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PLANNING FOR FLOOD RESILIENCE IN ROMANIA

Results and Lessons Learned from the RO - FLOODS Project

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ABBREVIATIONS AND ACRONYMS

AED	Annual expected damage
AEP	Annual exceedance probability
ANAR	National Administration “Romanian Waters”
ANCPI	National Agency for Cadastre and Land Registration
ANM	National Meteorological Administration
APSFR	Area of potential significant flood risk
AST	Appraisal summary tool
BCR	Benefit-cost ratio
CBA	Cost-benefit analysis
CIR	Rapid Intervention Center
CSO	Civil society organization
DARM	Damage Assessment and Risk Methodology
DDC	Water depth-damage curves
DSM	Digital surface model
DTM	Digital terrain model
EC	European Commission
EIB	European Investment Bank
EM-DAT	Emergency Events Database
ERDF	European Regional Development Fund
EU	European Union
FAQ	Frequently asked questions
FHRM	Food hazard and risk map
FIC	Crisis Fast Intervention Center
FRMP	Flood risk management plan
GCP	Ground control point
GDP	Gross domestic product
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographical information system
GNSS	Global Navigation Satellite System
GSURR	Global Practice on Social, Urban and Rural Development, and Resilience of the World Bank
HZ	Hazard data
IDF	Intensity-duration-frequency
IMU	Inertial measurement units
IGSU	General Inspectorate for Emergency Situations
INHGA	National Institute of Hydrology and Water Management
ISU	Inspectorate for Emergency Situations

LiDAR	Light detection and ranging
MCA	Multicriteria analysis
MEWF	Ministry of Environment, Water and Forests
MEWF	Ministry of Environment, Water and Forests
ML	Machine learning
NBS	Nature-based solutions
NGO	Nongovernmental organization
OGC	Open Geospatial Consortium
PFRA	Preliminary Flood Risk Assessment
PoM	Program of measures
RBA	River basin administration
RBMP	River Basin Management Plan
RP	Return period
RTK	Real-time kinematic
R2R	Ready-To-Respond framework
SEA	Strategic Environmental Assessment
SGA	Water Management System
SoP	Standard of protection
TAG	Technical Advisory Group of the RO - FLOODS Project
TB	Tera byte
TWG	Technical Working Group
UoM	Unit of management
UWV	Unmanned water vehicles
VHR	Very high resolution
WD	Water depth data
WFD	Water Framework Directive (2000/60/EC)
WISE	Water Information System for Europe
WMS	Web map service

PART I.

BACKGROUND AND CONTEXT

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Flood Risk in Romania

Romania is a flood-prone country. Since 2000, floods have claimed over 240 lives in Romania[1]. The 2005 and 2006 floods alone affected over 1.5 million people (claiming 93 lives), destroyed an important part of the country's flood risk management infrastructure, and caused estimated damages of over €2 billion[2].

A recent flood risk assessment conducted in 2021 at the behest of the Romanian Ministry of Environment, Water and Forests (MEWF) and the National Administration "Romanian Waters" (ANAR), with support from the World Bank in the context of the RO - FLOODS Project, estimates annual expected damage from riverine flooding, flash floods, and urban and coastal floods to add up to €1.7 billion, affecting over 40,000 domestic properties a year, on average, in Romania's 526 identified **areas of potential significant flood risk (APSFRs)**[3]. The same assessment projects that climate change will exacerbate these risks — causing €2.3 billion in damages annually — and affecting over 51,000 domestic properties on average every year.

Over the years, Romania has developed significant flood risk management infrastructure to protect its people. This includes over 11,000 kilometers of dikes along its rivers. The country has also developed substantial capacities to better prepare for flood events, for example, by improving early warning systems. Romania also developed a system to effectively launch an emergency response in case of flooding. However, given today's high flood risks and the anticipated increase due to climate change, additional efforts are required to further strengthen flood risk management and protect Romania's people, economy, and environment.

The EU Floods Directive

The purpose of the European Union (EU) Floods Directive (2007/60/EC)[4] is to provide a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences of floods for human health, the economy, the environment, and cultural heritage. To strengthen flood risk management, the Directive requires all EU Member States to develop and update **flood risk management plans (FRMPs)** for their territories. The FRMPs proceed in three clear stages over a six-year planning cycle (figure 1.1), as described below:

First, a **preliminary flood risk assessment (PFRA)** is conducted to assess the likelihood of flooding in watercourses, coastal areas, and urban environments. APSFRs are identified at this stage.

Next, **flood hazard and risk maps (FHRMs)** are developed for in-depth assessment of the probability and extent of flooding and the possible damage to be expected in the APSFRs identified.

Third, **FRMPs** with clear objectives and an integral program of measures are prepared to address the existing flood hazard and risk.

[1] International disaster database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters: **https://www.emdat.be/.**
[2] Romanian General Inspectorate for Emergency Situations. National Risk Assessment RO Risk: **https://www.igsu.ro/Resources/COJ/RapoarteStudii/Raport_Final_de_tara%20pt%20Condit%20ex-ante%202016.pdf**.
[3] According to the EU Floods Directive (2007/60/EC), APSFRs are to be identified during the PFRA "based on available or readily derivable information" (Art. 4.2). Romania reported its APSFRs and the methodology used to the European Commission on **https://inundatii.ro/resurse/, Directiva Inundatii – Ciclul 2, Evaluarea Preliminara a Riscului la Inundatii**
[4] **https://environment.ec.europa.eu/topics/water/floods_en**.

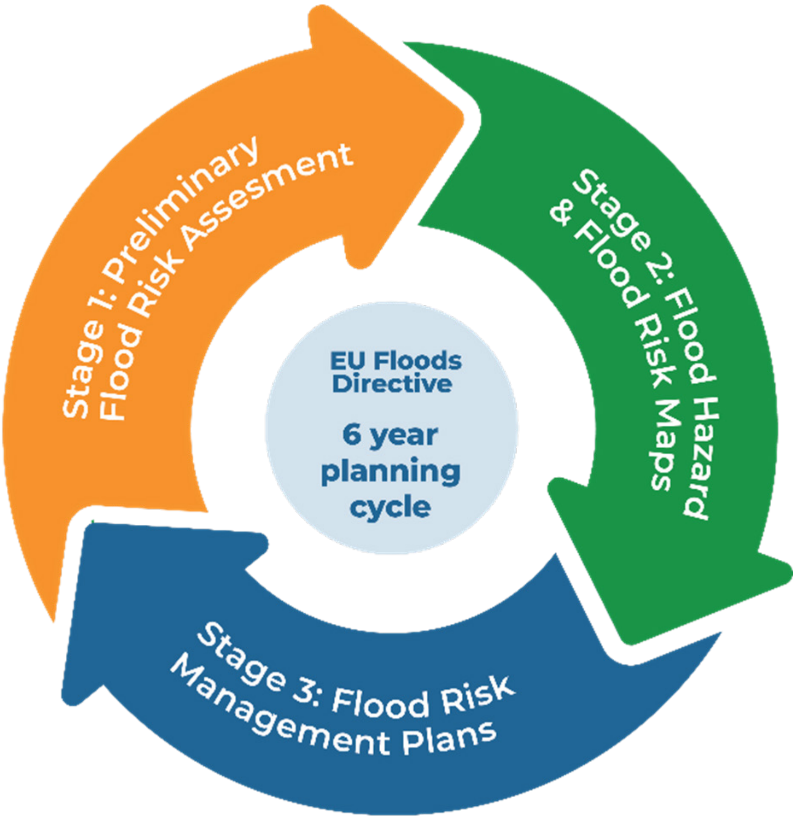

Figure 1.1 Planning cycle of the EU Floods Directive

As a member of the European Union, Romania implements the EU Floods Directive. In March 2016, Romania finalized the first implementation cycle by reporting 12 FRMPs to the European Commission (EC), one for each of its **12 units of management (UoMs)**. ANAR's 11 river basin administrations (RBAs) each are responsible for one UoM. The 12th UoM, the Danube River, is managed by ANAR headquarters. In September 2023, Romania finalized a second implementation cycle by sharing updated and substantially improved FRMPs for its 12 UoMs. These new plans, developed through the RO - FLOODS Project, lay out an integrated flood risk management strategy with measures to improve flood prevention and flood protection, as well as strengthen capacities for flood preparedness, response, and recovery.

This report summarizes activities conducted under the RO - FLOODS Project in order to implement the EU Floods Directive and to strengthen flood risk management in Romania. It is directed at professionals working in flood risk management and in water resources management in the EU and in other regions. After a general overview and summary of the Project, the report provides detailed technical descriptions of the Project's key activities and their results. Each chapter is self-explanatory, and readers can move directly to chapters of specific interest. Additional details can be found in specific reports prepared by the World Bank under the RO - FLOODS Project as indicated in the reference section of each chapter.

CHAPTER 2

OVERVIEW OF THE RO - FLOODS PROJECT

2. OVERVIEW OF THE RO - FLOODS PROJECT

Between October 2019 – September 2023, at the request of the Romanian Ministry of Environment, Water and Forests (MEWF), the World Bank provided Reimbursable Advisory Services under the “Technical Support for the Preparation of Flood Risk Management Plans for Romania” Project, also known as the RO - FLOODS Project. The objective of the Project was to support the operationalization of the second and third stages of the second implementation cycle of the Floods Directive — namely, the preparation of new flood hazard and risk maps (FHRMs) and the development of Flood Risk Management Plans (FRMPs) — and by doing so, to strengthen the country’s capacities for flood risk management.

The MEWF implemented the RO - FLOODS Project in close collaboration with the National Administration “Romanian Waters” (ANAR) and its 11 River Basin Administrations (RBAs), the National Institute of Hydrology and Water Management (INHGA), in addition to the World Bank’s technical support.

Results

The Project’s main outputs are Romania’s new FHRMs and the new FRMPs. These have been formally reported to the European Commission and were published on Romania’s new website for flood risk management (**https://inundatii.ro/en/resources/**). Leveraging the Bank’s global knowledge and international best practices, including experiences gathered from the implementation of the EU Floods Directive by other EU Member States, the RO - FLOODS Project developed and implemented new methodologies and innovative tools for planning integrated flood risk management and preparing FHRMs and FRMPs. These instruments and the different intermediate results derived from their application are further important outputs of the Project to improve Romania’s ability to prepare these plans during the next cycle. Together, this resulted in substantially improved capacities for flood risk management, the overall Project outcome.

The implementation of the RO - FLOODS Project included a wide variety of different activities, which can be roughly grouped under the following components:

- Data collection, data processing, and data management.
- Development of new methodologies for the Floods Directive’s implementation.
- Preparing new FHRM.
- Defining programs of measures for the new FRMP.

These components are described in more detail below.

Data collection, data processing, and data management

Effective flood risk management and the implementation of the EU Floods Directive require a substantial amount of technical data. For hydraulic modeling and the development of flood hazard maps, this includes meteorological and hydrological data, as well as topographic data, including, for example, digital terrain models and bathymetrical surveys. Flood risk assessment and the appraisal of proposed measures require data on the exposed elements to estimate expected damages and the potential benefits of measures to mitigate them.

Following a detailed assessment and reorganization of already existing data, the RO - FLOODS Project invested in the collection of additional data. The process included, among other features, new digital terrain models covering more than 28,000 km^2 and over 41,000 measured river cross-sections. Further, the Project generated an exposure data set with over 13 million features of 1,145 different typologies. These are exposed elements, such as residential housing, social infrastructure (e.g., schools, hospitals), or transport infrastructure (e.g., roads, railways).

All data — existing and newly collected — were thoroughly examined for quality before being stored in a well-structured data management system, following clear rules and naming conventions. All results — final and intermediate — from the hydraulic modeling, the risk assessment, or the development of the programs of measures (PoMs) were also included in the data management system, enabling their use for current and future implementation of the EU Floods Directive, as well as other flood risk or water resource management related tasks. Chapters 3 and 4 provide more details on data collection, processing, and management.

Development of new methodologies for the Floods Directive's implementation

A comprehensive stocktaking assessment, undertaken at the beginning of the RO - FLOODS Project, included careful analysis of the first cycle FHRM and FRMP, as well as a review of the comments and recommendations received from the EC. Next, the World Bank supported Romania to innovatively enhance its methodological framework for the implementation of the Floods Directive. Key updates and improvements to the existing framework include:

- **Flood hazard modeling** — new methodologies to cover additional flooding sources, characteristics, and mechanisms (now covering fluvial, pluvial, coastal, and flash floods), as well as a method to estimate the effects of climate change.
- **Flood risk assessment** — development of a national flood damage database and a methodology for quantitative flood risk assessment, also allowing Romania to estimate the impact of climate change on flood risk.
- **Development of programs of measures** — an updated catalog of measures, methodology for the appraisal and prioritization of measures using multicriteria analysis and cost-benefit analysis, a new unit cost database, and guidance for the identification and development of nature-based solutions (NBS).

The methodological framework's wide array of innovative tools has enabled Romania to update and improve its FHRMs and FRMPs. Although these new methodologies are not explicitly presented in this report, key aspects of their application and the related results are detailed in the chapters on hazard modeling and mapping, flood risk and damage assessment, and the development and prioritization of flood protection and prevention measures.

Preparing new Flood Hazard and Risk Maps

Using the reorganized and newly collected data and the new methodological framework, the RO - FLOODS Project prepared new FHRMs for 526 areas of potential significant flood risk (APSFRs). The maps have been developed for an average of five scenarios, including for floods with low, medium, and high probability, as well as for medium-probability floods with the effects of climate change.

A new Web map viewer allowed institutional stakeholders with local expertise to review, validate, and comment on draft maps. The same Web map viewer was used to consult the maps during the development of PoMs and to report the final maps to the EC. The maps are publicly accessible at **https://inundatii.ro/en/maps-portal/.**

Besides the new FHRM, the hazard modeling and risk assessment resulted in further valuable outputs including two-dimensional calibrated hydraulic models for assessing the impact of proposed flood measures on flood hazard and flood risk. The outputs also include a detailed flood damage and loss database with fact sheets and tabular outputs of flood risk profile with expected damages for different sectors in each APSFR. Chapters 5, 6, and 7 provide detailed explanations of the hazard modeling, risk assessment, and Web map viewer.

Defining programs of measures for the new Flood Risk Management Plans

The FRMPs are built on a set of clear objectives (see box 2.1). Comprehensive PoMs were developed for each FRMP to achieve these objectives. The individual measures of these programs were selected and prioritized based on their contributions toward achieving the objectives.

Objectives of Romania's second-cycle flood risk management plans

1. Avoid/Control risks associated to floods.
2. Reduce the negative impact of floods on population.
3. Reduce the negative impact of floods on infrastructure and economic activity.
4. Reduce the negative impact of floods on cultural heritage.
5. Reduce the negative impact of floods on environment and achieve/maintain the environmental objectives in accordance with WFD.
6. Enhance the level of awareness and resilience concerning flood risks, as well as increase the capacity for early warning, alarm and intervention, and response in case of emergency.
7. Enhance the level of adaptation to climate change impacts at the level of river basin and coastal area.
8. Maximize efficiency in achieving the flood risk objectives, considering the costs and available funding.
9. Improve the involvement of all stakeholders.

Romania's PoMs include structural flood risk management measures (e.g., hydrotechnical works along rivers or check dams in upper watersheds) as well as nonstructural ones (e.g., new policies for land-use planning to avoid construction in flood-prone areas).

Structural works for flood protection using grey infrastructure such as dikes or conveyance channels, can generate adverse environmental impacts and could exacerbate flood risks downstream. These interventions often are rigid with long life cycles and adapting those to changing conditions, for example, due to climate change, often leads to capital destruction. On the other hand, NBS (e.g., afforestation or riparian buffer zones) are more flexible to adapt to climate change and offer many benefits beyond flood protection, (e.g., biodiversity conservation, carbon sequestration, or opportunities for recreational activities and tourism). With the RO - FLOODS Project, Romania initiated a paradigm shift from flood protection works following the more traditional approach — using grey infrastructure — to a more integral and environmentally friendly approach — using NBS.

The starting points for the development of the PoM were the FRMP objectives, the new FHRM, and a catalog of measures listing all potentially viable measures to manage flood risks. The catalog has been developed in line with EU guidance and is based on experiences gathered in Romania and other parts of the world.

For the development of the PoM, possible measures were categorized under three distinct classes:
A. Measures adopted at the national level to reduce flood risk, through policies, guidelines, planning instruments, and capacity building.
B. Measures taken at the local level (APSFRs) to reduce flood risk, through prevention and protection.
C. Measures taken at both the national and local levels to manage residual flood risks through better preparedness, response, and recovery.

While the FRMP objectives, and the new FHRM and the catalog of measures served as the starting points for all three categories, the processes for identifying, appraising, and selecting measures differed.

Chapter 8 explains in detail the process for identifying, appraising, and prioritizing flood prevention and protection measures at the local level (Category B). This included the following steps:

- **Screening:** An initial analysis of potential measures identified feasible measures to be further assessed in subsequent steps. The analysis was based on the catalog of measures and local flood risk conditions.
- **Packaging** of the identified measures to develop viable alternatives to manage flood risk in each APSFR.
- **Appraisal, prioritization, and further refinement** of the identified viable alternatives based on clear and objective criteria and the assessment of costs and expected benefits.
- **Selection of most viable alternatives and promotion as high-priority projects.** This included further detailed assessment, and modeling of the alternative's impacts on flood hazard and flood risks and a detailed cost-benefit analysis.

Chapter 9 provides detailed information on how the RO - FLOODS Project promoted the use of NBS in this process to support Romania's transition towards greener FRMPs. Chapter 10 presents a key tool used in this regard - the floodplain potential map.

Since flood risks can never be fully eliminated through prevention and protection measures, and a residual risk will always remain, it is essential to also strengthen flood preparedness and response (Category C). This includes, for example, developing early warning systems, improving the capacity to assist during flood events, and establishing structures to provide relief and support recovery after flooding. Chapter 11 describes how the RO - FLOODS Project identified, assessed, and prioritized ways to further improve Romania's flood preparedness and recovery capacities.

Strengthening stakeholder engagement and communication

Effective flood risk management is only possible with the active participation of different sectors and the involvement of the affected citizens. Stakeholder engagement also is a key requirement of the EU Floods Directive. During the development of the first cycle FRMPs, Romania's water authorities struggled to effectively involve stakeholders — an aspect also noted by the EC in its review of the plans. The limited involvement of different sectors during the relevant planning also hampered the later implementation of many measures that require input and support from stakeholders beyond Romania's water sector. Therefore, in early stages of the RO - FLOODS Project, the World Bank together with the MEWF and ANAR developed a detailed strategy for improving stakeholder engagement and communication capacities and better involving different sectors in the implementation of the Floods Directive.

Based on this strategy, the RO - FLOODS Project realized a variety of activities, including developing a brand for flood risk management and setting up new communication channels (e.g., **https://www.indundatii.ro**), organizing a large number of workshops and consultations at different levels and at different times in the planning process, and raising awareness and strengthening capacities for engagement with marginalized groups. The RO - FLOODS Project has achieved significant improvements compared with the first-cycle implementation. This not only resulted in better engagement of stakeholders in the FRMP development but also to improve communication and cooperation beyond the activities related to the Floods Directive. Chapter 12 provides an overview of the results from these activities and chapter 13 provides a more detailed description of the Project's activities to engage marginalized groups in Roma communities on topics related to flood risk management.

Training and capacity building

The objective of the RO - FLOODS Project was to provide support in the implementation of the Floods Directive and by doing so strengthen Romania's capacities for flood risk management. All Project activities were realized together with Romanian authorities, creating a space for permanent exchange and learning by doing. With the World Bank's technical support, the World Bank together with the MEWF, ANAR, the RBAs, and INGHA developed and applied many new methods and innovative tools, strengthening the country's capabilities for flood risk and water resource management in general. To enhance competencies and know-how, the RO - FLOODS Project, in addition to continuous on-the-job training, developed and implemented a comprehensive training and capacity-building plan. Chapter 14 provides an overview of these activities and the results achieved.

PART II.

KEY ACTIVITIES, RESULTS, AND LESSONS LEARNED

This section provides more detailed and technical descriptions of selected key activities. For each activity, the main challenges faced are described, the approach chosen to address them, implementation results, and lessons learned. The chapters are directed at experts working on different aspects of flood risk management in Romania, the European Union, or in other parts of the world. The experiences gathered in a wide variety of fields, including, among others, data management, hydraulic modeling and risk assessment, strategic planning and investment prioritization, and stakeholder engagement, might also be of interest to experts working in water resource management, land-use planning, or related fields.

CHAPTER 3

DATA COLLECTION AND PROCESSING

3. DATA COLLECTION AND PROCESSING[5]

Summary

Effective flood risk management and the implementation of the EU Floods Directive require substantial technical data covering a variety of fields. Hydraulic modeling and the development of flood hazard maps require meteorological and hydrological data, topographic data, including digital terrain models (DTMs), orthophotos, bathymetrical surveys, information concerning existing flood protection infrastructure, and data on land use. Information on flood hazards is used together with data on exposure and the vulnerability of the population, environment, and social and economic assets to assess and map potential flood damage and risk. Significant efforts were made under the RO - FLOODS Project to rigorously assess the quality of the existing databases related to flood risk management. Subsequently important new data sets were acquired and processed to update existing datasets and fill gaps.

The challenge

Collecting and processing the huge amounts of data required in the relatively short amount of time available was a challenging task at the beginning of the RO - FLOODS Project. Key drivers for planning and defining the scope for data collection and acquisition were data availability and data quality (coverage, granularity, format, etc.). Type, granularity, and accuracy of available data also had to be considered during the development of new methodologies for flood hazard and risk modeling and mapping (see chapters 5 and 6), and for the approach used for preparing the programs of measures (PoMs) (see chapter 8 and 11).

The Project needed a coherent view of the legacy of past activities, including the data used during the first-cycle implementation. Thus, during the Project's stocktaking phase (November 2019–April 2020), the Ministry of Environment, Water and Forests (MEWF), the National Administration "Romanian Waters" (ANAR), and the National Institute of Hydrology and Water Management (INHGA), with World Bank support, thoroughly assessed the data used in the first cycle of the Floods Directive's implementation and in other projects carried out by these institutions. Data sets managed by other Romanian institutions were also assessed. This vital activity was designed to be able to complement data sets required to model all locations in Romania identified as an area of potential significant flood risk (APSFR).

Furthermore, key responsibilities had to be allocated and formally agreed. The Romanian government established that for the Floods Directive's second cycle, INHGA would provide the hydrological data, the National Meteorological Administration (ANM) would provide the meteorological data, and ANAR would provide information on existing hydraulic structures, while the World Bank would provide support for the remaining input data (mainly geometrical data sets such as DTMs and topo-bathymetrical data).

After careful evaluation of the existing data sets and the needs for the second-cycle implementation, the RO - FLOODS Project elaborated its approach to acquire the necessary data and defined robust quality check procedures for all data to meet consistent quality standards for existing and new and old information.

[5] Chapter prepared by Dragoș Gontariu, Todor Lambev and Amparo Samper Hiraldo. Contributions from Elena Daniela Ghiță, Aurelian Drăghia, and Lyubomir Filipov

Implementation

The data required to fill the gaps after assessing availability and quality of existing data included more than 38,800 square kilometers (km^2) of raw LiDAR) data, more than 28,000 km^2 of DTM data, digital surface model (DSM) data and orthophotos, more than 41,000 river cross-sections, and more than 13,000,000 features (exposed elements such as residential properties or transport infrastructure) in the exposure database (as shown in figure 3.1).

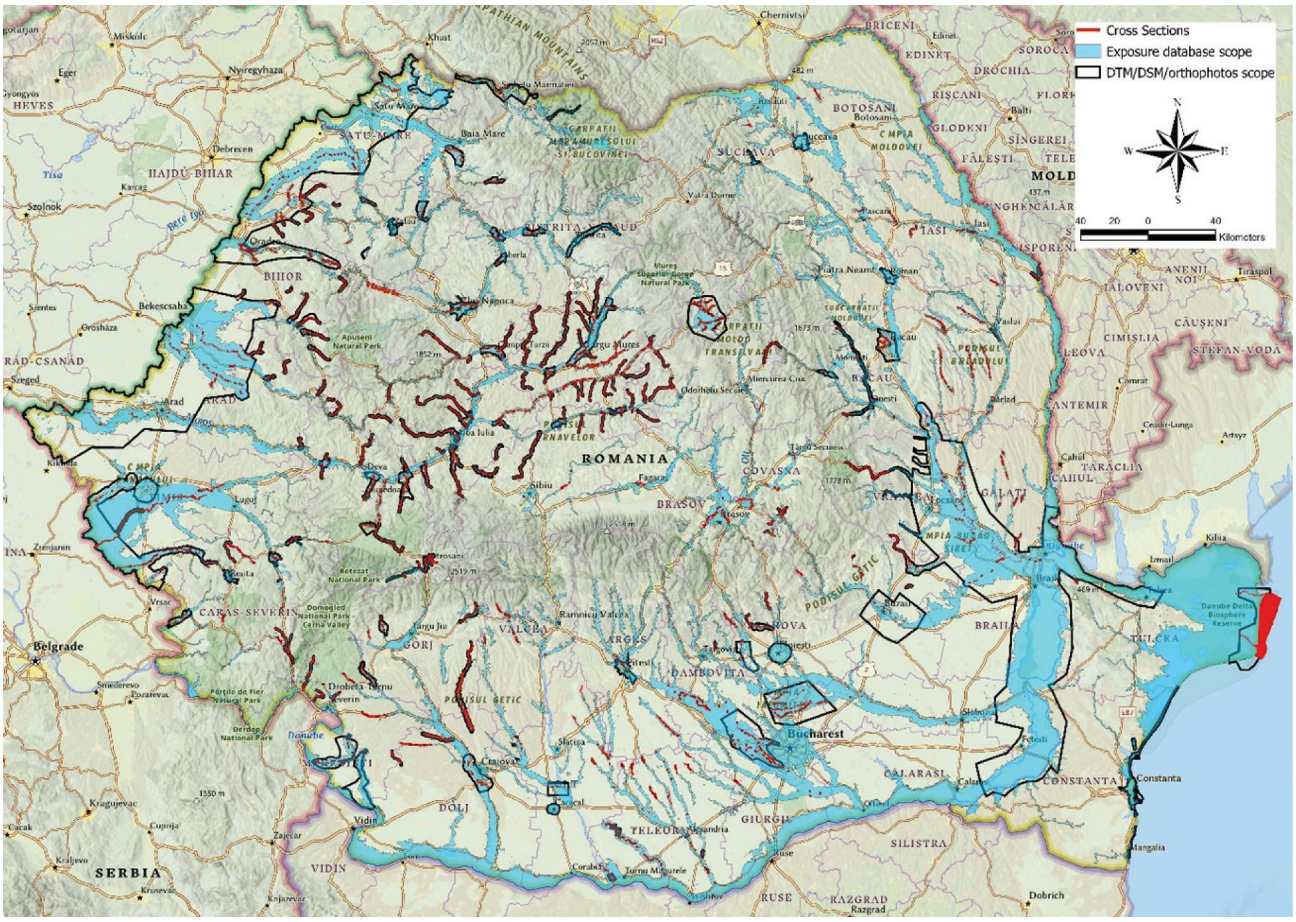

Figure 3.1 Scope for aerial data, cross-sections, and the exposure database

To ensure sufficient quality of data a consistent approach was developed from the outset. This included the methods of acquiring data, the technical requirements for surveys and raw data processing, the technical specifications for the equipment to be used, and the format in which data should be accessible.

Aerial data

Collecting data by aerial survey can be very efficient and effective. For the acquisition of this aerial data, airborne technology equipment was used, as it can acquire data with high quality and precision. DTM (sample shown in figure 3.2) and DSM data were collected following an airborne LiDAR approach and using Riegl scanners that penetrate vegetation to reach ground levels. The imagery data (orthophoto products) was collected using one high-quality Hasselblad and one Phase One medium-format camera. Airborne systems were also equipped with the latest navigation equipment, which included a global navigation satellite system (GNSS) for navigation and high-accuracy inertial measurement units (IMUs).

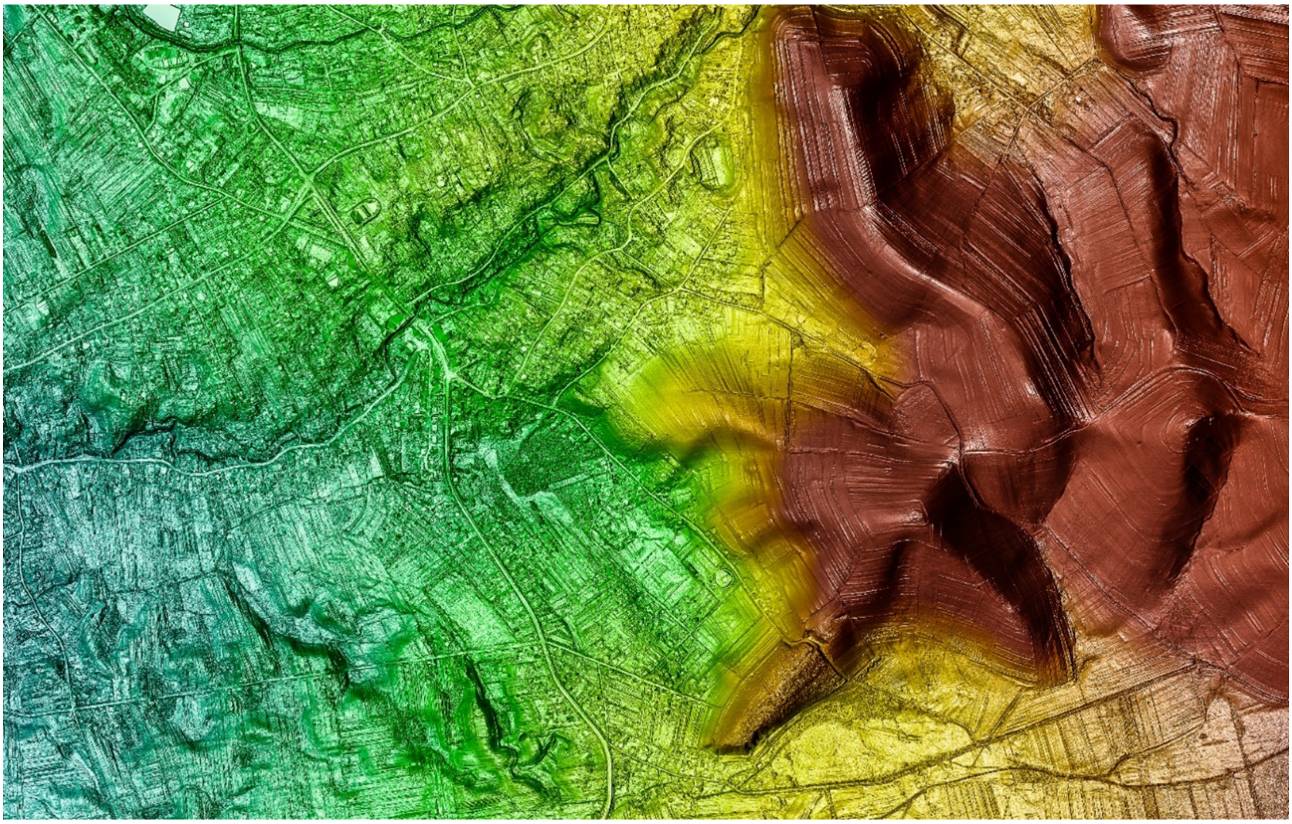

Figure 3.2 Sample from DTM data

With this type of equipment, combined with the processed navigation data and direct georeferencing, the Project achieved the high accuracy requirements. Direct georeferencing consists of a camera and boresight calibration to determine camera distortion and boresight misalignment without the use of ground control points (GCPs). With this relatively new technique, the data was georeferenced, and GCPs were used to check the direct georeferencing performance. Using filtering methods, the raw data were processed to obtain the necessary DTM and DSM needed for hydraulic flood modeling.

While the collection of data by aerial survey allows to cover large areas at once, the acquisition of these data collection services can be rather complex and time intensive. The acquisition process depends on a variety of factors, many of which are beyond practitioners' control. These include, among others, the types of permits required and the number of institutions that have to participate in the process, weather conditions, the time of year, quantity and quality of available equipment, the number of teams involved, a good distribution of GCPs, and the ability to divide large areas into batches. The Project had to overcome all these hurdles for a successful implementation within a relatively short time frame.

For aerial surveys as well as for the field surveys described below, timing during the year is very important. Seasonal vegetation and weather conditions can impose constraints. Additionally, significant/ major changes in the landscape (e.g., new facilities/ structures under construction) have to be considered in data management and analysis. Data collection during the Project has been carefully managed to accommodate such constraints or changes.

Ground Surveys

The locations to be surveyed — and their accessibility, river depths and widths, and local environments — were examined in advance. This allowed the field teams to prepare adequate equipment for these surveys.

All land and bathymetrical surveys were conducted using classic methods and equipment. These included a Real-Time Kinematic (RTK) GNSS base/rover, total stations, boat-mounted echo sounders, and, where needed, remote-controlled unmanned water vehicles (UWVs). For data collection using the GNSS, the TransDat 4.05 version was used. Precision is crucial here for a good replica of the terrain and the existing hydrotechnical works (e.g., dikes, dams) in the hydraulic model: the point measurements have approximately 5 centimeters (cm) of vertical and horizontal accuracy, and the river cross-sections represent the terrain and the riverbed with sufficient detail for flood modeling which allows an accurate calculation of the overbank flow and determination of flooded areas.

After collection, all data were sent to production and postprocessing, which generated the following outputs: descriptions of river cross-sections (example shown in figure 3.3), hydrotechnical and other engineering structures and their drawings (.dwg, .dxf), and the spatial coordinates of all measurements (X, Y, Z) organized in different formats (.txt, .gdb, etc.).

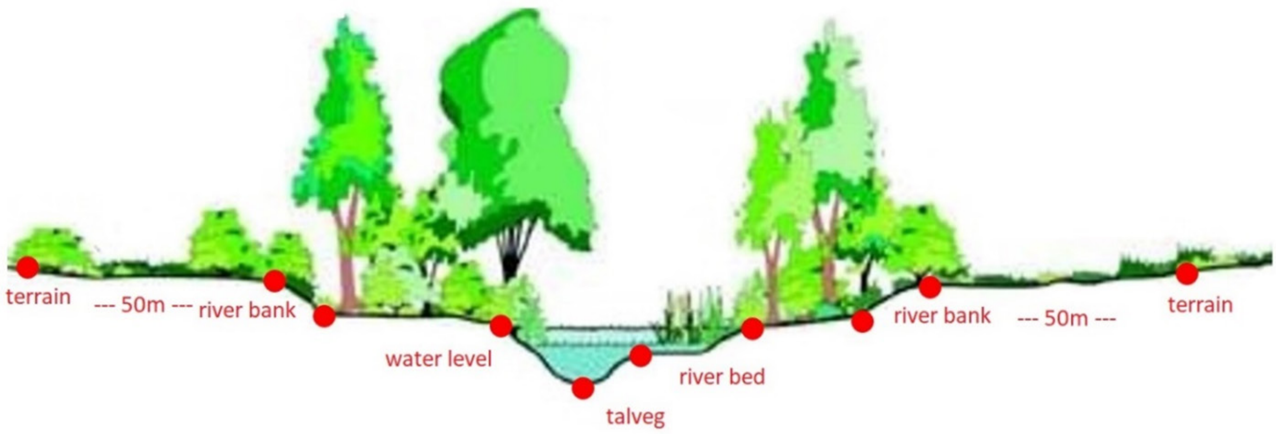

Figure 3.3 Example of a cross-section

The flooding of roads can have substantial impacts on economy and society. To study this aspect of flood damages quality data on road networks is crucial. The roads sector (e.g., the Brașov city belt) was mapped in line with best practices (i.e., mobile LiDAR mapping), and terrain representations based on cross-sections defining the road geometry were created. All structures along the road (e.g., bridges and culverts) were also measured. For this, terrestrial mobile LiDAR equipment (car mounted) was used in combination with classic GNSS RTK measurements. As spatial data was being collected, specific and close attention was paid to, for example, appropriate and clear descriptions of the riverbed and riverbanks, the scope's completeness, clear and clean orthophotos, and bridges' detraction from the DTMs.

As with the aerial data, it was important to clearly define the scope, precision, and accuracy of the products, methods, equipment and quality checks for acquiring and processing data, besides other important features, in the terms of references for external contractors used for data acquisition.

Exposure database

An up-to-date and comprehensive exposure data set is an important basis for good flood risk management. In the RO - FLOODS Project, this was developed to record all “receptors” (e.g., properties, roads etc.) in areas of flood risk. The data set became the basis of a damage and loss database populated with real and synthetic flood data from national and international sources, including a minimum set of typologies of buildings, land use, roads, railways, utilities, hydraulic infrastructure, and so on.

Machine learning (ML) and deep learning technology were leveraged to train and develop accurate feature extraction classification and an automatic attribute extraction model. The ML model was developed to extract the building footprints, social features, transport (road and rail networks), utility features, agriculture land, and other features using collected VHR (very high resolution) orthophoto imagery.

As shown in figure 3.4, this activity included:

- Preparing and curating training features for each broader category using orthophoto imagery.
- Developing models for localizing individual features on orthophoto imagery.
- Predicting features using the trained model.

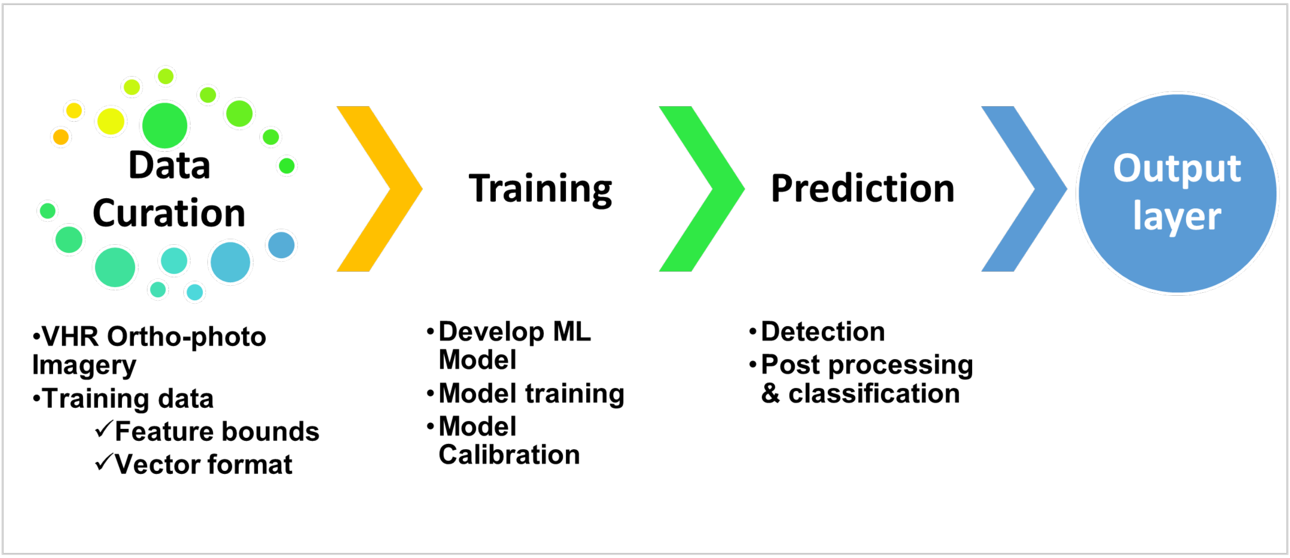

Figure 3.4 Methodology for feature detection and classification

For exposure data, many considerations needed to be taken into account regarding the methodology deployed. For developing the database, the precise methods to be used entailed decisions such as manual versus artificial intelligence/ML-based methods and the topology rules to be applied in transposing the reality into data (e.g., roads have to have polygons, which do not overlap with buildings). This is a complicated task, which required a rigid quality control process as described below.

Quality control and assurance

Data of inferior quality can have disastrous consequences. The Project's independent quality control activity examined over multiple cycles the intermediate and final outputs of all acquired data (aerial, ground, and exposure data sets). This activity included primary validation of the data geometry (topological consistency), attributes (typologies and classifications), completeness, descriptions, naming convention, format, and documentation quality (metadata and reports). Secondary validation took place in the field (tracing or remeasurement) or by mapping online tools. For instance, the quality of river cross-sections was checked using the following stringent criteria:

- Cross-sections must be numbered from downstream to upstream.
- Measurement precision within 5 cm of vertical and horizontal accuracy.
- The edges of bridges must be connected to the nearby terrain.
- The cross-sections' points must be surveyed from left to right in the direction of flow (from left bank to right bank in the direction of flow).
- All .txt files must have the same structure.

To correct errors a series of actions were carried out from minor editing all the way to remeasurement.

Results

The implementation of rigorous quality check resulted in obtaining the following high-quality data products:

- Raw LiDAR data covering more than 38,800 km^2.
- DTM, DSM, and orthophotos covering more than 28,000 km^2.
- More than 41,000 river cross-sections in total.
- Approximately 16,000 cross-sections measured along the APSFRs.
- Approximately 3,800 bridges and hydrotechnical structures.
- Approximately 550 weirs.
- Approximately 630 pipes.
- Approximately 5,500 GCPs.
- One automotive LiDAR data set for the Brașov bypass.
- One geodatabase (.gdb) containing exposure data with 9 categories and 45 shapefiles.
- Documentation and reports.

A coordinate reference system was used for all the data sets:

- **Horizontal coordinate system:** EPSG:3844 - Pulkovo 1942(58) / Stereo70.
- **Vertical coordinate system:** Black Sea 1975.

The parameters used for data transformation were officially provided by the National Agency for Cadastre and Land Registration (ANCPI) and used for TransDatRO 4.05. The final results were contained in more than 300,000 files and amounted to 4.5 terabytes of data, transferred to ANAR and MEWF after the Project.

The degree of accuracy of the outputs is described below:

- Three-band nadir-looking RGB (red/green/blue) aerial imagery of ground sample distance less than 20 cm.
- LiDAR data of expected point density of at least 8 points per square meter (m^2).
- Vertical and horizontal accuracy for DTMs, DSMs, land measurements, and bathymetry of 5 cm.

All these data sets are now available for use by Romanian authorities for future flood risk management as well as for other projects.

Lessons learned

Existing data and metadata were systematically organized for future utilization. The Project also documented in detail the methods, equipment, and methodologies used to collect data, as well as the different characteristics of the data sets. Five key lessons were learned in respect to improving quality and complementing data sets:

- **New technologies.** There is a continuous need to adopt new technologies in terms of data processing and data flow, as well as quality assurance/quality control procedures.
- **Clarification.** The scope, precision, and accuracy of all products, methods, and equipment for acquiring and processing data must be clarified before starting data gathering.
- **Quality control procedures.** For large projects such as RO - FLOODS, rigorous quality control procedures must be in place to ensure availability and quality of data. Also, teams must be trained to understand the scope of work and the procedures to be followed. This is essential for a consistent and unitary approach leading to homogeneous data sets.
- **Changes and updates.** All data collected and postprocessed should reflect recent changes/updates encountered in the field. The involvement of river basin administrations (RBAs) is fundamental because of their active knowledge of changes in the terrain of the basins they manage.
- **Next steps.** For the third cycle of the EU Floods Directive implementation, all the aspects outlined above should be reflected in the planning and preparation of activities related to additional data acquisition. In this way, Romania will be able to capitalize on the comprehensive second-cycle data acquisition.

References

- World Bank (2021): Reimbursable Advisory Services Agreement on Technical Support for the Preparation of Flood Management Plans for Romania. Output No. 3 Report on technical data collected (**https://inundatii.ro/wp-content/uploads/2023/11/ROFloods-Output-3_EN.pdf**)

CHAPTER 4

DATA MANAGEMENT

4. DATA MANAGEMENT[6]

Summary

Good flood risk management requires substantial quantities of highly diverse data. Effective data management was essential for the successful implementation of the different stages of RO - FLOODS: data collection and processing, hydrological and hydraulic modeling, flood risk assessment, and identification and appraisal of flood risk management measures. Effective data management was also needed as a diversity of stakeholders needed to access data and develop new data products throughout the Project. It was therefore essential to have a reliable data management system and having a clear and robust method of version control. This chapter describes the processes for the design and the effective implementation of data management, including standardized data structures, and naming convention. It shares the main challenges encountered, the key tasks carried out, the achieved results, and the most essential lessons learned.

Introduction

Data management was inherent to all components of the RO - FLOODS Project. The dedicated data management team was actively engaged in all relevant activities. At the outset, the team developed a standardized data structure and a naming convention for reorganizing the data generated during the first cycle of the Floods Directive implementation and for storing the data delivered during the second cycle.

This was a mammoth task and laid the foundation for effective data management throughout the Project and beyond. Some 1.58 million files with a total size of 39.04 terabytes (TB) were generated during the RO - FLOODS Project. This includes the 4.5 TB of data newly collected (see chapter 3). They were stored in the Azure Data Lake in a fully monitored single repository, which ensured that the information and file versions were up to date, and that there were no duplications or ambiguities. Data validation was an additional part of the Project's data management. Custom tools were developed for this purpose. These included geographical information system (GIS) processing scripts to ensure both format compliance and content quality.

The challenges

One of the first challenges in the RO - FLOODS Project was to design a data structure and a naming convention that anticipated the subsequent data management needs for the large number of activities to be realized for the Floods Directive implementation. The data structure and naming convention followed international best practices (e.g., the rules applied by Highways England[7]).

Another challenge was to restructure and rename a large amount of existing data (e.g., resulting from the first cycle of the Floods Directive implementation) so as to be compliant with the newly designed data standard. During the first cycle the RBAs independently generated data. This led to significant differences between data sets. As part of the initial phase of the Project these sets were cleaned and reorganized following the new standard.

[6] Chapter prepared by Aurelian Drăghia, Lubomir Filipov, Jerónimo Puertas Agudo, Amparo Samper Hiraldo. Contributions from Cristian Dinu, Mihai Pătrașcu, and Gabriela Piroșcă.
[7] Highways England - GG 184 Specification for the use of Computer Aided Design (2020) - **https://www.standardsforhighways.co.uk/tses/attachments/f184cf11-a54c-4f82-9a79-e5ff4332daf0?inline=true**

Coordination between the regional activities was vital. During the second cycle, 10 companies from different parts of the world were subcontracted to collect and deliver data for the RO - FLOODS Project. An additional challenge, therefore, was ensuring that these companies delivered their data in accordance with the Project's data standards. Finally, an innovative solution was needed for sharing data with the many different stakeholders involved in the Project, at a reasonable cost.

Task 1: The key data structure and naming convention design

Easy access to the relevant data was essential. A data structure was developed for that purpose, based on the five principles outlined below. These principles are applied in a cascade structure (figure 4.1), starting from a main folder (RO-FDI: Romania-Floods Directive Implementation):

- **Principle of structuring according to the project framework.** Data from the first cycle of the Floods Directive implementation (RO-C1 folder), the second cycle of the Floods Directive implementation (RO-C2 folder), or general data not specific to the Floods Directive (RO-FDIndependent folder) are stored in different containers.
- **Principle of structuring by activity.** Data were stored by the main Project activities, for example, modeling and mapping (RO-C2-MM folder) and the program of measures (PoM) during the second cycle of the Floods Directive implementation (RO-C2-PoM folder).
- **Principle of structuring by management unit.** All information on a RBA, for example, the models or maps produced, are stored in a clear and specific container (the RO-C2-MM-01 folder contains all information on the modeling and mapping activity produced during the second cycle in the first (01) RBA: Banat-01-RBA).
- **Principle of structuring by reporting unit.** For each unit of management (UoM), there are predefined units of reporting, which are the areas of potential significant flood risk (APSFRs) (RO-C2-MM-01-A024F contains data regarding modeling and mapping for the APSFR number 24 [Bistra] from the second cycle, located in Banat-01-RBA folder).
- **Principle of structuring by content type.** Data on categories such as hazard, risk, damage and loss calculations, and input stored. (RO-C2-MM-01-A024F-HZ contains hazard data for the APSFR number 24 [Bistra] from the second cycle, located in Banat-01-RBA folder).

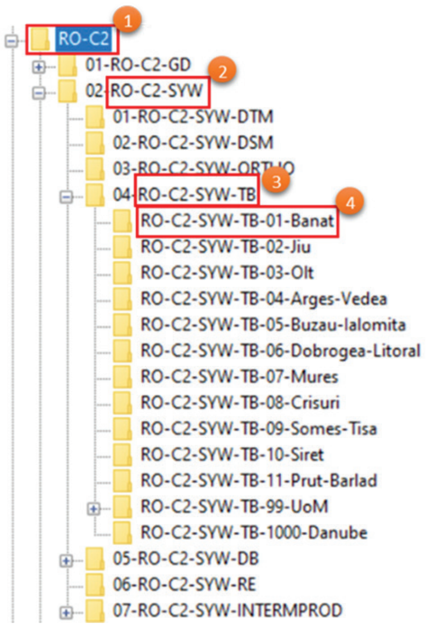

Figure 4.1 An example of the data structure for the topo-bathymetrical data stored by RBAs.

Acronyms:
RO – Romania,
C2 – second cycle of Floods Directive implementation,
GD – general documents,
SYW – survey works,
DTM – digital terrain model,
DSM – digital surface model,
ORTHO – orthophotos,
TB – topo-bathymetrical data,
DB – dike breach,
RE - reports,
INTERMPROD – intermediary products

It was essential to have in place a clear file naming system that had the agreement of everyone involved. Clarity on data naming for all deliverables generated during the current second cycle of implementation was achieved using five more principles:

- **Principle of using mini codes reflecting a folder's or a file's property.** A folder's name provides clear information about its contents through a series of codes. Some of these codes are based on the storage principles (as RO, C2, MM, 01, ...) and additional codes are meant to define the folder itself.
- **Principle of integrating file location in the file structure.** The names of folders and files contain the path in the file structure where they are located (e.g., the file RO-C2-MM-01-A004F-HZ-GIS-WD-BS-T10-FI-V1.tif can be located following this path: cycle 2 section, modeling and mapping, Banat RBA, APFSR Raul, Hazard folder).
- **Principle of integrating management units' and reporting units' IDs in file names.** Each UoM has received an ID, which ranges from 01 to 12 and is included in the name of the folders and files (e.g., ID 01-Banat).
- **Principle of integrating files' status and versions into their names.** This principle was used for file versioning (e.g., file RO-C2-MM-GIS-01-A033F_Poganis_Dikes-FI-V1.tif has the code FI [final] and code V1 in its name, indicating that this is version 1 and the final version of this file).
- **Principle of keeping a flexible section in file naming.** This principle was used to allow the stakeholders some freedom in introducing a few descriptive words/terms about documents while naming them (e.g., the file name RO-C2-MM-GIS-ALL_APSFRs_without_Pluvial-FI-V1.cpg has the free descriptive words "without Pluvial").

Task 2: Restructuring data from the first cycle as per the new data design

The first cycle of the Floods Directive implementation in Romania generated substantial data in terms of number of files, size, and typologies. There are over 1.5 million files and over 170,000 folders. To transform all of these data, a transformation tool, the FDI Toolbox, was developed. It helped with creating the needed structure efficiently, quickly, and in a way that was free from errors.

The toolbox successfully generated folder structures from zero, named folders following the naming convention, and copied files from source paths, besides creating a metadata in each resource folder—retaining valuable information from the original source. Compliance was satisfactory at the end of the reorganization process. In other words, data were reorganized quite efficiently as per the standard folder structure and naming convention.

Task 3: Data management

To effectively manage its data, the Project thoroughly applied the structure and naming convention as described above. All parties followed these rules in the production, modification, and use of the data. The Project stored its data mainly in the Azure Data Lake, Microsoft's cloud service.

To facilitate data management, the Project developed data dashboards for different components to have a clear representation of the status of the available data. This allowed users to collaborate in real time under the data management team's supervision.

Lessons learned

The data management team, consisting of data scientists and experts in cloud computing and GIS followed a rigorous process and continuously assessed and improved its data management. This was a necessary feature of a Project with the size of the RO - FLOODS, where a lack of effective data management would have had adverse impacts and caused delays for all other teams. Main lessons learned are:

- **Data structure and naming convention**. A robust and well-defined data structure and naming convention is essential for large and complex projects. It ensures efficiency in working with data, reduces the error rate, and makes data more usable overall.
- **Data access.** RBAs and other interested parties should have direct access to relevant data throughout the process. This needs to be improved in the next third cycle.
- **Unique storage.** Transfer of data between cloud containers generates synchronization conflicts. A unique storage (point of truth) would, hence, be advisable from the outset in future projects.
- **Data flows.** Clear flows between successive activities (one activity utilizing the data generated by another activity) must be established from the outset.
- **Using scripts.** Using various utility software and custom scripts when working with large quantities of data offers a significant advantage in terms of efficiency, standardization, and error reduction.
- **Using an issue tracker solution.** When two or more teams work on the same data, a solution for tracking issues must be used instead of email communication.

References

- World Bank (2021): Reimbursable Advisory Services Agreement on Technical Support for the Preparation of Flood Risk Management Plans for Romania. Output No. 3 Report on technical data collected (**https://inundatii.ro/wp-content/uploads/2023/11/ROFloods-Output-3_EN.pdf**)

CHAPTER 5

FLOOD HAZARD MODELING AND MAPPING

5. FLOOD HAZARD MODELING AND MAPPING[8]

Summary

Under the RO - FLOODS Project, new flood hazard maps have been developed for 526 areas of potential significant flood risk (APSFRs). Diverse flooding sources, characteristics, and mechanisms have been considered, which has required the development of very specific flood hazard assessment methodologies. In particular fluvial, pluvial, coastal, and flash floods have been analyzed. Additionally, dike breaching has been considered as an additional flooding mechanism in 204 locations, included in 69 APSFRs. These additional scenarios are essential in emergency response and preparedness and to help Romania manage its extensive dike network better. The development of the new flood hazard assessment methodologies considered data availability, prior experiences in Romania, international best practice, and the European Union (EU) Floods Directive requirements. A variety of hydraulic models were used under the RO - FLOODS Project to simulate flood events for multiple annual exceedance probabilities (AEPs). Thus, flood extent, water depth, and water velocity were estimated, and new flood hazard maps were developed for all APSFRs. The results of hazard modeling and mapping are essential for assessing flood risk and developing flood risk mitigation strategies and are an important tool for promoting flood risk awareness. The new hazard maps can be easily accessed by authorities and the public using the newly developed Web viewer (see chapter 7).

The challenges

Flood hazard assessment through hazard modeling and mapping is central in the development of reliable flood risk management plans (FRMPs). However, it is challenging in many ways. The flood hazard assessment resulted in hazard maps for each of the of APSFRs. These results provide a detailed picture of floods' magnitude in different scenarios in the APSFRs and are further used for risk assessment. The models themselves are used for evaluating potential flood mitigation measures (in the case of structural measures), helping Romanian authorities to plan and prioritize related investments.

This chapter describes the process of constructing hydraulic models and developing the hazard maps to be reported to the EC under the second cycle of the EU's Floods Directive. The Project's complexity and the limited time available resulted in multiple challenges during the development of the hazard models and maps. The most significant challenge was the collection, classification and structuring, and homogenization (at least in terms of data types and format) of the required data. These are time-intensive activities that necessarily precede modeling and mapping. The next biggest hurdle was to develop and run the models, ensuring their results reflect the reality in the study area and that the system performs without instabilities that could impair results.

Task 1: Collating, analyzing, and preprocessing the requisite data

For the modelling a variety of data was needed. Depending on the flooding mechanism (fluvial, pluvial, etc.), the sources of information may differ, since the type of analysis to be carried out is different. For developing the hazard models and maps two main sources of input data are required: topographical and hydrological data. A third category of data is also relevant and usually consists of documents, studies, previous projects, etc.

[8] Chapter prepared by Jeronimo Puertos Agudo, Amparo Samper Hiraldo, Cristian Dinu and Niculina Florescu. Contributions from Alexandra Petcana, Aurelian Drăghia, Juan Fernández Sainz, Ignacio Villanueva Lacabrera, Mădălin Dumitru and Cătălin Fusa.

As for most components of the RO - FLOODS Project, data collection, processing, and management were also crucial activities for hazard modelling. Hence, modelers were closely involved in data collection, storage, and structuring, considering the very specific methods enabling the use of data in the models (e.g., minimum number of vertices on river cross-sections, how a hydrotechnical survey should be presented, the digital format of different data types, which hydrological studies are necessary, etc.).

Modelers analyzed and processed all APSFR-level data to ensure that the topographic or hydrological data were correct in terms of extent (in the case of topographic data) and format so that they could be fed into the modeling software. Other types of analysis were performed on hydrological data to assess data consistency (accuracy, completeness, and correctness of the collected data).

Topography data

The topographical data used for modeling were mainly of three types: digital terrain model (DTM) data obtained with light detection and ranging (LiDAR) technology, topo-bathymetrical data from ground surveys, and detailed surveys of relevant hydrotechnical structures (bridges, weirs, dikes, etc.) (see chapter 4 and figure 5.1). All topographical data should be as recent as possible—preferably collected during the Project's implementation—although in certain cases, new data was unavailable for which old topographical data had to be used.

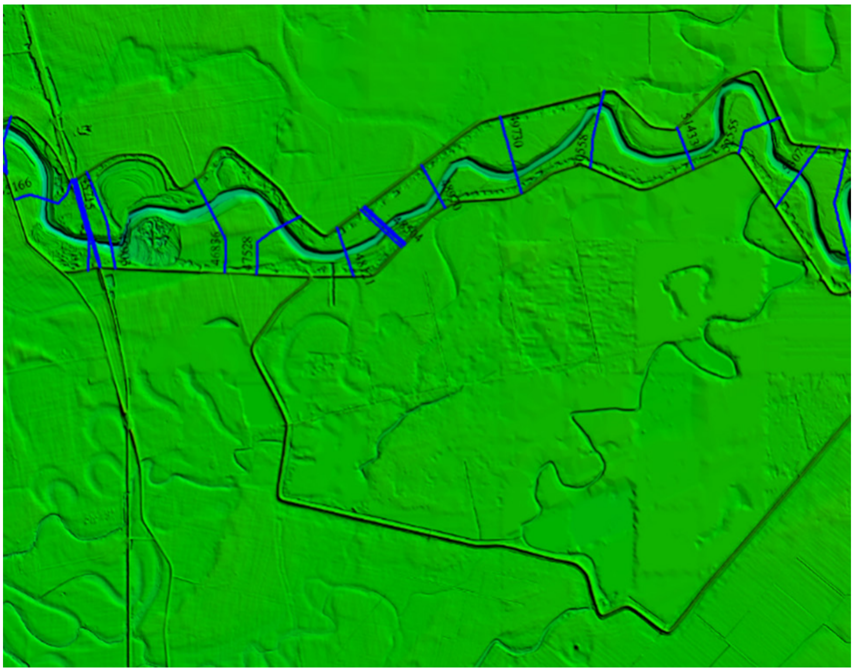

Figure 5.1 Example of a DTM, cross-sections, and relevant structures (dikes)

Modelers analyzed and preprocessed the topographical data to develop hazard models. Depending on the model type, modelers could either use all or a part of the topographical data (e.g., developing a two-dimensional [2D] model requires all main types of topographical data, whereas for a one-dimensional [1D] model, only topo-bathymetrical cross-sections and detailed surveys of structures are strictly necessary).

Adapting data format is an essential process while building hazard models. It is often necessary to transform topographical data into the format used by modeling software. Data format is typically not cross-compatible across modeling software.

Blending different sources of topographical data is a complex but essential process. Data homogenization (blending new and old data) and error debugging required significant efforts and constituted the first source of uncertainty. These activities were carefully planned and included multiple mechanisms to ensure quality and homogeneity of the final product.

Hydrological data

Depending on the type of the hazard model (pluvial, fluvial, urban or coastal), various types of hydrological/meteorological data were necessary as inputs. The main sets of hydrological and meteorological data were discharge and/or stage hydrographs, rainfall data, sea level and wave data. Usually there are two main types of hydrological/meteorological data: measured data (used for calibration of the models) and synthetic data (for multiple AEPs or return periods (RPs)). The hydrological data are generally obtained from hydrological studies, which in this case have been carried out by Romanian authorities, namely the National Institute of Hydrology and Water Management (INHGA).

Before developing hazard models, modelers analyzed consistency of the hydrological data and identified and highlighted eventual errors. These were then corrected by the authorities that first developed the respective data sets. Depending on how data was provided, modelers had to process synthetic data to feed into models. As an example, for the development of a synthetic discharge hydrograph, only the main parameters were provided. The hydrograph itself (as a time series) was then constructed based on these parameters. The same can be said about the rainfall hyetographs, which were constructed based on intensity-duration-frequency (IDF) curves (since only IDF curves were provided).

For the RO - FLOODS Project, the National Meteorological Administration (ANM) developed 22 IDF curves using a time series of precipitation data, mainly to cover urban areas. The INHGA delivered the basic information to build 2,154 synthetic hydrographs for nonregulated catchments and 63 additional hydrographs, which consider the effect of dams upstream of the study areas. All these data were processed and examined to avoid inconsistencies. Different approaches were followed to produce hydrographs in large catchments or in small—flash flood-prone—catchments. In all cases, specific analyses were conducted to consider the AEP1% climate change scenario (applied to the IDF curves or the hydrographs).

Other relevant data

Building the hazard models also required other relevant data. These included, among others, the operating rules for existing structures (in case of dams or other hydrotechnical structures that use operating rules), different studies or documents developed specifically for the modeled area (geotechnical studies in case of dike breach models), design standards (where existing data do not cover certain aspects of the modeled area), and rating curves at gauging stations.

The modelers analyzed all these data to ensure consistency and to process the relevant data for the models' implementation. As an example, the operating rules for a dam could now use a different reference system since it was constructed more than 40 years ago (e.g., a Baltic Sea topographic reference instead of the current Black Sea reference for which the zero values are not the same). In this case, a modeler had to transform the data, as per relevant legislation, to be compatible with the current system before developing the hazard model.

Task 2: Hazard modeling

Hazard maps are required under the Floods Directive. They are constructed using numerical models that can simulate how water flows down rivers and how it spreads out over floodplains if channel banks are overtopped. The same models — with changes to input data — can also simulate the overland runoff in urban areas or flash flood basins.

In essence, these models consist of a transcription of the highly complex reality into a mathematical simplification. The accuracy of the models' results will vary based on how the detailed reality is described in the model. Until a few years ago, flow models were essentially 1D, meaning that reality was described by means of cross-sections of channels, which were extended out to floodplains. Besides, in some cases, a single maximum constant discharge was used, instead of a realistic hydrograph (steady-state models).

Real flow patterns are not actually 1D in floodplains, near bridges, or in many other areas, so 2D models are necessary to appropriately describe floods. Besides, to know how effective accumulation areas are at controlling floods, or to account for the routing effect of floodplains, realistic hydrographs should be used instead of constant discharges. This is why 2D unsteady flow models are necessary.

In the first cycle of the Floods Directive implementation in Romania, most models were 1D, even steady flow. However, in this RO - FLOODS Project, all models are 2D. In some cases, depending on the situation, it may be beneficial to describe channels with a 1D approximation — which is reliable — and flood zones with a 2D description, which is connected via lateral structures. This approach, called 1D-2D, has also been applied in the current Project.

The RO - FLOODS Project used the HEC-RAS (2D) and MIKE software systems. These two software systems were chosen as some RBAs had previous models and some tradition in using either HEC-RAS or MIKE. For the future, it would be advisable to choose just one model for the whole country, as all the centralized quality control, map production, training, etc., is simpler if just one code is used. In this regard, it is important to point out that HEC-RAS is a free of charge software.

The improvements made in the second cycle are quite significant since all new models are 2D. The models' quality is evidently much better, although the effort involved is also much higher. However, the effort is worthwhile since the models can be used in the program of measures (PoM) to not only test grey or classical structures such as walls or dikes but also to assess the performance of nature-based solutions (NBS) as accumulation areas or polders. Romanian authorities can use these models as planning tools, beyond the scope of the Floods Directive.

When analyzing the hydraulic model performance, its accuracy is an important parameter. If 2D models are to be used, the resolution of the calculation mesh when building the model may differ, regardless of the DTM's accuracy. Generally, for areas with low socioeconomic development (e.g., agricultural areas), the mesh could be coarse. But for developed (e.g., urban) areas, the mesh needed to be finer. Mesh discretization inside a 2D model also depends on how the software will utilize the mesh to incorporate the topographic data into the models (figure 5.2). Certain modeling software will transform the DTM used as input based on the mesh setup, whereas others will extract information from the DTM for each cell of the mesh, with no changes to the terrain. The finer the mesh, the slower the model. Using a fine mesh everywhere is thus not a good approach when dealing with large models like the ones developed under RO - FLOODS. Creating an optimum mesh is critical.

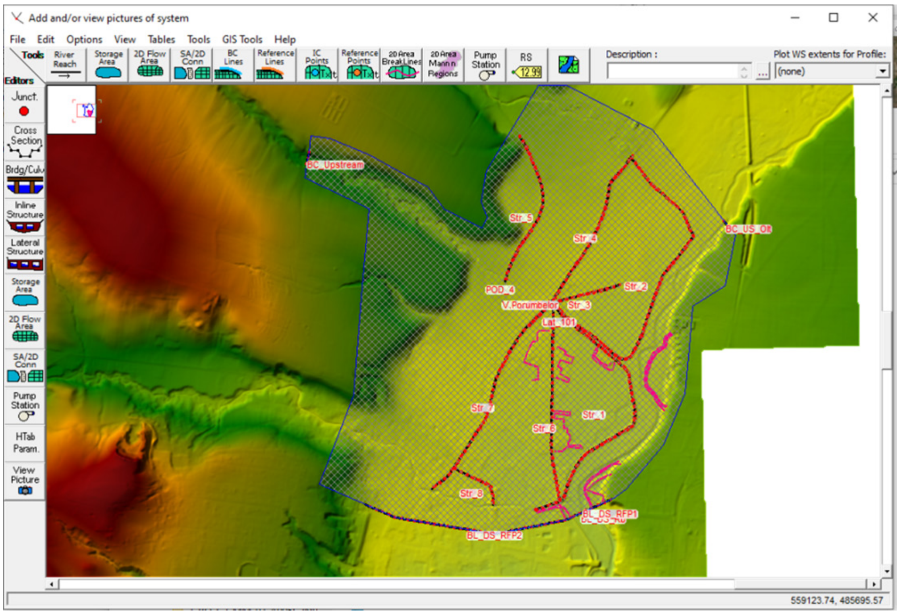

Figure 5.2 2D model setup: Definition of geometry and relevant structures

For flood models, certain parameters must be defined while outlining the geometry of the area to be studied. The dominant parameters are the roughness coefficient of the channels and the flooded areas. Depending on the available data and desired accuracy, this parameter can be defined as an aggregate value over a large area or as localized values based on land cover data. Different data sets have been used in RO - FLOODS to define these parameters, whose accuracy varies with mesh size.

Besides the coefficients associated with terrain and different land uses, the characteristics of various structures that can impact flood flow (e.g., bridges, dikes, dams, roads or railroads, and underpasses) will also be required.

After the definition of the geometry of the area and its hydraulic characteristics, the models' boundary conditions need to be defined. Depending on the flooding mechanism, source, or characteristics to be simulated, the models will incorporate different boundary conditions such as flows, precipitation, or waves, which in the end will generate the flooding.

For fluvial models, hydrological inputs can be defined at the upstream end (as a single-flow hydrograph). Otherwise, in case of long reaches, some lateral inputs (concentrated or distributed) will have to be defined along their length. This is essential to maintain the probability of exceedance along the entire reach and requires calibrating these distributions in some cases. For other types of models (e.g., pluvial), the meteorological input (i.e., rainfall) is distributed over the entire domain area.

Calibration and validation of the models were performed after geometry and boundary condition definition. Depending on available historical records at gauging stations or measured rating curves, this process is necessary in order to assure good performances of the models compared with real data. For rivers with no gauging stations, the parameters of the models can be estimated from calibrated rivers nearby or based on literature. The hazard maps are generated only after the calibration-validation process is performed.

A four-step process was followed to ensure models' quality and the completeness of the packages of information required to rerun or modify models in the future. First, modelers performed their own checks. Next, a peer review was implemented among the modelers who performed modeling in the Project. The aim here was for modelers to review each other's models. The third stage involved a complete review of the packages by a dedicated group of expert modelers from the World Bank. The experts verified that all models were able to run. They also tested the models' results and the products' completeness and quality. Finally, experts from RBAs analyzed the models' results (flooded areas, water depths, etc.) to verify they matched their on-field experience. A Web viewer was developed for this purpose.

The RO - FLOODS Project involved two modelling software systems. This made it difficult to analyze and present data in a consolidated manner. For the future, it would be advisable to choose just one software system. Nowadays, free models yield results as accurate as commercial models. Using a model like the HEC-RAS for entire projects could thus be a good option (Hydrologic Engineering Center 2021a, 2021b, 2021c).

Task 3: Hazard mapping

The Floods Directive requires considering at least three scenarios, corresponding to high, medium, and low AEPs of floods. For more detailed results, the RO - FLOODS Project realized five scenarios, generally corresponding to AEPs of 0.1 percent, 0.5 percent, 1 percent, 10 percent, and 33 percent. The additional AEPs yielded more accurate risk calculations. Additionally, a scenario corresponding to an AEP of 1 percent was developed including the effect of climate change. In specific cases, the AEPs were slightly modified to fit the existing hazard data from the first cycle of implementation.

Hazard maps were generated using different procedures, depending on the situation: the choice of a process relied on, for example, whether an APSFR was modeled in the second cycle, or first cycle, of the EU Floods Directive, the type of APSFR (fluvial, pluvial, etc.), and the model's setup. In general, once the models were run, the results were expressed in the form of different output parameters such as water level, velocity, and water depth. The modeling software utilized, used some geographical information system (GIS) processing module, or GIS processing procedures (internally or externally) to transform results into maps. In general, the maps obtained give a picture of floods' magnitude for each RP or AEP (figure 5.3).

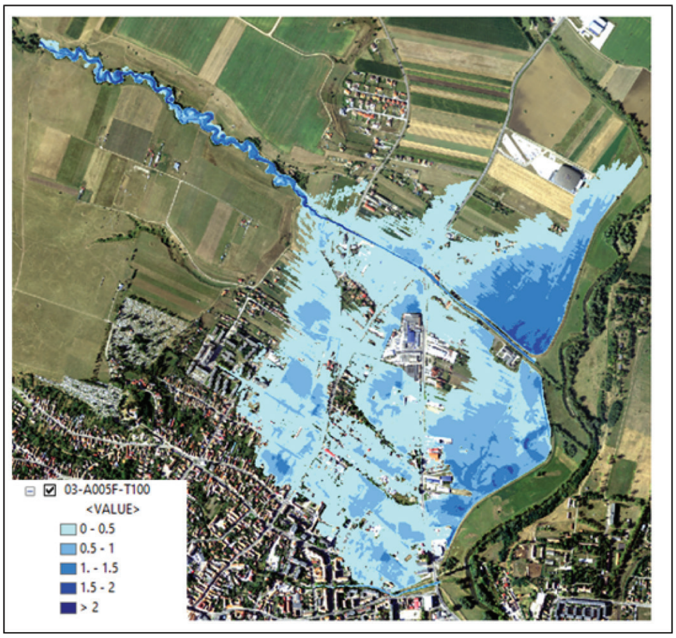

Figure 5.3 Model results: Water depth (AEP 1%)

Generally, three products were considered as integrated parts of hazard maps: (i) flood extent, provided in .shp file format, (ii) water depth, in raster format, and (iii) water velocity, also in raster format. These products represent the basis for further risk calculations.

However, in many cases, flooded areas in Romania had a very shallow sheet of water. For models with pluvial input (urban or flash floods, in general), since rain falls on the entire surface, the entire model domain is wet. In this case, the overall extent of the apparently flooded area can be misleadingly large. It is common, therefore, to establish level thresholds to deem an area as flooded (typically about 10 centimeters of water). This allows filtering maps to eliminate areas where water level is below the threshold and yields a more realistic picture. It is also common to present level distribution maps, which allow perceiving more quantitatively where water levels are relevant and where they are not.

For urban rainfall models, the effect of urban drainage has been taken into account considering a water abstraction equivalent to the capacity of the network, which, depending on the city, corresponds to a rainfall with a return period of 2 or 3 years, always considering a performance on the safety side. A more accurate calculation can be done in the third cycle, provided that complete information on the drainage network is available.

Although water level is the most important variable, effective floodwater circulation in the flooded areas — that is, if water velocity in the flooded area is not zero — can aggravate a flood's effect. Velocity distribution — as absolute values or vector fields (something more complex to represent in large extensions at a usual scale) — thus had to be included in Romanian hazard maps. In this RO - FLOODS Project, absolute values of velocity were included.

Results

The number of maps in this RO - FLOODS Project is quite impressive. Flood hazard and risk maps (FHRMs) were produced for 526 APSFRs, considering an average of five hazard scenarios. Since the APSFRs are generally large, the total amount of map sheets (DIN A3) is 123.275. This means a surface equivalent to almost three football fields (90 meters x 50 meters each). Seventeen full cities have been modeled using pluvial full-2D models. The urban population of these APSFRs is about 2 million, and all buildings and streets have been included in the models. Maps can be accessed through a web map viewer, further described in chapter 7. (**https://inundatii.ro/en/maps-portal/**).

The effort and precision in this Project represent a qualitative leap compared with the first cycle. This puts Romania in a very good position to face the third cycle. Moreover, all the information is appropriately stored and described so that it can be directly used. Models have been used to not only generate FHRMs but also define the measures for the selected prioritized projects included in the PoM. Since the models are 2D and unsteady, all types of measures can be tested, including NBS that help to retain and store water to reduce peak flows in the drainage systems.

In the future, the models can be used to all kinds of plans or projects, including the analysis of the performance of structural grey or green measures to prevent floods, the design of bridges or the demarcation of buffer strips along riverbanks in order to avoid inadequate urbanistic developments, among other possibilities.

Lessons learned

The success of the hazard modeling and mapping under the RO - FLOODS Project stems from multiple contributing factors and their interactions. But five issues stand out. They are presented below as key lessons to be carefully considered when planning similar assessments (including updating the FHRMs for the third cycle of the Floods Directive):

- **Task magnitude.** Data analysis and processing and hazard modelling and mapping task is a huge endeavor that can take up most of a project's resources (time, personnel, etc.). There are only limited possibilities for optimization and reductions in these activities, due to the essential visual checks and hands-on tasks. The data analysis and processing task could never be fully independent from modelling and that is the reason why these activities should overlap.

- **Data quality.** A large number of problems encountered during the Project were due to inconsistencies in the quality of the data for hazard modeling and the results from the first and second cycles of the EU Floods Directive. Data consistency and quality as produced by the RO - FLOODS Project should be maintained also for the third cycle.
- **Naming convention and data structure**. A large number of files has been generated for the models and hazard results. The corresponding storage requirement is substantial. It is crucial to maintain or improve the naming convention and data structure developed in the second cycle of the EU Floods Directive (see chapter on data management).
- **Quality control.** A dedicated team performed quality control for the models and for the hazard results immediately after their delivery. This was time-consuming but was the quickest way to identify errors. This procedure should also be applied in future modeling.
- **Software.** The use of two entirely different modeling software systems made it difficult to standardize procedures (modeling, quality control, training, etc.). For the third cycle of the EU Floods Directive, only one modeling software should be considered for standardizing the hazard modeling and mapping processes.

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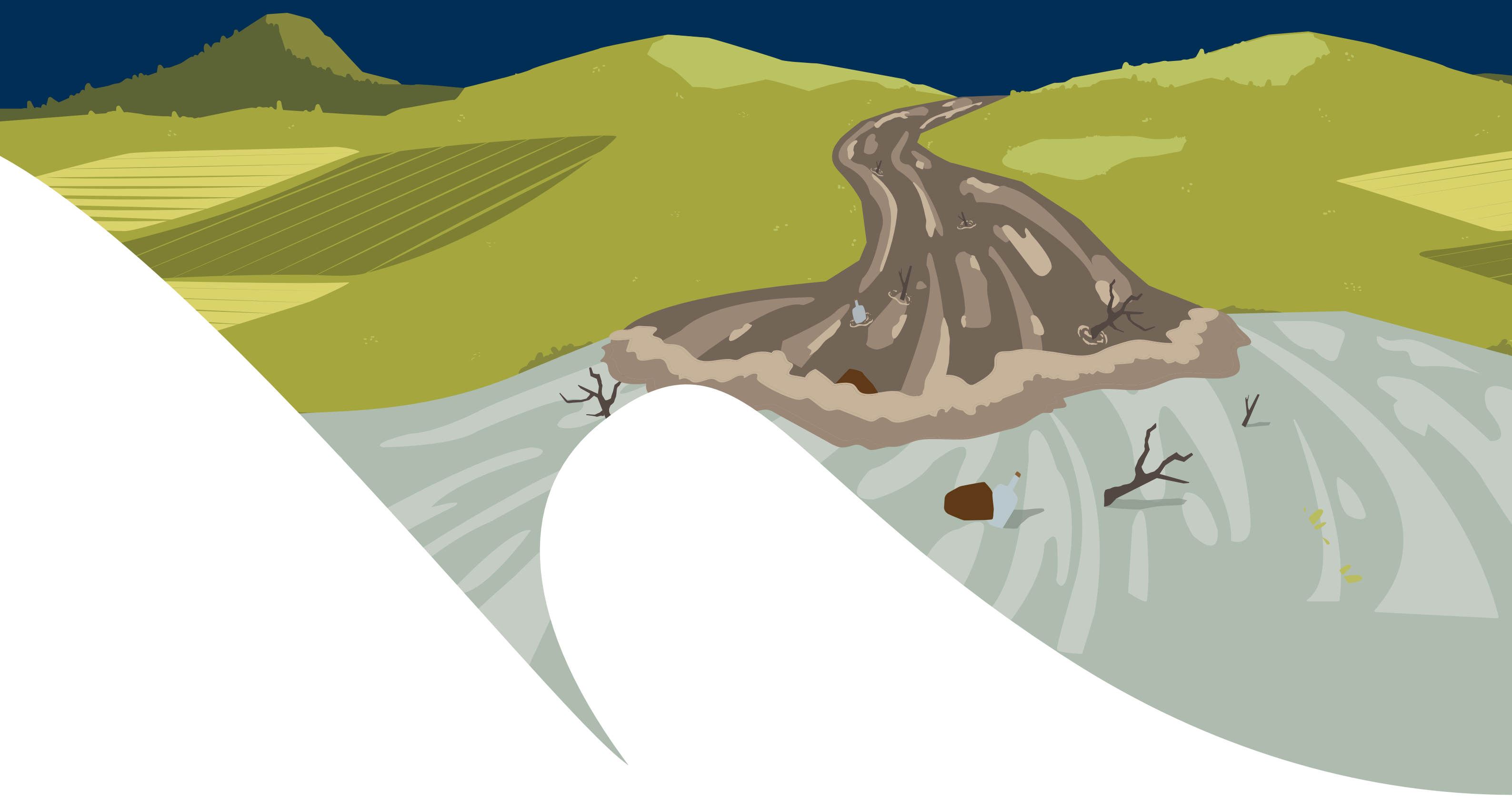
CHAPTER 6

FLOOD DAMAGE AND FLOOD RISK ASSESSMENT



6. FLOOD DAMAGE AND FLOOD RISK ASSESSMENT[9]

Summary

This chapter focuses on the flood damage and risk assessment. The assessment considered 526 areas of potential significant flood risk (APSFRs) — including fluvial, pluvial, flash flood, and coastal flooding. The exercise has produced numerous results and assessed and mapped tangible damages, indirect losses, and intangible effects. The results have been provided in different forms, including maps, geographical information system (GIS) presentations, and tabular data in fact sheets. The results indicate that Romania is at risk from significant flooding with huge associated damages. The country must adopt further risk mitigation measures to protect its population and property from flood risks.

The challenge

The fundamental basis of sound flood risk management is the assessment of flood risk (Penning-Rowsell et al. 2013). Only with such assessments is it possible to identify effective and efficient risk mitigation measures and formulate a plan — under a coherent flood risk management plan (FRMP) — to safeguard people and their properties against flood events in the future. Flood risk mapping also identifies "hot spots" that helps to prioritize relevant investments and alert organizations and the public to the flood risks faced. The Project's challenge here was to produce these risk assessments by combining exposure data and modeled hazard data in a way that was efficient and produced results that others could easily use.

This chapter therefore describes the process (figure 6.1) in the RO - FLOODS Project of assessing potential flood damage, the construction of a damage database for Romania, and the mapping of risk using that damage data.

The aim was to produce detailed and consistent flood risk data as the basis for flood risk maps and for the development of the new FRMPs. A comprehensive stocktaking and needs assessment of the first-cycle results was undertaken, and, in conjunction with the European Commission's (EC's) recommendations, a systematic methodology and workplan were devised for undertaking these activities in the available time.

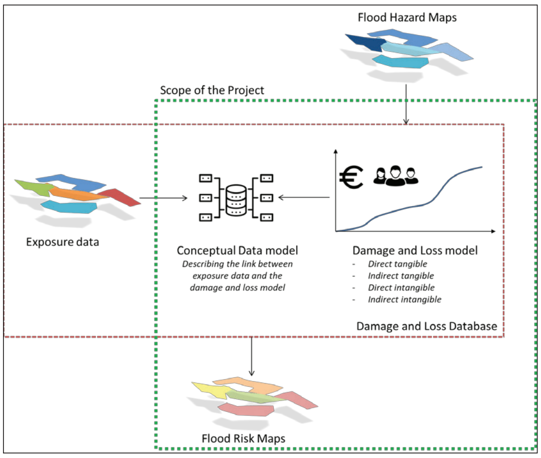


Figure 6.1 Schematic of the flood damage and risk assessment process

Task 1: Flood damage database

The now-classic application of water depth-damage curves (DDC) was the basis for the Project's approach to flood damage assessment (figure 6.2). A DDC relates the percent of damage or the estimated economic loss to a building's structural integrity and/or contents directly affected for a given water level (depth) (Plazak 1984). The approach has a sound scientific basis, which aligns with international best practices. It is eminently valid for the Romanian context and leads to realistic damage assessment for the local Romanian setting. The RO - FLOODS project has developed a database of such curves specific to Romanian context (as part of the Damage Assessment and Risk Methodology [DARM]).

[9] Chapter prepared by Juan Fernández Sainz, Edmund Penning-Rowsell, Elena Daniela Ghiță. Contributions from Mary-Jeanne Adler, Gerbert Pleijter

The Project deliberately designed the structure of the database to be flexible. It can be used further, for object-based risk evaluation (i.e., individual properties), but also for less high resolutions, perhaps using the Romanian Urban Atlas information or only the broad classes of land use from the Corine Land Cover maps. Any updates to the land use or its receptor information will be easy to add into the damage database for future assessments, e.g., the third-cycle implementation.

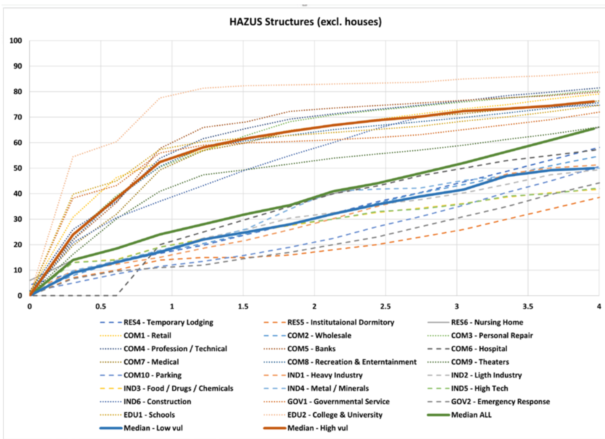


Figure 6.2 A sample of the DDC in the DARM

Based on the DARM database, total flood damage and loss were calculated in the RO - FLOODS Project based on four key subcomponents, as used in most flood damage and loss assessments worldwide:

1. Direct tangible damages. Direct tangible damage is the most studied and best understood class of flood impact. Examples of direct tangible damage are physical damage to:

- Housing structure and the property inventory.
- Physical damage to infrastructure and public utilities.
- Agricultural crop losses.

2. Direct intangible losses. Examples of direct intangible damages (those difficult to quantify in monetary terms because they are abstract or difficult to measure) are:

- Loss of life/mortality.
- Injury/morbidity.
- Damage to landscape or cultural heritage (not being direct damage to these assets but the loss of these assets for society).

3. Indirect tangible losses. Indirect tangible damages are damages caused by the disruption of an economy's physical and economic linkages, and the additional costs due to emergency services and other actions for preventing flood damage and other losses. They can be quantified in monetary terms. This includes, for example, loss of production for the companies affected by flooding, induced production losses of the companies' suppliers and customers, the costs due to traffic disruption, and the costs due to emergency services.

4. Indirect intangible damage. Examples of indirect intangible flood damage include mental trauma due to flooding or societal disruption among people or communities not directly affected by the flood waters.

Task 2: Calculation and mapping of flood damage and risk

RO - FLOODS undertook direct tangible damage and loss calculations, loss of life (direct intangible loss) calculations, and sectoral impacts (number of potential affected buildings, infrastructure, etc.) calculations. These calculations were undertaken using the following data sources:

- **Hazard data.** Different hazard data produced by the RO - FLOODS hydraulic modeling exercises — namely, water depth, water velocity and flood extent data, are needed (see chapter 5). Water velocity was used only to calculate loss of life in case of pluvial and flash floods models. The results were available for six annual exceedance probabilities (AEPs) with second-cycle modeling (33 percent, 10 percent, 1 percent, 0.5 percent, 0.1 percent, and 1 percent + climate change) and for four AEPs (10 percent, 1 percent, 0.1 percent/0.2 percent, 1 percent + climate change) for areas with first-cycle modeling only.

- **Exposure database.** For all 526 APSFRs to be reported under the second cycle, all property elements exposed to flooding in Romania (i.e., the "receptors") were mapped, resulting in a new and very detailed exposure data set which was described in chapter 3 . This exposure database for 1,145 typologies is a key Project output, and regularly updating the database and using it for other purposes (e.g., in spatial planning) are strongly recommended.
- **Damage and loss functions database.** As described above, 85 DDCs were developed to determine the direct flood-induced damages and flood-induced indirect losses for the number of property types.
- **Warning times.** Besides using water depth and flood extents, warning lead times were also used as input data for calculating potential loss of life.

The indirect tangible losses are calculated as percentage of the direct tangible damages and took into consideration only the costs for emergency interventions and traffic interruption. The total number of injuries is calculated based on the total number of fatalities – a fixed ratio between the fatalities and the injuries was applied. The total number of people suffering from indirect intangible consequences (such as Post Traumatic Stress Disorder) equals 25% of the potential affected population. These categories of losses were not mapped.

Mapping procedures

Substantial enhancements were undertaken in Romania during the implementation of the European Union (EU) Floods Directive's second cycle, compared with the procedures followed for the first cycle. These improvements resulted from the analysis of the first-cycle methodology and results and took into consideration the EC's feedback and comments. The updated damage and risk assessment methodology addresses the shortcomings and aimed to improve quality and the number of products even beyond the EU Floods Directive's requirements.

Thus, the flood damage assessments for this second cycle (1) covered different flood sources, characteristics, and mechanisms (namely, for fluvial, pluvial, flash floods, and coastal), (2) included an assessment of quantitative damage and loss (including direct, indirect, tangible, and intangible damages), (3) considered climate change for the calculation of the impact (for the 1 percent AEP and the annual expected damage (AED)), and (4) included the estimation of sectoral impacts. The AED is the cost due to damages and losses that would occur in any given year if monetary damages resulting from all hazard probabilities and magnitudes were spread out equally over time. It measures the flood risk level at all relevant locations investigated.

All the products above were calculated in the form of raster files and/or tabular data, and summary total values were produced for individual APSFRs, river basin administrations (RBAs), and at the national level for Romania.

Calculation procedure

The direct and indirect damage calculations were performed using vector files within a GIS platform. All exposed elements (properties) were assigned one of the 1,145 possible receptor typologies. However, performing the necessary damage and risk calculations requires each element's typology to be matched to one of the 85 available vulnerability DDCs, considering the types and subtypes under that element. The other parameters — the direct and indirect intangible damages, and the sectoral impact — were calculated using Python-automatized GIS routines. Finally, the potential life loss was calculated using raster processing of the hazard maps.

Validation and quality control

To give confidence in the results, the computation approach that was used has been manually validated on a sample basis. Also, the resulting values were compared to expected values, or the values recorded for previous historical flood events. This was quite successful: all these comparisons were satisfactory. Also, a strict quality control procedure to identify issues and inconsistencies within results was pursued.

Damage and risk mapping results

The results for all 526 APSFRs were aggregated and analyzed (see table 6.1). They were compared with the national gross domestic product (GDP) and the record of national historical flood impacts.

AEPs / AED	Total damage (€, millions)	Affected population (no.)	Domestic properties (no.)	Industries (no.)
T10 (10%)	3,532	382,069	105,896	6,114
T100 (1%)	21,684	1,239,897	416,746	23,586
T100CC (1% + climate change)	34,512	1,634,362	578,786	34,512
AED	1,729	152,451	40,293	2,329
AED with climate change	2,349	190,044	51,927	3,008

Table 6.1 Country-level RO-FLOODS flood damage and risk assessment results for Romania

The RO - FLOODS Project produced maps of total damages, AED with and without climate change, and sectoral impacts (for fluvial, flash floods, pluvial, and coastal APSFRs) using the damage curves in the DARM database discussed above. In sum, the damage and risk calculations resulted in a comprehensive suite of final products:

- **Fact sheets.** One fact sheet per APSFR, one fact sheet per RBA, and one national fact sheet.
- **Web map viewer.** A dedicated Web map viewer was implemented for the publication of the flood damage and risk assessment's results (**https://inundatii.ro/en/maps-portal/** see chapter 7).
- **Risk maps.** Risk maps in PDF format were also produced for the total direct tangible damages and the AED for individual APSFRs.
- **Tabular outputs.** These cover total direct tangible damage, indirect tangible damage, direct intangible damage, indirect intangible damage, and sectoral impacts for all AEPs and AEDs for all APSFRs.
- **GIS outputs.** Grid raster files for direct tangible damage, indirect tangible damage, direct intangible damage, indirect intangible damage, and loss of life for all AEPs for all APSFRs.
- **Hazard-risk graphs (see figure 6.3).** A hazard-risk ranking approach was followed to facilitate the prioritization of APSFRs for subsequent analysis. This was targeted at APSFRs that show particularly high damages and for which the extent of the flooded area (a key spatial planning metric) had to be considered.

Importantly, all these data are represented in GIS systems in accordance with the EU's INSPIRE Directive's[10] requirements and were prepared by Romania for the second cycle reporting in relation to the EU Floods Directive.

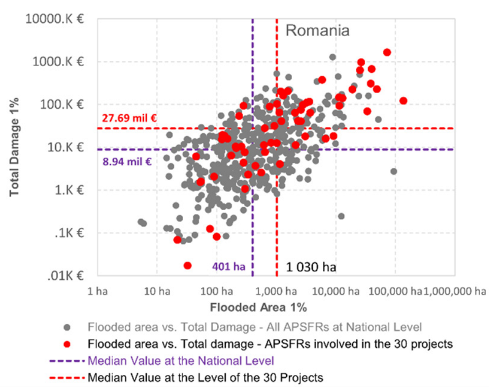


Figure 6.3 A graph of flood damage/areas flooded showing the 30 prioritized APSFRs

[10] The INSPIRE Directive aims to create a European Union Spatial Data Infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe and assist in policymaking across boundaries. **https://inspire.ec.europa.eu/**

Lessons learned

The RO - FLOODS Project's damage and risk assessment element involved strong multidisciplinary teams with specialist knowledge and international experience in the area. This teamwork has resulted in the following key lessons, with some suggestions for the future:

- **Damage model.** The damage model for the direct tangible flood damage requires a strong Romanian foundation, which can be obtained considering the most recent information from the Order of Romanian Architects. For the third cycle of Floods Directive implementation, it is recommended to compare the values used for the second cycle with the most up-to-date information and adjust the values where needed.
- **The task.** The task overall was mammoth and challenging. The damage and risk assessment were undertaken for 526 APSFRs for up to six AEPs. This meant that calculations had to be undertaken for up to 3,156 cases, and all the products outlined above had to be produced. The timeframe to undertake the task was very short. Additional resources thus had to be allocated to handle the work's magnitude. Several lessons in terms of efficient data management, result management, and quality control were learned during the implementation.
- **Data resolution.** The agreed resolution for the damage and risk assessment was a 4 x 4-meter (m) grid — a level of detail not common in national quantitative flood risk assessments. This created several issues during implementation, especially considering the hazard input (2 x 2 m grids) and the inconsistencies in the first cycle and second cycle AEPs for a particular APSFR. These issues had been addressed through greater cooperation between the RO - FLOODS Project's hazard modelers and risk modelers.
- **Quality control.** Several quality control procedures had to be implemented throughout the risk and damage assessment processes. The use of a semi-automatic quality control procedure proved to be beneficial in the context of the sheer volume of all the results that were produced.

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CHAPTER 7

WEB MAP VIEWER

7. WEB MAP VIEWER[11]

Summary

Under the RO - FLOODS Project, new flood hazard and risk maps (FHRMs) were developed for 526 areas of potential significant flood risk (APSFRs). A common Web platform was developed to use this rich information. The platform allowed stakeholders to review and validate draft maps prior to their publication on the web and was used for the formal reporting of FHRMs to the European Commission (EC).

This chapter reviews the main challenges, steps, and results of establishing a state-of-the-art open-source Web map portal for public consultation and reporting to the Water Information System for Europe (WISE[12]), in line with the EU INSPIRE Directive[13].

Key challenges

The models developed in the RO - FLOODS Project entail a transcription of the highly complex "ground" reality into a mathematical simplification to depict flood hazard areas and quantify the risks. As described in earlier chapters, the models' development required a number of different data sets, including topographical, hydrological, and risk exposure data. However, local field experts typically have the best knowledge of local water systems and flood-prone areas. Therefore, it was important to involve river basin administrations (RBAs).

The Web viewer was developed with an aim to overcome the following challenges:

- **Challenge 1:** to involve hundreds of experts, with different backgrounds, in providing timely feedback on substantial raster and vector data (1.58 million files with a total size of 39.04 terabytes) within a tight schedule and under fixed deadlines.
- **Challenge 2:** to fulfill the reporting requirements of the EU WISE.
- **Challenge 3:** to match the technical guidelines of the EU INSPIRE Directive.
- **Challenge 4:** to provide a shared space to upload a vast number of portable document format (PDF) maps as the final static output of the hazard and risk modeling for all APSFRs.
- **Challenge 5:** to provide the wider public access to dynamic hazard and risk maps.
- **Challenge 6:** to ensure platform's sustainability and scalability, keeping in view technical capacity and financial aspects for licenses and future maintenance.

Approach and solutions

The above challenges were seen by the Project as opportunities to introduce and establish a sustainable system that could be reused cost-effectively in the future and formulated the main strategic vision for the system as follows:

"The public web Geographic Information System (GIS) viewer is based on a free and open-source GIS architecture, is part of the overall spatial data infrastructure in Romania and provides all the necessary flood hazard and risk-related data in a format suitable for use by both policymakers and the wider public."

[11] Chapter prepared by Lubomir Filipov
[12] **https://water.europa.eu/.**
[13] **https://inspire.ec.europa.eu/.**

The following set of rules was defined as guiding principles in the system's design, development, and implementation:
Conceptual design principles. The system should:

- Bridge the information gap between technical modelers and a wider expert audience or open public.
- Provide easy access to a maximum set of data.
- Deliver flood-related data in both space (maps) and time (multiple versions and revisions, including first-cycle data).
- Be based on the principle of shared ownership of product (considering local feedback).
- Avoid repetition of information or multiple versions.
- Be targeted at policy makers and the wider public.

Technological principles. The system should also:

- Avoid creating another black box (many GIS portals in Romania were not working due to proprietary products, expired maintenance, lack of source code ownership, etc.).
- Be built around open-source solutions, to ensure that the systems can be implemented sustainably and cost-effectively in the long term, and to provide ownership of source code so that it can be reused for the third cycle.
- Be fully Web based, considering the number of users, the national coverage, and data accessibility by different target audiences: from the wider public to flood - and water-related experts and/or systems (desktop GIS software or Web-based systems via open Web map services).
- Be based on internationally recognized standards (e.g., International Organization for Standardization (ISO)[14] for metadata and Open Geospatial Consortium (OGC)[15] for Web services) and comply with the EU WISE reporting requirements and the technical guidelines for EU INSPIRE.

Result

The Web viewer portal was developed following an agile project management approach (figure 7.1)[16]. The process involved interactive technological sprints[17], where different parts of the whole system were delivered, feedback was collected, and enhancement was done for the Project phase.

The technological architecture was based on free and open-source software tools (e.g., PostgreSQL database with PostGIS extension, MapServer, OpenStreetMap tile server, etc.). This was first running on a cloud environment (Amazon Web Services and storage) and then moved to the server infrastructure hosted at the National Administration "Romanian Waters" (ANAR). The public Web viewer is available at: **https://inundatii.ro/en/maps-portal/**.

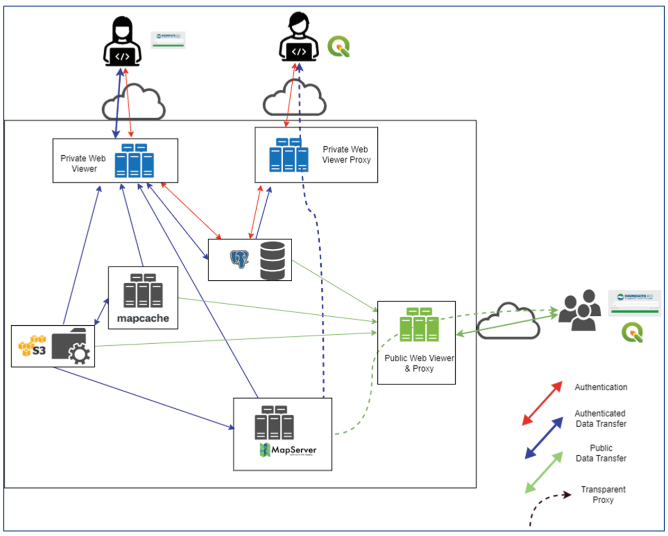


Figure 7.1 High-level system overview, showcasing the main system components

The Web viewer had two versions, private and public. Both versions are bilingual (Romanian and English versions), with appropriate metadata for each layer, and they both host all data from the first and second cycles of the EU Floods Directive implementation (orthophoto maps, risk exposure data, base map context layers, final versions of hazard and risk models). There are help

[14] **https://www.iso.org/standard/53798.html.**
[15] **https://www.ogc.org/.**
[16] **https://en.wikipedia.org/wiki/Agile_management.**
[17] **https://en.wikipedia.org/wiki/Design_sprint.**

guides (brief and detailed step-by-step tutorials, video guides) for both versions, besides complete source code with software packages, libraries, and installation and configuration guides, and so on.

The private Web viewer was used to collect stakeholders' feedback on the draft FHRMs. This version requires a username and password to access. The private Web viewer was used for quality control of the hazard and risk results and to collect local feedback based on stakeholders' knowledge of their respective areas. This version was a game changer for stakeholder consultations in Romania. It saved time by helping engage hundreds of users on a national scale.

The public Web viewer was used to publish the final versions of the FHRMs for the wider public and provide options for fulfilling the reporting requirements of the INSPIRE Directive and the EU WISE (figure 7.2). The Web services were used for reporting under the Floods Directive's requirement that a live connection to hazard and risk areas is to be established, rather than the use of static files (shapefiles), as under the previous reporting cycle. Further, the Web services (OGC Compliant Web map service and Web coverage service) were tested and modified to meet the latest technical reporting requirements of the EC INSPIRE Directive. The testing and modification utilized the INSPIRE test validation service[18], and helped deliver an INSPIRE-compliant view and download service.

The public Web viewer is one of the very few examples of successful national open-source GISs in Romania. It can be used as a benchmark for a state-of-the-art implementation in other topic fields.

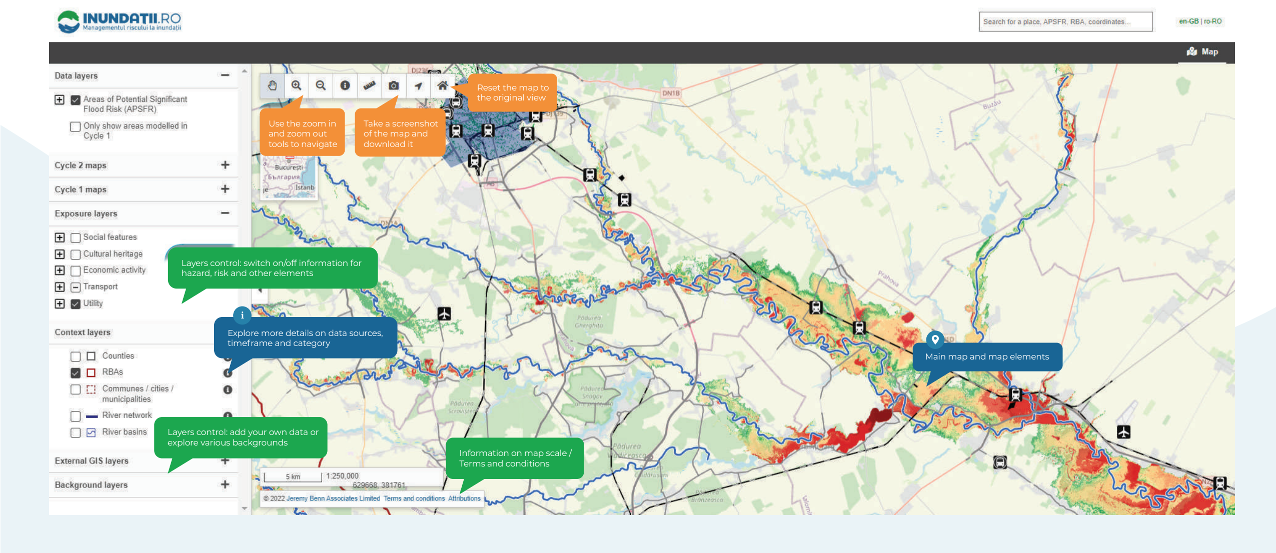
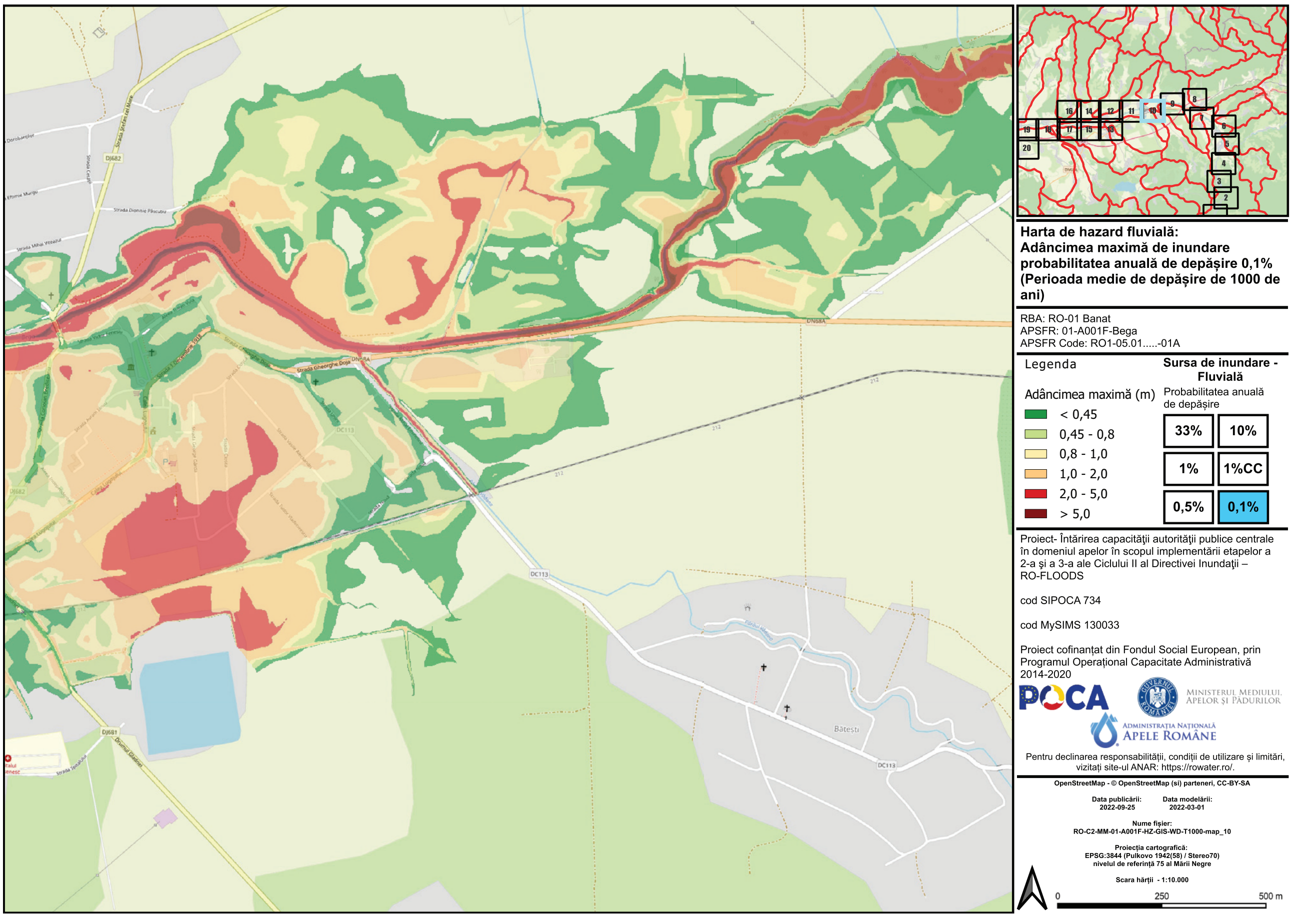


Figure 7.2 General overview of public Web Map Viewer

The public Web viewer also hosts and provides an interface to search and download PDF versions of all map types (hazard/risk) produced for each of Romania's 526 APSFRs and at a scale of 1:10,000 (figure 7.3). The public Web viewer has the following comprehensive functionality:

- Users can search by RBA, APSFR, x/y coordinates, or settlement names.
- Various navigation tools are available, for example, zoom in/out, pan, and measure.
- There are options to use Web map services to embed viewer results in third-party systems or software (e.g., ArcGIS or QGIS).
- There are also options for users to upload their own data via an OGC Web Map Service (OGC WMS) or a shapefile. This way, the data can be cross-checked against relevant hazard or risk data.

[18] **https://inspire.ec.europa.eu/validator/test-selection/index.html.**



Note: CC = Climate Change Scenario

Figure 7.3 An example of a flood hazard map (fluvial) in PDF format available on the Web viewer

Lesson learned

Many people were involved in the development and implementation of the RO - FLOODS Web viewer. Seven key lessons were thereby learned:

- **Stakeholder engagement and collaboration.** Clear communication and collaboration mechanisms were vital at each step of the Web viewer's development.
- **Data quality and standardization.** Ensuring the accuracy, consistency, and standardization of geographic data was obligatory for the proper functioning of the Web viewer and was successfully achieved through established data governance guidelines and procedures.
- **Scalability of infrastructure.** The system was designed with scale in mind, to accommodate growing data volumes and user demand. This was achieved through a cloud-based solution during the Project and with robust on-site infrastructure after it was completed.
- **Interoperability and integration.** The system was designed to be seamlessly integrated with other existing systems and databases. This was achieved by using open standards for convenient data sharing.

- **Security and privacy.** The Project has prioritized data security and data privacy (for the private Web viewer), encryption, and mitigation against the top 10 vulnerabilities of the Open Web Application Security Project (OWASP)[19].
- **Capacity building and training.** This was crucial for long-term system usability and sustainability. The World Bank team has supported Romania in conducting several training sessions for end users. The training has been delivered through detailed video guides, frequently asked questions (FAQs) material, training manuals, and technical system maintenance and administration guides for key system administrators.
- **Public awareness and engagement.** This is crucial for any system's success. The Project worked closely with various colleagues to ensure public engagement through the website, brochures, promotional videos, and campaigns.

[19] Open Web Application Security Project: **https://owasp.org/www-project-top-ten/**.

CHAPTER 8

DEVELOPMENT AND PRIORITIZATION OF MEASURES – FLOOD PROTECTION AND PREVENTION

8. DEVELOPMENT AND PRIORITIZATION OF MEASURES – FLOOD PROTECTION AND PREVENTION[20]

Summary

For the second cycle of the European Union (EU) Floods Directive, Romania has developed a well-researched program of measures (PoM) for its 526 areas of potential significant flood risk (APSFRs) in 11 river basin administrations (RBAs) and along the Danube River. This chapter focuses on flood prevention and protection measures and describes the processes and tools used for identifying, appraising, and selecting such measures for all APSFRs. Given the various challenges, including the huge overall scope of the task, time pressures, and the aim to advance "green" strategies, a robust and systematic methodology was developed to allow the necessary prioritization of promising measures. The methodology consisted of different steps, each concluding with choices regarding what should be further advanced, leading to progressively more focus and increased granularity, and resulting in 30 prioritized projects across Romania. The lessons learned from first-cycle implementation were well addressed, and the sheer magnitude and complexity of the challenge in this second cycle resulted in important new lessons for Romania for flood risk management in general and for the upcoming third cycle.

Key challenges and tasks

Needed improvements based on experiences made in the first cycle

The European Commission (EC) provided valuable feedback following Romania's submission of flood hazard and risk maps (FHRMs) and flood risk management plans (FRMPs) during the first cycle of the EU Floods Directive implementation. Although much of this feedback was positive, it also indicated some areas of improvement. In addition, the World Bank team did a comprehensive assessment of the Floods Directive implementation in Romania. All this feedback was examined in depth and translated into following tasks to be considered during the second-cycle implementation:

- The need to arrive at a comprehensive suite of flood risk management objectives and underlying indicators.
- The need for a clear link between the various indicators and the risk reducing measures assessed, such that their impact is quantifiable and subsequently can be monitored.
- The clear prioritization of measures. Further to using a comprehensive multicriteria analysis (MCA), it was also stressed that measures should be appraised and prioritized using a quantitative cost-benefit analysis (CBA).
- A strong requirement to ensure measures proposed are attuned to uncertainties of the future, especially regarding climate change.
- A drive to maximize the benefits from flood risk management by introducing sustainable strategies with nature-based solutions (NBS) and their combination with grey infrastructure.
- Finally, a development of integrated measures that contribute both to achieving the objectives of the FRMPs and of the associated river basin management plans (RBMPs) under the Water Framework Directive.

[20] Chapter prepared by Eric Huijskes, Jonathan Fisher, Elena Daniela Ghiță, and Edmund Penning-Rowsell. Contributions from Mary-Jeanne Adler, Sebastian Döbbelt-Grüne, Iozefina Lipan, Jeronimo Puertas Agudo, and Maria Stoica.

A formidable task

Addressing all 526 APSFRs across the country was a formidable task for Romania. This involved identifying over 5,000 flood protection and prevention measures, which were to be transformed into alternative strategies, and eventually progressing to 30 selected prioritized projects. The rationale behind the adopted limit of 30 such projects was based on Romania's expected capacities to manage their implementation and the likely available funding within the next years.

Going from the longlist of APSFRs to arrive at 30 realistic prioritized and deliverable projects was a huge challenge for the necessary phasing of all the work. This was further complicated owing to the necessary close involvement, throughout the process, of various parties, including all the RBAs, the relevant government ministries and agencies, and other key stakeholders.

The need to promote nature-based solutions and "green" infrastructure

Understandable concerns about the uncertainties surrounding the effectiveness of alternative green(er) solutions are partly responsible for the existing preferences for traditional "grey" flood defense measures, changing which requires time. Moreover, prior to the RO - FLOODS Project, Romania did not have clear guidance or a methodology and established processes for assessing and pursuing green(er) measures.

Time pressures and alignment with other plans

At the beginning of the RO - FLOODS Project, Romania had approximately two years to prepare the required FHRMs and FRMPs. In that period, the development of the PoM of the FRMP had to be coordinated with the development of the PoM for the RBMP under the EU Water Framework Directive.

A sound methodology

Key to the successful preparation of the PoM, addressing the challenges as described above was the development and consistent implementation of a sound overarching methodology. This included a set of flood risk management objectives, and a clear step-by-step process for the identification, development and prioritization of measures, and specific actions to promote NBS.

Clear flood risk management objectives and their integration into the process

To start the PoM process, it was essential to define the objectives for flood risk management in Romania. The following nine objectives were agreed by all parties concerned: promote NBS.

1. Avoid/Control risks associated to floods.
2. Reduce the negative impact of floods on population.
3. Reduce the negative impact of floods on infrastructure and economic activity.
4. Reduce the negative impact of floods on cultural heritage.
5. Reduce the negative impact of floods on environment and achieve/maintain the environmental objectives in accordance with WFD.
6. Enhance the level of awareness and resilience concerning flood risks, as well as increase the capacity for early warning, alarm and intervention, and response in case of emergency.
7. Enhance the level of adaptation to climate change impacts at the level of river basin and coastal area.
8. Maximize efficiency in achieving the flood risk objectives, considering the costs and available funding.
9. Improve the involvement of all stakeholders.

In terms of the identification, appraisal, and prioritization of prevention and protection measures, Objectives 2, 3, 4, 5, 7, and 8 are the most relevant. They are directly linked to the appraisal and prioritization of measures using MCA and CBA. The MCA included some 23 subcriteria, which covered social, economic, environmental, cultural, and implementability and this helped to prioritize the best options. Table 8.1 provides an example of how an objective is linked to MCA criteria and indicators and how this can be measured. The table list all six social subcriteria that accounts for 35/100 points in the overall weighting, compared to economic criteria (29/100), environmental criteria (24/100), cultural criteria (6/100) and implementability (6/100).

FRMP2 objective	Criteria (weight in percent)	Indicator	Data source
2. Mitigate the adverse impacts of floods on the population	Domestic properties (12%)	Number of properties (at a specific % of flood risk) protected or with increased protection	Damage loss assessment
	Human health (3%)	Number of people (at a specific % of flood risk) protected or with increased protection	Damage loss assessment
	Water abstraction for human consumption (9%)	Number of water sources protected	Drinking water – protected areas
	Social infrastructure (18%)	Number of assets (e.g., schools) protected	Damage loss assessment
	Recreational infrastructure (9%)	Proportion of assets (e.g., recreation centers) protected	Damage loss assessment
	Marginalized and poor communities (21%)	Number of people in poor and marginalized communities with increased protection	Defined in *"Atlasul Zonelor Rurale Marginalizate Locale din România"* based on GIS layers

Note: GIS = geographical information system.

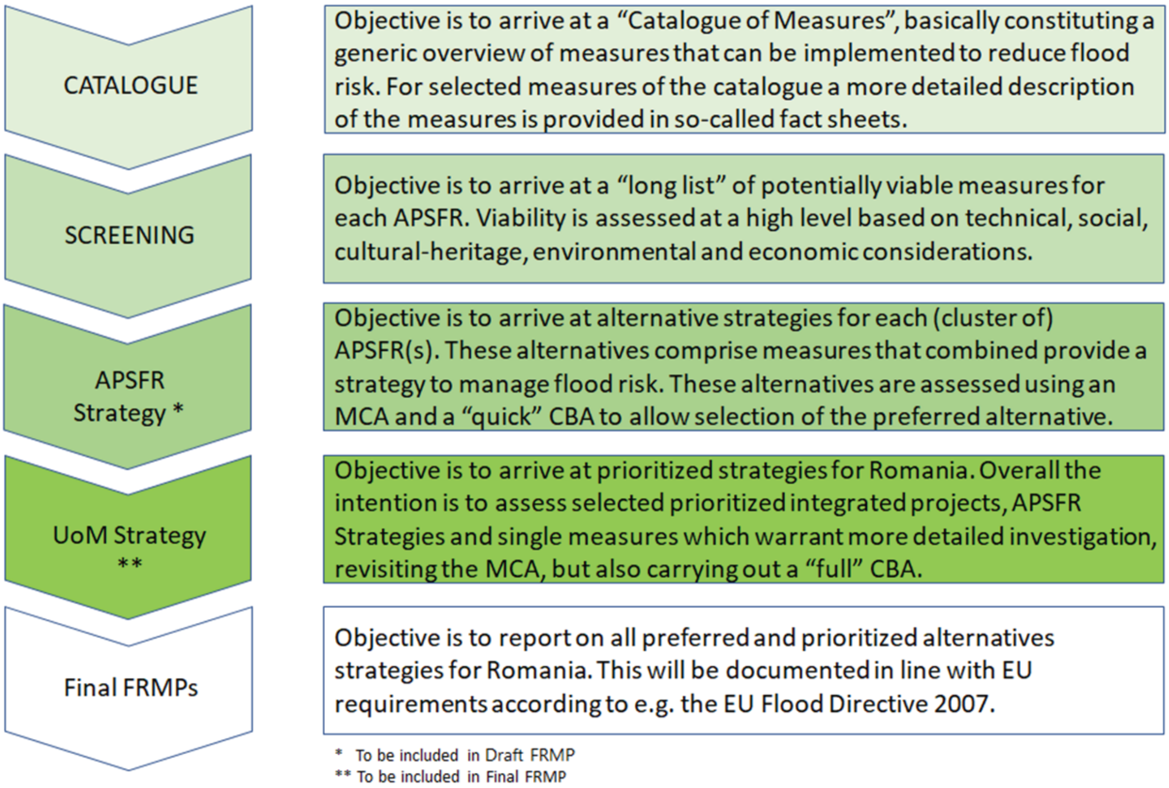
Table 8.1 Links between flood risk management objectives, MCA criteria, and indicators (example: social criteria)

With the above challenges in mind, a sound methodology was developed to identify, appraise, and prioritize risk mitigation measures for Romanian APSFRs in a systematic and consistent way. This methodology also ensured alignment with the requirements under other EU directives (e.g., water framework, habitats).

The main elements of the methodology are shown in figure 8.1. The catalog of measures used for the FRMPs was closely linked to the catalog used for RBMPs. During the first cycle, Romania faced an additional challenge: too many potential measures were thoroughly assessed at an early stage, leaving insufficient time and resources to better prioritize measures for subsequent implementation. To overcome this problem, the new methodology allowed screening out non-viable measures at an early stage in the process.

The process starts with qualitative assessments of readily available information. As a potential measure or combination of measures progresses through this phasing, the level of detail increased with more substantive and also more quantitative assessment and comparison of measures or combination of measures.

For each step shown in figure 8.1 (i.e., Screening, APSFR Strategy, and UoM Strategy), the Project developed tools that ensured systematic and uniform appraisal and prioritization. The screening phase started with the RBAs identifying a long list of potential flood risk reduction measures using the catalog of measures. These measures underwent an assessment using screening tables, which included questions that would allow "screening in" and "screening out" the measures for each APSFR. These questions covered economic, social, environmental, cultural, and feasibility considerations. The answers to these questions helped to assess the viability of the measures, in turn whether it would be worthwhile screening in a measure.



Note: UoM = Unit of Management.

Figure 8.1 Steps in the methodology for the PoM' development

Screened-in measures were subsequently promoted to the next phase, the APSFR Strategy phase, to be "packaged" in sets of measures as alternatives and appraised with a state-of-the-art Appraisal Summary Tool (AST). The AST consisted of an MCA and a CBA. This packaging of measures resulted in a logical and sensible mix of measures to constitute flood risk management alternatives for individual APSFRs. In certain cases, several APSFRs were clustered (i.e., combined) to develop more effective and more integrated alternatives to manage the associated flood risks.

Based on the MCA and CBA, for each APSFR or cluster of APSFRs, the risk mitigation alternatives were appraised, and a preferred alternative was identified. Based on the MCA's and CBA's results, and through discussions among experts from the RBAs and the National Administration "Romanian Waters" (ANAR) and other stakeholders, 30 high-priority projects were selected, assessed in more detail and further improved in the UoM Strategy phase. This meant that each UoM had two or three prioritized projects. In this final phase, the prioritized projects were further assessed using the models developed for FHRMs to arrive at hazard and risk maps for the "with measures" situations to compare with similar maps for the "without measures" situations. The detailed assessment, using the models, allowed the Project to revisit the MCA and confirm its rating and realize a more detailed CBA, now also including an assessment of ecosystem services. This way RO - FLOODS developed detailed information for each of the prioritized projects, facilitating the subsequent development of feasibility studies.

Implicit and explicit actions to promote NBS

Across Europe, there is a drive to promote more efficient and sustainable flood risk management strategies through including NBS. An important step to aid the inclusion of such measures was the development and use of a dedicated and subject-specific methodology, for identifying and assessing the many opportunities for increased natural flood retention and attenuation in floodplain areas and riparian zones. This was done along all rivers in Romania (see also chapter 9).

Further, various other steps implicitly promoting the inclusion of green measures were included within the overall PoM methodology. One example is the introduction of a hierarchy in the selection and packaging of measures. For the identification of measures for each APSFR, first the potential of green measures was investigated and only if these did not provide the expected level of protection, more traditional grey measures were considered. In the process of prioritization, the applied MCA included a comprehensive assessment of the alternatives' impacts on eight environmental criteria (e.g., biodiversity and fisheries). In the more detailed assessment of the 30 top-priority projects, ecosystem benefits of land-use changes were valued to provide fuller estimates of all benefits and enhanced benefit-cost ratios (BCRs). Additional activities included awareness raising, monitoring actual numbers of proposed green measures, and providing additional guidance and tools for integrating green measures.

Engagement of agencies and mobilization of local knowledge

The methodologies helped to ensure that the PoM was developed and appraised in a systematic and uniform manner across the country. Relevant Romanian agencies and institutes were involved in developing the methodology and tools, as well as in their application. Through this engagement, the Project was able to tap the valuable local knowledge.

Results

Ultimately all 526 Romanian APSFRs now have a preferred risk mitigation strategy documented in consistent factsheets as part of the PoM of each FRMP. The process also resulted in 30 prioritized projects, which were subjected to comprehensive modeling, yielding more insight into their reduced flood hazard and risk, and impacts.

The methodology and tools for screening and subsequently appraising and prioritizing measures have been well received by the ministries and agencies involved. This process has been significantly more effective, more uniform, and more systematic than it was during the first cycle. For all involved, there is now a clear link between the Romanian flood risk management objectives, the underlying indicators, the flood risk mitigation measures, and measurable outcomes in relation to those objectives.

Lessons learned

The following principal lessons were learned:

- **Screening.** Overall, more than 5,000 flood risk reduction measures were screened in for Romania. However, to use more than 20 questions to assess the measures' viability is quite demanding. At this stage of the process, for the third-cycle implementation, using a more limited number of key questions would likely be more than sufficient.
- **Low-risk APSFRs.** To focus on all 526 APSFRs is formidable. It soon became evident that not all APSFRs are equally important. It was decided to distinguish between medium- and high-risk APSFRs and low-risk APSFRs. This allowed a more basic treatment of about 150 low-risk APSFRs, substantially reducing the workload. For the next cycle, such differentiation is essential and will allow focusing on a more reasonable number of APSFRs.

- **The Appraisal Summary Tool.** The AST proved to be a powerful tool to document and appraise the impacts, costs, and benefits of alternative flood strategies. Especially in the UoM Strategy phase, its use in appraising the 30 prioritized projects yielded valuable insights. Whether such a detailed tool is needed to appraise alternatives of all APSFRs is questionable. A more pragmatic and simpler tool could be sufficient.
- **Risk information.** The development and appraisal of flood risk reduction measures had various interactions with other packages of work and sub-deliverables, including the development of the hazard and risk maps. Following a clear workplan ensured that the critical path was kept in mind at all times. Inputs from each stage were delivered on time for the appraisal and development of the PoMs. Also, considering the tight schedule of the Floods Directive implementation that allows only six years to complete all three stages (the PFRA, the preparation of the FHRM and the preparation of the FRMP) it is essential to have all hazard and risk maps available before starting the development of PoM.
- **Flood protection standards.** The Romanian National Strategy for Flood Risk Management specifies target standards of protection (SoPs) for various land-use categories. These standards must be met in the medium and long term. An example of such a SoP is that a dike must be able to protect urban area and contain a design flood that occurs on average once in 100 years (i.e., an annual exceedance probability of 1 percent). However, in some cases, achieving this target 1 percent SoP may not be realistic for all urban areas due to economic, technical, social, cultural, or environmental reasons. Also, often in the case of green measures, the 1 percent SoP cannot be met in its entirety. This potentially results in the rejection of what could otherwise be a promising measure. It should therefore be permissible to identify and appraise an alternative strategy that could only achieve partial protection (>1 percent SoP) — provided that the alternative does not preclude the future achievement of the 1 percent SoP in its entirety. Such partial SoP options were included only in a few cases in the RO - FLOODS results. However, for future cycles, it is recommended to further and more rigorously explore a more flexible use of SoP.

References

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- World Bank (2022): Reimbursable Advisory Services Agreement on Technical Support for the Preparation of Flood Risk Management Plans for Romania. Output No. 6 Report on advice provided to MEWF in the preparation of 12 draft Flood Risk Management Plans for public consultation. (**https://inundatii.ro/wp-content/uploads/2023/11/ROFloods-Output-6_EN.pdf**)

- World Bank (2023): Reimbursable Advisory Services Agreement on Technical Support for the Preparation of Flood Risk Management Plans for Romania. Output No. 7 Report on advice provided to MEWF in the preparation of 12 final draft Flood Risk Management Plans. (**https://inundatii.ro/wp-content/uploads/2023/11/ROFloods-Output-7_EN.pdf**)

CHAPTER 9

IMPROVING FLOOD RISK MANAGEMENT PLANS BY INTEGRATING GREEN MEASURES

9. IMPROVING FLOOD RISK MANAGEMENT PLANS BY INTEGRATING GREEN MEASURES[21]

Summary

Nature-based solutions (NBS) and their combination with traditional ways of flood protection based on grey infrastructure provide opportunities to reduce flood risks to an acceptable level while offering a variety of co-benefits ranging from reduction of CO2 emissions, nature conservation and rehabilitation of biodiversity, to enhanced local economic development for example through tourism. Romanian authorities start to recognize the potential of NBS for flood risk management and seeks to better integrate green approaches to improve their flood risk management strategies. Substantial efforts were made by the RO - FLOODS Project to support and further promote this paradigm shift from conventional flood risk protection with grey infrastructure to better balanced green and grey flood risk management strategies.

This chapter summarizes specific challenges faced in introducing green measures and shows how the RO - FLOODS Project addressed these challenges, supporting Romania in developing "greener" and more efficient Flood Risk Management Plans (FRMP).

Context

Given traditional flood protection strategies based on grey structural measures often adversely impact the environment and may exacerbate flood risk downstream, more integral and nature-based approaches are recommended. Experience and scientific evidence show that nature-based strategies can be efficient, offer multiple benefits, and can represent a more effective approach to climate change adaptation. Hence, the European Union's (EU's) requirements for flood risk management — embedded in the Floods Directive, or the Water Framework Directive and the Habitats Directive, the European Commission's (EC's) guidance for flood risk management, and recommendations by many multilateral organizations promote better balancing green and grey approaches.

According to the EC, NBS are solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions solutions[22].

Romania has already begun using NBS such as natural water retention measures and started to adopt initiatives, which combine "green" measures with "grey" infrastructure. A well-known example is the Lower Danube Green Corridor, which is the largest wetland protection and restoration program in Europe, that was initiated in 2000 by Romania, Bulgaria, Moldova, and Ukraine[23]. Despite this emblematic program and other successful pilot projects, NBS are still not widely used in Romania. The first cycle FRMPs entailed less than 4 percent new green interventions .

[21] Chapter prepared by Elena Daniela Ghiță, Maria Stoica and Iozefina Lipan. Contributions from Sebastian Döbbelt-Grüne, Jonathan Fisher, Erik Huijskes and Lucian Stan.

[22] https://op.europa.eu/en/publication-detail/-/publication/edab5ab8-94b7-11ee-b164-01aa75ed71a1/language-en/format-PDF/source-297979812

[23] https://www.icpdr.org/publications/ten-years-green-corridor

Challenges

When assessing Romania's flood risk management practices at the beginning of the RO - FLOODS Project, several challenges for the integration of NBS in flood risk management were identified:

- **Awareness.** Although there are numerous published research papers and guidelines on integrating NBS in flood risk management, there remains skepticism about such measures, and local authorities continue to be reluctant to adopt them in addressing flood risk. By contrast, traditional structural measures were the first choice.
- **Knowledge base.** There is a lack of specific guidance on identifying and appraising NBS adapted to the local Romanian context**.** Furter, designing and planning NBS is not yet integrated in university programs. The lack of technical expertise, along with gaps in understanding of the land-acquisition-related legislation for green initiatives, was identified as a further bottleneck for promoting NBS.
- **Interinstitutional coordination**. NBS implementation requires coordination among a variety of stakeholders from different sectors, including spatial planning, agriculture and fishery, nature protection and tourism, among others. So far, there is limited coordination between these groups on flood risk management.
- **Legislation.** The majority of the national flood risk management standards and legislation were adopted for traditional structural flood protection. Thus, the current framework tends to promote grey infrastructure over green and more integral approaches.

Approach

A strategy entailing multiple activities was adopted to overcome the above challenges and improve institutional capacity. It included the following components:

- **Workshops, technical meetings and exchange of experience** with authorities (EU/ national/ local) to create awareness and showcase good practices from other countries and Romania.
- **Elaboration of a legal study** to assess the legal aspects for land acquisition and compensating for flood water storage on private/public land.
- **Elaboration of a methodology for determining floodplains' potential for wetland restoration and dike relocation and developing maps** for individual river basin administrations (RBAs) that show viable floodplains for such green interventions (described in more detailed in chapter 10).
- **Improvement of the methodological framework** for developing programs of measures (PoMs) for flood risk management so that NBS can be identified and prioritized (described in more detailed in chapter 8).
- **Better integration of NBS measures in the catalogue of measures and development of fact sheets** to showcase the measures' benefits (figure 9.1).
- **NBS-related training sessions** with Romanian authorities to develop skills and enhance the knowledge for identifying and implementing such measures.
- **Continuous coordination in the development of river basin management plans (RBMP).**

In particular, changes to the methodology for identifying and prioritizing the PoM paved the way for greener FRMP. For the multicriteria analysis (MCA), 8 of the 23 indicators used for appraising measures are directly linked to environmental aspects (e.g., biodiversity, naturalized rivers [related to hydro-morphology], climate change vulnerability, and CO2 sequestration). This promoted the integration of green measures. The cost-benefit analysis (CBA) performed allowed a quantitative assessment of the benefits of green measures besides their contribution to achieving the flood risk management objectives.

WISE Reporting Measure Type Code M31
Romanian Measure Code M31- RO17

Domain: PROTECTION

Measure Type: Natural flood management / runoff and catchment management – River and floodplain management

Potential Measure: Re-meandering, Restoration of channel and floodplain features (incl. reforestation of riverbanks for mitigation of erosion phenomena)

Watercourse before and after re-meandering. Case study presented in
http://nwrm.eu/
http://riverwatch.eu/en/the-morava-anniversary-project-2014

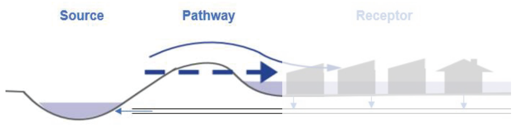
Outcome of the measure

Making a river more sinuous can reduce flood peaks, water velocities and attenuate flow by slowing and storing flood water. The extent of this flood risk effect depends on the length of river restored relative to the overall size of the river catchment

Description of the measure

- River restoration reintroduces meanders to rivers and restores physical process.
- The measure could involve reforestation of riverbanks for mitigation of erosion phenomena

Elements of exposure model that measure can manage



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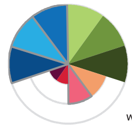
Opportunities for multiple-benefits from measure



Bigger segment denotes greater potential for benefits from the measure

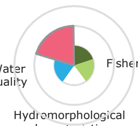
Potential effects on WFD status

(P) Potentially positive
(X) Potentially negative*

Quality elements potentially affected:
Biology: **Aquatic Flora*, Benthic Invertebrates*, Fish***
Hydromorphology: **Flow**, Groundwater Connectivity, **Continuity, Sediments, Depth, Width, Substrate, Riparian Zone**
Physico-chemical/chemical: Temperature, Oxygen, Salinity, Acidification, **Nutrients, Polluting Substances**
*A negative impact may occur if the measure adversely effects another area within the waterbody.

Examples of typical mitigation measures:
Riparian habitat enhancement e.g. Develop bankside buffer strips
Habitat improvement e.g. introduce gravels for fish
Likelihood that residual effect will still trigger an Article 4.7 assessment *: Unlikely

Potential negative impacts of measure on selected aspects



Bigger segment denotes greater potential scale of impacts from a typical measure.

*Equivalent to CIS 36 Applicability Assessment; decision on whether 4.7 tests are met will always be site specific.

WISE Reporting Measure Type Code M31
Romanian Measure Code M31- RO17

Domain: PROTECTION

Measure Type: Natural flood management / runoff and catchment management – River and floodplain management

Potential Measure: Re-meandering, Restoration of channel and floodplain features (incl. reforestation of riverbanks for mitigation of erosion phenomena)

Scale of measure and benefits

	Small (very local less than 1km)	**Medium**	**Large** (catchment wide hundreds of sq. km)
Size of measure	■	■	

	Small (flood cell or smaller)	**Medium** (5 km – 15km)	**Large** (APSFR / catchment)
Spatial scale of benefits delivered by measure	■	■	

	Partial (some flood cells or to lower design standard)	(Not to full standard of protection or full spatial protection)	**Full** (protection of the entire APSFR to design standard)
Potential reduction in flood risk	■		

	Short (construction completed)	**Medium** (1 to 3 years)	**Long** (10 or more years)
Time horizon for benefit to be realised	■	■	■

Complementary Measures

The measure can be included with other measures to protect flood risk to maximise the potential for multi-functional benefits. For example, re-meandering of a watercourse could be carried out in conjunction with the setting back of flood defence levees and dikes.

Potential funding sources

EU level
- Biodiversity strategy
- EU Cohesion Fund
- European Agricultural Fund for Rural Development (EAFRD)
- EU Common Agricultural Policy (CAP)
- European Regional Development Fund (ERDF)
- EU Solidarity Fund (EUSF)
- LIFE Fund
- InvestEU
- Horizon 2020
- European Investment Bank (EIB)

National level
- Ministry of Agriculture and Rural Development – Romania (MARD)
- Ministry of Environment, Waters and Forests – Romania (MEWF)
- Non-governmental organisations (NGOs)
- National Administration Romanian Water (NARW)

Responsible Authorities

- **M.E.W.F.** - Approves, ensures the financing and monitors the implementation of projects.
- **N.A.R.W.** - Implements and monitors on the field, development of projects according to the technical specifications.
- **M.A.R.D.** - Identifies together with NARW the lands required for the implementation of the projects and offer the agreement to use.
- **Local Authorities and City Councils** - Provide the necessary funds for promoting their own local flood protection options;

Note: APSFR = areas of potential significant flood risk; sq. km = square kilometer; WFD = Water Framework Directive; WISE = Water Information System for Europe.

Figure 9.1 An example of a fact sheet for green infrastructure

Further, prioritized measures were subject to a "robustness test" against the Habitats Directive to determine whether the strategies are likely to impact the favorable conservation status of Natura 2000 sites (both Sites of Community Importance and Special Protection Areas) and to identify opportunities to make their status favorable or restore or improve it. For areas of potential significant flood risk (APSFRs) coinciding with heavily modified waterbodies (defined under the Water Framework Directive), special attention was given to all possible opportunities to work with natural processes to tackle flood issues.

Results

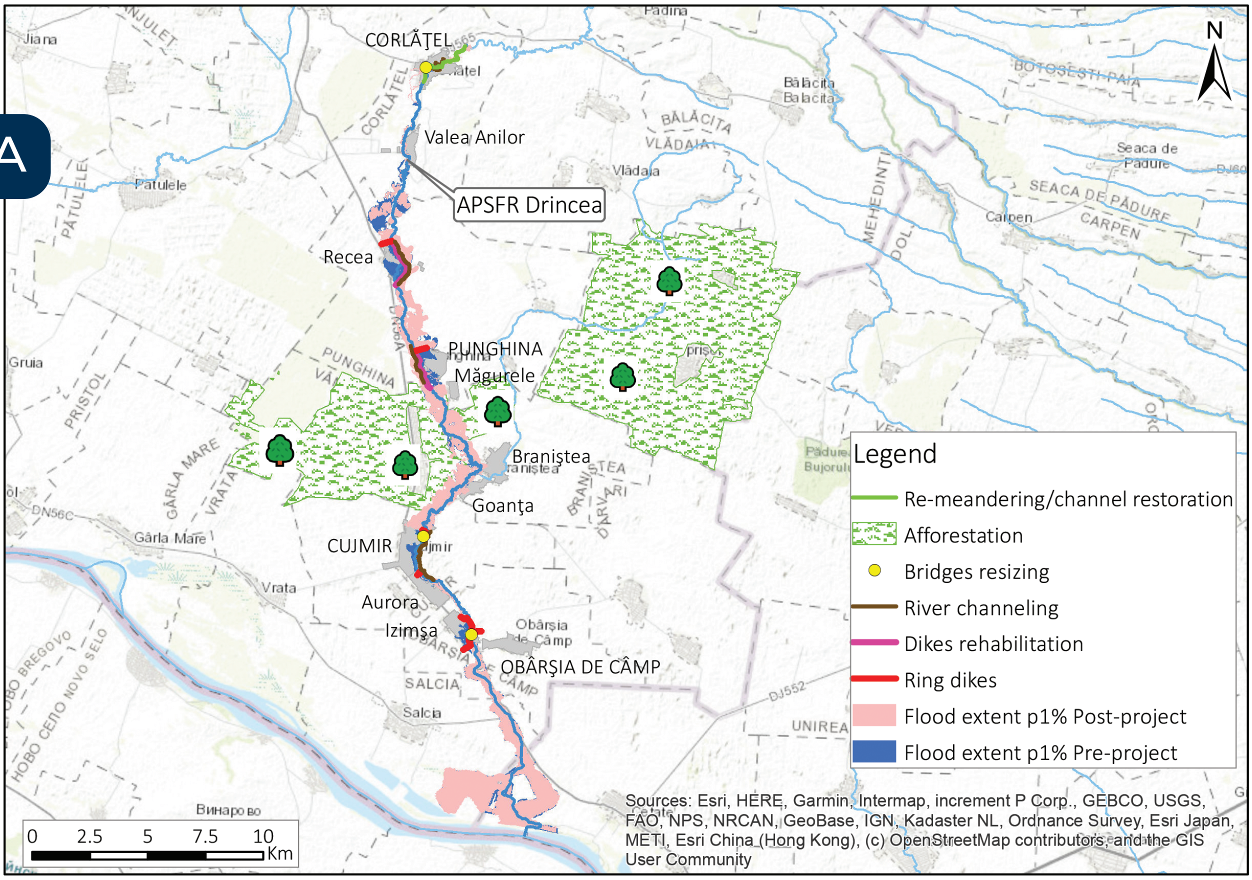
The interventions over the past three years to enhance institutional capacity in Romania to embrace greener technical solutions for addressing flood risk and raise awareness on their benefits for the society produced the following results:

- **Enhanced knowledge and increased awareness of greener technical solutions, including a specific guideline for and a large number of experts trained** in the identification, appraisal, prioritization, and promotion of NBS in flood risk management strategies.
- **Maps that indicate areas with potential for floodplain restoration and dike relocation** for implementing NBS for all RBAs and can be further used when planning interventions to address flood risk.
- **New FRMPs with many green and grey-green measures to strengthen flood prevention and protection**. This includes measures along rivers and within flood plains, as well interventions upstream in the watershed, such as forestations.

Following are some strategies of the new FRMPs that include green measures:

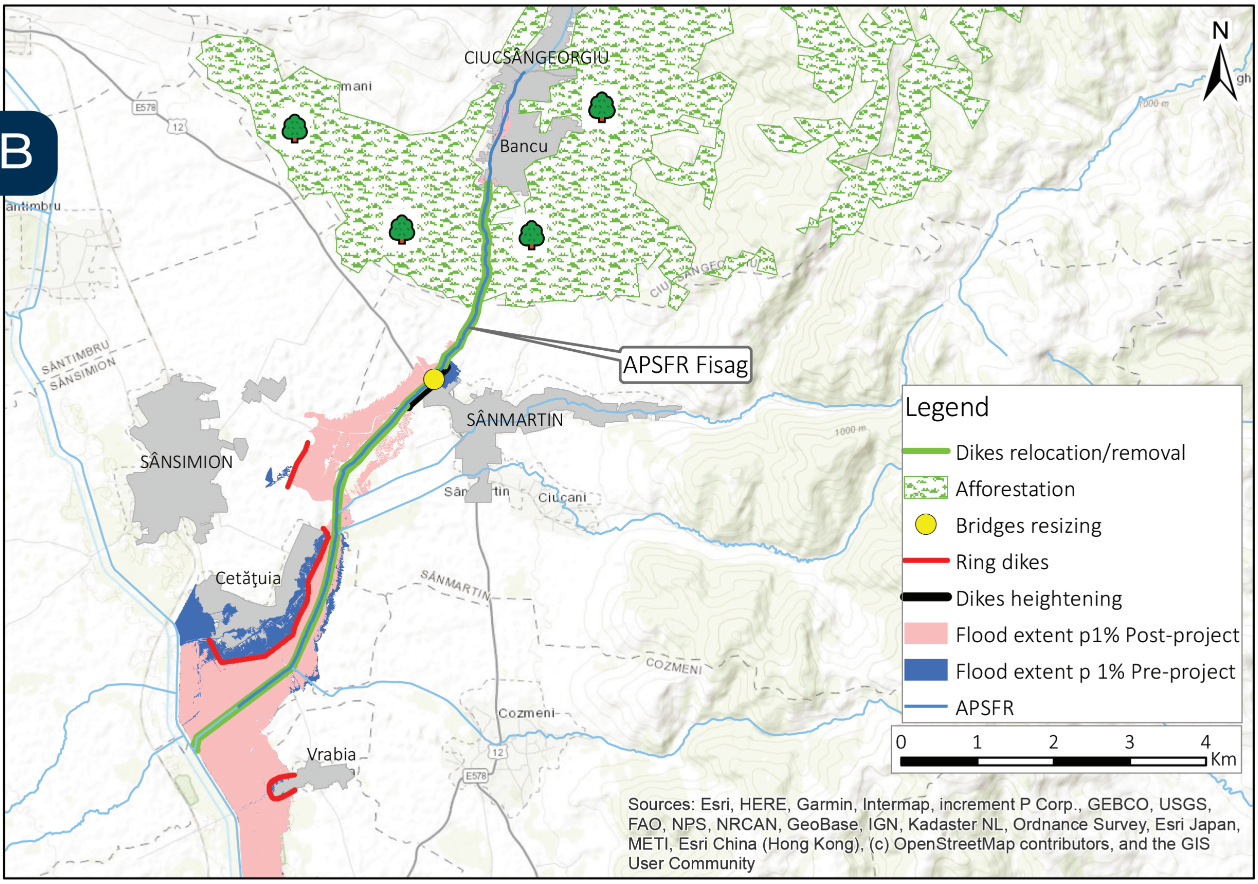
- The strategy proposed for the Drincea river (figure 9.2a) in the Jiu RBA includes measures to restore the riverbanks through the creation of vegetative protection, measures to enhance the bridges' flow transit capacity, local regularization works for the riverbed (including measures to stabilize the riverbed), rehabilitation and extension of dikes to enclose the infrastructure that protects the localities and increase of forestry areas in the river basin. Besides enhanced protection of localities against floods, the riverbanks' restoration will stop their erosion.
- The strategy proposed for the Fișag river (figure 9.2b) in the Olt RBA includes the removal of the existing longitudinal dikes, which narrow the Fișag river, and the creation of ring dikes to protect the localities in the confluence area with its collector, the Olt river; the heightening and rehabilitation of dikes in Sanmartin locality; the consolidation of upstream torrential valleys to control sediment transport; the maintenance or increase of forestry areas in the upstream part of the river basin; and the enhancement of the bridges' flow transit capacity. This project will result in flood risk mitigation, more space for the river, and better control of sediment transport.
- The strategy proposed for the Luncavița river (figure 9.2c) in the Dobrogea-Litoral RBA focuses on nature restauration. It includes the removal of the Luncavita dam and the creation of new natural retention areas on both riverbanks' floodplains.

A



CORLĂŢEL
Valea Anilor
APSFR Drincea
Recea
PUNGHINA
Măgurele
Braniştea
Goanţa
CUJMIR
Aurora
Izimşa
OBÂRŞIA DE CÂMP
Salcia
Legend
Re-meandering/channel restoration
Afforestation
Bridges resizing
River channeling
Dikes rehabilitation
Ring dikes
Flood extent p1% Post-project
Flood extent p1% Pre-project
0 2.5 5 7.5 10 Km
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

B



CIUCSÂNGEORGIU
Bancu
APSFR Fisag
SÂNMARTIN
SÂNSIMION
Cetăţuia
Cozmeni
Vrabia
Legend
Dikes relocation/removal
Afforestation
Bridges resizing
Ring dikes
Dikes heightening
Flood extent p1% Post-project
Flood extent p 1% Pre-project
APSFR
0 1 2 3 4 Km
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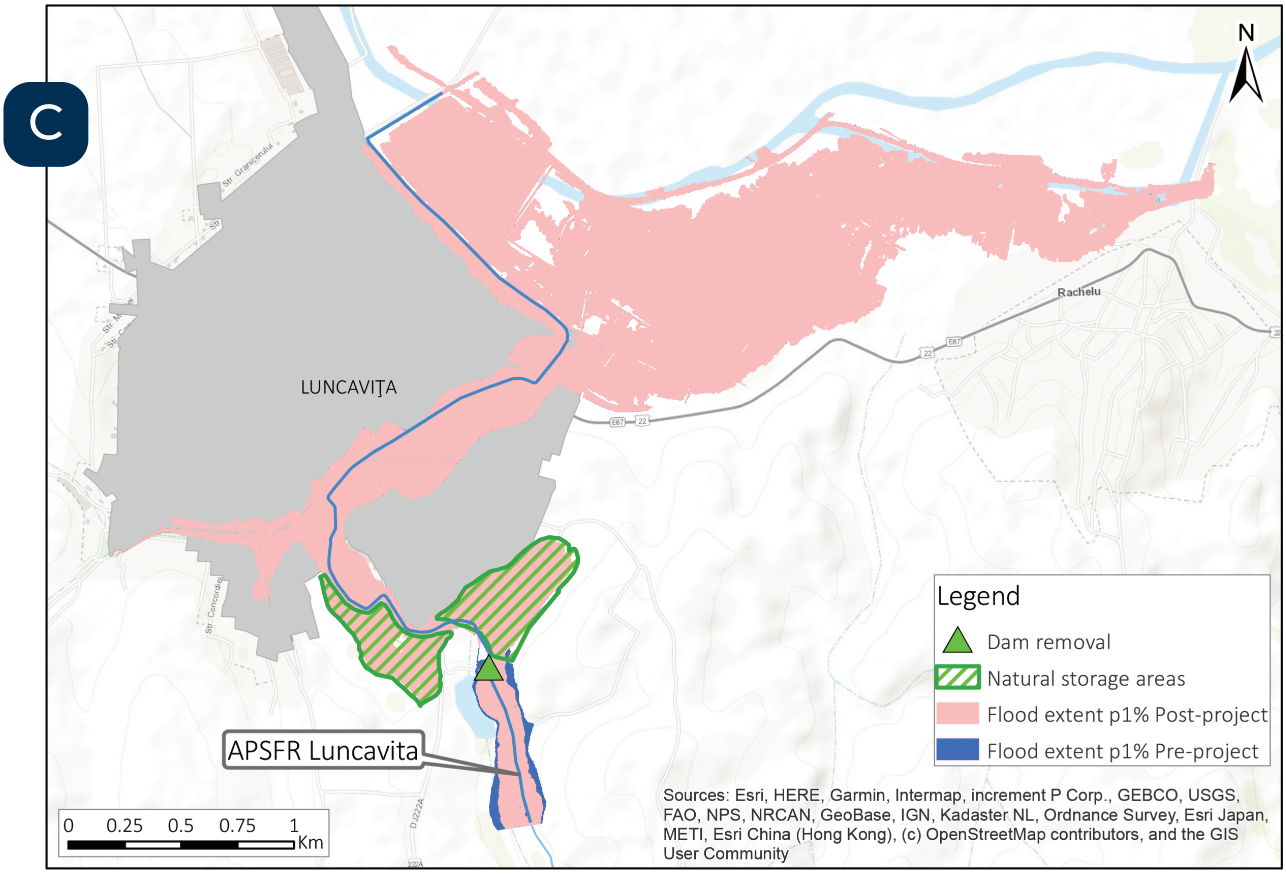
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Note: APSFR = area of potential significant flood risk; km = kilometer; m = meter; Q1% = flow hydrograph for annual exceedance probability of 1%

Figure 9.2 Three strategies to address flood risk of (a) the Drincea river, (b) the Fișag river and (c) the Luncavița river.

Lessons learned

Romania has made encouraging progress toward greener flood risk management, although efforts should continue, especially during the FRMP's implementation. The successful dialogue and collaboration established between relevant stakeholders will significantly impact the valuation of natural processes' potential for addressing the challenges under a changing environment.

The experience in the second cycle of the Floods Directive implementation in Romania produced lessons learned that are worth sharing and to be considered:

- **Efforts to raise awareness should continue** perhaps under the framework of national campaigns, with a particular emphasis on engaging local stakeholders. There are numerous opportunities to include such measures in development planning, and the benefits for communities are multiple in the long term.
- **More work should be done to build alliances with relevant stakeholders** at the local level, including environmental nongovernmental organizations (NGOs), to promote and implement NBS. Better coordination with the highly relevant agriculture sector is needed.
- **Systematic review of the legal framework** is needed to identify remaining obstacles and make adjustments were needed.
- **More tools could be developed to substantiate NBS selection** for addressing flood risk, **and existing tools could be improved** based on in-depth research of all environmental impacts.

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  (**https://inundatii.ro/wp-content/uploads/2023/11/ROFloods-Output-6_EN.pdf**)
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  (**https://openknowledge.worldbank.org/entities/publication/ddda3ed0-096e-59dd-a25d-3de884254eba**)

CHAPTER 10

FLOODPLAIN AND CATCHMENT ANALYSIS TO IDENTIFY GREEN MEASURES

10. FLOODPLAIN AND CATCHMENT ANALYSIS TO IDENTIFY GREEN MEASURES[24]

Summary

This study under the RO - FLOODS Project was undertaken to develop and implement a methodology to identify and assess potential floodplain areas and riparian zones, to enhance natural flood retention and attenuation along Romania's rivers. The study was designed to provide supporting information to facilitate the identification and appraisal of nature-based solutions (NBS) within the development of the program of measures (PoM).

The study's key outputs were a basic floodplain typology for large rivers and a method for classifying flood risk reduction potential for large and small rivers. These outputs have been provided nationally and with greater granularity for individual river basin administrations (RBAs). This information was a key input for the development of PoMs and resulted in "greener" and a more integrated flood risk management plan (FRMP).

The challenge

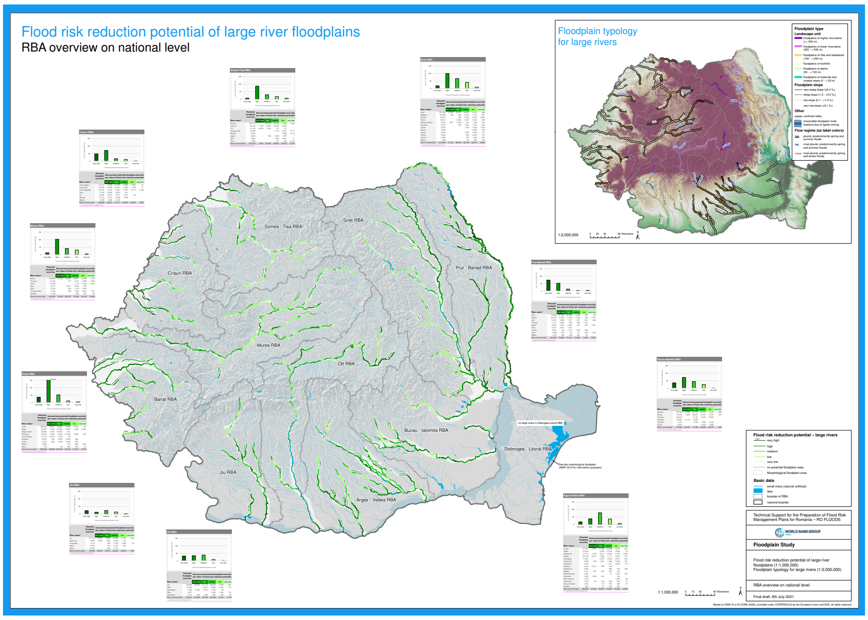
In the first cycle of the Floods Directive implementation, green measures where either not addressed or only rarely considered within the PoM's development. Key challenges were the limited awareness about the use of NBS and the lack of knowledge how to identify green flood risk management measures and appraise their potential. Fundamental data, including on active and potential floodplains, were not yet available and had to be generated to locate search areas for potential implementation of green measures.

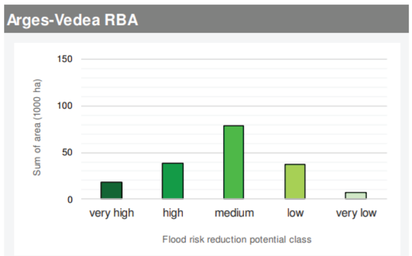
Implementation

A floodplain study was conducted at national level for all Romanian rivers early during the FRMP's preparation (figure 10.1). Large rivers were initially separated from small rivers[25], to facilitate their analysis based on different approaches.

For both small and large river datasets, the Project developed a step-by-step approach, using data readily available on a national scale that enabled both consistency and flexibility, ensuring high quality results across the country. Among the data sets used were the river network, the flood hazard maps from the first cycle, the mapping of riparian zones from the Copernicus Land Monitoring Service[26], existing geomorphological and soil maps of Romania and a 10m digital elevation model provided by Copernicus. After a pilot application and evaluation within one catchment, all steps have been applied on the national level.

[24] Chapter prepared by Sebastian Döbbelt-Grüne, Uwe Koenzen and Erik Huijskes.
[25] Large river = catchment area > 1,000 km² and an area of potential significant flood risk (APSFR) with significant floodplain areas
[26] **https://data.europa.eu/data/datasets/dat-191-en?locale=en**





River name*	Potential floodplain area (ha)	Summarised potential floodplain area (ha) per class of flood risk reduction potential				
		very high	high	medium	low	very low
Arges	57,737	4,979	17,338	24,599	9,970	851
Sabar	27,843		4,228	19,726	3,866	23
Dambovita	27,419	1,208	3,614	14,846	4,248	3,504
Vedea	26,135	6,871	7,252	7,117	4,018	877
Ciorogarla	11,907		2,875	5,584	2,913	535
Teleorman	7,690	795	1,051	1,945	3,599	301
Cotmeana	4,343			1,512	2,656	174
Calmatui	3,481	2,574	658	248		
Dambovnic	2,550			1,306	979	265
Neajlov	2,147	697	633	504	313	
Raul Doamnei	1,981			37	1,670	275
Calnistea	1,899	1,299	432		168	
Raul Targului	1,674				1,586	88
Glavacioc	1,576	63	275	669	528	41
Paraul Cainelui	1,076		67	573	389	47
Burdea	897		91	324	482	
Sum of area (ha)	**180,356**	**18,486**	**38,514**	**78,989**	**37,385**	**6,981**

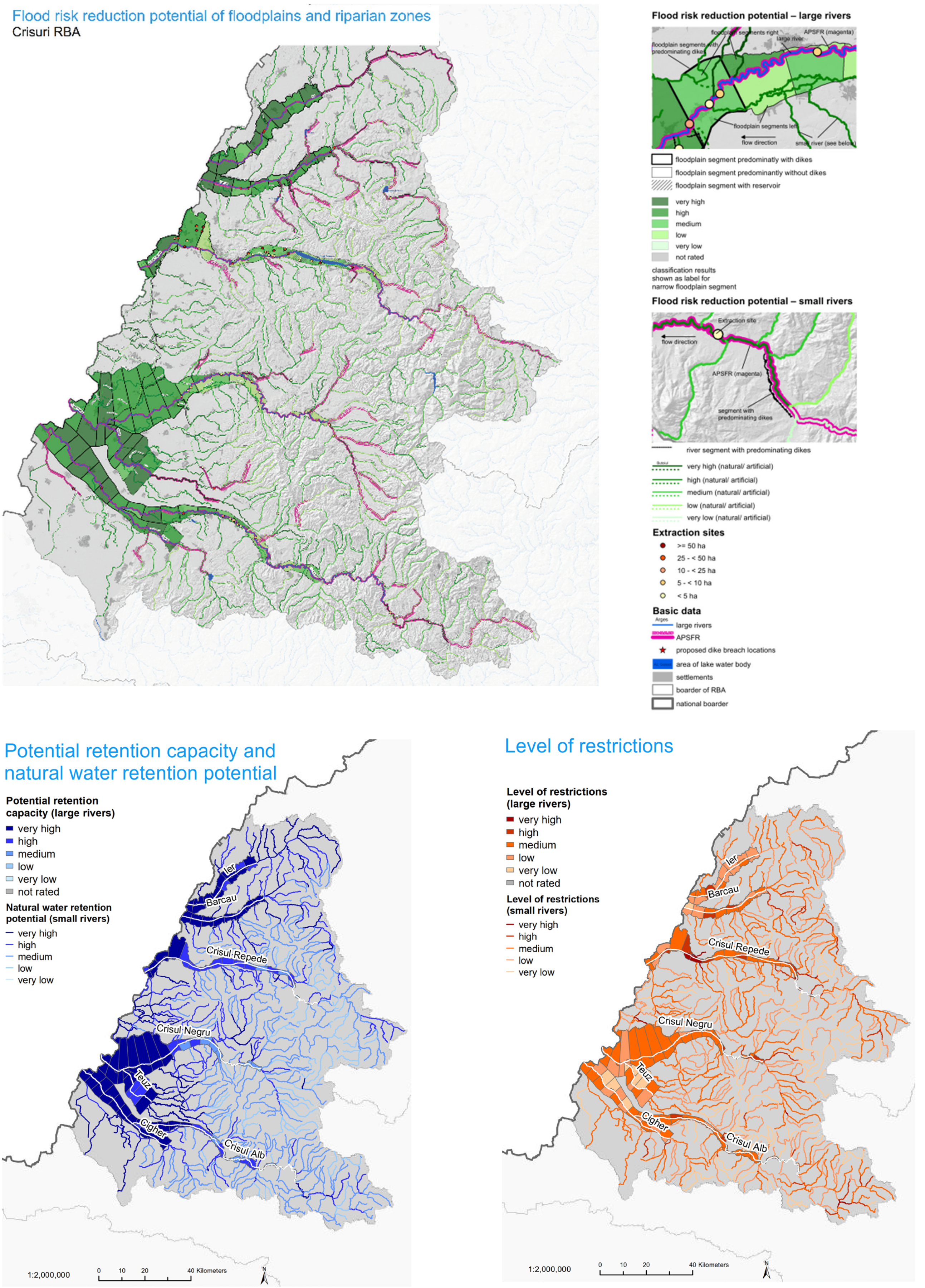
* sorted by potential floodplain area

Figure 10.1 Flood risk reduction potential and typology of large river floodplains at the national level

Within a first step of the methodology, actual and potential floodplain areas have been identified for large rivers. Key characteristics of a floodplain typology were implemented to classify these floodplains. In parallel, potential riparian areas were identified for small rivers using a buffer approach. After this, for both, small and large rivers, a classification method of flood risk reduction potential was developed (figure 10.2), to generate comparable assessment results across different river sizes.

Overall Classification						
		B) Level of restrictions				
		very high	high	medium	low	very low
A) Potential retention capacity	very high	2	3	4	5	5
	high	2	2	3	4	5
	medium	1	2	2	3	4
	low	1	1	2	2	3
	very low	1	1	1	2	2

Figure 10.2 Classification of flood risk reduction potential



Note: ha = hectare

Figure 10.3 Flood risk reduction potential and underlying assessments of large river floodplains and riparian zones of small rivers within the Crisuri RBA

All steps were executed effectively and efficiently under a detailed desktop analysis conducted at different spatial scales.

- Height categories from a digital surface model.
- Landscape units.
- Relief maps.
- Flow regime (discharge curves of gauging stations).
- Floodplain slope.

For both large and small rivers, flood risk reduction potential was assessed based on carefully selected criteria considering not only the potential but also restrictions within floodplain areas and riparian zones. These classification criteria were selected based on the analysis of the readily available data set. Examples are:

- Actual, potential, and morphological floodplain areas and their interrelationship in terms of size.
- The share of medium flood probability (1% annual exceedance probability).
- Floodplain slope.
- Land-use potential.
- Share of small woody features.
- Share of irrigation and drainage facilities.
- Area of extraction sites.
- Land-use restrictions.
- Share of protected areas.
- Density of linear infrastructure.
- Share of settlements.

Results

Overall, an enormous length of over 80,000 km of rivers, including more than 9,000 km of large rivers, was analyzed and assessed under the study.

For all rivers, including small and large rivers, flood risk reduction potential was determined based on a five-category classification, which ranged from “very low” to “very high.” For this classification, the potential retention capacity for large rivers and natural water retention potential (for small rivers) have been combined with the level of restrictions in each unit of assessment.

Key products developed include:

- An overview map nationally, which illustrates the flood risk reduction potential of large river floodplains, and a summary of the classification results for individual RBAs (figure 10.1).
- Detailed maps for individual RBAs, which show the flood risk reduction potential and the results of its classification, as well as limitations for all large and small rivers (figure 10.3).

Lessons learned

Through the combination of common and readily available data sets, in many cases based on remote sensing, the RO - FLOODS Project developed valuable maps for identifying and showing the high potential of green measures for the reduction of flood risks at a national scale and at the national and river basin level. Main lessons learned in this respect are:

- The analysis of commonly available data sets, based on remote sensing, such as digital elevation models and land use maps allow to realize highly specific assessments on the potential of NBS on a large scale in relatively short time.
- Maps and the visualization of potential areas of green measures are a powerful tool for raising awareness for NBS in flood risk management, in particular when flood hazard and flood risk maps are a key instrument for the planning of measures.

Consideration of additional data can allow a more detailed identification of viable areas for implementing specific green measures. Information on land-use planning, public-owned land, agricultural soil productivity, contaminated sites, etc. should be considered to locate green measures and define the potential scale of specific measures such as reconnection of floodplain features and floodplain restoration.

Further training in the developments and use of specific data products and maps is needed for ANAR and the RBAs. Practical training should be provided to further improve the knowledge base and create capacities for mapping benefits and possible restrictions for the use of NBS at the level of APSFRs.

For the third cycle of the EU Floods Directive implementation, activities related to floodplain and catchment potential and green flood risk management measures should be planned and prepared by ANAR considering all the above aspects to further support the shift towards greener and better FRMP. This goes hand in hand with aligning FRMP development better with the fourth cycle of the implementation of the EU Water Framework Directive. In this way, Romania can comprehensively capitalize on the second cycle as described in this and other chapters of this volume.

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CHAPTER 11

DEVELOPMENT AND PRIORITIZATION OF MEASURES – FLOOD PREPAREDNESS AND RESPONSE

11. DEVELOPMENT AND PRIORITIZATION OF MEASURES – FLOOD PREPAREDNESS AND RESPONSE

Summary

One of the central strategies to reduce flood risk in Romania is to enhance Romania's preparedness capacities and capabilities. This chapter describes measures related to flood forecasting, early warning, response, rescue, relief, and recovery. The chapter analyzes the gaps and needs surrounding flood preparedness and response in Romania and how to translate this into an improved Preparedness Package. Specific attention is paid to three distinct elements, each of which have individually contributed toward the proposed package. These elements are (i) the framework of the analysis, (ii) the specific geographic information system (GIS) analyses, and (iii) the Project's approach to justify the package. Regarding the last element, several approaches were defined simultaneously to support thorough decision-making and elaborate the final and preferred version of the package. Implementing this package will result in a step change of Romania's preparedness and response capacities and capabilities, making its population more resilient and ensuring greater safety during future flood events.

Key challenges and tasks

Prevention and protection measures at the level of individual areas of potential significant flood risk (APSFRs) will contribute to substantially reduced flood risks. APSFRs — but also locations not identified as APSFRs — will nevertheless face a residual risk. To manage and reduce this residual risk, Romania intends to enhance its flood preparedness, including through building awareness surrounding floods, strengthening flood forecasting capacities, and strengthening civil protection to respond during flood events. During the first cycle of the EU Floods Directive implementation, Romania invested in various preparedness infrastructure. This included setting up a more elaborate monitoring network for improving flood early warnings as well as enhancing rapid response and recovery capacities throughout the country. Under the RO - FLOODS Project, the intention has been to build on these steps, to eventually propose an integrated package of emergency preparedness measures, which can further enhance Romania's flood risk management capacities and capabilities.

Understanding the institutional setting

Flood forecasting and early warning, emergency response, and support in post flood recovery involve a variety of institutional stakeholders besides the National Administration "Romanian Waters" (ANAR) and its river basin administrations (RBAs). These include the General Inspectorate for Emergency Situations (IGSU) and its local entities under the Ministry of the Interior, as well as the National Meteorological Administration (ANM) and the National Institute of Hydrology and Water Management (INHGA) under the Ministry of Environment, Water and Forests (MEWF). Further, local authorities and county councils play an important role in preparing for and recovering from flood events.

The numerous institutions involved in activities related to flood preparedness all have specific roles. Additional responsibilities may arise, as a flood event itself evolves, potentially escalating into a (significant) major flood and hence a humanitarian crisis.

[27] Chapter prepared by Eric Huijskes, Mary-Jeanne Adler, Edmund Penning-Rowsell, and Jeronimo Puertas Agudo. Contributions from Jonathan Fischer, Juan Fernándes Sanz and Amparo Samper Hiraldo.

To define the need for being better prepared and responding to flood events the specific responsibilities of each stakeholder needed to be fully understood and described. To arrive at a package of measures to improve flood preparedness, these organizations and the professionals fulfilling these roles needed to be successfully engaged in the development of the package itself.

Translating gaps and needs into a package.

Romania is a flood-prone country and has valuable knowledge and experience to leverage for preparation and response to flood events. There is an adequate legal and institutional framework in place. Relevant information, the needed facilities and equipment, as well as skilled personnel is often available. Leveraging this expertise in responding to floods and reviewing practices from other parts of the world, the RO - FLOODS Project identified possible measures for the integrated preparedness package to close the identified gap between the current situation and Romania's aspirations for enhanced preparedness.

Prioritization and economic justification

Because of the multitude of public institutions involved in emergency response, the diversity of the possible measures, and the variety of events and their locations, it is not easy to appraise and prioritize preparedness measures. While the costs of such measures can generally be assessed quite easily, their benefits in flood risk mitigation are far more difficult to assess and quantify. This is in view of the complex dynamics and conditionality to make the required measures function as needed; together, at the right time, and at the right place. In other words, traditional multicriteria analysis (MCA) and cost-benefit analysis (CBA) used for justifying structural flood risk reduction schemes are likely to not be sufficient or wholly appropriate for justifying a preparedness package. Therefore, a different approach had to be developed.

Key elements of the adopted approach

The overall approach

A crucial starting point for arriving at the improved Preparedness Package is to understand Romania's current flood risk and the envisaged measures to reduce flood risks. To address flood risk and arrive at flood risk management plans (FRMPs) for all RBAs and the Danube River, Romania has defined a clear set of nine flood risk management objectives. Objective 6, given below, focuses on the Preparedness Package:

"Enhance the level of awareness and resilience concerning flood risks, as well as increase the capacity for early warning, alarm and intervention, and response in case of emergency."

Several indicators underlie Objective 6. They have been identified to help define possible measures and assess their potential impact (table 11.1). Each indicator has been assessed for the baseline scenario: the current situation.

The main indicators underlying FMR Objective 6 are:

A. Reduction of damage due to the Preparedness Package

B. Reduction of fatalities due to the Preparedness Package

Sub-indicators:

C. Availability of improved forecasting and warning products (lead time, deterministic versus probabilistic)

D. Number (in percentage of total) of rapid intervention centers (CIR) and/or Crisis fast intervention centers (FIC) within 20 minutes reaction time for localities and 90 minutes intervention time for flood protection damaged infrastructure of APSFRs

E. % of people in the high risk APSFRs receiving flood warnings through different channel (RO-Alert, direct warning, sirens alarming)

F. % of people acting upon the flood warnings

G. % of people that receive awarness campaigns (mainly by involving them in annual exercises)

Note: FRM = flood risk management.

Table 11.1 Indicators for the Preparedness Package

To arrive at a final Preparedness Package, an approach with three distinct tracks was defined. The framework provided the basis for appraising and selecting measures:

1. Stakeholder-driven track: Involvement of relevant organizations in identifying gaps and needs via different approaches, workshops, meetings, and desk-based research.

2. Analysis-driven track: Various fact-finding approaches aimed at quantifying challenges and assessing needs. This also included the use of questionnaires, GIS analyses, and benchmarking with comparable international experiences.

3. Justification track: Building on the flood risk management objective-setting process to arrive at well-founded approaches, which, in combination, provide sound justification for Romania investing in the final proposed package

Importantly, the package was developed in an iterative manner. Each iteration included new information resulting from other activities of the Project to substantiate choices. Also, justification followed an iterative approach, which was tuned to the evolving package of items. This ensured the buy-in of the ultimate beneficiaries and potential funding agencies. The overall approach is shown in figure 11.1, and key aspects are further explained below.

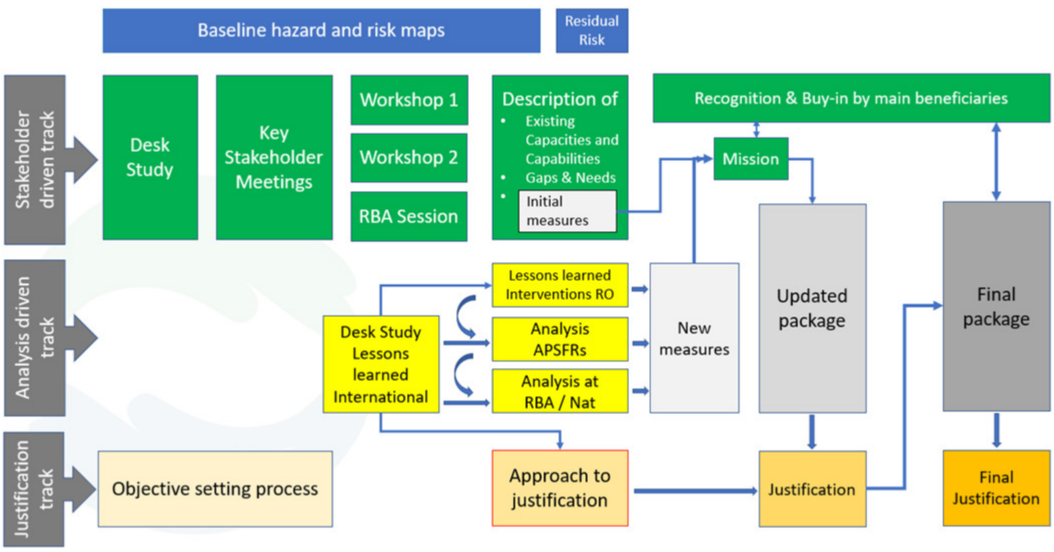

Figure 11.1 Process to develop and justify the Preparedness Package

Stakeholder-driven track with the R2R framework

The stakeholder-driven track included numerous interactions with key beneficiaries of the package. These interactions aimed at defining gaps and needs. In this process, all parties had to discuss relevant matters systematically and in a manner that could be understood, since that would ensure all bases were covered. To this end, the Ready-To-Respond (R2R) framework was used (see figure 11.2 source: GFDRR and GSURR 2017). Its application in the meetings and workshops yielded an initial package of over 100 possible measures, which resulted from the first iteration, and provided a sound basis to later optimize, refine, and prioritize the measures.

Figure 11.2 Core components of the emergency preparedness and response system according to the R2R framework

Source: GFUDRR and GSURR 2017

Analysis-Driven Track — Use of GIS

The analysis-driven track involved the use of various techniques, including GIS to analyze issues (i.e., flood risk) in relation to measures of the Preparedness Package.

A key question here concerned whether the current intervention centers of the IGSU or RBAs can intervene with operatives and equipment at flooded sites in due time, as per the mandates according to the law. In this case, all APSFRs were mapped, three points were identified for each (their middle and outer limits), and the driving time on the available roads to the nearest intervention center was assessed.

The maps revealed quite a lot of information. They showed that indeed (as expected from the gap analysis), ANAR does not need additional intervention centers of its type (i.e., centers with mobile barriers, earth moving equipment, pumps, etc.). However, IGSU needs more intervention centers of its type (i.e., general response centers, equipped for multi-hazard interventions) (see figure 11.3).

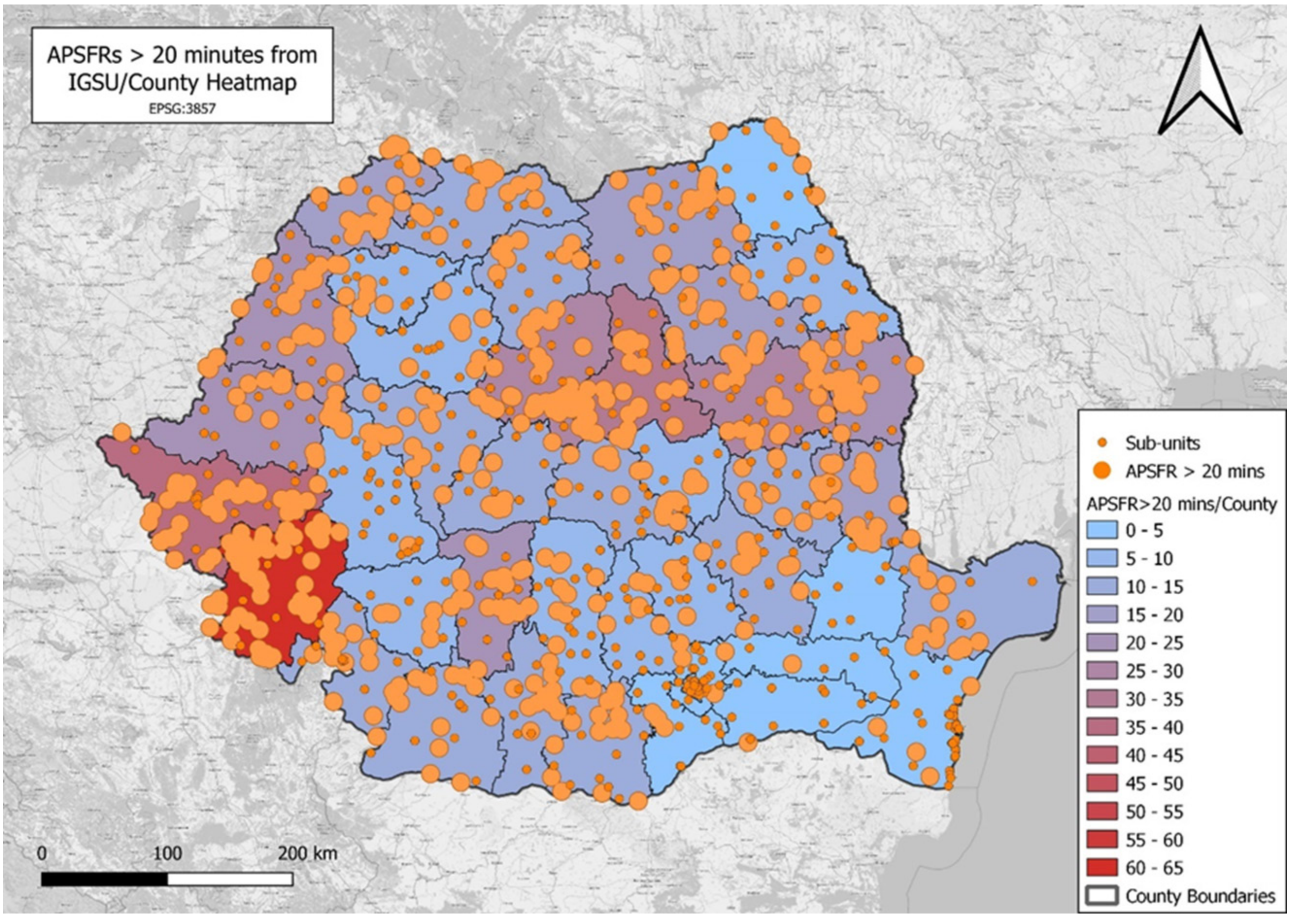

Figure 11.3 All locations and the number of APSFR locations not fulfilling the 20-minute criterion for IGSU subunits.

Also, the relative risk that each center needs to manage was mapped (see figure 11.4). This helped assess where needs are likely to be higher. The large orange dots in figure 11.3 represent all locations that do not comply with the IGSU's 20-minute travel time requirement. The number of relevant locations is represented by shading for different counties. Light blue represents a lower challenge and dark red represents significant challenge. In figure 11.4, the average risk for individual RBAs is shown for each center. Again, blue represents a lower challenge and red represents a substantial challenge.

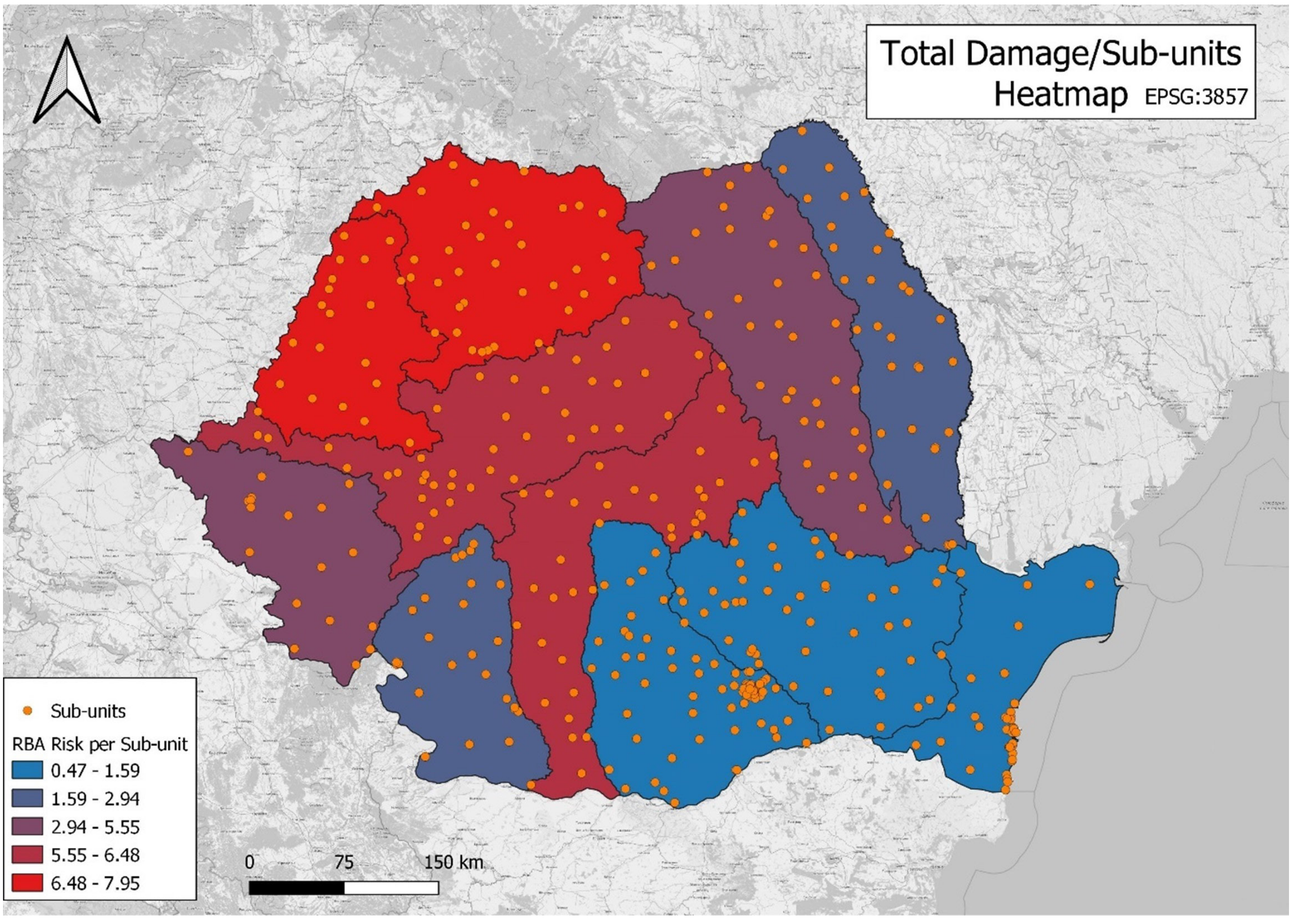

Figure 11.4 Relative risk (Annual Expected Damages (AEDs)) per IGSU subunit for individual RBAs

All these analyses helped to justify and prioritize the Preparedness Package.

The justification track and its outcomes

A sound approach to justification was needed to help secure approval and funding of the Package. The complexity of the process as well as the characteristics of the package meant that it needed to be carried out at three levels: the overall package, sub-components of the package, and at a measures level.

Four approaches were defined (briefly described in table 11.2). Performing all four approaches revealed that all 28 proposed measures of the final package were justified by at least two approaches (I and III), and some were even justified with three or all four approaches.

Approach	Type	Level	How relevant investment was justified
I	Qualitative	Individual measures	Each item was justified by clear qualitative statements. The intensive process to arrive at the proposed 28 measures—starting with a long list of more than 90 measures, which have been refined and optimized—also further instils confidence. Weak measures on the list have been discarded.
II	Literature	Individual measures	All measures were justified using widely recognized literature or based on whether they fulfilled legal obligations. In various cases, this can also be substantiated quantitatively—with economic underpinning in some cases. A thorough review of the Sendai Framework for disaster risk reduction in relation to each of the 28 proposed measures shows a rationale for advancing these measures as part of Romania's flood risk management strategy.
III	High-level CBA	Overall package	The high-level CBA has shown that the entire package contributes to a significant step change for Romania and is practically viable, with a benefit-cost ratio of about 1 based on flood risk benefits alone. However, the package can be deemed easily justifiable when considering the fact that it can also help achieve benefits associated with other hazards (e.g., fire, pollution spills).
IV	Detailed CBA	Subpackage	There was a strong-to-moderate justification for various items that are typically jointly implemented to address flood risk. This analysis acknowledges the fact that for more severe events, which more or less simultaneously affect more than one APSFR, there may be limitations regarding what can be done. This approach utilizes the concept of benefit pathways (Environment Agency 2015).

Table 11.2 Justification approaches and their outcomes

A potential funding agency was engaged in the justification process. This ensured that the approach adopted aligned with the agency's expectations.

Results and conclusions

The result was a proposal for an improved Preparedness Package. The package's development yielded 28 measures and entailed a proposed investment of nearly €400 million. An assessment was conducted for the entire preparedness package to understand the staff requirements of the relevant agencies for implementing the package and working with it in the coming years. This was also translated into an implementation and a monitoring plan.

Table 11.3 shows that the overall package results in a step change in capacities and capabilities, enhancing value in flood risk mitigation in Romania. For indicators A and B, the analysis showed that in the current baseline preparedness situation, the benefits amount to an estimated 3 percent risk mitigation, whereas the package is expected to result in a 5 percent reduction.

No.	Indicator	Baseline	Target with package	Years to target
A	Reduction of damage (AED) due the Preparedness Package	Approximately 3% of €1.72 billion (risk assessment)	Approximately 5% of €1.72 billion (risk assessment)	3
B	Reduction of fatalities due to the Preparedness Package	Approximately 3% of 70 (risk assessment)	Approximately 5% of 70 (risk assessment)	3
C	Availability of improved forecasting and warning products	<48 hours deterministic	>72 hours probabilistic	3
D	Number (in percentage of total) of FICs of IGSUs within 20 minutes reaction time for localities and number of RICs and water management systems (SGAs) of RBAs travel time within 90 minutes for intervention for flood protection damaged infrastructure of APSFRs	RBAs: RIC 80%, SGA: 96% IGSU units: 51%	RBAs: RIC 80%, SGA: 96% IGSU units: 75%	2
E	Percentage of people in high-risk APSFRs receiving flood warnings through different channels (RO-Alert, direct warning, alert via siren)	75%	95%	2
F	Percentage of people acting upon flood warnings	50%	>75%	3
G	Percentage of people receiving awareness campaigns (mainly through their involvement in/with annual exercises/ pamphlets/maps)	20%	>50%	3
H	Percentage of campaigns specifically addressed to marginalized communities	< 1%	>25%	3

Table 11.3 Baseline and target values for individual indicators for the enhanced Preparedness Package

The following conclusions can be drawn from the preparedness package's development process and the resulting package itself:

- Given the inevitable constraints on funding for flood prevention and protection measures, residual flood risks will remain high in Romania for the foreseeable future. An effective and efficient preparedness package — implemented over years and not decades — will therefore be essential.
- Justification of a preparedness package requires carefully considering the costs and effectiveness of possible measures, and a holistic approach is essential to ensure benefits are adequately assessed and coherent measures are developed. Numerous measures benefit other areas besides APSFRs (i.e., areas not designated as APSFRs also face a flood risk) and flood risk (i.e., preparedness measures can be used to address other hazards and risks such as fires or earthquakes). Also, the complexity and dynamics in the measures' implementation means that diverse approaches are to be adopted to justify the recommended measures and investments and instill confidence in them among funding agencies and the ultimate beneficiaries.
- Various tools and concepts helped develop and assess the package (e.g., the R2R framework, GIS, and the benefit-pathways concept) (Parker et al. 2008; Environment Agency 2015).
- Improved preparedness can help Romania make a step change in mitigating flood risk in the short to medium term. This is indeed essential given the long time needed to implement prevention and protection measures (up to 10 years) and other national measures, such as spatial planning (of the order of a generation). Preparedness improvement is substantially quicker and can cover the whole of Romania.

Lessons learned

The preparedness package is a crucial component of the overall flood risk management strategy for Romania. While a lot of emphasis is placed on defining prevention and protection measures for the APSFRs, the development of the package was deliberately addressed separately, targeting residual risk in the broadest sense. Not only will the package reduce flood risk for all, including non-APSFR areas, but there are also various benefits of the package in relation to other hazards. Furthermore, the geographic scale of flood events as well as the potential geographic spread of the benefits of measures of the package generally exceed the scale of a single APSFR or cluster of APSFRs. Building on this, two key lessons were learned:

- **Development tracks.** One key lesson learned is that to arrive at the preparedness package different routes in parallel need to be pursued. Three tracks were defined. The first track is stakeholder driven and defines gaps and needs jointly with the main stakeholders concerned. The second track is analysis driven and is based on a factual analysis of capacities and capabilities. The final track concerns the justification of the measures identified and assessed in earlier tracks.
- **Multiple justification approaches.** Zooming in on the justification approach, there is no single silver bullet to justify the preparedness package. The complexity and diversity of all elements of the preparedness package is such that various approaches are needed to justify the package. Four different approaches were defined, and all items were subjected to at least three, but in many case all four. Using all four provided valuable insight and provided maximum confidence in the justification of the individual measures as well as the overall package.

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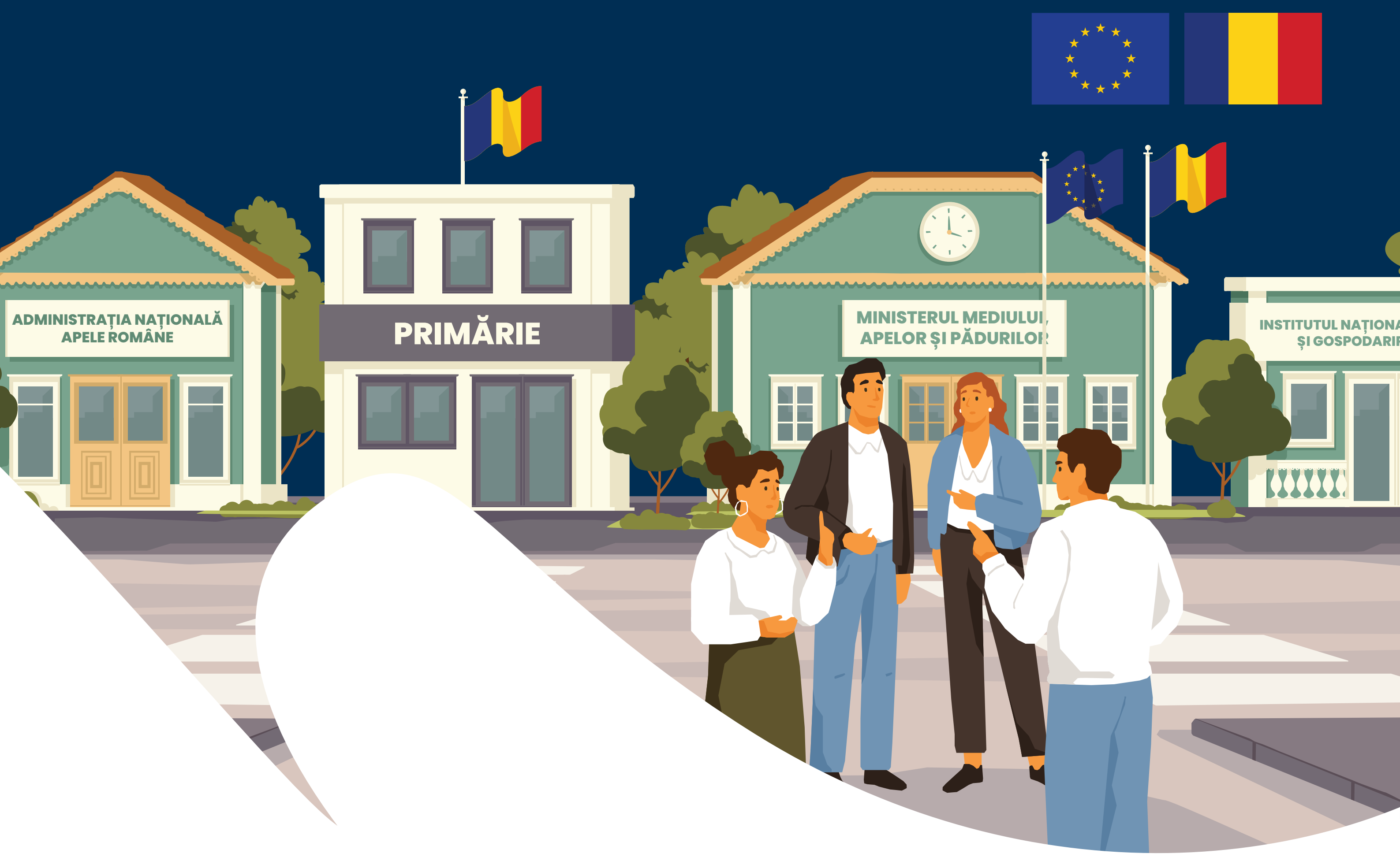
CHAPTER 12

STAKEHOLDER ENGAGEMENT



12. STAKEHOLDER ENGAGEMENT[28]

Summary

The challenge of increasing stakeholder engagement capacity within Romanian water authorities was addressed through the development and implementation of a strategic stakeholder engagement plan for the second-cycle implementation of the Flood Directive. The initial challenge encompassed both a lack of staff with social expertise in stakeholder engagement, coupled with low public trust in authorities and a limited civic tradition of engagement in public projects.

The stakeholder engagement strategy aimed to enhance engagement processes and foster the integration of flood risk management into regional and local decision-making. The strategy emphasized the need for inclusive and diverse representation, especially of nongovernmental organizations (NGOs), civil society organizations (CSOs), and vulnerable communities, while offering flexibility to adapt to evolving project phases.

Key activities included the establishment of online communication channels, such as the **https://inundatii.ro/** website and associated branding (INUNDATII.RO), and social media campaigns. Different mechanisms were utilized for stakeholder engagement at the national, regional, and local levels, including a technical advisory group (TAG) and technical working groups (TWGs). A formal public consultation process gave the stakeholders an opportunity to share their input.

The challenge

The stakeholder engagement concept, introduced in 1984 (Freeman 1984), is a relatively new construct for Romania, especially in institutional settings. Although some countries in the European Union (EU) have been integrating stakeholder engagement in public sector projects for decades, there is still a lack of consensus on and a clear understanding of what it means (Kujala et al. 2022). Stakeholder engagement presented a twofold challenge for Romanian water authorities: (1) limited staff with social expertise in stakeholder engagement, and (2) public distrust in authorities combined with a limited civic tradition to engage in public/infrastructure projects. Although the Ministry of Environment, Water and Forests (MEWF), the National Administration "Romanian Waters" (ANAR), and river basin administrations (RBAs) have well-defined communication plans and follow EU and national regulations on public consultation, they had not previously engaged stakeholders strategically following a structured approach across flood risk management plans' (FRMPs') full development cycle. Awareness and capacity enhancement at all levels of Romanian water authorities was thus the key challenge for them engaging stakeholders.

The MEWF, ANAR, and RBAs received the World Bank's support in formulating and implementing a stakeholder engagement strategy for the second cycle of the Floods Directive implementation. The Bank built on and addressed the findings from the stocktaking assessment of the first-cycle FRMPs and the European Commission's recommendations on the same.

[28] Chapter prepared by Ioana Dobrescu and Cosmin Feodorov

Key activities

Stakeholder engagement strategy

Recognizing that the national and regional water authorities did previously engage with stakeholders to some extent, the fact often was that this engagement was poorly documented and ad hoc, lacking transparency. A strategy was needed to structure, strengthen, and broaden their stakeholder engagement efforts.

The stakeholder engagement strategy was developed to achieve two main objectives:

- Improving the water authorities' stakeholder engagement process, with the MEWF, ANAR, and RBAs leading the effort.
- Stimulating the integration of flood risk management aspects in the (spatial) planning and decision-making of other regional and local authorities, NGOs, companies, and individual citizens (stakeholders).

The strategy document was crucial in helping the water authorities comprehend how engagement differs from communication and consultation. It offered suggestions for different types of engagement activities and preliminary stakeholder mapping nationally as well as regionally (RBAs). It also listed online and offline tools and techniques for communication, engagement, and consultation. The document also contained descriptions of existing capacities within the water authorities and an estimate of the resource requirement for their implementation while aligning with the MEWF's and ANAR's existing communication plans.

The strategy aimed at a balanced coverage of national, regional, and local stakeholders across territory and geography, with a particular emphasis on a more inclusive and diverse representation and active participation of NGO, CSOs, and vulnerable communities. Despite its comprehensiveness, the strategy was flexible to a degree and allowed the beneficiaries to adapt as the Project progressed and choose the most suitable approach for each phase.

Figure 12.1 shows the differences and relationship among the communication, stakeholder engagement, and stakeholder consultation phases as FRMP development progressed.

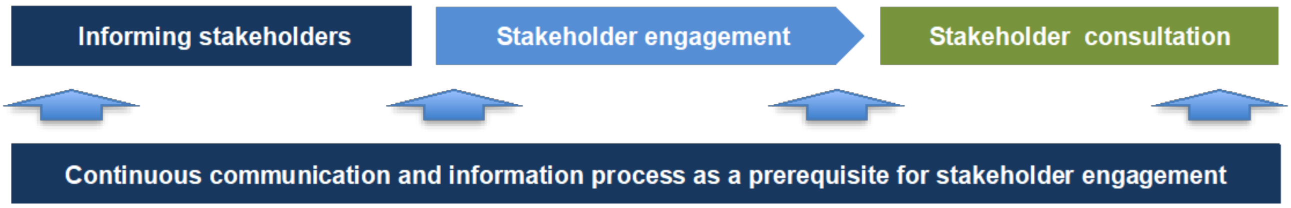


Figure 12.1 Three pillars of the stakeholder engagement strategy

For all the activities described below, the stakeholders invited were selected based on thorough stakeholder mapping and analysis in the Project's early stages. Stakeholders were mapped nationally as well as regionally (RBAs) and included all categories of stakeholders to be informed and/or engaged, that is, public institutions, the private sector, NGOs, the academia, interest groups, and citizens. The stakeholder analysis represents a living document, which is continuously updated nationally by the MEWF and the ANAR and regionally and locally by RBAs as the FRMPs were being developed.

Information and communication

The communication aspect of the second-cycle implementation in Romania has a significantly stronger online and digital presence compared to the first cycle.

To provide visibility to the Project and to flood risk management efforts in Romania, a branding initiative was launched under the name INUNDATII.RO[29] (figure 12.2). Branding under this initiative considers logos, fonts, color palettes, and other digital identity elements. The centerpiece of the online communication efforts was the newly developed website **https://inundatii.ro/**, which serves as a knowledge and resource hub, not only for the RO - FLOODS Project, but also for all information related to flood risk management in Romania.

Figure 12.2 The INUNDATII.RO brand and the Transform Awards prize [30]

The website features a Web map viewer (**https://inundatii.ro/en/maps-portal/**) for viewing the flood hazard and risk maps (FHRMs), the new FRMP, and resources for public and stakeholders. It facilitates stakeholder engagement and is linked to the National Meteorological Administration's (ANM's) and National Institute of Hydrology and Water Management's (INHGA's) meteorological and hydrological alerts (**https://inundatii.ro/en/weather-warnings/**).

The website — launched in early 2022 — is administered by ANAR. Additional communication channels, including a dedicated Facebook page (Inundatii.ro - **https://www.facebook.com/inundatii.ro**) and a YouTube channel (inundatii.ro - **https://www.youtube.com/@inundatiiro**), were created to provide Project updates and flood-related content (figure 12.3).

[29] Inundatii is the Romanian word for floods.
[30] **https://agerpres.ro/economic-intern/2022/04/08/mmap-brandul-inundatii-ro-premiat-cu-medalia-de-bronz-in-cadrul-concursului-transform-awards-europe--899738**

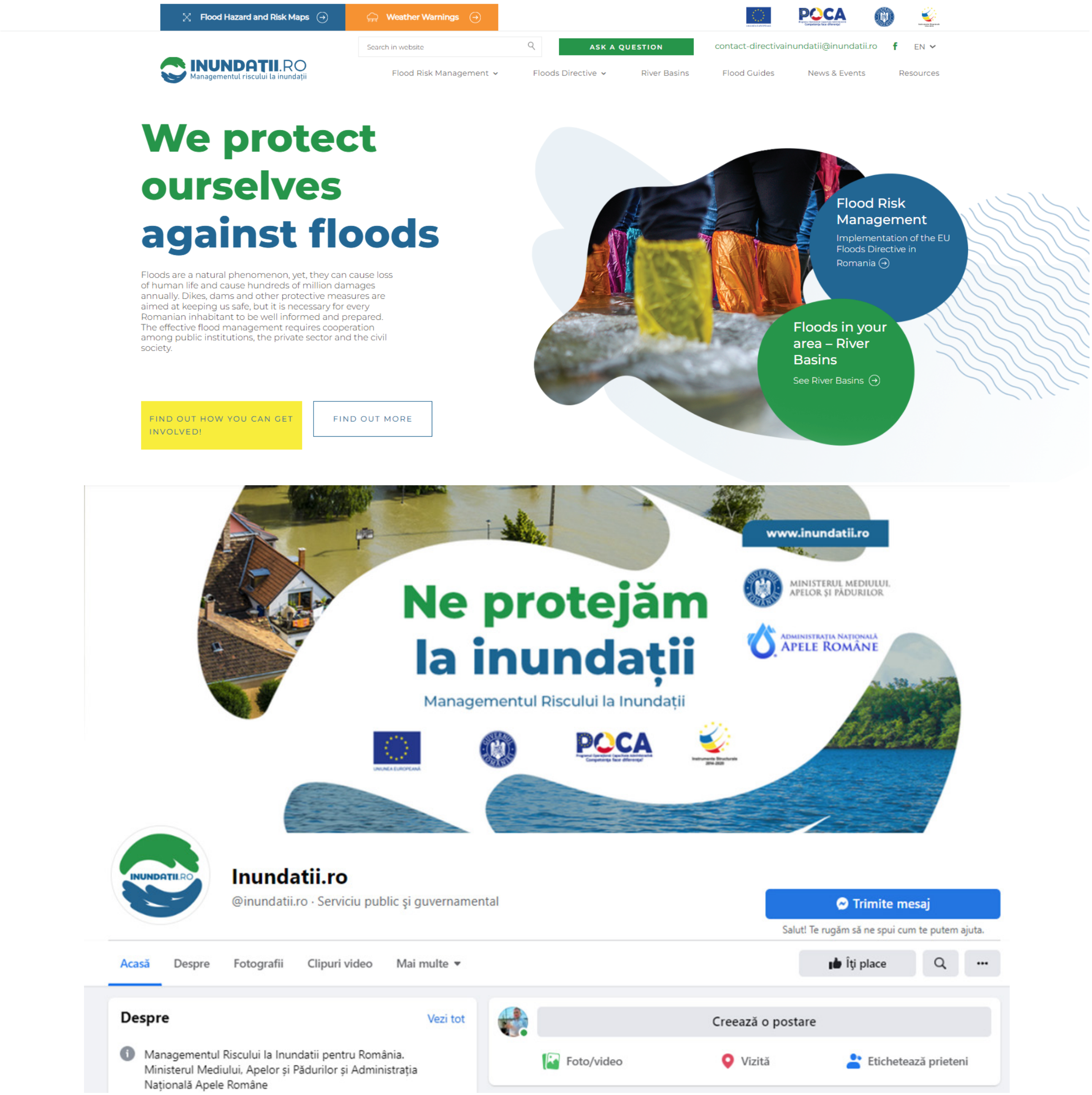


Figure 12.3 INUNDATII.RO website and Facebook page

The MEWF and ANAR received the World Bank's support in raising awareness about the RO - FLOODS Project and the new online communication channels and updating FHRMs through online advertising campaigns via **https://inundatii.ro/** and the social media channels.

Besides these efforts, the MEWF, ANAR, and RBAs used conventional communication methods such as emails, press releases, media, conferences, and meetings with stakeholders to communicate Project milestones. Given the limited capacity within the water authorities, the World Bank assisted in developing communication and engagement materials, including brochures, animations, and short videos (figure 12.4).

Note: FHRM = flood hazard and risk map.

Figure 12.4 RO - FLOODS video animation and FHRM teaser[31]

Stakeholder engagement at the national level

Two stakeholder consultation mechanisms — a TAG and TWGs — were formally established to support interinstitutional coordination and engage stakeholders from relevant sectors within the Project. The TAG consisted of national-level stakeholders acting as a strategic advisory group throughout the Project's duration, while TWGs were formed based on a specific theme and convened to facilitate knowledge sharing among stakeholders and serve as an inspiration for the development of the program of measures (PoM).

The TAG met eight times, addressing key phases of Project implementation, while the TWGs met more frequently, on topics such as nature-based solutions (NBS) and stakeholder engagement. The TAG as well as TWG meetings gave an opportunity to share project results, discuss feedback, and present the Project implementation status to stakeholders from different sectors, including the central government (ministries, national agencies — forestry, agriculture, transport, energy, etc.), local or regional public authorities, academia, or NGOs. Other meetings during the PoM development were focused on specific stakeholders like NGOs or the ones relevant for the Danube.

In addition, several dedicated meetings were organized for each Project phase, to engage relevant national and/or regional stakeholders. These meetings were prepared with the World Bank's support and hosted by the MEWF, ANAR, or RBAs. The meetings were online as well as in-person (when COVID-19 restrictions were lifted) and were organized for gathering stakeholders' input and buy-in at each phase of the PoM's development, as well as engaging them in the FHRMs' validation. More than 600 stakeholders participated in the meetings for the PoM's development. They included representatives from municipalities, environmental agencies, water operators, other government ministries and agencies from different sectors (forestry, agriculture, transport, energy, spatial planning), NGOs, and academia.

[31] https://www.youtube.com/@inundatiiro

A dedicated tool, the Web Map Viewer, helped engage stakeholders in the review and validation of the FHRMs. Relevant institutional stakeholders — totaling up to 350 individuals, representing 21 organizations — were assigned a private user account for the Web map viewer. They could view draft maps and provide comments on them via this account. Before this tool's launch, training was provided to 250 participants. RBAs and the World Bank provided continuous technical support throughout the review and validation process.

Stakeholder engagement at the regional level (RBAs)

Besides stakeholder engagement at the national level, RBAs performed specific activities within their territories. They engaged regional and county-level stakeholders (e.g., county councils and land, roads, and forestry authorities, farmers, among others). The World Bank supported RBAs in enhancing their institutional capacity to prepare a stakeholder engagement process and conduct it via stakeholder meetings for each stage of the PoM development. The support provided consisted of:

- Dedicated communication materials specific to each phase: presentations, brochures, and other written material.
- Workshops and training for the RBAs to understand how to organize stakeholder engagement meetings.
- Guidelines on how to organize stakeholder engagement meetings.
- On-the-job training for RBA staff.
- Technical and strategic support, in the form of dedicated World Bank team members for each RBA.

RBAs organized meetings in multiple formats — online, face to face, and hybrid — depending on the context and resources available. On average, each RBA organized four general stakeholder meetings specific to the different phases of the PoM's development and two River Basin Committee meetings for presenting the Project and to obtain official approval for the FHRMs and the FRMP. Feedback was collected for all meetings, and the World Bank identified areas for improvement and discussed them with ANAR and RBA representatives in dedicated meetings.

Stakeholder consultation

The formal public consultation process for the draft FRMP, and the Strategic Environmental Assessment (SEA) process, provided further opportunities for (national) stakeholders to engage and provide comments on the FRMP.

With the publication of the draft FRMP, including the publication of other preliminary planning results (the areas of potential significant flood risk [APSFRs] fact sheets with the proposed measures), the RBAs had also formally begun public consultations. RBAs were requested to keep a record of all comments received and report on their impact on the final FRMP (e.g., changes to measures, agreement for further consideration in the third cycle). Although efforts were made to involve stakeholders, little feedback was received in writing or during meetings. However, World Bank staff helped RBAs integrate the obtained feedback into the fact sheets and the final FRMP.

Lessons learned

It must be stated that stakeholder engagement is a relatively new practice and challenging to adopt for Romanian authorities overall. This was reflected in the staff's limited experience, that often resulted in reluctance and discomfort in performing the activities prescribed by the strategy. Further, institutional stakeholders were often not accustomed to actively participate during meetings or through writing. The combined efforts of the World Bank and the Romanian water authorities helped overcome these challenges, leaving many successful experiences and valuable lessons that could be learned:

- The stakeholder engagement process yields favorable outcomes when executed consistently and systematically. It equips stakeholders with comprehensive project knowledge and clear expectations, leading to more prompt responses in formal and informal communication.
- The importance of patience and persistence is worth emphasizing. The progress achieved over the past three years is a testament to the continuous effort invested, which resulted in visible advancements in different stages.
- Stakeholders' awareness of discussed topics, addressed issues, expectations, and roles significantly enhances their understanding and fosters increased participation, feedback, and collaborative conflict resolution.
- Stakeholder engagement practices enable organizations and stakeholders to access information and share it among themselves. Easy access to well-presented and clearly organized information and data facilitates improved decision-making, which contributes toward project goals and benefits a larger number of stakeholders. Stronger stakeholder engagement not only results in better feedback received but also expands the pool of stakeholders providing valuable insights.
- The **https://inundatii.ro/** website, specialized training programs with on-the-job support, direct engagement and meetings with key stakeholders, social media platforms, and video materials have been the most valued tools and channels over the past three years.

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CHAPTER 13

ENGAGEMENT OF ROMA AND MARGINALIZED COMMUNITIES

13. ENGAGEMENT OF ROMA AND MARGINALIZED COMMUNITIES[32]

Summary

The Roma who live in marginalized communities, often face a combination of social, economic, and environmental challenges. Living in segregated settlements, they lack access to basic services such as clean water, sanitation, education, and healthcare. Additionally, these settlements are frequently located in areas that are more vulnerable to risks like flooding or pollution, which can exacerbate the difficulties these communities face.

Efforts to enhance flood management strategies in Romania have been ongoing; however, the needs the Roma living in marginalized communities and in areas prone to flooding have not been always addressed to the same extent. This oversight can lead to the development of strategies that do not fully address the unique needs and circumstances of these vulnerable communities.

Engaging the Roma in the planning and implementation of flood prevention and mitigation measures was facilitated through a dedicated pilot program carried out under the RO - FLOODS Project. Through participation and by incorporating the perspectives of the Roma, the pilot aimed to ensure that flood mitigation strategies were not only technically sound but also socially inclusive, recognizing the importance of local knowledge and the specific needs of different community members in reducing flood risks and enhancing overall resilience.

The pilot provided ANAR and the River Basin Administrations (RBA) with a better understanding of the needs and perspectives of Roma communities. By actively involving the Roma in flood risk management, authorities have gained insights into the specific challenges and requirements of this marginalized group, which may have been previously overlooked, and thus improved the authorities' planning and implementation capacity.

The challenge

The final results of the 2021 census reveal that the self-declared Roma ethnic population represents 3.4 percent, amounting to 569,477 individuals, of the total population for which ethnicity is available, which is 16,568,900 people[33]. It is estimated, however, that the share of Roma population is higher.

A 2021 Roma survey[34] shows that 78 percent of the Roma population is at risk of poverty. Around 70 percent of them are experiencing different kinds of housing deprivation (for instance 40 percent of Roma people are living in households without tap water inside the dwelling). In addition, many Roma still face obstacles related to registration of legal property. Lack of decent housing affects their health and is a barrier in accessing or completing education or to labour market entry.

Historically, many Roma communities have been typically located in the peripheries of cities or in urban ghettos. Be it for historical spatial segregation, lack of alternatives, evictions from more central areas to the periphery, the Roma communities settled in areas that are separated from the non-Roma population. Frequently these areas are characterized by substandard environmental conditions, such as exposure to flooding or pollution, which further contribute to their social and economic marginalisation. Social exclusion, discrimination, and a lack of respect further perpetuate this disadvantage across generations.

32 Chapter prepared by Oana Ivan, Cosmin Feodorov and Denisa Meirosu
33 National Institute of Statistics, **https://insse.ro/cms/sites/default/files/com_presa/com_pdf/rpl2021_date_provizorii_profil_teritorial_ian_2023.pdf**
34 European Union Agency for Fundamental Rights, Roma in 10 European Countries, 2022

Consulting the Roma communities that are vulnerable to natural disasters such as floods, that may not have always been engaged on such topics and may face additional challenges (e.g., housing issues), is an essential step in enhancing the society's readiness and preparedness in the face of disasters. To increase their capacity on this front, the Romanian flood management authorities were in search of advice on how to carry out community-specific flood risk management for Roma communities to strengthen their flood resilience.

Approach

Based on a set of criteria, Roma communities in three different locations affected by floods were selected and engaged using a systematic approach, which included community visits, stakeholder mapping, and roundtable meetings with relevant stakeholders in the area. From preparation to implementation, the activities were carried out with the support and local knowledge of the respective RBAs. The experience with the three pilot communities served as the basis for developing a Community Engagement Guide to support the water management authorities and other public institutions in better engaging and interacting with marginalized communities, including Roma.

The three locations selected were Dăroaia, Roşia Montana commune (Alba County — Mureș RBA), Bărbuleşti (Ialomiţa County, Buzău-Ialomița RBA), and Păuleasca, Micești commune (Argeş County, Argeș-Vedea RBA). The following criteria were used for this selection:

- A significant share of Roma population in the community.
- Location of communities in areas at risk of flooding.
- Selection of cases representative of their geographical and cultural context, reflecting the sociocultural diversity of Roma.
- Different levels of internal organization at community level, namely the existence of: (1) strong leadership of the Roma community leader, (2) leadership exercised through multiple community leaders, and (3) weak to nonexistent leadership.

In addition to the Roma communities, the RO - FLOODS Project engaged a diverse range of stakeholders across different administrative levels: locally, the city hall, at the county level, the Inspectorate for Emergency Situations (ISU), the County Council, the Prefecture, the Water Management System (SGA), and representatives of minority groups. At the regional level, RBAs were part of the engagement process.

Developing a Three -Phase roadmap for community engagement piloting

The pilot activities were structured around three distinct phases. In the first phase, the stakeholder and issue mapping were prepared. Dialogues with stakeholders (community and authorities) was carried out in the second phase, while the third phase consisted of field visits to flood-affected Roma communities, accompanied by authorities.

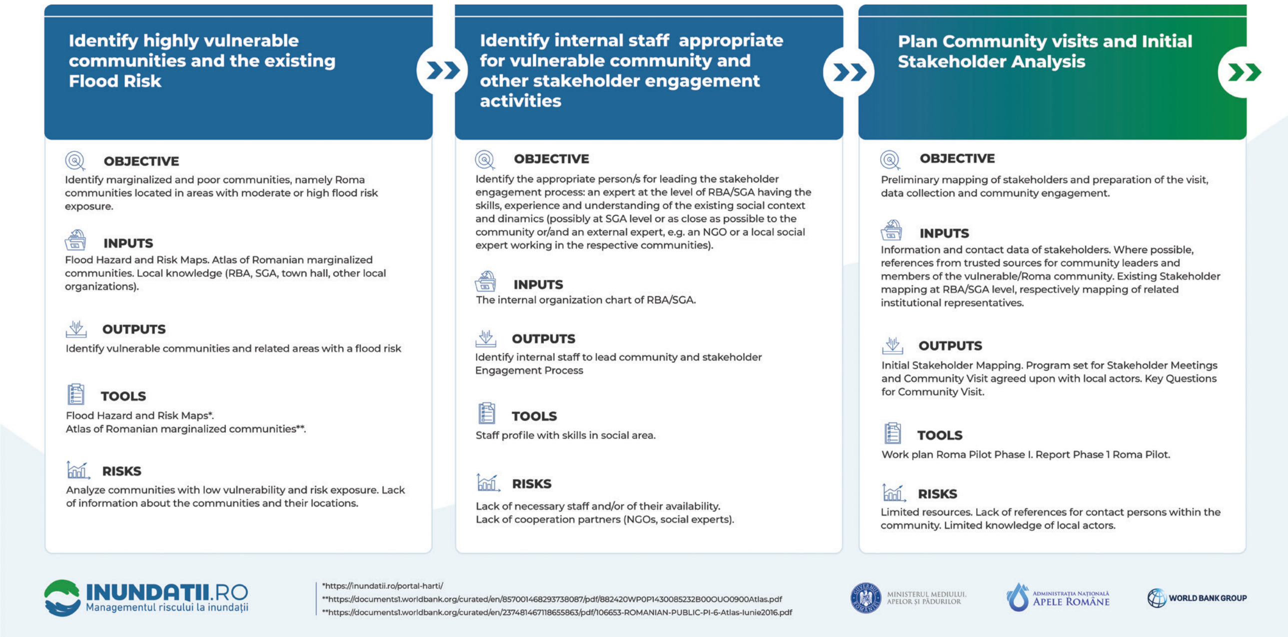
Results

The pilot studies produced promising results for enhancing Roma engagement. The Roma communities were more willing to engage in dialogue with the authorities, shared important local knowledge that informed official strategies and plans, became more aware of the challenges and approaches to managing flood risks, jointly agreed new arrangements for flood risk management, and created a platform for future dialogue. Based on these experiences, a Community Engagement Guide was produced; the guide details each step of the process (see Table 13.1) starting from the "grassroots" and considers the socio-cultural and economic characteristics of the community selected. The guide is expected to support the water authorities with practical and simple advice to engage with the Roma communities affected by flooding.

1.	Identify highly vulnerable communities and the existing flood risk
2.	Identify internal staff appropriate for vulnerable community and other stakeholder engagement activities
3.	Plan Community visits and Initial Stakeholder Analysis
4.	Initial community visit(s) and stakeholder meetings
5.	Check Information identified on site and that received from the community and stakeholders
6.	Prepare Report on initial meetings
7.	Plan stakeholder and community members roundtable
8.	Conduct roundtable with Stakeholders and community members
9.	Discuss and adapt the action plan with the community
10.	Implement the action plan on possible flood risk mitigation measures
11.	Monitor Implementation of the Action Plan
12.	Inform on the progress achieved based on the action plan
13.	Continuous communication and update the action plan based on results and feedback obtained

Table 13.1 Thirteen steps of the Community Engagement Guide

An excerpt of the Guide is presented in figure 13.1, while the guide can be accessed at **www.inundatii.ro** — Resource Section / Other documents — **https://inundatii.ro/en/resources/**.



Note: NGO = nongovernmental organization

Figure 13.1 Excerpt from the Community Engagement Guide

The positive outcomes underscore the added value of integrating the Community Engagement Guide into all upcoming flood risk management initiatives. The experience gained from the three chosen communities highlighted the importance of ongoing dialogue and communication among all key stakeholders. Such collaboration is key to adapting to the evolving challenges presented by climate change, which is likely to increase the frequency and severity of flood events. The systematic use of this guide will enhance awareness and strengthen the ability of both the authorities and Roma living in marginalized communities to better prepare for flood risk management.

Lessons learned

The following lessons learned are valuable insights gained from the pilots. These lessons, emanating from almost one year of interaction with the communities selected for piloting represent valuable guidance for the water authorities, when replicating similar actions as well as for peers from other sectors that are working with marginalized communities. They also have the potential for dissemination to wider audiences that could be encouraged to integrate these lessons into broader practices.

- **The context.** Situational awareness and an organized approach are needed to involve vulnerable communities and achieve positive results.
- **Progress is possible.** Fostering dialogue between the authorities and Roma communities can yield positive results. Despite initial skepticism and difficulties to build and maintain trust, most of the participants in this pilot acknowledged that collaboration is possible.
- **Time scale and challenges.** Collaboration of this type is a lengthy process, although the stakeholders involved are generally open to finding solutions together to challenges identified.
- **Authorities and awareness.** There are representatives of public authorities who are aware of the context of the vulnerable communities and acknowledge the benefit of a dedicated approach. This is a strength on which community engagement can be built.
- **Champions.** There are representatives of public authorities who acknowledge and flag that there are cases of discrimination against certain members of the communities, often including the Roma. Such individuals can be champions for continuing community engagement activities and for fostering an environment of inclusivity and respect, thus adding social responsibility to the technical or administrative role of public authorities.

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CHAPTER 14

TRAINING AND CAPACITY BUILDING

14. TRAINING AND CAPACITY BUILDING[35]

Summary

Like the other European Union (EU) Member States, the Romanian government strives to enhance its flood risk management capacities and build resilience to floods. This chapter summarizes the activities aimed at enhancing Romania's flood risk management capacities developed during the second cycle implementation of the Floods Directive under the RO - FLOODS Project. The focus was on enhancing institutional and human resource competences (know-how) and capabilities (instruments), to enable informed decision-making for sustainable flood risk management in Romania.

At the start of the Project, the existing as well as the required capacities for flood risk management were assessed. The resulting gap analysis provided the basis for a strategic capacity building plan, which was developed and implemented under RO - FLOODS. The plan encompassed multidisciplinary topics and actions at various levels., including updating the methodological framework for implementing the Floods Directive and developing and a variety of tools and instruments to facilitate its use. Important new skills were acquired by the participants of several training programs in areas such as data management, flood hazard and risk modeling and mapping, geographic information system (GIS), the use of green infrastructure (GI) and nature based-solutions (NBS), multicriteria analysis (MCA) and cost-benefit analysis (CBA), and stakeholder engagement and communication.

The challenge

Since flood risk management encompasses many complex and interconnected resource-intensive processes, capacity building in this area is a continuous pursuit, addressing all stakeholders and for all flood risk management components (i.e., flood prevention, protection against floods, preparedness to face floods, and post flood response and recovery). The capacity building approach of RO - FLOODS considered the newest technologies and methods available in flood risk management, and followed a process wherein needs assessments and the capacity building plan were updated continuously.

In this context, the biggest challenge was to narrow down the scope for building capacities and focus efforts in key areas, considering the available resources. Other challenges encountered in this process related to, among others, COVID-19 restrictions, stakeholders with different levels of technical expertise and prior experience, and workload and time availability of the target audience.

Needs assessment

Considering the challenges above, the first step was a detailed assessment of the relevant stakeholders' needs. This carefully orchestrated assessment began with an evaluation of the Floods Directive first cycle of implementation in Romania. The evaluation used different methods, for example, desk studies, interviews with management and operational staff, and workshops. Several aspects, including the resulting flood risk management products, the existing legislation in the field, interinstitutional relations, institutional capacities, and the existing knowledge base, were comprehensively analyzed. The assessment's findings were discussed and validated with the key stakeholders, including the Ministry of Environment, Water and Forests, the National Administration "Romanian Waters" (ANAR), the National

[35] Chapter prepared by Elena Daniela Ghiță and Cosmin Feodorov.

Administration "Romanian Waters" (ANAR), the National Institute of Hydrology and Water Management (INHGA), and river basin administrations (RBAs).

Five areas of interventions were identified as crucial for Romania to strengthening flood risk management capacities:

- The existing and prospective knowledge base and data management.
- Improvement and application of the methodological framework.
- Promotion and inclusion of NBS in flood risk management.
- Consolidation of flood resilience in marginalized and poor communities.
- Enhancement of communication and multistakeholder engagement.

The capacity-building plan

As a second step, a strategic capacity-building plan was developed to address the limitations related to the above key areas of interventions and guide immediate and medium-term actions to be implemented during the RO - FLOODS Project. These actions envisioned three levels: individual, institutional, and systemic (or aggregate level, including the water-related institutions and their relations). The aim was to improve the institutional arrangements, leadership, knowledge, and accountability of Romanian authorities, following international best practices. Central to the capacity-building plan was to ensure a thorough understanding and appropriate use of the tools developed during the RO - FLOODS project.

To encourage the continuity of the training program in the future, the capacity-building also delivered useful annexes, which have lists of online libraries on water topics, open learning platforms, and details of free online training courses.

Implementation of the capacity-building plan

Initially, the capacity-building plan had to be adapted considering COVID-19 restrictions. The planned in-person meetings, workshops, and training sessions were conducted virtually — which actually made far greater attendance possible with no risk to the participants' health. The virtual format, however, brought other challenges. The required information technology (IT) infrastructure and software resources had to be enhanced. Also, new skills had to be developed to help the participants use the online platforms appropriately and effectively, following new guidance documents, and different techniques were applied to encourage them to stay active and involved.

Training sessions and activities ranged in difficulty from a beginner level to more advanced content. Additional activities and tools were developed to increase the relevant institutional capacities whenever a significant need for knowledge consolidation was identified.

The training activities had to be planned in such a way that it responded to the inevitable constant changes in the staff availability (e.g., emergency situation interventions, inspections in the field etc.). In some cases, depending on the implementation phase of the Floods Directive and progress, these changes in activities' planning involved the flexible rethinking of content, methods, or types of training sessions.

Results

Implementation of the capacity-building plan resulted in:

- A total of **41 training sessions** conducted over 68 days for more than 2,500 participants, with 60 participants per training session on average. This was far higher than if face-to-face training would have been conducted.
- A total of **16 parallel studies to enhance the knowledge base or develop new methodologies** (e.g., *on data structures and policies on naming conventions, legal aspects for land acquisition and compensating for flood water storage on private/public land, areas for floodplain restoration and dike relocation and green guidance, Roma pilot for community engagement, and stakeholder engagement strategy*).
- Over **30 tools** developed to facilitate flood risk management activities (e.g., *a loss and damage database, damage curves, fragility curves for dike breach modeling, a Web Viewer, a unit costing database, the Appraisal Summary Tool, maps showing potential for floodplain restoration and dike relocation, and online communication channels*).
- Over **60 workshops, technical working groups, and technical meetings** on topics related to the areas of interventions listed above.

Following are some of the most important technical skills and essential knowledge acquired by the participants:

- **Knowledge base and data management skills:**
  - To create and maintain database structure and naming conventions.
  - To prepare data and choose appropriate tools and settings for an analysis.
  - To quantify spatial patterns using spatial statistics and analyze change over time to identify emerging "hot spots".
  - To apply best practices to optimize geodatabase performance.

- **Improvement and application of the methodological framework:**
  - To identify the data needs for flood hazard and risk modeling and mapping.
  - To use and change parameters within hydraulic models.
  - To export the results of hydraulic modeling and process them.
  - To create flood hazard and risk maps.
  - To evaluate the quality of flood hazard and risk maps.
  - To use multicriteria analysis and cost-benefit analysis.
  - To perform robustness checks, including, for example, related to climate change impact.
  - To prioritize investment.
  - To identify the legislative tools to be considered for specific types of financial funds and programs.
  - To evaluate the eligibility to apply for different types of financed funds and programs.
  - To estimate a project's resource and budget requirements, accounting for the eligible expenses for different financial funds and programs.
  - To elaborate on the applications requested for different types of financial funds and programs.

- **Promotion and inclusion of green infrastructure/NBS for flood risk management:**
  - To recognize the key characteristics for floodplain typologies.
  - To identify potential riparian areas for attention.
  - To promote green infrastructure and NBS measures and evaluate their potential to reduce flood risk.

- **Consolidation of flood resilience in marginalized and impoverished communities:**
  - To identify marginalized and impoverished communities facing a flood risk.
  - To engage with these communities.
  - To create awareness about flood risk in impoverished and marginalized communities.

- **Enhancement of communication and multistakeholder engagement:**
  - To identify and analyze the stakeholders for different needs/stages of the planning process.
  - To plan interactions with the stakeholders and use a variety of strategies for that purpose.
  - To identify the resources required for interacting with stakeholders, based on the stakeholders' typology.
  - To identify proper channels for communication.
  - To tailor content based on the audience's profile.
  - To formulate appropriate messages and use appropriate media.

While the training sessions aimed to foster growth at an individual level, the studies and tools aimed for institutional changes (i.e., improvement of the institutional procedures in place). Systemic changes (e.g., consultations, open dialogue) were also targeted, using the workshops and the technical working group. Surveys and feed-back loops during and after training events were used to adjust the learning program and confirmed the overall high satisfaction of the participants.

With the successful implementation of the capacity-building plan, Romania substantially improved its capacities for the EU Floods Directive implementation and for flood risk management in general. This capacity improvement has been achieved in terms of individual skills acquired and methodologies, tools, and studies. The new skills, methodologies and tools are already being applied by the target group of the capacity building plan, which included members of 15 public institutions, including MEWF, ANAR, the RBAs, INHGA and IGSU. Nevertheless, this does not mean that the process should stop here — continuous capacity building must be ensured for all institutions involved in flood risk management as well as their younger, more experienced professionals, to subsequently build resilience to flood events.

Lessons learned

Based on the experience in the RO - FLOODS Project, the following key aspects should be considered for the successful implementation of a program to build flood risk management capacities:

- **Enhance communication.** The program should include from its very outset effective communication between its developer and recipients. This will help secure accurate feedback for timely adjustments to content or methods or means, which are crucial for the program's success. Open dialogue should be encouraged by all means available.
- **Promote proactive participation.** A training program's performance can be assessed based on the active participation of its participants. Participation can be stimulated using different means to capture attention. It could be stimulated, for example, by combining different learning techniques, offering the participants opportunities to directly interact with trainers or interact among themselves, especially when complex topics are approached. Active involvement of participants could also be ensured by asking them to come up with solutions for different challenges.
- **Exemplify theoretical aspects.** Practice showed that the theory of flood risk management was much better understood when real-world examples were presented.
- **Combine theoretical learning with on-the-job learning.** Allowing the recipients to apply in their daily routine the knowledge acquired during the training sessions is a good way to evaluate their understanding of theory. Such exercises will reveal which topics have to be strengthened or consolidated.

- **Ensuring that a trainee is fully available to participate in training.** Successful implementation of a training program requires the involved authorities to ensure that the trainees are not burdened with other tasks in the training period and that their sole priority is acquiring the knowledge. Training sessions may occasionally neglect this aspect, resulting in trainees struggling to focus during class.
- **Exploit cascaded training opportunities.** Identify trainees who demonstrate a thorough understanding of the theory of flood risk management and effective communication skills. Train them to be able to train their colleagues, in turn ensuring knowledge is effectively maintained and transferred with minimum resources.

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CHAPTER 15

CONCLUDING REMARKS

15. CONCLUDING REMARKS

The RO - FLOODS Project successfully supported Romania with the implementation of the EU Floods Directive. The Project resulted in the development of new flood hazard and risk maps for all 526 areas of potential significant flood risk and 12 new flood risk management plans (FRMPs) for Romania's 11 river basin administrations (RBAs) and for the Danube River. The flood risk assessment conducted under the FRMP demonstrates the substantial flood risks Romania is currently facing and how they will increase due to climate change. The FRMP's programs of measures (PoMs) provide a comprehensive agenda for Romania to effectively manage and reduce flood risks, protecting its people, economy, and environment.

The full implementation of the developed PoMs in the coming years will be a significant challenge for Romania, considering the available resources for flood risk management in the country. Clear and objective prioritization of all measures under different categories and across the RBAs will, however, allow Romania to spend its limited resources for the highest-impact flood risk mitigation measures first.

The RO - FLOODS Project also successfully increased Romania's technical capacities for flood risk management. The wealth of data, innovative tools and methods, and new know-how created through the Project has enabled Romania to better study and assess flood risk, better plan and make the required investments in flood risk management, and will also allow Romania to further improve its implementation of the EU Floods Directive.

As part of the RO - FLOODS Project, the World Bank, together with the Ministry of Environment, Water and Forests, the National Administration "Romanian Waters" (ANAR), the 11 RBAs, and the National Institute of Hydrology and Water Management (INHGA), adjusted or newly developed and tested a variety of approaches for different areas of flood risk management, including collection and processing of large amounts of data, hazard modeling and risk assessment, and identification and appraisal of measures for effective communication and stakeholder engagement. This report provides a summary of the Project's key results and the lessons learned from it — through which, the Project can contribute to better future planning for flood resilience in Romania, Europe, or elsewhere in the world.