ROMANIA

REIMBURSABLE ADVISORY SERVICES AGREEMENT ON TECHNICAL SUPPORT FOR THE PREPARATION OF FLOOD RISK MANAGEMENT PLANS FOR ROMANIA (P170989)

Output No. 2

Report on the review and update of methodological guidance provided to MEWF on the following: (i) methodology for the assessment of damages: (ii) methodology for the evaluation of flood hazard and risk; (iii) revision of catalog of flood risk management measures; (iv) methodology to assess the impact of hydrotechnical works on ecosystems: (v) methodology for cost-benefit analysis; (vi) methodology for multi-criteria analysis; and (vii) methodology for the prioritization of measures and projects.

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MINISTERUL MEDIULUI, APELOR ȘI PĂDURILOR

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Purpose

This report was delivered under the Reimbursable Advisory Services Agreement on Technical Support for the Preparation of Flood Risk Management Plans for Romania signed between the Ministry of Waters and Forests and the International Bank for Reconstruction and Development on October 16, 2019. It corresponds to Output 2: *Report on the review and update of methodological guidance provided to MEWF on the following (i) methodology for the assessment of damages, (ii) methodology for the evaluation of flood hazard and risk, (iii) revision of catalog of flood risk management measures, (iv) methodology to assess the impact of hydrotechnical works on ecosystems, (v) methodology for cost-benefit analysis, (vi) methodology for multi-criteria analysis, (vii) methodology for the prioritization of measures and projects.*

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Abbreviations

ANAR	The National Administration Romanian Waters
AEP	Annual Exceedance Probability
AFU	Appraisal Flood Unit
AST	Appraisal Summary Table
APSFR	Areas of Potential Significant Flood Risk
BCR	Benefit-Cost ratio
CBA	Cost Benefit Analysis
CLC	Corine Land Cover
DTM	Digital Terrain Model
EAD	Expected Annual Damage
FD	Floods Directive
FRMP	Flood Risk Management Plan
FHM	Flood Hazard Map
FHRM	Flood Hazard Risk Map
GD	Government Decision
GDP	Gross Domestic Product
HEC-RAS	Hydrologic Engineering Center-River Analysis System
IDF	Intensity-Duration-Frequency
IGSU	General Inspectorate for Emergency Situations
INHGA	National Institute of Hydrology and Water Management
JASPERS	Joint Assistance to Support Projects in European Regions
MCA	Multi-Criteria Analysis
MEWF	Ministry of Environment, Water and Forests
NBS	Nature Based Solutions
NWRM	Natural Water Retention Measures
NPV	Net Present Value
OSM	Open Street Map
PFRA	Preliminary Flood Risk Assessment
PLL	Annual Potential Loss of Life
PoM	Program of Measures
RAS	Reimbursable Advisory Service
RBA	River Basin Administration
RBMP	River Basin Management Plan
SEA	Strategic Environmental Assessment
UoM	Units of Management
WFD	Water Framework Directive

1. Introduction

This “Report on the review and update of methodological guidance provided to MEWF” (further named the Report) represents the second output as specified in the Reimbursable Advisory Services Agreement (RAS) signed between the Ministry of Environment, Waters and Forests (MEWF) and the World Bank (WB) on October 16, 2019 for the provision of **“Technical support for the Preparation of Flood Risk Management Plans (FRMP) for Romania”** (further named the Project). The overall objective of this Reimbursable Advisory Service is to support the Government of Romania strengthen the capacity of the Ministry of Environment, Water and Forests (MEWF) and the National Administration “Romanian Water” (ANAR) in their implementation of the EU Floods Directive (2007/60/EC). More specifically, the World Bank will support Romania with the development of the Flood Hazard and Risk Maps (FHRM) and with the preparation of Flood Risk Management Plans (FRMP), the second and third stage of the implementation of the Floods Directive.

Component 1 of the Project, the stocktaking assessment, was finalized with the delivery of **Output 1, Report on Stocktaking and Workplan** in April 2020. During the stocktaking phase, the World Bank, together with MEWF and ANAR thoroughly assessed Romania’s capacities for flood risk management and analyzed the implementation of the EU Floods Directive (FD). This included an assessment of the Preliminary Flood Risk Assessment of the first cycle (reported in 2012) and of the second cycle (reported in 2019), as well as Romania’s first cycle Flood Hazard and Risk Maps (reported in 2014) and the 12 Flood Risk Management Plans, one for each of the 11 River Basin Administrations and one for the Danube (reported in 2016). Based on this assessment, the World Bank prepared a detailed workplan for providing technical support to Romania for their development of the second cycle FHRM and FRMP within the implementation of the RAS, until December 2022.

The underlying strategy of this workplan, as already agreed upon during the preparation of the Project in 2019 is built on two important activities: Support in the development of methodological guidance (Output2) and assistance to establish the knowledge base (Output3). These are the needed requirements for providing support in the modelling of flood hazard and flood risk (Output4), for assistance for the preparation of draft FHRM (Output5), assistance in the preparation of 12 draft FRMP (Output6) and of 12 final draft FRMP (Output7), and for strengthening the administrative capacity in water management (Output8).

During the stocktaking phase, the World Bank analyzed the existing methodological framework, as used during the first cycle implementation, identified gaps and areas for improvement and discussed together with MEWF and ANAR the outline of the new methodologies to be used for the development of the second cycle FHRM and FRMP. The proposed new methodologies for flood risk management in Romania and for MEWF’s and ANAR’s development of the second cycle FHRM and FRMP were prepared with the support of international and local experts and in close cooperation with MEWF, ANAR, INHGA and all other relevant stakeholders.

This report on the review and update of methodological guidance to MEWF (Output 2) summarizes the work leading to this new methodological framework and provides in its annexes the proposed new methodologies. Following a brief summary of the results from the stocktaking assessment and the description of the purpose of the proposed new methodological framework, the report provides information on the activities realized to produce the new instruments and gives a comprehensive overview of the new framework. This includes the Methodologies for Flood Hazard Modelling and Mapping, the Methodology for Damage and Loss Assessment and Risk Mapping, and the Methodology for the Development of Programs of Measures. This includes a new Catalogue of Measures, Fact Sheets for prioritized measures and an Appraisal Summary Table (AST) in form of an excel tool for realizing the multi-criteria analysis (MCA) and the cost-benefit-analysis (CBA).

2. Background: Methodologies used for the first cycle implementation of the EU Floods Directive

For the implementation of the EU Floods Directive during the first cycle, Romania developed a set of methodologies including:

- Methodology for Preliminary Flood Risk Assessment and the delineation of Areas of Potential Significant Flood Risk;
- Methodologies for Flood Hazard and Risk Assessment;
- Methodologies for Flood Hazard and Risk Mapping;
- Framework Methodology for the Development of Flood Risk Management Plans at the level of the River Basin Administration (including their Programs of Measures);
- Methodology for prioritizing flood risk management measures based on multi-criteria analysis with cost-benefit elements.

During the stocktaking phase, the World Bank assessed these methodologies and their application, analyzing also the report of the EU Commission on Romania's FRMP and the EU audit on the implementation of the EU Floods Directive in Romania. Further, the World Bank team realized a large number of interviews with actors involved in FD implementation, including MEWF, ANAR, the Institute of Hydrology and Water Management (INHGA) and representatives from ANAR's 11 River Basin Administrations (RBA).

While the methodologies in general were developed in accordance with EU Guidance, their application revealed several shortcomings. The level of details of these methodologies was not always consistent and clear and explicit guidelines for their correct application did not exist in all cases. Moreover, the methodologies were not formally adopted.

The accuracy and quality of the FHRM developed with these methodologies were inconsistent. Due to the inadequate method for the selection and appraisal of measures, many Programs of Measures (PoMs) did not clearly identify the high priority measures and did not provide the needed information to facilitate further detailed planning and funding. Consequently, the implementation progress of the FRMP from the first cycle is still very limited.

The following paragraphs provide an overview of the main shortcomings of the methodologies to be improved in the context of this project. A more detailed assessment can be found in Output1 of the RAS, the Report on stocktaking and workplan.

Methodology for Preliminary Flood Risk Assessment (PFRA) and the delineation of Areas of Potential Significant Flood Risks: This method was developed and implemented by INHGA and ANAR during the first cycle of the EU Floods Directive. Based on lessons learned, INHGA and ANAR adjusted the approach and applied it for the second cycle in 2019, prior to the commencement of this Project. The PFRA is not part of the RAS and the method was therefore not assessed in further detail.

Nevertheless, the World Bank highly recommends assessing the application of the method used during the second cycle and consider its adjustment for the third cycle. While the applied method correctly identified Areas with Potential Significant Flood Risk (APSFR) for different flood sources and mechanisms, it also produced APSFR for fluvial floods of different sizes across multiple scales. As the APSFR is a basic unit for assessing flood risks and for reporting to the EU, it would be good to delineate APSFRs of a comparable size.

Methodologies for flood hazard and risk assessment and for developing FHRM: The Romanian national legislation (GD 663/2013) provides basic guidelines for hazard and risk assessment and for developing flood maps, describing necessary steps for the hazard maps (topographical studies, hydrological and hydraulic studies, additional studies, mapping) and the necessary steps for developing the risk maps (e.g. identification of potential affected receptors, assessment of the vulnerability of exposed elements). The law does not provide details regarding the modelling approach, nor the format and quality of required input/output data, the boundary conditions or the necessary steps for calibration and validation of the hydraulic models etc. Further it does not provide any guidance how to integrate climate change in flood hazard and flood risk mapping.

Consequently, during the first cycle of the EU Floods Directive, only hazard maps for fluvial sources (no other flood sources mechanisms and characteristics were reported) that did not include an estimation on the impacts of climate change on future flooding were developed. The modelling and maps were produced using different approaches resulting in products of different accuracy and quality. Substantial additional work was conducted by INHGA and ANAR before being able to report the hazards maps from different RBAs to the EU and before using them for the development of flood risk maps. Mainly due to the lack of detailed exposure data, the flood risk maps developed by INHGA and ANAR were based on a qualitative assessment. As there was only limited data available, there also was no method in place for quantitative risk assessment to be applied on the national scale during the first cycle. Only for the Danube, a quantitative flood risk assessment was realized, in the context of the Danube FLOODRISK project. The qualitative risk assessment has its limits, as it does not provide the required information (damage and loss assessment) for realizing detailed cost-benefit-analysis and hence for informed decision-making on future investments in flood risk management.

Methodologies for the Development of the Flood Risk Management Plans and their Programs of Measures (PoM): In order to develop consistent FRMP in all Units of Management (UoM), Romania produced a Framework Methodology for the Development of the FRMP and their PoM, that included a catalogue of flood risk management measures and methods for the prioritization of measures.

The catalogue was developed based on international best practices. While it provided a good overview of possible measures, it lacked a more detailed description of the different options and their expected impacts on the environment. It also did not clearly define the competent authorities and relevant actors for further planning and implementation.

The methods for the screening and appraisal of measures to be included in the PoM followed the EU Guidance and included a multi-criteria-analysis followed by a cost-benefit-analysis. The objective of the screening was to identify a set of possible measures to tackle the flood risk problems in each APSFR and unit of management (UoM). During this step, potential measures were correctly classified based on their technical feasibility, their impacts on the environment and their social acceptance. Nevertheless, the approach did not allow to screen out unviable measures based on expert judgment at an early stage. This would have decreased the number of measures to be further assessed and led to a more efficient planning process. While the screening included the possibility to earmark measures that would have been excessively expensive, it did not provide a clear benchmark for this parameter.

After the screening, Romania applied their methodology for prioritization of measures, using a Multi-Criteria-Analysis (MCA). The purpose of this step was to assess and prioritize the long list of measures from the screening phase and identify a short list of priority measures to take forward for the Cost-Benefit-Analysis (CBA). The MCA covered all main impacts of measures and devised an objective basis for determining scores for the different impact categories, based on international best practices. Nevertheless, its application failed to achieve its objective of a sensible prioritization as a vast majority of measures were deemed of “high priority”. Further, the MCA process was so onerous and time consuming for ANAR and INHGA to carry out that there was subsequently no time or resources left to do any of the CBAs needed to justify funding of any of the priority measures.

For the CBA, in order to justify schemes and secure funding, the Ministry of European Funds and ANAR developed a good tailored guide[1]. This was soundly based on the EU Guidance on appraisal of investment projects of more than EUR 50 million financed under the EU Cohesion Policy. Unfortunately, ANAR and INHGA had no time or resources left available to systematically and consistently develop or apply this CBA methodology to all the prioritized projects during the first cycle. Thus, no CBAs were done or reported properly in the first FRMP and consequently, the PoMs were inadequate for securing funding.

3. Purpose of the new methodological framework

The development of a new methodological framework, together with the improvement of the knowledge base are of crucial importance for developing improved FHRM and FRMP under the second cycle of the EU Floods Directive and hence an important aspect of the RAS and World Bank’s technical support.

The main purpose of the methodologies is to provide clear guidance to MEWF and ANAR for the development of the FRHM and FRMP. It shall guarantee a consistent approach to the development of the FHRM and FRMP across the country in all UoMs, but also leave flexibility to adjust the approach to regional particularities, for example concerning the availability of data. Instruments and standalone methods of the new framework, such as the damage assessment will also be of use for activities not directly related to the development of the FHRM and FRMP according to the EU Floods Directive and will substantially contribute to strengthen Romania’s capacity in flood risk management in general. While the new methodological framework is developed specifically for the second cycle implementation, it shall also form the base for development of FHRM and FRMP of the third cycle and beyond.

The new framework will enable MEWF and ANAR to correctly implement the EU Floods Directive, while complying to other relevant legislation. The methodologies reflect all the requirements of the EU Floods Directive. Their application will further guarantee for example that Programs of Measures of FRMP are compliant with the Water Framework Directive (2000/60/EC), the Habitat Directive (92/43/EEC) and other relevant national and European environmental legislation. The correct application will also produce the needed information for public consultations and for the implementation of a Strategic Environmental Assessment (2001/42/EC) and develop PoM with the relevant evidence needed to justify funding according to the requirements of different sources (e.g. EU cohesion funds).

The purpose of the new methodologies is also to enhance the quality of the FHRM and FRMP by complementing the existing methods and integrating additional features. Among the improvements

[1] https://sgg.gov.ro/new/wp-content/uploads/2017/09/ANEXA-10.pdf

included in the new framework are the assessment of the hazards deriving from different flood sources, characteristics and mechanisms (e.g. fluvial - the only flood source reported in the first cycle, pluvial floods, coastal floods, dike breach floods and flash floods) as well as the inclusion of climate change in the analysis. The new framework also includes the development of a national flood damage and loss database and a method for quantitative risk assessment. The new methodologies for developing the PoM assess the impacts of potential measures on ecosystems, clearly identifying additional benefits, such as environmental benefits and including them in the appraisal and prioritization process.

4. Development of the new framework

In addition to the thorough assessment of the methodologies used under cycle I, as described in detail in Output 1 and briefly summarized above, **the World Bank Team analyzed international best practices and methodologies used or currently being developed in Europe and globally**. The analysis included a detailed desktop study, as well as, a large number of expert interviews with representatives from flood authorities in other Member States (e.g. Austria, Germany, Poland) and with experts from think tanks and research institutions (e.g. Joint Research Center of the EU, GFZ-Potsdam, Flood Hazard Research Center Middlesex University, International Water Management Institute).

The World Bank Team also assessed in detail the latest developments in other EU Member States as presented and discussed in the Working Group on Floods of the EU Commission. This Working Group was established in the context of the Common Implementation Strategy for the Water Framework Directives. It organizes regular thematic workshops among the Member States to exchange experiences in flood risk management and experiences made with new methodologies for the development of FHRM and FRMP according to the EU Floods Directive[2].

Based on the review of international best practices and considering the existing methodologies, as well as the local conditions and the available resources and capacities, the World Bank Team developed a concept for the new framework and its methodologies. The amount and accuracy of available data, as well as the data still to be produced in the context of the RAS were carefully taken into consideration. The concept was then discussed, reviewed and agreed together with MEWF, ANAR, INHGA and the General Inspectorate for Emergency Situations (IGSU). Further on, the World Bank consulted with JASPERS, the Joint Assistance to Support Projects in European Regions of the European Investment Bank.

The new framework includes all the requirements for the new methodologies as identified already during the planning of the RAS and listed in the RAS Agreement, but proposes a different configuration and set up. Instead of the originally envisaged separate methodologies, as listed below:

a. methodology for the assessment of damages,
b. methodology for the evaluation of flood hazard and risk,
c. revision of catalog of flood risk management measures,
d. methodology to assess the impact of hydrotechnical works on ecosystems,
e. methodology for cost-benefit analysis,
f. methodology for multi-criteria analysis,
g. methodology for the prioritization of measures and projects,

the new framework consists of the following:

[2] Result of the Thematic Workshops of the Working Group documented in the CIRCABC Library, https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp

(i) Methodology for Hazard Modelling and Mapping, corresponding to (b) of the former configuration
(ii) Methodology for Flood Damage and Loss Assessment, corresponding to (a) of the former configuration
(iii) Methodology for Risk Maps, corresponding to (b) of the former configuration
(iv) Methodology for Developing Programs of Measures, corresponding to points (c) to (g) of the former configuration

The next chapter of this report provides an overview of the new framework and shows how the Methodology for Developing Programs of Measures, includes a new catalogue of measures, a way to assess the impact of measures and hydrotechnical works on ecosystems and a comprehensive approach to the identification and appraisal of measures and integrated projects using multi-criteria analysis and cost-benefit analysis.

Once the concept had been agreed upon with MEWF, ANAR, INHGA and IGSU, the World Bank developed terms of references for the preparation of the new methodologies, indicating in detail the scope of work, activities, timeline and the expected preliminary and final results.

The work on the new methodologies included a large number of interviews, workshops and meetings between the extended World Bank team, Romanian authorities and other relevant stakeholders. Inception reports, intermediate results and the draft final products were discussed intensively with MEWF, ANAR and INHGA. The many contributions from the different actors were assessed and then integrated in the new methodologies, resulting in a comprehensive set of methodologies, adapted to the Romanian situation and improving the existing methodologies from the first cycle.

5. Overview of the new methodological framework:

As mentioned before, the new methodological framework includes four methodologies that will be briefly described in this section. The full methodologies can be found in the annex of this report.

The first methodology to be applied is the Flood Hazard Modelling and Mapping methodology that constitutes a sound framework to assess flood hazards for fluvial floods, pluvial floods, flash floods, dike breaches and coastal flooding, incorporating climate change and providing guidance to create standard maps for all the flood sources, characteristics and mechanisms. As a result of applying this methodology the draft Flood Hazard Maps will be created.

The new methodological framework also includes a Methodology for Flood Damage and Loss Assessment and Risk Mapping, including the development of a national damage and loss database. Together with the new exposure dataset, that is being developed in the context of the RAS (Output3), this will allow Romania to realize a full damage assessment and hence a quantitative risk assessment, an important input for the prioritization and justification of investments in flood risk management.

This methodology also describes the process to develop flood risk maps, based on the flood hazard maps. This includes determining the total damage for different flood types for 5 return periods, calculating the Expected Annual Damage (EAD) and the Annual Potential Loss of Life and then mapping these results at a predefined scale and with predefined consistent color systems and legends. The draft Flood Risk Maps will be created as a result of applying this methodology.

The Methodology for the Development of the Programs of Measures includes a new catalogue of measures and methods for the identification, packaging, screening and appraisal of potential flood risk measures. It provides guidance on the development of flood risk strategies at the APSFR level, helps to identify and further assess integrated projects at catchment levels and supports in the consolidation of the most promising measures and integrated projects into programs of measures at the level of river basins. Finally, the FRMP will be drafted as a result of applying this methodology.

The following sub-sections provide a short summary of each of the newly developed methodologies. Section 5.e further provides an explanation on the impact of hydrotechnical works on ecosystems, and how the impact of new potential measures on the environment is being assessed, when applying the new Methodology for Developing Programs of Measures.

a) Methodology for Flood Hazard Modelling and Mapping

The Flood Hazard modelling and mapping methodology provides a solid and sound framework to calculate and map flood hazards for different flood sources, mechanisms and characteristics incorporating climate change and using the best practices in Europe and beyond. The methodology establishes a step by step approach for calculating the hazards and mapping fluvial floods, flash floods, pluvial floods in urban areas, dike breaches and coastal flooding. Note that this methodology does not include the calculation of the necessary hydrological inputs as this is full responsibility of INHGA, however brief references are made in this document. Overarching principles of the methodology are:

- Number of Annual Exceedance Probabilities (AEPs): five annual exceedance probabilities should be defined based on the FD and Expected Annual Damage calculations requirements. These probabilities are 33%, 10%, 1%, 0.5%, 0.1% and climate change will be applied on 1%. Note that only three probabilities are to be reported to the EC and four to be mapped;
- Modelling outputs: the main modelling outputs should be selected considering the main drivers of damages. These are the maximum floodwater depth, extents and velocities and, in some cases, the rise rate and the duration;
- Modelling approaches: the framework provides two approaches for two levels of data availability to be applied in Romania to adapt to the local specificities and proposes detailed approaches to be applied in this cycle and/or next cycles: Tier 1 (detailed approach - detailed data is available or would be available in the future) and Tier 2 (simple approach – no detailed data is available);
- Use of license software: Romanian stakeholders required that the modelling software to be used under the second cycle of the FD should be mainly free licensed. The widest used free license software for hydraulic modelling in Romania is HEC-RAS, a good candidate to be used under the second cycle of the FD. Note that if model results are strongly affected by software limitations and resources are available to use commercial software, the use of the last option could be recommended to obtain more accurate model results. The WB team did a thorough review of the available license free software, highlighting the advantages and disadvantages of them. A complete overview of the available free licenses software in the market is available in the Annex 1.1 of this document, jointly with a comparison of free license and commercial software results in two pilot locations in Romania in the Annex 1.2;
- Compound flooding: in this cycle of FD implementation the flood sources will be treated separately and modelled independently as the compound flooding approach is complex and data

and modelling intensive. However, this approach could be considered for the future cycles when more data becomes available.

As mentioned before, a set of general steps has been defined to guide the modeler to consistently implement the framework in the whole country without any deviation for fluvial floods, flash floods, pluvial floods in urban areas, dike breaches and coastal flooding. These steps will guide the modeler in the model definition and setup, simulations, uncertainty analysis, post processing of results and hazard mapping. A brief general description of what each of the steps entail is provided below:

1. Model domain: the model domain should be defined considering where hazard results are required e.g. APSFR;
2. Boundary conditions: the conditions outside the model domain need to be defined, as rivers are continuous systems flowing from the head waters to the sea. The conditions should be established both in upstream and downstream boundaries. Both boundaries depend on the type of flood source, characteristic and mechanism. For example, the upstream boundary of a fluvial ASPFR could be an inflow hydrograph and lateral inflow from tributaries and a water level for the downstream boundary condition. On the contrary, the boundary conditions for a pluvial APSFR in urban area are a hyetograph and a water level at the end of the model domain downstream;
3. Relevant data: all necessary data need to be collated and processed to be ingested into the model. The accuracy of the model results is linked to the data resolution and accuracy. Some of the data types relevant for this methodology and flood sources are DTM, building footprints, cross sections, bathymetry, bridges, culverts, weirs, dams, IDF curves, etc.;
4. Hydraulic modelling approach: a two-Tier approach is envisaged to account for the available and future data granularity: Tier 1 (detailed approach - detailed data is available or would be available in the future) and Tier 2 (simple approach – no detailed data is available). The decision of using one approach or the other should be based on the current data availability and the resources accessible. For both approaches different options of hydraulic modelling could be used such as 1D, 1D quasi-2D, 1D-2D and 2D hydraulic models. Note that if results could be achieved with 1D or 2D the 1D-2D approach is not recommended;
5. Model schematics: this should be decided based on the approach (tier) and the type of the hydraulic modelling and the physical characteristics of the APSFR. For example, for the 2D model schematization mainly the grid type and the resolution, the representation of features within the DTM and the roughness coefficient are essential. Other items that are important for the model schematization are cross sections (spacing, location, orientation, etc.) and the representation of structures (bridges, culverts, weirs, dams, etc.) and others;
6. Calibrate and validate/verify: the hydraulic models should be calibrated and validated and/or verified where possible with the available data. At least three historic events should be used to calibrate if available and one to validate to check that the model has not been overly calibrated. If no data is available for calibration, a reality check should be conducted with any available data such as flood marks, satellite mapping, orthophotos with flood extent, etc.
7. Run AEPs: the hydraulic model will be run for 5 AEPs and for 1% plus climate change. Climate change is integrated in different ways depending on the flood source, e.g. an increase for peak discharge, rainfall and sea level rise, etc.
8. Uncertainty analysis: A pragmatic approach is adopted in this methodology to derive uncertainty buffers conducting sensitivity tests increasing and decreasing variables such as roughness,

boundary conditions, initial water levels in storages and dams, etc. The results on the sensitivity test could be translated into a bound in the hazard map to be used by experts as uncertainty bound;

9. Postprocessing results: as mentioned before the modelling results to be provided are the maximum floodwater depth, extents and velocities and, in some cases, the rise rate and the duration. For example, floodwater depth could be a raster file for 2D modelling and an average maximum depth across the whole of the 1D cross-section or storage area. These results should be calculated and postprocessed if needed to be finally mapped and as well as used for the risk mapping. Additional results could be calculated and provided such as tabular results, etc.;
10. Produce Flood Hazard Maps: all flood sources should be mapped in the same way and following the standards set in the mapping guidelines.

A detailed description of the step by step approach for the two levels of modelling for fluvial flood, flash floods, pluvial floods, dike breaches and coastal flooding is included in the Annex 1.

The proposed approaches for Tier 1 and Tier 2 for the different flood sources, characteristics and mechanisms including climate change are listed below. The selection of the tier should be made depending on the data available, size of the river/APSFR and the use of commercial or free modelling software depending on the resources available:

- Fluvial flooding:
  - Tier 1a: two dimensional (2D) hydraulic modelling approach;
  - Tier 1b: 1D-2D hydraulic modelling approach;
  - Tier 2: 1D dimensional modelling approach;
  - Climate change: based on INHGA's study on climate change impact on flows, three regions are defined for 2050 horizon: a region with no change in flows, a region with moderate change in flow applying a 1.1. increase coefficient and a region with significant flow change applying a 1.2 increase coefficient.
- Pluvial flooding:
  - Tier 1: two-dimensional model (2D) with a grid size between 2x2 and 5x5 m^2;
  - Tier 2a: two-dimensional model (2D) with a grid size about 5x5 m^2;
  - Tier 2b: two-dimensional model (2D) with a grid size about for building area 5x5 m^2 for building area and 20x20 m^2 for green areas;
  - Climate change: increase the peak design rainfall by 20%.
- Flash flooding: to be applied for catchments smaller than 10 km^2, for bigger catchments fluvial floods methodology would be applied:
  - Tier 1a: Fully hydrodynamic 2D hydraulic free model solving the full shallow water equations using flexible and fine mesh with the possibility of GPU usage;
  - Tier 1b: 2D hydraulic model solving the shallow waters equations together with details of structures and buildings included in the DTM with a grid size with an average of 5 m^2;
  - Tier 2: 2D hydraulic model solving the shallow water equations together with details of structures and buildings included in the DTM with a grid size with an average of 25 m^2;
  - Climate change: based on the INHGA study on climate change impact on flows, three regions are defined for 2050 horizon: a region with no change in flows, a region with moderate change in flow applying a 1.1. increase coefficient and a region with significant flow change applying a 1.2 increase coefficient.

- Dike Breaches:
    - Tier 1: derive fragility curves and apply probabilistic approach;
    - Tier 2: breach values are assumed based on published guidance.
- Coastal flooding:
    - Tier 1: simplified joint probabilistic approach, wave transformation, overtopping and inundation modelling;
    - Tier 2: extreme sea level projection method;
    - Climate change: 2mm/year sea level rise and wave heights to be increased by 20%.

b) Flood damage assessment and the development of a damage and loss database

The damage and loss methodology aims at determining the estimated aggregated national potential economic losses caused by large scale Romanian flooding. In this methodology, two approaches are distinguished:

1. **Damage and Loss assessment:** The total damage comprises the sum of four subcomponents: (1) direct tangible, (2) indirect tangible, (3) direct intangible, and (4) indirect intangible damages.
2. **Impact assessment:** Determining the adverse effects of flooding on the society in general: human health, cultural heritage, the environment and economic activities. This is based on part-quantification and narrative rather than full quantification.

The first of these is shown below:

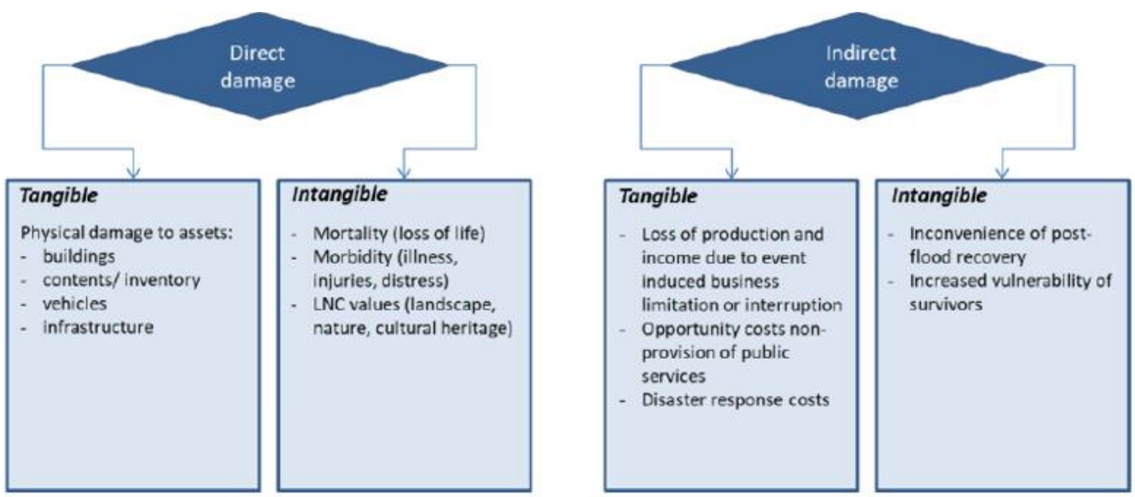

Figure 1: Damages classes, Methodology for Flood Damage & Loss Assessment and Risk Mapping

The methodology operates by (1) assessing **maximum damage values** for each typology (e.g. a residential dwelling; an urban office building) and (2) applying a **percentage susceptibility to damage (%)** at each potential flood depth at the property, forming (3) a **depth/damage curve**. For the maximum damage values the following data is used:

- Estimated construction costs of the Order of Romanian Architects (2019).
- Maximum damage values from international literature. The primary sources are MCM (Multi-Colored Manual for Flood Risk Assessment, UK), HAZUS (USA) and SSM (Flood Damage Modell from the Netherlands) corrected based on GDP/PP to match the Romanian setting.

The susceptibility data is based on international literature plus local expertise and judgements (building and flooding specialists, etc.).

This methodology (with its maximum damage values and depth damage curves) offers a hybrid solution for damage modelling at three levels of detail. These use **land use** and an **object-based model**, the latter having a higher level of detail and more typologies. The methodology thereby has:

- ***Level 1***. Uses **land use** based for example Corine Land Cover (CLC), BEAM and Open Street Map (OSM).
- ***Level 2***. The level 2 damage model is **a combination** of CLC from Level 1 and the land-use typology of the Urban Atlas available for 24 regions in Romania.
- ***Level 3***. Level three is the **object-based** method. The typologies in this level are the existing assets in Romania, based in the first instance on existing exposure data and later on the dataset being developed in context of the RAS.

The process of aggregation between levels is shown here for a sample of depth/damage curves (here the aggregation between **level 2**, below, and **level 1,** above).

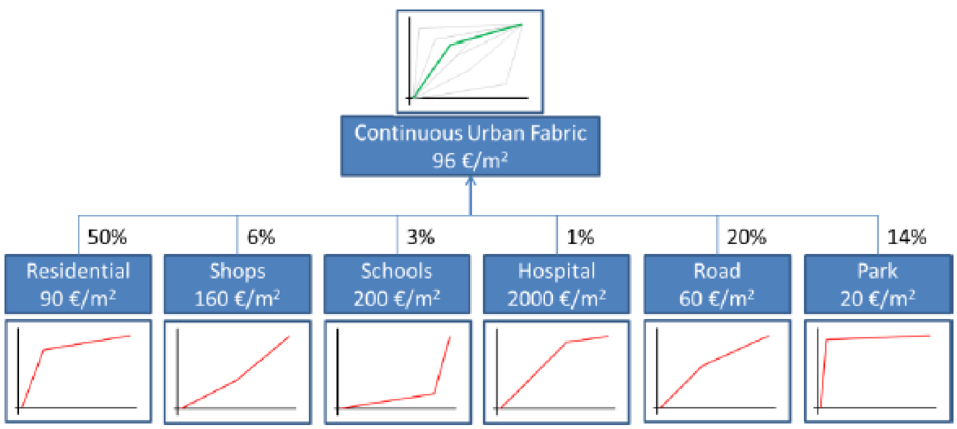

Figure 2: Example for the aggregation of objective based level to land use based level damage modelling

For intangible damages and losses (direct and indirect) the methodology assesses the potential loss of life (mortality) and injuries (morbidity), monetized based on Romanian and appropriate international data. The values herefore are yet to be determined to be used with this methodology. The proposal for loss of life is:

1. To use an adapted approach (based on **Jonkman**) for coastal and fluvial flooding. The approach has a strong empirical basis.
2. For pluvial and flash flooding to use the pluvial approach of the **SUFRI** method based on depth, velocity, sliding and dragging values; this fits the nature of these types of flooding and expected mechanisms leading to loss of life in Romania.

In line with best international practices, mortality rates should be applied (using this two-strand methodology) to the potential population at risk. This is the population exposed to flooding at the onset of flooding, and likely evacuations should be taken into account to determine the effective number of people at risk. Morbidity is calculated using a mortality vs. morbidity ratio (from international literature). The expected number of people with injuries is then determined using a similar approach as that for determining the expected number of casualties. The number of people suffering from mental health effects (indirect intangible damage) is determined as a fraction of the population at risk (again based on international literature).

The results will serve as input to evaluating the Program of Measures (i.e. in the multi criteria analysis and the cost benefit analysis) to determine their priorities and economic efficiency. Steps within the application of the methodology will include:

1. Create, maintain and improve the available exposure, hazard, and population data, and the depth/damage curves and ratio factors, gauging their estimated accuracy.
2. For each selected Romanian flood risk location (e.g. river basin or APSFR), for at least 5 return periods:
    a. Use exposed elements, hazard maps, damage curves and various ratio factors to assess total tangible and annual average damages. Apply appropriate monetary values from the flood damage and loss database.
    b. Use population maps, hazard maps, data on potential loss of life, mortality/morbidity ratios, etc. to assess total and annual average intangible damage/losses. Apply appropriate monetary values.
3. Inspect the results to spot issues in input data and, if any, then improve the input data where there is least estimated accuracy. Recompute the above results. When these results have been quality checked, assess and record the estimated accuracy of both input and output data.

c) Methodology for Developing Flood Risk Maps

The annual expected value of potential flood damage/loss is the basis for the risk mapping. This is derived as indicated below as the area under a graph of damage/losses against probabilities of occurrence. These curves have not been completed yet but will be available for the use of this methodology.

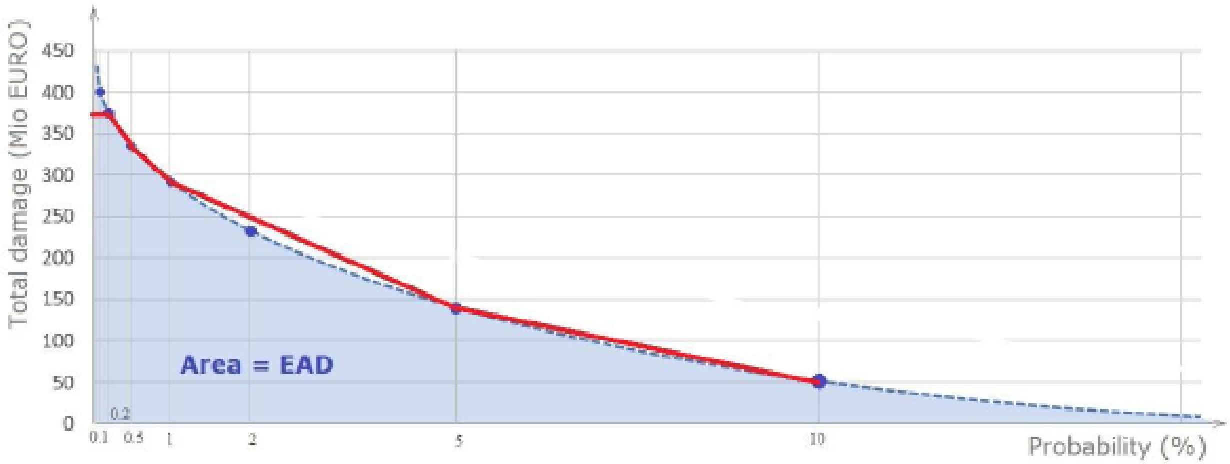

Figure 3: Total flood damage for different probabilities to determine the Expected Annual Damage, Methodology for Flood Damage & Loss Assessment and Risk Mapping

Major steps within the Flood Risk maps methodology include the following:

1. Determine the total damage for each flood type (fluvial, pluvial, dike breach, coastal and flash flooding) and each of 5 return periods (e.g. 3, 10,50, 100, 1000 years);
2. Determine the Expected Annual Damage (EAD) and the Annual Potential Loss of Life (PLL) for each flood type;
3. Map the results at agreed resolutions and consistent color systems;
4. Create metadata & describe the process and accuracy for all input and output data.

The outcome should be at least:

- Summed annual expected damage for the flooded area and maps with the spatial distribution of the annual expected damage [per grid cell] (see map below). This is for the total damage and the four subcomponents: (1) direct tangible, (2) indirect tangible, (3) direct intangible, and (4) indirect intangible damage.
- Summed annual expected value for the flooded area and a map with the spatial distribution of the annual expected value [per grid cell] of the population at risk, number of casualties, number of injuries and number of people suffering from mental health issues.
- A map with the spatial distribution of the annual expected value [per grid cell] of the mortality (indicating the probability of loss of life).
- When relevant, the above listed output should be generated for the various different types of flooding (fluvial, pluvial, dike breach, coastal, flash flooding).

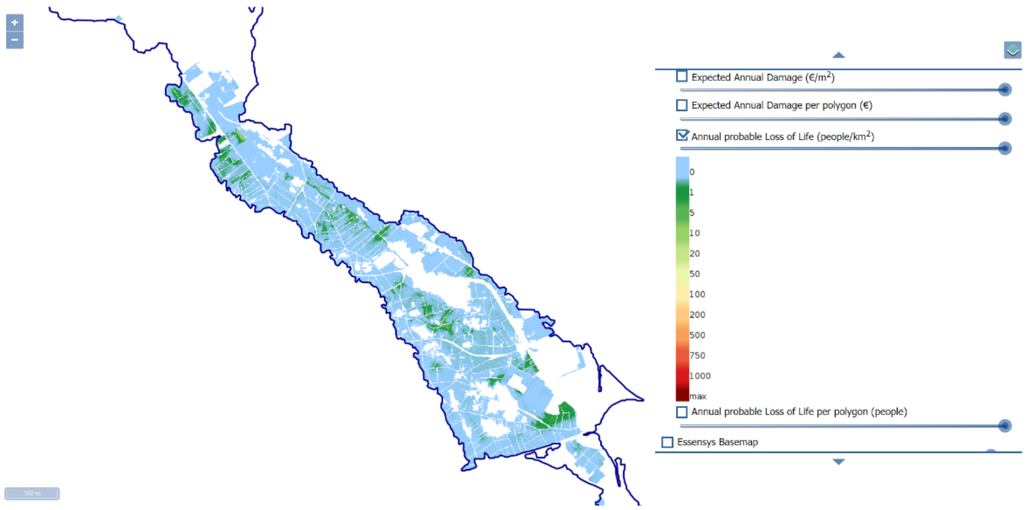

Figure 4: Example for a flood risk map, Methodology for Flood Damage & Loss Assessment and Risk Mapping

A pilot testing of the methodology has been undertaken (for Dâmbu River) but at this stage with ‘dummy’ flood damage and loss data. The results show that the urban areas as well as the infrastructure contribute significantly to the overall damage; the contribution from agriculture appears to be minimal.

A detailed description of these steps and of the pilot studies can be found in the Methodology for Flood Damage & Loss assessment and Flood Risk Mapping (Annex 2).

d) Methodology for Developing Programs of Measures

The PoM methodology aims to provide a systematic, consistent and rigorous method of arriving at Programs of Measures for Flood Risk Management Plans with effective and efficient measures that could actually be funded and implemented. It is comprised of the following elements:

1. A Catalogue of Measures and Fact Sheets describing selected measures;
2. Guidelines for the delineation of Appraisal Flood Units (AFU);
3. Packaging and screening of possible measures at AFU level;
4. Prioritization of feasible measures through a Multi-criteria Analysis (MCA) and a simple Cost-Benefit-Analysis (CBA) at APSFR level;
5. Checks, Robustness tests and further assessments including a full CBA of the selected top projects in order to come up with draft programs of measures for each FRMP.

The following figure provides a schematic overview of the entire process:

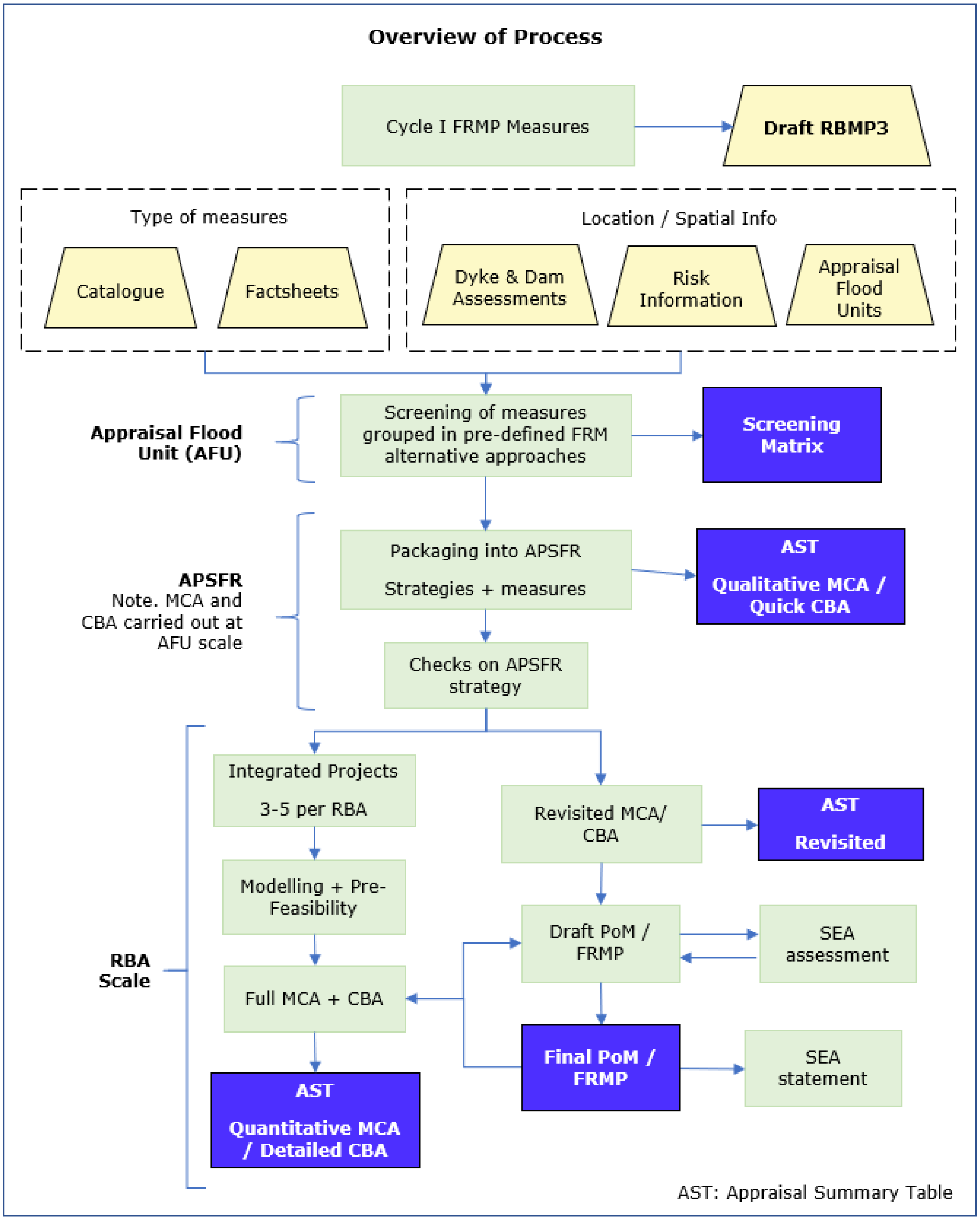

Figure 5: Overarching methodological process for the Program of Measures, Methodology for Developing PoM

Annex 3 to this report provides a description of the overall methodology, as well as a detailed manual for the use of the Multi-Criteria-Analysis and the Cost-Benefit-Analysis using the Appraisal Summary Table. This tool has been developed using Microsoft Excel and can be found in Annex 3.4. The Catalogue of measures can be found in Annex 3.1, the factsheets in Annex 3.2 and the Guidelines for the delineation of AFU in Annex 3.3.

Catalogue of Measures and Factsheets

The new Catalogue of Measures has been developed based on the existing catalogue and following EU Guidance. It provides a comprehensive list of the following categories of possible measures that can be used individually or in combination with other measures to manage flood risks in Romania:

- Prevention;
- Protection;
- Preparedness;
- Recovery and Review.

For each of the 65 listed measures, this identifies the flood sources and characteristics that can be managed by it; the Responsible Authority and the Level of application. Some of the measures are to be applied at a national level (e.g. land use planning policies to avoid new risks) but most are to be applied at regional or local level.

For 24 prioritized measures, selected because of their contribution to reduce flood risks, separate fact sheets with the following additional information have been prepared:

- Description and expected outcome;
- A typical photograph;
- A scheme to show if the measure addresses flood sources, pathways or receptors;
- Potential to deliver different multi-functional benefits (green infrastructure);
- Potential impacts on water bodies according to the Water Framework Directive (2000/60/EC), possible mitigation and requirement for a potential Article 4.7 process at the project level;
- Potential impacts from the measures according to the Habitats Directive (92/43/EEC);
- Possible funding sources and responsible authorities for delivery of the measure;
- Information on possible other complementary measures;
- Size, spatial scale and potential reduction in flood risk and time horizon for realization.

Delineation of Appraisal Flood Units

The defined and reported APSFRs of the second cycle (in particular the fluvial APSFRs) in many cases cover large areas and long river stretches. These large APSFRs cannot be used as a basic unit for the identification and appraisal of possible measures and therefore must be further be subdivided into so-called Appraisal Flood Units (AFUs). This task can be realized based on readily available data and local expert judgement. The guidelines for the Delineation of AFU provide a step by step approach for ANAR and its River Basin Administrations to implement this task with the support of the World Bank.

Packaging and screening of possible measures at AFU level

The purpose of screening is to eliminate unviable measures and create a short list of measures that are appropriate for managing flood risk at relevant spatial scales. A preparatory step of the screening is the identification of possible structural measures, that were already proposed in the first cycle FRMP. These have to be reported to ANAR's team working on the implementation of the WFD.

Initiating the screening, and in order to reduce the effort required, the measures from the catalogue will be grouped into pre-defined flood risk management alternatives. These have been defined by grouping measures which reduce flood risk through a similar approach (e.g. adapting existing infrastructure, attenuating upstream flow or runoff, diverting flow, containing flood level, preparing and responding to floods). The alternatives are:

- FRM Alternative 1: Re-purpose of existing non-flood management infrastructure;
- FRM Alternative 2: Catchment scale and disperse actions to reduce flow downstream;
- FRM Alternative 3: Inline storage on main watercourses or tributaries to reduce flow downstream;
- FRM Alternative 4: Diversion of flow around and away from risk areas;
- FRM Alternative 5: Improved conveyance of flow;
- FRM Alternative 6: Refurbish or enhance defenses to achieve standard of protection;
- FRM Alternative 7: Containment of flood level;
- FRM Alternative 8: Containment of flood level with other options;
- FRM Alternative 9: Flood resilience, preparedness, and emergency response.

Some measures feature in more than one alternative. While the approaches focus on fluvial flood risks, the above-mentioned alternatives in many cases also apply for pluvial flood risks (including flash floods). Where not, the methodology proposes a specific tailor-made approach to address pluvial flood risks. For coastal flood risks, three typically coastal oriented alternatives have been defined: hold the line, realignment and walk away.

Based on readily available information, including the assessment of existing flood management infrastructure, dam and dike conditions, the different alternatives for each AFU will be compared against predefined baseline situations. The screening of the different alternatives has the following steps:

I. **Technical** to check that it is technically feasible
II. **Economic** to identify any impacts on economic activity and to estimate initial costs and benefits of the measure and derive its indicative Benefit-Cost ratio (BCR).
III. **Social** to identify any impacts on communities **and cultural** to identify any impacts on cultural heritage assets so as to flag potential issues.
IV. **Environmental** to identify any possible impacts on water body states (with respect to the Water Framework Directive) or Natura 2000 sites (with respect to the Habitats Directive) so as to prompt search for alternatives and/or mitigation measures that will need to be carefully considered and costed in the MCA prioritization and CBA. This may prompt the need to consider assessments for potential exemption under article 4.7 of the WFD.

The screening will be documented with a simple summary table of the results (++, +, neutral, -, -- or?) with supplementary comments. The findings shall be discussed and agreed with relevant stakeholders to identify a list of at least 3 feasible and potentially viable alternative strategies for each AFU.

Prioritization of feasible measures through a Multi-criteria Analysis (MCA) and a simple Cost-Benefit-Analysis (CBA) at AFPSR level

Using the Appraisal Summary Table (AST) the impacts and costs of the alternative strategy identified for the AFUs during the screening can be systematically assessed with either qualitative, quantitative or monetary measures depending on the availability of data. This will be done using a set of criteria, including social, environmental, economic, cultural and technical aspects. The specific weight of the different criteria is still to be defined by MEWF and ANAR during the process of setting the overall objectives of the FRMP.

All AFU alternatives within an APSFR are brought forwards for packaging into APSFR Strategies at catchment scale. At this point, the results from the modelling of the flood hazard and flood risks for the second cycle FHRM will become available. These will help to refine the damage and risk assessment information to better identify the potential flood benefits of the different alternatives.

The performance of the APSFR Strategies at catchment scale is to be appraised through qualitative MCA for at least three different alternatives (including the baseline). A simple CBA is carried out to ensure the alternatives are economically viable. The MCA and simple CBA is to be carried out for each AFU. This is because the AFUs have been defined so that small scale local significant impacts are not diluted within a larger scale APSFR. In this way, we will be able to identify significant impacts, such as deterioration of WFD Waterbody status, that might have not been captured within an MCA of some of the longer APSFRs with multiple AFUs.

As a result of this stage at least three alternative APSFR Strategies at catchment scale have been developed with a description of the spatial extent, type and scale of measures. The strategies should include resilience, preparedness and emergency response measures for the AFUs where the APSFR measures are unable to offer the full target standard or protection. Each alternative will be documented in the AST and be assigned the following indicators:

- MCA score (weighted) for each category (Social, Economic, Environmental, Cultural and Technical aspects);
- Annualized costs in €million;
- Total MCA score (weighted) / annualized cost;
- Ranking of alternative MCA score (weighted) / annualized cost scores;
- Incremental MCA benefits / costs and cost of additional unit of benefit, to test the incremental (or additional) benefit for each more costly alternative;
- BCR and Net Present Value (NPV) through a quick CBA.

Further, the AST has a Summary-MCA tab that enables the analyst to review the sensitivity of ranking of alternatives to:

- The weighting of relative importance of categories;
- Worst-case and best-case cost estimates and pessimistic and optimistic MCA scoring;
- The increase in costs of the highest-ranking alternative required for the 2nd ranking to be equal highest rank;
- The number of criteria where the highest-ranking alternative scores lower than the 2nd ranking alternative.

These sensitivity tests will identify where, and how assumptions in the appraisal could affect the decision to select one alternative above another. The appraisal also allows the analyst to review and improve the alternatives. The highest performing (ideally the top two) APSFR alternative packages of measures should be considered in the next stage of the process. The alternatives are to be retained for the SEA assessment, and if necessary WFD and Habitats Directive assessments.

This stage will further produce valuable relevant information for the parallel process of the Strategic Environmental Assessment realized by MEWF. The methodology also provides guidance at when to involve relevant stakeholders in the process of developing the APSFR strategies at catchment scale.

Checks, Robustness tests and further assessments including a full CBA of the selected top projects in order to come up with draft programs of measures for each FRMP.

At this stage the methodology translates the alternatives developed at APSFR level into programs of measures at the level of UoMs. Further, integrated projects with a catchment approach to managing flood risk will be identified and assessed in more detail. These projects will tend to have a high inclusion of blue and green infrastructure, significant biodiversity gains and restoration of geomorphic processes. If needed, also grey infrastructure, in particular for protecting urban areas can be included.

For the purpose of developing the PoM, the highest-ranking strategies at APSFR level will be subject to checks for funding source availability, climate change adaptation and compliance with the WFD and Habitats Directive. Integrated projects will be identified by selecting and potentially further grouping APSFR Strategies at catchment level within an RBA. They may not need to be geographically connected and will eventually include a full range of different types of measures.

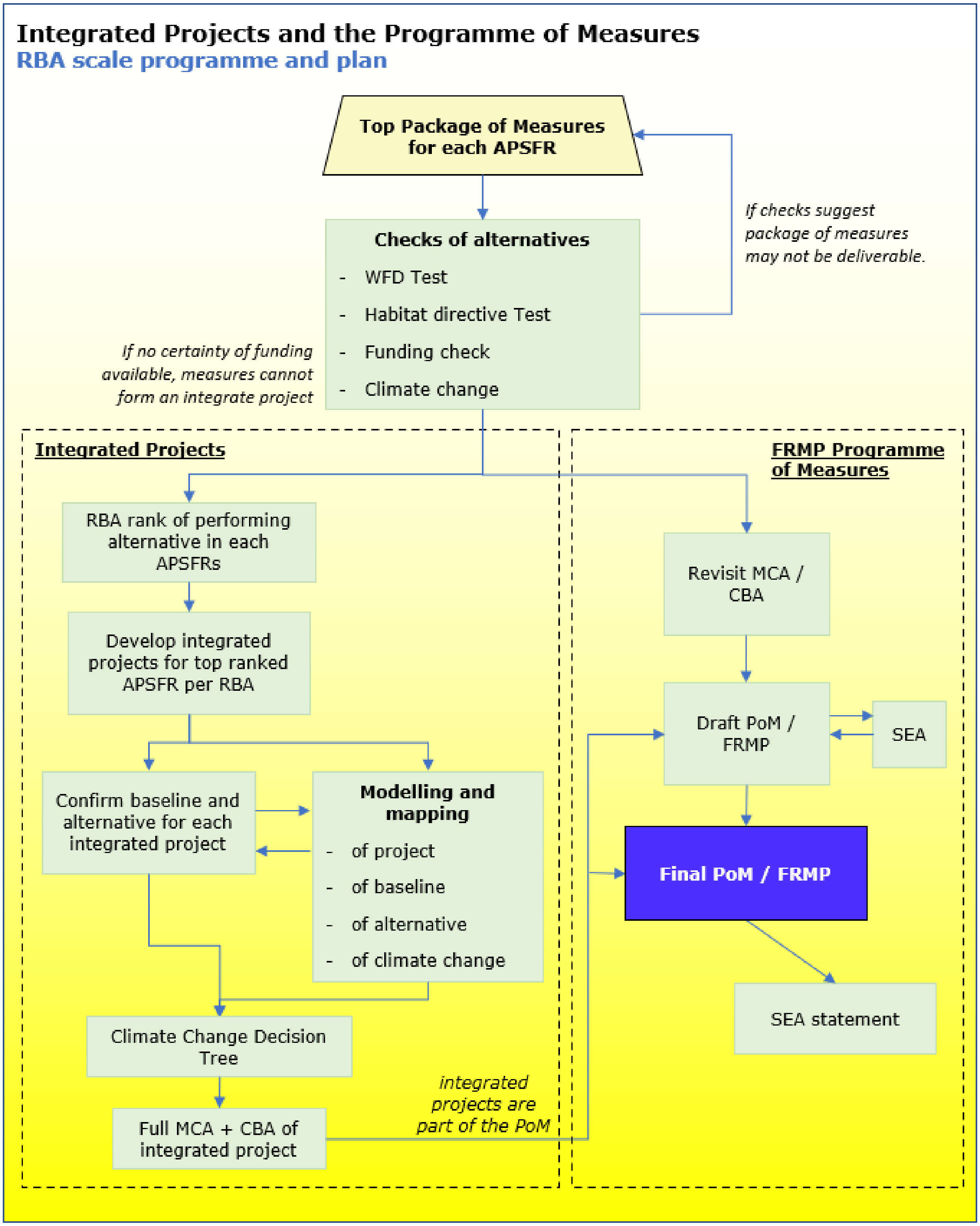

Figure 6: Identifying integrated projects and Programs of measures, Methodology for the Development of Programs of Measures

Identified integrated projects will be subject to further assessment, including additional modelling and mapping of the flood risks, a decision tree analysis, and then a full quantitative and detailed CBA where data is available. These decision tree analyses are aimed at evaluating future uncertainty. In other words, they will allow us to understand the performance of a decision made now under possible future flood risk conditions considering climate change and the influence of the initial decision on how these measures can be adapted to respond to future flood risk.

The draft Program of Measures is to include the Integrated Projects and the top performing APSFR Strategies for areas not covered within an Integrated Project for each APSFR or AFU in the RBA. The PoM will include a review of the MCA and CBA and then collation into the draft PoM and draft FRMP. This is subject to SEA Assessment. After statutory consultation the final PoM and final FRMP is produced and the SEA Statement prepared.

e) Assessing the impact of hydrotechnical works on ecosystem using the Methodology for PoM

The PoM Methodology developed includes all relevant mechanisms needed to assess potential impacts of flood protection measures on the environment with all its relevant components such as ecosystems on FRMP level. This covers potential impacts of hydrotechnical works, generally treated as grey infrastructure, as well as of Natural Water Retention Measures (NWRM) or Nature Based Solutions (NBS), so called green infrastructure, that might also lead to adverse impacts on the environment. Therefore, the methodology takes all flood protection measures from the Catalogue of Measures and their potential impacts into account.

Flood protection measures tend to have impacts on water bodies and aquatic ecosystems. Hence, the methodology and its instruments focus on the requirements of the Water Framework Directive and its objectives. Nevertheless, the potential effects on semi-aquatic and terrestrial ecosystems need to also be considered. The Habitats Directive and related objectives for Natura 2000 areas within the potential floodplains are one specific example out of those.

Catalogue of Measures and Factsheets

The Factsheets describe and classify potential key impacts of important flood protection measures on the environment on a generalized level. The aim of this instrument is to deliver standardized basic information for deriving opportunities for multiple benefits from measures as well as for assessing potential adverse impacts of measures. The focus is on water related factors such as objectives and quality elements according to WFD including examples of mitigation measures and indications for possible Art 4(7) tests. Furthermore, potential impacts on other environmental factors such as biodiversity, Natura 2000 and landscape and aesthetics are classified. Size and spatial scale of measures deliver additional information for comprehensive assessments of potential impacts from measures on environment.

Screening of potential measures

As a preparatory step of the screening, all already identified structural measures with potential adverse effects on WFD objectives will be listed and reported to ANAR's team developing the third cycle River Basin Management Plans. This pre-screening includes the review of the first cycle FRMP measures and any other ongoing projects in planning or implementation.

Within the screening for the new FRMP, all viable measures will be checked upon their potential impacts (positive and negative) on the objectives of WFD and Habitats Directive. This could be for instance the ecological status of natural water bodies or the ecological potential of heavily modified surface water bodies. Potential effects will be screened within the AFUs as well as upstream and downstream across the catchment if relevant for a certain measure. Especially within river systems, the ecological continuum is key for comprehensive appraisal applications.

The Factsheets are the basis within the methodology used as a starting point for the qualitative appraisal of measures within the screening. A simple summary table of the environmental screening results with supplementary comments serves as basis for integrating the results into the process. Based on this, measures with significant adverse impacts could already be adapted or replaced by other measures with less impacts but same flood protection benefits. If a possible Art. 4(7) test according to WFD is likely to be expected for a specific measure, this could be avoided by selecting an alternative. Overall, the environmental screening delivers one key step to arrive at a revised shortlist of potentially viable measures, which will be combined to define alternatives and assess those to determine at least the top 3 ranked alternatives per AFU.

Besides, the environmental screening provides basic information for WFD and Habitats Directive related aspects within preparatory notes on AFU level feeding into the SEA process that will be undertaken in parallel. Vice versa, basic knowledge from the SEA process (e.g. the SEA objectives) can already be considered during the screening, as this shall be provided beforehand.

Prioritization of feasible measures at APSFR level (Multi-criteria Analysis, MCA)

Using the Appraisal Summary Table (AST) the environmental impacts of the alternatives identified for the AFUs during the screening will be systematically assessed in a qualitative or quantitative manner depending on the availability of data. While the assessment of potential impacts requires more specific knowledge and data of the AFU, APSFR and the catchment at this stage, the results from the screening as well as the generalized information from the Factsheets deliver supporting information for this step. The environmental criteria within the MCA can take a key role for packing and refining sustainable APSFR Strategies at catchment scale depending on frame conditions and deliver the basis for a quantitative assessment of the likely environmental impacts for the refined alternatives. The appraisal is to be carried out for each AFU so that potential significant adverse impacts e.g. on biological quality elements such as fish will not be diluted by this larger scale at APSFR level.

The environmental assessment also provides detailed information within preparatory notes and reports on AFU/APSFR level to feed into the SEA process. All relevant knowledge and data from the SEA process possible to be delivered will be integrated in the assessment.

APSFR Strategies at river basin level, FRMP Program of Measures and Integrated projects

The iterative assessments of potential environmental impacts from measures enable to identify effective and efficient APSFR Strategies at river basin level, that are likely to impact the environment, its ecosystems, habitats and species as less as possible. Therefore, the Program of Measures is likely to pass the SEA process successfully and end with a positive SEA Statement. At the same time, the methodology focusses on opportunities for multiple benefits on the environment that provides a key role to determine the integrated projects. This enables to access additional funding sources such as the EU Life Program for green infrastructure measures.

6. Application of the methodological framework

The methodological framework presented here was developed to provide guidance for the preparation of the Flood Hazard and Risk Maps and Programs of Measures of the second cycle Flood Risk Management Plans. The methodologies outline the needed steps for flood hazard and risk modelling, for the visualization of the results in maps, for the identification, packaging and prioritization of flood risk management measures and ultimately for the development of programs of measures, all in line with the EU Floods Directive.

Qualified experts with different areas of expertise are required to correctly implement the different instruments to achieve the final outputs (FHRM and FRMP). While the general approach is clearly defined, intermediate steps of some of the methods might need to be adjusted, for example due to constraints in timing, the unavailability of certain data products or additional information obtained or available resources to implement it.

The competent authorities for the application of this methodological framework are the Ministry of Environment, Waters and Forests, ANAR and its 11 River Basin Administrations and INHGA. As the scope of work outgoes the available human resources and expertise of the Romanian authorities, external consultants have to be contracted to support in the application of these methodologies.

In the context of the RAS, the World Bank will provide support for the application of these methodologies to develop the second cycle FHRM and FRMP. This will also include extensive training to professionals of MEWF, ANAR and its RBA and INHGA. This way the RAS will also contribute to sustainably strengthening Romania’s capacities for flood risk management beyond developing FHRM and FRMP of the second cycle. Many tools of the new methodological framework will be used for flood risk management tasks, not only directly related to the FD implementation and will set also the basis for future implementation cycles of the FD.

Annexes – as separate documents and files

Annex 1: Methodology for Flood Hazard Modelling and Mapping

Annex 1.1 Overview of flood modelling techniques and free license software

Annex 1.2 Pilot study report

Annex 2: Methodology for Damage & Loss Assessment and Risk Mapping

Annex 3: Methodology for the Development of Programs of Measures

Annex 3.1: Catalogue of Measures

Annex 3.2: Factsheets of selected measures

Annex 3.3: Guidelines for the Delineation of Appraisal Flood Units

Annex 3.4: Appraisal Summary Table (Multi-Criteria Analysis, Cost-Benefit-Analysis)