain situations. The complexity arises from the multifaceted nature of risks, involving numerous stakeholders, interdependent systems, and unpredictable variables. For instance, a single hydrometeorological disaster can impact infrastructure, disrupt communication networks, and affect various population groups differently, requiring a coordinated response from multiple agencies and organizations. Uncertainty further complicates risk management by introducing unpredictability into the equation. Hydrometeorological emergencies can escalate rapidly, with evolving conditions that make it difficult to anticipate the exact nature and scope of the response needed. Factors such as weather changes or unforeseen cascading impacts can alter the dynamics of a hydrometeorological emergency requiring constant reassessment and adaptation.

When we talk about leadership in disaster risk management, it is not just about managing the process of eliminating risks and threats, but much more. Leadership encompasses a whole set of skills and knowledge that contribute to dealing with hazards, but also with managing processes, and resources, making and executing decisions in a short period, under increased pressure of hazards, taking into account timely, efficient and effective handling, through rational use of resources and respecting the rights and peculiarities of the affected population. Consequently, the leaders in disaster risk management need to have specific characteristics and skills given that they are in a specific environment i.e. in the prevention and preparedness segment, leadership is more static by taking pre-planned actions, while in the response phase, leadership is dynamic and active and requires making decisions in a short period, for the use of resources, saving life and goods, ensuring successful event handling.

According to Boin et al.[33] there are five key tasks to be successful in risk management leadership: *sense-making* (understanding and interpreting the emergencies and crises to inform decision-making i.e. leaders have the responsibility to look for opportunities to solve emergencies and crises and to deal with them); *decision-making and coordination* (making strategic decisions and coordinating the implementation of those decisions across various agencies and organizations and leaders have the responsibility to make final decisions and in doing so should reach out to all groups in the affected community); meaning-making (leaders are at the centre of attention during the response and their ultimate responsibility is to direct the public's attention to the true sense of dealing with the event while motivating the stakeholders to become active in the situation while communicating effectively to provide a coherent narrative and reassure stakeholders), *accounting* (evaluating and explaining actions taken, ensuring

[31] Mullins, L. J. (2002) Management and Organisational Behaviour. Sixth edn. United Kingdom: Financial Times Publishing.

[32] Maxwell, J. C. (2007) The 21 Irrefutable Laws of Leadership: Follow Them and People Will Follow You. Rev. edn. Nashville, T.N.: Thomas Nelson

[33] Boin, Arjen, t'Hart, Paul, Stern, Eric & Sundelius, Bengt. 2005. The Politics of Crisis Management: Public Leadership under Pressure. New York: Cambridge University Press.

transparency and accountability i.e. leaders guide the involved parties to the right end to eliminate the hazards and risks and move forward) and *learning* (the ultimate imperative of good leadership where the leader is analyzing the response to identify lessons learned and improve future risk management strategies).

Leadership[34] skills are the abilities and knowledge that leaders have to perform their role. Leaders in the disaster risk management system need to be experts in the field who will know how to make their knowledge and experience available, aware of the environment and community, hazards, exposure and vulnerability of risk elements, and able to partner and collaborate with all subjects, communicative and adaptable to the harsh conditions of emergencies and disasters.

Essential leadership and decision-making skills for disaster/civil protection managers include a combination of personal attributes, strategic thinking, and practical tools. Here are the key elements:

- *Decisiveness* is the ability to make prompt and effective decisions. In emergencies and disasters, delays can have serious consequences. Quick, well-informed decisions can save lives and resources. An example would be ordering an immediate evacuation when a flood changes direction.

- *Adaptability and flexibility* are the ability to adjust strategies and approaches in response to changing situations. Emergencies and disasters are unpredictable, and the ability to pivot quickly is crucial for effective response and recovery. An example would be changing evacuation plans based on real-time weather updates.

- *Effective communication* with clear and concise exchange of information. It aims to ensure that all stakeholders are informed and coordinated, reducing confusion and enhancing response efforts. Leveraging multiple channels, adapting messaging, and fostering two-way dialogue can build trust and facilitate coordinated flood response efforts. For example, to conduct regular updates to the public and coordinate with other stakeholders.

- *Situational awareness* means understanding the current situation, including the scope and potential impact of the hydrometeorological risks. Leaders must continuously monitor the situation, gather reliable data, and maintain a clear understanding of the evolving challenges. It enables informed decision-making and effective resource allocation. An example would be to monitor multiple information sources to get a comprehensive view of the flood.

- *Strategic thinking and planning* is the ability to plan for various risks and potential scenarios and consequently develop long-term strategies and actions. This approach helps in preparing for and mitigating the impact of emergencies and disasters before they occur. For example, to lead the process of designing a flood early warning system or development of a flood preparedness operational plan.

- *Collaboration and teamwork* result in effective and efficient coordination and cooperation with other stakeholders, organisations, communities or international entities. Emergencies and disasters always require a coordinated response from multiple local, national and international entities. Leaders must foster a culture of trust, open communication, and shared decision-making to navigate complex challenges. In this context, an example is the establishment of partnerships at all levels, including foreign entities for flood mitigation or flood response.

- *Risk assessment and management* refer to the identification of potential risks and the development of risk mitigation strategies which result in the reduction of the Likelihood and impacts of emergencies and disasters i.e. conducting regular flood risk assessment and regular updating of flood preparedness plans accordingly.

- *Resourcefulness* is the ability to find quick and clever ways to overcome difficulties and ensures that disaster managers can effectively utilize limited resources. An example would be the improvisation with available resources when standard supplies are exhausted e.g. during the May 2014 floods in Serbia.

- *Knowledge of technology and tools* is proficiency with the latest technologies and ICT solutions and tools used in disaster risk management. It significantly improves the overall risk management process as well as the timeliness, efficiency and effectiveness of operational planning and response. E.g. use of GIS for mapping flood impacts and coordination of response activities in the affected area with prioritization of vulnerable groups of citizens.

- *Training and development* is the ongoing education, knowledge building and skills enhancement for oneself and the team. It keeps the emergency responders prepared for mitigating, preparing, responding and recovering from existing and emerging risks and threats and enhances the overall professional competencies. E.g. professional training, knowledge-building sessions and workshops, simulation and field drills or certification programmes for disaster managers.

[34] Kapucu, Naim and Montgomery Van Wart. 2008. "Making Matters Worse: An Anatomy of Leadership Failures in Managing Catastrophic Events", Administration and Society 40, 7, 711–740.

- *Empathy and compassion are* understanding and addressing the needs and emotions of affected individuals and communities. It helps in building trust and ensuring that the response efforts are community-centred e.g. risk communication and provision of psychological support.

- *Ethical leadership* is leading with integrity, transparency and accountability. It aims to build mutual trust with the public and ensures that all actions are just and fair. Balancing competing priorities, assessing risks and trade-offs, and ensuring equitable outcomes are crucial considerations. E.g. transparent decision-making processes and accountability in the use of resources for flood mitigation and response.

- *Understanding Uncertainty and Complexity* - Navigating the dynamic and unpredictable nature of hydrometeorological risks demands a profound grasp of both uncertainty and complexity. Leaders must be adept at making informed decisions amidst incomplete data and swiftly changing conditions.

- *Transformative approach* - In an increasingly unpredictable world, disaster management requires a transformative approach that goes beyond traditional reactive methods. Future crises, characterized by their complexity and scale, necessitate leaders who are innovative, adaptive, and forward-thinking.

- *Risk anticipation* is the proactive process of identifying, assessing, and preparing for potential hydrometeorological hazards and threats before they materialize into full-blown emergencies or disasters. It involves a forward-looking approach to foresee and mitigate emerging risks, thereby enhancing the preparedness and resilience of systems and communities.

- *Decision-making frameworks* provide structured approaches to analyze information, assess risks, and make timely, informed decisions.

- *Resilience and adaptability* - Effective emergency management requires cultivating resilience and adaptability to navigate the uncertainties and complexities of emergencies and disasters.

- *Continuous Learning and Improvement* - Effective emergency management requires cultivating resilience and adaptability to navigate the uncertainties and complexities of emergencies and disasters. Leaders must foster a culture of continuous learning and preparedness to respond swiftly and effectively.

- *Creativity* is an often overlooked but essential skill for disaster managers. It involves thinking outside the box, generating innovative solutions, and adapting to rapidly changing situations. In the high-pressure environment of disaster risk management, creative problem-solving can make the difference between success and failure.

- *Sustainability and innovation* refer to the integration of sustainable practices into disaster risk management to address long-term environmental impacts and to foster a culture of continuous learning and innovation, regularly updating practices based on new insights and technologies.

- *Foresighting the future* involves proactive planning, anticipating emerging trends, and preparing for potential scenarios to enhance readiness and response capabilities. It requires a forward-thinking approach that integrates foresight into strategic decision-making processes. By integrating trend analysis, scenario planning, technological advancements, collaborative networks, training, and policy adaptation, disaster risk management can enhance resilience and readiness in an increasingly uncertain world. To build resources and capacities as well as mitigating measures before disasters strike, the effective use of anticipatory analysis and foresight is becoming indispensable. With the help of early detection and the proper recognition and analysis of alarm signs and patterns, civil protection authorities can react pre-emptively. Foresight can also potentially help assess disaster impact and cascading effects.

By integrating these essential elements, disaster managers can lead effectively and make sound decisions under the pressure and complexity of emergencies and disasters.

ANNEXES

ANNEX I – GLOSSARY

Avalanche - A mass of snow, rock, ice, soil, and other material slides swiftly down a mountainside.

Blizzard – A severe snowstorm characterised by poor visibility, usually occurring at high latitudes and in mountainous regions.

Coastal storm surge - A storm surge is a large-scale increase in sea level due to a storm. Low atmospheric pressure allows sea level to rise, and gale force winds combined with the Earth's rotation force water towards the coastline.

Disaster - A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.

Disaster risk management - Application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.

Flood - An overflow of water onto normally dry land. The inundation of a normally dry area is caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Ponding of water at or near the point where the rain fell. Flooding is a longer-term event than flash flooding: it may last days or weeks. ***Flash flood*** - A flood caused by heavy or excessive rainfall in a short period, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam.

***Hailstorm* -** a form of solid rain consisting of balls or irregular lumps of ice, measuring between 5 millimetres and 15 centimetres in diameter.

Heavy snowfall - The snowfall in an area or country is the amount of snow that falls there during a particular period.

Resilience - The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

Thunderstorm - a rain-bearing cloud that also produces lightning.

Tornado - A violently rotating column of air touching the ground, usually attached to the base of a thunderstorm.

Tropical cyclones (typhoons and hurricanes) - **Typhoon** is a giant, rotating storm that brings wind, rain and destruction. Hurricanes and typhoons are both kinds of tropical cyclones. **A hurricane** is a storm system rotating around an area of low pressure, which produces strong winds and heavy rain. Technically the system is called a tropical storm if wind speeds are between 34 and 63 knots, and it is only classified as a hurricane if the wind speed exceeds 63 knots. A hurricane is on average 500 miles wide and 10 miles high and moves forward like an enormous spinning top at a typical speed of 17 knots.

ANNEX II – CORRECT ANSWERS (Quiz, Pre-Training Assessment Test)

Note #1 - Quiz:

#1: Which of the following is not a hydrometeorological hazard?
Correct answer: C – Earthquake.

#2: What is the most frequent and costly hydrometeorological hazard?
Correct answer: B – Flood.
As per the Human Cost of Disasters 2000 – 2019 publication during these two decades floods were the most frequent hazardous events with 3,254 events in total.
https://www.undrr.org/publication/human-cost-disasters-2000-2019

#3: According to the United Nations High Commissioner for Refugees, how many people have migrated because of weather-related disasters like droughts, floods, etc.?
Correct answer: D – 21.5 million.
Weather-related disasters have displaced an estimated 21.5 million people since 2010. These climate refugees have fled droughts, windstorms, hurricanes, fires, and other disasters that make it difficult to access food or meet their basic needs.

#4: FEMA estimates that 13 million Americans live within one. Another study in an environmental journal estimates that as many as 41 million Americans live within one. What is it?
Correct answer: A – 100-year flood zone.
The 2018 Study[2] shows that the total US population exposed to serious flooding is 2.6–3.1 times higher than previous estimates and that nearly 41 million Americans live within the 1% annual exceedance probability floodplain (compared to only 13 million when calculated using FEMA flood maps). The population and GDP growth alone are expected to lead to significant future increases in exposure, and this change may be exacerbated in the future by climate change.

#5: Which is the deadliest flooding event in Europe during the period 1950 – 2020?
Correct answer: D – 1953 North Sea flooding in Netherlands and Belgium.
The storm surge in the Netherlands and Belgium in 1953 remains Europe's deadliest flood in the period, with 2,551 fatalities, 9% of total Dutch farmland flooded, 187,000 animals drowned, and 47,300 buildings damaged of which 10,000 were destroyed.

#6: What is the average annual loss (AAL) due to flooding in Europe during the period 1980 and 2020?[3]
Correct answer: A.

Note 2: Pre-training Assessment Test

#1 Hydrometeorological hazard is a process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage
Correct answer: True.

#2 What is the main goal of disaster risk reduction?
Correct answer: B - Reduce the impacts of all disasters.
Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.

#3 What are the main components of disaster risk management?
Correct answer: A - Prevention/mitigation, preparedness, response, recovery.
Successful disaster risk management requires the implementation of all these four components/elements

***#4 What type of disaster risk management is explained in the following case*? It promotes the involvement of potentially affected communities in disaster risk management at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for disaster risk reduction.**
Correct answer: C - Community-based disaster risk management.

#5 Which notion describes resilience?
Correct answer: C - The ability to adapt, transform and recover from the effects of a hazard.

#6 What is the purpose of conducting risk assessment in disaster risk management?
Correct answer: C - To identify and analyze potential hazards and their impacts.
Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend.

#7 Risk and hazard assessment include:
Correct answer: C – Both qualitative and quantitative data and information to have a full understanding of the context.

#8 Which of the following is the first step in the risk assessment process?
Correct answer: B – Hazard identification.
Disaster risk assessments include the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities concerning likely risk scenarios.

#9 What is the limitation of the following definition? Definition: Innovation means doing things in a new way, or creating new things.
Correct answer: B - It includes creative actions that, in isolation, are not strictly innovation.

#10 Which of the following technologies is most commonly used to improve disaster resilience through early warning systems?
Correct answer: D - Geoinformation Systems (GIS)

ANNEX III – ADDITIONAL RESOURCES

Practical Work (Structured Practical Exercise)

Scenario

During the last decade, the Municipality of Astoria on several occasions was affected by disastrous events e.g., torrential floods in 2015, 2019, 2021 and 2023, wildfires in 2018 and 2022, and prolonged heatwaves in 2017 and 2018. As a result, there were losses of human lives, damages and losses to the local level infrastructure and businesses, and exacerbated vulnerabilities disproportionally affecting the communities and their members. Furthermore, the COVID-19 pandemic crisis impacts its socio-economic development and communities in an unprecedented way. All these events weaken municipal resilience texture and lead to increased social inequalities.

To advance the resilience-building agenda at the local level, on 01 July 2024, the municipal authorities adopted the **Local Level Disaster Risk Reduction Strategy** paving the way for the **establishment of a framework for inclusive and sustainable disaster risk management on the local level**. This strategy refers to a set of disaster risk reduction measures and actions that will be implemented in a multi-risk, multi-hazard and multi-sector way while leaving no one behind.

To implement the objectives for achieving a disaster-resilient municipality, the local authorities are obliged to follow the best global, regional and local policies and standards, as well as the national normative and institutional frameworks. Accordingly, through the municipal department of emergency services, a priority list of measures and actions was prepared and adopted by the Council of the Municipality. Accordingly, the following actions were prioritized:

- **Review** of existing normative framework and best practices for community-based disaster risk management;
- Implementation of **municipal risk and hazard assessment**;
- Conduct of **Vulnerability and Capacity Assessment**;
- Establish partnerships with the private sector, academia and civil organizations;
- Preparation of the operational planning documents together with the local-level **Disaster Risk Management Plan**;
- **Identification of immediate and emerging needs of the affected communities;**
- Establishment of communication and coordination framework with the **adoption of the Crisis Communication Plan.**

ASSIGNMENT 1: RISK AND HAZARD ASSESSMENT

The starting point in disaster risk management on the local level is the disaster risk assessment including the vulnerability and capacity assessment of the municipality or the local communities.

As a part of this assignment, please focus on the disaster risk assessment preparation through the implementation of some of its phases:

1. Identify key stakeholders in your municipality and their roles in the local level disaster risk reduction:

Key stakeholders	Roles in DRR	DRM Cycle phases: (M-Mitigation; P-Preparedness; R-Response; Re-Recovery)

2. Identification of gaps and challenges in building resilience to hydrometeorological hazards (at least three for each phase)

Risk management phase	Gaps/challenges	Recommended actions
Prevention/mitigation	•	•
Preparedness	•	•
Response	•	•
Recovery	•	•

3. Fill the example chart for the hydrometeorological hazards in the template below:

Problem/issue/ hazard	Potential risk	Vulnerabilities	Capacities	Immediate needs	Mitigation actions
Flood	•	•	•	•	•
Heatwave	•	•	•	•	•

4. List at least 2 vulnerabilities and adequate capacities for these hazards:

Problem/issue/ hazard	Vulnerabilities	Actions to transform vulnerabilities into capacities
Flood	•	•
Heatwave	•	•

5. For the mitigation actions listed under point 3, please add what type of innovation technology/solution can be applied.

Problem/issue/hazard	Mitigation actions	Innovation technology/solution
Flood		
Heatwave		

Your responses should be brief and up to the point with a total length not exceeding 1.5 pages.

ANNEX IV– ADDITIONAL RESOURCES

Dive deeper into these topics through engaging videos, enriching your understanding and fostering collaborative learning.
10 things you should know about disaster risk reduction.
There's no such thing as "natural" disasters.
What makes people vulnerable to disasters?
Before the Flood Full Movie National Geographic
Most Powerful Forces on Earth: Heatwaves | Fatal Forecast | Free Documentary
Floods and Landslides in BIH
Germany's flood catastrophe one year on | DW Documentary
DocFilm - Flash Floods in Europe - The Traumatic Aftermath
Record drought poses serious threat to Europe's environment and critical infrastructure | DW News
Scorching heat and 'biblical' floods: What is the Omega weather system? | DW News
Sendai Framework for Disaster Risk Reduction 2015 – 2030.
The Sendai Framework and the Sustainable Development Goals.
What is the 'Paris Agreement', and how does it work?
The European Green Deal
Integrated Approach to Disaster Risk Management: Prevent, Residual Risk, Prepare, Respond, Recover
Floods are increasing WAY faster than we expected
Mapping and Managing Floods in Europe: Examples from the Netherlands, Ireland, and Austria
Copenhagen: How to flood-proof a City
The Ten Essentials for Making Cities Resilient
Disaster Risk Register
EU for disaster-resistant Serbia - Register of risks at Dubai Expo
An Introduction to EFAS, the European Flood Awareness System
DisasterAWARE® Reduces Disaster Risk, Saves Lives
Croatian company uses big data to better predict and manage flood risk
Open Data for Resilience (OpenDRI) Initiative
When Disaster Strikes Maintaining Network Functionality in the Face of Unexpected Events
Drones in an Age of Extreme Weather
Artificial Intelligence for Natural Disaster Management | WMO & UNEP | Webinar
EENA Webinar: Galileo Emergency Warning Satellite Service - Updates from the STELLAR Project
Early Warnings for All Initiative

Unlock Insights: Delve into Hydrometeorological Hazards, Risks, Resilience, and Adaptation Through Engaging Texts and Publications!
Human costs of disasters 2000 - 2019
Serbia Floods 2014 PDNA Report
Bosnia and Herzegovina Floods, 2014 - Recovery Needs Assessment
Study on Climate Change in the Western Balkans
UNDP: How extreme weather increases inequality
United Nations Office for Disaster Risk Reduction (2023). Regional Assessment Report on Disaster Risk Reduction 2023: Europe and Central Asia.
OECD Climate Action Monitor 2023
Black Swan Series: Why Preparing for Future Black Swans Helps You Grow Today - Diane Pierson
What will the future bring when it comes to climate hazards? - Overview
Inclusive and sustainable disaster risk reduction efforts feed on science and technology, experts say - UNDRR
The European Green Deal - A growth strategy that protects the climate - EC
United Nations Office for Disaster Risk Reduction - Europe's opportunity to manage risk and build resilience: Recommendations to the European Green Deal
Resilience for Ensuring Inclusive Local Communities and the SDGs
Flood risk already affects 1.81 billion people. Climate change and unplanned urbanization could worsen exposure
The Connections Between Population and Climate Change Info Brief
2024 Climate and Catastrophe Insight
UNDP. UNDRR. Early Warning Systems Stakeholders Mapping Exercise Across Central Asia
ICTs, data and vulnerable people: a guide for citizens
Novel multi-sector partnerships in disaster risk management Results of the ENHANCE project
People-Centred Early Warning Systems
Guidance notes on building critical infrastructure resilience in Europe and Central Asia
A catalogue of best practices for building flood resilience
Technical guidance on comprehensive risk assessment and planning in the context of climate change
Hazard definition and classification review: Technical report
Risk-Informed Development
Brief communication: Strengthening coherence between climate change adaptation and disaster risk reduction through policies, methods and practices in Europe
Comprehensive Disaster and Climate Risk Management (CRM)
United Nations University: Building Climate Resilience: Lessons from the 2021 Floods in Western Europe
The Role of Cloud Computing in Business Continuity
SmartFLOOD - AI-based Global Flood Hazard Mapping Platform
Everything you need to know about 5G.
Cell Broadcast for Early Warning Systems: A review of the technology and how to implement it
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COVALEX

HYDROMETEOROLOGICAL HAZARDS

– RISK AND MITIGATION –

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