Danube Flood Risk Management Plan

ICPDR IKSD

International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

Part A – Basin-wide overview Update 2021

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Table of content

Disclaimer

This Flood Risk Management Plan for the Danube River Basin District, further referred to as the Danube Flood Risk Management Plan (DFRMP) Update 2021, is based on information received from the ICPDR Contracting Parties by 03 February 2021.

Sources other than the competent authorities have been clearly identified in the Plan.

A more detailed level of information is presented in the national Flood Risk Management Plans. Hence, the Danube Flood Risk Management Plan should be read and interpreted in conjunction with the national Flood Risk Management Plans.

The data in this report has been dealt with, and is presented, to the best of our knowledge. Nevertheless, inconsistencies cannot be ruled out.

In this report, the terminology of the EU Floods Directive was applied by the authors. In a common language, the "low probability" scenarios should be considered as events that are very rare and would maybe happen once in a human lifetime. "Medium probability" events usually mean "100-year floods", which could happen once (or even more often) in the same generation cycle. The so-called "high probability" events are quite common compared to the before mentioned ones, since they can be experienced several times during a lifetime. The statistical probability expresses the uncertainty of the time frame of the flood phenomena; hence these events can happen in many years but also tomorrow. The flood experts in the Danube River Basin work continuously on being prepared for the projected conditions.

List of Tables

List of Acronyms

APC	Accident Prevention and Control	ICPDR	International Commission for the Protection of the Danube River
APSFR	Areas of Potential Significant Flood Risk	IED	Industrial Emissions Directive
AT	Austria	IMGIS	Information Management & GIS
BA	Bosnia and Herzegovina	IPPC	Integrated Pollution Prevention and Control
BAT	Best Available Techniques	ISRBC	International Sava River Basin Commission
BG	Bulgaria	JPM	Joint Programme of Measures
CBA	Cost-Benefit Analysis	km	kilometre
cm	centimetre	LC	Land Cover
CZ	Czech Republic	MA	Monitoring and Assessment
DE	Germany	MD	Moldova
DRBD	Danube River Basin District	ME	Montenegro
DRBMP	Danube River Basin Management Plan	MoE SR	Ministry of the Environment of the Slovak Republic
DRPC	Danube River Protection Convention	NARW	National Administration "Romanian Waters"
EC	European Commission	NGO	Non-Governmental Organization
EFAS	The European Flood Awareness System	NWRM	Natural Water Retention Measures
EG	Expert Group	OVF	General Directorate of Water Management in Hungary
EIA	Environmental Impact Assessment	PFRA	Preliminary Flood Risk Assessment
EU	European Union	PP	Public Participation
EU WGF	EU Working Group on Floods	PS	Permanent Secretariat
EUCP	EU Civil Protection	RBD	River Basin District
EULEX	European Union Rule of Law Mission in Kosovo	RBM	River Basin Management
EUR	Euro	RO	Romania
EUSDR	EU Strategy for the Danube Region	RS	Republic of Serbia
FD	Floods Directive	SEA	Strategic Environmental Assessment
FEM	Floodplain evaluation matrix	SI	Slovenia
FHRM	Flood Hazard and Risk Map	SK	Slovak Republic
FIPs	Future Infrastructure Projects	SWMI	Significant Water Management Issues
FP	Flood Protection	TG	Task Group
FRM	Flood Risk Management	UA	Ukraine

FRMP	Flood Risk Management Plan	UK	United Kingdom
GIS	Geographic Information System	UN	United Nations
ha	hectare	UNDAC	UN Disaster Assessment and Coordination
HEC-RAS	Hydrologic Engineering Centres River Analysis System	UoM	Unit of Management
HR	Croatia	WFD	EU Water Framework Directive 2000/60/EC
HU	Hungary	WWF	World Wildlife Fund

List of Figures

List of Annexes

1 Introduction

1.1 General characterisation of Danube River Basin

The Danube River Basin (DRB) is the “most international” river basin in the world covering territories of 19 countries. Those 14 countries with territories greater than 2,000 km^2 in the DRB cooperate in the framework of the ICPDR. With an area of 807,827 km^2, the DRB is the second largest in Europe. Some of its basic characteristics are given in the following Table 1.

In accordance with the EU WFD the Danube and its tributaries, transitional waters, lakes, coastal waters and groundwater form the Danube River Basin District (DRBD). The DRBD covers the Danube River Basin (DRB), the Black Sea coastal catchments in Romanian territory and the Black Sea coastal waters along the Romanian and partly Ukrainian coasts.

Table 1: Basic characteristics of the Danube River Basin District

DRBD area	807,827 km^2
DRB area	801,463 km^2
Danube countries with catchment areas >2,000 km^2	EU Member States (9): Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Slovak Republic, Slovenia, Romania. Non-EU Member States (5): Bosnia & Herzegovina, Moldova, Montenegro, Serbia and Ukraine
Danube countries with catchment areas <2,000 km^2	EU Member States (2): Italy, Poland Non-EU Member States (3): Albania, FYR Macedonia, Switzerland
Inhabitants	approx. 79 Mio.
Length of Danube River	2,857 km
Average discharge	approx. 6,500 m^3/s (at the Danube mouth)
Important water uses and services	Water abstraction (industry, irrigation, household supply), drinking water supply, wastewater discharge (municipalities, industry), hydropower generation, navigation, dredging and gravel exploitation, recreation, various ecosystem services

The DRB is not only characterised by its size and large number of countries but also by its diverse landscapes and the major socio-economic differences that exist. Table 2 provides an overview on the shares of countries of the Danube River Basin and the population within the DRB.

Table 2: Shares and population of countries in the DRB

Country	Code	Coverage in DRB (km^2)	Share of DRB (%)	Percentage of territory within the DRB (%)	Population within the DRB (Mio.)
Albania	AL	126	0.02	0.4	< 0.01
Austria*	AT	80,600	9.96	96.1	8.40
Bosnia and Herzegovina*	BA	38,289	4.73	74.9	3.20
Bulgaria*	BG	47,235	5.84	42.6	3.57
Croatia*	HR	35,120	4.34	62.1	2.90
Czech Republic*	CZ	21,681	2.68	27.5	2.70
Germany*	DE	56,184	6.94	15.7	10.07
Hungary*	HU	93,000	11.49	100.0	9.80
Italy	IT	565	0.07	0.2	0.02
Moldova*	MD	12,505	1.55	36.9	1.10
Montenegro*	ME	6,413	0.79	46.4	0.20
North Macedonia	MK	109	0.01	0.4	< 0.01
Poland	PL	430	0.05	0.1	0.04
Romania*	RO	232,193	28.93	97.4	19.50
Serbia*	RS	81,974	10.13	92.8	7.00[1]
Slovakia*	SK	47,084	5.82	96.0	5.40
Slovenia*	SI	16,420	2.03	80.7	1.80
Switzerland	CH	1,809	0.22	4.4	0.02
Ukraine*	UA	30,820	3.81	5.1	3.03
Total		**802,558**	**100.00**	**-**	**78.75**

*) Contracting Party to the ICPDR

The Danube is formed by the confluence of the Breg and Brigach rivers. Not only are the confluence of the Breg and Brigach called the source of the Danube, but also the source of the Breg as the larger of the two formative streams. The Danube flows predominantly to the south-east and reaches the Black Sea after approximately 2,857 km, dividing into the 3 main branches, the Chilia, the Sulina, and the Sf. Gheorghe Branch. At its mouth the Danube has an average discharge of about 6,460 m^3/s. The Danube Delta lies in Romania and partly in Ukraine and is a unique “UNESCO World Heritage Site”. The entire protected area covers 675,000 ha including floodplains, natural lakes and marine areas. The Danube is the largest tributary into the Black Sea.

Some of the largest tributaries of the Danube are characterised in Table 3 below, including information on their key hydrologic characteristics.

Table 3: The Danube and its main tributaries (1st order tributaries with catchments > 4,000 km^2)

River	Enters the Danube at	Length in km	Size of catchment in km^2	Average discharge in m^3/s
Danube	-	2,857	801,463	6,500
Lech	Marxheim (near Donauwörth), Germany	254	4,125	115
Naab	Regensburg, Germany	191	5,530	49
Isar	Near Deggendorf, Germany	283	8,964	174
Inn	Passau, Germany	515	26,130	735
Traun	Near Linz, Austria	153	4,257	150
Enns	Mauthausen, Austria	254	6,185	200

[1] The data from Serbia do not include any data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

Morava/March	Devín, Slovakia	329	26,658	119
Raab/Rába	Győr, Hungary	311	10,113	88
Vah	Komárno, Slovakia	398	18,296	161
Hron	Near Štúrovo, Slovakia	278	5,463	55
Ipel/Ipoly	Near Szob, Hungary	197	5,108	22
Sió	Near Szekszárd, Hungary	121	9,216	39
Drau/Drava	Near Osijek, Croatia	893	41,238	577
Tysa/Tisza/Tisa	Near Titel, Serbia	966	157,186	794
Sava	Belgrade, Serbia	861	95,719	1,564
Tamis/Timis	Near Pančevo, Serbia	359	10,147	47
Velika Morava	Near Smederevo, Serbia	430	37,444	232
Timok	Bulgarian-Serbian border	180	4,630	31
Jiu	Near Gighera, Romania	339	10,080	86
Iskar	Gigen, Pleven Province, Bulgaria	368	8,684	54
Olt	Turnu Mugurele, Romania	615	24,050	174
Yantra	Svishtov, Bulgaria	285	7,879	47
Arges	Olteniţa, Romania	350	12,550	71
Ialomita	Near Hârşova, Romania	417	10,350	45
Siret	Galaţi, Romania	559	47,610	240
Prut	Near Reni, Ukraine	950	27,540	110

1.2 Floods and flood risk management in DRB

Through the centuries, the Danube countries suffered from many disastrous flood events. The most significant among these is the 1501 flood on the upper Danube, considered to be the largest summer flood of the last millennium, causing extensive devastation down to Vienna, and presumably, its impact was extreme downstream to the Danube Bend at Visegrád. Among the ice jam-induced floods, the one of 1838 has historical significance. It devastated a number of settlements from Esztergom to Vukovar, including the towns Pest, Óbuda and the lower parts of Buda on the territory of today’s Hungarian capital. In recent years the major floods occurred in 2002, 2006, 2010, 2013 and 2014 resulting in casualties and damages to economic activities amounting to billions €. An extremely rare coincidence of relatively large floods occurring in 2006 in the sub-basins of the Upper Danube at the same time as flooding on the Tisza, Sava and Velika Morava led to a very serious 100-year flood event along more than 1000 kilometres of the Danube River. The flooding stretched from the Morava mouth to the southern tip of the Csepel Island in Hungary, downstream of the Tisza mouth in Serbia and along the whole Romanian section of the Danube where highest historical flows and water levels were recorded. The extent of flooding in Romania was the largest in the last hundred years.

Contrary to the massive single flood events on the Danube which occurred in 2002 or 2006 due to high precipitation volume in a short time, in 2010 the scattered character of the rainfall throughout the whole year and throughout the most of the Danube River Basin led to a high number of damaging flood events at the local level. The floods in 2010 led to 35 casualties and the total damages reaching about two billion €.

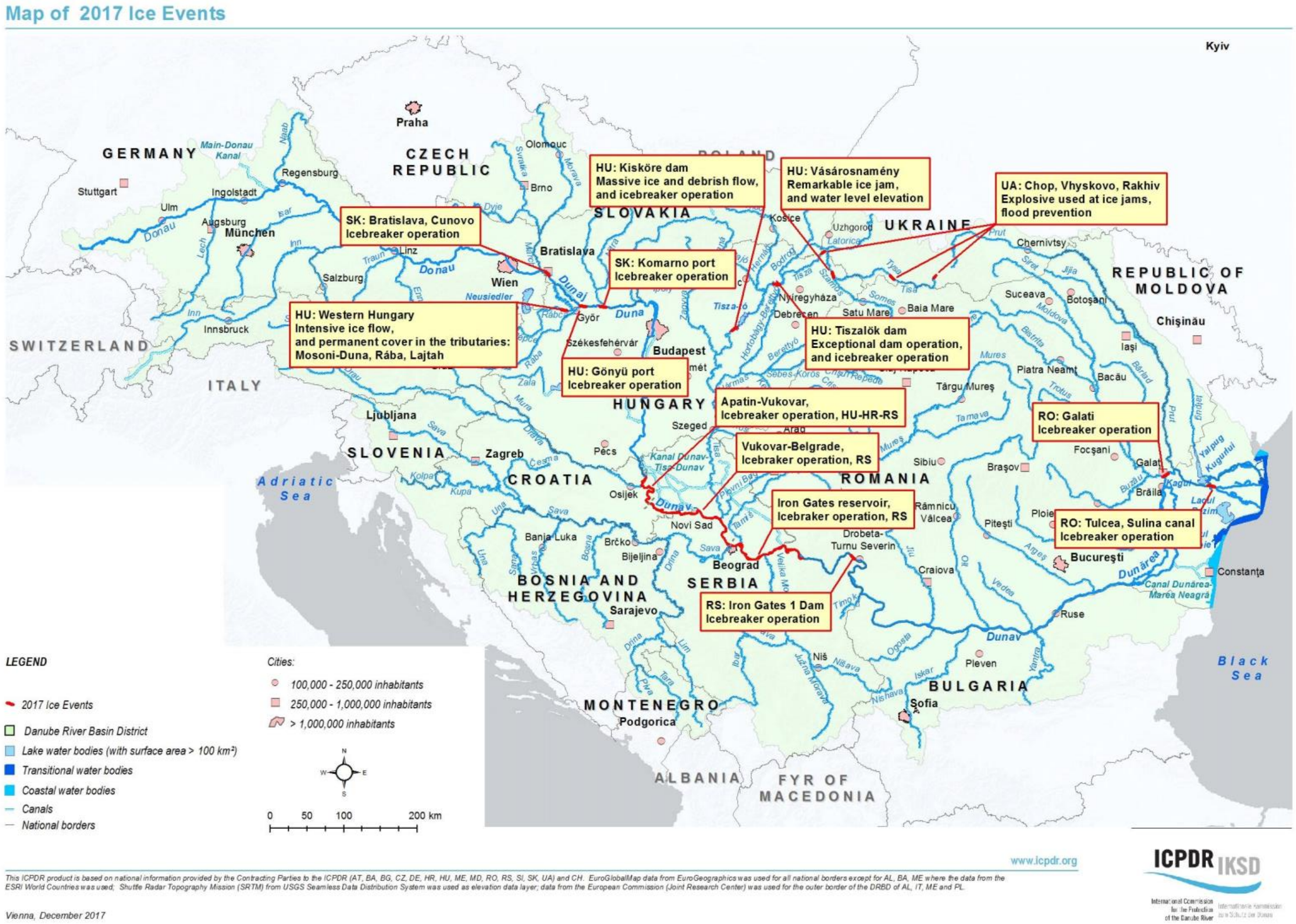
The specific meteorological situation in Central Europe in the end of May 2013 led to massive floods in the Upper Danube catchment in the beginning of June which had an impact further downstream. In many tributaries of the Upper Danube the return periods of 100 years and more were recorded. The coincidence of peak flows of the Saalach River and Salzach River as well as the Inn River and the Danube River led to a record water level at the Passau gauge that is only comparable to an event 500 years ago. In Hungary the highest ever Danube water levels were observed. Floods in June 2013 caused 9 casualties and the total financial consequences in the Danube River Basin amounted to 2.4 billion €. Disastrous floods occurred in May 2014 along the middle and lower parts of the Sava River

Basin. New historical water level maxima were recorded on mid and lower Sava, as well as on its tributaries. 79 casualties, 137 000 evacuated people and damages of almost four billion € underlined again the need for an effective flood risk management.

The very cold weather in January/February 2017 brought many countries in the Danube Basin and its tributaries to an especially bleak situation. Ice drifts appeared and aggregated into ice jams along the entire length of the Danube. Fortunately, the low water conditions prevented occurrence of flooding and the contingency measures ensured that no casualties were reported during that event and damage and disruption were kept to a minimum. Summary of the ice events in 2017 and measures applied is shown in the Figure 2.

Figure 1 Hungarian icebreakers on duty near Apatin, Serbian-Croatian border (*credits OVF*)

Figure 2 Summary of the reported measures and events



In response to the danger of flooding the ICPDR adopted already at the ICPDR Ministerial Meeting on 13 December 2004 the Action Programme for Sustainable Flood Prevention in the Danube River Basin[2]. The adoption of the EU Floods Directive had its impact also on the implementation of the ICPDR Action Programme both in terms of technical content and of the implementation time plan, given that the ICPDR Action Programme itself foresaw incorporating the future developments of the EU flood policy.

In 2009 seventeen sub-basin flood action plans were published by the ICPDR. They were based on 45 national planning documents and covered the entire Basin. They provided the first ever comprehensive overview of actions to reduce flood risk in the Danube Basin. In drawing up the plans, measures were first elaborated at the national level in each of the ICPDR states. Joint discussions between countries sharing particular sub-basins then took place to create a harmonized plan for the entire area of each sub-basin. The finalized action plans reviewed the current situation and set targets and respective measures for reducing adverse impacts and the likelihood of floods, increasing awareness and level of preparedness and improving flood forecasting. The targets and measures were based on the regulation of land use and spatial planning; increase of retention and detention capacities; technical flood defenses; preventive actions (e.g. flood forecasting and flood warning systems); capacity building; awareness and preparedness raising and prevention and mitigation of water pollution due to floods (http://www.icpdr.org/main/activities-projects/flood-action-plans).

At the ICPDR Ministerial Meeting in 2016 the Danube Declaration was adopted, in which the Danube Ministers recognized that even though floods are natural phenomena which cannot be prevented in their entirety, there is an urgent need to increase the investments in flood risk management as this will reduce the likelihood and severity of negative flooding consequences and – in the long run – be less expensive than compensating for flood damages. To further promote a harmonised Danube basin-wide flood risk management the Danube countries have developed in 2015 - building on the ICPDR Action Program for Sustainable Flood Prevention adopted in 2004 and the seventeen sub-basin flood action plans published in 2009 - the first Danube Flood Risk Management Plan (DFRM Plan) in line with the EU Floods Directive.

The Danube Ministers endorsed the DFRM Plan and committed to implement the measures foreseen in the DFRM Plan and in their national flood risk management plans. They underlined their common objectives agreed upon for the basin-wide level, i.e. to avoid new flood risks, to reduce existing flood risks, to strengthen resilience against floods, to raise public awareness and to promote the solidarity principle by avoiding exporting of flood problems to neighboring countries. With the measures agreed in the DFRM Plan priority was given to measures with positive downstream effect such as natural water retention, warning systems, reduction of risk from contaminated sites in floodplain areas or exchange of information.

[2] https://www.icpdr.org/main/activities-projects/flood-risk-management

Directive 2007/60/EC on the assessment and management of flood risks (EU Floods Directive, FD) entered into force on 26 November 2007. This Directive now requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. With this Directive also reinforces the rights of the public to access this information and to have a say in the planning process.

FD Article 7 requires member states to prepare flood risk management plans for all areas identified as being at potentially significant flood risk (APSFR) under Article 5 or Article 13(1) (a), and areas covered by Article 13(1)(b), on the basis of the maps prepared under Article 6. FD Article 14(1) stipulates that the flood risk management plan(s) shall be reviewed, and if necessary updated, including the components set out in part B of the Annex to the FD, by 22 December 2021 and every six years thereafter.

The part B of the Annex to the FD refers to components of the subsequent update of flood risk management plans:

1. any changes or updates since the publication of the previous version of the flood risk management plan, including a summary of the reviews carried out in compliance with Article 14;
2. an assessment of the progress made towards the achievement of the objectives referred to in Article 7(2);
3. a description of, and an explanation for, any measures foreseen in the earlier version of the flood risk management plan which were planned to be undertaken and have not been taken forward;
4. a description of any additional measures since the publication of the previous version of the flood risk management plan.

The flood risk management plans (FRMP) must set out appropriate objectives for the management of flood risk within the areas covered by the plan. The objectives must focus on reducing the adverse consequences of flooding for human health, the environment, cultural heritage and economic activity. Where appropriate, the plans should focus on reducing the likelihood of flooding and/or on using non-structural measures, including flood forecasting and raising awareness of flooding (Article 7(2)). The flood risk management plans shall include measures for achieving identified objectives (Article 7(3)).

The subsequent updates of flood risk management plans shall contain an assessment of the progress made towards the achievement of the objectives referred to in Article 7(2).

This update of the Flood risk management plan for DRBD is produced in line with the FD Article 8 (3) according to which where an international river basin district, or unit of management referred to in FD Article 3(2)b, extends beyond the boundaries of the Community, Member States shall endeavour to produce one single international flood risk management plan or a set of flood risk management plans coordinated at the level of the international river basin district;

This update of the Danube Flood Risk Management Plan sets out appropriate objectives for the management of flood risk on the level of the international river basin district covering the whole Danube catchment. It highlights the objectives and issues relevant for the basin-wide perspective and as such it is complementary to the national flood risk management plans, which provide all necessary information on measures, flood maps and other national activities in the sector of flood protection, prevention and mitigation in a more detailed way.

2 Conclusions of the preliminary flood risk assessment

2.1 PFRA

According to FD the Member States shall, for each river basin district, or unit of management referred to in FD Articles 3(2)(b) and 14(1), or the portion of an international river basin district lying within their territory, undertake a preliminary flood risk assessment (PFRA) in accordance with FD Article 4. Based on available or readily derivable information, such as records and studies on long term developments, in particular impacts of climate change on the occurrence of floods, a preliminary flood risk assessment shall be undertaken to provide an assessment of potential risks. The assessment shall include at least the following:

a) maps of the river basin district at the appropriate scale including the borders of the river basins, sub-basins and, where existing, coastal areas, showing topography and land use;

b) a description of the floods which have occurred in the past and which had significant adverse impacts on human health, the environment, cultural heritage and economic activity and for which the likelihood of similar future events is still relevant, including their flood extent and conveyance routes and an assessment of the adverse impacts they have entailed;

c) a description of the significant floods which have occurred in the past, where significant adverse consequences of similar future events might be envisaged;

and, depending on the specific needs of Member States, it shall include:

d) an assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity, taking into account as far as possible issues such as the topography, the position of watercourses and their general hydrological and geomorphological characteristics, including floodplains as natural retention areas, the effectiveness of existing manmade flood defense infrastructures, the position of populated areas, areas of economic activity and long-term developments including impacts of climate change on the occurrence of floods.

In the case of international river basin districts, or units of management referred to in FD Article 3(2)(b) which are shared with other Member States, Member States shall ensure that exchange of relevant information takes place between the competent authorities concerned.

On the basis of a preliminary flood risk assessment as referred to in FD Article 4, Member States shall, for each river basin district, or unit of management referred to in FD Article 3(2)(b), or portion of an international river basin district lying within their territory, identify those areas for which they conclude that potential significant flood risks exist or might be considered likely to occur (so called Areas of Potential Significant Flood Risk (APSFR)). The identification of areas belonging to an international river basin district, or to a unit of management referred to in FD Article 3(2)(b) shared with another Member State, shall be coordinated between the Member States concerned.

The ICPDR report on preliminary flood risk assessment published in 2019 presented information on major flood events that occurred in the Danube River Basin District focusing primarily on the last two decades. It summarized the methodologies and criteria used at the national level to identify and assess floods that occurred in the past and their past adverse consequences (including whether such consequences would be ‘significant’) and whether the likelihood of such floods remains relevant. It also addresses the methodologies and criteria used to identify and assess significant floods that occurred in the past that would have significant adverse consequences were they to reoccur in the future and methodologies and criteria used to identify and assess potential future significant floods and their potential adverse consequences. In reference to the FD Article 4(2)(d) a description is provided in this report of the assessment at the national level of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity.

This document also provided a brief description of the methodology used at the national level for the identification of areas of potential significant flood risk as required by FD Article 5 as well as the methodology agreed by the ICPDR to identify the areas of potential significant flood risk in the Danube River Basin District including those having a transboundary character. For a better visualization of the progress, a separate chapter on revisions during the 2nd flood risk management cycle has been added to the report.

The impacts of the climate change were addressed in a specific chapter. To respond to the provisions of FD Article 4(3) and Article 5(2) a summary on the steps taken by the ICPDR Contracting Parties to ensure the exchange of relevant information on PFRA between competent authorities in the DRBD and the description of international coordination of APSFR that has taken place between the ICPDR Contracting Parties is provided as well.

This report set the necessary basis for the update of flood hazard and flood risk maps and for the preparation of the Danube Flood Risk Management Plan Update 2021. At the same time, it provided the public and stakeholders with an important evidence that the areas with potential flood risk in the Danube River Basin are being taken care of for the benefit of all inhabitants and countries of the Danube River Basin.

2.2 APSFR in the Danube River Basin District

The areas of potential significant flood risk (APSFR) in the Danube River Basin District are shown on the map below and are indicated in red color. The design and background data of the map follow the approach of the ICPDR for WFD reporting on level A (international river basin district). In the Danube River Basin Management Plan, the river network is displayed using 4,000 km^2 catchment size as a threshold. This approach has been followed with the view of ensuring a joint flood risk management – river basin management reporting by 2021.

<u>The data on APSFR were agreed to be provided in the following geometry types:</u>

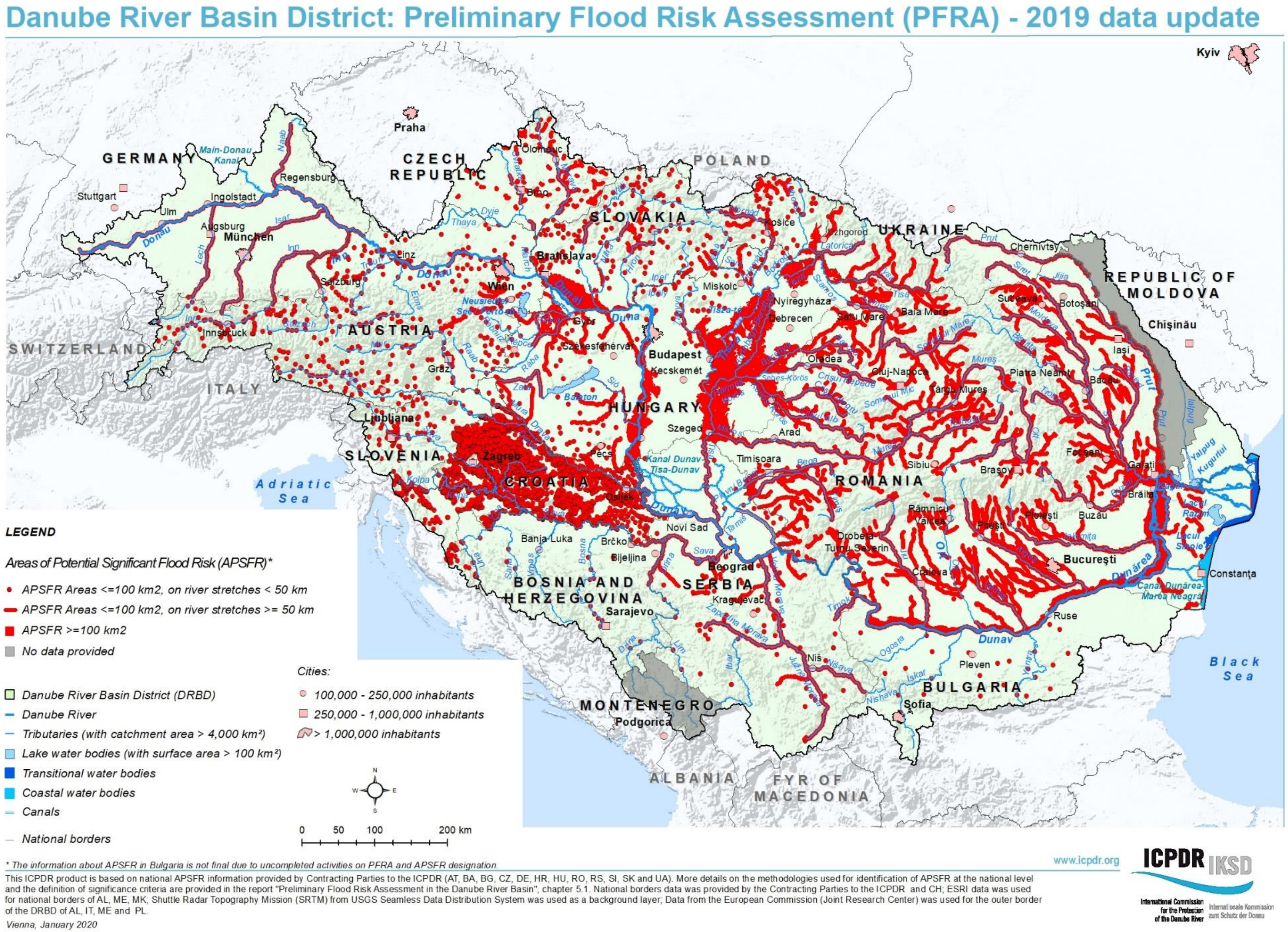
Polygon: Recommended for areas >= 100km^2

Line: Recommended for river stretches >= 50km. If the APSFR is located on a reported river (>4000km^2 catchment), the same geometry should be used as reported with the river segment dataset. However, the segmentation does not need to match.

Point: Recommended for areas <100km^2 and river stretches <50km.

The map in **Error! Reference source not found.** shows the status as of October 2019. Moldova and M ontenegro did not deliver APSFR data.

Figure 3 PFRA in DRBD



3 Conclusions on flood hazard maps and flood risk maps

According to the FD the Member States shall, at the level of the river basin district, or unit of management, prepare flood hazard maps and flood risk maps, at the most appropriate scale for the areas identified under FD Articles 5(1) and 14 (1).

The preparation of flood hazard maps and flood risk maps for areas identified under FD Article 5 which are shared with other Member States shall be subject to prior exchange of information between the Member States concerned.

Flood hazard maps shall cover the geographical areas which could be flooded according to the following scenarios:

(a) floods with a low probability, or extreme event scenarios;

(b) floods with a medium probability (likely return period ≥ 100 years);

(c) floods with a high probability, where appropriate.

For each scenario the following elements shall be shown:

(a) the flood extent;

(b) water depths or water level, as appropriate;

(c) where appropriate, the flow velocity or the relevant water flow.

Flood risk maps shall show the potential adverse consequences associated with flood scenarios referred to above and expressed in terms of the following:

(a) the indicative number of inhabitants potentially affected;

(b) type of economic activity of the area potentially affected;

(c) installations as referred to in Annex I to Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) l which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;

(d) other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution

3.1 Flood hazard map

MAP 1 Hazard and flooding scenarios

The agreed format is as follows: A3 map of flood hazard and flooding scenarios, showing the DRBD and rivers with catchment areas >4000km^2, lakes >100km^2, transitional and coastal waters. The large flood hazard areas are reported and displayed as polygons, while smaller areas are reported as lines or points (the same criteria as used for the APSFR map[3]). The map shows the flood hazard area polygons using zero outline thickness.

The ICPDR agreed that two scenarios (flood hazard areas with medium and low probabilities) are relevant for displaying the flood hazard maps on the level of the international Danube River Basin District. Red color is used on the map for the low probability floods (extreme events) and orange color for the medium probability floods. Medium probability scenario is shown on top of the low probability scenario, so in some cases it can overlay the low probability scenario. If no information is available, the whole country's area is displayed with a grey overlay.

The national definitions of floods with medium and low probability are as follows:

Country	Medium probability	Low probability
DE	HQ100	HQ1000 / HQextreme
AT	HQ100	HQ300
CZ	HQ100	HQ500
SK	HQ100	HQ1000/extremely dangerous flood
HU	HQ100	HQ1000
HR	HQ100	HQ1000 with no flood protection facility, protected systems considering dike failure
SI	HQ100	HQ500
RS	HQ100	HQ1000
BA	HQ100	HQ500
BG	HQ100	HQ1000
RO	HQ100	HQ1000
UA	HQ100	HQ500
MD	HQ10-20	HQ100

The 100 years flood scenario is an agreed one, applied by all ICPDR Contracting Parties (with the exception of Moldova). Any further streamlining would create an enormous effort (both financial and resources) in doing so. Besides that it has to be mentioned that a common risk mapping based on streamlined probabilities had already been conducted along the main river stem in the frame of the

[3] Areas >=100km² as polygons, areas < 100km² and river stretches >= 50 river-km as lines, and areas < 100km² and river stretches < 50 river-km as points

EC SE Europe Project Danube Floodrisk and is referred to and published at the ICPDR homepage: https://www.icpdr.org/main/activities-projects/danube-floodrisk-project

Some countries announced problems with the agreed catchment threshold as the most significant inundation areas are not located on the major rivers and will therefore not qualify for the level A map.

The ICPDR discussed the issue of the application of the catchment size threshold and agreed that the level A map has to show all inundated areas placed on the river network with catchments >4000km^2 and can also show the significant inundation areas in the smaller catchments if a country decides for such option. In such a case, an explanation has to be provided on the map - that the areas which are not placed on the displayed river network, are on the rivers with catchments <4000km^2, and are being considered to be of a major importance at the national level.

3.2 Flood risk maps

The assessment of flood risks on the basin wide level is coordinated through the activities of the ICPDR Flood Protection Expert Group. This ICPDR expert body has agreed that the following flood risk maps should be developed at the basin wide level:

- MAP 2 Risk and population
- MAP 3 Risk and economic activity
- MAP 4 Risk and installations with the potential to cause pollution
- MAP 5 WFD protected areas (2 maps)
- MAP 6 Cultural heritage sites

MAP 2 Risk and population

The agreed format is as follows: A4 map on Risk and population is prepared using white background and showing country borders, the DRBD, the Danube River and country capitals. The number of affected population in each country is shown by a bar chart with 3 bars per each country (one bar for each scenario). 2D bars are used, data for high probability scenario are shown on the left side of the graph and the number of affected population is indicated in the bars in thousands for each scenario. If the number is less than thousand then the label “<1000” is displayed. If no data were provided by country, then the label “NO DATA” is displayed instead. Red color is used for low probability floods, orange for medium probability floods and yellow for high probability floods. An explanation is provided that data are given for the part of the country belonging to the Danube River Basin District.

No tributaries are displayed on maps 2-4 and 5b.

MAP 3 Risk and economic activity

The agreed format is as follows: Three A4 maps are presented (one for each scenario) using white background and showing country borders, the DRBD, the Danube and country capitals. Each map shows a 2D pie chart for each country displaying the share of inundated area by class of economic activity. If no data were provided by country, then the label “NO DATA” is displayed instead. The size of the affected total area in thousand km^2 is shown below each pie chart. Corine LC colors are used in the chart. An explanation is provided that data are given for the part of the country belonging to the Danube River Basin District.

ICPDR agreed on the following aggregation of Corine Land Cover classes to be used for reporting of economic activities:

- Agriculture: 211 - 244 (all agricultural areas)
- Industry: 121 (industrial and commercial units)
- Infrastructure: 122 - 124, 131 - 132 (road and rail networks, seaports, airports, mineral extraction sites, dumps)
- Urban areas: 111, 112, 141, 142 (urban fabric, green urban areas, sport and leisure facilities)
- Others: all other classes

MAP 4 Risk and installations with the potential to cause pollution

ICPDR agreed that this map should have the same layout as the Map 2. The charts show the number of IPPC and Seveso installations in each country.

MAP 5 WFD protected areas

ICPDR agreed on two maps: One is based on the available Danube RBMP map of areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant NATURA 2000 sites designated under Directive 92/43/EEC and Directive 79/409/EEC. The other map of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7 and of the affected bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/ECfollows the layout of the other risk maps as indicated above.

MAP 5a

This is an A3 map, showing protected areas (based on DRBM Plan Update 2021 - MAP 19) superposed in a semi-transparent way on the flood hazard areas (for low probability floods scenario). Only those flood hazard areas that are overlapping (partly or entirely) the protected areas, are selected (as a whole object) and displayed in red color. The different types of protected areas (Bird, Habitat and other protected areas) are not distinguished.

MAP 5b

This is an A4 map with the same layout as the map 2. The number of affected protected areas in each country is shown by a bar chart - with 3 bars per each country (one bar for each scenario). The total numbers of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7, and of the affected bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/EC, is indicated in the bars.

The ICPDR agreed that the >4000km^2 catchment threshold has to be applied also for all risk maps, to keep the consistence between the hazard and risk maps.

MAP 6 Cultural heritage sites

This is a standard ICPDR A3 map, showing UNESCO cultural heritage sites, numbered downstream. Information on the next page contains site/name, coordinates, photo and the description of potential impacts (few sentences on what can be damaged).

3.3 Conclusions drawn from the maps

To ensure a coherent approach with river basin management planning the flood hazard and flood risk maps were prepared for the catchments with the area larger than 4000 km^2. These maps show the potential adverse consequences associated with different flood scenarios and serve as an effective tool for information, as well as a valuable basis for priority setting and further technical, financial and political decisions regarding flood risk management. On the basis of these maps the ICPDR Contracting Parties were required to establish a Flood Risk Management Plan coordinated at the level of the international river basin district.

More detailed information on flood hazard and flood risk maps is provided in the updated Summary Report on implementation of Article 6 and 14 (2) of the Floods Directive in the Danube River Basin District. That report provides an overview of methods used at the national level for preparation of flood hazard maps in the DRBD Countries focusing on the approaches to identify, assess or calculate the flooding extent and flooding probabilities or return periods. Information is also provided of methods (including criteria) used to prepare flood risk maps in the DRBD Countries. The available links to flood hazard and risk maps available electronically in the ICPDR Contracting Parties as well as to other relevant documents are shown as well.

The set of maps presented in this plan includes the updated FHRMs from the 1st cycle and the new flood risk map of potentially affected cultural heritage sites. It must be pointed out FD allows using FHRM data from the 1st management cycle stating that maps shall be in each management cycle reviewed and if necessary updated.

Flood hazard map

ICPDR agreed that two scenarios (flood hazard areas with medium and low probabilities) are relevant for the level of the international river basin district. The medium probability floods are almost unanimously based on 100-year recurrence period (with the exception of MD, where the lower recurrence period stems from shorter data series) and the respective hazard area covers 54,046 km^2 in the Danube River Basin. The recurrence interval of floods with low probability varies mostly from 300 to 1000 years (with the exception of MD) and the respective hazard area covers 82,116 km^2 in the Danube River Basin. The delineation of the flood hazard areas is based on the national methodologies which are described in the ICPDR Summary Report on implementation of the Article 6 of the Floods Directive in the Danube River Basin District. The flood hazard map for the Danube River Basin District has been prepared in the scale of 1: 4,500,000 and the goal of the map is to provide a general overview for the whole basin. For more detailed information including flow velocity and water depth it is necessary to view the national maps. The links to these maps are provided in the chapter 12.

Flood risk maps

The map on risk and population shows the population potentially affected by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. In the inundation areas addressed in this Plan there are at least 1,008,273 people affected by floods with high probability, at least 2,909,609 people affected by floods with medium probability and at least 5,411,397 people affected by floods with low probability.

The maps on risk and economic activity display the share of inundated area by class of economic activity (according to Corine Land Cover) for low, medium and high probability floods. The agricultural areas have the major share among the different types of the economic activity followed by the category “others” which however combines a number of various activities. Approximately 33,059 km^2 of agricultural areas are potentially affected by low probability floods in the Danube River Basin District. The largest urban area potentially affected by low probability floods is in Hungary (905 km^2).

The map on risk and installations with the potential to cause pollution shows the number of IPPC and Seveso installations affected by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. Floods with high probability affect at least 90 installations, floods with medium probability affect at least 241 installations and floods with low probability affect at least 548 installations in the Danube River Basin District.

There are two maps on risk and WFD protected areas. One map is showing Natura 2000 protected areas superposed in a semi-transparent way on the flood hazard areas (for low probability floods scenario). Only those flood hazard areas that are overlapping (partly or entirely) the protected areas, are displayed. The second map displays the total numbers of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7, and of the affected bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/EC by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. Floods with high probability affect at least 886 drinking water and recreational water areas, floods with medium probability affect at least 1073 drinking water and recreational water areas and floods with low probability affect at least 1356 drinking water and recreational water areas in the Danube River Basin District.

No data for flood maps were provided by Ukraine, Moldova and Montenegro.

Changes in flood risk assessment methodology and database improvements in some countries (e.g. AT) led to changes of the number of potentially affected people. Therefore, any statistically sound comparison of potentially affected people in the Danube River Basin between 2015 and 2021 (which was intended to be used for the evaluation of progress in implementing measures) was not possible.

4 Objectives

Article 7(2) FD stipulates that Member States shall establish appropriate objectives for the management of flood risks for the areas identified under Article 5(1), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding.

The ICPDR agreed upon the following objectives of the Flood risk management plan for the Danube River Basin District:

- Avoidance of new risks
- Reduction of existing risks
- Strengthening resilience
- Raising awareness
- Promoting the solidarity principle

These objectives focus on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity and address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the DRBD.

During the first flood risk management period the ICPDR flood experts were carefully considering if all these objectives are able to sufficiently cover at the basin-wide level all needs for the management of flood risks in the DRBD and they came to the conclusion that these objectives are broad and robust enough to accommodate all relevant topics including the impacts of the climate change.

4.1 Avoidance of new risks

Urban planning as well as urban, rural and industrial development and construction should take into account the requirements of flood prevention. All activities concerning agriculture, forestry management, energy, transport, spatial planning and development, etc., shall be planned and carried out without having negative impacts on increasing of the risk of flooding. Special focus must be put on activities planned in parts of flood risk areas that might have negative upstream or downstream effects. Not to increase the risk potential, the extension of development land into areas affected by flood risk must be avoided.

4.2 Reduction of existing risks

The purpose of FD is to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods. All FD implementation steps in the Danube River Basin District: PFRA, development of flood maps and of the Flood Risk Management Plan have been accomplished following this principle.

4.3 Strengthening resilience

To improve its resilience against flooding the society has to have an adequate emergency response during and immediately after flooding to limit adverse effects and it shall recover to regain a standard of living comparable to or better than the pre-flooding status.

4.4 Raising awareness

Preparedness is a result of awareness and is based on the necessary information to make the individual recognise his possibilities of action. It is the personal responsibility of anyone who lives and works by or on the river, and broader in the potentially flooded area, to adapt his use of the water and all activities to flood risks. So, everyone must know the risk and take it into account appropriately when acting. Problems associated with floods are often not sufficiently recognised and acknowledged. The authorities should ensure that the information concerning flood prevention and protection plans is transparent and easily accessible to the public. The information provided to the effected communities should also include communication of opportunities how they can adapt e.g. their land use practises to natural circumstances on floodplains. All measures linked to public information and awareness raising are most effective when they involve participation at all levels. Public participation in decision-making is a cornerstone of successful implementation of integrated and comprehensive management plans, both to improve the quality and the implementation of the decisions, and to give the public the opportunity to express its concerns and to enable authorities to take due account of such concerns

4.5 Promoting the solidarity principle

The solidarity principle is very important in the context of flood risk management. In the light of it, countries should be encouraged to seek a fair sharing of responsibilities, when measures are jointly decided for the common benefit, as regards flood risk management along water courses. FD stipulates that in the interests of solidarity, flood risk management plans established in one Member State shall not include measures which, by their extent and impact, significantly increase flood risks upstream or downstream of other countries in the same river basin or sub-basin, unless these measures have been coordinated and an agreed solution has been found among the Member States concerned in the framework of article 8 FD.

4.6 Progress in implementation of DFRMP

The progress in implementing the DFRMP is monitored in the frame of the meetings (twice a year) of the ICPDR Flood Protection Expert Group (FP EG) as well as by a controlling conducted by the meetings of the ICPDR Heads of Delegations (Standing Working Group Meetings and Ordinary Meetings). All DFRMP Annex 2 measures, the relevant best practice measures and new and ongoing initiatives are presented to, communicated to and discussed by the FP EG. Presenting new ideas as well as discussions on potential consortia and project partners are important part of the FP EG meetings. If problems in project implementation occur these are addressed appropriately by the Flood Protection Expert Group.

The requirements of the Annex A of the FD concerning FD implementation and DFRMP updates are addressed in this Plan as follows:

II. *Description of the implementation of the plan:*

II/1 *a description of the prioritisation and the way in which progress in implementing the plan will be monitored;*

Addressed in the Chapter 5

II/2 *a summary of the public information and consultation measures/actions taken;*

Addressed in the Chapter 12

II/3 *a list of competent authorities and, as appropriate, a description of the coordination process within any international river basin district and of the coordination process with Directive 2000/60/EC.*

Listed in the Annex 3

B. *Components of the subsequent update of flood risk management plans:*

B.1 *any changes or updates since the publication of the previous version of the flood risk management plan, including a summary of the reviews carried out in compliance with Article 14;*

The changes and updates are addressed in the respective sections of the DFRMP.

B.2 *an assessment of the progress made towards the achievement of the objectives referred to in Article 7(2);*

The progress made is addressed in the chapter 4.7. The progress made towards the achievement of basin-wide objectives of the DFRMP is addressed primarily through the implementation of the best practices projects which are presented in the textboxes throughout the whole document.

B.3 *a description of, and an explanation for, any measures foreseen in the earlier version of the flood risk management plan which were planned to be undertaken and have not been taken forward;*

This is addressed in the Chapter 5.5.6 and in the Annex 2.

B.4 *a description of any additional measures since the publication of the previous version of the flood risk management plan.*

New projects and initiatives like DARREFORT or HORIZON2020 insurance are described in this plan and in its Annex 2.

4.7 Progress in achieving objectives

In principle and in contrast to national FRMP or APSFR FRMP, an indicator/parameter-based evaluation on a Danube basin-wide level is hardly possible. Having in mind the very general, non exhaustive and guiding focus of the DFRMP, the evaluation had to be done in a descriptive way. Stress was given to highlighting the work of the ICPDR Flood Protection Expert Group and explaining the processes referring to the projects, joint initiatives, collaborations, etc. in more detail. This approach clearly outlines the added value of the international cooperation under the ICPDR.

The progress in achieving of basin-wide objectives of the DFRMP is addressed primarily through the implementation of the best practices projects which are presented in the textboxes throughout the whole document.

	**CZECH REPUBLIC**	**Status:** Ongoing
	Target area: Czech Republic	
Project:	**Developing and modernisation of hydrological gauging stations network**	

An observation of surface water and groundwater are the first step in understanding of the hydrological processes in nature. Czech hydrometeorological institute (CHMI) ensures detailed monitoring of water levels as well as water quality. The total amount of watergauge stations operated by CHMI is 504 nowadays. Within the Morava river basin (belonging to the Danube river basin) there are 151 hydrological stations. The aim of this project is to modernize and extend gauging station network to provide necessary information for securing the flood forecasting and warning service. Realization of the project will improve reliability and accuracy of measuring of the water level in reconstructed gauging stations. Their tolerance to higher discharges and bigger floods will increase at the same time. It will also improve probability of functional measuring during critical events and provide available information for managing flood protection.

Between 2019 and 2022 the total number of 47 watergauge objects will be reconstructed, whereas 24 of them are situated within the Danube catchment.

Each reconstruction needs specific technical solution according to particular options of each locality. It comes from longterm experience with running the gauging stations, knowledge of flow dynamics and its influence on functionality of the station such as blocking the measuring profile by mud and alluvium held by water etc. Therefore, each gauging station had to be handled in separate project done by company who has experience with structures determined for water level observations and in cooperation with CHMI hydrologists.

4.7.1 Promoting the solidarity principle during Danube ice event 2017

Over what will be remembered as the big chill of late 2016 to early 2017, about 170 km of the Danube were entirely frozen. On the Hungarian section of the river, only a variable rate of ice drift was observed while, to the south, Serbia faced a much larger problem. In the most critical areas near Belgrade and Kladovo, the river froze to a depth of up to four meters. Shipping was suspended in Hungary and ice breakers were called out to clear the waterway, but the worst of the ice just over the border remained, with no concerns about which nation it endangered.

Cross-border ice control has a long history on the Danube River. Beyond navigation concerns, the risk of flooding from accumulated ice is a looming threat to the population. Devastating, fast-rising ice-jam floods between the Hungarian border and Vukovar, Croatia, in particular require a strong alliance of Serbian, Croatian and Hungarian protection efforts. The three countries manage this protection through an international trilateral agreement to address events – such as floods, ice-drift, or pollution – on the part of the river known as the 'section of common interest', where such events affect all three countries.

With such deep ice jams floating menacingly offshore, Serbian water authorities declared an emergency situation and the trilateral partners swung into action. The Hungarian water management directorates and the General Directorate of Water Management played key roles in the intensive operations that followed, cooperating smoothly with their Croatian and Serbian counterparts.

Altogether four Hungarian icebreakers were deployed to smash ice blocks and prevent damage to bridges and ships moored along the waterway. Two of the ships – Jégtörő XI and Jégtörő VI (Jégtörő means icebreaker in Hungarian) – broke through the ice jam in Dalj and kept the ice discharge lane clear for traffic.

The other two ships – Széchenyi and Jégtörő VII – moved to the Serbian section of the Danube between Novi Sad and Belgrade, technically outside the area covered by the trilateral agreement. However, given the emergency situation, Serbia and Hungary agreed that the icebreakers had to be deployed beyond the common interest section. Hungary didn't hesitate, and its ships set off to destroy the ice threatening its neighbours. These actions were a demonstration of smooth transboundary partnership and are also reminders of the importance of cross-border cooperation and solidarity, principles at the core of ICPDR actions

5 Measures and their prioritisation

Flood risk management plans shall include measures for achieving the objectives established for the management of flood risks for the areas identified under FD Article 5(1), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding. In accordance with Art 14 FD these measures shall be reviewed, and if necessary, updated by 22 December 2021 and every six years thereafter.

The measures described in this plan address all phases of the flood risk management cycle and focus particularly on prevention (i.e. preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas or by adapting future developments to the risk of flooding), protection (by taking measures to reduce the likelihood of floods and/or the impact of floods in a specific location such as restoring flood plains and wetlands) and preparedness (e.g. providing instructions to the public on what to do in the event of flooding).

The FP EG agreed that only the strategic level measures reflecting the activities on the level of an international river basin district shall be presented in the Flood risk management plan for DRBD. This category includes measures with transboundary effect and measures applicable in more countries of the basin such as awareness raising, warning systems or ice protection measures. Therefore, this plan contains a general list of measures providing thus a basin-wide overview of types of actions to be taken by countries to address the flood risks. The detailed description of all planned measures is presented in the national flood risk management plans to enable progress monitoring.

The measures presented in this plan are the planned measures and their implementation subjects to technical and financial conditions at the national level.

To better demonstrate key actions of basin-wide importance the measures described in this chapter are combined with the examples of best practices which are presented in textboxes throughout the whole document.

5.1 Prioritisation

Presenting only the strategic level measures in this plan can be considered as a basic prioritization criterion, which was applied for the level of the international Danube River Basin District. Selecting the measures for this plan the priority was given to measures with upstream/downstream effect such as natural water retention, warning systems, reduction of risk from contaminated sites in floodplain areas or exchange of information. The top priority was given to Natural Water Retention Measures (water retention and giving more space to rivers) and to measures addressing the climate change but the importance of the structural measures was also recognized.

As regards impacts of climate change the options were favored that are robust to the uncertainty in climate projections through

- Focusing on pollution risk in flood prone zones;
- Focusing on non-structural measures when possible;
- Focusing on “no-regret” and “win-win” measures;
- Focusing on a mix of measures.

In addition, prevention through the catchment approach was favored and a long-term perspective in defining flood risk measures was taken into account (e.g. with respect to land use, structural measures efficiency, protection of buildings, critical infrastructure, etc).

The overview of all measures reported by the Contracting Parties and selected as relevant for the level of the international Danube River Basin District are presented in the Annex 2.

5.2 Joint implementation of measures

The major ICPDR platform for a joint implementation of the strategic level measures are the transboundary projects supporting DFRMP. These projects shall i.a.:

- Reflect the objectives and priorities set in this plan for the management of flood risks;
- Have a transboundary character;
- Help to implement the needs listed i.a. in the Annex 2.

Details of these projects are provided in the chapter 7 of the Annex 2 of this plan. These measures are co-financed with the aim of strengthening cross-border cooperation. All these measures taken are following an overarching concept of reducing the flood risks in the DRB.

5.3 EU Strategy for the Danube Region

The EU Strategy for the Danube Region (EUSDR) is a macro-regional strategy adopted by the European Commission in December 2010 and endorsed by the European Council in 2011. The Strategy was jointly developed by the Commission, together with the Danube Region countries and stakeholders, in order to address common challenges together. The Strategy seeks to create synergies and coordination between existing policies and initiatives taking place across the Danube

Region. The Priority Area 5 (PA5) of the EUSDR deals with managing environmental risks including flood risk management[4].

The synergy between ICPDR and EUSDR PA5 activities on flood protection, prevention and mitigation is an inevitable prerequisite for an efficient implementation of the FD in the Danube River Basin. ICPDR has a clear mandate for coordinating flood risk management on Danube River Basin District (level A) based on the Danube River Protection Convention (DRPC) and the EU Floods Directive. This includes establishment of a basin-wide Flood Risk Management Plan in coordination with national plans and sub-basin plans. EUSDR supports the measures foreseen for the Flood Risk Management Plan and provides mechanism for developing related projects on flood risk management, especially flood mitigation.

Cooperation with EUSDR Priority Areas 4 “Water Quality” and 6 “Biodiversity and landscapes, quality of air and soils” helps to enhance and refine measures especially in the fields of water protection, biodiversity and Green Infrastructure.

5.4 Climate check of flood risk measures

The ICPDR Climate Change Adaptation Strategy contains an overview of guiding principles, which provide support for the integration of adaptation to climate change into river basin management, including flood and drought risk management. Adaptation is being carried out with a priority given to win-win, no-regret and low-regret measures that are flexible enough for various conditions.

These guiding principles include under “Awareness raising, early warning and preparedness measures” a recommendation to perform a climate check of flood risk measures.

It is mentioned in the chapter 5.1 that in the frame of their prioritization those DFRMP measures were favored which are sufficiently robust to the uncertainty in forecasting of climate change impacts. This robustness has been achieved through focusing on pollution risk in flood prone zones; on non-structural measures when possible; on “no-regret”, “win-win” and a mix of measures.

The impacts of climate change are addressed in more details in the chapter 9 of this plan.

Climate check of flood risk management measures at the national level:

5.4.1 Germany

The effects of climate change are considered when updating the flood risk management plans of 2015 as to § 75 Abs. 6 Federal Water Act (WHG). The German Working Group on water issues of the Federal States and the Federal Government (LAWA) convened an expert panel to analyze the effects of climate change on different aspects of water policies. Uncertainties due to climate change are undeniable. Still, many measures and courses of action exist that are beneficial for FRM and improvement of flood protection, independent of how the future climate will ultimately change. Those, concerning mainly water policy adaptation strategies tolerate a large spectrum of changes and are furthermore flexible and adjustable as well as robust and efficient. All measures in the LAWA-BLANO catalogue, which is the basis for the planning of measures in Germany, have been

[4] https://environmentalrisks.danube-region.eu/

analyzed as to these aspects through the LAWA expert group. In summary all measures can adapt to climate change and reduce existing and new risks. About half of the measures (13/29) work the same way with or without climate change, no loss of effectivness is expected because of climate change. These measures can be found in all different aspects of FRM. For about the same amount of measures (12/29) no final statement was possible. Climate change may have an impact on the effectiveness of those measures. In the least amount of cases (4/29) climate change is expected to have a negative impact on the effectiveness of the measures. These 4 measures are regional planning, designation of floodplains, urban land-use planning and adapted landuse and belong to the aspect of “prevention”, type “avoidance”.

All strategic measures are independent of climate change. No negative impacts are to be expected on the effectiveness of the measures.

Furthermore, several categories of adaptation to climate change have been developed to explain the effects. The measures can be an adaptation to changing flood risks, to the increasing frequency of flooding and to increasing flash floods.

Details can be found in the LAWA-BLANO measure catalogue in the Annex 1 to the LAWA recommendations for the compilation, revision and updating of flood risk management plans (2019).

5.4.2 Austria

The catalogue of measures in Austria comprises of 36 types of measures addressing all relevant aspects of flood risk management. All measures are linked to potential contributions to the Austrian climate change adaptation strategy comprising of highlighting options for actions. E.g. the measure “Flood aware spatial planning and building regulation” is contributing to the climate change adaptation strategy option for action “Coping with climate change challenges to safeguard a sustainable land use development by consequent application derivation of planning goals and instruments as well as by the preservation of ecosystem services.”

5.4.3 Czech Republic

The hydrological characteristics, especially design flood levels and discharge return periods are being updated using data from last decades when the climate change impact is noticeable.

Flood forecasting process must reflect changing patterns in precipitation events and hydrological response of the catchments. To deal with increasing uncertainty of input data for hydrological modelling, various hydrological forecast products are issued using a probabilistic approach and a special effort is focused on flash flood forecasting. Widening of the forecast portfolio is supported by the project on prevention of security risks caused by extreme meteorological events.

5.4.4 Slovakia

Measures addressing climate change are based on the analysis of outputs of a scientific study on incorporation of climate change scenarios in calculation of design discharges using mathematical hydrological models. The flood risk management system based on the Flood protection Act no 7/2010 coll. includes preventive measures in watercourses and in agricultural, forest and urbanized landscapes. The whole range of potential measures are tested during preparation of flood risk management plans and in a frame of their prioritization in terms of their effectiveness using mathematical hydrodynamic models, which form the basis of flood hazard maps and flood risk maps with integrated climate change scenarios.

5.4.5 Hungary

In Hungary, the “Second National Climate Change Strategy 2014-2025, with a view to 2050” has been completed. The Strategy shows tendencies and describes the expected processes, which include the increase in the frequency of major floods. Hungary reviewed the Flood Design Water levels in 2014, the analysis options are performed using several methods, and the statistical analyses are performed using flow modeling (1D). Based on the studies, flood levels and flood yields with different probabilities of occurrence can be modified. In the modelling, the effects of climate change can be taken into account primarily by analyzing the hydrological time series. The longest possible time series were taken into account when recording the hydrological edges, thus ensuring that both the recorded load levels and the shape of the flood wave were as accurate as possible. Since even the longest time series were up to 112 years old, in many cases it was necessary to extrapolate from the available time series. This was done using the available data, taking into account the changes. Thus, it was also able to take into account the effects of climate change, as trends in the data sets outlining the changes.

5.4.6 Slovenia

Detailed climate change scenarios for Slovenia were prepared. Therefore, hydrological (for example the existing Q100 values) and meteorological characteristics of the river basins which include 86 of Slovenian APSFRs could be checked for changes as a consequence of (expected) climate change. These results were used in the preparation of the Slovenian Preliminary Flood Risk Assessment Update and resulted in larger or smaller flood hazard areas, which were later used to identify the areas of potentially significant flood risk.

Climate change scenarios and their expected consequences (increase or decrease of projected Q100 flows and levels) are also being taken into account when detailed design of structural flood risk reduction measures is being done.

Slovenian catalogue of flood risk reduction measures includes 20 types of measures and for each single one of them its contribution to the climate change adaptation is analysed.

5.4.7 Croatia

Although certain climate change aspects have been included in the first Croatian Flood Risk Management Plan, full integration has started with the Preliminary Flood Risk Assessment in 2018. Results of the comprehensive regional climate change models produced during development of national Climate Change Adaptation Strategy have been used for river basin management and flood risk management oriented analysis in the framework of a separate project. It is forseen that all subsequent planning and related documents, including the Programme of Measures will include and in further detail develop required measures leading to climate change proofing of all flood risk (and river basin management) measures. It should be noted that, since the first Flood Risk Management Plan, all feasibility studies for flood risk mitigation measures cover climate change related aspects.

5.4.8 Serbia

Possible impacts of climate changes were addressed in general in the review of the PFRA in 2019 and were also considered within the preparation of flood hazard maps.

Climate check of flood risk measures will be considered in the Flood Risk Management Plan, which is under preparation.

5.4.9 Bosnia and Herzegovina

Bosnia and Herzegovina prepared flood hazard and flood risk maps within the IPF5 "Flood Hazard and Flood Risk Maps Project in Bosnia and Herzegovina”. Preparation of first FRMP started in 2020.

In addition to assessing the present flood risk, activities of FHRM project also included an assessment of future flood risk as a result of potential climate change.

Potential impact of climate change was explored by a 1D hydraulic modelling of the 51.5 km pilot section length of Bosna River. This area suffered most during the May 2014 floods.

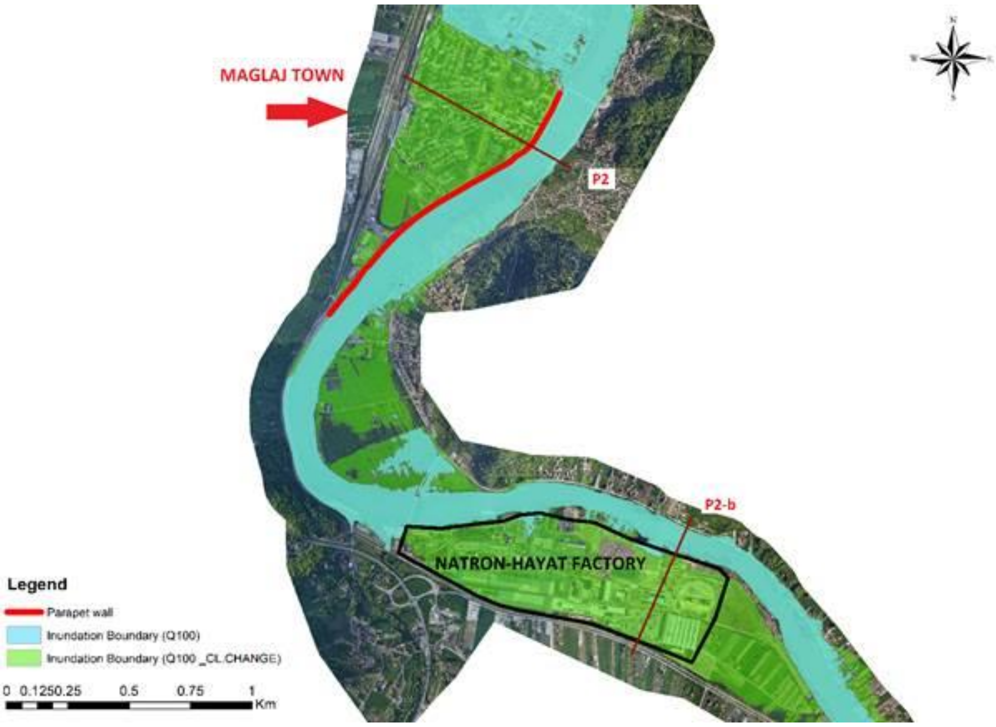
Selected was RCP 4.5 emission scenario as the most likely one given the growing international concerns about climate change. An expected increase of 17% of flood discharge was used for the modelling, based on the future 75th percentile Q_{100}.

Future 75th percentile 100-year peak discharges for Bosna river basin in BiH under RCP 4.5

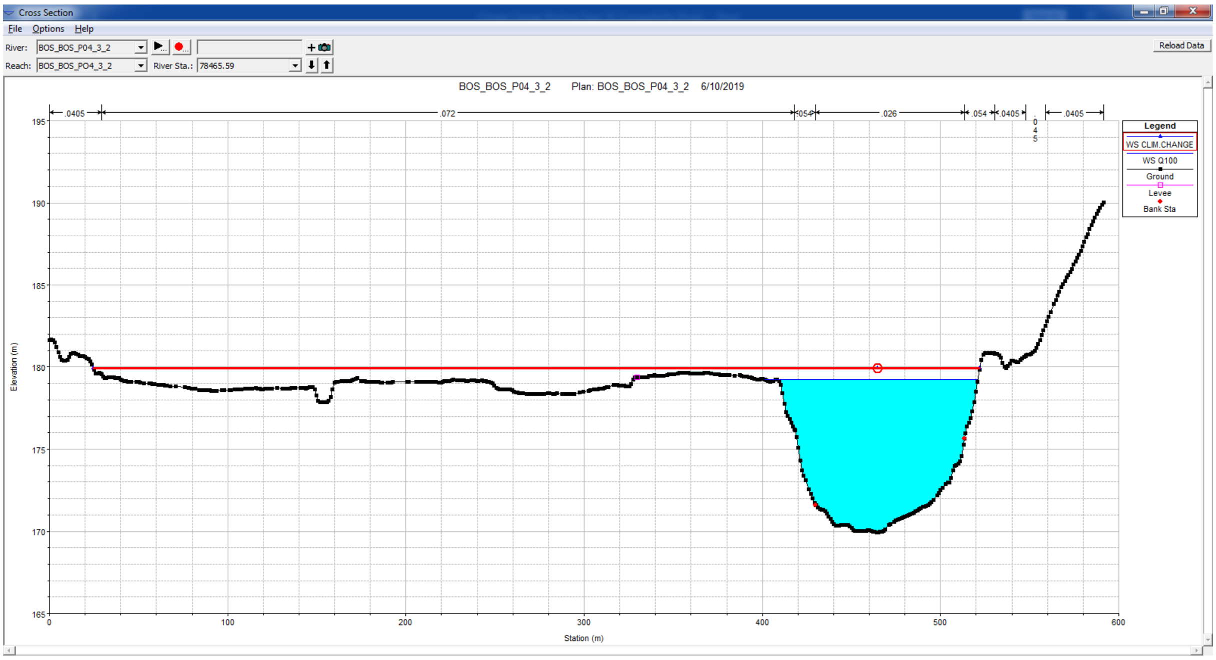
River	sub-catchment area km²	100-year Peak Discharge m³/s				%Change from Base[1] 100-year peak discharge		
		Base[1]	2006-2035	2036-2065	2066-2095	2006-2035	2036-2065	2066-2095
Bosna	3104	597.2	689	695.8	711.9	15%	17%	19%
	1916	316.4	366.1	366.5	373.7	16%	16%	18%
	1536	772.6	848.5	899.3	932.4	10%	16%	21%
	3278	461.8	530.1	534.6	551.2	15%	16%	19%

The aim of the climate change scenario modelling was to identify which locations along the pilot river stretch are most vulnerable to future 100-year design discharges. The results of the climate change analysis for the pilot stretch of Bosna River indicated that a level of protection provided by existing structures, particularly around cities and major towns, would be justified (see the visuals below).

The recommendation based on modelling results is that the first FRMP for Bosnia and Herzegovina should incorporate the impact of expected climate change along the pilot section on River Bosna when selecting flood risk mitigation measures.



Impact of climate change in Maglaj municipality



Profile P2-b Natron-Hayat factory

5.4.10 Romania

In the first cycle of WD reporting process, the measures included in the FRMPs were not related to climate change. Only the win-win category measures could be assimilated for the following types of measures: retention restoration measures (floodplain, wetlands etc.) – RO_M04; natural water retention measures in urban/populated areas – M_05; natural water retention measures through changing or adapting landuse in agriculture and forest management – M_06 and M_07; other measures for water level reduction (i.e. dike relocation, restoration or/and maintenance of the attenuation volumes of the reservoirs etc.) – M_08.

In the ongoing project "Strengthening the capacity of the central public authority in the field of water in order to implement the stages 2 and 3 of the second cycle of the Floods Directive - RO-FLOODS” a review will be made of the national Catalogue of measures including available scenarios, modelling predictions and any information regarding downscaling in Romania, paying attention to the meteorological and hydrological variables. A framework will be created for incorporating uncertainties into modelling of various floods risk (decision under deep uncertainty, robust and resilient decision making, scenario neutral).

The national, international and EU approaches to integrate Climate Change into FHM will be evaluated. Climate Change Scenarios and the existing estimates of Climate Change impacts and also uncertainties of various hydrological models results and regional distribution of resulted impacts will be assessed (11 RBAs and the Danube).

One of the project results will be a methodology to integrate Climate Change in the development of the new FHM of APSFR-2, proposing a way to integrate Climate Change in the use of existing FHM of APSFR-1 (either standardized threshold neither additional buffers).

5.4.11 Bulgaria

In the first Flood risk management plans in Bulgaria only some very general aspects of the impact of climate changes on the flood risk are included. The analysis of climate change impact was done schematically, without specific data on precipitation characteristics and related types of floods. These issues are more deeply addressed in the national documents related to the second cycle of the FD implementation.

The national PFRA Methodology has been updated, addressing the climate changes by newly developed approaches: an approach to assess the impact of climate change on the frequency and scale of all types of floods and an approach for assessing the future risk of potential floods caused by heavy rainfall (incl. flash floods). According to the updated PFRA-Methodology, the impact of climate change on floods is being examined by analyzing several precipitation indicators that are most directly related to significant floods: total annual precipitation, annual maximum 24-hour precipitation, annual number of days with precipitation over 20 and 40 mm. For the analysis, climatic reanalysis data for the period 1961-2017 were used. With regard to future climate change, regional climate models developed under the MED-CORDEX project have been used. The results of the climate change analysis were used in the identification of areas for future floods and in the delineation of the APSFR.

The national methodology on Flood hazard mapping has also been updated, considering the potential impact of the climate changes on flood hazard. The updated FHRM methodology includes newly developed methods for modeling and mapping of the pluvial and flash flooding. The proposed method is based on two-dimensional hydrodynamic modeling of direct precipitation (rain-on-grid), in which the surfaces of surface runoff and surface water retention are dynamically modeled. Climate change scenarios are incorporated as additional model runs, which take into account the latest available climate change projections for rainfall intensity, and river flows for Bulgaria. River flow projections are used to ensure appropriate downstream boundaries for independent models.

Measures aimed to the reduction of flood risk will be planned in the second FRMP for all areas for which the flood hazard is expected as a consequence of climate change. A process of update of the national catalogue of measures is ongoing and it is expected that additional measures contributing to the climate change adaptation will be included.

5.4.12 Ukraine

In Ukraine, Flood Risk Management Plans should be developed by 2022. Currently, a preliminary flood risk assessment has been completed and the flood risk and flood hazard maps are being prepared. As for the inclusion of climate change issues in the Flood Risk Management Plan (program of measures), it can be assumed that this issue will not be included in the first cycle of the Plan (in terms of specific measures) in Ukraine, due to the lack of verified data of the correlation between climate changes and its influence on floods formation.

5.4.13 Moldova

Under the Plan for the Flood Risk Management approved by the Government in July 2020, there was elaborated program of measures that would contribute to the achievement of general and specific goals. Measure packages contain both structural and non-structural measures. The following principles were used as the basis for defining the program measures: using the format that can be implemented; ensuring sustainable development: a measure proposed for one section of the river will not negatively affect another section; proposed measures should not have negatively affected climate; practicality and feasibility; compliance with legislative and regulatory acts that currently are into force.

Measures to be taken at national level are those non-structural or secondary measures that are mainly aimed at strengthening institutional capacity, through updating plans/ maps, developing mechanisms / strategies / criteria / regulations, creating warning systems, etc. to ensure effective risk management floods at the national level; measures to be taken in the Moldovan part of the Danube River basin includes structural (or priority) measures aimed at building and /or rehabilitation of infrastructure that prevent or reduce the risk of flooding within the basin; non-structural (or secondary) measures are those institutional measures that, through the development or improvement of regulations, allow for the development of policy measures that ensure effective flood risk management within the basin.

Thus, in addition to structural measures, the Plan also contains a number of non-structural measures, which, on the one hand, are aimed at protecting human settlements and economic activities, and on the other hand, are aimed at creating favorable conditions for environmental protection. The main environmental goal of the Plan is to introduce elements of the ecosystem approach into the flood risk management process. This goal will be achieved on the basis of an economic assessment of the feasibility of creating flooded areas, increasing the carrying capacity of river channels, ensuring the functionality of existing polders, that is, introducing measures of an ecosystem approach to flood risk management. In addition, the Plan contains a number of measures aimed at adaptation to and mitigation of the climate change impacts, such as: establishing and restoration of forest shelter and water protection strips, etc. In order to analyze the possibility of providing rivers with more space for managing of water level, it is envisaged to carry out feasibility study addressing transferring of constructions located in inundated area and preventing new constructions in sector Criva - Lipcani - Drepcauti in the Prut River upstream (Briceni district).

5.5 Types of measures and progress in their implementation

5.5.1 Measures to avoid new risks

Inappropriate physical planning as well as urban, rural and industrial development and construction in the areas of potential significant flood risk will lead to future damages, losses and casualties. All such activities shall be planned and carried out without having any impacts on increasing of the risk of flooding.

	AUSTRIA	**Status:** Ongoing
	Target area: Austria	
Project:	**Hazard Zone Planning in Austria**	

In Austria flood hazard zone plans have to be elaborated (at least for APSFRs), however the coverage across AT is much higher. These plans delineate inundated areas and flood intensities (a product of flow velocities and water depths). This is done on a high resolution (scale 1:2000). The plans are then communicated to the public and discussed with potentially affected people, leading to implications or recommendations in spatial planning. The flood hazard zone plans are based on federal legislation (Water Act, Forest Act). Spatial planning is regulated on provincial level; therefore, the results of the flood hazard zone plans are incorporated in these (9) legislations differently.

Copyright: Revital

The preventive measures focus on avoiding the location of new or additional receptors in flood prone areas. They are essential for the land use planning policies or regulation. The key measures adopted in countries include preparation and update of hazard zone plans and their incorporation into regional land use planning, spatial plans, building regulation and emergency management decisions. They also include flood adapted planning and construction, flood adapted handling of water-hazardous substances, legal restrictions for construction activities on flood risk areas and prevention of any increase of the damage potential in flood hazard areas via properly designed spatial plans and/or legislation.

General preparedness is being enhanced through measures that establish or enhance flood event institutional emergency response planning. These include flood-related inspection on rivers, water reservoirs and water structures, development of scenarios and action plans for localization of flooding, ensuring smooth data and information exchange between institutions responsible for flood defense, updates of the flood protection plans and the hydrological characteristics such as design flood levels, discharge return periods reflecting also the climate change projections. These activities lead to updates of operation plans of flood protection systems and of operative flood defence plans and their harmonization with other stakeholders such as civil protection. Organisation of flood emergency operations, simulation exercises and trainings especially with local fire brigades and potentially affected inhabitants is a vital component of preparedness measures.

<table>
<tr><td rowspan="2"></td><td>GERMANY</td><td>Status: Implemented</td></tr>
<tr><td colspan="2">Target area: Baden-Wuerttemberg</td></tr>
<tr><td>Project:</td><td colspan="2">Declaration of statutory floodplains</td></tr>
<tr><td colspan="3">
The most effective and most cost-efficient method to avoid new flood risks is keeping the flood areas, which can be seen in the flood hazard maps, free of new buildings. Therefore, in Germany the land-use in designated floodplains which are potentially flooded with a return period of one hundred years (HQ_{100}) is restricted. The restrictions contain amongst others the prohibition of new building zones and new structural facilities. In general, the installation of new oil-based heating systems is prohibited.
The federal states in Germany are responsible for the designation of the floodplains. In Baden-Wuerttemberg the designated floodplains are statutory, so that no further administrative procedures at local level are necessary for the definition of the floodplains or the implementation of restrictions. This has amongst others an advantage that it is possible to react more quickly to potential changes in the flood areas, based e.g. on impacts of climate change, changes in hydrology or construction of flood protection systems. For this purpose, the flood hazard map shall be reviewed, if necessary updated and republished. The usages potentially endangered by an extreme flood event ($HQ_{extreme}$) shall be avoided or planned and implemented in an adapted form. The installation of new oil-based heating systems is only permitted under certain conditions. Both for new planning and for existing plans the most current flood areas must be correctly included in the planning and approval of urban land use plans.
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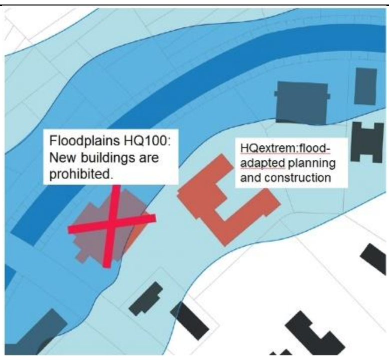
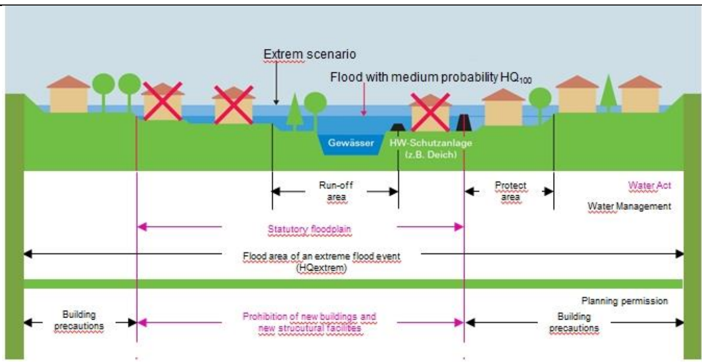
<tr><td colspan="2">
</td><td>
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The other measures to establish or enhance preparedness for flood events to reduce adverse consequences include e.g., insurance, financial precautions, new regulation of the financial circumstances, communication of flood risk, permanent monitoring, inspection and maintenance of erosion control and flood protection structures, maintenance of existing flood protection facilities, promotion of best practices in emergency flood defense, assessment of the embankment/levee condition and an efficient cooperation on bilateral and regional level. Providing targeted information referring to individual responsibility and options for object-oriented measures is also an important tool.

The protection measures include assistance in urban pluvial flood risk management, improvement of retention capacity on catchment scale (restoring retention areas and natural water retention measures), restoration of flood plains and sedimentation areas, structural protection measures, object oriented measures, relocation and reallocation and improvement of river inspection.

5.5.2 Measures reducing the existing risks

The EU Floods Directive requires Member States to take adequate and coordinated measures to reduce the risk of adverse consequences, especially for human health and life, the environment, cultural heritage, economic activity and infrastructure associated with floods. It is essential that the measures to reduce these risks are, as far as possible, coordinated throughout a river basin to ensure their effectiveness.

The preventive measures aim to remove receptors from flood prone areas, or to relocate receptors to areas of lower probability of flooding and / or of lower hazard. This includes removal of illegally built constructions, barriers, and other artificial obstacles located in flood hazard areas and in the river's bed, removal of potential sources of pollution from flood hazard areas and relocation of most endangered population based on the information from risk maps.

In case the removal/relocation is not possible the measures are taken to adapt receptors to reduce the adverse consequences in the event of flood actions on buildings or public networks. Such measures include flood adapted renovation especially in the urban areas, promotion of good practice for the construction of residential and infrastructure facilities in floodplains, object oriented measures, adaptation of constructions to flood hazard intensity, physical protection of buildings, flood adapted handling of water-hazardous substancesor reassessment and modification of vulnerable infrastructure (esp. road and railroad crossings on rivers), improvement of rainwater drainage or actions reducing vulnerability to floods and training and encouraging population to implement flood self-protection measures.

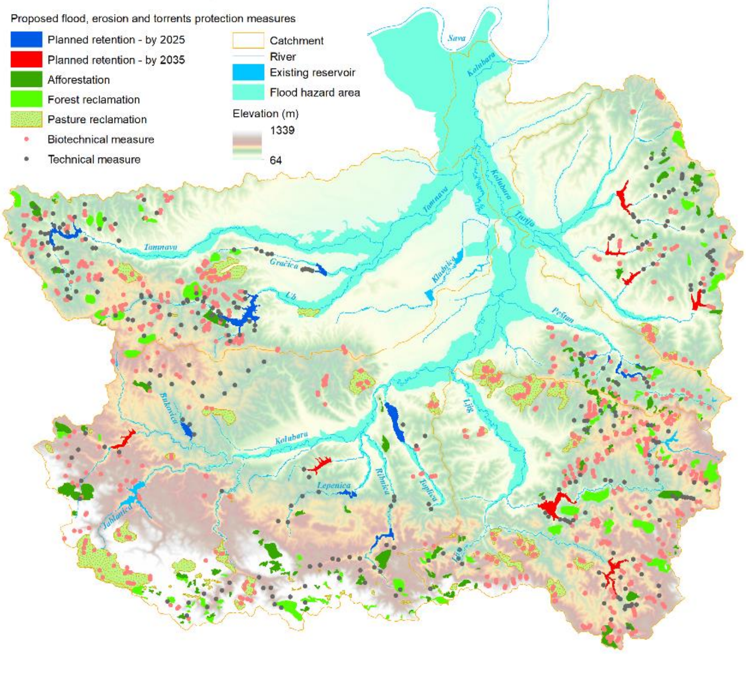
Other prevention measures include modelling and assessment of flood risk and flood vulnerability to ensure the most reliable information for planners as well as for public. Compilation and regular update of hazard zone plans provides a good basis for land-use and urban planning. Regular upgrade of flood defence plans leads to minimization of risk of flooding. Use of good agricultural practice principle by e.g., proper selection and rotation of plants increases water retention. Technical and safety supervision of water structures including the update/preparation of technical documentation for the existing flood protection structures, flood defence and for the use and management of the operational regime of reservoirs increases the flood protection safety. Establishing efficient bilateral cooperation with all neighbouring countries, including common actions on transboundary rivers during flood and ice defence is essential not only for flood prevention but also for implementing the solidarity principle. Effectiveness validation of flood mitigation and protection measures by hydraulic modelling ensures that the applied measures are sufficiently robust. Other prevention measures also include update/preparation of registers of hydraulic structures and of torrents and preparation of standards and norms for the maintenance of flood protection structures, erosion and torrents protection structures and drainage systems and for the implementation of flood defense.

	**SERBIA**	**Status:** Implemented
	Target area: Kolubara River basin	
Project:	**Study on Flood Risk Management in the Kolubara River Basin**	

Following the disastrous floods in May 2014 which affected the entire Kolubara River basin (with an estimated EUR 900 million to one billion damage) a study was prepared with the main objective to define a concept for integrated flood protection in the basin.

Hydrological and hydraulic models were used for the reconstruction of the May 2014 floods and for simulation of 100- and 1000-year flows. About 410 km of rivers, most of them previously identified as APSFR, were modelled and flood hazard maps prepared. The results revealed that the statistical ranks of peak flows in May 2014 in the middle and lower parts of the basin were between 300 and 500 years. Potential flood damage was assessed by using the extent of the 2014 flood and risk data at present (2015) and in the future (2035), revealing that a new catastrophic flood would cause 50% greater damage than the 2014 flood, if the planned developments in the basin were to be fulfilled by 2035. Therefore, a set of structural and non-structural flood protection measures was proposed. The proposal included new structures for attenuating flood waves (20 flood retention reservoirs), erosion control measures and measures for natural retention of water in the basin (technical, biotechnical, biological, agrotechnical and other measures) and, reconstruction or construction of levees to increase flood protection level of the most important areas. Total cost of the proposed structural measures was estimated at EUR 200 million.

A variety of non-structural measures were proposed as well, which should be implemented by the water sector, safety and rescue services, hydro-meteorological services, health services, spatial planners, nature conservation, municipalities, reservoir users, as well as citizens, non-governmental organizations, companies and entrepreneurs in flood hazard areas.



	**AUSTRIA**	**Status:** Revisions Ongoing
	Target area: Austria	
Project:	**National Hazard Overview & Risk Assessment Austria**	

In Austria a Private Public Partnership of the insurance industry together with the federal ministry was set up as an output of the 2002 flood analysis. It aims at communicating flood risk to the citizens as well as supporting insurers to define their premiums. Starting with floods the tool (www.hora.gv.at) was enriched by information of other natural hazards leading to the tool of the so called “risk passport” where it is possible to assess his or her own risk against different natural hazards. The HORA tool is currently in a phase of revision where additional tools and visualisation options will be implemented to further increase the flood awareness of Austrian citizens.

Copyright: BMLRT

The protection measures rely on natural water retention, enhancement of infiltration, in-channel works, restoration of active and former floodplains and on the reforestation of banks. These measures restore natural systems to help slow flow and store water. They include natural water retention in the catchment, in wetlands and in settlement areas, restoration of active and former floodplains and sedimentation areas. Revitalization of rivers in general leads to enhanced water retention. Important are also the erosion protection measures in the whole river catchment areas (e.g., erosion control trenches, terraces at hill slopes), the measures supportive to rainfall infiltration e.g., by reduction of soil sealing, by improvement of infiltration properties of forest soils or by interruption of trajectories of concentrated runoff (including those on the forest roads) and the technical forestry measures to influence interception and transpiration of forest vegetation. Sustaining the existing forests and afforesting new areas, especially in hilly and mountain areas prone to erosion is an efficient way to maximize water retention at the precipitation areas.

Because the water retention brings multiple benefits not only to reducing flood risks but also reduce the water scarcity and to achieve the environmental objectives of the EU Water Framework Directive more detailed info about this issue is provided in chapter 6.

	ROMANIA	**Status:** Implemented
	Target area: Romanian Black Sea Coast	
Project:	**Protection and rehabilitation of the southern part of the Romanian Black Sea coast in the area of Constanța and Eforie Nord”**	

The phenomenon of erosion of the Romanian Black Sea Coast became visible after the '60s, the causes being multiple. They can be mainly associated with climate change, complex port development and changes in the Danube flow regime, which over time have affected the natural morphological balance of the coastal zone. The coastal area between the Chilia arm to the north and Vama Veche to the south was analyzed, studies, hydraulic modeling and diagnostic analysis of erosions and their effects on the environment were carried out, and a coastal zone management strategy was drawn-up, the Coastal Master Plan, over a time horizon of 30 years.

The specific objectives of the Master Plan are:

- development of a programme of measures for the protection of the coastal zone against erosion, rehabilitation and protection of the shoreline, adjacent areas and land and marine ecosystems;
- protection of economic infrastructure and social objectives endangered by marine erosion processes;
- implementation of an integrated coastal and medium-term coastal zone monitoring programme, to support maintenance operations.

Investments were needed to help reducing the impact of climate change on the southern Black Sea coast, as well as to protect human communities and the environment in these areas. The investment has a positive impact on the safety and quality of life of the inhabitants, by restoring the beaches and protection structures in the vicinity of which are located housing and socio-economic objectives. The works consisted of new constructions for dissipating the energy of the waves that affect the shoreline, artificial sanding of the beaches and constructions for the protection of the shoreline and the retention of sand on the beach (extension on a length of 7.3 km of beaches in the coastal area of the Black Sea, increasing by 33 ha the surface of the beaches of the Romanian coast in 5 areas, construction of 11 emerged dikes and 6 submerged dikes).

Water flow regulation measures involve physical interventions to regulate flows aiming to increase the capacity of the river channel to be able to cope with elevated flows during flood events. They are based on construction, modification or removal of water retaining structures (structural measures) and on regulation of the hydrological regime. The aim of water flow regulation is increasing of storage volume and discharge capacity and, hence, increase of safety.

Key flow regulation activities include planning, construction/reconstruction, expansion, operation, and maintenance of flood retention systems. Construction, maintenance, repair or reconstruction of water structures such as dams and reservoirs, dry or semi-dry reservoirs, polders and bypass canals are the measures which provide more space for the water and reduce flood peak discharge. Construction and proper operation of polders and reservoirs effectively reduces the flood peak. Promotion of best practices in managing multi-purpose reservoirs helps to increase water retention. Green infrastructure measures (relocation of dikes and designation of natural retention areas where applicable) are in emergencies supported by the use of mobile protecting constructions. Supportive activities are the optimisation of operational rules and service regulations for water retaining structures.

	ROMANIA	**Status:** Ongoing
	Target area: Romanian Black Sea Coast	
Project:	**Reduction of coastal erosion - Phase II (2014-2020)**	

The purpose of this project is to ensure protection against the erosion of the shoreline in annual average conditions as well as during events with a recurrence period of up to 1/100 years, for a projected lifespan of 50 years.

The specific objectives are:

- Protecting the Black Sea coast in the territory of Romania from the effects of coastal erosion by developing a programme of specific works that have in view the rehabilitation and protection of the shoreline, adjacent lands and land and marine ecosystems;
- Protecting the economic infrastructure and social objectives endangered by marine erosion processes;
- Implementation of an integrated coastal zone monitoring programme to support medium and long-term operations and maintenance works.

In the first stage, works will be carried out in the Edighiol and Periboina weirs and Mamaia, Tomis-Cazino area, Agigea and Eforie areas.

In the second stage, works will be carried out in the Costinesti, Olimp, Jupiter-Neptun, Balta Mangalia-Venus-Aurora, Mangalia-Saturn and 2 May areas.

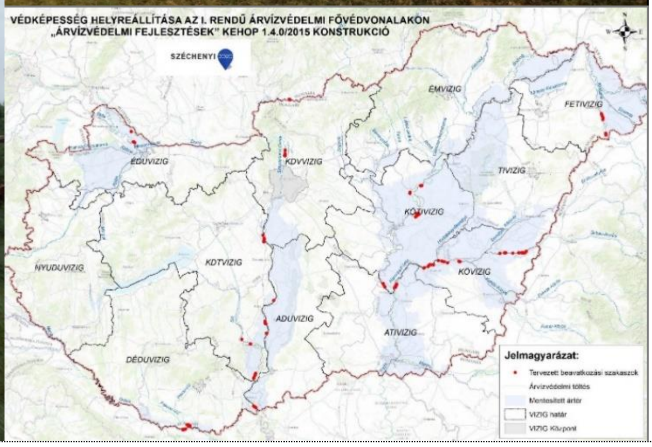
The channel and floodplain works cover flood protection and retention measures, measures to reduce hydro morphologic alterations, construction of mobile flood protection systems, construction, modification or removal of structures, alteration of channels and dykes and also sediment dynamics management. The structural measures (dikes, dams, flood protection walls, dunes, beach ridges or mobile flood defences) are complementary to the green infrastructure measures increasing safety in case that flood water retention cannot cope with the water volumes. They require regular maintenance and proper restoration in case they were damaged by previous floods. To lower the water level the possibilities of removal of transversal structures in the rivers are explored and the discharge capacity of bridges, culverts and inundation structures is being increased. The channels of water courses are maintained (removal of deposits, maintenance of vegetation) to ensure the adequate flow capacity.

Development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance is an important tool to implement sediment management measures to maintain river conveyance capacity (see more details in chapter 5.5.6.1).

	HUNGARY	**Status:** Implemented
	Target area: Hungary	
Project:	**Restoration of flood protection capacity on main flood protection dykes**	

The nationwide project mostly ensures the reinforcement of the sections of the Danube, Tisza and Körös protection lines that need to be confirmed during the 2016 surveys. The implementation of the project has increased the flood safety of nearly forty settlements. Within the framework of the project, the protection line sections with the exceptionally low protection capacity were strengthened, because the flood protection embankment is low or weak due to the cross-section and the poor nature of the subsoil, which is prone to slipping and washing. The primary goal of the project was to make the line of defence effective on these sections as well, and to minimize unpredictable flood phenomena (sand boils, pipes, slope slip, dike collapse). In addition, the aim was to increase the height deficit on sections where it is risky to raise the flood defence embankment temporarily (with sandbags) at least to the point of protection. The Hungarian General Directorate for Water implemented the developments on the first-level state main defence lines managed by the Water Directorates under its professional management. The extent of the investment is characterized by the fact that 10 of the 12 regional water directorates in Hungary are territorially involved in the implementation of the project. As part of the local flood defence development, sheet piles and gap walls were built into the embankment.

Information about the project: http://vedkepesseg.ovf.hu/

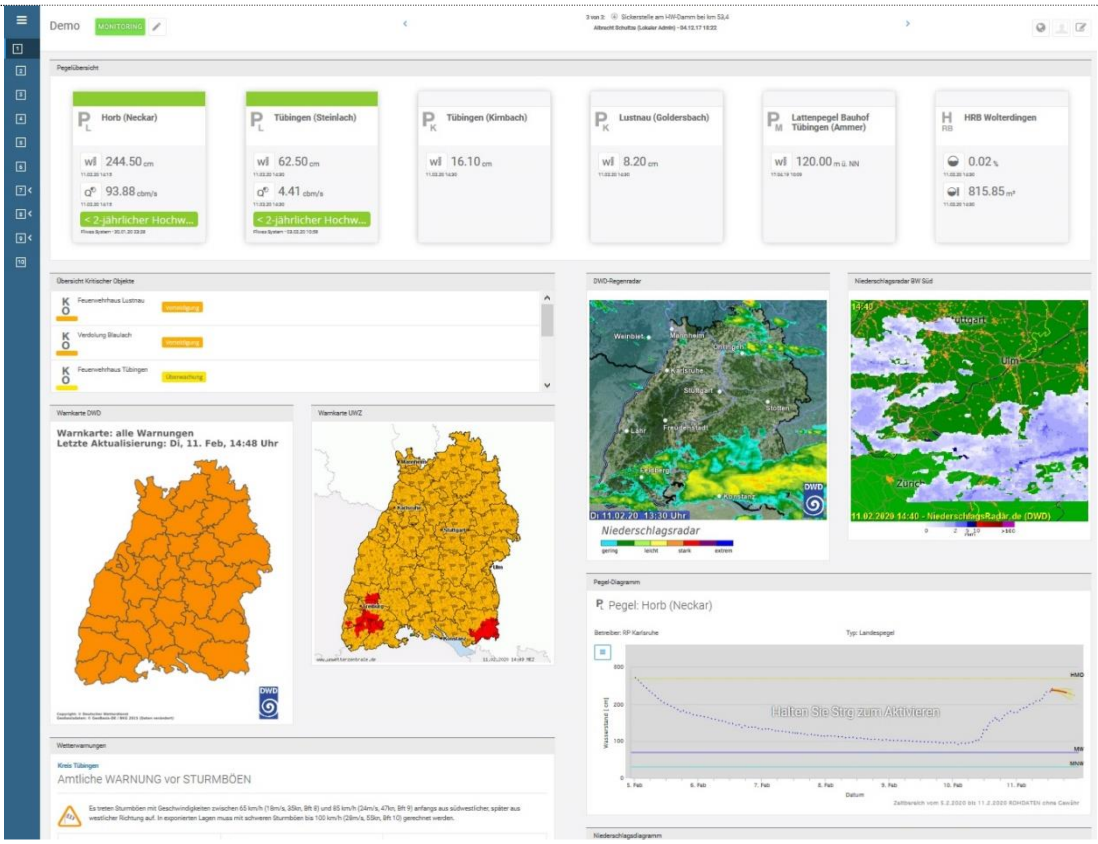


Surface water management covers measures involving physical interventions to reduce surface water flooding especially in an urban environment. To achieve this the infiltration structures to catch the rainfall water (e.g. drainage channels in settlements) have to be constructed, properly maintained (kept clear) and, if necessary, repaired. Construction of new or improving the capacity of the existing urban drainage systems is planned. Use of green roofs and rain gardens contributes positively to increasing the water retention in urban areas. To avoid pollution problems the flood protection measures on sewerage systems will be taken including construction of retention storages on sewerage system. Surface water management also include compensation of sealing by increasing infiltration, rainwater management and providing information via hazard indication maps of potential pluvial flooding (surface water runoff).

	**GERMANY**	**Status:** Implemented
	Target area: Federal State of Baden Wuerttemberg	
Project:	**Flood Information and Warning System FLIWAS 3.0**	

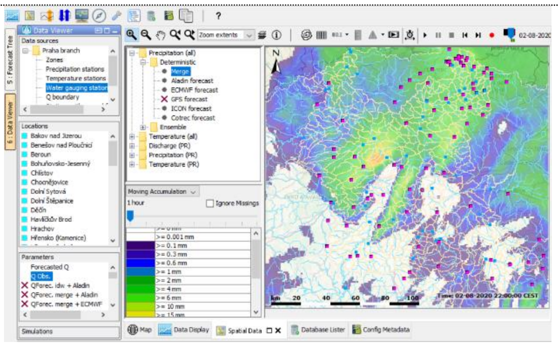
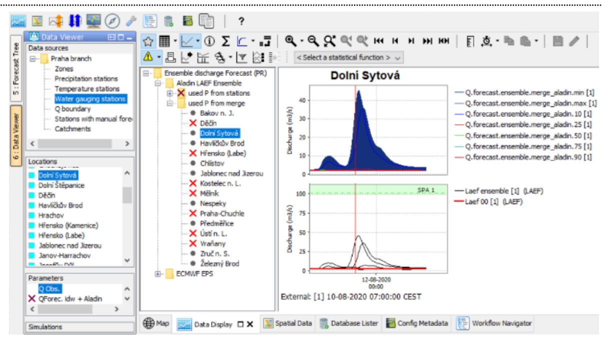
The Flood Information and Warning System FLIWAS 3.0 is a web-based application for providing and exchanging information on flood crisis management for the federal state of Baden Wuerttemberg. It is intended for use by public authorities and emergency services. The project was launched in 2015 and finished in 2019. Currently, FLIWAS is used in Baden Wuerttemberg by 1,100 people.

FLIWAS is suitable for desktop computers and mobile devices. It provides a wide range of flood-related data and information, such as current and predicted rainfall, current and predicted water levels, fill levels of flood retention basins and status of critical infrastructures. Users can include emergency plans and share additional information, for example situation reports and maps. Add user defined threshold values such as predefined water levels, FLIWAS will automatically send messages to the user. The user interface of FLIWAS is highly configurable and can be adapted to the individual needs of any administration. Last but not least, FLIWAS enables authorities to operate their flood retention basins in a coordinated way. This helps to reduce water levels in the upper reaches of the Danube River and to mitigate damages in the middle and lower reaches of the Danube River.



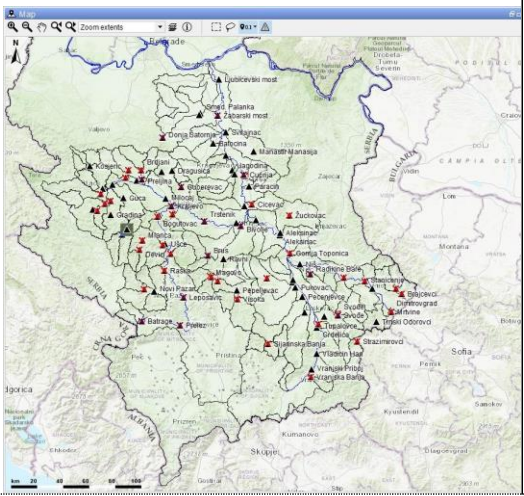
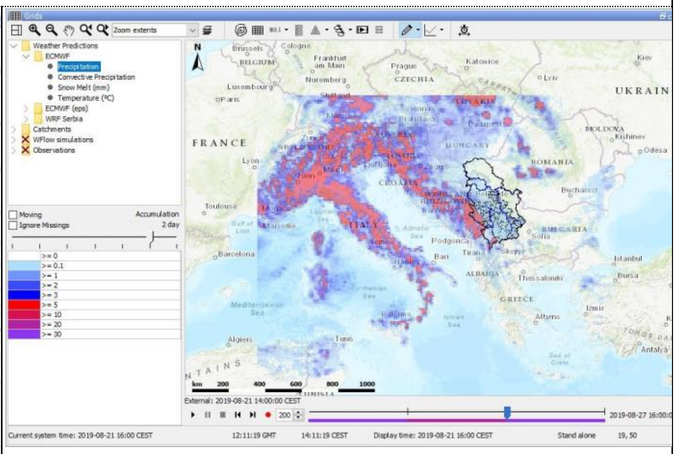
5.5.3 Strengthening resilience

Resilience is the ability to cope and respond before, during and after a flood event occurs. The society affected by floods shall recover to regain or increase a standard of living comparable to the pre-flooding status. The sound resilience concept requires having clear management objectives for preparedness-oriented activities as well as for recovery and review. Ensuring sufficient preparedness includes measures to establish or enhance flood forecasting or warning systems, measures to establish or enhance flood event institutional emergency response planning (contingency planning) and measures to establish or enhance the public awareness or preparedness for flood events.

	**CZECH REPUBLIC**	**Status:** Implemented
	Target area: Czech Republic, partialy Austria and Slovakia	
Project:	**Implementation of Delft-FEWS platform into flood forecasting system**	
Delft-FEWS is an open modular data-handling platform for flood forecasting and warning systems. CHMI implemented the system to its operational flood forecasting service over the period 2017-2019 with a support of the Operational Programme Environment (EU Cohesion fund). Essentially, the system enables collection, quality control and editing of hydrometeorological data from various sources including numerical weather forecast. Data is then used to feed hydrological models. For that purpose, existing AquaLog and HYDROG models were implemented to Deft-FEWS environment. FEWS platform enables customized operation at regional forecasting offices through developed sets of workflows including ensemble forecasting, automatic run of models as well as sequenced computations among areas of responsibility of various regional offices from upstream to downstream. Project included the HW infrastructure solution with server instance and stand-alone pc regimes. Within the Morava River basin, there are 26 forecasting profiles in the Czech Republic including 3 forecasting profiles abroad. The last forecasting river profile is the gauging station Hohenauan der March below the confluence of Morava and Dyje rivers situated on Slovak-Austrian border. For the operation of flood forecasting service, the international cooperation is necessary because a significant part of the upper Dyje catchment spans across Austria and there is also Myjava River basin in Slovakia.		
		

The measures to enhance flood forecasting and warning systems are ongoing or planned in all Danube countries. These include research and development projects and best practice projects, revision and completion of forecast profiles and flood announcement limits, construction of local warning and notification systems, creation of expert systems to analyze measured data, building new monitoring systems based on radar and precipitation stations, introducing new forecasting models based on automated precipitation and gauging stations as well as use of radars and satellite imagery. Emphasis is given to making the measured data available to relevant services in real time, improving the early-warning systems and systems for issuing timely warning to population at risk, especially on river basins without structural flood protection and upgrading the international exchange of meteorological and hydrological data. Special attention is given to building of early-warning systems focusing on flash floods.

<table>
<tr><td rowspan="2"></td><td>SERBIA</td><td>Status: Implemented</td></tr>
<tr><td colspan="2">Target area: Velika Morava River basin</td></tr>
<tr><td>Project:</td><td colspan="2">Development of the Flood Forecasting and Warning System for the Velika Morava river basin</td></tr>
<tr><td colspan="3">The project was initiated at the project kick-off meeting, held on August 29, 2019, at the Republic Hydrometeorological Service of Serbia (RHMSS) in Belgrade. This forecasting system has been implemented for the Republic Hydrometeorological Service of Serbia (RHMSS) during the period of August 2019 till March 2020 by Deltares, along with the Centar Građevinskog fakulteta d.o.o. Zagreb and Mihailo Anđelić as subcontractors. During the project implementation, all partners have maintained fruitful and mutually beneficial cooperation with the RHMSS, the Water Directorate of the Ministry of Agriculture, Forestry and Water Management, the World Bank and the independent advisor - Prof. Dr. Jasna Plavšić. The project is part of the larger Serbia National Disaster Risk Management Program, which is financed by the Trust Fund provided by the European Commission on behalf of the European Union and administered by the World Bank.

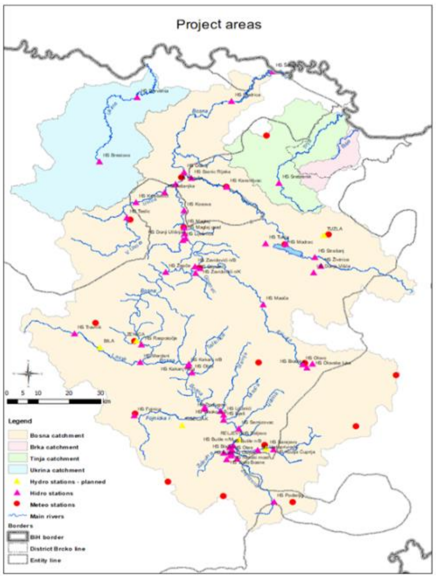
In accordance with the Terms of Reference (ToR), the principal objective of the project was to build a hydrological model that supports flood forecasting embedded in a real-time operational platform, without inclusion of a hydraulic model and training components. The Consultant has developed, calibrated and verified two hydrological models for the Velika Morava catchment - a semi-distributed HEC-HMS and a fully distributed Wflow model. These models are integrated in an independent Delft-FEWS client-server application hosted at the RHMSS in a Test and Production environment, fed with real-time observations from the RHMSS WISKI database, csv files and deterministic and ensemble Numerical Weather Prediction models. The forecasting results contain forecasted river flows and water levels derived from rating curves for 16 hydrological stations on Zapadna, Južna and Velika Morava. These results are checked with crossing of warning levels, which may result in additional alerts to be sent out by the RHMSS.</td></tr>
<tr><td colspan="3"> </td></tr>
</table>

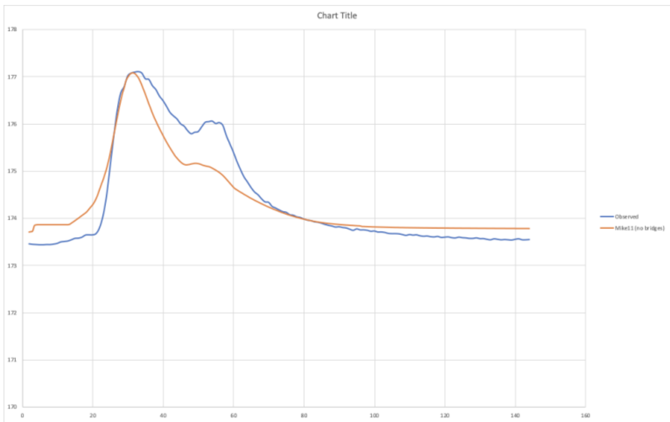
Harmonization of the flood alert and warning systems in transboundary basins with the neighbouring countries is a prerequisite of a fast and effective cross-border information flow which enables to increase the forecasting periods. Improvement of international exchange of meteorological and hydrological data is thus central for ensuring efficient operation of international warning systems. More information on this topic is provided in chapter 5.5.6.3.

Preparation and update of emergency and crisis plans at local/regional/country level is an essential prerequisite to efficient flood resilience. Of equal importance is preparedness activities, such as training, exercise and professional support of flood and crisis authorities and non-governmental organizations; improvement of cooperation between different sectors (prevention, preparedness, response and recovery stages), institutions, professionals and volunteers involved in flood management; and pre-assignment of technical devices and materials for protection and search and rescue activities during floods.

<table>
<tr><td rowspan="2"></td><td>BOSNIA AND HERZEGOVINA</td><td>Status: Ongoing</td></tr>
<tr><td colspan="2">Target area: Bosna River</td></tr>
<tr><td>Project:</td><td colspan="2">Development of Hydrological Flood Forecasting System for Sava River Basin (Bosna River)</td></tr>
<tr><td colspan="3">Overall objective of the Project is to support the development of integrated flood risk management in BiH in line with the EU Floods Directive. Project purpose is to support weather and hydrological data collection, systematization, indexing and improvement of acquisition services, as well as establishment of consistent HFFS on a common IT platform accessible to the appropriate institutions, primarily to the project beneficiaries – water agencies and hydrometeorology institutes. The Project will support the implementation of measures of the Flood Action Plan for flood protection and river management, through consistent and coordinated development and implementation of cutting-edge tools and technologies for flood forecasting and strengthening capacities of Hydrometeorological Services and Water Agencies in BiH.

The main purpose of the Project is to Integrate information and communication infrastructure and observation systems in BiH to enable automatic, accurate, reliable, timely and consistent hydrometeorological data acquisition services data collections store and improve access to databases and information on weather and hydrological conditions; as well as to Establish consistent hydrological flood forecasting system (HFFS) on a common IT platform to provide synoptic meteorological and hydrological services, hourly forecasts and informing on potential hazardous flood events to the responsible government bodies at the state and entity levels, institution in charge for flood and civil protection, and thus increase social, economic and environmental safety. The Project will be implemented until end of March 2021.</td></tr>
</table>



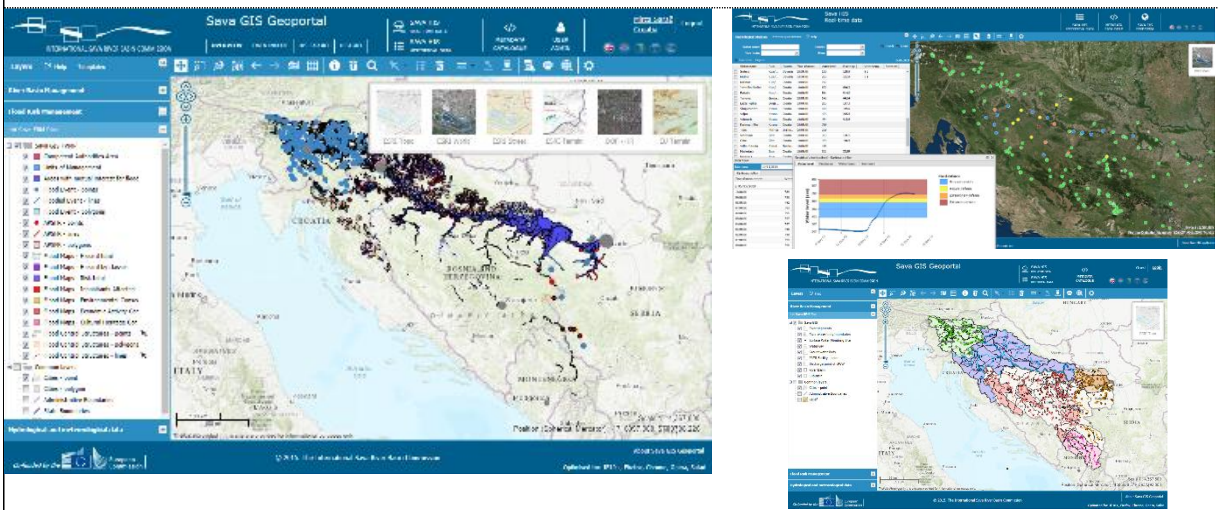


Coordination in operative flood management is increasingly important with more floods affecting multiple countries and exceeding peak historical levels in the last years.

INTERNATIONAL SAVA RIVER BASIN COMMISSION	**International Sava River Basin Commission (ISRBC)**	**Status:** Implemented
	Target area: Sava River Basin countries (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia)	
Project:	**Geographical & Hydrological Information System of the Sava River Basin (Sava GIS & Sava HIS)**	

Sava GIS was established by ISRBC and put into operational use since April 2016 with the goal to enable the ISRBC community sharing and disseminating of information and knowledge about protection of the water resources and water management activities in the Sava River Basin. Sava GIS is fully functional through the Sava GIS Geoportal - www.savagis.org which is scalable and flexible tool for data visualization and management, supports multilingual usage and implements open source technologies as well as open web services. Editing, loading and retrieving data and metadata is also enabled to the registered users. Sava GIS geodatabase model was significantly expanded in order to make it compliant to the EU WFD and EU FD Reporting Guidance and the ICPDR's Danube GIS and currently enables storing of datasets relevant for: river basin management planning and flood risk management planning (management; historical floods; preliminary flood risk assessment; areas with potential significant flood risk; flood hazard and risk maps; measures for reduction of flood risk; flood protection structures).

As integral part of Sava GIS, the system for exchange of hydrological and meteorological data and information, Sava HIS has also been established, with the main goal to support the Sava countries in sharing and disseminating of hydrologic and meteorological data and to enable an effective common channel for exchanging and viewing data in emergency situations, primarily those related to flood events. Sava HIS is fully functional through the Sava GIS Geoportal and can be also reached through www.savahis.org



One of the outcomes of the Flood Survey conducted by the coordination of EUSDR PA5 after the extreme floods on the Danube River in 2013/14 was the need to harmonize/coordinate Operative Flood Management Plans (OFMPs) along the Danube [5].

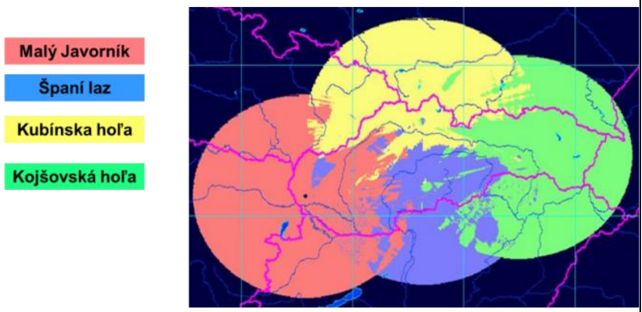
[5] L. Balatonyi (EUSDR PA5): Study on operative flood management plans

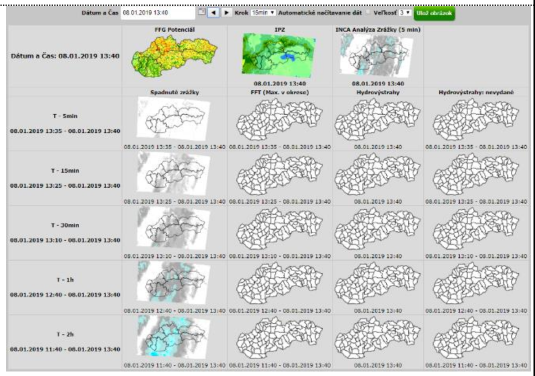
	**Slovakia**	**Status:** Implemented
	Target area: Slovak Republic	
Project:	**POVAPSYS Flood Warning and Forecasting System**	

The key purpose of the POVAPSYS Flood Warning and Forecasting System system built in 2015 was production of early and high-quality forecasts of the meteorological and hydrological situation, including warnings of extreme flood events and the online dissemination of this information to the flood protection authorities. The hydrometeorological network feeding the system contains 137 automatic rain gauge stations, 78 automatic meteorological stations, 216 snow scales and cylinders, 19 weather cameras, 12 off-road vehicles, leveling and GPS devices and ADCP devices for discharge measuring. Within the building of remote sensing methods, a system of receiving data from circumpolar satellites was completed. Two new observation spots were built - radar towers on Kubínska hola and Spani laz including the installation of new radars. New radar network should ensure reliable monitoring of a long-term intensive precipitation connected with stratiform cloudiness as well as the short-time storm floods usually interfering with small limited areas. New radars were delivered and installed also on two existing radar towers Maly Javornik and Kojsovska hola. The measurements by new radars are submitted to the Composite Radar Information System. Radar horizon composite map for Maly Javornik, Kojsovska hola, Spaní laz and Kubinska hola shows which of radars provide minimum visible height at the given point.

HYPOS systems (data collection control, visualization, control of model running, etc.), HelpDesk (issues tracking system), Electronic tool for manual - water level forecasting, Hydrological data management line (processing and storage of discharge measurements, discharge rating curves), Meteorological data management line (processing and storage of meteorological data), Delivery and Visualization Service of products (export of outputs to users) and other smaller systems have been developed.

A part of the POVAPSYS is a sub-module for flash-flood forecasting. It supports decision making process of hydrologists during convective precipitation season. The system is based on the WMO Flash-Flood Guidance System (FFGS). In its Slovak adaptation, INCA system is used as a combined information for precipitation analysis and soil saturation is computed by model of antecedent precipitation index (API). The system works in 5-minute time step and spatial resolution of a 1 km grid. Outputs from INCA analysis are summed up to different time intervals (5 min, 15 min, 30 min, 1 hour and 2 hours) and results are compared with values of a so-called FFG potential. The latter is defined as vulnerability of a territory to flash-floods, determined on basis of selected geographical and climatological features. If the sum of precipitation for certain time interval is higher than FFG potential, the district with high probability of flash-flood occurrence is marked in colour. New comprehensive flood forecasting system allows to ensure and improve the collection of input data not only from Slovakia but also from neighboring countries and to provide numerical forecasts for more than 100 new water gauge stations. In the framework of international data exchange, output of the POVAPSYS can be a valuable input for flood forecasting and warning system for the downstream countries.





Individual and societal recovery activities focus on clean-up and restoration activities (buildings, infrastructure, etc.); medical and phyco-social support (mental health supporting) actions, including managing stress; disaster financial assistance (grants, tax), including disaster legal assistance and disaster unemployment assistance. The measures adopted by the Danube countries include assistance with post-flood repair, restoration activities, aftercare planning and elimination of environmental damage. Support is provided to activities of humanitarian organizations and volunteers during and after floods. Properly designed and effective financial aid and insurance schemas are of major importance.

In case of pollution caused by a flood event the evaluation and repair of damages as well as clean-up and restoration activities (mould removal, ensuring well-water safety and securing hazardous materials containers) are to be carried out.

5.5.3.1 Flood information service in the Danube River Basin

Activities associated with protection against floods are governed by the respective legislation of each Danube state (the Water act, the Act on Crisis Management, the Act on Integrated Rescue System etc.).

Flood protection authorities and Emergency authorities are bodies of the state, regional or municipal administration fully responsible in pertinent areas for organization of the flood monitoring services. These authorities' co-ordinate and control the activities of other participants involved in the flood protection. The individual states of emergency depend on the water levels or discharges, which are defined for every section of the river according to the local/national flood risk and emergency management plans. The state of alert generally occurs when the water level rises above the river channel. The states of danger, state of emergency and severe situation are proclaimed at the behest of the competent river basin authority with reference to the hydrological forecast. The key tasks of meteorological services of the Danube countries in the area of flood forecasting include monitoring and forecasting of the weather situation, and advisory and warnings on dangerous weather events such as heavy precipitation, storms, hail etc. Quantitative precipitation forecast belongs to the most important activities of the meteorological services and it is provided through the use of numerical weather modelling by the top European Meteorological Services (France, Germany, and UK). This information is supplemented by data from the meteorological satellites and maps of rain intensities provided by national meteorological radars.

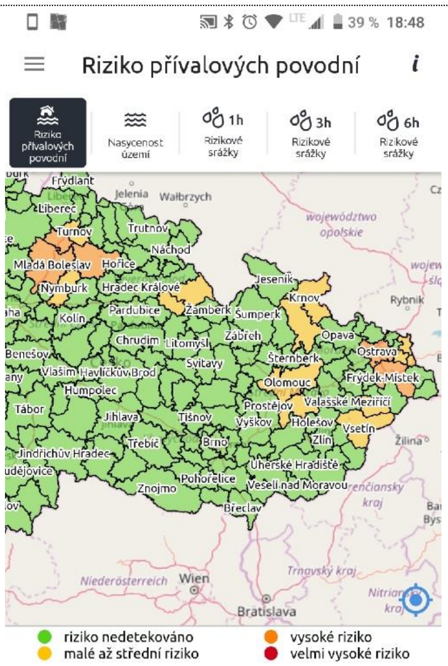
The hydrological services monitor the current situation on the rivers in the Danube river basin by gauging stations which provide regular hydrological information that is supplemented with the data from the River Basin Authorities. Hydrological data include those on flow regulation in reservoirs which influence the flood transit.

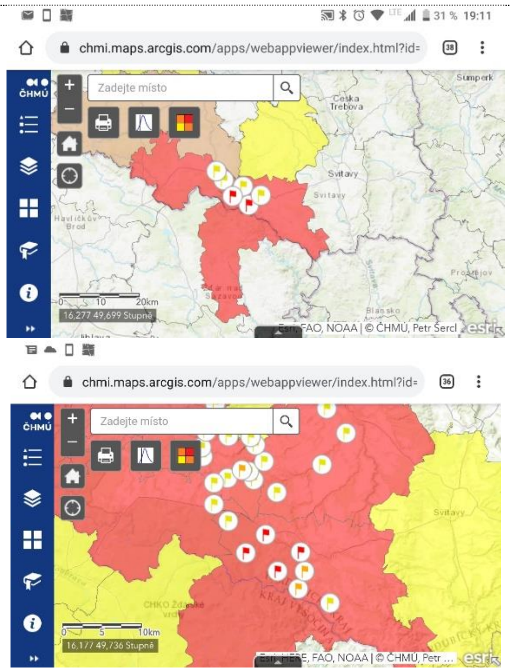
	**CZECH REPUBLIC**	**Status:** Implemented
	Target area: Czech Republic	
Project:	**Flash flood indicator**	

Flash flood indicator project deals with the calculation of the probability of occurrence of flash floods resulting from torrential rainfall events. This approach highlights the requirement of more accurate prediction of torrential rainfall along with its location to improve the accuracy of flash flood forecasting. However, it is possible to identify areas where the occurrence of intense rainfall, due to the physical-geographical characteristics, has possibly occurred leading to saturated soil conditions, resulting in an increased probability of flash floods to occur. Estimates of rainfall using weather radar adjusted data of ground observations and nowcasting methods can be used to detect (calculate) the current probability of flash floods to occur over the forecast lead time. For this purpose, it is possible to use established and simple methods for rainfall-runoff modelling, such as the USA Soil Conservation Service (SCS) Curve Number (CN) method and the unit hydrograph, and to use the data of antecedent soil moisture conditions together with the physical-geographical and soil characteristics of the watershed.

Within this project, a system of procedures, termed the "Flash flood indicator (FFI)", was developed. This approach tries to solve the issues outlined above using GIS tools. Its main outputs are the current soil moisture conditions, the potential risk precipitation of a given duration and the real-time estimation of the flash floods occurrence hazard within a given territory. The FFI has been operated since 2010 at the Central Forecasting Office of the Czech Hydrometeorological Institute (CHMI), but until 2016 was in experimental operation only, and in 2016 was tuned. Its results during 2017–2019 were evaluated in detail and since 2020 the FFI has been one of the important parts of forecasting system at the CHMI.

Outputs of Flash flood indicator are published via web and mobile application available for iOS and Android.





National forecasting methodologies were improved by developing and introducing hydrological models into the forecasting service. The hydrological forecasting system is connected to the meteorological forecasting system. Rainfall-runoff and routing models are calibrated for all main river basins and river reaches in the DRB. Data on observed precipitation and quantitative precipitation forecast enter to the models and this allows to extent the lead time up to 72 hours. In winter period the snow melting model is used within the systems. The overview of main water gauging stations in the DRBD is provided in Figure 4.

Figure 4 Main water gauging stations in the DRBD

The flood forecasting services regularly provide hydrological forecasts to the River Basin Authorities and other stakeholders and publish them on websites. In case of flood they inform the flood protection authorities and other participants involved in the flood protection about flood danger and flood evolution. Warning messages are disseminated as soon as the extreme meteorological or hydrological conditions have been forecasted, and during floods they are accompanied by information on the flood evolution and its further prediction.

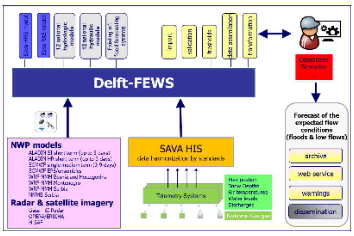
The ICPDR decided to develop the Danube Hydrological Information System (Danube HIS). The DanubeHIS shall display data on the water level, discharge (indication value with an explanatory disclaimer), water temperature and precipitation (from the station closest to the gauging station). The countries will submit their data on a voluntary basis depending on their availability. The data will be shown for the Danube and its major tributaries. The scope of the DanubeHIS is providing Danube basin-wide level basic hydrological and meteorological near real time data in a standard format, and, if possible, the validated long-term data series, for flood risk management or for any water related scientific activities in DRB.

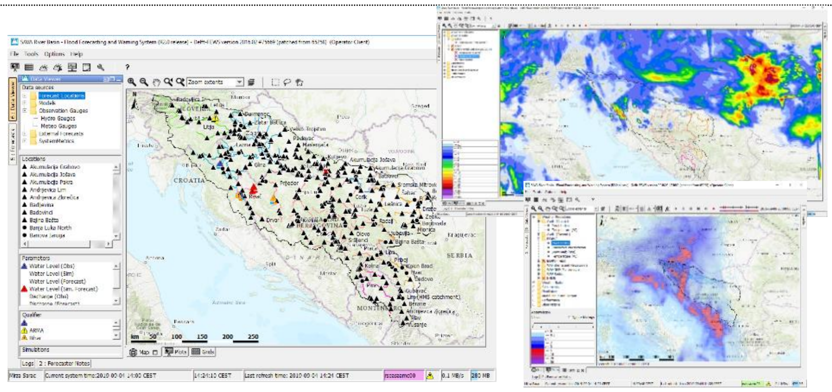
INTERNATIONAL SAVA RIVER BASIN COMMISSION	**International Sava River Basin Commission (ISRBC)**	**Status:** Implemented
	Target area: Sava River Basin countries (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia)	
Project:	**Flood Forecasting and Warning System in the Sava River Basin (Sava FFWS)**	

ISRBC, in close cooperation with the relevant national institutions of the Sava countries established Sava FFWS and put it into operational use in October 2018. Sava FFWS is a unique forecasting system at the international level, implemented as an open and flexible platform for managing the data handling and forecasting processes, allowing a wide range of external data and models to be integrated. This concept is particularly important for the five Sava countries, each with its own specifics in terms of organization of the water sector, stage of development of monitoring and forecasting systems, and legal and regulatory framework for flood risk management. In addition to eight different numerical weather prediction models, weather radar and satellite imagery, outputs of the existing national forecasting systems, and different local hydrologic and hydraulic models, Sava FFWS also integrates Sava HIS (see the example Sava GIS&HIS), as a data hub for the observed hydrological and meteorological real-time data as well as the Sava HEC-HMS and HEC-RAS models (see the example Sava modelling) which represent backbone of the system.

The organizational structure of the system is quite complex: Sava FFWS is installed at the hosting sites in the four countries and consists of one primary and three back-up installations in the national institutions, while the archive and web servers are located in ISRBC. The system is operationally used by 9 organizations – hydrometeorological services and water agencies. Working together internationally through the Sava FFWS significantly improves cooperation among related institutions while maintaining countries' own autonomy in monitoring, modelling, forecasting and warning.

In order to ensure the smooth operation of the system and its regular maintenance and performance control of the system, as well as training of engaged personnel, in July 2020 the Sava countries (and ISRBC) signed a MoU on cooperation concerning regular functioning and maintenance of the Flood Forecasting and Warning System in the Sava River Basin. This agreement will ensure the long-term sustainability of Sava FFWS as well as its further developments.





At present, the DAREFFORT project initiated by EUSDR PA5 is supporting ICPDR in developing the Danube HIS. The main aim of the DAREFFORT (Danube River Basin Enhanced Flood Forecasting Cooperation) project is to give a comprehensive overview about the complex national flood and ice forecasting systems and to eliminate the shortcomings of the existing forecasting practices as well as improve the exchange and availability of hydrological and meteorological data between the participating countries with establishment of the Danube Hydrological Information System (Danube HIS). The Evaluation report on flood and ice forecasting systems and methodologies in the Danube countries produced in the frame of the DAREFFORT project provides more detailed information on flood information services in DRB. More information on the project is provided in the chapter 5.5.6.3.

5.5.3.2 The European Flood Awareness System (EFAS) for the Danube River Basin

After the Danube and Elbe floods in 2002 the European Commission initiated the development of a European Flood Awareness System (EFAS) to increase the preparedness for floods in Europe. EFAS was developed in close collaboration with the ICPDR and the national hydro-meteorological services sharing the Danube river basin amongst others. The aim of EFAS is to gain time for preparedness measures before major flood events strike, particularly for large trans-national river basins such as the Danube, both on country as well as European level. This is achieved by providing complementary, added value information to the national hydrological services and by keeping the European Response and Coordination Centre[6] informed about ongoing floods and about the possibility of upcoming floods across Europe. Since 2012 EFAS is running fully operational as part of the Copernicus Emergency Management Service[7].

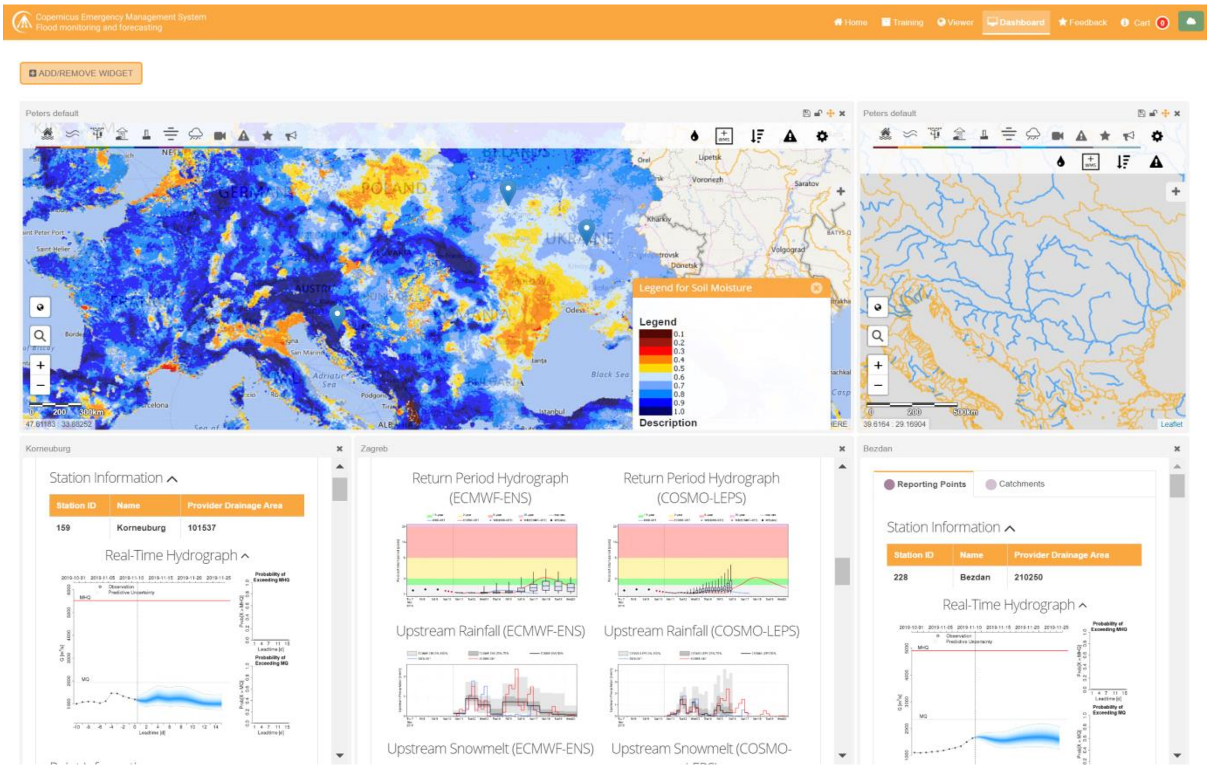


Figure 5 Screenshot of the EFAS web interface

EFAS provides the national authorities with a wide range of flood forecast information such as medium-range flood forecasts with a lead time of 10-15 days, impact forecasts, flash flood forecasts with up to

[6] http://ec.europa.eu/echo/en/what/civil-protection/emergency-response-coordination-centre-ercc

[7] https://emergency.copernicus.eu/

48 hours lead time and seasonal outlooks for the coming months. The information can be accessed by the EFAS partners either through a password protected web site[8] (see example Figure 5) or through web services. All relevant flood forecasting authorities in the Danube river basin are EFAS partners.

EFAS is constantly being further developed with regular new model calibrations including more in-situ data or changes to the model setup and by improving its products. Through collaboration at the Danube river basin as well as at the European scale EFAS fosters knowledge exchange and data sharing amongst the national hydro-meteorological authorities and hence is an essential tool to improve overall flood risk management in the Danube river basin.

5.5.3.3 DAREnet project

DAREnet is a network of practitioners dealing with flood resilience in the Danube River Region, supported by a continuously evolving multi-disciplinary community of stakeholders consisting of policy makers, academics, industry and many more. ICPDR is an active project partner.

DAREnet is organised as a network of national practitioner networks, led by dedicated DAREnet National Contacts (DNC). The DNCs are building in their countries multi-disciplinary practitioner communities to collect information about innovation needs and opportunities in an ongoing dialogue. The DAREnet project will unite these national communities in an open ecosystem to foster synergies, innovation and its uptake across the Danube Region. The network is supported by a broad range of stakeholders from policy, industry and research. EUSDR PA5 actively supports the implementation of the project.

The DAREnet project will enable Flood Management Practitioners in the Danube River Region:

- to connect and exchange with national and European stakeholders in a truly collaborative environment;
- to identify and analyse by and for themselves relevant innovation gaps;
- to translate the gaps into a joint innovation strategy to improve flood resilience in the future.

Until 2022, DAREnet will deliver an annual Innovation Roadmap highlighting promising innovation opportunities to cope with the main environmental and societal challenges of the region. The Roadmap is the result of a systematic assessment and prioritisation of promising Innovations (i.e. Roadmapping cycle). The DAREnet Roadmap lays the basis for concrete innovation initiatives, practitioner-driven and “bottom-up”. For this, DAREnet publishes regular calls for initiatives, enabling practitioners to formulate and develop their ideas with the support of the DAREnet network.

Both, Roadmap and Initiatives, will be proactively promoted towards national and European Policy Makers to support future innovation strategies in the region.

5.5.3.4 Improvement of emergency response

Establishment of the EUSDR PA5 Disaster Management Working Group (EUSDR PA5 DM-WG) supports the emergency response and preparedness elements of managing environmental risks and the

[8] www.efas.eu

realization of Action 3. “Strengthen disaster prevention and preparedness among governmental and non-governmental organizations”.

Extending the cooperation and joint efforts of the countries in the Danube Region presents an opportunity for reaching a common understanding and developing standards regarding the management of environmental risks. Developing recommendations for the civil protection organizations and fire and rescue services involved in disaster management would encourage standardized response activities. In order to achieve its objectives, EUSDR PA5 DM-WG will cooperate with ICPDR in all activities concerning flood risk and river basin management to achieve good synergy and to contribute to their work with disaster response viewpoint.

The members of EUSDR PA5 DM-WG are nominated by each Danube county (one member from governmental and one member from non-governmental sector) to ensure the involvement of all relavant actors. According to the Concept the EUSDR PA5 DM-WG objectives are as follows:

- provide a platform for cooperation between relevant stakeholders from the 14 Danube countries in the field of disaster management;
- cooperate with ICPDR in all activities concerning water management to achieve good synergy and to contribute to their work with disaster response viewpoint;
- support the European Union Civil Protection Mechanism (DG ECHO) in cross-border and regional level disaster management with the involvement of authorities and (volunteer) non-governmental organizations;
- trigger discussions and activities concerning disaster preparedness and response elements in the management of environmental risks;
- work on the development of recommendations for volunteer organizations involved in disaster response in the Region;
- support this initiative at policy level by developing “Minimum standards for civil protection organizations and fire and rescue services involved in international or cross-border disaster response in the Danube Region”;
- identify existing practices and procedures to minimize duplications.

EUSDR PA5 has been supporting the operative level activities, such as:

- DAREX 2019 – International flood exercises simulation with inter-institutional participation, on 4-7 July 2019 in the Upper-Tisa. PA5 organized a full-scale field exercise focusing on flood protection training and response activities with more than one hundred participants. Governmental organizations, volunteer rescue teams from SK, RO and HU participated with a common goal to be better prepared in case of flooding when regional or cross-border assistance is needed.
- organization of an international workshop on Operative Flood Management Planning:
  The Operative Floodrisk Management Plan workshop supported establishing an operative management forum. The event was organized on 27November, 2019 by PA5 in Pécs, Hungary with the involvement of experts from Water and Disaster Management agencies from 6

counties (DE, HR, HU, RO, RS, SI). The workshop was connected to the initiative of developing harmonized/coordinated operative flood management plans (OFMPs) along the Danube[9].

5.5.4 Raising awareness

It is the personal responsibility of anyone who lives and works in the area of potential significant flood risk, to adapt all his activities to flood risks. This requires communication to citizens in an appropriate and understandable way on flood risks and on opportunities how they can adapt to the natural circumstances. The awareness raising measures include presentation of flood hazard and flood risk maps, flood risk management plans (including natural water retention measures and associated consequences to adaptive land use) and of emergency management plans to public, organizing training campaigns (e.g. training of local fire brigades and inhabitants) and other educational activities focusing on flood preparedness among municipalities, introduction of water management issues into schools (from the elementary school to the university level) and increase of participation of population in the flood management and emergency response works. Of special importance is informing public by daily reports about the situation during the flood events. Involvement of public media is very helpful especially by producing flood leaflets, films or TV broadcasts and organising media campaigns. An essential issue for both flood resilience and awareness raising is making available of effective insurance policies and financial precautions and informing the population in floodplains on the necessity of establishing flood insurance.

It has to be however pointed out that floods are natural events and the high probability floods provide positive effects on the ecosystem. They supply floodplains and connected wetlands with water ensuring fish reproduction and nutrient reduction. The combination of flooding with compatible land use leads to a range of positive effects for the well-being of the society.

5.5.5 Promoting the solidarity principle

Countries shall not apply measures which, by their extent and impact, significantly increase flood risks in the countries neighbouring upstream or downstream. Countries should take all possible steps not to export the flood problems to their neighbours.

The measures applied in the Danube countries include natural water retention and flood retention (it reduces the volume of water flowing down to the neighbour country); development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance; analysis of up and downstream effects and coordination if compensation is needed; relocation of river dikes making more space for water, improvement of torrential flood control and constructing infiltration structures to retain the rainwater.

For an effective implementation of the solidarity principle an intensive international cooperation on all elements of flood protection, prevention and mitigation is an essential prerequisite.

[9] L. Balatonyi (EUSDR PA5): Study on operative flood management plans

Implementation of bi- and multilateral projects and measures for transboundary or bordering rivers strengthens the understanding, promotion and implementation of the solidarity principle.

Solidarity principle plays a key role in the prioritization of measures relevant for the international Danube River Basin District and therefore its further description including the practical examples of its application are provided in the chapter 11.

5.5.6 Progress in implementation of basin-wide measures

Progress in implementing measures is being assessed through evaluation of DFRMP Annex 2 projects progress. The results of the selected key activities are presented below. Information about the progress in implementation of natural water retention measures is provided in the chapter 6.3 and in the Annex 5. Additional international project activities are presented in the chapter 7 of the DFRMP Annex 2.

5.5.6.1 Danube Sediment project

The ICPDR identified in the past a changed sediment regime in the Danube River as an issue. To tackle this, EUSDR PA5 Hungarian coordination financed the project elaboration. Finally, 14 project partners and 14 strategic partners came together in the DanubeSediment project. The partnership included numerous sectoral agencies, higher education institutions, hydropower companies, international organisations and nongovernmental organisations from nine Danubian countries. The project results confirmed the assumption that there is a sedimentation tendency when the river is dammed, while erosion mainly occurs in the free-flowing river sections. One result of the sediment regime analysis can be seen in the following figure: Since the construction of the major hydropower plants, the total suspended sediment input to the Danube Delta and the Black Sea decreased by more than 60 %. The mean annual suspended sediment load decreased from ca. 60 and 40 Megatons per year historically to ca. 20 and 15 Megatons per year nowadays. From Ceatal Izmail to the Black Sea, the suspended sediment load is decreasing, although there are also uncertainties at the last monitoring stations due to tidal influence from the Black Sea[10].

Socio-economic development has gradually altered the Danube River and its tributaries and consequently changed the sediment regime. The DanubeSediment project identified the key drivers of these changes such as flood protection, hydropower, navigation, water supply, land use (agriculture and urbanisation) and dredging. These key drivers cause key pressures that strongly impact the sediment regime of the Danube, for example transversal structures, river training and maintenance works. Transversal structures for hydropower use and water supply, like dams and weirs, interrupt sediment continuity to a large extent. Bank protection measures and cut-off side channels as well as flood protection dykes hinder the lateral exchange of sediments.

[10] measured at the monitoring station Ceatal Izmail for the input into the Danube Delta for 1931–1972 and 1986–2016; input to the Black Sea measured and summed up for the stations Periprava, Sfantul Gheorghe Harbour and Sulina for 1986–2016 and determined from the stations Periprava (measured), Sfantul Gheorghe Harbour and Sulina (back calculated) for 1961–1972

The DanubeSediment project developed an in-hand Sediment Manual for Stakeholders offering assistance for sediment-related actions in the Danube River Basin and for future programmes of sediment-related measures. The Manual provides a collection of good practice examples, highlighting the benefits and impacts of measures that improve the sediment balance and continuity. It also describes the good practice measures for each key stakeholder group including flood risk management. The flood risk management measures on a catchment scale cover (i) minimizing anthropogenically caused excessive debris flow, mass movements and landslides; (ii) reducing surface runoff by infiltration and retention and (iii) controlled sediment transfer at barriers (improve sediment continuity). The regional scale measures recommended by the DanubeSediment project focus on (i) reconnecting side-channels or enhance floodplain erosion; (ii) opening or removal of flood dykes; (iii) relocation or set-back of flood dykes; (iv) removal of natural near-river levees (bank erosion or mechanical); and (v) restoring wetlands. The local scale measures include local bank protection and modification or removing barriers (weirs or ramps).

<u>DanubeSediment project recommendations:</u>

The DanubeSediment project recommends the restoration of the sediment balance and that the dynamic equilibrium of the riverbed should be a main priority for flood risk management. Changes in the riverbed, whether long-term or short-term, can have negative impacts on flood protection during flood events. Erosion of the riverbed can cause instability of flood protection measures or can lead to a failure of the protection measures during flood events. Sedimentation can raise the riverbed level and consequently the water surface level, and thus causing earlier inundation. Furthermore, sediment trapping in impoundments or reservoirs can raise flood water levels and remobilise of fine sediments during large floods, thereby increasing the damage in case of flooding. Thus, the DanubeSediment project recommends the development of a sediment management concept and the implementation of measures to improve the sediment regime and to reduce river reaches with sedimentation or erosion for flood risk management.

To improve the understanding of sediment processes during flood events, the implementation of sediment monitoring activities during flood situations as well as event documentations for post flood analyses is recommended in flood risk management tasks. This also helps to improve the process understanding in impoundments and reservoirs, free-flowing sections and their interaction. The data collected can also serve as input and calibration and/or validation parameters for numerical simulations. Numerical simulations used for flood forecasting, to plan or evaluate measures to mitigate floods, should include sediment transport and morphological processes. The consideration of sediments in the planning phase of flood protection measures is of high importance, since high amounts of sediments can be transported during flood events and significant changes of the riverbed (erosion and sedimentation) can occur.

The project supports the intention of ICPDR of improving a transnational effort to restore rivers' natural floodplains, which will reactivate the ability of natural wetlands and floodplains to alleviate negative flood impacts and besides flood mitigation, this will lead to ecological benefits in the form of maintaining biodiversity, frequent recharging underground aquifers and availability of cleaner water for drinking, areas for recreation, opportunities for tourism. The preservation and recovery of flood inundation areas, especially in free-flowing sections prone to erosion, reduces flow velocities and bed shear stress during flood conditions, and prevents or reduces riverbed erosion.

In the past, the Upper Danube was over-regulated over long stretches for flood protection but also for navigation and is now being restored to more natural conditions. This was a long learning process that took place in the Upper Danube over many decades. Therefore, the same mistakes should not be made in the (nearly) natural river reaches, which still exist, for example in sections of the Lower Danube.

Attention should be given to enabling the lateral sediment exchange by improving or removing existing flood dykes, where possible, and avoiding additional interruptions. Lateral erosion shall be allowed at locations where it has no significant negative effects, e. g. on flood protection for settlements. Removal or set-back of flood dykes reduces the discharge concentration and the water levels in the main channel and subsequently reduces the sediment transport capacity, thus counteracting riverbed degradation.

The DanubeSediment project recommends fostering river restoration measures, including side channel and meander reconnection to counteract the reduction of river width and length that was historically often undertaken to improve flood protection. It is also recommended to consider the morphological spatial demand of a river and the effect of extreme events in relation to sediment transport and morphological changes such as avulsion, widening or erosion, to reduce the damage potential. Securing this enlarged fluvial corridor and making room for the river is an important goal that should be considered in catchment-oriented spatial planning.

It is recommended to allow bank erosion to prevent or reduce natural levee formation, where possible. If natural removal by bank erosion is not an option, artificial removal might be considered as an option to allow an earlier inundation into the floodplains. This can be important since the degradation of lateral connectivity between main channel and floodplain increases water levels in the main channel at bankfull discharge, thereby causing higher shear stress occurs and increasing the risk of bed level degradation.

Furthermore, it is necessary to consider bed level changes that might occur during flood events. Morphological changes can result in significant bed level changes, which consequently changes the water level during floods. Flood protection measures should take the movable bed and the resulting water level differences into account in the planning stage of technical flood protection.

Furthermore, in reaches with erosional tendencies, a stabilisation or even an increase of the riverbed is recommended. Mitigation measures have to consider how to compensate the increasing bed and consequently increasing water level.

In reaches where sedimentation occurs, e.g. due to sediment trapping in impoundments or reservoirs, sediment routing by e.g. sluicing, or more frequent removal, e.g. environmentally friendly or flood-conditioned flushing, should be encouraged. This decreases flood water levels and the remobilization of fine sediments during large floods and consequently decreases the damage in the developed and cultivated foreland.

If dredging is performed for flood protection, we recommend reinserting the dredged material into the river system in areas with sediment deficits. Alternatively, use the coarse sediment to build natural structures such as gravel islands where these fit the natural river pattern.

5.5.6.2 Danube Floodplain project

The major catastrophic floods that occurred along the Danube Basin in last decades, neccesitated for adequate and coordinated measures to reduce flood risk without conflicts related to the WFD objectives.

In this respect, 24 partners from 10 countries from the Danube basin worked together in the Danube Floodplain project towards developing and improving the transnational water management and flood risk prevention simultaneously with preservation of the benefits for biodiversity conservation. The project budget is 3.673 mil EUR.

The specific objectives were: to improve knowledge, among the countries within the Danube River Basin, related to water management through restoration of floodplains, combination of classical and green infrastructure, natural retention measures, involving all related stakeholders and to commonly agree further actions on floodplain restoration and preservation.

The main activities within the project were:

- to update the floodplain areas inventory and their ranking using the Floodplain Evaluation Matrix-FEM method;
- to assess, by using the pre-selected pilot areas, the efficiency of floodplain restoration projects in the Danube District and,
- to develop tools for increasing the knowledge and cooperation of experts, practitioners, decision makers and stakeholders on floodplain restoration.

The main outputs of the project (DRB Floodplain Management Strategic Guidance, Manual aiming at cross sectoral cooperation and a Roadmap for action), finally agreed in cooperation with ICPDR will contribute to the development of better policies for the region:

1) The Danube basin wide floodplain restoration and preservation manual for practitioners is addressing mainly the key restoration approaches, potential win-win measures to mitigate flood risk through floodplain restoration and conservation actions. The DFP manual refers to the key results of technical work packages of the project (floodplain delineation, floodplain evaluation and ranking, Cost Benefit Analysis including assessment of ecosystem services, a synthesis of win-win measures having in view the WFD, FD and BHDD). A general concept for floodplain management through a step by step instruction of how to plan and implement restoration projects, how to solve potential conflicts in an integrated way, involving all related stakeholders is also included. The design of an efficient restoration project should include clear goals and objectives, sufficient baseline data and historical information, integrated planning and comprehensive design, and long-term monitoring.

The DFP Manual offers assistance for floodplain restoration measures, related actions and steps in the Danube River Basin and for future approaches in the planning and implementing floodplain restoration and conservation processes. Hence the DFP propose sequential steps starting from conceptual planning, preliminary activities, implementation and post-implementation actions, evaluation of the projects related to these types of projects. The DFP Manual provides a collection of good practice examples, addressed either to restoration but also to the conservation of floodplains, by highlighting the benefits in terms of floods, ecological status but also to the biodiversity and ecosystem services;

2) A Danube River Basin Sustainable Floodplain Management Strategic Guidance summarizing the key findings of the manual targeting a wider audience;

The Strategic Guidance defines the baseline for future floodplain restoration and conservation actions and management in the Danube Basin and major tributaries. It aims to improve the lateral connectivity through floodplain restoration and to highlight the benefits of a green approach comparing to the classical grey solutions leading to a sustainable use and protection of the Danube River.

The DFP Strategic Guidance is a strategic document that seeks to improve awareness on challenges related to the reducing of flood risk by maintaining a balance between social, ecological and biodiversity aspects. It suggests floodplain restoration measures that can be implemented to reduce flood risk in the Danube River Basin.

3) A Danube River Basin Roadmap which formulates an action plan how to move forward in order to be able to realize multipurpose restoration projects after the project end. These necessary actions, the agreed deadlines on Danube wide level, and the responsibilities are defined on both a basin-wide and national levels comprising agreed next steps towards realizing floodplain-related projects.

Roadmap of floodplain restoration will clearly define the follow-up actions, first for the national stakeholders involved in pilot areas, but also for the DRB scale in order to update DFRMP and DRBMP for the next reporting cycle.

5.5.6.3 Improvement of flood forecasting – DAREFFORT project

The main aim of the DAREFFORT project is to give a comprehensive overview about the complex meteorological and hydrological measurements and data collection, which has a long history in all countries (more than hundred years). Generally, regular network of meteorological and hydrological gauging stations in the Danube River Basin started to develop in the 19th century. Nowadays almost all countries provide a modern network of hydrological and meteorological stations to ensure real-time data used in forecasting and warning procedures and flood forecasting models.

All countries have extensive exchange of meteorological and hydrological data and information with domestic and foreign institutions. Hydrological services exchange data and information with neighbouring countries for border and cross-border watercourses. The harmonization of flows for border profiles is performed in accordance with pre-defined hydrological criteria and agreements.

The DAREFFORT project will deliver an overview about the present status of the national forecasting capabilities and the visions for future improvement.

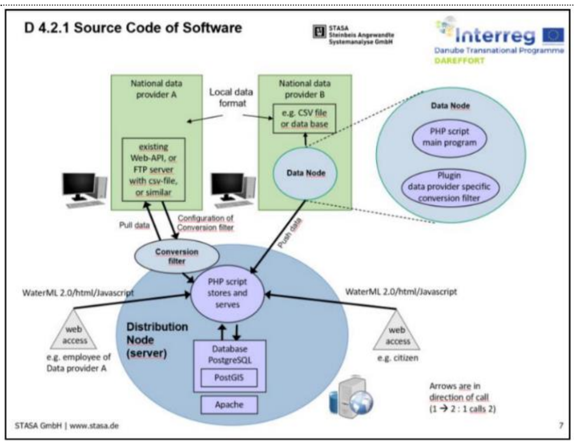
	**Hungary, Germany, Austria, Slovakia, Croatia, Romania, Bulgaria, Slovenia, Ukraine** **(Provided by EUSDR PA5)**	**Status:** Ongoing
	Target area: Danube River Basin	
Project:	**Danube River Basin Enhanced Flood Forecasting Cooperation**	

The reliable and comprehensive hydrologic data is the basis for sound forecasting in any country of the Danube Basin. None of the flood risk mitigation measures serves better the protection of human lives and the social estate than enhancing the preparation time to avoid catastrophes that could have been caused predicted floods. The most cost effective non-structural tangible solution which highly reflects the solidarity principle is the improvement of forecasting capabilities on basin-wide scale.

The Danube River Basin Enhanced Flood Forecasting Cooperation (DAREFFORT) project (6/2018 - 5/2021) will deliver an outstanding overview about the present status of the national forecasting capabilities and from the partners and the stakeholders will derive the common goals in order to develop the existing system in a comprehensive way. The mutual understandings will be recorded in a common vision of the partners. The partners jointly work out the policy recommendations for the ICPDR in support of the establishment of the Danube Hydrological Information System (DanubeHIS) which is a fundamental step towards flexible and sustainable data exchange. The main focus is to enhance the access to the recorded hydrological data and to provide harmonized distribution for all the countries in the Danube catchment. For this purpose, an interface software will be installed at national hydrometeorological institutes of the DRB to provide standardized data services being also a data source for the European Flood Awareness System (EFAS). The project supports the professional discussions on international level through organising the Danube Forecasting Forums (DAFF) in 2019 and 2021. As a pilot action, a specific implementation of a hydraulic routing model will be tested and demonstrated for the Danube sector between Bogojevo and Iron Gate Reservoir for understanding the possibilities of international capacity sharing. The project outcomes will be transformed into a guideline and a publicly available e-learning material for benefit of all users.

DAREFFORT project is a transnational initiative led by Hungary (VIZITERV Environ Ltd) and received a Letter of Recommendation from the Steering Group of EUSDR PA5. It is financed by the Interreg Danube Transnational Programme. Its preparation was supported by the Hungarian Ministry of Foreign Affairs and Trade.

Further information about the project: http://www.interreg-danube.eu/approved-projects/dareffort



The project partners are collecting the inputs from stakeholders and other interested parties in national expert workshops and results of professional discussions on the international level through the Danube Forecasting Forums (DAFF).

DAREFFORT project is a horizontal initiative to implement a flood risk mitigation measure in a joint and sustainable way on a catchment level. Further information on the project is available at: http://www.interreg-danube.eu/approved-projects/dareffort

5.5.6.4 Coordination of operative flood management plans

Coordination in operative flood management is increasingly important with more floods affecting multiple countries and exceeding peak historical levels in the last years. One of the outcomes of the Flood Survey conducted by the coordination of EUSDR PA5 after the extreme floods on the Danube River in 2013/14 was the need to harmonize/coordinate Operative Flood Management Plans (OFMPs) along the Danube.

That is why one of the measures of the Danube Region Operative Flood Management and Cooperation Programme (DR Oper&Cooper) - included also in the DFRMP adopted by the ICPDR and all the 14 Danube countries (2015) - is to coordinate the operative flood management and civil protection plans in the Danube Basin. This includes the evacuation plans and procedures, safeguarding people, goods, emergency rescue plans, etc. considering the benefits of the civil protection mechanisms for the shared flood basins or stretches of common interest to better use the available resources. An international workshop was organized by the EUSDR PA5 Hungarian co-coordination on the 27 November 2019 in Pécs.

The aim of the workshop was to exchange information about the best intervention practices and to review flood protection equipment, materials, resources and sets available in case of an emergency situation.

5.5.6.5 Setting up a flood protection education network in the Danube River Basin

In the frame of the flood protection education network, EUSDR PA5 supported and organised the following activities:

- workshop for vocational education-university representatives in 2017
- collaboration on protection education among universities (HU, DE, RS, SK)
- preparation of the InterFloodCourse project in 2018 – creating curricula and teaching material by experts of 7 Danube River Basin countries
- accredited international postgraduate course on flood protection at the Hungarian National University of Public Service (advertising the 2-semester course in 2020/2021 academic year in cooperation with the Belgrade University)
- financing the preparation of an e-Learning material on flood protection (2019)

5.5.6.6 Enhance coordination of operative flood protection methods and equipment

ICPDR and the EUSDR PA5 actively supporint the DAREnet project activties, which ongoing project supports flood management practitioners across the EU Danube River region to deepen and broaden their Research, Development and Innovation (RDI) related collaboration. It provides concrete perspectives for further development, industrialisation and uptake of innovations of highest relevance for practitioners, and lays the basis for concrete innovation initiatives, practitioner-driven and “bottom-up”.

Task 2: Build advanced training and appropriate capacity of the flood rescue teams and civil protection operative units

EUSDR PA5 has been supporting the operative level activities, such as

- DAREX2019 – International flood exercises simulation with inter-institutional participation Between 4-7 July 2019 in Upper-Tisa, PA5 organized a full-scale field exercise focusing on flood protection training and response activities with more than one hundred participants. Governmental organizations, volunteer rescue teams from SK, RO and HU participated with a common goal to be better prepared in case of flooding when regional or cross-border assistane is needed.
- Operative Flood Management Plans Study - The Operative Floodrisk Management Plan workshop helped the realization establishing operative management forum. The event was organized on 27 November 2019 by PA5 in Pécs Hungary with the involvement of experts from 6 counties (DE, HR, HU, RO, RS, SI) from Water and Disaster Management agencies. The workshop was connected to the initiative of developing harmonized/coordinated operative flood management plans (OFMPs) along the Danube[11].

5.5.6.7 Danube H2020 Insurance Project

Given the size and diversity of the Danube River Basin, scientific models covering the entire basin area are rare, those specifically investigating flood risks under climate change in the entire basin are even rarer[12]. To assess the changes in the occurrence of extreme events such as flooding, the classical climate change impact assessment of comparing average values of a projected future period (e.g. 2020–2049) with a historical baseline period (e.g. 1970–1999) are insufficient when assessing events with frequencies longer than those periods (e.g. a 100-year flood event). Probabilistic modelling increases confidence of risk assessments of low-probability, high-impact flood events and represents the standard approach in, for example, the insurance industry. Combining the approaches from climate impact research and the insurance industry, a probabilistic, high-resolution flood model for the entire Danube River basin (the Future Danube Model) was constructed as part of the EU-funded H2020_Insurance project (2017–2020) and in cooperation with insurance partners. Crucially, it includes a weather generator that is able to create consistent synthetic meteorological driving. It increases the number of extreme weather events by expanding the 30-year input data to a 10’000-year timeseries, maintaining the statistical characteristics of the original data. It was not only driven by observation-based data but also by two climate change scenarios of the 21st century and a 4-member GCM-RCM ensemble (global-regional climate model combinations) in an attempt to provide a robust assessment of fluvial flood recurrence and damages under past and future climatic conditions.

[11] L. Balatonyi (EUSDR PA5): STUDY ON OPERATIVE FLOOD MANAGEMENT PLANS

[12] Mauser, W., Stolz, R., 2018. Revision and Update of the Danube Study: Danube River Basin Adaptation. Ludwid-Maximillians-University Munich.

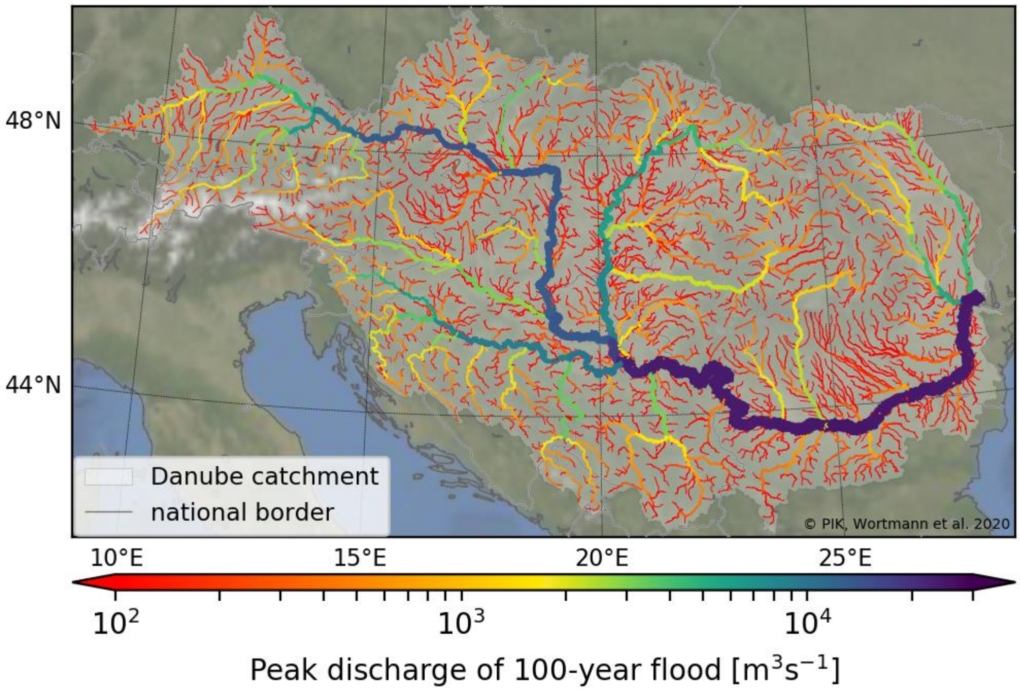


Figure 6 Peak discharge of the historical 100-year flood, driven by the EOBS observation-based data of 1970-1999

The model's ability to provide an integrated, all-basin evaluation of peak flood discharge is notable (such as the 100-year peak discharge given in Figure 6). Since it simulates transient, daily discharge in all river segments simultaneously, upstream and tributary effects are fully accounted for and realistic events are simulated throughout the basin. The integrated model setup, however, requires certain assumptions, such as the reference period of 1970–1999 for model calibration and the generation of stochastic meteorological event sets. As a consequence, reoccurrence levels may not directly correspond to locally determined flood statistics (e.g. official flood statistics at point locations).

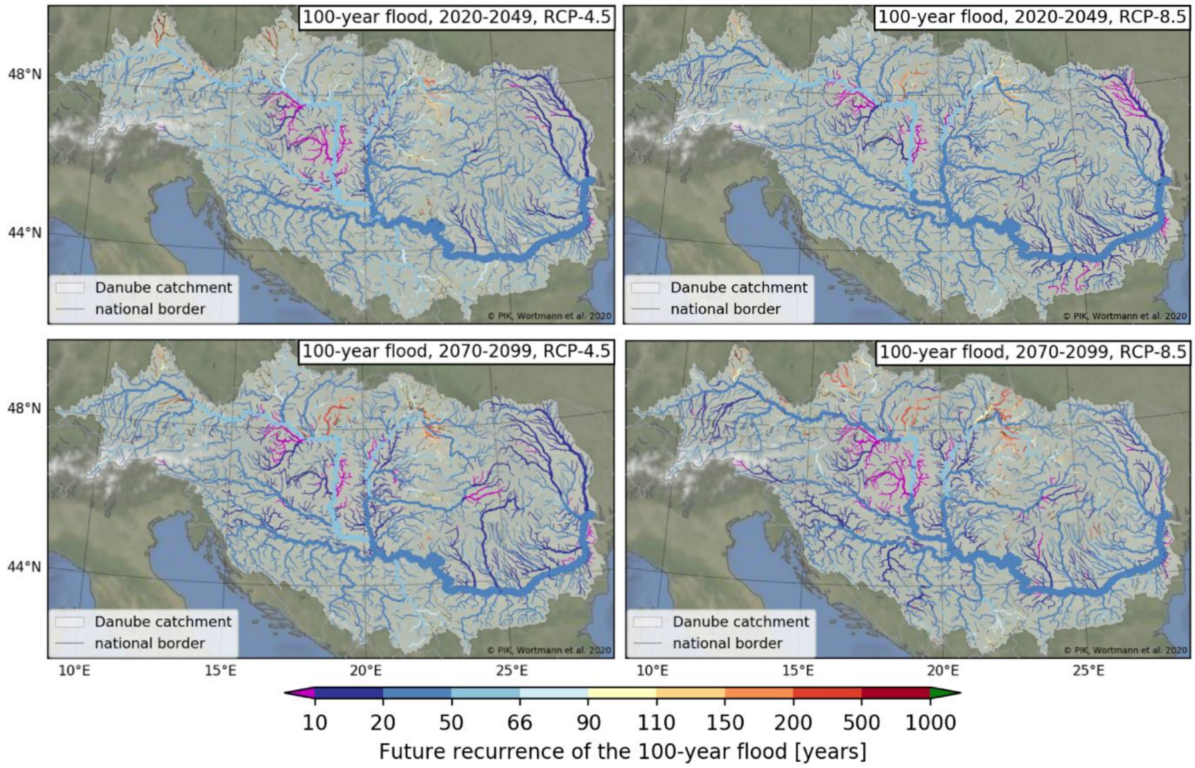


Figure 7 The future recurrence of the historical 100-year peak discharge (Figure 6) under the RCP-4.5 (left) and RCP-8.5 (right) scenario, in 2020-2049 (top) and 2070-2099 (bottom). Signals are median values over simulation driven by four climate model combinations. Dotted lines mark stream segments where two models indicate opposing signals of change.

6 Water retention

6.1 Flood retention

Flood retention structures are artificial constructions or natural barriers providing a retention volume to decrease a flood's peak. The retention can be provided by reservoirs, detention and retention basins, flood polders and by wetlands/floodplains. All flood retention structures contribute to flood attenuation and their planning, construction, operation, maintenance and reconstruction is given a top priority in this plan due to their substantial downstream effect

6.2 Towards better environmental options in flood risk management

Traditional measures to reduce negative impacts of floods include constructing new or reinforcing existing flood defence infrastructure such as dykes and dams. There are, however, other and potentially very cost-effective ways of achieving flood protection which profit from nature's own capacity to absorb excess waters. Such green infrastructure measures shall play a major role in sustainable flood risk management in the Danube River Basin District. Win-win solutions need to be the focus of flood risk management.

Integrated flood risk management must focus on sustainable water management and measures which work with nature are becoming more important, as they contribute to the strengthening of the resilience of nature and society to extreme weather events.

EU environmental legislation asks for the evaluation of better, feasible environmental options to the proposed structural changes to rivers, lakes and coasts, if these changes could lead to a deterioration of the status of these waters. The Water Framework Directive, Habitats Directive, Environmental Impact Assessment and Strategic Environmental Assessment Directive set out such requirements and strive to balance maintaining human needs whilst protecting the environment with the ultimate goal of achieving a sustainable approach to water management. Natural flood management considers the hydrological processes across the whole catchment of a river or along a stretch of coast to identify where measures can best be applied, with a focus on increasing water retention capacities.

6.3 Progress in implementation of natural water retention measures

Natural water retention measures are measures that aim to safeguard and enhance the water storage potential of landscape, soil, and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes. They support Green Infrastructure by contributing to integrated goals dealing with nature and biodiversity conservation and restoration, landscaping, etc. NWRM provide multiple benefits, including flood protection, water quality and habitat improvement. They are adaptation measures that use nature to regulate the flow and transport of water so as to smooth peaks and moderate extreme events (floods, droughts, and desertification). They reduce vulnerability of water resources to climate change and other anthropogenic pressures. They are relevant both in rural and urban areas.

NWRM often have lower costs than alternatives, such as grey infrastructure for flood risk management. Their cost-effectiveness, however, is often not well-known and in particular needs to be considered in terms of their multiple benefits.

Examples of natural water retention measures include:

- Sustainable Forestry Practices: e.g. riparian forests, afforestation
- Sustainable Agriculture Practices: e.g. buffer strips, crop practices, grasslands, terracing, green cover (organic farming helps to increase the water infiltration capacity and resulting retention potential)
- Urban Measures: e.g. Sustainable Drainage Systems (filter strips, swales), Green Roofs
- Measures for increasing storage in catchment and alongside rivers: restoration of wetlands, floodplains, lake, basins and ponds, re-meandering, natural bank stabilization
- Other Measures for increasing Groundwater Recharge

For practical reasons for larger scale floodplain/wetland restorations the legal and financial background (like incentives for land use change) have to be clarified and solved at the national level. The land use change and the wide range of landownership requires special knowledge on proper stakeholder involvement for which trainings and capacity building for planners and responsible bodies would bring great benefit. Sound land use planning at the local level supports maximizing natural water retention. Promotion of natural water retention also improves the resilience of ecosystems adjusted to flooding and limits adverse effects for nature.

6.3.1 FRAMWAT project

The ongoing FramWat project aims to establish a common regional framework for flood, drought, and pollution mitigation by increasing the buffer capacity of the landscape with the use of Natural (Small) Water Retention Measures (N(S)WRM) approach in a systematic way. Project partners are developing methods which translate existing knowledge about N(S)WRM into river basin management practice. The project is focused on identification of potential locations, effectiveness of the N(S)WRM as well as policy integration, and economic instruments.

The project developed the GIS tools (FroGIS), which is now publicly accessible and has been already used to analyze the needs and possibilities of water retention in six pilot catchments. The project completed a review of existing effectiveness indicators of N(S)WRM and developed static and dynamic tools, which are now able to select a specific mathematical model for each pilot catchment based on the recognition of the catchment characteristics, problems in water management, and planned methods of implementing solutions as well as the availability of data. FroGIS was used on 6 river basins to provide the information on the best locations and type of measures with cumulative effect. The Decision Support System (DSS) structure was finalized and Concept Plans were developed.

A close cooperation with all stakeholders was ensured since the beginning of the project. This included exchange of ideas and expectations with key stakeholders and national trainings on the use of GIS tool (FroGIS) and on testing the approach for the effectiveness methodology. Policy level stakeholders discussed with the project team the development of the guidelines and action plans with the aim of better addressing the current gaps and problems of integration of N(S)WRM's into the river basin management plans.

The project has been focusing on the development of the final version of DSS as well as correct calculations of N(S)WRM costs on a river basin scale. A step-by-step manual to assess the effectiveness of the system of measures in the river basin, and guidelines on how to improve water balance and nutrient mitigation by applying N(S)WRM were developed.

6.3.2 LIFE-MICACC

The „Municipalities as integrators and coordinators in adaptation to climate change“ (LIFE-MICACC, lead by the Ministry of Interior of Hungary, supported by the EUSDR PA5) project addresses a key cross-sectoral issue: the use of natural water retention measures in climate change adaptation and sustainable water management. It seeks ecosystem-based solutions for the mitigation of the water challenge in Hungary. Water resources and ecosystems are primarily impacted by climate change, but water retention is also a key element in climate change adaptation. On the local level, restoring the hydrological cycle and creating green infrastructure also contribute to mitigating the effects of climate change, e.g. extremities. The project demonstrates the various benefits of ecosystem-based adaptation approaches in the field of water management and sustainable land use at the municipality and catchment level.

The 5 partner municipalities in Hungary (Bátya, Püspökszilágy, Rákócziújfalu, Ruzsa, Tiszatarján) are the pilot sites, where small-scale NWRM interventions in CCA will be developed and tested. Under the frame of the project it will prepare model solutions for the different typical water risks, amplified by climate change Hungarian municipalities face. Besides, 23 other municipalities are involved in the project as external cooperating partners and primary target group of capacity building and replication activities. At least 5 transfer sites (in addition to the 5 pilot sites) will be chosen from them, where plans for the replication of the demonstrated NWRM models will be adopted.

	**Hungary** **(Provided by EUSDR PA5)**	**Status:** Ongoing (01/09/2017 – 31/08/2021)
	Target area: Improving the climate resilience and adaptation capacity of vulnerable municipalities by reducing risks stemming from climate change in Hungary and implementing natural water retention measures	
Project:	**Municipalities as integrators and coordinators in adaptation to climate change (MICACC)**	

The municipalities play a key role in coordinating adaptation to climate change at local level. The „Municipalities as integrators and coordinators in adaptation to climate change" (LIFE-MICACC, led by the Ministry of Interior of Hungary) project addresses a key cross-sectoral issue: the use of natural water retention measures (NWRMs) in climate change adaptation and sustainable water management. It seeks ecosystem-based solutions for the mitigation of the water challenge in Hungary.
During the project the practical applicability and viability of selected NWRMs in climate adaptation has been tested and demonstrated. Practical knowledge was gained from the 5 test cases (in field trips, at online conferences, on roadshow-s, short films, a guide and case studies). Since these local NWRMs serve as model solutions that can be implemented elsewhere replication was fostered. It is planned to build locally coordinated catchment partnerships around a joint vision and prepare plans for the upscaling of NWRM solutions to catchment level, involving stakeholders. In the frame of the project several innovative and user-friendly smart IT tools (e-learning modules, mobile application, Water Risk Filter) have been created. The Adaptation Guide introduces the whole process and the steps how to make NWRMs. Thus, the LIFE-MICACC project helps and encourages the decision-makers of municipalities to implement more NWRMs at their settlements.
The 5 pilot sites represent typical water risk situations connected to small municipalities in Central-Eastern Europe, amplified by climate change. A very important element of the project is to demonstrate which and how ecological-based local 'assets' are accessible for municipalities to adapt. In many cases, there is no need for expensive investments, as municipalities own and have the right to use their different local 'assets'. They have institutional, infrastructural, human and cultural assets available, and all these are based on local natural assets.

- Püspökszilágy: slowing the flow to protect the settlement against flash floods (with leaky wooden dams)
- Bátya: an innovation in rainwater management (clay pit on the outskirts of the village, one-hectare wetland habitat)
- Rákócziújfalu: no inland water is wasted (water reservoir created from municipal investments) Ruzsa: wastewater is valuable (pond by grey water reuse for better microclimate, small drainage canal with three small wooden sluice gates)
- Tiszatarján: landscape management on the foreshore (the clay pit system was completed with a new pool to increase the amount of retained water)

The LIFE-MICACC project received a Letter of Merit from the Steering Group of EUSDR PA5 and the PA5 HU coordination supported the internationalization of the project results in the DRB countries.

Further information about the project: https://nwrm.bm.hu



6.3.3 Danube Floodplain project

In addition to general info provided under 5.5.6.2 the Danube Floodplain project outcomes concerning NWRM are presented here.

Within the Danube Floodplain project, the effect of floodplain restoration measures in different flood events was assessed by applying hydrodynamic 2D models in five pre-selected pilot areas to investigate the hydraulic efficiency of the measures.

The pilot areas are: Begečka Jama (10.13 km^2) in Serbia and Bistret (176.98 km^2) in Romania (both located along the Danube River), while the other three areas are situated on the Danube tributaries: Krka (85.56 km^2) in Slovenia on the Krka River, Middle Tisza (49.51 km^2) in Hungary on the Tisza River, and Morava (147.37 km^2) at the Morava River at the border between Slovakia and the Czech Republic. Two restoration scenarios (realistic and optimistic) have been assessed (in cooperation with national authorities as well as the identified stakeholders) in comparison with the current state for three hydrological events (HQ_{2-5}, HQ_{10-30} and HQ_{100}).

The measures considered for realistic scenarios (when all possible planned measures are implemented) in each pilot area include:

a) for Begečka Jama - cleaning and widening of the existing connecting channel between Danube River and Begečka Jama lake and weir reconstruction which allow fish migration; floodplain terrain modification via the deepening of existing oxbows and channels and the excavation of new channels between the deepened oxbows, which would allow for the controlled inflow/outflow from the system; increase the diversity of the river morphology as a result of the excavation, deepening and cleaning of oxbows, and existing and new channels; creation of new fish spawning areas which contribute to the maintenance and increase of biodiversity;
b) for Bistret - construction of a recreational and fish-farming lake in the area of Rast; relocation of the dikes in the confluent area of Desnaţui River with Bistret Lake; creation of a large water drainage channel to supply Lake Bistret and to facilitate the natural flow of Desnatui River back in the Danube;
c) for Krka - a combination of a corridor enabling floodplain activation and measures to increase water conductivity in the riverbed through Kostanjevica, thus lowering water levels within the settlement. It comprises the riverbed deepening of the northern stream of the Krka river through Kostanjevica, and an inundation at the bifurcation, and a corridor to the floodplain;
d) for Middle Tisza - increase floodplain area by dike relocation, land use change through arable land to pasture, create fish spawning area;
e) for Morava - removal or adjustment of selected barriers (weirs, sills); removal of levees; dykes relocation (to include the cut off sidearms in the floodplain area).

In the optimistic scenario (which includes more extensive measures, when the maximum capacity of flood protection is obtained by restoration measures without constraints of real limitations), the measures are as follows: for Begečka Jama –the same as in the realistic scenario; for Bistret - additional dike relocation is considered on the Danube close to the villages along the alluvial terraces; for Krka - three corridors enabling floodplain activation, and river bed deepening of the northern stream of the Krka river through Kostanjevica, and an inundation at the bifurcation; for the Middle Tisza – an increase of the floodplain area by dike relocation and controlled dike overtopping, land use changes (cultivated land to pasture, controlled afforestation, creating new wetland habitats such as e. g. lakes); for Morava - dykes relocation, renewal of river pattern, reconnection of oxbows with the main Morava channel (at present state they are behind the dyke) and the deepening of existing oxbows.

6.3.4 Coca-Cola - WWF “Partnership for a living Danube”

WWF, the Coca-Cola Foundation and Coca-Cola System agreed on a seven years partnership to restore vital wetlands, river sections and floodplains along the Danube River and its selected tributaries by the year 2020, and to promote the wise use of freshwater resources in the Danube Basin. The regional programme includes nine restoration projects in six countries: Hungary, Croatia, Serbia, Romania, Bulgaria and Austria. Five projects have been completed by May 2020, and another four are in various stages of development.

More details on this cooperation are provided in the chapter 7.5 of the Annex 2 and in the Annex 5.

6.4 National activities towards water retention in the Danube River Basin District

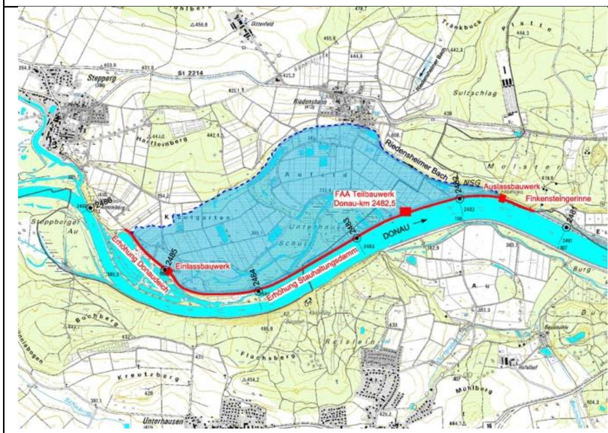
6.4.1 Germany

A major pillar of the flood protection strategy in the Danube River Basin in Germany is the flood storage polder concept in Bavaria. In the last years several locations for new flood storage polders have been identified like Riedensheim/Danube, Öberauer Schleife/Danube, Katzau/Danube or Seifener Becken/Iller-Danube. The new flood storage polder Seifener Becken/Iller-Danube is in operation since 2007. The construction of Riedensheim/Danube was finished in 2019. Additional locations of retention areas besides the River Danube flood storage polders in the catchment of the Danube River have been identified in studies by the Technical University of Munich (TUM) and other institutions between 2014 – 2017. Further studies by (local) water authorities also looked for possible locations and profound impact analyses as a basis for decision making were carried out.

	GERMANY	**Status:** Implemented
	Target area: Danube downstream of Riedensheim to Ingolstadt	
Project:	**Flutpolder Riedensheim**	

The project is located between Rennertshofen and Neuburg an der Donau in the county Neuburg – Schrobenhausen. Start of construction was 2015 and with overall costs of 38 Mio. € the construction was finished in 2019. The reactivation of this 220 ha large natural floodplain created a retention volume of 8.300.000 m³.

The polder Riedensheim is part of a polder chain along the Bavarian part of the Danube. In case of an extreme flooding event the flood polder assists in reducing water levels in the downstream damage hotspots of Neuburg and Ingolstadt. When it is run individually there is already a high effect for the direct downstream areas. Along with the not yet implemented polders Großmehring or Katzau cross-regional effects can be expected all the way to Regensburg or even Deggendorf.



An additional field of this Bavarian flood protection strategy is to retain the water in case of a flood event in the state-owned reservoirs, by natural water retention and barrage management. The existing reservoirs like Sylvensteinspeicher/Isar-Danube are being improved continuously. In June 2013 it was possible to retain around 129 million m^3 in the state-owned reservoirs during the flood event. Start of the construction of the new flood retention basin Feldolling/Mangfall-Inn-Danube was in 2016. Also, relocation of settlements has been successfully carried out in some areas like Isarmünd (Wasserwirtschaftsamt Deggendorf) or Moos (Wasserwirtschaftsamt Ingolstadt) in order to strengthen the water retention.

In Baden-Wuerttemberg the Integrated Danube Program (IDP) was launched for the Danube River Basin in 1992. The aim of the IDP is the conservation and the development of natural habitats combined with the demands of flood protection on the Danube in Baden-Wuerttemberg. Many local measures are continuously implemented. Important measures of the program are for example the flood control basin in Wolterdingen and the renaturation of the Danube between Hundersingen and Binzwangen, both finished in 2012.

6.4.2 Austria

Austria strives to preserve natural water retention areas and where possible to restore or even create new water retention areas. Along the River Danube this has been recently done by relocation of settlements and dykes to provide more water retention during floods as well as by removal or adaptation of constructions along and in the river under ecological aspects. In some cases, even cut off back waters had been reconnected to the main river stem (mainly in the national park east of Vienna). Further, numerous EU LIFE projects had been conducted in the Danube catchment to enhance the ecologic status (groundwater recharge, habitat availability, dynamic morphology, water retention, etc.) by, at the same time, contributing to flood risk reduction.

6.4.3 Czech Republic

Water retention in the river basin is one of the possible flood protection measures and can be used where the suitable area is available. This approach is also mentioned in the Strategy for floods protection in the Czech Republic as important measure for areas with suitable geomorphological conditions. In the frame of the actual national programme “Support for flood protection IV” and the Operational Programme Environment in the Czech Republic the measures focused on increasing of water retention (like extension of floodplains, controlled inundations, dry reservoirs or water reservoirs with retention volume) have priority, primarily in the areas of potential significant flood risk.

As the contribution to the water retention can be included also the requirement of Czech Water Act No. 254/2001 Coll. to ensure first of all soaking and retention of rainfall in the built-up places.

6.4.4 Slovakia

Natural water retention measures have been designed in the frame of preparation of flood risk management plans. Natural water retention measures belong to preventive flood protection measures that contribute to natural water accumulation at suitable locations in accordance with the

Article a) section 2) paragraph 4 of the National flood protection act no. 7/2010 Coll. This type of measures is generally applied at locations where natural flooding has already occurred and where it is applicable with regard to the land ownership rights.

Areas with a natural potential for flood transformation are identified within the flood risk maps, and the practical realisation of the retention function is described in flood risk management plans. As part of the development of new measures, measures of water accumulation and water retention are also included. Subsequently, these are tested in terms of efficiency and effectiveness. Based on these analyses these measures are prioritized for specific risk areas.

6.4.5 Hungary

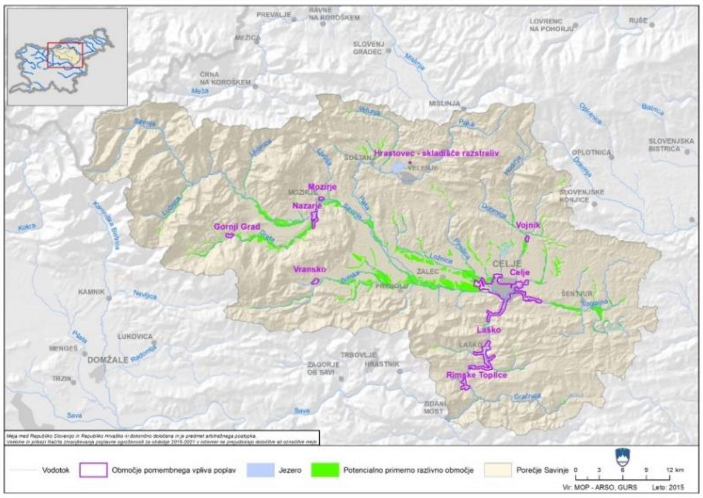
In Hungary the water storage capacity is limited by the low-land formations and 1-2 cm inclination in wide regions. Along the Danube River neither the subsoil conditions nor the lack of space makes the retention possibilities favourable. Beside the geographical problems the volume of the necessary storage is that high which is nearly impossible to handle with field retention. In case of the Tisza River, the ongoing New Vásárhelyi Plan has the water retention in the outmost focus aiming to establish numerous reservoirs and create sufficient storage capacity.

30 flood control reservoirs have been built in the Tisza valley, 6 of them within the Vasarhelyi programme (Capacity: 721 million m^3). In the Körös River system 5 reservoirs are operating. (Capacity: 386 million m^3). The flood control reservoirs situated along the rivers and the part of the flood control system and has local flood peak reducing effect. The first element of the Improvement of the Vásárhelyi Plan was the reservoir of Cigánd – Tiszakarád. The reservoir is situated among four settlements in the Bodrogköz: Cigánd, Nagyrozvágy, Pácin and Ricse. Total area of the reservoir covers 25 km^2 – it approximately equals to that of the Lake Velence. The height of embankments, that are grass-covered earthworks, is 4.5 metres on average with a crown width of 5 metres and their total length is 23.8 km. The retention basin is able to receive and store approximately 94 million m^3 of water when fully filled up. The second element of the Program was Tiszaroff. Total area of the retention basin covers 22.8 km^2 . The height of its embankments, that are grass-covered earthworks, is 4.5 metres on average with a crown width of 5 metres and their total length is 23.1 km. The reservoir is partly encircled by the existing main flood control constructions on a section of 8840 metres, while there are embankments constructed on the rest. The retention basin can receive and store approximately 97 million m^3 of water when filled up completely.

In the 2014-2020 financing period, the storm storage reservoirs building programme has started. These reservoirs will be located in hilly areas (Baranya, Vas and Zala counties). In increasingly frequent flash floods (pluvial floods), the forecast often arrives late because the gathering and the formation of a flood wave take hours, so there are no days available to prepare for the defence. Therefore, the emphasis should be on prevention. It is possible to prevent and manage hilly water damage events and to reduce the extent of damage by constructing storm reservoirs on small hilly watercourses, as the extent of bed formation under the reservoir can be reduced and water flows will be more balanced. The location is the West-Transdanubian area (Vas and Zala County). In February and March 2018, public forums were held in all 5 affected settlements, where those interested could get an idea of the investment schedule, the construction works and the effects of the development.The construction work has been finished in the first quater of 2021..

6.4.6 Slovenia

Important part of a holistic approach in preventive flood protection is the designation of larger natural flooding areas without significant damage potential and determination of their potential effect on flood extent (volume, peak). The appropriate regime for agricultural, forest and other type of areas must be established, and a legal mechanism of their protection must be provided. Significant part of catchments consists of narrow inundation areas where no significant effect can be expected, but it is still an important approach in reducing the flood risk. Introduction of damage potential on existing flooding areas is already prevented by conditions and limitations on local, municipal and national level of planning, in case of changed hydrological conditions the compensatory measure must be provided to keep the retention capacity and not to worsen the hydraulic situation downstream. In Slovenian Flood Risk Management Plan for all the river basins a preliminary identification of the larger natural water retention areas was conducted.



Identification of the larger natural water retention areas in the Savinj River Basin (from Slovenian Flood Risk Management Plan)

This is the basis for a larger project/activity to actually preserve and actually implement/establish these areas in the processes of spatial planning and other activities.

6.4.7 Croatia

Croatia's draft Flood Risk Management Plan (FRMP) reflects the orientation towards emphasizing the natural water retention areas and flood retention areas for the flood prevention and flood protection. As a prevention measure, the FRMP provides for the continuation of ongoing activities on formal introduction of a special level of protection and maintenance of natural water retention and wetland areas and boundaries of the public water domain in the process of physical planning. As a protection measure, the FRMP encourages selection of technical solutions that will ensure:

- Retention of water in the watershed as long as possible and allowing room for watercourses to slow down the runoff;
- Preservation, restoration and enlargement of areas that can retain flood waters, such as natural water retention areas, wetlands and floodplains;

- Prevention of pollution of water and soil by harmful substances during flood events in areas reserved for flood water retention by land use restrictions and administrative measures;

- Continue creating lowland retentions in the areas of former floodplains for the purpose of flood flow reductions and flood protection of downstream areas;

- Usage of the existing lowland retention areas for meadows and grazing areas or for restoration of alluvial forests;

- Identification and preparation of protection and management programmes for floodplains and retention areas that could be used as natural water retention areas.

In the prioritization of the flood protection measures, the natural water retention and flood retention measures (i.e. Green Infrastructure measures) are emphasized over the structural flood protection measures where their application is technically and economically feasible.

Concerning the financing of the flood protection measures in Croatia from the EU structural funds, it is stated in the Operational Programme Competitiveness and Cohesion 2014-2020 that measures supporting the Green Infrastructure will be prioritized (over structural flood protection measures) where its application is technically and economically possible and effective in order to enhance the natural flood risk management. Other structural measures such as retention reservoirs, embankments strengthening or drainage channels will be considered in line with the appropriate environmental objectives, namely preserving coherence and connectivity of Natura 2000 sites.

During 2020, two comprehensive EU financed national projects have been launched in order to

- Assess further possibilities for introduction of green water retention measures,
- Develop guidance for design and assessment of such measures.

Along with the planning and management activities, several new projects in the field of enhancing water retention have been lauched such as:

- DravaLife (http://www.drava-life.hr/hr/naslovnica/)
- INTERREG „WetlandRestore - Restoration of Wetlands in Middle Danube " (https://www.interreg-croatia-serbia2014-2020.eu/project/wetlandrestore/)
- NATURAVITA (https://naturavita-project.eu/)

6.4.8 Serbia

Study on Flood Risk management in the Kolubara River Basin (with the support of the United Nations Development Program - UNDP) was prepared after catastrophic floods of 2014. The aim of the Study and its result was to harmonize spatial and economic development plans and infrastructure systems development. The study provides information on future works that are important for the water regime and to be integrated into complex flood protection over the river basin, analyzing appropriate criteria for adequate protection of areas (settlements, infrastructure, industry, etc.). One of the significant results of the Study is that it envisages the construction of 20 retentions in the Kolubara basin.

https://geoportal.srbijavode.rs/visios/Kolubara

6.4.9 Bosnia and Herzegovina

The analysis of hydromorphological and topographic conditions showed that the river basins in Bosnia and Herzegovina lack bigger areas in river valleys that could be used for natural water retention purposes. Significant lowland areas are located only along the Sava River in the north of the country, but these areas are covered by the existing Sava flood defense system - polders consisting of Sava defense embankments, pump stations and a channel network. River valleys of other watercourses in the Sava River Basin in Bosnia and Herzegovina, are quite narrow and with noticeable fall of terrain and are densely populated, so they are not suitable for forming a natural retention, namely, for the flood protection.

Following the catastrophic floods in May 2014, documentation preparation activities were initiated to consider the possibility of forming natural retentions in the area along the Sava River. Several localities have been analyzed and it is generally concluded that they are of insufficient capacity and do not provide the necessary effects of reducing the level of the Sava River. Also, during the analysis, the problem of ownership of land, which would be used as a retention area, was raised. Namely, most of the land under consideration is privately owned, which would require significant funds for land acquisition.

6.4.10 Romania

In Romania, reservoirs and polders with a total volume of 5.15 bn. m^3 are available for flood retention (4.03 bn. m^3 in permanent reservoirs, 0.61 bn. m^3 in temporary reservoirs and 0.51 bn. m^3 in polders).

Construction of small new temporary reservoirs and polders was foreseen in the Flood Risk Management Plans for the 2015-2021 implementation period with a total volume of 316,4 mn. m^3. In addition, 14 new permanent reservoirs with a total volume of 235 mn m^3, 19 ha wetland and 0,5 ha reconnection were planned. For some of these requests for funding have been placed.

During the period 1994-2003, 7137 ha of wetlands were restored in Babina and Cernovca (Danube Delta), Balta Geriului (Olt-Danube confluence), Carasuhat (in Dobroudja), Fusea (middle part of Arges Floodplain), in Ciobarciu (Iasi county), in Comana (Giurgiu county), in Ciocanesti, Haralambie, Soimu, Albina, Fermecatu, Cianu Nou, Tramsani and Turcescu (Danube islands). 455 ha of wetland restoration is ongoing in Garla Mare and Vrata in the Danube Floodplain (Mehedinti county).

Ecological and economical programme for the Romanian sector of the Danube Floodplain approved by the Governmental Decision no. 1208/6.09.2006 is reconsidering the strategy for sustainable development and flood defence lines of settlements in the floodplain of the River Danube. This strategy is based on an assessment of the suitability of various flooding scenarios and the public opinion. In this context during 2006 - 2008, the National Institute of Research-Development "Danube Delta" issued a study regarding Ecological and Economical Resizing of the Danube floodplain in the Romanian sector. The programme has been established as a decision tool and is structured on three levels - identification, assessment and suitability - as follows: reconsidering the line of defence against flooding of localities; evaluating the suitability of the premises of economic activities designed for restructuring (agricultural/polders and water storage); and returning to nature of polders leading to wetlands conservation. At present the implementation aspects are being analysed and stakeholder's consultation is ongoing.

Potential zones for controlled flooding (water retention to cut the peak flow) are presented in county plans for flood protection (renewed every four years, last version was issued in 2018).

In the "Strengthening the capacity of the central public authority in the field of water in order to implement the 2nd and 3rd stages of Cycle II of the Flood Directive - RO-FLOODS" project, new suitable areas for wetlands, river reconnecting and dikes relocation will be identified.

6.4.11 Bulgaria

The analysis of the floods, which occurred in the recent years, made clear that the existing structural flood protection measures are insufficient for an effective flood protection, even more in the changing climate. This finding highlights the need of a new, more integrated approach to flood risk management, including wider use of non-structural measures and nature-based solutions. The Bulgarian national catalogue of flood-protection measures includes a variety of measures for natural water retention: wetlands restoration; afforestation of riverbanks and floodplains; restoration of the natural riverbeds, meanders and floodplains. These measures will be planned on suitable locations depending on the existence and the efficiency of other flood protection facilities. A national methodology for floodplain's evaluation is planned to be developed, based on the results of Danube Floodplain project. This methodolody will serve as a basis for further activities, related to the floodplains restoration and preservation.

6.4.12 Ukraine

The potential volume of the flood runoff accumulation in existing four flood-protective reservoirs of the "Chornyj mochar" system is 28.64 mio m^3. By accumulating the flood runoff these reservoirs can protect 11,500 ha of arable lands from inundation. At present, construction of 39 accumulative mountain reservoirs is proposed in the Scheme on complex flood protection in the Tisza River basin in the Transcarpathian region, 6 out of which are considered as urgent, 14 as immediate and 19 as perspective with total accumulation volume 257.3 mio m^3. In addition, 6 accumulative lowland polders (3 urgent and 3 immediate) with total accumulation volume 121.6 mio m^3 are proposed as well.

The essence of the flood regulation is the accumulation of the peak part of the floods in the specially envisaged flood-protective reservoirs and polders and operation of the accumulated volume during the flood diminution. The result of such regulation is a considerable decrease of maximal discharges and levels in the rivers, what, in turn, would allow to reduce hydraulic load on the existing flood protection system. At the same time the discharge decrease in the rivers will facilitate the slowdown of the negative riverbed processes: riverbed meandering, bank falling, motorway bed and railway erosion, protective dikes' base and pier erosion, alluvial filling of the bridge holes and hydro-technical structures and so on. But the most important is the fact that the decreasing of discharge in the river will considerably reduce the risk of protective dikes' base erosion and as consequence will increase its reliability.

6.4.13 Moldova

As structural flood protection measures (dykes, dams) are often insufficient to properly protect against floods, especially in conditions of changing climate, ecosystem based measures including creation of the water retention areas, wetlands restoration, small rivers' re-naturalization (meandering), afforestation of river banks/ creation of water protection strips, are becoming now a matter of concern in flood prevention. Thus, among such measures, in the Flood Risk Management Plan for the Danube-Prut and Black Sea River basin District (2020-2025) the following are included: carrying out Feasibility Studies for establishing three wetlands - Camenca (500 ha, middle Prut, Falesti district), Cantemir-Stoianovca (200 ha, lower Prut, Cantemir district) and Sarata-Rezeşi (200 ha, lower Prut, Leova district); and improving conditions of forests and water protection strips (1770 ha). The Management Plan for the Danube-Prut and Black Sea River Basin District (2018-2023) also presumes a number of non-structural measures aiming at water retention, e.g., afforestation in the Danube-Prut and Black Sea River Basin District, planting of 15 ha of water protection strips along the Prut River tributaries Ciuhur and Nirnova, and another small river - Cahul (this measure was successfully completed in spring 2020), etc.

7 Coordination with WFD

FD Article 9 stipulates that Member States shall take appropriate steps to coordinate the application of FD and that of Directive 2000/60/EC (WFD) focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in WFD Article 4. In particular:

1. the development of the first flood hazard maps and flood risk maps and their subsequent reviews as referred to in FD Articles 6 and 14 shall be carried out in such a way that the information, they contain is consistent with relevant information presented according to WFD. They shall be coordinated with, and may be integrated into, the reviews provided for in WFD Article 5(2);

2. the development of the first flood risk management plans and their subsequent reviews as referred to in FD Articles 7 and 14 shall be carried out in coordination with, and may be integrated into, the reviews of the river basin management plans provided for in WFD Article 13(7);

3. the active involvement of all interested parties under FD Article 10 shall be coordinated, as appropriate, with the active involvement of interested parties under WFD Article 14.

Flood risk management is probably the policy with the best potentialities for synergies with other aspects of water management and beyond, provided that adequate strategies are implemented. The traditional engineering solutions (dams, channelisation or dykes) deliver results for the case of floods which they are designed for. There is however always a residual flood risk. Each flood protection structure may be overtopped or breached. Thus, the occurrence of floods cannot be avoided completely, and the consequences of future floods are likely to have an increasing social and economic impact. Moreover, floods are a natural phenomenon and the high probability floods can have obvious benefits for society and ecosystems, e.g. for ground water recharge or for fish production. Thus, another approach of flood risk management is now promoted: an integrated flood risk management focusing on prevention, protection and preparedness (including forecasting). In this framework, making space for river and coastal flooding in the areas where the human and economic stakes are relatively low, represents a more sustainable way of dealing with floods. The conservation and the restoration of the natural functions of wetlands and floodplains, with their ability to retain floodwaters and reduce the flood wave, are a key feature of this strategy, thus allowing important opportunities for synergies with WFD implementation.

	**AUSTRIA**	**Status:** Ongoing
	Target area: Catchment scale to be applied in AT	
Project:	**Integrated Rivers Solutions in Austria**	

The EU-funded Austria-wide project LIFE IP IRIS Austria supports integrative planning approaches as a new way for the ecological remediation of our rivers while improving flood protection at the same time.

Integrative river basin management coordinates the objectives and programmes of measures of the National River Basin Management Plan (according to the EU Water Framework Directive) with those of the National Flood Risk Management Plan (according to the EU Floods Directive) and also takes into account other uses of rivers. For this purpose, the planning instrument “River Development and Risk Management Concept” – “*Gewässerentwicklungs- und Risikomanagement-konzept*” was developed.

This planning instrument will be extensively tested in seven Austrian river basins as part of the Integrated LIFE Project IRIS (Integrated River Solutions in Austria). By means of interdisciplinary and cross-sectoral planning processes, guiding principles and concepts of measures will be developed for river courses with a total length of almost 600 km. Also, structural river restoration measures to improve the ecological status as well as flood protection will be implemented in the LIFE project. https://life-iris.at/en/

In 2015, the European Commission[13] communicated “Actions towards the “good status“ of EU water and to reduce flood risks”. This document highlights that measures such as the reconnection of the

[13] Communication from the Commission to the European Parliament and the Council. The Water Framework Directive and the Floods Directive: Actions towards the “good status” of EU water and to reduce flood risks. COM(2015) 120 final, Brussels, 9.3.2015

floodplain to the river, re-meandering, and the restoration of wetlands can reduce or delay the arrival of flood peaks downstream while improving water quality and availability, preserving habitats and increasing resilience to climate change. The EC also highlights EU funding possibilities MS should make use of such as LIFE integrated projects or Horizon2020.

7.1 Promoting integration within ICPDR

In the Danube Declaration adopted at the ICPDR Ministerial Meeting in 2016, the Danube Ministers, in light of the valuable and encouraging lessons learnt from the ongoing implementation of the EU Water Framework Directive and the EU Floods Directive, underlined the cross-cutting character of water management and the need for integration of all relevant sectors. In particular they emphasized the importance of the ICPDR activities in coordinating the EU Floods Directive and the EU Water Framework Directive. The ICPDR developed the DFRM Plan and the DRBM Plan in a parallel process exploiting synergies in particular with regard to information exchange, efficiency of measures and the active involvement of all interested parties. In the implementation phase of both plans the Danube Ministers committed to further strive for realizing win-win measures, e.g. by seeking options for the conservation and restoration of the natural functions of wetlands and floodplains.

As a practical follow-up of this commitment the ICPDR discussion paper[14] lists potential conflicts but also highlights potential synergies between WFD and FD. For example, natural water retention measures can contribute to the fulfilment of both directives. Furthermore, the following recommendations were recognized in the paper:

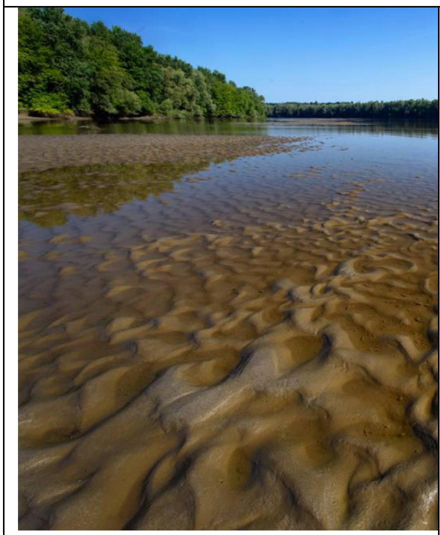
- Implementation of concept “Giving more space to rivers”;
- Prioritisation of measures;
- Integrated planning on catchment scale to identify win-win solution;
- Application and further investigation of effectiveness and efficiency of NWRMs.

A good example of synergies between the WFD and FD is production of the PFRA for the Danube River Basin: To produce PFRA several ICPDR Contracting Parties used data that they had collated as part of the WFD process to assist with their contribution to the overall PFRA for the Danube. For example, in Austria the available geo-data on risk receptors such as population, infrastructure, potential pollutants, WFD protected areas and cultural heritage that had been collected as part of the WFD process were used. In Bulgaria the criteria used for the assessment of the significance of floods were: the number of people affected; affected important industrial and infrastructure objects; affected IED plants; polluted Natura2000 protected areas and drinking water protected areas. These data sets had already been collated digitally as part of the process to meet the requirements of the WFD.

[14] Discussion paper – Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits. ICPDR 2020.

<table>
<tr><td rowspan="2"></td><td>CROATIA</td><td>Status: Ongoing</td></tr>
<tr><td colspan="2">Target area: 4 Natura 2000 sites (67.800 hectares) along Drava River from Dubrava Križovljanska (rkm 322,8) to Osijek (rkm 15)</td></tr>
<tr><td>Project:</td><td colspan="2">DRAVA LIFE - Integrated management of rivers</td></tr>
<tr><td colspan="3">Key natural features of the riverine ecosystem are being restored through an inter-sectoral cooperation between Hrvatske vode - national agency for water management, regional public institutions for nature protection (Virovitica – Podravina County, Varaždin County, Koprivnica - Križevci County) and NGOs (Green Osijek, WWF Austria) showcasing an innovative approach of river management on several sites along the Croatian Drava. Total budget of the project is 4,592,898 €.

The restoration actions include opening and creation of new side-arms, removal and modification of embankments and groins, as well as the preservation of retention areas and natural steep riverbanks. Numerous types of endangered habitats and species within Natura 2000 sites will benefit from these actions. The restoration of side arms and channels will enhance the flood control within the existing floodplains. These measures will positively influence the lowering of high-water levels locally, and divert the water away from settlements, bridges, roads and dikes. Restoration of seven pilot Drava sections between rkm 312 and rkm 98 will be carried out without affecting the safety of the existing flood control system and individual structures. The project will also have a positive effect on groundwater supplies, as the restoration actions will improve the river water infiltration into the groundwater and thus stabilize and lift groundwater levels. This will also increase the resilience of Drava's floodplain ecosystems to combat negative impacts of climate change.

More information available on: http://www.drava-life.hr/en/home/</td></tr>
<tr><td colspan="2"></td><td></td></tr>
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Another good example of coordination between FRMP and RBMP on the Danube is the ICPDR's plan to meet the requirements laid out by the framework provided by WFD Article 14 along with FD Articles 9 and 10, with regards to the subject of public participation and communication. Implemented during the course of development for the third Danube RBMP and second FRMP for the Danube River Basin – for the implementation cycle 2021 to 2027 – consultations measures include:

- The active participation of all of the ICPDR's accredited observers involved in the ongoing work of the ICPDR. The remit of ICPDR observers has them bringing to the table a wide variety of stakeholders in the Danube River Basin, covering interest groups concerned with culture, economy, society, and the environment, all adhering to the goals of the Convention. The connective tissue between observers and the ICPDR is a shared 'community responsibility', essential to achieving long-term sustainable water management goals. Their involvement includes the provision of their input into the development of both the Danube RBMP and FRMP;

- Specific discussions held with selected key stakeholders about ICPDR activities regarding the implementation of the WFD and FD. These stakeholders include the navigation sector, hydropower, sector and agriculture. The results of these discussions will be made publicly available;
- Raising awareness and informing wider stakeholder groups about the opportunity for public participation, the activities and the timetable regarding the third Danube RBMP and second FRMP via a wide range of engagement measures (e.g. websites, social media, newsletters, meetings). Methods for reaching the public are ever on the rise and are vital when putting together an approach to engage the public and raise awareness. This can facilitate broader support for policies, along with improved efficiency in implementation.
- After the identification of the Significant Water Management Issues (SWMIs) in accordance with the EU WFD, a stakeholder workshop was held to support the development of the plan. Through such a workshop, a larger and very focused group of people was involved in the formalization of the third Danube RBMP and the second FRMP.

7.2 Examples of win-win measures

The examples of flood risk mitigation measures that contribute to WFD objectives are as follows:

- restoration of former wetlands/floodplain areas, increasing their territory, demolition of existing dykes (like summer-dykes) or dyke relocation
- creation of new wetlands
- restoration of meandering capacity of rivers
- restoration of side-branches
- restoration of oxbows and lakes, use them for water storage
- elimination of invasives on the active floodplain
- reforestation on catchment
- retention of water, precipitation and sewage
- building reservoirs on the floodplain, change of land use and applying natural water retention measures
- regulations in land use (e.g. no new buildings on floodplains, increase area of grasslands/wet meadows next to the main channel instead of low profitable arable lands)
- change land use that is resistant to floods (e.g. to grasslands/wet meadows on the floodplain instead of sensitive crops)
- modify agriculture subsidy systems in order to ensure incentives for natural water retention measures, which can reduce floodpeak downstream, mitigate climate change effects, reduce drought risk, improve biodiversity status and ecological status of waters. Examples of land use to be supported by CAP: changing to wet meadows, grazing areas like grasslands, reed management, bee keeping)

These examples of measures are put for consideration to the flood managers and more details on these measures are presented in the Chapter 5.

7.3 Floodplains/wetlands reconnection

The wetlands/floodplains and their connection to river water bodies play an important role in the functioning of aquatic ecosystems and have a positive effect on water status. Connected wetlands/floodplains play a significant role when it comes to retention areas during flood events and may also have positive effects on the reduction of nutrients and improvement of habitats. As an integral part of the river system they are hotspots for biodiversity, also providing habitats for e.g. fish and waterfowls that use such areas for spawning, nursery and feeding grounds.

The ICPDR's basin-wide vision is that floodplains/wetlands all over the DRBD are re-connected and restored. The integrated function of these riverine systems contributes to the development of self-sustaining aquatic populations, flood protection, climate change adaptation and reduction of pollution in the DRBD.

The following management objectives will be implemented by 2027 as steps towards the vision:

- For the DRBMP Update 2021, efforts will be continued and further measures will be identified for the conservation and restoration of existing and the restoration of former (potential) wetlands/floodplains with reconnection potential to ensure biodiversity, the good status in the connected river, flood protection and pollution reduction. Beneficial effects are expected to be manifold, including improvements like the provision of fish habitats for spawning, nursery and feeding.
- As 80% of the former wetlands/floodplains in the DRBD are considered to be disconnected, ongoing restoration/mitigation efforts and measures are needed in order to further improve the reconnection of former (potential) wetlands/floodplains in the entire DRBD. Activities on the implementation of the Floods Directive and the elaboration of the FRMP are significantly contributing to the compilation of inventories of connected and disconnected wetlands/floodplains and therefore increase the knowledge on reconnection potential.
- The EU funded Danube Floodplain project (2018-2021) aims to improve transnational water management and flood risk prevention while maximizing benefits for water status and biodiversity conservation. The expected outcome is improved knowledge among the countries located within the DRBD related to integrative water management through restoration of floodplains, combination of classical and blue/green infrastructure, natural retention measures and the involvement of all related stakeholders.
- Further good practice promotion and knowledge exchange on measures related to disconnection of adjacent wetlands/floodplains are needed.

Progress in implementation of measures from DRBMP Update 2015:

In total, 11 adjacent wetlands/floodplains, covering an area of 15,130 ha, were indicated in the DRBMP Update 2015 to be addressed by measures by 2021. Construction works are ongoing for one wetland/floodplain with an area of 4,526 ha and planning is on-going for another wetland/floodplain with an area of 2,650 ha. For 7,954 ha, which are already partially reconnected, no further measures are planned.

The approach chosen for the Joint Programme of Measures in the DRBMP to protect, conserve and restore wetlands/floodplains is a pragmatic one, taking into account a background of 80% wetlands/floodplains loss. The Danube countries provide information on all wetlands/floodplains >500 ha and smaller ones of basin-wide significance, with a definite potential for reconnection; as well as on respective reconnection measures to be undertaken by 2027.

The analysis shows the area of floodplains/wetlands to be reconnected by 2027 for both the Danube River and its tributaries. The inter-linkage with national RBM Plans is vital for wetlands/floodplains reconnection as significant areas are expected to be reconnected also to rivers with catchment areas <4,000 km^2 and with surface areas <500 ha having also positive effects on the water status and habitats of larger rivers.

Activities on the implementation of the FD and the elaboration of the Flood Risk Management Plans are significantly contributing to the compilation of inventories of connected and disconnected wetlands/floodplains and therefore increase the knowledge on reconnection potential. The value of the Flood Hazard Maps elaborated for the Danube Flood Risk Management Plan Update 2021 are in particular pointed out in this context. This is considered as important also due to the multiple benefits of wetlands/floodplains reconnection for flood and drought mitigation, groundwater recharge and climate adaptation[15].

And last but not least it is necessary to point out that conserving wetlands through nature based solutions and ensuring resilience to disasters creates a link not only between the WFD and the FD but it covers the Nature Directives as well and addresses also goals of the new EU Biodiversity Strategy for 2030.

7.4 Future infrastructure projects

The ICPDR’s basin-wide vision for future infrastructure projects is that they are conducted in a transparent way using best environmental practices and best available techniques in the entire DRBD – impacts on deterioration of the good ecological status/ecological potential and negative transboundary effects are fully prevented, mitigated or compensated.

The FIP analysis in the DRBMP concludes that 35 FIPs have been reported for the DRBD and the majority of them are located in the Danube River itself. For 9 FIPs, SEAs have been performed during the planning process. Further, EIAs have already been performed for 14 FIPs and are intended for another 18 FIPs. 16 FIPs are expected to have a negative transboundary impact on other water bodies and 15 FIPs are expected to provoke deterioration of water status, for which exemptions according to WFD Article 4(7) are applied.

The management objectives include precautionary measures (best environmental practices and best available techniques) that should be implemented to reduce and/or prevent impacts on water status. For new infrastructure projects, it is of particular importance that environmental requirements are considered as an integral part of planning and implementation right from the beginning of the process. In the framework of the ICPDR, respective guidance has been developed in this regard for inland navigation (Joint Statement) and hydropower (Guiding Principles). Both documents describe

[15] More information can be obtained from the EU Policy Document on Natural Water Retention Measures available at https://circabc.europa.eu/sd/a/2457165b-3f12-4935-819a-c40324d22ad3/Policy%20Document%20on%20Natural%20Water%20Retention%20Measures_Final.pdf

respective processes in detail and the organisation of regular meetings to facilitate the follow-up discussions will help the exchange of experiences for practical application. The management objectives also indicate precautionary measures with regard to sustainable flood risk management.

7.5 National activities towards coordinating FD & WFD implementation

7.5.1 Germany

The Flood Risk Management Plans in Germany were coordinated with the correspondent River Basin Management Plans. According to FD Article 9 both directives were coordinated particularly with regard to improving efficiency, to information exchange and common advantages for the achievement of environmental objectives laid down in WFD Article 4.

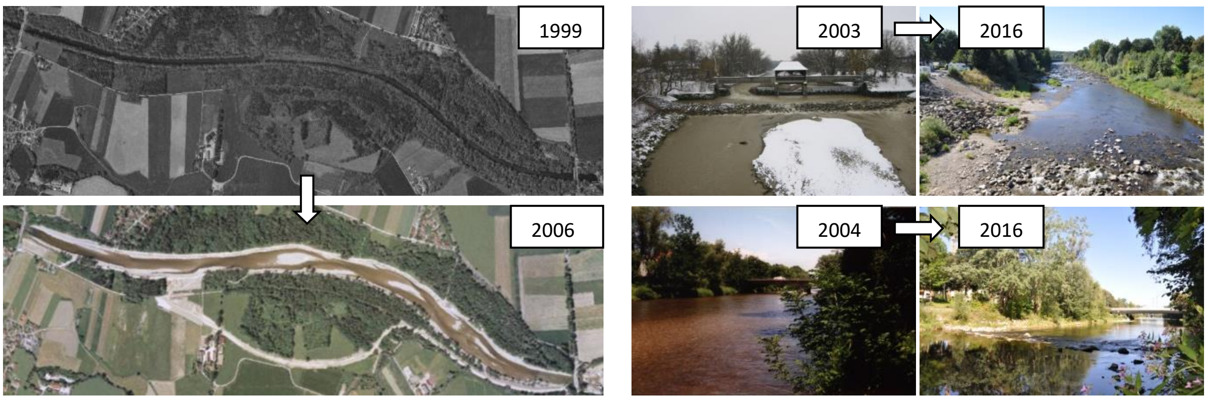
	**GERMANY**	**Status:** Implemented
	Target area: Bayern, Augsburg, Wertach river	
Project:	**Wertach vital**	

The Wertach used to be a widely branched wild river. Due to the straightening in the second half of the 19th century, all well-known problems, e.g. sinking of groundwater level, undermining of bridges and banks, loss of flood plains and in consequence loss of natural habitats, were enhanced.

In 1997 the project "Wertach vital" was launched. The aims were to integrate the ecologial transformation of the Wertach, the protection the urban area of Augsburg against a 100-year flood and considerations as to leisure and repose.

After the enormous flood of 1999 with damages of about 100 million €, the project was even more important and welcomed. Due to the unique consequent public participation throughout the whole project (its so called “open planning” idea), the project was very successful. Many measures following the EU Flood and Water Framework Directive were reached, e.g. natural water retention in wetlands, recovery of floodplains, improvement of hydromorphological conditions, installation of dikes / dams or flood protection with walls / dunes / beach ridges / mobile flood defense. The river and the region are now closer to nature, safer, attractive and are often used as a favorite recreation area.

„Wertach vital“ is more than just flood protection - it is a sustainable solution for the Wertach river and the region.



Before the processes started the German Working Group on water issues of the Federal States and the Federal Government (LAWA) provided the „Recommendations for the coordinated implementation of FD and WFD" which names the requirements and the possibilities of coordination and provides a structured approach. This was done to ensure the coordination between the two directives during the preparation of the FRMP and the RBMP.

Although the objectives of both directives differ, nevertheless, both appeal to the environment as a subject of protection. Also, both directives operate in nearly identical area, the river basin districts. Hence, it is appropriate to examine the intended measures of each directive in order to identify potential synergies or conflicts for the objectives of the respective other directive. Generally, potential synergies are expected during the planning process, in prioritization and realization of measures and their effect to the objectives and also in the active involvement of all interested parties and the public, taking into account the common schedule for the reporting as well as for the data supply.

Synergies are mainly to be expected in the choice of measures for the FRMP and the WFD programs of measures. Potential conflicts between the objectives of both directives, for example the realization of measures of technical flood protection systems, cannot be excluded a priori. Those conflicts can make it necessary to adapt the achievement of objectives or terms according to WFD or to adapt the measures for the special water body / waters segment according to one of both directives. In individual cases a careful consideration is to be carried out. If necessary, an exception to the objectives of management in favour of essential measures of flood risk management is conceivable.

In the first step, a joint LAWA-BLANO -catalogue of measures was developed which includes the measures of FRMP and RBMP. In connection with the development of this joint LAWA-catalogue a general preliminary examination of the desired effects of measures already took place. All measures of the catalogue were assigned to one of the following categories:

M1: measures which support the objectives of the respective other directive.

M2: measures which can cause a conflict. These will be checked individually in the further planning process.

M3: measures which are not relevant for the objectives of the respective other directive.

A detailed explanation of the categories M1, M2 and M3 are described in the recommendations mentioned above. The allocation of measures to these categories can be found in the updated LAWA-BLANO measure catalogue in annex 1 to the LAWA recommendations for the compilation, revision and updating of flood risk management plans (2019).

7.5.2 Austria

In Austria the competent authority for implementing the WFD and FD is the Federal Ministry of Agriculture, Forestry, Environment and Water Management and, therefore, inherently has a strong link in the national implementation of both directives. This will also be expressed by common activities especially in the frame of public participation. Both, the Flood Risk Management Plan as well as the River Basin Management Plan consider and discuss synergies and possible conflicts in the frame of implementation. On project level numerous EU LIFE projects had been established and conducted contributing to both directives. To ensure implementation of WFD Article 4(7) when planning flood protection measures fulfilling the requirements of this article is obligatory for receiving funding in AT.

First preliminary results and concepts are available in the draft FRMP. In the frame of the public participation process the coordination of the WFD and FD will be continuously conducted, this process is ongoing. The final results will be incorporated into the FRMP accordingly and will be available by 22.12.2021.

7.5.3 Czech Republic

Basic principles of coordination of water management planning are based on the Water Act (Act no. 254/2001 Coll.) and the Decree of Ministry of Agriculture and Ministry of the Environment no. 24/2011 Coll. on the river basin management plans and plans for flood risk management. Commission on planning in water sector is a joint body of the two ministries. Other members of the Commission are representatives of river boards, regional authorities and expert institutions. The Commission covers the planning processes in the water sector, particularly the planning under the Water Framework Directive on water policy, with the aim to achieve good water status.

There is Flood Directive working sub-group for coordination of activities of the Floods Directive implementation, which supports the decisions of competent ministries in the managing the flood risk. Sub-group members are representatives of ministries, the Czech Hydrometeorological Institute, Water Research Institute and all river boards of the CZ. Since 2008 the subgroup meets and discusses the procedures of implementation of the Directive and links to the entire flood protection system in the Czech Republic and brings the information to the Commission on planning in water sector.

Coordination of Flood Risk Management Plans (under FD) and River Basin Management Plans (under WFD) is based on the production of basis for meeting the objectives of both directives at the level of River Management Plans for sub-basins. The measures proposed in the River Management Plans for sub-basins to meet the objectives of the WFD are designed to have a positive effect on the reduction of flood risks. These include particularly measures to improve the hydromorphological conditions, which also lead to increase of natural overflowing, measures supporting the retention of water in the landscape, infiltration of rainwater into the groundwater, etc.

Coordination from the Plans for Flood Risk Management side lies in finding such measures, which do not deteriorate mainly ecological status of water

7.5.4 Slovakia

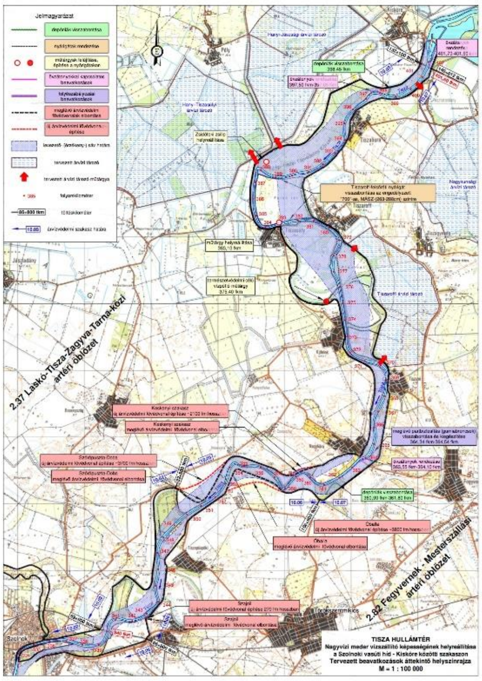
According to the valid Slovak water Act and WFD, the first flood risk management plans (FRMP) are coordinated with the updated river basin management plans (RBMP). Implementation time plans of WFD and FD at the national level are synchronized, in order to enhance tools of water management in the river basins. The synergies are strongly emphasized by the fact, that there is one common competent authority responsible for the implementation of both WFD and of FD and this is the Ministry of the Environment of the Slovak Republic. The national FRMP will be approved by the Slovak Ministry of the Environment (MoE) and will form component of the RBMP.

The FRMPs are subject to an environmental impact assessment, following which all comments raised in the assessment process will be incorporated. In addition, a strong link between the proposed measures and the measures of the RBMP is envisaged in the framework of drawing up the plans, given the consultation of the public and representatives of NGOs.

7.5.5 Hungary

In Hungary, the planned area for the flood risk and hazard mapping and for river basin management is the same because the Flood Risk Management Plans are part of an integrated river basin management. The purpose and means of the flood risk management concept should be aimed at ensuring the rational and uniform water resources management. When planning the measures to reduce the risk of floods, the undesirable environmental effects of the operation of flood risk management systems should be minimized.

<table>
<tr><td rowspan="2"></td><td>Hungary</td><td>Status: Ongoing</td></tr>
<tr><td colspan="2">Target area: Tisza River Basin in Hungary</td></tr>
<tr><td>Project:</td><td colspan="2">Improving of riverbed flood capacity in Tisza River between Szolnok and Kisköre</td></tr>
<tr><td colspan="3">The terrain and vegetation conditions and structures of the floodplain should not endanger but promote the drainage of water and the operational safety of flood protection facilities. This project serves this purpose in the middle section of the Tisza, freeing the path to the blonde river between Kisköre and Szolnok and providing a faster, barrier-free flow. Within the project, the critical river narrowing will be eliminated through relocation of embankments, shallows will be removed, and the landmarks that prevent flooding will be removed as well as the overgrown vegetation.

The reconstruction of the floodplain includes the demolition of terrain formations that prevent the recession of floods, but also includes works for nature conservation purposes. These include the removal of the landfills along the Kanyari canal, the removal of the Pityóka landfill on the left bank of the Tisza, and the reconstruction works of the Zsidófoki sluice in Pély in order to replenish the Patkós backwater. The management of the flood drainage strip includes spatial planning activities to be carried out in order to improve the flood capacity. The project involves the demolition of the Tiszaroff-Felsőrét summer dyke and renovation of one hydraulic structure. It is justified to arrange the shallows in several places, such as on the left bank of the Tisza, on the section above the Kisköre railway bridge, on the right bank of the Tisza, on the Kanyari section, and on the left bank of the Tisza below and above the Nagykörű ferry crossing. One of the most important parts of the project is the relocation of the main flood protection lines to eliminate critical bottlenecks and give more space for floods. Information about the project: http://tiszahullamter.ovf.hu/informaciok.html
http://www.vtthullamterrendezes.hu/</td></tr>
<tr><td colspan="3"> </td></tr>
</table>

Reviewing the first flood hazard and risk maps, Hungary has been taking all efforts to keep adverse environmental impacts at minimum. During the harmonization of WD and FD, the measures included in the Flood Risk Management Plans were divided into groups of measures, and their general characteristics have been collected. Highlighting its flood protection objectives, the positive and negative effects of a measure on a water body have been explored and were the opportunities for mitigation and compensation that may be required. A total of 17 types of flood risk mitigation measures are distinguished. Hungary identified nearly 2,000 measures, which can affect 193 water bodies.

7.5.6 Slovenia

Coordination of the WFD and FD activities is being conducted in different ways and on different levels of planning. It is for example done by organising common workshops emphasizing the synergies of both kind of measures. It is also done by common presentations of the RBMP and FRMP in the public consultation and participation process.

One of the most important coordination activities was performed in the Slovenian Flood Risk Management Plan, where 20 types of the flood risk reduction measures were identified. They are listed in the following table:

Measure	Relation of the measure with the WFD goals		
	SYNERGY	POTENTIAL CONFLICT (has to be dealt with at the level of detailed planning)	IRRELEVANT
U1 Določevanje in upoštevanje poplavnih območij / Flood hazard and flood risk mapping	x		
U2 Identifikacija, vzpostavitev in ohranitev razlivnih površin visokih voda / Natural water retention measures	x		
U3 Prilagoditev rabe zemljišč v porečjih / River basin wide land use adaptation	x		
U4 Izvajanje hidrološkega in meteorološkega monitoringa / Hydrological and meteorological monitoring	x		
U5 Vzpostavitev in vodenje evidenc s področja poplavne ogroženosti / Flood risk related databases	x		
U6 Izobraževanje in ozaveščanje o poplavni ogroženosti / Raising awareness about flood risk	x		
U7 Načrtovanje in gradnja gradbenih protipoplavnih ukrepov / Structural flood protection measures		x	
U8 Izvajanje individualnih (samozaščitnih) protipoplavnih ukrepov / Individual flood protection measures	x		
U9 Redno preverjanje učinkovitosti obstoječih (gradbenih) protipoplavnih ureditev / Continous efficiency control of the flood protection measures			x
U10 Redno vzdrževanje vodotokov, vodnih objektov ter vodnih in priobalnih zemljišč / Water infrastructure maintenance works		x	
U11 Izvajanje rečnega nadzora / River basin control	x		
U12 Protipoplavno upravljanje vodnih objektov / Proper management of flood, water, hydropower and other infrastructure		x	
U13 Zagotavljanje finančnih resursov za izvajanje gospodarske javne službe urejanja voda / Providing enough financial resources for maintenance works			x
U14 Priprava načrtov zaščite in reševanja ob poplavah / Contingency planning		x	
U15 Napovedovanje poplav / Flood forecasting			x
U16 Opozarjanje v primeru poplav / Flood warning			x
U17 Interventno ukrepanje ob poplavah / Flood intervention activities		x	
U18 Ocenjevanje škode in izvajanje sanacij po poplavah / Flood damage assessment			x
U19 Dokumentiranje in analiza poplavnih dogodkov / Post flood event analysis			x
U20 Sistemski, normativni, finančni in drugi ukrepi / Financial, system, international river basin coordination and other measures		x	

For each type of measures its relation to the achievement of WFD goals was assessed. Table above shows the relation of each of the types of the flood risk reduction measures to the achievment of WFD goals. In relation to the achievement of the WFD goals we can classify flood risk reduction measures in three types:

- measures producing synergies with the WFD goals (flood hazard and flood risk mapping, natural water retention measure, land use adaptation, hydrological and meteorological monitoring, etc.);

- measures that are irrelevant to the achievement of the WFD goals (flood forecasting, flood warnings, flood damage assessment, etc.) and
- measures which can cause a potential conflict with the WFD goals and which must be dealt with at the level of detailed planning/desing (structural flood protection measures, water infrastructure maintenance works, etc.).

7.5.7 Croatia

Croatia's Flood Risk Management Plan (FRMP) is an integral part of the River Basin Management Plan (RBMP). Both planning processes (river basin management and flood risk management) are carried out in parallel, with the same lead agency (Hrvatske Vode) responsible for preparing both the RBMP and the FRMP. In this planning process, links between the Water Framework Directive (WFD) and the Floods Directive (FD) are emphasized. Measures which can simultaneously contribute to the objectives of the RBMP and the objectives of the FRMP are prioritized.

As a protection measure, the FRMP provides for the improvement of the integrated water management and flood risk management in the aspect of planning of measures of construction and maintenance of flood protection structures and systems through:

- Development of a methodology for establishment of ecologic potential of the heavily modified water bodies under the influence of flood protection structures and systems,
- Establishment of a classification system for the ecologic potential of the heavily modified water bodies under the influence of flood protection structures and systems,
- Monitoring of ecological potential of the heavily modified water bodies under the influence of flood protection structures and systems (according to the established classification system)

By implementation of this measure during the first and second FRMP cycle, coordination between the WFD and the FD will be further enhanced.

7.5.8 Serbia

The links between flood risk management and river basin management are indicated in the Water Management Strategy of the territory of the Republic of Serbia until 2034.
(http://www.rdvode.gov.rs/doc/Strategija_FINAL.pdf)

Development of River Basin Management Plan is ongoing. Flood Risk Management Plan is expected to be completed by the end of 2021, which should contain compliances with the requirements of the Water Framework Directive.

7.5.9 Bosnia and Herzegovina

The first RBM Plans in Bosnia and Herzegovina (2016-2021), prepared within the project "Capacity Building in the Water Sector in Bosnia and Herzegovina" funded by the European Union under IPA 2011, were adopted in 2018. Currently, activities are in progress to update the first plan, i.e. to develop a second RBM Plan for the period 2022-2027. In all the activities of the mentioned plan, it was sought to achieve the set goal - to reach good status of all waters in the Sava River Basin in

Bosnia and Herzegovina. When defining measures from the program of measures, attempts have been made to coordinate with flood protection activities (since the FRMP has not yet been done). This is particularly evident in the study of hydromorphological pressures and impacts on watercourses in Bosnia and Herzegovina. Flood risk management is one of the integrative issues of the first water management plan.

7.5.10 Romania

The National Administration "Romanian Waters" (NARW) is the state authority responsible for the implementation of both Directives - Directive 2000/60/EC (WFD) and Directive 2007/60/EC (FD). As a result, the main responsibilities of the NARW include the development of River Basin Management Plans and Flood Risk Management Plans, based on hazard and flood risk maps made for areas with significant potentially flood risk (APSFR).

In order to prepare FRMPs for the river basins in Romania, a series of methodologies were developed. The way in which the environmental objectives of WFD have been taken into account in the FRMPs (Articles 7(3) and 9) is as follows:

a) Identifying the flood risk management objectives. The specific objectives cover four basic criteria: social, economic, environmental and cultural heritage. Regarding the environmental criterion, three flood risk management objectives have been established, in close connection with the EU Water Framework Directive:

    - Support for achieving and preserving good ecological status (GES)/good ecological potential (GEP) in accordance with the requirements of WFD;
    - Minimizing the risk of floods on protected areas for water intakes for human consumption;
    - Minimizing the risk of flooding on potentially polluting units: number of areas covered by the IED Directive (2010/75/EU), the Wastewater Directive (91/271/EEC) and the Seveso III Directive (2012/18/EU) at flood risk;

b) Evaluating performance of the flood risk management measure based on a scoring system: In the process of prioritizing flood risk management measures, in order to consider the benefit of each measure, its performance is evaluated for each flood risk management objective with a score. The score given to each measure varies between 0 (if the measure damages the GES/GEP) and 5 (if the measure is without prejudice to the GES/GEP for water body).

c) Setting methodological recommendations in defining the measures.

    - Development of a Catalogue of potential measures at national level (23 types of measures have been proposed). These measures address the five areas of action: prevention, protection, public awareness, training, response and restoration/reconstruction.
    - in line with the EU guidelines and the recommendations by the DG Environment and DG Regio, out of the 23 types of measures, 22 are non or light structural, only one being structural (hard engineering works).
    - Regarding non-structural measures, it was recommended that they be applied at the level of APSFRs, but for the significant improvement of flood risk management, it was recommended to apply them to the whole river basin.

- Types of measures proposed in the Catalogue of Potential Measures, which are considered for coordinating the development and implementation of the FRMPs and RBMPs, are classified in the category „Protection“ (coded RO_M04, RO_M05, RO_M06, RO_M07 and RO_M08). The application of this type of measures is done at the level of APSFR and/or river basin.

7.5.11 Bulgaria

According to the Bulgarian legislation, the units of management for FD implementation are the same as those used for the WFD implementation – the River Basin Districts. River basin Directorates are the competent authorities in charge for the elaboration of the Flood risk management plans coordinated by the Ministry of Environment and Water. The River Basin Management Plans (RBMPs) and Flood Risk Management Plans (RBMPs) are being elaborated with the support of the World Bank, which would ensure coherence and allow for synergies in the elaboration of both plans. Both FRMPs and RBMPs will be adopted by the Council of Ministers.

According to the provisions of Article146i (2) of the Water act, the information and the data collected for the development of river basin management plans shall also be used for producing the FRMP.

According to Article 146 (1), item 4 of the Water Act, in the development of the FRMP, the WFD environmental objectives related to the quantity and quality of water are taken into account. In the national catalog of measures for flood risk management, the environmental impact of the implementation of each measure is specified. In the process of planning and prioritization of measures in the FRMP, the compatibility of each measure with the environmental objectives in the RBMPs is assessed in three stages: positive, neutral and negative. The potential negative impact of the structural flood protection projects on the hydromorphological and ecological status of surface water bodies is being evaluated in the RBMP and where appropriate, exemptions under Art 4(7) of WFD are being applied.

7.5.12 Ukraine

Aiming to implement the Association Agreement between Ukraine and the European Union, the Action Plan on implementation of the Association Agreement was approved by the Decree of the Cabinet of Ministers of Ukraine №1106 on 25.10.2017. The State Service of Emergency is responsible for the development of Flood Risk Management Plans. The Ministry of Environmental Protection and Natural Resources of Ukraine is responsible for the development of River Basin Management Plans. Activities on both Plans development foresees inter-departmental and inter-ministerial interaction. In 2014, the Government Office for European Integration has been established in order to ensure an effective implementation of the Association Agreement between Ukraine and the European Union.

7.5.13 Moldova

According to the Association Agreement Moldova-EU signed in 2014, Moldova has to transpose five environmental Directives, including WFD and FD into the national legislation.

The Flood Risk Management Plan for the Danube-Prut and Black Sea River Basin District is directly related to the Danube-Prut and Black Sea River Basin District Management Plan, approved by the Government on October 3, 2018 and was prepared in accordance with the FD and national regulations. In fact, the Management Plan for the River Basin District is a basic document reflecting the main measures applicable to management in all sectors of the national economy, measures for water resources management at the basin and local levels, including measures proposed for flood risk management. A good example of synergism of both Directives is the public participation and communication during preparation of draft Plans.

A process of step-by-step integration of the Flood Risk Management Plan into the River Basin District Management Plan is ongoing, the respective measures were outlined in the Program of Measures. From the date of its approval by a Governmental Decision, the start of the activities under the Program and the Plan was envisaged with the efforts to ensure synchronization of these activities. Ministry of Agriculture, Regional Development and Environment is a competent authority for both development and implementation of both Plans. Thus, acting through the Agency Apele Moldovei, the Ministry is responsible for monitoring the implementation of both Plans as well as for providing to the River Basin Committee consolidated reports on implementation of Program of Measures accompanying both Plans.

8 Cost-benefit analysis

FD stipulates that when available, for shared river basins or sub-basins, a description of the methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects shall be provided in the flood risk management plan. The summary of existing national approaches to the cost-benefit analysis (CBA) is provided below.

8.1 National CBA activities

8.1.1 Germany

Economic evaluations constitute a regular part of German flood risk management. This reflects the idea that the use of economic instruments, methods and procedures support an effective flood risk management, such as decision-making, vulnerability and risk assessment, the analysis and prioritisation of measures and the financing of FRM-measures. The process of identifying and selecting measures constitutes the basis to a successful FRM. In Germany, this process runs across several levels of water management. Cost-benefit analysis is part of the execution process for all structural measures because many of these measures are supported by national funds or funds from the federal states. Hereby, various regulations and requirements are to be followed. Economic evaluations are in the wider sense an integral part of the framework and the key factors that influence the FRM-process.

In Germany, the FD and its requirements met an existing operational system of FRM. However, the implementation of the FD requirements led to optimisations in the pre-existing planning processes. In consequence, flood risk maps were prepared (Article 6 FD) and areas with a significant flood hazard transparently made public for all actors involved. This constitutes the basis for the systematisation of the pre-existing and continuous process of joint flood risk handling across local and regional borders.

8.1.2 Austria

Cost-benefit analysis is inherent to Austria's funding system for structural flood protection measures. CBA is obligatory for measures with "substantial financial effort or wide macroeconomic range". Simplified CBA analysis are applicable to projects with total costs ranging from 110.000€ to 1.000.000€. Comprehensive CBA are obligatory for projects exceeding 1 Mio. € of total costs. CBA in Austria is structured in 15 work steps as follows:

1. geo information
2. characteristic flood scenarios
3. hydrodynamic modelling
4. socio-economic information
5. vulnerability assessment
6. damage potential estimation
7. benefit estimation
8. cost estimation
9. benefit cost ratio and sensitivity analysis
10. assessment of people exposed
11. assessment of intangible effects
12. overall assessment
13. comparison of alternatives and choice of "optimal alternative"
14. description of residual risk
15. report and documentation

More information is available at https://www.bmlrt.gv.at/wasser/wasser-oesterreich/foerderungen/foerd_hochwasserschutz/knu_sw.html

8.1.3 Czech Republic

No cost benefit analysis in flood risk management was applied as there was no methodology available for the evaluation of the benefit of the flood risk protection measures mentioned in the national Flood Risk Management Plan for the Danube River Basin District.
For the purpose of evaluation of particular flood protection measures by strategic experts the efficiency ratio is calculated using the expected flood damages and the costs of the measures.

8.1.4 Slovakia

In the past there have been experiences with the application of cost-benefit analysis (CBA) on the level of each concrete flood protection measure/project in Slovakia. For each relevant project proposal also appropriate assessment according Art. 6.3 and Art. 6.4 of Habitat Directive and assessments according requirements of EIA Directive had to be carried out.

In line with the national legislation, the flood damage on the assets is defined as estimation of costs based on the usual prices in the affected region, which are necessary to be spent on restoration of damaged assets into the initial status before a flood event.

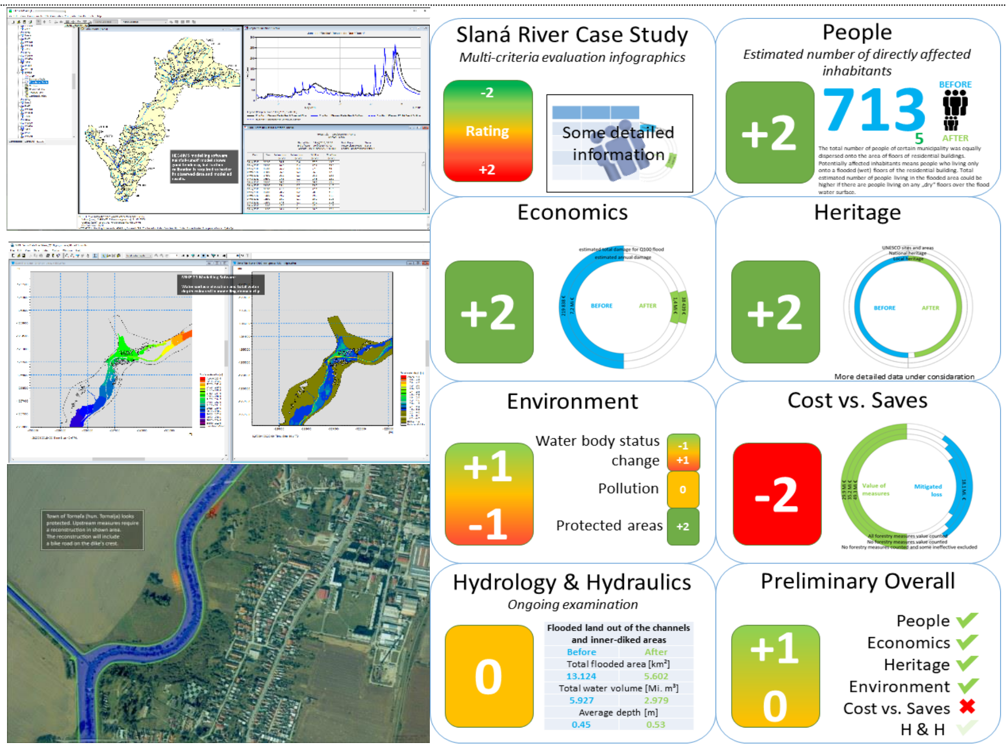
The determination of damage in the previous cycle does not include all types of damage and the value of costs caused by high floods. Following the incompleteness of the determined damages, a new methodology is being prepared within the 2nd cycle of the FRMP, which covers both direct and indirect damages as well as damages that are financially evaluable and not financially evaluable.

	SLOVAKIA	**Status:** Ongoing
	Target area: Transboundary basin of Slaná/Sajó River	
Project:	**Multi-criteria Analysis Concept for 2nd Flood Directive Planning Cycle in Slovakia**	

Experience gained from the first FD planning cycle showed some weak points such as negative cost-benefit analysis results suggesting too expensive measures; unclear “out-of-the-area” effects and impacts of planned measures; or the absence of unmonetizable elements in the entire CBA process. A ball-method was proposed for six main groups: people, economics, cultural heritage, environment, financial costs vs. saves analysis of proposed measures (“CSA”) and hydrologic & hydraulic (“H&H”) evaluation, to be comparable and synthetize monetizable and unmonetizable elements into the single one resulting score for measures in certain area of potentially significant flood risk. To emphasize the importance of a system of chained related measures and its “out-of-the-area” effect (area of potentially significant flood risk) the international catchment of Slaná/Sajó River was chosen as a pilot area.

Hydraulic water flow modelling supported with hydrologic rainfall-runoff model is providing necessary inputs in the analysis. This analysis evaluates prolonged modelled area with the lower end in Hungary. If H&H will show no negative impact for Hungarian partners, no further assessment would be necessary. In case of worsening of the existing flood protection efficiency, entire evaluation process would be applied in the whole area of prolonged model including previously non-evaluated parts in Slovakia and in Hungary. The ongoing study conclusions are as follows:

- The study showed for the Slaná river reach an overall rating as (slightly) good, however a bad rating was indicated for CSA and H&H analysis and this analysis is still ongoing.
- The proposed measures sufficiently protect people, economic assets, cultural heritage sites and minimize environmental threats by pollution sites (also in WFD protected areas).
- Potential impact on the water body status due applied measures varies from (slightly) bad to (slightly) good depending on modelling variables and it requires further examination.
- Assessment of costs for measures vs. prevented damage looks quite negative in the most optimistic scenario; the major problem being the loss of potential damage share for 50-years flood because it has been removed from national legislation. Potential annual 50-years damage looks to be the biggest compared to the currently legislatively required 10-, 100- and 1000-year flood damage. Potential losses for production and services seem to be an appropriate replacement in this case. The unmonetizable elements can have a significant impact on the result as well.



Investment costs, including the costs of their design and subsequent maintenance, are determined on the basis of indicative price indicators.

The ranking of measures is based inter alia on their efficiency indices, which are calculated as the ratio between the estimated avoided potential flood damages and the estimated overall costs (for preparation, land purchase, implementation, operation and maintenance) of given measure during its lifetime. The lifetime period of the flood protection measures/structures equals to 100 years in Slovakia.

8.1.5 Hungary

In the Hungarian FRMP great importance is given to the efficiency of the flood risk management measures. To put this across a so called "planning assistance tool" has been developed which includes each measure which is associated with the aims and principles of the flood risk management. It calculates the effect of both the structural and the non-structural measures and their investment costs. Calculation of the effects is based on the risk reduction results; the costs consist of the specific investment and maintenance costs. In the process of implementation of the Hungarian FRMP, the measures and groups of measures are compared with each other and ranked by means of the Multi-Criteria Analysis.

The Multi-Criteria Analysis is divided into two groups, the economical and the non-economical evaluation, where the economical evaluation is the CBA (Cost-Benefit Analysis) itself. The non-economic effects are the impacts on human life and health, cultural heritage, ecological impacts, water-management planning and other aspects. Evaluation of these non-economic effects is done in two levels. The first level is a disqualifying or exhaustive level, where there are fixed conditions (minimum-terms) to keep, and when they are breached, the measure is excluded from further investigation. The second level is an optimization task, where beyond keeping the minimum-terms, the economical and non-economical effects are compared, analysed and evaluated and measure efficiency is calculated.

In the CBA, it is calculated with a period of 30 years, where the number of the years can be set by decision. The basis of the calculation is the comparison of the accumulated costs over the 30 years period and the resulting risk reduction of the same period. Thus the benefit consists of the risk reduction, the reduction of the prevention costs and external effects over the 30 years, where the risk reduction is calculated with the re-preparation and re-calculation of the flood hazard and risk maps, which change according to the effects of the measures. The costs include the investment, design and implementation costs as well as the operational costs. The operational costs include the running and maintenance costs and production costs. As for the calculation, the effect of the real-term change of the asset values is taken into consideration. The future asset values are designed on 2013 base price, which means that inflation is not taken into account.

The cost-benefit ratio of the measure will be acceptable, if it is above the fixed minimum demand, which is 110% in Hungary. It was an interesting experience to examine the efficiency of the planned flood risk management measures on the pilot area of Zagyva-Tarna in Hungary. According to the results of the CBA calculations based on FRMP, there could be remarkable efficiency differences in partial water-catchments, when applying uniformly designed measures for the whole water catchment. The efficiency in the partial water-catchments varied between 5-10% and 300-400%, although the calculated efficiency of the measure for the whole pilot area was 121%. These results came from the FRMP version, in which the level of the existing, but – according to the present legal regulations – unsatisfactorily built dikes were uniformly raised to the legally specified level.

8.1.6 Slovenia

According to the Decree on establishment of flood risk management plans (Official Gazette of the Republic of Slovenia, No. 7/2010) flood risk management plans should take into account the aspect of costs and benefits. Cost-benefit analysis is an important element in the process of selection and prioritisation of measures of the Flood Risk Management Plan. CBA is already obligatory for public funded investments in flood protection exceeding 300 000 EUR according to the Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance (Official Gazette of the Republic of Slovenia, No. 60/2006 and 54/2010), and many different methods and approaches for the assessment of benefits of flood protection measures were applied in the past. A unified method for the assessment of benefits was developed in 2014 for the purpose of flood risk management plans. Benefits are assessed as a reduced value of expected annual damage after the implementation of certain measure or combination of measures. For the development of the method the data on damages during past flood events were taken into account. Benefits of the measures for human health, environment, cultural heritage and economic activity are assessed in monetary terms. Besides direct and tangible values the monetary assessment includes also some indirect and some intangible values as well. Benefits, which are not assessed in monetary terms, are listed.

8.1.7 Croatia

Since first FRMP analysis of costs and benefits is one of essencial steps in flood risk management measures development. On the program level, costs and benefits of the structural measures are assessed in the framework of *Multiannual programme of construction of water regulation and protection facilities and amelioration facilities*, which is the basis for implementation of the structural flood protection measures in Croatia and included in the programme of measures of FRMP. On the project level, more comprehensive CBA is applied as one of key elements for selection of most appropriate flood risk management measures. During the first and second flood risk management cycle, several studies have been launched and prepared in order to inprove multiple aspect of cost benefit analysis such as potential financial damages to properties (NACER), adverse consequences to human helth, landmine impact on flood risk etc.

8.1.8 Serbia

Cost benefit analysis was not applied in Serbia.

8.1.9 Bosnia and Herzegovina

The application of partly modified cost- benefit analysis in flood risk management in the Federation BiH has begun through the creation of a strategic document entitled "Evaluation of the Current Flood Protection Level in the Federation of Bosnia and Herzegovina and Improvement Program Drafting" which was conducted end of 2002. In this document, 31 flooded areas in the Federation BiH (major river valleys and karts' fields) were considered for which the economic and financial analysis have been implemented in order to define the costs and benefits. Benefit is presented by reducing the damages on certain flood area, and the costs include the funds needed for the construction of structures as well as their maintenance and other expenses that may arise during the use of the facility. Based on the defined costs and benefits, using the internal rate of rentability, the ranking of flood areas was carried out from the aspect of profitability of their investment in flood protection of these areas. The internal rate of profitability is defined as the rate of interest for which all the costs and benefits are equal, and it represents the maximum rate for which the loan is profitable.

After creation of the above ranking, no additional and separate cost-benefit analysis for the purpose of flood risk management was made. The necessity for such economic analysis is recommended by the adopted "Water Management Strategy of the Federation of Bosnia and Herzegovina 2010 - 2022". Recently, this method was used in the justification of investments in flood protection or in construction of flood control structures in relation to the value of the defended area.

8.1.10 Romania

Two national acts rule the cost-benefit analysis for infrastructure related to water, depending of the financing sources in Romania.

For national funds, the Governmental Decision 907/2016 on the stages of elaboration and the framework content of the technical-economic documentation related to the objectives / investment projects financed from public funds is in charge.

In this act, four elaboration stages of technical-economic documentation related to the objectives / investment projects financed from public funds are foreseen (1st stage: Conceptual note and design theme, 2nd stage: Pre-and feasibility studies and approval of technical and economic indicators, 3rd stage: the project for authorizing the execution of works and issuance of construction permit, 4th stage: the technical execution project).

For accessing the European funds, the National Guide for cost-benefit analysis was elaborated in 2017. This guide has been prepared by the National Structural Instruments Coordination Authority with the support of external consultants and in consultation with the relevant Managing Authorities and the European Commission's General Directorate for Regional Policy.

8.1.11 Bulgaria

During the first cycle of implementation of the FD, the CBA analysis of the programs of measures in FRMPs in Bulgaria was performed according to a national methodology, elaborated through funding by the Operational Program “Environment”. In the second cycle FRMPs, the CBA methodology is in the process of being updated, with support from the World Bank, through funding by the OP “Environment”. The CBA is a decision support tool having a key role to play in informing on the performance of different options or sets of options for flood risk management to be included in a Program of Measures (PoMs). The CBA methodology is proposing a number of analytical methods that can be used to compare and rank the performance of policy options. Alternative technical options analysis, multi criteria analysis, cost-benefit analysis and, cost effectiveness analysis, are considered standard approaches for evaluating the economic and wider aspects of flood risk management measures in the development of a Programs of Measures and prioritization of measures. The main stages of the implementation of the CBA for the preparation of the PoMs include: development of methods for financial and economic analysis; development of an approach for analysis of risk and sensitiveness; development of an approach for the assessment and selection of economically effective Program of measures; elaboration of National Guidance for implementation of the Methodology.

8.1.12 Ukraine

The Order on public investment projects preparation was re-approved by the Resolution of the Government of Ukraine in 2015. The economic effect forecast including the cost-benefit analysis, forms a chapter of the Order in its current and previous versions. At the same time there is no clear methodology on CBA calculations, especially for the calculations on flood protection activities' effectiveness.

The "Complex flood protection Scheme for the Tisza River basin in Transcarpathian region" contains a chapter on flood protection activities' effectiveness assessment, which relates the effectiveness calculations to the public costs economy in order to reimburse compensations and to carry out the repair works, reduce of the probable floods damages, and also receive additional budget revenue due to the protected agricultural lands' yields. However, it has to be pointed out that ecological and social benefits are the main results of the flood protection measures' implementation.

The methodology of the CBA calculations would require further specification when elaborating the flood risk management plans at the regional level.

8.1.13 Moldova

Regulation on the Flood Risk Management approved by the Governmental Decision no. 887 of 11 November 2013 does not fully comply with the Flood Directive 2007/60/EC. The structure and content of the Flood Risk Management Plan outlined in the above Regulation does not envisage cost benefit analysis of the proposed measures. Yet, during the preliminary flood risk assessment (2013-2016), the areas with high, medium and low flood risk were identified and mapped and also the damage caused by possible damage was calculated. For this asessment, the ratio of the depth of flooding to the damage caused was used. Generally, the concept of flood risk was considered as a combination of the likelihood of a flood occurrence and its consequences, i.e., damage caused. 12 indicators of the flood risk were used, divided into three categories according to severity of the impact on the population (5 indicators), on the economy (3 indicators) and on the environment (4 indicators). The quality of data used for the preliminary flood risk assessment was considered as moderate and high what is a prerequisite for applying of the assessment methodology. An impact level analysis was also performed including variables such as: destination of area, population density in each settlement, location of water pumping stations, presence of protected areas, cultural sites and sources of water contamination. Yet, when elaborating the Program of Measures accompanying the 6-year Flood Risk Management Plan for the Danube-Prut and Black Sea River Basin District, due to some specific reasons, the above assessments were not used for the evaluation of benefits resulting from implementation of measures in certain areas vs. damages caused by possible floods. Nevertheless, the Plan provides costs of measures, and the selection of measures addressing rehabilitation/ building of dykes was, *inter alia,* based mainly on a cost-benefit ratio, i.e., the socio-economic efficiency of proposed measures was partially considered. In fact, the dykes proposed for construction/ rehabilitation were those situated close to the settlements to avoid any threat to human health and damage to property. These had priority over the areas of arable lands, potential damage to which is a priori much less.

9 Impacts of climate change

A general question to be considered in the implementation of the Floods Directive is if the potential changes to flood risks induced by climate change require a changed flood risk management approach. Examples are: changes of duration, intensity and frequency of floods, shifts in time season of flood occurrence, intensified coastal flood risks (related to both sea level rise and increased storm surges), floods in ephemeral rivers (in particular in drying regions), changed patterns in snowmelt, ice-jam floods and more regulated rivers due to hydropower production. Flood risk management should take into account the impact of climate change on the hydrological behavior of the catchment, both in natural (reference) and altered (modified) conditions - for instance rivers regulated for hydropower production or with flood defenses - since it may change the floods regime; this requires the integration with the river planning process under the WFD. Risk reduction responses may also include different approaches to land use planning, the role of climate change in civil protection policies, and learning to live with and adapt to floods if preventing them is not possible.

EU WFD CIS Guidance document n° 24 - River Basin Management in a Changing Climate[16] provides support to river basin managers in incorporating climate change in the next river basin management cycles. It also addresses the specific issues relating to flood risk having in mind the need of close interlinking of flood risk management and river basin management in future.

Guidance document points out that future changes in the intensity and frequency of extreme precipitation events, combined with changing land use, are expected to cause an increase in flood risk across much of Europe. The Flood Directive shares many features of the WFD, such as the cyclical approach to risk assessment, preparation of management plans, and consultation process. However, what distinguishes the Flood Directive from the WFD is that the risk assessment places safety issues at the centre. Many of the guiding principles formulated for the river basin management are therefore directly applicable to flood management.

The Floods Directive further highlights the need for coordinated action on climate change throughout the RBD, particularly where there are transboundary or shared flood risk issues. Some information collected under the WFD is of relevance to flood management. The Preliminary Flood Risk Assessment also requires that past floods are taken into account, so efforts to homogenize and remove biases from river flow records will be helpful to trend detection more generally.

WFD and flood risk management objectives potentially overlap in several places with respect to climate change. For example, more frequent floods can have benefits for aquatic ecology, soil fertility, groundwater recharge and biodiversity. WFD Article 4(6) makes provision for temporary deterioration in the case of extreme floods but should not be used by Member States as a means of avoiding WFD obligations.

[16] https://circabc.europa.eu/sd/a/a88369ef-df4d-43b1-8c8c-306ac7c2d6e1/Guidance%20document%20n%2024%20-%20River%20Basin%20Management%20in%20a%20Changing%20Climate_FINAL.pdf

<table>
<tr><td rowspan="2">INTERNATIONAL SAVA RIVER BASIN COMMISSION</td><td>International Sava River Basin Commission (ISRBC)</td><td>Status: Implemented</td></tr>
<tr><td colspan="2">Target area: Sava River Basin countries (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia)</td></tr>
<tr><td>Project:</td><td colspan="2">Hydrologic and hydraulic modelling in the Sava River Basin</td></tr>
<tr><td colspan="3">
US Government has provided a technical support through USACE to ISRBC and Sava countries by developing a comprehensive hydrologic model of the Sava River basin and a hydraulic model of the Sava River. Both models were developed within two phases of development and at the end integrated under the Sava FFWS forecasting platform (see example #4) and delivered to the relevant institutions of the countries. During the models' development several workshops were organized for experts from the national institutions and conducted by the leading experts from USACE to transfer the knowledge how to use models.

The hydrologic Sava HEC-HMS model development was a major undertaking to provide detailed hydrologic analysis of the entire Sava River Basin. The main goal of the model was to produce discharge hydrographs that can be coupled with and imported into the Sava hydraulic model. The model consists of a basin-wide integrated model and 21 separate model of each major Sava River tributary. The model was calibrated as an event-based model.

In 2019-2020 this model was upgraded by national experts, with the coordination and technical support of ISRBC. The activity included re-calibration and validation of the model for the long-term data series.

In addition to the hydrologic model, the unsteady Sava HEC-RAS hydraulic model was also developed. The hydraulic model includes the Sava River mainstem and the downstream sections of the major Sava tributaries. Geometry development for this model was based on a combination of a different information collected from national institutions: existing models, data on structures (bridges, inline and lateral structures, etc.) and the retention areas along the Sava main course. The model geometry of the overbank areas was based on LiDAR data collected in 2017. The model was calibrated on three characteristic flood events.

The cooperating countries have a direct benefit from the successful development of the Sava River Basin models in flood forecasting and warning, but it is planned to use the models' potential for many other purposes: sediment transport analysis, water pollution modeling, low-flow analysis, climate change and nautical studies, etc.
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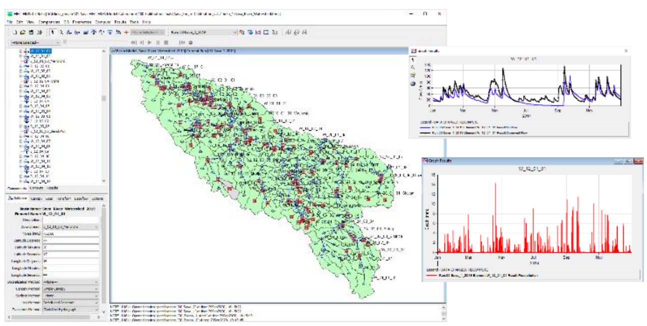
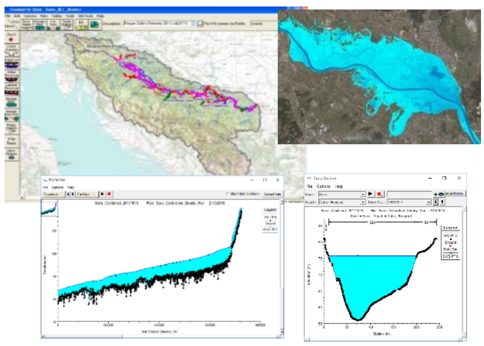
<tr><td colspan="3"> </td></tr>
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At the Danube Ministerial Conference in 2016, the Ministers appreciated the "ICPDR Strategy on Adaptation to Climate Change" adopted in 2012 and its integration into the updated DRBM Plan and the DFRM Plan. Welcoming the historic Paris Agreement agreed on 12 December 2015 under the UN Framework Convention on Climate Change and taking note of the rapid progress made in research about climate change and adaptation in general as well as in the Danube River Basin the Ministers asked the ICPDR to foresee an update of its strategy, in particular with regard to its knowledge base, in 2018 in order to prepare the updated strategy in time for the next planning cycle of the EU Water Framework Directive and EU Floods Directive.

Germany was nominated as Lead Country for this activity in the frame of the ICPDR. In this function, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety supported a and update of the Danube climate change adaptation study with the aim of providing foundations for a common, Danube-wide understanding of future impacts of climate change on water resources and suitable adaptation measures as a basis for the update of the Danube Climate Adaptation Strategy.

The Revision and Update of the Danube Climate Change Adaptation Study was initiated by the ICPDR and supported by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety to revise the findings of the first Danube study conducted 2010-2011 (report January 2012). The updated study supports a Danube wide understanding of the impact of climate change on hydrology and water availability in the light of the new IPCC report AR5 and improved regional climate models. The outcomes of the study should provide an analysis of projects conducted between 2012 and 2017 and a comparison to the findings of the first Danube study. The work on the second study was finished in 2018.

The Danube Climate Adaptation Study update highlights that the projection of the future development of floods with regard to their intensity, timing and frequency is considered to be a challenging and uncertainty afflicted task. This can be traced back to various factors. The origin of floods can be very diverse: long and persistent rainfall events, storm precipitation, and rain on snow events. Another crucial factor is the terrain characteristics: mountains and lowlands, small and big catchments, geological conditions, soil properties. Moreover, there is great human influence on the surface which can contribute to flood development: agriculture, forestry, soil sealing, and river regulation. Despite these factors, which influence flood intensity, timing and frequency, the analysed documents coincide with an increase in future flood risk and intensity, mainly in small and mountain catchments.

At the level of the Danube River Basin the review of the available information indicates more frequent high/extreme floods and increasing flood risk however the certainty of this projection is low.

In the Upper Danube River Basin, a general increase in flood risk and floods is projected. A particular increase in winter and possible increase in spring and early summer is expected. A decrease of flood risk in summer is highly uncertain. The forecasts of floods are accompanied by high uncertainty since knowledge of the future development of meteorological extremes, in particular precipitation, is insufficient.

In the Middle Danube River Basin, there is an increase in flood risk, intensity and duration expected and, in particular, an increase in flood risk in rivers originating from mountains and in mountain headwater catchments. A shift of flood peaks to earlier month and a higher possibility of flood events during dry periods due to storm precipitation during droughts is foreseen.

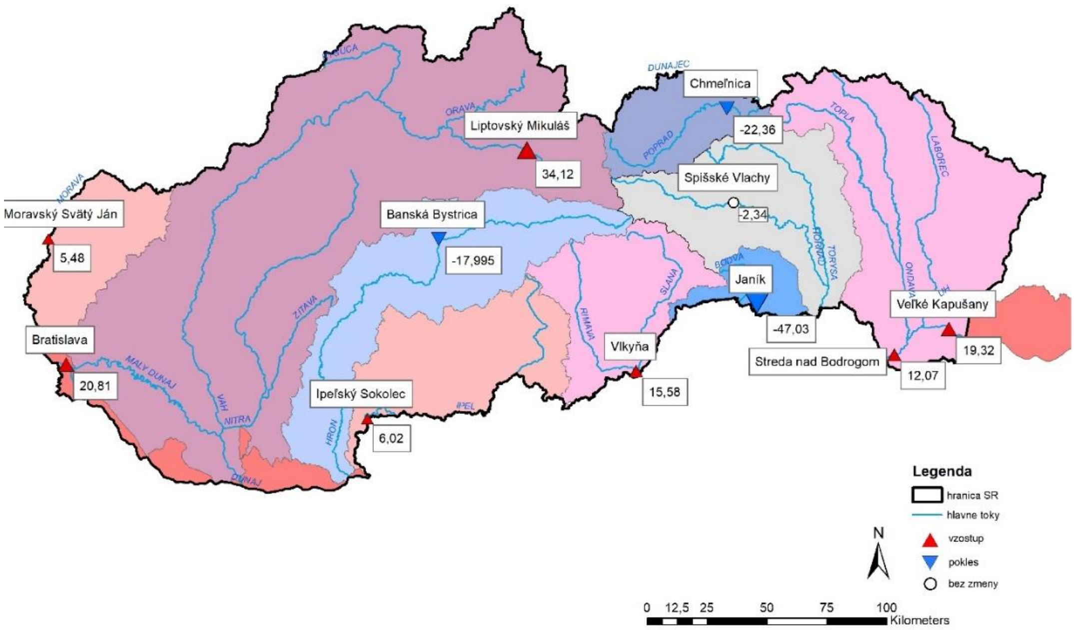
The projection for the Lower Danube River Basin is similar to that for the Middle Danube River Basin with the exception of less early spring floods due to reduced snow cover.

In general, floodings are expected to become more frequent due to an increase in extreme events, although uncertainty is significant due to the high variability in precipitation. Similar to the previous study, for adaption measures mainly maintenance, improvement and enlargement of flood protection services and constructions are addressed. Thereby, often the functions of natural retention areas, both for ecological and safety reasons, are mentioned. Furthermore, there seems to be a common understanding for the demand of restrictions in future development along flood prone areas.

	Slovakia	**Status:** Under implementation
	Target area: Selected profiles in sub catchment of Danube basin in Slovakia.	
Project:	**Climate change impact study on 100-year floods**	

Study on the Impact climate change on 100-year flood provides an analysis of the modelled expected change in floods (100-year) for 11 selected profiles in sub catchment of Danube basin in Slovakia. In the first phase, 572 time series of average daily flows for 26 stations were analyzed. Relationships between peak and maximum average daily flows were derived. For 242 time series, trends were analyzed and frequency analysis was performed fitting the GEV distribution function. The possibilities of using data for regional conditions in Slovakia from the latest climate projections of global and regional models from the EURO-CORDEX initiative, as well as the outputs from two hydrological models from the SWICCA database (Service for Water Indicators in Climate Change Adaptation) within the Copernicus service were analysed. The advantage of the SWICCA database is the availability of a large number of climatic and hydrological model outputs for a number of European river basins, as well as the latest knowledge on the state of the climate and modelled estimates of its development in one place. The SWICCA database is constantly developing and supplemented by the necessary data. Its ambition is to provide users with a finer resolution of the outputs from the RCM models and to extend the reference period from 30 years to the longest possible period in the past.

To estimate the 100-year flood, a frequency analysis was applied to each element of the climate and hydrological model output ensemble. The statistical distribution of generalized extreme values (GEV) was used. In case the data showed a significant trend, the non-stationarity of the environment was also taken into account. The bias of hydrological models' outputs was corrected by the variance scaling method. The results indicate an increase in Q_{100} for seven gauges, a decrease for three gauges and for one station no change in Q_{100} (change more than ± 5%). Based on the results, it is recommended to apply hydrological data from the SWICCA database, preferably for large to medium-sized river basins.



The ICPDR Strategy on Adaptation to Climate Change aims at offering guidance on the integration of climate change adaptation into ICPDR planning processes. It promotes action in a multilateral and transboundary context and serves as reference document influencing national strategies and activities. The ICPDR Strategy on Adaptation to Climate Change 2012 was updated and revised in the year 2018 taking into account new scientific results (primarily those published in the Danube Climate Change Adaptation Study) and implementation steps taken in the Danube countries.

The ICPDR Strategy on Adaptation to Climate Change highlights that due to the expected changes in climatic conditions, water availability is likely to decrease in the southern and eastern parts of the DRB, whereas it will remain unchanged or even increase in the northern and western part. Changes in water availability can highly differ locally and regionally. Nevertheless, a north-westward shift of regions affected by water stress is expected until the end of the 21st century. Runoff is projected to significantly decrease until the end of the 21st century, whereas only little change is projected in the next decades. According to precipitation, changes in runoff seasonality are expected. The assessment of future extreme hydrological events like floods and droughts includes high uncertainty. However, there is consensus that extreme hydrological events will occur more often and be more intense.

Generally, an intensification of flood events all over the DRB is expected. Small and mountain catchments will be most affected. Within the basin, there are different local tendencies, especially for the development of extreme flood events. An increase in flood intensity and frequency is likely to occur with emphasis on small and medium flood events, especially in alpine regions in late winter/spring, triggered by changes in winter precipitation and snow storage.

Short-term flood events may occur more frequently. For small catchments, an increase in flash floods due to more extreme weather events (torrential rainfall) is expected (e.g. in the Carpathian Range or the Sava and Tisza headwaters).

The ICPDR Strategy on Adaptation to Climate Change presents guiding principles, which provide support for the integration of adaptation to climate change into flood risk management. There is a strong recommendation to start adapting flood risk management to potential climate change as soon as possible, when information is robust enough, since full certainty will never be the case.

The respective measures include:

- Performing a climate check of flood risk measures
- Favouring options that are robust to the uncertainty in climate projections
    - Focus on pollution risk in flood prone zones
    - Focus on non-structural measures when possible
    - Focus on “no-regret” and “win-win” measures
    - Focus on a mix of measures
- Favouring prevention through the catchment approach
- Taking account of a long-term perspective in defining flood risk measures (e.g. with respect to land use, structural measures efficiency, protection of buildings, critical infrastructure, etc).
    - Include long-term climate change scenarios in land-use planning
    - Develop robust cost-benefit methods which enable taking into account longer term costs and benefits in view of climate change.
    - Use economic incentives to influence land use [Link insurance]
- Assessing other climate change adaptation (and even mitigation) measures by their impact on flood risk:

- Hydropower and flow regulation
- Link with water scarcity

10 International coordination

FD in its Articles 4, 5, 6, 7 and 8 requires that all elements of FD implementation in an international river basin district are coordinated by all countries sharing that river basin.

The international coordination of the implementation of FD including preparation of basin-wide preliminary flood risk assessment, flood hazard and flood risk maps as well as flood risk management plan has been accomplished through the ICPDR. There has been a vast experience existing from preparation and implementation of the ICPDR Action Programme on Sustainable Flood Protection in the Danube River Basin that has been utilized in the process of achieving the goals of FD.

10.1 ICPDR

The International Commission for the Protection of the Danube River (ICPDR) is an International Organization consisting of 14 cooperating states (Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Slovakia, Slovenia, Serbia, and Ukraine) and the European Union who have committed themselves to implement the Danube River Protection Convention (Figure 8). The ICPDR deals not only with the Danube itself, but also with the whole Danube River Basin, which includes its tributaries and the groundwater resources.

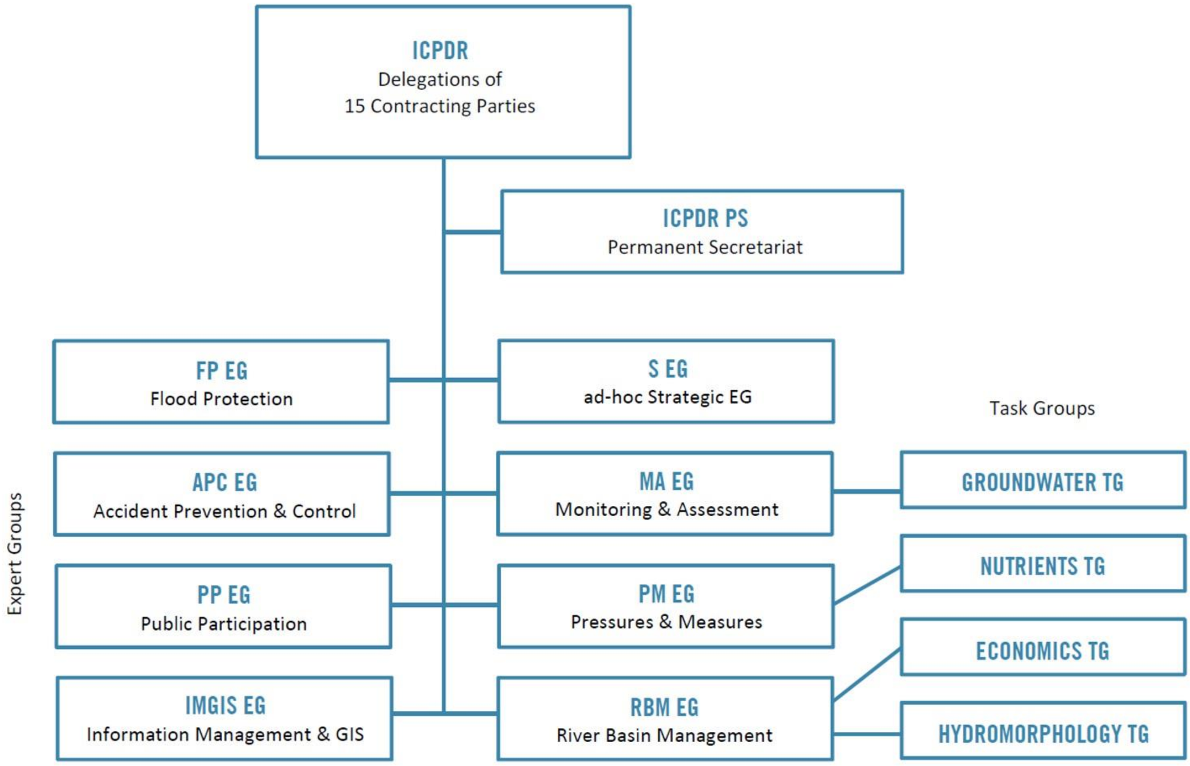


Figure 8 ICPDR Organigram

The goal of the ICPDR is to implement the Danube River Protection Convention (DRPC) and make it a living tool. In addition, the ICPDR is the body that coordinates the implementation of EU Water Framework Directive and EU Floods Directive in the Danube River Basin.

The ICPDR mission is to promote and coordinate sustainable and equitable water management, including conservation, improvement and rational use of waters for the benefit of the Danube River Basin countries and their people. The ICPDR pursues this mission by making recommendations for the improvement of water quality, developing mechanisms for flood and accident control, agreeing standards for emissions and by assuring that these are reflected in the Contracting Parties' national legislations and applied in their policies.

10.2 Flood risk management in the Danube River Basin District

River basins, which are defined by their natural geographical and hydrological borders, are the logical units for the management of waters. This innovative approach for water management is followed by the EU WFD and has been adopted by the EU Floods Directive. In case a river basin covers the territory of more than one country, an international river basin district has to be created for the coordination of work in this district.

The Danube and its tributaries, transitional waters, lakes, coastal waters and groundwater form the Danube River Basin District (DRBD). The DRBD covers the Danube River Basin (DRB), the Black Sea coastal catchments in Romanian territory and the Black Sea coastal waters along the Romanian and partly Ukrainian coasts.

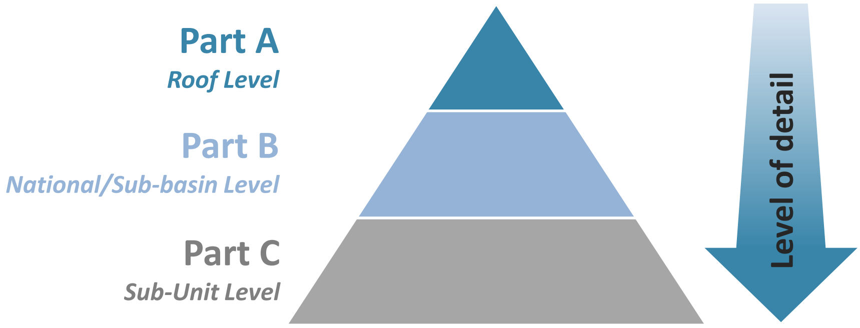


Figure 9: Three levels of management for WFD implementation in the DRBD showing the increase of the level of detail from Part A to Part B and C

Due to reasons of efficiency, proportionality and in line with the principle of subsidiarity, the management of the DRBD is based on the following three levels of coordination (see Figure 9):

- ⇨ **Part A**: International, basin-wide level – the Roof Level;
- ⇨ **Part B**: National level (managed through the competent authorities) and/or the international coordinated sub-basin level for selected sub-basins (Tisza, Sava, Prut, and Danube Delta);
- ⇨ **Part C**: Sub-unit level, defined as management units within the national territory.
  - ⇨ The investigations, analyses and findings for the basin-wide scale (Part A) focus on rivers with catchment areas >4,000 km^2
  - ⇨ The ICPDR serves as the coordinating platform to compile multilateral and basin-wide issues at Part A ("Roof Level") of the DRBD. The information increases in detail from Part A to Parts B and C.
  - ⇨ The list of competent authorities is provided in the Annex 3.
  - ⇨ The coordination at the basin-wide level (level A) has been accomplished through the activities of the ICPDR Flood Protection Expert Group

The flood risk management issues in the international sub-basin of the Sava River are managed by the International Sava River Basin Commission (ISRBC, http://www.savacommission.org/).

In the sub-basin of the Tisza River the flood risk management related international project generation and coordination is managed by the Tisza Group of the ICPDR (http://www.icpdr.org/main/activities-projects/tisza-group).

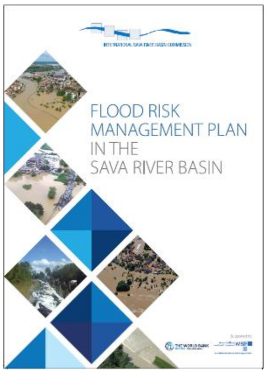
The transboundary aspects of flood risk management between the neighboring countries in the DRBD are covered by the bilateral agreements and are dealt with on a regular basis by the bilateral commissions. The list of bilateral agreements is provided in the Annex 4.

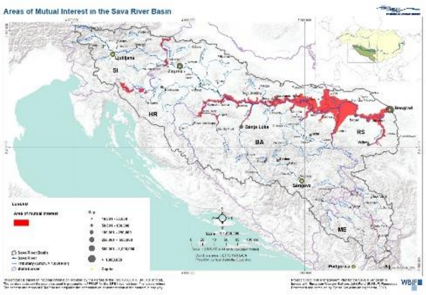
	International Sava River Basin Commission (ISRBC)	**Status:** Implemented
	Target area: Sava River Basin countries (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia)	
Project:	**Flood Risk Management Plan in the Sava River Basin (Sava FRMP)**	

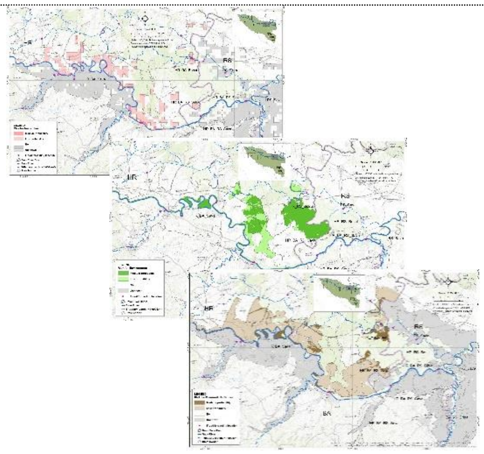
The joint Sava FRMP, prepared by ISRBC in close cooperation with the relevant national institutions, was officially approved by the ISRBC Parties at their 8th Meeting held in Sarajevo on October 24, 2019. Sava FRMP represents a milestone in the cooperation of the Parties leading towards fulfilment of one of the main objectives of the Framework Agreement on the Sava River Basin – to prevent or limit hazards and reduce and eliminate adverse consequences, including those from floods.

Based on national Areas with Potential Significant Flood Risk, Sava FRMP identified 21 Areas of Mutual Interest for flood protection at the Sava River Basin level (AMIs), as basic units for analyzing the flood risks, with a total surface of 5,659 km2, representing 5.8% of the Sava River Basin area and home to 1.4 million people. In AMIs, 38 structural measures were identified with a total value of over € 250 million while at 42 non-structural measures were also identified, that mostly relate to the entire AMIs or the Sava River Basin. The implementation of the measures will strongly contribute to meeting the commonly agreed objectives – avoidance of new flood risks, reduction of existing flood risks during and after the floods, strengthening resilience, raising awareness about flood risks and implementing solidarity principle. Coordination mechanisms at the Sava River Basin level and cooperation in case of extraordinary flood defense were also analyzed, with recommendations for improvements.

The Sava FRMP in all official languages of the ISRBC Parties, as well as in English and Montenegrin, is available at: www.savacommission.org/sfrmp/







11 Promoting the solidarity principle

Solidarity principle is one of the objectives of the Flood risk management plan for the Danube River Basin District as described in the chapter 4.5.

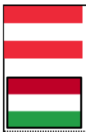
The ICPDR is fully aware of importance of application of the solidarity principle; one should not pass on water management problems in one region to another. That is why the ICPDR agreed that the measures with downstream effects shall have the key priority at the basin-wide level (i.e., measures like natural water retention, warning systems, reduction of risk from contaminated sites in floodplain areas, exchange of information).

	**Hungary, Croatia and Serbia** **(Provided by EUSDR PA5)**	**Status:** Implemented
	Target area: Promoting the solidarity principle on the Danube between Hungary, Croatia and Serbia	
Project:	**Danube ice event 2017**	

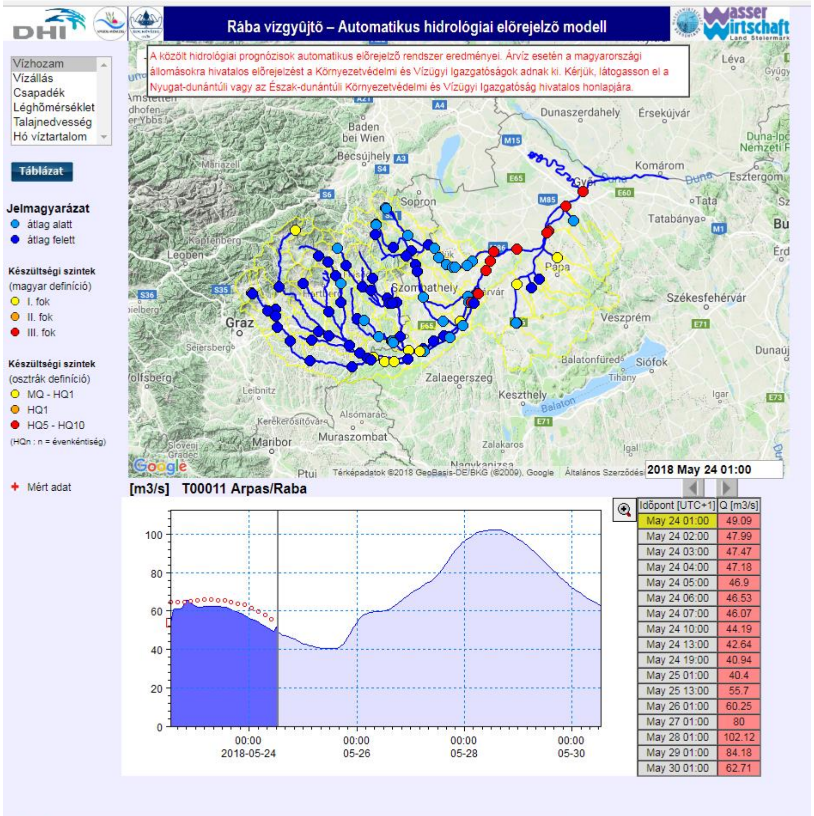
Cross-border ice control has a long history on the Danube River. Beyond navigation concerns, the risk of flooding from accumulated ice is a looming threat to the population. Devastating, fast-rising ice-jam floods between the Hungarian border and Vukovar, Croatia, in particular require a strong alliance of Serbian, Croatian and Hungarian protection efforts. The three countries manage this protection through an international trilateral agreement to address events – such as floods, ice-drift, or pollution – on the part of the river known as the 'section of common interest', where such events affect all three countries. In 2017 about 170 km of the Danube were entirely frozen. With massive ice jams floating menacingly offshore, Serbian water authorities declared an emergency situation and the trilateral partners swung into action. The Hungarian water management directorates and the General Directorate of Water Management played key roles in the intensive operations that followed, cooperating smoothly with their Croatian and Serbian counterparts. In the Hungarian section of the river, only a variable rate of ice drift was observed while, to the south, Serbia faced a much larger problem. In the most critical areas near Belgrade and Kladovo, the river froze to a depth of up to four meters. Shipping was suspended in Hungary and ice breakers were called out to clear the Hungarian waterway, but the worst of the ice remained over the border, therefore additional actions were needed on the Cratian and Serbian Danube.

Altogether four Hungarian icebreakers were deployed to smash ice blocks and prevent damage to bridges and ships moored along the waterway. Two of the ships – Jégtörő XI and Jégtörő VI – broke through the ice jam in Dalj (Croatia) and kept the ice discharge lane clear for traffic. The other two ships – Széchenyi and Jégtörő VII – moved to the Serbian section of the Danube between Novi Sad and Belgrade (being formally outside the area covered by the trilateral agreement). However, given the emergency situation, Serbia and Hungary agreed that the icebreakers had to be deployed beyond the common interest section. Hungary didn’t hesitate, and its ships set off to destroy the ice threatening its neighbours. These actions were a demonstration of a great transboundary partnership and they are also reminders of the importance of cross-border cooperation and solidarity principles forming the core of ICPDR activities.

To avoid the negative downstream effects the national legislation shall contain provisions stipulating that flood risk management plans shall not include measures which, by their extent and impact, significantly increase flood risks in other countries (as it is the case in e.g., the German Federal Water Act (WHG)).

	**Austria – Hungary**	**Status:** Implemented
	Target area: Raab/Raba catchment in Hungary and Austria	
Project:	**Raab flood 4 forecast**	

Both in the Austrian and in the Hungarian part of the Rába River catchment flood events lead to flooding and consequently to a risk to life and infrastructure. It is therefore in the interests of the flood prevention and disaster management organizations to receive information in the event of a flood as early as possible on how the expected floods are developing so that disaster relief planning can be carried out efficiently across borders. The overall goal of the project was to significantly reduce the risks of floods in the Rába catchment area by presenting expected floods in terms of their spatial extent and time course in a warning tool that was developed.
The core outputs of the project are the updated flood forecasting model Rába and the warning tool for the presentation of the expected flooding areas. The project beneficiaries are the operators of forecast models, the institutions responsible for the flood and disaster management as well as the population affected by the flood. The Raab Flood 4Cast project was supported by EUSDR PA5.
Information about the project: https://www.interreg-athu.eu/en/raabflood4cast/



The top measures applying the solidarity principle rely on natural water retention and flood retention by making every effort to retain rainfall at the spot, storing excess water locally, only then letting the water be discharged to the water-course and further downstream to the neighbouring country. These measures include natural water retention in the catchment, in wetlands and in settlement areas, soil sealing reduction, restoration of flood plains and sedimentation areas, land-use changes (grassing, afforestation) and planning and construction of flood retention systems.

Instrumental to the efficient application of the solidarity principle is transboundary cooperation. Establishing efficient bilateral cooperation with all neighbouring countries, including common actions on transboundary rivers during flood and ice defence is an effective tool to reducing downstream impacts of floods. More information on the international cooperation is provided in Chapter 10.

An efficient cooperation is also needed between the national flood monitoring and warning services enabling rapid exchange of data on flood events and warnings. A supportive element is the use of the Danube EFAS – the flood-warning-system among Danube countries (see chapter 5.5.3.2).

12 Public information and consultation

Disclaimer:

At time of publishing, some contents of this chapter remain incomplete and in draft form only since the online Public Participation event has not yet been held. Sections 12.1.4.3 – 12.1.4.6 have been left empty as of the time of publication. These will be filled out and reported on once the public consultation process has been completed.

Similarly, the public information and consultation activities at the national level are ongoing and the text below requires further revision.

Therefore, this chapter will be thoroughly updated following the completion of the public consultation period at the end of September 2021 to include all the relevant information, comments and feedback received.

12.1 Danube River Basin District

12.1.1 Objectives of Public Participation within the legal setting of the Floods Directive

The ICPDR is committed to active public participation in its decision-making. The commission believes that this facilitates broader support for policies and leads to increased efficiency in the implementation of actions and programmes. Active consultation with stakeholders as well as the public takes place throughout the entire cycle of all ICPDR activities, ranging from developing policies, to implementing measures and evaluating impacts. A legal framework for this is provided by Article 14 of the EU Water Framework Directive along with Articles 9 and 10 of the EU Floods Directive.

12.1.1.1 Detailing public information and consultation activities for the development of the 2nd DFRMP in a changing environment

With an increased awareness of environmental issues, a growing appreciation for the ways in which the environment affects public health, plus the more direct contact of social media, public participation in these processes is very much on the rise. The ICPDR is taking this opportunity to further open its doors and mechanisms to invite the public to participate in a variety of ways – and the public is growing increasingly engaged as a result. This is a vital shift, considering that environmental policy and management only succeed if key stakeholders feel engaged, and buy into the design of all the actions concerned.

Today, a ‘bottom-up’ approach means that people can share information and responsibilities; they can partake in the design of programmes; monitor and evaluate progress; and all without central management. Key forms of participation, such as the dissemination of information, public advocacy, public hearings and litigation, assist environmental decision-makers in identifying the concerns of the general public. A recent shift towards decentralising strategies also encourages the active participation of organised groups, communities, and citizens at a more local level.

12.1.1.2 A New Approach

So what does this mean for the ICPDR? One of our core principles is to encourage public participation in all our activities and decision-making wherever possible - so it most definitely means good things for all of us! The increasing number of ways in which the public can be reached is useful for broadening our methods and putting together a new approach for engaging the public, exploiting raising awareness in order to facilitate broader support for our policies and greater efficiency in their implementation.

12.1.2 ICPDR Observer Organisations

In keeping with commitments to engage the public, the ICPDR maintains a close relationship with a variety of organisations – representing public interest – defined by the DRPC as “observers”.

While observers are not granted decision-making rights, they actively participate in all meetings of ICPDR expert groups and task groups, as well as plenary meetings (Standing Working Group and Ordinary Meetings). Active participation means that delegates of observers have both access to information including all technical meeting documents as well as the right to contribute to all discussions.

Observers represent a broad spectrum of stakeholders in the Danube River Basin, covering social, cultural, economic and environmental interest groups adhering to the goals of the Convention. The connective tissue between observers and the ICPDR is a shared ‘community responsibility’, essential to achieving long-term sustainable water management goals.

Institutionally, observers can include interest groups, non-government organisations (NGOs), and intergovernmental organisations (see list below). Observers are accepted upon approval by the ICPDR and have to meet a defined set of criteria laid down in “IC 185 Guidelines for Observers”.

As of 2021, there are 24 organisations approved as observers, all of which had the opportunity to contribute to the development of this management plan through the relevant expert groups, task groups and plenary meetings.

ICPDR Observers as of 2020

Black Sea Commission (BSC)
Carpathian Convention
Central Dredging Association (CEDA)
Danube Competence Center (DCC)
Danube Civil Society Forum (DCSF)
Danube Commission (DC)
Danube Environmental Forum (DEF)
Danubeparks
Danube Tourist Commission (DIE DONAU)
Danube Sturgeon Task Force (DSTF)
European Anglers Alliance (EAA)
European Barge Union (EBU)
European Water Association (EWA)
Friends of Nature International (NFI)
Global Water Partnership (GWP/CEE)
International Association for Danube Research (IAD)
International Association of Water Supply Companies in the Danube River Catchment Area (IAWD)
International Hydrological Programme of the UNESCO (IHP/Danube)
International Sava River Basin Commission (ISRBC)
RAMSAR Convention on Wetlands
Regional Environmental Center for Central and Eastern Europe (REC)
VGB PowerTech e.V. (VGB)
viadonau
World Wide Fund for Nature – Danube-Carpathian Programme (WWF-DCP)

12.1.3 Updating ICPDR public participation practices

The first DFRMP as stipulated in the FD has been subject to public consultation. Carried out in two main phases, we collected comments from the public during the update, seeking their response on:

1. the timetable and work programme including public consultation measures;
2. the draft flood risk management plan;

These public consultations each spanned periods of at least six months, utilising the ICPDR network to gather and disseminate information. The resulting timetable and work programme as well as the proposed update to the plan was then published and made publicly accessible.

The update to proceedings for the DFRMP Update 2021 follows on with this programme of public consultation based on the previous plan. This forms an additional and more direct approach to public participation, along with information, promotion and educational initiatives aimed at keeping our stakeholders and the public well informed as a matter of daily business using social media, ad-hoc communications and queries, and maintaining our web presence.

12.1.4 Informing & being informed: Public consultation for the DFRMP Update 2021

Communities can become more meaningfully involved in the work of the ICPDR if they are well informed - and have opportunities to inform the ICPDR in response - about its objectives and structure. This is a constant concern and key activity for the ICPDR throughout the year. However, when it comes to the six-yearly DRBMP & DFRMP Updates, these channels for informational exchange become vital to the process at the level of public participation, with the public having the opportunity to directly feed into and shape the update itself.

12.1.4.1 Informing the public

Public information, educational initiatives and outreach activities are therefore already being utilised to support public involvement, in addition to the more general use of social media as a communication tool. The ICPDR is engaged in the following public participation activities:

- public information dissemination. This includes social media posts, technical and public reports, brochures and general publications (e.g. Danube Watch);
- awareness-raising educational resources, including environmental education. This includes a variety of proposed new materials, awareness raising activities (e.g. the annual Danube Day festivities) and outreach;
- public consultation activities. These can be events such as Q&A sessions regarding the development of flood risk management plans, and the opening of subject-related communication channels or consultation workshops. The use of ICPDR.org for publishing information about these issues is essential.

Acting early is important. By ensuring buy-in and a sense of ownership in our target audience at an early stage of the process, any basin/sub-basin approach will stand a better chance of success. The benefits of early engagement in the development and design of our two plan updates and projects include:

- increasing stakeholder awareness of the various issues in the related river basin district and sub-basins before environmental problems become worse and thus harder to resolve;
- fewer misunderstandings, fewer delays and more effective implementation and monitoring;
- the resulting smoother implementation of the DRBMP leads to more cost-effective solutions;
- all later decisions are more likely to receive public acceptance, commitment and support. Attitudes to the decision-making process will also be generally improved;

12.1.4.2 Being informed by the public

Just as important as us communicating with the public is the public communicating with us. A key part of the ICPDR's communication strategies is direct consultation and enabling the public to send all of their comments and raise all of their concerns regarding Danube flood risk management issues. This could be suggestions for new wording in the draft plan, raising questions, providing fresh scientific or local/regional information - everything is of value.

Major activities happen at six-month intervals. For example, we collected comments on our draft timetable, work programme, and the statement of our consultation measures in the period from December 2018 to June 2019. We have done the same for the consultation phase on the SWMIs – finalized in June 2020.

All comments on the draft DRBMP & DFRMP are collected via a dedicated email address (**wfd-fd@icpdr.org**), a bespoke online questionnaire, an online public consultation workshop, as well as via information campaigns in Danube Watch.

12.1.4.3 Comments received in writing

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12.1.4.4 The Voice of Stakeholders: Public consultation workshop

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12.1.4.5 Alternative routes: Online questionnaire

To expand the potential target groups of public consultation beyond expert stakeholders, a simple and easily accessible online questionnaire was developed and published via the ICPDR website for stakeholders and the public in all basin languages. This questionnaire related to general aspects of the DFRMP Update 2021, seeking to discover knowledge gaps in the general public. As such, it also served as an information tool to draw attention to the plan and the other public consultation measures – in particular, the online stakeholder consultation workshop and the opportunity to comment on the plans in writing.

The online questionnaire surveyed opinions about the efficacy of the first DFRMP since 2015, general knowledge about the Danube River Basin and attitudes towards proposed measures from the DFRMP Update 2021… .

12.1.4.6 Alternative routes: Social media

Aiming to further expand the potential reach of this consultation (especially within the general public who would not feel attracted to the other consultation measures), a social media campaign was implemented in parallel to the preparation for the stakeholder consultation workshop. The campaign relied on small and interesting pieces of information ("factoids") aiming to attract attention to water management issues, and ultimately the draft management plans. These posts were distributed via the ICPDR's own social media channels, with additional support requested from all Observers. Priority for this was given to Facebook, backed up with Twitter (hashtag #DanubeVoice) during the stakeholder workshop. The social media campaign helped to cross-link the different consultation tools.

12.1.5 Ensuring transparency: Reporting on consultation activities

In line with the ICPDR's principles of transparency, all comments collected throughout the public consultation process requesting changes or additions in the draft DFRMP Update 2021 were collected and processed by the relevant ICPDR expert or task groups. A final report covering the public consultation outcomes was published alongside with the final Management Plan Update in December 2021, giving a detailed account of the measures pursued and the original sources for the comments received. Furthermore, an additional table recorded individual requests to the relevant DFRMP chapter to which they relate, along with the name of the party who raised it and how the comment was dealt with. Also recorded was whether or not such requests resulted in changes, (information is given on which); if it was rejected, a reason is given as to why. The report was sent to all organisations and individuals that participated in the public consultation activities and was published on ICPDR.org.

12.1.6 Connections with national level public consultation

The DFRMP is intended to provide a basis for basin-wide policy, augmented by national and sub-basin management plans. The basin-wide process of drafting of these management plans was thus also developed in conjunction with national-level endeavours in the field of public consultation, thus taking into account specific priorities throughout the region. This supports the plan's position between the responsible authorities and interlinks national-level public consultation activities with those at basin-wide level. All information related to the DFRMP consultation measures were thus collected and centrally published via ICPDR.org. Information on the ICPDR documents in question was in turn published on the respective national consultation websites. In addition to online resources and unified basin-wide planning documents, meetings of the ICPDR and its expert group for public participation further supported a basin-wide exchange on the national consultation work.

12.1.7 Connections with the Danube River Basin Management Plan Update 2021

All activities related to public consultation described in this chapter were sought to mirror to the greatest extent possible the steps towards the finalisation of the Danube River Basin Management Plan Update 2021 (DRBMP). This applies in particular to the publication of the timetable and work programme including public consultation measures in 2019; and the public consultation measures for the draft management plan, which were linked to the draft DRBMP Update 2021. In adherence to this approach, both Plan Updates were covered by one joint online questionnaire. Furthermore, the stakeholder consultation workshop was planned as a joint activity to highlight the interlinkages between both the DRBMP and the DFRMP. An additional benefit of addressing both draft plans within one questionnaire and one workshop maximized efficiency, synergies and attendance.

12.2 Public information and consultation at the national level

12.2.1 Germany

In Germany public information and consultation are stipulated in § 79 WHG. All results of the preliminary flood risk assessment, the flood hazard maps and flood risk maps are available for the public in "WasserBLIcK" www.wasserblick.net/servlet/is/136377/ .

The federal states provide more detailed information:

Baden-Württemberg: www.hochwasserbw.de

Bayern: www.lfu.bayern.de/hochwasserrisikomanagement

Public consultation attends the development of Flood Risk Management Plans and is running similar to the consultations for the WFD.

12.2.2 Austria

The public information and consultation process for the Flood Risk Management Plan in coordination with the river basin management plan had officially been started on 21 January 2015. The consultation process lasts for 6 months, until the 21 July. The plans will be published by 22 December 2015 according to the EU Floods Directive and EU Water Framework Directive.

This is work in progress and will be updated in autumn 2021.

Information referring to the three steps of FD implementation and a Web GIS application is publicly available under http://wisa.bmlrt.gv.at

PFRA/APSFR: https://maps.wisa.bmlrt.gv.at/vorlaeufige-risikobewertung-2018

FHRM: https://maps.wisa.bmlrt.gv.at/gefahren-und-risikokarten-zweiter-zyklus

FRMP:

https://www.bmlrt.gv.at/wasser/wisa/fachinformation/hochwasserrisiko/RMP2021.html

Information specially processed for the public is provided under: www.wasseraktiv.at

12.2.3 Czech Republic

Flood Directive (Art. 9, 10) as well as Water Framework Directive (art. 3, 14) require public to be informed and involved. The obligation to publish and make available for public comments of following documents is defined in Czech legislation, namely in the Water Act (Act no. 254/2001 Coll.):

- Preliminary flood risk assessment and identification of areas with significant flood risk (2011)
- Timetable and program of work on river basin management plans and flood risk management plans (2012)
- Flood hazard maps and flood risk maps (2013)
- Production of draft river basin management plans and draft flood risk management plans (2014)
- River basin management plans and flood risk management plans amended according to the evaluation of consultations with water users and the public (2015)

These documents must be available to the public for comments for a period of 6 months. They are published on the websites of relevant ministries, river boards and regional authorities. The announcement of publication is done via official boards of the relevant ministries and regional authorities. Draft flood risk management plans are submitted together with the draft national river basin management plans and draft river management plans for sub-basins.

The Flood information system (POVIS) at http://www.povis.cz is used to inform professionals and the general public about basic documents and news from the field of flood protection and implementation of the Flood Directive.

Results of mapping of flood hazard and flood risks have been made available for public on 22 December 2013 on the website of the central data warehouse http://cds.chmi.cz . During March and May 2014, the Ministry of the Environment organized 15 seminars in county seats on this subject.

In accordance with the terms of Flood Directive and Czech legislation the draft Flood Risk Management Plan in the Danube basin has been published for comments of public on the POVIS website since 22 December 2014 (http://www.povis.cz/pdf/PZPR_dunaj.pdf). At the same time river management plans for sub-basins have been published on the websites of the respective river boards together with their annexes containing documentations of areas with significant flood risk are. Comments to the published documents can be stated within 6 months, which mean until 22 June 2015.

In order to discuss the proposed draft flood risk management plans proposals and documentations of areas with significant flood risk Ministry of Environment in cooperation with respective regional authorities and river boards have been organizing seminars during February and March 2015.

Flood hazard maps of the 2nd cycle of implementation have been made available for public in December 2019 on the website https://cds.mzp.cz/

12.2.4 Slovakia

Ministry of the Environment of the Slovak Republic (MoE SR) is the competent authority for the implementation of the Directive 2007/60/EC (FD). Active involvement of all interested parties, coordination of the flood risk management plans with river basin management plans as well as public information and consultation are established in the Act No. 7/2010 Coll. on Flood Protection. Into this national law the Directive 2007/60/EC has been transposed.

The Ministry of the Environment of the Slovak Republic, as a gestor of flood risk management in the Slovak Republic, arranges consulting activities with all affected entities, the public and NGOs, about which it informs through its website.

12.2.5 Hungary

The FD stipulates that the Member States shall encourage active involvement of interested parties in the production, review and updating of the flood risk management plans. The Directive has been implemented to the national law through the 178/2010 (V.13.) governmental decree. In the 10§ (2) section, the involvement of the Regional and National Water Management Committees for the development process is legally obliged. The 13. § (2) section instructs the designer to organize information exchange platforms and discussion forums for the affected population.

The public consultation of the first flood hazard and risk maps were held July - August 2015 took place in 12 venues. On 22 June 2015, a briefing was held at the meeting of the National Water Management Council. In addition, as part of the project's PR program in 2 locations, additional mainly the civilian population an information event took place. Informing the public on the Internet on the vizugy.hu water management website in July 2015 started. They were published on this interface prior to the national information forums reconciliation versions of hazard and risk maps and risk management measures proposals, measures grouped by type. For a simple, illustrative presentation of the proposed flood risk management measures an educational short film was also made, which can also be viewed on the Internet.

Involving society is an integral part of river basin management and flood risk management planning. Its aim is for the knowledge, views and aspects of those involved to come to the surface in time, for decisions to be based on common knowledge and for realistically implemented, jointly agreed measures to form a plan. The flood risk reduction measures are intended to increase flood safety, but social expectations must be reconciled with nature and environmental interests. It is essential that stakeholders (conservationists, anglers, farmers, people living in tourism, forestry, etc.) organizations (eg. municipalities) should be involved in the planning process. The process of involving society will only achieve its goal if the time available is sufficient for meaningful consultation. Therefore, at least six months should be allowed in the planning process so that the completed documents can be read and commented on in writing.

During the first revision of FRMP Hungary will provide three to six months to express opinions three times during the three years of planning. The public consultation of the revised Flood Risk Management Plans and river basin management plans will be implemented at the same time. The whole public consultation will be finished by December 15, 2021.

The public consultation period takes the form of forums held in 12 different venues, typically in the 12 Water Directorates: four forums per month for the three months of the semester, at the end of which events, opinions received and suggestions are evaluated. Each WD forum will be organized in coordination with the forum convened for the social consultation of the Flood Risk Management (FD) project.

Planned invite participants:
- Rural development specialists, settlement planners
- Water planners and designers, authorities,
- Chambers of agriculture, hunting chambers, chambers of engineering, chambers of industry
- Water directorates and national parks
- Regional water management committees.

12.2.6 Slovenia

In Slovenia, the public participation process for the Flood Risk Management Plan is conducted in each of the three phases of the Floods Directive implementation even though it is not necessary.

Public participation process is already done in the phase of the preparation of the Preliminary Flood Risk Assessment. All the results and expert studies which were the basis for the preparation of the Preliminary Flood Risk Assessment were published and and public was allowed to participate already in this stage of the Floods Directive implementation. All the maps, data and expert studies were publicly published at:

https://www.gov.si/teme/nacrt-zmanjsevanja-poplavne-ogrozenosti/ .

All flood hazard and flood risk maps are also published and publicly shown as a part of the Slovenian Water Management Atlas, which is published at:

https://gisportal.gov.si/atlasvoda

When preparing the national Flood Risk Management Plan a long public participation and consultation process is envisaged. Draft of the Flood Risk Management Plan is made publicly available and is presented in detail in all of the 8 Slovenian water management areas/river basins.

All of the phases of the Floods Directive implementation in Slovenia (ie. the preparation of the Slovenian Flood Risk Management Plan) in the forms of maps and documents are also part of the Slovenian Water Management Cadastre and are available at:

http://www.evode.gov.si/index.php?id=86

http://www.statika.evode.gov.si/fileadmin/03_Nacrti_in_programi/NZPO%202017-2021.zip

All of the Slovenian flood risk management data, maps, studies and graphic viewers are published at the Slovenian eVode (eWater) portal which is available at:

http://www.evode.gov.si/

12.2.7 Croatia

The public consultation procedure is carried out based on the applicable laws and regulations, i.e. Art. 45 of the Water Act (Official Gazette 66/19) and the associated bylaws.

First Flood Risk Management Plan has passed public participation procedure in line with WFD requirements as well as public participation in the frame of Strategic Environmental Impact Assessment. In addition, the neighbouring countries were consulted as required by EESPO Convention.

Same activities are forseen in the second planning cycle. Timetable is available at: https://www.voda.hr/sites/default/files/dokumenti/program_rada_plana_2022.-2027.pdf

For the public information and consultation, unique WEB page regarding all WFD and FD activities has been designed at https://www.voda.hr/hr/upravljanje-vodnim-podrucjima-upravljanje-rizicima-od-poplave

In particular, all documents produced for planning cycle 2022 - 2027 are available at:
https://www.voda.hr/hr/planska-razdoblja/plansko-razdoblje-2022-2027

Preliminary flood risk assessment 2018 is available at https://www.voda.hr/hr/prethodna-procjena-rizika-od-poplava-2018, and current flood hazard maps and flood risk maps are available at https://www.voda.hr/hr/karte-opasnosti-od-poplava-karte-rizika-od-poplava-2014

On the same web page, draft Plan and other relevant documents will be available.

12.2.8 Serbia

Obligations related to public information and consultations in the process of RBMPs development are regulated in the Law on Water, articles 38 and 39. Article 50 of the same Law states that the procedure for FRMP is the same as for RBMP, and thus will include active public participation in the plan preparation and delivery process. According to Art. 38 the Ministry is obliged to provide written notification to the National Water Conference, and to notify the wider public via public media of the commencement of the preparation/updating of the FRMPs, and the progress of its preparation and any significant issue in the respective water district.

The notice about the commencement of preparation or updating of the plan shall include an outline of the contents of the plan and identify the required consultations, the dates for the preparation and adoption of the plan, and the address of the competent authority from which additional information may be obtained.

The preparation of the Flood Risk Management Plan for the territory of the Republic of Serbia is at the beginning. For the moment, only a table and a map presenting all APSFRs is available at:
http://www.rdvode.gov.rs/lat/uredjenje-vodotoka.php

12.2.9 Bosnia and Herzegovina

Since Bosnia and Herzegovina is not an EU Member State, the beginning of the preparation of the First Flood Risk Management Plan is scheduled for mid-2020, with the financial support of the EU Delegation to Bosnia and Herzegovina from IPA 2016 funding instrument. It is planned to develop 6 Flood Risk Management Plans: 2 for the Federation of Bosnia and Herzegovina, 2 for the Republic Srpska, 1 for Brcko District and 1 plan covering the whole Bosnia and Herzegovina.

In design of these plans, the procedures of public participation in the preparation and adoption of the water management plan will be used (these procedures are prescribed by the Water Law). This implies the active participation of all interested parties, professional and general public in the process of drafting the plans in question.

The Contractor shall support beneficiaries in conducting public consultation process during a six months period. Public consultations will be done for five Draft Flood Risk Management Plans and their respective Strategic Environmental Assessments. Public consultation process will be led by the beneficiaries, however the Contractor will be responsible to develop plan for public consultation, provide logistical support, actively participate in the process, develop tools for collection of comments, gather all comments and keep track of them and finally prepare Report on Public consultation.

12.2.10 Bulgaria

The public information and consultations in the process of development of FRMP are regulated by the Bulgarian Water act. The draft documents elaborated at each stage of the FRMP-development are being published and made available to the public for consultation and written comments. The legislation requires publishing of the documents and the start of public consultation to be announced via a special announcement in the national media. In order to ensure an active involvement of the public in the process of flood risk management, a cycle of stakeholders-meetings is organized during the process of consultation. Representatives of various types of stakeholders are invited to participate in the meetings: local authorities - municipalities and regions; civil protection units, water users; scientific organizations, NGO's etc. Additionally, the documents published for consultations are being presented on the Basin Council – a state-public advisory commission which assists the operation of the Basin Directorate. All comments and recommendations received in the process of public consultation are being considered in the final version of the document. The published documents, including information about the public consultations are available on following links:

PFRA:

The report - http://www.bd-dunav.org/content/upravlenie-na-vodite/plan-za-upravlenie-na-riska-ot-navodneniia-2022-2027/

Information about the stakeholder's meetings: http://www.bd-dunav.org/content/konsultacii-s-obshtestvenostta/konsultacii-pri-aktualizaciia-na-purn-2022-2027/

APSFR:

http://www.bd-dunav.org/content/upravlenie-na-vodite/plan-za-upravlenie-na-riska-ot-navodneniia-2022-2027/

FRMP:

will be published on the web-address:

https://www.moew.government.bg/bg/vodi/planove-za-upravlenie/planove-za-upravlenie-na-riska-ot-navodneniya-purn/planove-za-upravlenie-na-riska-ot-navodneniya-2022-2027/

http://www.bd-dunav.org/content/upravlenie-na-vodite/plan-za-upravlenie-na-riska-ot-navodneniia-2022-2027/

12.2.11 Romania

The results and reports of the EU 2007/60 Directive on the Assessment and Management of Flood Risks implementation are available for public information and consultation on National Administration „Romanian Waters" and National Institute of Hydrology and Water Management web-portals www.rowater.ro and www.hidro.ro .

The links for specific steps of implementation are:

Preliminary flood risk assessment - https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/epri/

Flood hazard and risk maps - https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/harti-de-hazard-si-risc-la-inundatii/

Flood risk management plans - https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/planul-de-management-al-riscului-la-inundatii/

Other statistics resulting from the EU Flood Directive –

https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/directiva-analizata-statistic/

In the 1st cycle of reporting, a communication plan has been created related to the development of the Flood Risk Management Plan which refers on two aspects:

a) Making available to the public, in chronological order, the results of the preliminary flood risk assessment (PFRA), hazard and flood risk maps;

b) Active involvement of stakeholders in the development of the FRMPs.

In accordance with the FD, the Communication Plan on the FRMP included information and consultation actions, addressing the formal, legislative aspects of communication, as well as the public participation activities which are not regulated, but which should be encouraged by the authorities implementing the FRMPs through the involvement of stakeholders.

The general objective of this plan was on the one hand to organize all information, consultation and public participation activities, but also to implement these types of communication activities among the population exposed to the negative effects of floods. These objectives have been integrated at three levels: national (national coverage at central level), basin-wide (at the level of river basins and Basin Committees) and local and county (at the level of counties, communes, localities that may be at risk and that may be affected by the negative effects of floods).

At the level of the general public and stakeholders, communication was done by organizing (i) public information and consultation activities following which the public reaction can be assessed; and (ii) organizing public participation activities, following which the public's contribution to decision-making can be assessed.

At the level of actors involved in flood risk management, the communication was carried out by involving the responsible authorities in the process of planning and organizing communication activities on FRMPs. This also included strengthening the role of Basin Committees and training responsible staff in flood risk management.

The public consultation was done through the information points, scientific presentations, media, online communication (newsletter, questionnaires), workshops/round tables and public debates.

In the second cycle of reporting for FRMPs it is intended to:

- Improve communication about flood risk management to create awareness and facilitate continuous engagement developing a communication platform and appropriate tools, including social media;
- Improve stakeholder engagement and pubic consultation within the existing framework and available capacities and financial resources now with more stakeholders;
- Improve monitoring and reporting of public consultations and stakeholder engagement.

A stakeholder engagement & public consultations strategy for the second cycle will be developed to:

- Formalize the consultation process: Give clear directions for compliance with the existing administrative framework and all the legal requirements;
- Adaptive process management: provide flexible tools and instruments adapted to local conditions for NARW, RBA and consultants developing FHM, FRM and FRMPs with their PoM;
- Set specific and measurable objectives for communication and stakeholder engagement with clear links to all stages of the FD implementation

12.2.12 Ukraine

Public information concerning flood risks for Tisza river basin in Ukraine is provided via web-site (www.buvrtysa.gov.ua):

- weekly information about water management situation
- warning in a case of possible flood event
- executed flood protection and flood risk reducing measures.

Interactive on-line map of hydrological situation is functioning on the web-site, which allows revising information from 50 automated measuring stations of the system AIMS Tysa (precipitation, water level, air temperature). The informative activity includes also workshops, ecologically oriented actions and other events for public, especially for youth.

12.2.13 Moldova

Public consultations of the draft Flood Risk Management Plan for the Danube-Prut and Black Sea River basin district were conducted at both local and national levels in 2019-2020. In addition, draft Plan was presented at the meeting of the Danube-Prut and Black Sea River basin district Commission which includes representatives of state institutions involved in water management, local public authorities and environmental NGOs. The content of the Plan has been communicated to the public as well as the benefits and opportunities to be brought by Plan for public authorities, NGOs, water users and general public. Minutes of the public consultations are available at the website of the Agency Apele Moldovei (www.apelemoldovei.gov.md).

In addition, Flood Risk Management Plan was posted on the Governmental portal www.particip.gov.md representing the platform for informing broad public about developed draft policies, strategies, governmental decisions, laws, regulations, etc. to ensure public feedback on above documents followed by their improvement.

Currently, Flood Risk Management Plan including flood hazard and risk maps are available at the website of the Ministry of Agriculture, Regional Development and Environment (www.madrm.gov.md), Agency Apele Moldovei (www.apelemoldovei.gov.md), and the Plan itself - on portal www.legis.md, representing state register of legal acts ensuring free public access to all legislative and regulatory acts published after June 23, 1990, including updated information on their amendments and additions.

13 Conclusions and next steps

The 1st Danube Flood Risk Management Plan adopted in 2015 set the flood risk management priorities for the Danube River Basin until 2021. It represented a milestone in the ICPDR's work towards sustainable flood risk management addressing all aspects of flood risk management focusing on prevention, protection and preparedness, including measures for achieving the established objectives and calls for solidarity among all ICPDR Contracting Parties.

The Danube Flood Risk Management Plan Update 2021 outlines the key flood risk management priorities for the Danube Basin until 2027 and is a principal instrument for coordination of the implementation of the EU Floods Directive in the Danube River Basin. At the same time, in line with Article 9 of the FD, this plan demonstrates the efforts made by the ICPDR in coordinating the application of the FD and of the WFD, focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of the WFD. Development of Danube River Basin Management Plan under EU Water Framework Directive and of the Danube Flood Risk Management Plan under the EU Floods Directive are elements of integrated river basin management in DRB.

Danube Flood Risk Management Plan Update 2021 summarizes the results of the updated preliminary flood risk assessment (PFRA) which was undertaken to provide an assessment of potential risks stemming from floods and presents the areas of potential significant flood risk (APSFR). The results of the updated PFRA also provided the public and stakeholders with an important evidence that the areas with potential flood risk in the Danube River Basin are being taken care of for the benefit of all inhabitants and countries of the Danube River Basin. For the APSFR in catchments >4000km^2 the flood hazard maps and flood risk maps (FHRMs) have been produced and are presented in this Plan. This set of maps includes the updated FHRMs from the 1st cycle and the new flood risk map of potentially affected cultural heritage sites.

During the first flood risk management period the ICPDR flood experts were carefully considering if the objectives of the first DFRMP are able to sufficiently cover at the basin-wide level all needs for the management of flood risks in the DRBD and they came to the conclusion that these objectives are broad and robust enough to accommodate all relevant topics including the impacts of the climate change. The progress in achieving of its objectives is addressed in this plan primarily through the implementation of the best practices projects which are presented in the textboxes throughout the whole document.

The updated Plan presents the strategic basin-wide level measures to prevent and reduce damage to human health, the environment, cultural heritage and economic activity. Special attention in the DFRMP Update 2021 is given to measures employing areas which have the potential to retain flood water, such as natural floodplains as well as the other areas enabling controlled flooding. In the frame of their prioritization those measures were favored which are sufficiently robust to the uncertainty in forecasting of climate change impacts. This robustness has been achieved through focusing on pollution risk in flood prone zones; on the application of non-structural measures when possible; and on "no-regret" and "win-win" measures. The major ICPDR platform for a joint implementation of the strategic level measures are the transboundary projects supporting DFRMP. The progress in implementing DFRMP measures was assessed through evaluation of the achievements of international projects.

The ICPDR is fully aware of importance of application of the solidarity principle in the flood risk management stipulating that one should not pass on water management problems in one region to another. That is why the ICPDR agreed that the measures with downstream effects shall have the key priority at the basin-wide level (i.e., measures like natural water retention, warning systems, reduction of risk from contaminated sites in floodplain areas, exchange of information). An overview of the public information and consultation both on the national level and on the basin-wide level is also provided in the Plan.

The elements of the Danube Flood Risk Management Plan will be periodically reviewed in future on a regular basis respecting the flood risk management planning periods, and after each review they will be updated to reflect the latest level of knowledge. Reporting on the Danube Flood Risk Management Plan implementation progress will be done via national representatives in the ICPDR FP EG.