Preliminary Flood Risk Assessment in the Danube River Basin

ICPDR IKSD

International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

Summary Report on implementation of the EU Floods Directive in the Danube River Basin District

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Table of content

1 Introduction

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

Member States shall coordinate their flood risk management practices with all countries sharing an international river basin, including non-Member States, and shall in solidarity not undertake measures that would increase the flood risk in neighboring countries. In addressing the Directive 2007/60/EC the Member States shall take into consideration long term developments, including climate change and sustainable land use practices.

According to FD the Member States shall, for each river basin district, or unit of management referred to in FD Article 3(2)(b), or the portion of an international river basin district lying within their territory, undertake a preliminary flood risk assessment (PFRA) in accordance with paragraph 2 of 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 preliminary flood risk assessment, shall be reviewed, and if necessary updated, by 22 December 2018 and every six years thereafter. The PFRA will be used by Member States as the basis for identifying areas where potential significant flood risks might exist, or might be considered likely to occur.

Prior to the adoption and implementation of the FD the International Commission for the Protection of the Danube River (ICPDR) already addressed the issue of flood risk management on a basin-wide level by adopting the Action Programme for Sustainable Flood Prevention in the Danube River Basin at the ICPDR Ministerial Meeting on 13 December 2004.

The key milestone in the implementation of the ICPDR Action Programme was the publication of 17 sub-basin flood action plans in 2009. These plans are based on 45 national planning documents and provide the first ever comprehensive overview of actions to reduce flood risk in the Danube Basin. They 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 are 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.

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 - 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 apply 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.

This report informs the European Commission, the stakeholders and public on the achievements made in the international Danube River Basin District in response to the provisions of the Article 14 of FD. It is an update of the first report on Preliminary Flood Risk Assessment in the Danube River Basin published by the ICPDR in 2012.

2 Overall approach and methodology of PFRA

This chapter summarizes the methodologies and criteria used 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.

2.1 Germany

The standard basis for conducting the preliminary assessment in Germany is the recommendation for the “Approach to be used in the preliminary assessment of flood risk under the European Floods Directive” [Empfehlungen für die Überprüfung der vorläufigen Bewertung des Hochwasserrisikos und der Hochwassergebiete nach EU-HWRM RL] developed by LAWA (German Working Group of the Federal States on Water Issues – Bund/Länder Arbeitsgemeinschaft Wasser). Following these recommendations, all available information, or relevant information that was easy to obtain, was used to formulate conclusions about potential significant flood risks.

The basis for this consideration was the water body network, which also forms the basis of Directive 2006/60/EC (water bodies with a catchment larger than 10 km²) and waters, which are known to have flooded in the past, and which experts consider may also be the source of flood events with significant adverse consequences in future.

To harmonize the preliminary assessment of flood risk in Germany an overall approach has been agreed with the German Federal States in 2017. It was applied for the Danube and all important tributaries, based on the results of the PFRA in 2011.

The preliminary risk assessment based on Art. 2 (2) of the Floods Directive covers the following different types of floods: fluvial floods, pluvial floods, groundwater; artificial infrastructure failure of impoundments and excessive demands imposed on artificial infrastructure sewerage systems.

The existing analyses of the adverse consequences of floods that have occurred in the past show clearly that significant flood risks arise only from regional or supraregional floods with probability of occurrence higher than average (HQ100) in average-to-densely populated areas. These fluvial floods are caused by surface waters. Pluvial floods do not show a significant but a general risk as they can occur everywhere.

To assess the adverse consequences of future potentially significant floods, an analysis was made of the danger of flooding and the possible adverse impacts in the river basins, and the risk was then deduced by means of GIS methods.

The entire process was managed by water management experts and the results subsequently checked for plausibility. More information is available at:

http://www.lawa.de/documents/00_LAWA_Empfehlungen_vorl_Bewertung_HW_Risiko_a30.pdf

2.2 Austria

1st cycle of implementation:

In Austria the preliminary assessment of flood risk was conducted on the basis of an expanded nationwide river network (catchments larger than 10 km^2 plus selected torrent catchments smaller than 10 km^2). All available geo-data on flood hazards and risk receptors (population, infrastructure, potential pollutants, WFD protected areas, cultural heritage) were put together in a geo-database. In this geo-database flood risk data from various sources was integrated and attributed to river-stretches of 500 m. The results were classified into five flood risk classes (very high, high, moderate, low or no risk) separately for each risk receptor.

The most important thresholds for “high flood risk” were:

- 100 persons (inhabitants + employees) in flooded areas per 500 m river stretch
- destruction or blockage of important infrastructure facilities for several days
- destruction of cultural assets of national importance and
- heavy pollution of protected areas.

In a first step, data on the adverse consequences of past floods were collected, assigned to the river stretches in the geo-database and classified according to the five risk classes. Flood zones (data sources: HORA and more detailed hazard studies) provided the basis to assess the adverse consequences of potential future floods in the geo-database. They were overlaid with data of the risk receptors.

All risk assessments for past and future floods were finally combined to assess the “total risk per river stretch” considering only the highest risk class for each river stretch. Future development of land use was taken into account, in case that reliable data was available.

As a result a total of about 1,840 km - relating to 5.2 % of the total river length that has been assessed - are classified as having high or very high flood risk in the Austrian part of the Danube River Basin. The predominant causes for the assessment of high and very high risks are the residential population and economic activities (employees) in flood prone areas, followed by traffic infrastructure. Due to Austria's alpine topography, land use is particularly located in lowlands and valleys including flood prone areas.

2nd cycle of implementation:

Due to a significant increase in data availability and data accuracy, the method of the preliminary flood risk assessment for the 2nd cycle has been adapted in Austria. In contrast to the 1st cycle information on inhabitants is now available in real time (daily update) on building level. The PFRA is based on point information on inhabitants, distinguishing between permanent and non-permanent residents, raster information on people at work and inundation area information based on hydrodynamic modelling. The PFRA aggregates potentially affected people on municipal level. As a first indicator risk is assigned to all municipalities (2098) in Austria based on the categorization:

No risk	0 calculated people potentially affected
Low risk	1-50
Medium risk	50-500
High risk	500-5000
Very high risk	>5000

Based on this prioritisation and numerous additional information such as:

- probability of presence (permanent and non-permanent residence)
- dedicated (zoned) undeveloped building land
- predicted population development 2030
- past significant floods
- overnight stay due to tourism
- pluvial flood risk indication
- flood characteristics (torrents, mud flows)
- hot spots
- critical infrastructure
- risk trend (potentially affected people calculated in the 1st cycle PFRA compared to the numbers of the 2nd cycle PFRA)
- other (expert judgement)

the APSFR are delineated along the river stem. The delineation of APSFR are based on the 1st cycle information and are changed, deleted, created or adapted where needed. The documentation of changes and the associated reasons for change are of high priority to assure an accurate evaluation of goal achievement in the frame of the elaboration of the 2nd flood risk management plan.

2.3 Czech Republic

In the Czech Republic the FD was fully transposed in February 2011 by the Act No 150/2010 Coll., the amendment of the Act No. 254/2001 Coll. on Waters and by the Public Notice on RBMPs and FRMPs. Article 13 of the FD was not applied. The three units of management (the national parts of the Danube, Elbe and Oder River basins) are the same as used for the Water Framework Directive. The competent implementation authorities are the Ministry of Environment and the Ministry of Agriculture. Public communication and information is partly provided by Flood Information System POVIS, www.povis.cz, where public can find all relevant information and documents about implementation of the directive.

The preliminary flood risk assessment has been prepared since 2008 for the whole country area using the same methods based on spatial analyses and available information:

- Reports on the assessments of significant floods;
- Designed floods (5, 20, 100 year return period and 10 000 years for dams);
- Fundamental Base of Geographic Data (map scale 1:10 000);
- Data of the Czech Statistical Institute;
- National Culture Heritage Database;
- IRZ Integrated Register of Pollution, SEVESO (both under IPPC);
- Extent of past floods in 1997, 2002, 2006, 2009, 2013.

The method of the preliminary flood risk assessment has not changed for the 2nd cycle.

Due to country location in the upper parts of the international river basins, as well as due to hydrological and geomorphological characteristics, people suffered in the past mainly from fluvial and flash floods caused by long and/or intense precipitation. Other type and sources of floods such as debris flows, snowmelt, and landslips were very rare, mostly of a local importance or accompanying fluvial floods.

National criteria for the significant past flood used in the database developed for the purpose of the preliminary flood risk assessment are as follows:

Flood Type	Criteria
Fluvial flood	• flood with a medium probability (Q_{100}) at least; • observed at more than three gauge station profiles; • affected an area of river basin larger than 2,000 km^2 .
Flash flood	• caused three and more casualties or economic loss higher than 250 million CZK.
Dam brake or failure of hydraulic structure	• if primary cause/source is independent of natural flood, the criteria is: three and more casualties; • if occurring due to natural flood, the criteria are: flood with a low probability (Q_{500}) downstream a construction site or failure which caused three or more casualties.
Other type of flooding	• caused economic loss higher than 250 million CZK

It was assessed that potential adverse consequences of future floods will not differ from past experiences. Important developments affecting future floods are not expected in the Morava river basin.

2.4 Slovakia

Act No 7/2010 on flood protection is the basic legislative document transposing the Directive 2007/60/ES into the Slovak legislation. The preliminary flood risk assessment, its reassessment and updating is based on this Act. PFRA is performed in the whole territory of Slovakia in the respective river basins.

Ministry of Environment of the Slovak Republic (MoE SR) is in charge of PFRA preparation, reassessment and updating via river basin authorities. The task group „Floods“ was formed in order to support implementation of the Directive 2007/60/ES. This task group led by the MoE SR consists of the representatives of river basin authorities, other relevant organizations in the frame of the MoE SR, Slovak Academy of Science and selected universities, self-governing regions, municipalities, other administrators of watercourses and the representatives of private sector.

Determination of the geographic areas with an existing significant flood risk was based on the analysis of the occurrence of floods and their consequences in the Slovak territory in the period 1997-2017. Finally, only fluvial floods were assessed as having potential significant adverse consequences. The following criteria were taken into account in the selection of areas and their ranking:

- repeated occurrence of floods in the period 1997-2017 or/and flood potential;
- final “flood index” was calculated coming out from flood consequences where the number of affected inhabitants was the most important factor and based on GIS analysis, weights to all of the factors were determined.

In the “flood index” and ranking of areas with an existing significant flood risk a number of factors within the groups of adverse consequences on human heath, environment, cultural heritage, and economic activities were taken into account.

2.5 Hungary

The national implementing regulation of the EU level Flood Directive was introduced in 2010 and it has not changed remarkably since then (178/2010. (V. 13.) Korm. rendelet). The responsible governmental entity is the Ministry of Interior (BM). The executive management body is the General Directorate of Water Management (OVF) which has the 12 regional Water Directorates (VIZIG) assigned.

Hungary formed and executed a national project called “ÁKK” to deliver the necessary analyses and national reports. It delivered the methodology, maps and plans; even implemented some of the risk management measures. In the second cycle, the “ÁKK-2” project has started and it updates all the former parts with the degree of necessity. The review of the methodology is already done and consequently it affected the PFRA/APSFR part. However, the Hungarian party considers the conclusions of the first PFRA/APSFR as still valid information but the database of remarkable floods was extended with the 2013 Danube event that reset the highest ever recorded water levels. The experts took in account the conclusions of the Second National Climate Change Strategy 2017-2030/2050 (NÉS-2) that draws attention to increased risk of local flash floods in certain regions.

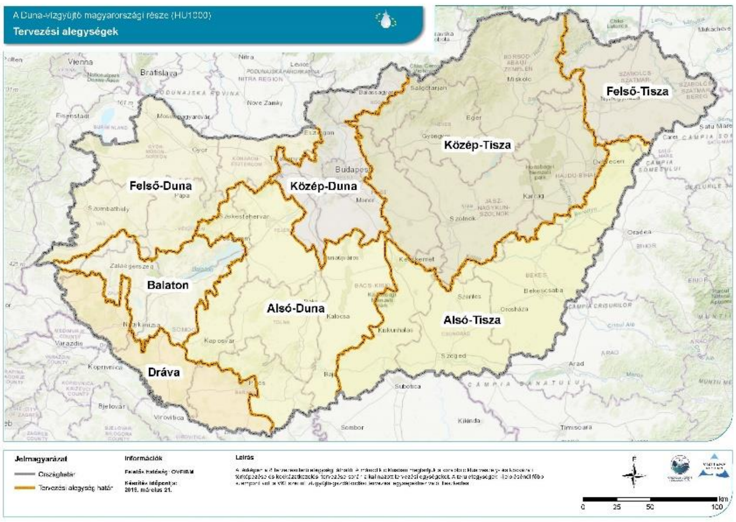
The domestic status quo did not change. The overall national aim is to provide protection against 100-year events’ potential inundation all over the country. As it was stated in the 2011/2012 first report, three flood types are considered to designate the hazards:

- Floods of river sections protected by dykes (FLUVIAL, riverine floods);

- Inland inundations (EXCESS water).
- Floods of river and stream sections not protected by dykes (PLUVIAL, flash floods);

The level of implementation is the Danube Basin "HU1000" for the whole country. It is divided internally to four sub-basins and eight units are created under that level to provide harmonization with the river basin management. The number of the APSFR areas changed slightly comparing to the former values. The following table and picture show the details.

EU FD [UoM, basin]	WFD [sub-basin]	EU FD [Sub-Unit]	APSFR FLUVIAL	APSFR EXCESS	APSFR PLUVIAL
Danube basin	Danube	Felső-Duna	30 db	11 db	25 db
		Közép-Duna	17 db	5 db	16 db
		Alsó-Duna	20 db	10 db	15 db
	Balaton	Balaton	1 db	5 db	7 db
	Dráva	Dráva	11 db	1 db	22 db
	Tisza	Felső-Tisza	28 db	14 db	3 db
		Közép-Tisza	60 db	23 db	30 db
		Alsó-Tisza	20 db	22 db	0 db
Total			187 db	91 db	118 db



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2.6 Slovenia

The aim of PFRA in Slovenia was determination of APSFR. The work was done for whole territory of the country. All available / relevant information that was easy to obtain, was used to enable conclusions to be drawn about potential significant flood risks.

The basis for definition of hazard potential was hazard indication map containing data from flood events and flood models:
(http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso), upgraded with attributes such as maximum water levels, return period of flood, type of flood, date of commencement and duration (days) of flood, type/degree of adverse consequences, etc.

Identifying the highest registered elevations/discharges from the national database and using an information on morphology of the river network (based on 1:25,000 scale) and the expert judgment, the additional area of flood hazard was defined. The data were available for fluvial and seawater floods. There were no data with indication of possible significant pluvial and groundwater floods as well as floods from artificial infrastructure sewerage systems. In the assessments, the flood defense infrastructure was not considered.

The existing analyses of the adverse consequences of floods that have occurred in the past show, that the sources of adverse consequences are not only the areas near larger rivers.

The future development is not considered as relevant in PFRA, because of the applied prevention measure in "Governmental decree on conditions and limitations for constructions and activities on flood hazard areas"(http://www.uradni-list.si/1/content?id=88381). This decree requires that the future development should take place outside the flood hazard areas. In case of an extension of an existing infrastructure, the measure for reducing the existing flood risk should be applied before the extension works should start.

There is no evidence of an influence of the climate change on the frequency of fluvial floods and the trends of discharge peaks are slightly declining. The trends of average sea level and the frequency of floods increase.
(http://www.arso.gov.si/o%20agenciji/knji%c5%benica/publikacije/Okolje_se%20spreminja.pdf , Okolje se spreminja. Podnebna spremenljivost Slovenije in njen vpliv na vodno okolje, MOP ARSO, 2010).

An analysis of damage potential (human health, environment, cultural heritage, economic activities) was made, and the potential flood risk index was then deduced by means of GIS methods. This resulted in potential flood risk areas classified by the damage risk index. In the 2nd cycle, the APSFRs were classified by using 6 classes of loss potential, namely human health, environment, cultural heritage, economic activity, social infrastructure and infrastructure.

2.7 Croatia

The obligation of undertaking PFRA in accordance with the FD is regulated under Article 110 of the Water Act, which includes the following: maps of the river basin districts including the borders of sub-basins and, if needed, coastal areas, showing topography and land use; a description of floods which have occurred in the past; and an assessment of the potential adverse consequences of future floods. When undertaking the PFRA, the methodological approach is adjusted to the available stock of data, and the basis for the assessment of recipient, i.e. assessment of damage, was (i) the data from the CORINE Land Cover of 2006, (ii) the statistics about the population and settlements from the 2001 Census (the data from the 2011 Census still hasn't been processed; upon its publication, the revision of PFRA can be expected), (iii) the sites of major industrial plants and smaller settlements not visible on the Corine Land Cover, (iv) the data base managed by Hrvatske vode, and (v) the available data on the locations of waste disposal sites.

According to FD Article 2(2), the PFRA in the Danube River Basin District includes four different types of floods: fluvial floods, pluvial floods - erosion and flash floods-torrents and artificial infrastructure failure. Account was also taken of the data on the floods recorded in the past. Data on groundwater floods was not available at the time. The assessment analyzed all the watercourses within the national network of watercourses with a catchment area larger than 10 km^2, and, exceptionally, the watercourses with smaller catchment area, particularly in the part concerning torrents.

For an administrative scope of each individual settlement, preliminary assessment of flood risks was undertaken and they were classified into four main categories of risk:

- High flood risk, for which detailed flood risk maps and flood hazard maps will be prepared, as well as a special system of emergency measures in case of a flood event under the Operative Flood Defence Plan;
- Moderate flood risk, for which detailed flood risk maps and flood hazard maps will be prepared;
- Low risk, for which additional analyses will be made, if needed;
- Insignificant flood risk, for which additional analyses will be made, if needed.

The basic criterion for the classification into the above-mentioned categories was adjusted to the need for the preparation of flood risk management plans under the European Floods Directive, operative flood defence, and different approaches to efficient, environmentally sensitive and financially affordable flood protection.

2.8 Serbia

The provisions of FD were included in Law on Water enacted in 2010. Art. 47 of the Law on Water set the obligation for preparation of PFRA for Serbian territory. PFRA in Serbia was conducted based on a methodology published in 2012.

PFRA was prepared for the whole territory of Serbia by the responsible Ministry, but with an active participation of all responsible institutions such as public water management companies, hydro-meteorological service and scientific institutes.

PFRA concluded that significant damages were caused by fluvial floods.

The PFRA process started in 2009 with the preparation of a questionnaire on floods that occurred between 1965 and 2011. Data on past floods were collected from Civil Protection units at the level of municipalities and from water management companies and institutes. Only those floods, which caused large-scale damage, or floods that endangered more than 100 households or 300 inhabitants and/or covered 50 km^2 and/or had important social consequences were identified as being significant. It was assumed that all significant past floods could occur again.

Potentially flooded areas are unprotected areas and areas that may be flooded in case of failure of the existing flood protection structures, with adverse consequences on human health, environment, cultural heritage and economic activity. They were assessed by taking into account the topography of the terrain, hydrology, the effectiveness of flood protection system, the position of populated areas and areas of economic activity.

For the PFRA the following digital data was used:

- GIS map 1:300,000 containing: administrative borders, relief, hydrography, cultural heritage, communications, settlements, hydropower plants, industrial facilities, digital terrain model;
- Corine Land Cover 2000 (EEA);
- GIS map of indicative flood areas prepared in 2006, containing the potential flood areas, which are the result of different hydraulic studies or show the extent of past floods from post-flood analyses;
- Map of levees and dams;
- Data on the population.

The main problem in PFRA was the lack of digital data on economic activities, potential sources of pollution, and protected areas.

2.9 Bosnia and Herzegovina

The Floods Directive [Article 4 (2) (b) and (c) requires an assessment of the floods that occurred in the past and which form part of the PFRA. Areas that have been flooded and suffered significant negative consequences from floods in the past can still be at significant risk. Therefore, these areas are analyzed to assess whether they are part of the APSFR.

Most of these flood data do not exist. This also confirms the volume of data collected during the development of the PFRA. Therefore, some areas were used to describe locations and photographs based on which the reconstruction of certain flood events was carried out, in order to define flood polygons. The assessment of the damage caused by these floods is based mainly on estimates made by civil protection units.

During the preparation of the PFRA, questionnaires (Word, Excel format and hard copy) were sent to local communities, maps and brochures in which the project was briefly presented, and the scope and types of data collected. The completed questionnaires were delivered by the largest number of municipalities.

All data has been processed so that a unique table is created in Excel format, and identified flood areas are drawing in CAD, based on descriptions, pictures, maps and other data received from municipalities. Mostly we use maps with scale 1: 25,000, orthophotos, and the flooded areas were drawn. After that, the integration into the GIS database was performed and the flood risk indexes were calculated.

Values of flood risk index (I) for polygons of historical floods were defined in such a way that smaller polygons were defined within each flood polygon using Corina Land Use. Within each smaller floodplain, all impacts that contribute to the value of the flood index are added. Finally, the overall index for each flood polygon is obtained by adding individual indices for smaller polygons within the same flood polygon.

For each flood polygon of historical floods (from categories of very significant and significant), a "segment" is defined which mostly contributes to the values of the total index (eg flooded arable land, endangered objects, flooded roads, endangered factories, monuments, etc.).

A historical flood event is information that is limited only to the areas and places where the flood occurred and where flood information is collected. In addition, flood risk assessment can be carried out by analysis floods that can happen in the future.

In order to be able to analyze these areas, the only way is modeling. So far, practice in Bosnia and Herzegovina has been the modeling of flood lines using the data "read out" from topographic maps of different scales. Thus, for large watercourses, the most common maps were 1: 25.000, while more detailed maps were used for smaller watercourses. Hydrological processing of cells was used as input data (flows and water levels). Characteristic flows are defined according to the following principle:
• flows 1/20, relevant for the protection of agricultural land,
• flows 1/100 relevant to the protection of urban areas and
• flows 1/500, as flows that may have "catastrophic" consequences.
Hydraulic analysis based on these data resulted in areas (polygons) that could be affected by floods (hazard maps in accordance with the definitions of the Floods Directive).
Flooding polygons that may occur in the future are taken from the existing strategic documents. The possible consequences for human health, the environment, cultural heritage and economic activity for the floods that could happen in the future are estimated in the following way. Corine 2000 was used as the basis for information on how to use the land. Given the scale of 1: 100,000, Corine angry flood areas have been corrected using orthophoto images. After that, the objects within the flood polygons are drawing as input for the flood risk assessment model.
An analysis for the scenario has also been carried out when there are no data on the number and type of facilities and activities within floodplains. Only information that can be obtained from the Corine layers is used. In this way, we wanted to check the possibility of using Corine for the needs of quick and rough estimates of possible consequences. Comparison of data obtained only on the basis of Corine and data on objects within the floodplains was performed. The values of the flood risk index (I) as well as the "segment" that most contribute to the values of the total index are defined in the same way as for historical floods.

2.10 Romania

In Romania, the Floods Directive (FD) has been transposed into national legislation in February 2010 by a new Water Law, in its 5th section (Management of flood risk). The authorities responsible for the implementation of the FD are the Ministry of Waters and Forests (MWF), the National Administration "Romanian Waters" (NARW) and the National Institute of Hydrology and Water Management (NIHWM). There is a management unit responsible for the FD implementation in each Water Basin Administration of NARW corresponding to the national river basin.

The Methodology for fulfilment the reporting requirements of the Floods Directive (Cycle 2, 2016-2022) - the preliminary flood risk assessment stage was carried out by the National Institute of Hydrology and Water Management together with National Administration "Romanian Waters".

The PFRA methodology follows the main steps performed in the 1st cycle of FD implementation:

1. In the first phase, an inventory was made of major floods that occurred in the past, based on information gathered from documentary sources (2010-2016). This inventory identifies significant floods, either in terms of hazard probability of occurrence or based on impacts (recorded damages). In general, floods for which the probability of occurrence is greater than 10 % are not taken into account, although the ones that had maximum flows greater than the flow corresponding to warning level of defense were taken into consideration. For hydrologically poorly monitored river sectors, the probability of overflows was estimated based on an "expert judgment";
2. In the second phase: the preliminary list of flood sectors was supplemented with other floods, possibly located on smaller watercourses, which are known to have caused

particular damages (especially if there were victims). The description of the significant floods includes: the spatial and temporal location of a flood, its extension, the probability of flooding, the type of flood, the magnitude of the associated negative consequences, etc.

3. In the third phase, significant historical and characteristic events were selected depending on the socio-economic and environmental consequences. Thus, categories of criteria have been defined according to the consequences of the flood (on human health, on economic activity, on cultural heritage and environmental consequences). For each of these types of consequences, indicators and associated threshold values have been established, on basis of which floods are designated as "significant" at national level (in terms of damage).

The criteria for identifying significant historical floods in terms of damage in the first stage are shown below:

Criteria category/ Type of consequences	**Indicator**	**Thresholds value**
Consequences for human health	Losses of human lives	Minimum 10 deceased/missing people
	Nr. of affected social units	Minimum 2 affected social units (town halls, schools, hospitals etc)
Consequences for economical activity	Nr. of affected economical units	Minimum 10 economical units
	Nr. of affected roads	Minimum 200 km of affected (national, county and local) roads
	Nr. of affected houses	Minimum 100 houses/event or minimum 30 for areas/locality, which events were focussed and intense
Consequences for environment	Nr. of affected IPPC units	Minimum 1 affected unit
Consequences for cultural heritage	Nr. of affected objectives (churches and monasteries etc)	Minimum 1 affected unit

In order to identify the significant historical events, in the 2nd cycle of Floods Directive implementation, the consequences of the floods were analyzed with the help of other two indicators of damage assessment: an I_p - population indicator (considered as a priority criterion) and a socio-economic one - I_{s-e} indicator. The definition of these criteria consisted in identifying the objectives affected by the floods and assigning weights that would reflect the importance of these objectives.

The weights of the criteria presented above have been applied for each locality affected by the floods of each event, these being classified in the category of the affected localities significantly if they meet at least one of the following thresholds: population criterion $I_p > 0$ and socio-economic criterion $I_{s-e} > 50$.

In determining the sections that form a significant event, the values of I_{s-e}> 25 were taken into consideration, if they are completed on the same section of 1-2 localities with the value of the indicator I_{s-e}> 50. All localities from an event that meet these criteria have determined the river sectors affected by significant historical events.

In addition, the selection of events was amended by the "flood typology criterion": if there were several historical floods on the same watercourse, e.g. 3 to 5 significant floods with similar production typologies, it was considered 1-2 floods for the EC, the predominant criterion being the one related to the damages.

All values of the above criteria are valid for one event; the criteria for the number of victims and the economic ones (number of houses, km of affected roads) were considered as priorities for the event's classification as significant historical events.

The preliminary list of identified significant historical events was also amended by the application of a hydrological criterion, which took into account the magnitude of the flood. This criterion was based on: the size of the hydrographic area on which the flood occurred; the frequency of flood; the probability of exceeding the maximum flow rate, recorded at the hydrometric stations; the size of the flow rates compared to the flow rates corresponding to the defense levels - warning, flood, danger - existing at hydrometric stations.

For this purpose, the same value of the probability of flood occurrence was used as it was in the case of the preliminary selection of significant historical events identification, respectively maximum flows recorded with the probability of exceeding less than 10%. However, for the delimitation of the river sectors affected by the significant historical floods, the maximum rates recorded during the event at all hydrometric stations, and in particular at the hydrometric stations located on or near the affected river sections, were analyzed in the GIS environment.

These analyses at the national level resulted in identification of 32 significant historical flood events covering 882 river sectors affected by them.

More information is provided at www.rowater.ro , www.hidro.ro and www.map.gov.ro

2.11 Bulgaria

The FD was fully transposed in the national legislation by the amendment of the Water act in August 2010. The units of management under FD are the same as used for the WFD implementation – the River Basin Districts. In Bulgaria there are four units of water management – Danube RBD; Black Sea Basin District, East Aegean RBD and West Aegean RBD. The PFRA is to be performed for each of the Basin Districts separately. Responsible organizations are the Basin Directorates. Art. 146a of the Water Act states that PFRA is to be performed in accordance with the common national methodology, issued by the Minister of Environment and Waters. This Methodology was adopted in July 2011. It determines the working steps, sources of information, methods and the criteria for the assessment of the significant past floods and their adverse consequences as well as the negative consequences of potential future floods. According to the provisions of the national law the consequences of floods are to be assessed with respect to the main risk receptors as required by the FD: human health, economic activities, environment and cultural heritage.

The assessment of the past floods, their significance and the likelihood of their future re-occurrence is based on the information collected from different national sources: the information from local authorities (an inquiry of the municipalities was conducted); historical records; reports of the "Fire Safety and Rescue" Directorate General; reports and analysis's of the National Institute of Meteorology and Hydrology; GIS data and maps of past floods. Analysis and assessment were performed by means of GIS, using the available national GIS data in a scale 1:100,000 covering river network; dams, settlements; infrastructure objects; land use and IPPC facilities. Additionally topographic maps in a scale 1:25,000 and 1:5,000 are used.

The criteria used for the assessment of the significance of floods are: the number of people affected; affected important industrial and infrastructure objects; affected IPPC plants; polluted Natura2000 protected areas and drinking water protected areas. For the assessment of the potential future adverse consequences, additional data from the National Statistical Institute on the alteration of the population and its density and data on the infrastructure development obtained from the Ministry of Agriculture and Food and the Ministry of Economy, Energy and Tourism were used.

Information about Bulgaria is not final due to still on-going activities on PFRA and APSFR designation.

2.12 Ukraine

Association Agreement between Ukraine and the European Union entered into force on 01 November 2014. The FD has been transposed into national legislation by modified Water Law in October 2016. The State Emergency Service of Ukraine (SESU) of the Ministry of Interior Affairs of Ukraine is the main authority responsible for the implementation of the FD together with State Agency on Water Resources of Ukraine and others central bodies.

The Methodology on Preliminary Flood Risk Assessment was developed by SESU and approved by the Ministry of Interior Affairs on 17.01.2018. According to the resolution of Cabinet of Ministers from 25.10.2017 on the Association Agreement implementation, the Preliminary Flood Risk Assessment was completed in the end of 2018.

The national approach and FD requires undertaking a PFRA for each certain River Basin District, also for the Danube RBD, which includes 4 sub-basins: Tisza, Prut, Siret Rivers and Lower Danube River sub-basins. Identification of significant past floods applies the significance criteria of past flood events and the description of their consequences, mechanism and characteristics of flooding. The criteria for identification of past significant flood events are based on compliance with the two following factors:

- Past flood event should match the emergency situation connected with flooding and its qualification characteristics (defined in National classifier of emergency situations);
- Past flood event should match the object level of emergency situation connected with flooding (defined in Procedure of classification of emergency situations).

In Danube River Basin District in Ukraine 247 significant flood events were identified for the period 1992-2017 with fluvial origin of flooding.

2.13 Moldova

The Hydrological Forecasting Division had developed forecasting methods that are periodically updated. The data on historical floods that occurred in the past, on the maximal flood discharge and flooded areas are used for the preliminary assessment of the flood risk in Moldova for of 1, 5 and

10% probability. For the forecasting of the flooded areas, the data on the floods that occurred in the past are used.

According to the Resolution of the Republic of Moldova, the "Waters of Moldova" Agency had developed an action plan for mitigation of the flood consequences, improvement of the water management system and flood protection. The action plan has three sections: short term, medium term and long term (for the next decades) actions. The plan also foresees the reconstruction and building of new dams and barrages.

3 Historical floods in the Danube River Basin

This chapter provides information on major flood events that occurred at the scale of the Danube River Basin District focusing primarily on the last decade. It refers to both floods that 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 (FD art 4.2.(b)) as well as to significant floods which have occurred in the past, where significant adverse consequences of similar future events might be envisaged (FD art. 4.2(c)).

Through many centuries, records of the occurrences of floods have been kept in the Danube countries. The most known 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.

During the last century the major flood events occurred in 1902, 1924, 1926, 1940, 1941, 1942, 1944, 1954, 1965, 1970, 1974 and 1991. Last decades brought a series of massive flood events the most significant being those of 2002, 2006, 2010, 2013 and 2014.

3.1 Floods in 2002

In August 2002 a 100-year flood caused by over a week of continuous heavy rains devastated large parts of the Danube River Basin, killing dozens, dispossessing thousands, and causing damage of billions of Euros. The floods started with heavy rainfall in the Eastern Alps, which resulted in floods in Bavaria and Austria, and then the floods gradually moved eastwards along the Danube.

In Bavaria, floods affected the Danube from Regensburg to Passau, and many tributaries including the Inn, Traun, Salzach and Regen. Thanks to flow regulation structures, the negative impacts of the flooding were substantially reduced. The utilization of reservoirs at Dillingen and at Ingolstadt helped to reduce flood peaks considerably. The extent of damage to infrastructure and private properties amounted to 230 million Euro. The Austrian states of Lower and Upper Austria and Salzburg suffered heavily from the floods. More than 10,000 homes were damaged, infrastructure was destroyed, and the total damage exceeded three billion Euros. In the Morava River Basin, about 20 communities were affected by floods. Major damage was caused to urban settlements, infrastructure and agriculture. Damages amounted to approx. EUR 11.7 million (7 million for state and municipal property and 4.7 million for private property). In Slovakia, the areas mostly affected by flooding included parts of central Slovakia inundated by flash floods and the area around Bratislava impacted by the Danube flood. 144 settlements and 8,678 hectares of land were flooded. Damages amounted to EUR 36.2 million and emergency measures cost some EUR 2.2 million. Several municipalities in Hungary were affected by the flooding of the Danube near Visegrád. About 2,000 people had to be evacuated, and 4,370 homes were damaged. Flash floods in the Suceava region of northern Romania caused 11 casualties, while 1,624 houses were flooded, and more than 1,000 km of roads and 567 bridges were destroyed. Gas, electricity and communication networks were also badly damaged.

3.2 Floods in 2006

In 2006, a serious spring flood occurred in the Danube River Basin, the result of specific meteorological weather conditions. Heavy floods inundated Central and Eastern Europe due to melting snow and heavy rainfall. Swollen rivers and rising groundwater levels caused widespread damage and forced thousands to leave their homes. For the first time in history, high water was recorded on the Danube, Sava, and Tisza at the same time – this rare coincidence caused an extreme flood event in the main Danube (primarily in the Central and Lower Danube reaching a 100-year return period).

3.2.1 The Upper Danube

A sudden temperature rise and heavy rainfall activity at the end of March resulted in a fast snowmelt. While only minor floods of a 2-5 year return period occurred on the main Upper Danube, floods up to a 100-year return period developed on many smaller tributaries in Germany, Austria, Czech Republic and Slovakia, which led to an increased Danube flooding downstream. Such runoff events represent a typical spring flood; however, this flood event was significant with regard to its discharge hydrograph and volume. While in the German and Austrian stretches of the Danube River the flood hydrograph had two well-marked peaks, this was not so evident on the Slovak stretch. This was the result of the influence of the Danube's left side tributary, the Morava River, in the Devín profile at the Austrian-Slovak border (river kilometer 1879). The critical flood flow proceeded slowly downstream the Danube with specific time delays from Passau (km 2225) to Sturovo/Esztergom (km 1719) on a stretch of approximately 500 km. Simultaneously, flood waves passed along the Morava, Váh and Hron rivers. On 3 April, a 1,500 m^3/s peak discharge on the Morava flood coincided with a 5-6,000 m^3/s flood peak on the Danube at Devín. A 1,200-1,400 m^3/s flood peak on the Váh entered the Danube one day before the peak of the recipient arrived.

3.2.2 The Middle Danube

Meteorological conditions in the Upper Danube area had an important impact on the development of the extreme flood event on the Middle Danube, especially in the Budapest region. The meteorological conditions in the Carpathian region were of prime importance for the Tisza River Basin upstream of Szeged. By mid-February, water reserves accumulated in snow cover in the Tisza region reached approximately 150% of the multi-annual average for the given period. A significant amount of snow accumulated also in the Maros/Mures valley (where the water reserves recorded exceeded the multi-annual average by 70 %) and in the Körös/Crisul river system (where levels were exceeded by 30 %). The combination if heavy precipitation and the snow melt resulted in an exceptional runoff in the Tisza basin. Moreover, flooding on the Sava River took a long time, beginning in mid-March and lasting until mid-May. During this time, the river flow was always between 3,000 m³/s and 4,000 m³/s (a return period of 1-5 years). This way, the rare coincidence of relatively large and prolonged floods on all the main tributaries of the Central Danube Basin resulted in one of the largest floods recorded in the lower Danube stretch.

3.2.3 The Lower Danube

A relatively long period of precipitation was recorded between mid-March and the end of April in the Carpathian mountain area. As a result, a high discharge from all the major tributaries in the region (such as the Timis, Jiu, Arges, Ialomitsa, Siret and Prut) was recorded over several weeks. The extremely rare coincidence of relatively large floods occurring simultaneously in the Upper Danube, Tisza, Sava and Velika Morava rivers resulted in a very serious 100-year flood event downstream of Serbia. Throughout the entire Lower Danube, historically significant flows and water levels were registered, being the largest recorded during the last hundred years. The registered flows had maximum values of 15,600 -15,800 m³/s, similar to those in 1895. Unusually, there was also a long period of high flood alert on the Danube downstream of the Iron Gate, lasting more than 6 weeks. Several dyke breaches occurred, especially on the Romanian side.

3.3 Floods in 2010

According to climatic data, the 2009-2010 hydrological year (measured from November to November) produced the largest amount of precipitation ever observed in many parts of the Danube region. The layer of snow and rain along the central Danube exceeded the multiannual average by 1.5 to 2.0 times, a maximum never observed since systematic instrumental weather observations have been available. Contrary to the massive single flood events on the Danube as 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. Except of German and Austrian part of the Danube River Basin, where only minor floods occurred, all other countries suffered from considerable flooding causing casualties and massive damages.

In Czech Republic, the largest floods in May were on the Morava tributaries with return periods between 10 – 50 years. After this first precipitation wave the elevated soil saturation caused the second flood event in the beginning of June despite the rainfall in that time was not so strong. These floods had return periods between 10 – 100 years and were evaluated as the second most significant summer flood event in the Morava basin during the last 100 years.

The extreme floods were recorded in Slovakia mostly in May and June. Altogether there were 206 days of flood alerts until the end of August (85 % of the time) and the floods affected the whole territory of the Slovak Republic. High saturation of the Nitra river basin in June 2010 caused flood with the estimated peak discharges Q_{20}-Q_{50} in Nitrianska Streda and Nove Zamky. Extreme flood events, which resulted from long-lasting rainfalls in the beginning of June, occurred in several river basins of the Central Slovakia. The return period of floods in the Slana and Rimava river basins was estimated to 50 years. In the Litava at Plastovce (the Ipel River tributary) the flood peak discharge was estimated to Q_{100}. Eastern Slovakia has been continuously affected by floods since the mid May.

Extreme rainfalls in the beginning of June, combined with high saturation of river basins in this region, caused floods with return periods 50–100 years in several river reaches.

Hungarian river reaches experienced several significant flood waves resulting from intensive rainfall events either directly or as a superposition of a number of floods following subsequently. Multiple floods on the tributaries resulted in a significant Danube flood wave upstream of Budapest, equal to the third largest one of the last century causing serious transport limitations within the city of Budapest. The Vienna-Budapest railway line was also endangered while the motorway M1 was cut by a flash flood induced damage for a couple of days. Extreme character of the events was manifested on streams of the Slana/Sajó river network together with Hornád/Hernád and Bodva/Bódva where two or three subsequent flood peaks in May-June exceeded historical flood crest (water level) or peak discharge maxima of the year 1974. Lower Hernád Valley was mostly saved by intensive flood protection works by constructing a temporary dike of 40-km length. Water levels reaching historical maximum levels occurred on the River Tisza at Tiszaujváros and the recently completed emergency reservoir (detention basin or polder) of Tiszaroff was opened reducing the flood peak by 15-20 cm easing the load on the flood protection of the city of Szolnok. The year 2010 was denoted in Hungary with the highest number of the flash flood events (510) since such statistics are available (1980).

In Slovenia fluvial foods, flash floods and karst phenomena floods occurred accompanied by landslides. Floods reached their peak between 18 to 22 September. The discharge return period varied from less than 5 years to more than 50 years.

Flood events on the Croatian rivers were caused not only by an extreme precipitation in the territory of Croatia but also due to a large inflow from the upstream parts of the river basin in the neighboring countries. At many hydrological stations, the maximum water levels, which occurred during 2010, exceeded or were only slightly below those recorded during the previous 35 years. This period was chosen because in 1975 the flood relief structures for the Sava and Kupa rivers were either constructed or put into operation. In the Sava upstream of Sisak and in the western left-bank Sava tributaries, extremes occurred during the large water wave in September 2010. The eastern left-bank tributaries achieved their maximums in June, and the largest right-bank tributaries, the Kupa and the Una, during December 2010. Preliminary statistical analyses showed that the large water wave in the upper section of the Sava river basin in September was the occurrence of a 100-year return period. The flood maximums, which occurred in June, had occurrences between 25- and 100-year return periods, and those in December between 10- and 50-year return periods.

In Bosnia and Herzegovina, the key flood events were registered at the beginning of January 2010 on Una, Sana, Vrbas and Bosna River with the recurrence period ranging from 5 to 100 years. Main floods in the Drina basin were caused by the extreme precipitation in Montenegro’s and Serbian’s part of river basins. Flow rate of the Drina river, at the confluence to the Sava river, was over 4,000 m3/s what is the highest flow recorded in the last 50 years. The recurrence period of the Sava river flow downstream the confluence with Drina, almost reached 100 years (6,000 m^3/s).

The hydrological situation in Serbia was highly unfavourable throughout the whole year with repeated floods on nearly all national and international rivers. A prime example is the Sava River, where floods occurred at the very beginning of the year, in the summer, and in December 2010. Flood defence activities in Serbia lasted for 185 days, during the most of these days emergency flood defence was in force. Rapid snowmelt and rainfalls generated flood waves on many rivers in Serbia already in December 2009 and this situation continued in January and February 2010. The most serious events exceeding emergency flood defence stages occurred on the Sava River, the Timok River, and the rivers in Banat. The most adversely affected was the Timok River Basin, where the soil was already saturated by snowmelts and rainfalls in the previous year and an exceptional runoff occurred in the second half of February and in the second half of April with absolute maximum levels recorded at many gauge stations, with return periods estimated at 20-100 years. Frequent and abundant rainfalls induced flood waves in the Velika Morava River Basin in April 2010. The most dangerous situation was recorded along the most downstream section of the Juzna Morava River, where the historical maxima were exceeded (at Aleksinac and Mojsinje gauge stations on 21 April).

At the end of June a flood event occurred in the Kolubara River Basin (a right tributary of the Sava, near Belgrade) caused by abundant rainfall, reaching soil already saturated by previous rains. New extremes were recorded on many tributaries and the Kolubara River itself, where the return period of peaks was estimated at 50-100 years.

In the Drina River Basin, the most extreme flood event occurred in the end of November and the beginning of December. Flood waves on the Drina and its tributaries were induced by extreme rainfalls in Montenegro and Bosnia and Herzegovina, where 100-200 mm of rain fell in 3 days. Flood waves on the Drina tributaries (Piva, Tara, Ćehotina, Lim and Jadar) and the main course were exceptional, such that hydropower reservoirs could not retain them. A new maximum was recorded on 3 December at Radalj, the most downstream gauge station on the Drina River. As a result, a flood wave also occurred on the Sava River in Serbia, where emergency flood defence was declared at the beginning of December.

In Romania, the major flood events have been registered between June and August. In June, danger and inundation water levels were exceeded on Crasna and Tur (both in Somes-Tisa basin) and on Timis, Barzava and Moravita River (Banat region). On 1-3 July danger water levels have been recorded on the Upper Olt at Tomesti, on the middle Siret (Lespezi-Dragesti sector) and on the Prut River (Oroftiana-downstream Stanca sector) while the inundation level was observed on Olt and several Siret tributaries. In the second half of June and beginning of July the whole North-Eastern Romania has been affected by continuous significant precipitation which induced successive massive floods especially on the Siret and Prut rivers, reaching historical values recorded in 2005 and 2008.

The hydrological situation in February/March in Bulgaria (high water in the Timok combined with groundwater floods) caused floods in Bregovo. In June, high water levels were observed on the Orshova River.

In Ukraine in May, the high flood levels were recorded at the lower Tisza and Latorytsa. On 20 May Latorytsa at Chop reached 701 cm (the historical maximum being 750 cm) while in December at the same station the historical maximum was reached.

The major pluvial floods on the Prut in Moldova occurred in June-July. In the first decade of June, upstream the Costeşti-Stînca reservoir the pluvial flood led to the rise of water level by approx. 2.0 m and to inundation of the floodplain of Briceni district. In the beginning of July, the inundation of floodplains from Briceni and Edineţ districts and of the railway embankment of the Bălţi – Cernăuţi districts occurred. Few days later a flood wave on the Prut increased the water level near Şirăuţi village by 5.10 m and the maximal discharge reached 2,020 m^3/s. This led to inundation of floodplains and of some localities of Briceni district. In the sector Costeşti - river mouth, floodplains and farm lands were inundated and the water supply for the Ungheni district was jeopardized.

3.4 Floods in 2013

The specific meteorological situation in the 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. Later in June, the torrential rains caused flash floods and fluvial floods in several regions of Romania and Bulgaria.

In many tributaries of the Upper Danube, the return periods of 100 years or 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 had been measured 500 years ago. Along the Austrian Danube gauge, data showed peak discharges that have not been recorded during the past 200 years. The flood wave progressed throughout the Slovak section of the Danube from Bratislava to Štúrovo while in the middle and lower part of Danube discharges exceeded value of the 100 year return period in all water gauge stations. In Hungary the highest ever Danube water levels were observed.

National flood warning and monitoring systems worked properly and informed the responsible water management and flood mitigation authorities on time. In addition, the European Flood Awareness System (EFAS) issued 13 flood warnings of different levels between 28 May and 10 June for parts of the Danube River and its tributaries.

Substantial flood interventions took place especially on the Upper Danube but flood protection activities were carried out in all affected areas and they employed thousands of operatives and volunteers as well as a large number of vehicles, machines and devices.

Floods in June 2013 caused 11 casualties in Austria and Romania. The total financial consequences of floods in June 2013 in the Danube River Basin amount to 2.4 billion € which includes the financial losses and costs of the flood protection works.

This most recent flood event has again confirmed the necessity for modern and effective flood protection measures to protect the population and secure economic activities. It also reiterated the basic fact that even the most up-to-date protection systems can only provide a certain level of security and that there is no possibility to fully exclude the residual risk. The flood protection measures must be therefore considered as a part of an integral flood risk management, taking into account the occurrence of extreme flood events being a natural phenomenon.

The efficient protection against floods in the upper part of the Danube basin may however lead to transferring more water downstream during extreme flood events. To avoid such development in future the application of solidarity principle, which is one of the objectives of the Flood risk management plan for the Danube River Basin, is essential.

3.5 Floods in 2014

Days of extensive rainfall on pre-saturated soil caused devastating floods in Western Balkans in May 2014. Due to specific cyclone in mid-May 2014, a large portion of the Sava River Basin within Croatia, Bosnia and Herzegovina and Serbia was hit by continuous, heavy rainfall. Intensive precipitation in the second half of April and the beginning of May preceded this event and caused a high saturation of soil. This combination caused flash floods, erosion and landslides along small watercourses, but also disastrous flooding along the Sava River main course and its right tributaries.

In the period from 17 to 20 May 2014 at hydrological stations on the middle course (Slavonski Kobaš, Slavonski Brod, Slavonski Šamac, Grebnice, Županja and Jamena) and the lower course of the Sava River (Sremska Mitrovica, Šabac) the highest water levels in history of measurements were registered. The absolute maximum recorded on the stations were direct consequences of extremely large inflow from the Bosna (4,200 m^3/s), the Vrbas (1,700 m^3/s), the Drina (4,000 m^3/s), and subsequently the Una River (1,750 m^3/s).

The inflow from tributaries had a major impact on propagation of flood wave along the Sava River, and also influenced the timing of extreme water levels. The extremely high water levels at stations downstream of the Bosna River mouth (Slavonski Šamac, Grebnice, Županja, Gunja and Jamena) and the Drina River mouth (Sremska Mitrovica and Šabac) occurred on 17 May, when the extreme inflows from these tributaries emerged. The increase of inflow from the Vrbas River on 18 May induced maximum water levels downstream of this tributary (Davor, Slavonski Kobaš and Slavonski Brod), but without further increase on downstream stations. Water levels on the most downstream section of the Sava River (Belgrade) were influenced primarily by the Danube River, which was not high. That is why the highest level in May 2014 was significantly lower than the extreme of 2006.

DHMZ measured 6,008 m^3/s at Slavonski Šamac at water level of 889 cm. Based on the hydrological analysis it was concluded that this discharge had a return period of 1000 years. Historical maxima were recorded in the middle and lower parts of the basin on 15 May, both on the Bosna main course and on tributaries (Krivaja, Usora and Spreča). The return period of the flood peak on the Bosna River was 500 years, and 100 years on tributaries. Sudden rise of water level (more than 6 m in less than 24 hours) was recorded on hydrological station Doboj. As a result, floods with disastrous consequences occurred in cities as Zavidovići, Maglaj and Doboj.

The rough estimate based on satellite imagery revealed that the flooded areas were very large: 266.3 km^2 in B&H (Federation B&H 179.5 km^2, Republic of Srpska 72 km^2 and Brčko District 14.7 km^2), 53.5 km^2 in Croatia, and 22.4 km^2 in Serbia.

In Croatia, 38,000 people were affected by May 2014 flood. In the most critical southern Slavonia region, around 9,000 inhabitants were evacuated and two casualties were registered. The economic impact of floods in Croatia was estimated at 300 million EUR.

In Bosnia and Herzegovina, floods affected about 1.0 million people in central, north and east areas of the country were 90,000 people were evacuated. The floods caused 25 casualties. In sum, the total economic impact of the disaster (destruction or severe damage to property, infrastructure and goods as well the effects of destruction on livelihoods, incomes and production, among other factors) is estimated at 2.04 billion EUR, which represents an equivalent of nearly 15% of the B&H GDP.

In Serbia, the floods affected 1.6 million people in 38 municipalities mostly located in central and western Serbia. The floods and landslides caused 51 casualties, 23 of which were by drowning. About 32,000 people were evacuated from their homes, out of which 25,000 were from Obrenovac. The total economic impact of the disaster was estimated to 1.53 billion EUR.

4 Potential adverse consequences of future floods

In reference to the FD art. 4.2(d) a description is provided here on the assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity. As far as possible issues such as the topography, the position of watercourses and their general hydrological and geomorphological characteristics shall be taken into account. This step of implementation is also including floodplains as natural retention areas, the effectiveness of existing manmade flood defence infrastructures, the position of populated areas, areas of economic activity and long-term developments including impacts of climate change on the occurrence of floods.

4.1 Germany

To assess the adverse consequences of future potentially significant floods, an analysis was made of the danger of flooding and the possible adverse impacts in the areas, and the risk was deduced from this.

The flood risk was assessed by evaluating the available data on topography, hydrology and land use. In addition to the factors mentioned in FD Article 4.2 (d), the existing flood plains and flood-control installations were taken into account. The development of the land use on a medium and long-term time-scale using available water-management reference frameworks and the information provided by spatial and regional planning institutions were also taken into consideration.

The ascertainment of possible risks took particular account of the location of populated areas and the location of areas of economic activity. Taking this as a basis, the adverse effects were then assessed either directly, using potential damage and the number of persons affected, or indirectly, using regional criteria. Consideration was also given to major long-term developments like climate change, demographic change and foreseeable economic development.

4.2 Austria

1st cycle of implementation:

For the assessment of the potential adverse consequences of future floods in Austria, the modeled flood areas of the “Flood Zoning System Austria” (link: http://www.hora.gv.at /) and, where available, more detailed hazard studies were applied. The hydrodynamic models are adapted to the geomorphological characteristics and topography of watercourses and floodplains. The actual effects of floodplains as natural retention areas and the effectiveness of existing manmade flood defense infrastructures are integrated in the models.

Populated areas and areas of economic activity are accurately represented by gridded data of inhabitants and employees. Information about long-term residential and economic developments was taken into account in a final review of the assessment by expert evidence. Estimations on the impacts of climate change show a very high level of uncertainty in Austria. In recent studies, future changes in flood discharge due to climate change ranging from –4% to +10% were computed for several river catchments. These values are far below natural variations in present flood discharge.

2nd cycle of implementation:

In the frame of the FD implementation to Austrian law it was determined that hazard zone plans have to be established for all APSFR. These plans are based on high resolution data combined with 2D hydrodynamic modelling and, therefore, allows hazard assessment to a scale of 1:2000 (single object). Additionally, due to the elaboration of flood hazard and flood risk maps in the 1st cycle of the FD implementation the hazard information quality increased substantially (closure of gaps, increase in model accuracy). Therefore, for most parts of Austria information based on 2D hydrodynamic modelling is now available. For areas with no such information, the FHRM maps of the 1st cycle had been consulted which are available for approx. 40.000 km of rivers.

4.3 Czech Republic

The past changes during 1940s – 1960s such as different agriculture practices, building large dams and regulation of the rivers, have affected character of floods. In future only small local changes in land-use, land-cover, urbanization, and population density around the rivers are expected.

Hydrological and geomorphological conditions and land-cover were analyzed to define “critical points”, locations of potential flooding after very intense showers at borders of urban areas.

Potential adverse consequences of future floods were assessed by spatial analyses of medium probability floods (Q100) along the rivers. Approximately 5 % of inhabitants live in a potential flood risk with medium probability and 5 % of value of major types of properties is at risk. There was available information about flood extent for high and medium probability on other river stretches for the 2nd cycle. Percentage of inhabitants living in a potential flood risk with medium probability and the value of major types of properties being at risk have slightly declined (tenths of %).

Climate change study did not affirm any trend or important changes in conditions, which could cause neither different character of floods in future, nor their different seasonal distribution.

4.4 Slovakia

Slovakia considered various scenarios in potential future flood risk evaluation. Torrential rains causing pluvial flooding scenario was in all cases insignificant due adverse consequences. Several large areas situated on the East Slovakian Plain and long strip on the right side of the Váh River could cause severe damage due ending lifetime of the flood protection. Some dikes are about 200 years old and problems are appearing during almost every event. Flood extent was drawn according to a few dike breaches in 60-ties. Hydrological data is changing on the Danube River and huge area along the Danube is becoming unprotected. Some dike stability problems appeared during last few years and also back-water is necessitating additional protection measures in Danube’s tributaries. Danube FLOODRISK project data was taken into account as indicative flood extent for considered scenarios (end 2010). Detailed hydraulic modelling for 1st cycle FRMPs showed there are other areas with significant flood risk among numerous APSFRs. 1st cycle APSFRs were aggregated into larger, more synergic APSFRs of the 2nd cycle and the newly identified localities were included.

Potential of future flood occurrence was calculated for all APSFRs based on scientific study of Comenius University team. Experts differed between local and regional flood potential. The local potential covers mainly flash floods of small catchments. The regional potential represents evaluation of larger watercourses floodplains and larger catchments. The average potential of medium or higher level was considered as significant. APSFRs with lower potential without past events were rejected.

4.5 Hungary

Several activities serves the preparation for the future scenarios. It is foreseen that all the listed measures in the national flood risk management plan (HU-FRMP) will be successfully implemented until the end of the second EU FD reporting cycle.

In 2014, after the 2013 Danube flood event, the P=1% design flood level (MÁSZ) have been recalculated for the app. 2.800 km river reaches all over the country based on the Q1% flood discharges considering the climate change effects. In the second implementation cycle, these new water balance values are the basis for the fluvial flood calculations which also consider dike failures and their transport on land with potential disaster elimination measures (LOKTERV). The average increase in the water levels is in the 1.0-1.5 m range. The values implemented in the legislation and thus it remarkably decreased the conformity of the existing defense infrastructure with the requirements. Also the open floodplain areas designated by numerical modeling to see the real extent of such future events. Sustainable floodplain management plans (NMT) created with the purpose to stabilize or decrease the peak level of flood conveyance. “MÁSZ”, “LOKTERV” and “NMT” activities are listed in the HU-FRMP as measures in 2016 and they are completed.

In the “ÁKK” project, the groundwater and excess water characteristics were re-evaluated based on the latest datasets. The state-of-the-art analysis had extensive investigation to all potential effects and carried out a complex excess-water hazard index (Komplex Belvíz-veszélyeztetettségi Mutató - KBM). This new method is capable to provide information on the vertical scale of the inland inundation caused by increased groundwater tables in Hungary.

The Second National Climate Change Strategy 2017-2030/2050 (NÉS-2) states that almost all the hilly areas in the country have medium risk for flash floods. The Mecsek, Keszthelyi-hegység, Bakony, Cserhát, Cserehát, Bükk and Mátra regions are considered to be a more vulnerable area than the average. In order to manage the possibility of the increased re-occurance, the number of the considered river streams were broadened by individual analysis and expert judgement by the VIZIG.

HU-FRMP also indicates the “TELVIZKAR” measure (completed). Those settlements, which lie on open floodplain areas, were supplied with tailored contingency plans to face with fluvial, pluvial and excess water hazards. They are prepared for the future scenarios with the latest information available.

4.6 Slovenia

The potential flood risk areas were assessed by evaluating available data on flood hazard potential and damage potential. The results are potential flood risk areas classified by the risk potential index.

The future development is not considered as relevant in PFRA, because of applied prevention measure in “Governmental decree on conditions and limitations for constructions and activities on flood hazard areas” (http://www.uradni-list.si/1/content?id=88381). According to this decree, the future development should be outside of a flood hazard area. If it is an extension of an existing infrastructure, the measure for reducing the existing flood risk should be applied before the extension can begin.

There is no evidence of an impact of the climate change on frequency of fluvial floods while the trends of discharge peaks are slightly declining. The trends of average sea level and the frequency of floods increase. See: (http://www.arso.gov.si/o%20agenciji/knji%c5%benica/publikacije/Okolje_se%20spreminja.pdf, Okolje se spreminja. Podnebna spremenljivost Slovenije in njen vpliv na vodno okolje, MOP ARSO, 2010,).

4.7 Croatia

Due to hilly and mountainous areas with high rainfall intensities, alluvial lowlands of the Danube, Drava, Mura, Sava, Kupa and Una rivers and their tributaries, towns and settlements located in potentially endangered surfaces and unfinished protection systems, the Danube River Basin District in Croatia is at considerable flood risk. High and moderate risks were identified in many areas of the country.

Protection systems along large rivers are partly unfinished and consist of defensive dikes, wide flood zones and large lowland retention areas, which enable a significant reduction of peak discharges. Such approach also contributes to the reduction of flood risks in the downstream countries and at the same time preserves natural values (Lonjsko polje, Kopački rit and other areas). Protection systems for torrential floods in smaller river basins, which consist of mountain retention areas, reservoirs and lateral canals, are mostly unfinished.

Further investments in the development of protection systems for reduction of identified flood risks and mitigation of consequences of climate changes will be implemented according to the Multiyear construction programme for regulation and protection water works and amelioration water works, which is in preparation.

4.8 Serbia

The largest potentially flooded areas are along the Danube, Tisza, Sava, Drina, Velika Morava, Južna Morava, and Zapadna Morava rivers, covering almost 12,000 km^2 (measured on a 1:300,000 scale map). These lowlands host the largest cities and economic activities.

Approximately 1,500,000 people in Serbia are directly or indirectly endangered by potential future fluvial floods. All large populated areas are protected, mostly from 100-year flood, and effectiveness of structural defences is satisfactory. Nevertheless, new developments in flood prone areas can lead to an increase of risk. The impact of climate change was not taken into account in the first PFRA, due to a lack of research related to this topic.

4.9 Bosnia and Herzegovina

It can be said that the rivers in Bosnia and Herzegovina in the Sava River Watershed have the character of a torrent with narrow river valleys and a significant subsurface decline. Flood protection is mainly carried out on the construction of river beds in urban areas with a significant number of inhabitants and economic facilities.

The area near the Sava River has a built-up system of flood protection facilities consisting of embankments, pumping stations, channel network and flood protection houses and centers. During the catastrophic floods of May 2014, a part of the flood protection facilities was damaged, which was rehabilitated during that year. With the funds collected by international donors in Brussels in mid-2014, reconstruction and securing the necessary level of protection of flood protection facilities is being carried out.

According to analyses of spatial plans, the trend of urbanization development is obvious. As a result, the value of the land will increase and so will the possible flood damages.

Terrain topology in Bosnia does not allow for development of natural retention areas, so the urbanization has a significant impact on development plans.

As regards the impacts of climate change according to the research conducted by the Intergovernmental Panel on Climate Change (IPCC) on the Sava River catchment area in Bosnia for the period of 2000-2050, no significant changes in climate are to be expected.

4.10 Romania

The determination of the potentially floodable areas of the future extreme events was made based on complete and homogenous information collected at the national level and on simplified methodologies. The evaluation of the consequences was done by considering indicators that illustrate the risk exposure of the four categories of receivers mentioned by the text of the Floods Directive.

In order to identify the potentially floodable zones several simplified methodologies were developed within the NIHWM (within the 1st Cycle of the Flood Directive – second stage, VULMIN project, RO-RISK project etc).

The identification of river sections or areas where significant future events can occur ("Future floods"), even if no significant historical floods have been recorded, is one of the principles for designating APSFRs. The river sections, established on the basis of expert judgement and of the local knowledge of the watercourses regarding the risk of floods, were analysed in the light of methodologies previously developed by NIHWM. These were: a) methodology for the determination of the hazard for flash-floods and important run-off on the slopes, torrents, streams and the related risk; and b) the IFF susceptibility index (within the VULMIN project), at the country level resulting in 64 river sectors.

For the designation of these areas, the efficiency of the existing flood protection infrastructures was also analysed.

A simplified method using a special GIS processing of the topographic data provided by DTM was used to identify the flood zones. For the delimitation of flood zones, a series of parameters obtained by GIS processing of the DTM were used. These indicators are closely correlated with the extension of the major riverbeds:

- Modified Topographic Index (MTI);
- the height of the land above the watercourse (relative altitude);
- the distance to the watercourses (drainage lines);
- minimum field curvature.

These parameters were combined using a Fuzzy Logic system approach using the GRASS-GIS application.

The result obtained was a GRID type layer with values from 0 to 100, representing the degree of probability that a pixel belongs to the flood zone. To calibrate the GIS method for delimiting the flood zones, the results of the hydraulic modelling in the minor and major riverbed of the main rivers in Romania were used, with two probabilities of exceeding the maximum flow: 1 % and 0.1 %.

At the level of the whole country, the application of the methodology was made on the digital model of the SRTM with the resolution of 30 m, using a threshold of 59 and one of 51.

Following the use of the threshold value of 59, a floodable area of about 40,000 km^2 was identified in Romanian territory, of which about 39,380 km^2 are located along the rivers (with hydrographic basins bigger than 10 km^2 or the length of the watercourse of over 5 km). The difference is made up of areas identified as floodable, but not related to the minor rivers, usually located on the flat interfluvial lands. The threshold of 51 led to an increase of the flood zone by about 4,000 km^2.

For the run-off simulation using the hydrological model (CONSUL of NIHWM) in the climate change hypothesis, two long-term simulations were performed, the first simulation being for the reference period 1971-2000, and the second one for the period 2021-2050.

Generally, at altitudes above 400 m, the increase of approximately 10-20% of the maximum flows was found and the necessity of extending the flood zones obtained by the method with Fuzzy and GIS systems was analysed. The areas obtained for different probabilities of exceeding the maximum flow were compared, where they were available, respectively 0.1 %, 0.5 % and 1 %.

At the country level, there was an extension of the flood zone from 1 % to 0.5 % by 1.14 times. The conclusion was that the extension of the flood zones in the 0.5 % scenario could be used as an extension in the climate change scenario. Then the results of the Fuzzy-GIS method were calibrated using the limits of the mentioned scenario. Finally, a new threshold was set for the value of the model when considering climate change, respectively 51 (instead of 59, set for the current situation).

The methods used to assess flood risk should reflect not only the areas affected by floods and their magnitude, but also the potential consequences, expressed either quantitatively (monetary) or qualitatively (degrees of intensity), being a combination of hazard and presence or degree of flooding receptor exposure.
Flood zones obtained by the simplified methodology based on Fuzzy-GIS systems and the assessment of potential negative consequences were used for the following situations:

- determining the maximum potential consequences (related to all areas susceptible to floods, whether or not they are declared APSFR), in the current situation and taking into account the climate changes;
- identifying potential river sections to be affected by floods that may occur in the future;
- designation of APSFRs where there are no recorded or known direct damages from historical events;
- filling in the information on the consequences for the APSFRs where historical events were recorded.

4.11 Bulgaria

To assess the future danger of flooding and future potentially significant floods an additional analysis by GIS methods is being performed considering the topography and the hydrologic conditions. The potentially flooded areas are calculated for medium probability (Q100) of flooding. This analysis is conducted for the river sections, which are preliminarily specified as potentially vulnerable in view of close proximity of critical objects such as: populated areas, significant industrial plants; main infrastructure facilities, sources of pollution, protected areas and cultural objects.

For the assessment of the potential future consequences, the long-term development is taken into account, considering the trends in the alteration of population, the industrial and infrastructure projects.

There is not enough available information on climate changes in Bulgaria and especially regarding their influence on the future floods. For the PFRA the impact of climate changes will be assessed in specific cases depending on data availability.

Information about Bulgaria is not final due to still on-going activities on PFRA and APSFR designation.

4.12 Ukraine

Identification of potentially significant future floods applies the criterion of significance of potential (future) flood events and description of their value of potential flood risks.

The criteria for identification of potential adverse consequences of future floods are based on the following factors:

- Future flood event should match the local or higher level of emergency situation connected with flooding (defined in Procedure of classification of emergency situations);

- The settlements, objects of economic activity, environment and cultural heritage should be covered by preliminary inundation zone of the HQ1 scenario.
- The presence of moderate flood risk (3) or higher flood risk (4,5) according to the Methodology on PFRA.

The value of potential flood risk could be calculated by the combination of above-mentioned factors, the level of emergency connected with flooding and the probability of flood event.

4.13 Moldova

Assessment of flooding of the settlements resulting from dyke breaches is ongoing.

5 APSFR

5.1 APSFR methodology

This chapter provides a brief description of the methodology used at the national level for the identification of areas of potential significant flood risk.

5.1.1 Germany

In Germany, any person who may be affected by floods is obliged, as far as this is possible and reasonable, to take suitable preventive measures as a protection against adverse consequences of floods and to reduce possible damage (Section 5 (2) Federal Water Act). There is a public interest in protecting the community at large, if floods are a threat to the life of the population or if economically relevant material damage frequently occurs to such an unusual extent that it affects a larger number of people.

Within the first management cycle, areas with a potentially significant risk could be found along sections of water in which there is a particularly high flood risk of supra-local importance compared to the entire river basin. Based on these results, the preliminary assessment of flood risk in Germany was now harmonized, using an overall approach that has been agreed with the German Federal States in 2017. It is applied in three steps:

1. Initial Position: Consideration of APSFR from 2011 for the Danube and all important tributaries
2. Examination of changes since the last assessment within the existing APSFR
3. Examination of the additional water body network whether relevant changes since last assessment lead to a different risk assessment.

Adverse consequences for human health and economic activity depend on a variety of factors, especially the extent and density of settlement and potentially affected industrial and industrial real estate areas.

Furthermore, there are potentially significant risks to the environment as a protected natural resource that are caused by industrial enterprises in the flood plain that handle or store environmentally hazardous substances. If the relevant locations of these industrial enterprises are situated in a corridor along the waters under consideration, these have been taken into account when defining sections of water with a potentially significant flood risk.

If protected nature reserves, protected areas for drinking water abstraction or bathing waters are affected, water section can also be defined with a potentially significant flood risk.

In addition to municipalities that can be expected to have cultural assets, World Cultural Heritage Sites and, where relevant, outstanding objects included in lists of registered monuments, were identified as objects with a particularly high flood risk potential.

The definition of potentially significant risk areas is checked for plausibility on the basis of expert knowledge.

5.1.2 Austria

1st cycle of implementation:

In Austria, APSFR were identified on the basis of the results obtained in the preliminary flood risk assessment. The aim was to identify areas where flood risk is of supra-local importance and has already actively been managed or should be managed in future.

The two highest risk classes (very high and high assessment of “total risk” in the PFRA) correspond approximately to the significant flood risk under Article 5. The minimum criteria for identifying APSFR are stretches of at least 1.5 km at “high flood risk” or any stretch of “very high flood risk”, respectively. For practical reasons these stretches can be combined to larger APSFR.

As a result, Austria identified 391APSFR with an average length of 7 km. More than half of the APSFR are already protected by structural defenses against floods up to a 30 years return period or higher.

2nd cycle of implementation:

Based on lessons learnt from the first cycle and uncertainties inherent to the assessment method the delineation method for APSFR in the 2nd cycle had been adjusted. To increase awareness and outline the responsibilities of municipalities in the frame of flood risk management the PFRA results had been published based on the indicator “potential affected inhabitants in the inundation area per municipality”. Based on this information APSFRs had been delineated along the river stem to identify relevant rivers and tributaries for further actions. As a more reliable information was available during the whole process, the number of APSFRs for the 2nd cycle slightly increased to a total number of 416 from 391 covering approx. 3000 km of rivers compared to 2700 in the 1st cycle of implementation in Austria.

5.1.3 Czech Republic

Methodology of identification of the areas with potentially significant flood risk addresses potential adverse consequences of future floods (Art. 4 d). The key factors taken into account were the number of permanent residents and the value of properties affected by designed floods of 5, 20 and 100 year return period. A year loss functions of different return periods helped to include the existing flood defenses (hydraulic structures) and then the matrix of APSFR variants helped to set up the thresholds: 25 inhabitants affected /year, 3 million EUR affected properties /year. Localities with potential sources of heavy pollution and national cultural heritage affected by designed flood of 100 yrs return period were taken into consideration as well. Comparing the extent of past significant floods (1997, 2002, 2006, and 2009) with the lists of priorities of Regions, a list of river sections defining the final APSFR was prepared. In the Czech part of the Morava river basin 583 kilometers of river sections were identified as APSFR. In the Czech part of the Vah river basin (Vlara catchment) 34 kilometers of river sections were identified as APSFR.

Described methodology has not changed for the 2nd cycle in general. Only the threshold of affected properties /year has been increased to 3.3 million EUR. In the Czech part of the Morava river basin 684 kilometers of river sections were identified as APSFR. In the Czech part of the Vah river basin (Vlara catchment) 34 kilometers of river sections were identified as APSFR.

5.1.4 Slovakia

The territory of Slovak republic was divided into many localities. For all localities past events are recorded. Data of flood potential scientific study of Comenius University by Minar et al. 2005 were added to the analyses. Mainly in localities without known past events and their adverse consequences was this type of data very important. Neighboring localities with same known past events or any expert synergy consideration were aggregated into common APSFRs. Spatially based adverse consequences were calculated for all aggregated regions. Comprehensive index and weighting system was applied. 195 APSFRs of almost 800 localities were identified as having potential significant flood risk within 2018 update.

5.1.5 Hungary

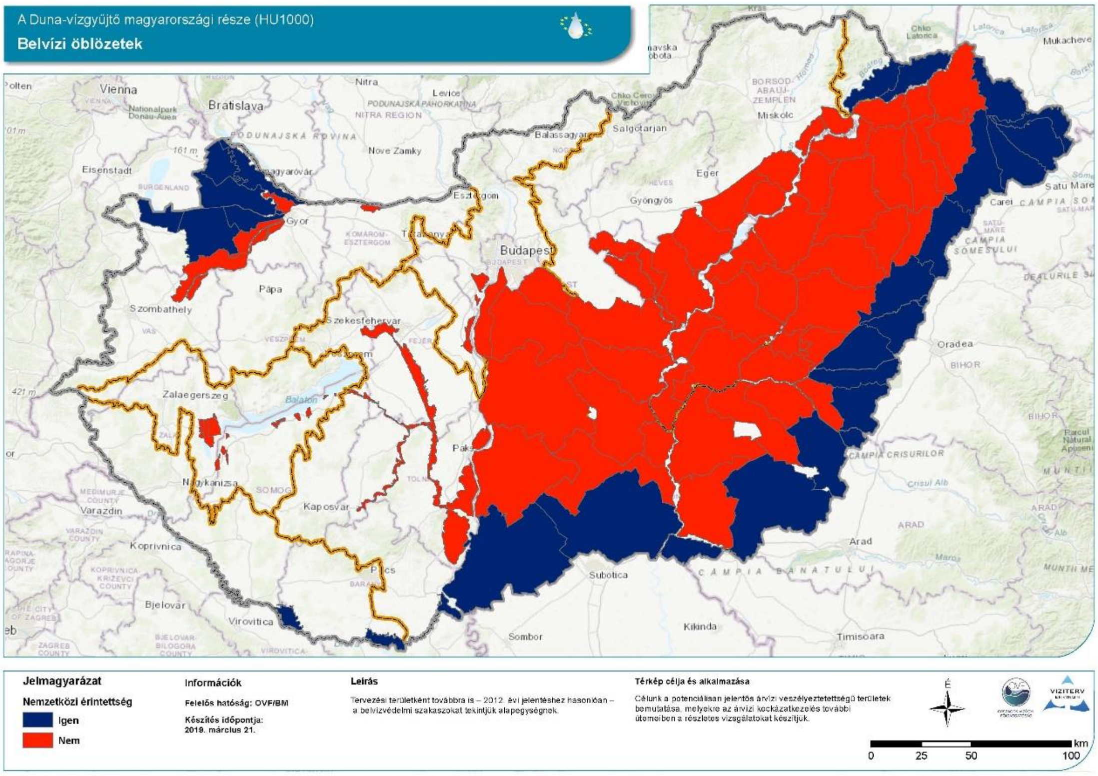
The aim of the preliminary flood risk assessment is the delineation of the areas designated for detailed analysis. The development of the methodology in the “ÁKK-2” project did not change the original national perceptions and adopted the 1st cycle designations with some modifications. Generally, it is concluded that the risk management measures only reduce the hazard probability or the magnitude of the risk but do not decrease the area to concern.

Along the river sections that are protected by dams, the endangered areas were defined first in 1977 (“ármentesített öblözetek” – floodproof embanked floodplains). The hazard mapping activities in the 1st cycle have redrawn these boundaries with the extent of the P=0,1% hazard map. Additionally the open floodplain areas introduced to the APSFR group. The number of the planning units is 187 and their summarized area is 19,402 km^2 that is about 21% of the whole country.

The flash flood prone areas delineated based on a study made by the University of Pécs in the 1st cycle. The results of the climate change studies led to increase the involvement of river courses in the execution. The number of the planning units is 118 and their summarized length is 3,367 km. Some of them indicated with only points in the annexed map due to the visualization criteria.

In case of excess waters, the original basis is the hazard map developed by Pálfai (Final excess water map of Hungary, ATIVIZIG 2001) and the national planning units are the official excess water management districts. These remained the same and the complex excess-water hazard index calculated horizontally. The number of the planning units is 91 and their summarized area is 44,587 km^2 that is about 48% of the whole country.

In the maps annexed to this present ICPDR document, the Hungarian excess water APSFR areas are not visualized. This is due to the fact they cover huge area of the country and hide other relevant patterns and it is a quite unique national phenomena anyhow which is hard to be compared to other countries' data. However, there are regions which have clear transboundary character. Bellow the original national report format can be investigated.



5.1.6 Slovenia

The potential flood risk areas classified by the risk potential index were the basis for selecting the areas of potential significant flood risk (APSFR). The criteria were based on classes for different damage potential as human health, environment, cultural heritage, economic activities. Classes were defined by a quantile method.

The APSFRs were classified by using 6 classes of loss potential, namely human health, environment, cultural heritage, economic activity, social infrastructure and infrastructure. The approaches were defined by the quantitative method. In view of the harmful consequences and potentially important environmental risks (natural resources, drinking water, natural reserves), potential flood risk areas have been identified, classified according to the risk potential index (those with a value of loss potential higher than 6 were taken into account). These areas were the basis for the selection of areas of potentially significant flood risk (APSFR). The criteria were based on classes for different loss potentials, such as human health, the environment, cultural heritage, economic activities.

The definition of APSFR is checked on the basis of expert knowledge and will be finalized in cooperation with the decision makers.

5.1.7 Croatia

For an administrative scope of each settlement, preliminary assessment of flood risks was undertaken and they were classified into four main categories of risk:

- High flood risk, which includes frequently flooded areas of settlements, large industrial complexes (outside of settlements), large infrastructural facilities, and waste disposal sites;
- Moderate flood risk, which includes defended areas of settlements, large industrial complexes (outside of settlements), large infrastructural facilities, waste disposal sites, and frequently flooded agricultural areas;
- Low flood risk, which concerns defended agricultural areas and other frequently flooded areas (pastures, forests, and the like);
- Insignificant flood risk, which concerns all other remaining areas.

The assessment of flood risk complexity was obtained based on the results of the priority weighting approach. In spatial terms, it was defined by overlapping the assessed areas under the impact of different types of floods, taking also into account the size of a settlement according to the following categories:

- Settlements with up to 100 inhabitants;
- Settlements with 100 – 1,000 inhabitants;
- Settlements with 1,000 – 10,000 inhabitants; and
- Settlements with more than 10,000 inhabitants.

Based on the assessed complexity of flood risks, a high flood risk was divided into two subcategories:

- Very complex high flood risk - when it concerns areas under the impact of several types of floods;
- High flood risk - other areas under high flood risk.

The above classification with sub-categorization is based on the provision of Article 115 of the Water Act, according to which the tasks of flood defence, ice defence, and protection from erosion and torrents are an emergency service. For that reason, it was already in the PFRA phase necessary to assess those areas where an increased risk might be expected due to the superimposition of adverse effects of different types of floods.

In the second cycle, several adjustments of methodology for designation of areas of potentially significant flood risk have been done in order to apply more systematic and transparent approach with better theoretical concept as well as to include additional data. New information such as flood hazard maps developed in first cycle of flood risk management, cultural heritage as well as future developments including results of regional climate change modelling and assessment of future regional economical activity intensification have been used in study. Assessment consists of three basic steps: assessment of preliminary flood risk, modification of preliminary flood risk and verification of areas of potential significant flood risk.

5.1.8 Serbia

Areas of potential significant flood risk are the areas along river sections, which were exposed to a significant flood in the past and/or are endangered by a potential future flood.

APSFR in the river basins with a catchment area above 4,000 km^2 (Danube, Sava, Tisza, Begej, Tamiš, Drina, Lim, Velika Morava, Zapadna Morava, Ibar, Južna Morava, Nišava and Timok) are considered as being the most significant. The total length of these rivers is about 2,500 km (measured in GIS, 1:300,000) and there are flood protection structures along these rivers with the length of about 1,650 km (Annual Plan for Flood Defence, 2011). Since the most of the riparian land along these rivers is protected from 100-year flood, floods had occurred in the past only locally or along the non-protected sections. However, the largest cities and many settlements are located in flood-prone areas and may be flooded in case of structures failure or overtopping. Therefore, most of the APSFRs at the largest rivers in Serbia were identified based on the criterion that floods may potentially occur in the future. Total length of APSFRs along these rivers is almost 2,000 km (measured in GIS, 1:300,000).

In addition, APSFR at smaller rivers were identified, mainly based on past floods.

List and map showing 99 APSFRs, which were identified for the territory of the Republic of Serbia, were published in the beginning of 2012 at the Ministry of Agriculture, Forestry and Water Management website (www.rdvode.gov.rs)..

5.1.9 Bosnia and Herzegovina

The APSFR in Bosnia nad Herzegovina (for FBiH and RS) was developed in three steps:

(i) The first step was to collect data. Municipalities in both entities were provided with "Flood Event Questionnaires". In PFRA for RS developed in 2014, immediately after flood event, flood lines were recorded on field with precise flood water levels using GPS technology.

(ii) The second step involved the development of a methodology. In both entities, the same basic criteria for the methodology for estimating significant flood risks were set. Flood risk was expressed through the flood risk index obtained by adding up all negative impacts, taking into account the extent of the flooded area and four impact categories required by the EU Floods Directive (human health, environmental protection, cultural and historical heritage, economic activities). Specific criteria of importance were assigned to these impact categories. All negative impacts were added together and if the total number of points for a single flooded area was 100 points or greater than the flood was considered **significant**. Flooded areas with over 500 points were rated as **very significant**. At the time of development of the PFRAs, data on depths and flow velocities were not known. Values were therefore assumed. Based on the above formulations, floods were classified into four categories.

Flood risk classification

Index	Significance
0-50	Not significant
50-100	Moderately significant
100-500	Significant
> 500	Very significant

(iii) In the third step, PFRAs were carried out, with the following results:

Federation of BIH: Floodplains on watercourses in Category I and II watercourses were identified in accordance with the defined classification. Floods were classified into historical and potential (floods that may occur in the future) and APSFRs were defined for the most vulnerable areas where the risk was considered to be significant or very significant.

Republika Srpska- Sava River Basin District: Flood areas for historical floods and potential future floods were defined as result of PFRA in Republika Srpska.

Postscript:

In November 2012, PFRA for Sava River Basin District has been prepared, which included the flood event in 2010. In June 2014, PFRA for Sava River Basin District was prepared that included the flood event in 2014. In March 2015, an Addition to the PFRA for Sava RBD– Flood Classification was prepared, where flood classification has been made by classifying historic and potential floods by classes: very significant, significant, moderately significant and not significant. APSFRs areas were defined in March 2016, as Addition to the PFRA 2014.

5.1.10 Romania

In the 1st Cycle of the implementation of the Flood Directive, the APSFR were selected taking into account:

- areas provided with flood protection works (with a dike length bigger than 5 km);
- results obtained in the PHARE project – „Contributions to the development of the flood risk management strategy";
- river sectors/subject areas of the significant floods of the past, respectively the envelope of these historical floods.

In the 1st Cycle, for the APSFR for which there was no physical assessment of the damages and no monetary assessment, the localities, the affected population, transport infrastructure and agricultural land were evaluated using statistical methods based on information from CORINE Land Cover and supplemented with data on important socio-economic objectives.

In the 2nd Cycle of implementation, the methodology for establishing APSFR has been improved taking into account the following general principles:

- evaluation of significant historical events indicating that the area is currently at risk of flooding or recurrent flooding; compared to the significant historical floods selected, where a minimum threshold was used for the socio-economic indicator of 50, in the case of APSFRs only the river sections were selected for which the population criterion ($I_p > 0$) and/or the socio-economic criterion $I_{s-e} > 200$;

- the assessment of the potential risk to the floods indicates that the area is considered to be of national or critical strategic importance in case of major emergencies (such as affecting hospitals, international airports, schools, transport infrastructure etc.);
- expert judgment method (areas subject to severe flood risk) that can be confirmed by detailed national level analyses.

In order to determine the APSFRs, information currently available has been taking into account, such as:

- river sections established as APSFR in first cycle of the Flood Directive implementation;
- the sections of the watercourses on which significant historical floods occurred during 2010-2016;
- areas that were identified as being affected by significant historical floods after the implementation of Cycle I of the Flood Directive, respectively after 2012, and which met the hazard and risk criteria taken into account when defining APSFRs at national level in cycle I; these were identified during the elaboration phase of FRMPs;
- the spatial extension of the hazard for flash-floods and important run-off on the slopes, torrents, streams, as well as the related risk;
- the results obtained within the VULMIN project ("Vulnerability of settlements and the environment to floods in Romania in the context of global environmental changes - 2012-2017, respectively sections of water courses susceptible to flash-floods);
- localities affected by floods from abundant short/long-term rainfall and poor drainage;
- areas susceptible to flooding, in the form of flood envelopes resulting from modelling with Fuzzy - GIS GRASS systems and applying some GIS processing methods to the DTM;
- spatial data for assessing the potential impact of the flood (potential consequences).

As a consequence, the establishment of APSFR in the second cycle of reporting, as well as the extension of some sections APSFR from Cycle I, were based on:

- significant historical events that occurred during 2010-2016, and which consequences had values of $I_p > 0$ or $I_{s-e} > 200$;
- expert judgement and local knowledge of water courses regarding flood risk; confirmed by the following sources:
  - Spatial extension of the hazard for flash-floods and significant run-off on the slopes, torrents, streams, as well as the associated risk (Risk FF=3-5 or Hazard FF=5);
  - the IFF susceptibility index from the VULMIN project (IFF = 3-5);
  - significant historical floods with low impact, I_{s-e} = 50-200;
- areas that were identified as being affected by significant flooding during the elaboration phase of FRMPs from first cycle, confirmed by the two analyses mentioned above.

In addition, APSFR established in the 1st cycle were analysed in correlation with the presence or absence of vulnerable localities and other risk receptors in order to eliminate small subsectors that do not present a major risk.

5.1.11 Bulgaria

Preparation of APSFR is still ongoing. Only preliminary results are shown in the chapter 5.2.

5.1.12 Ukraine

Identification of APSFR includes the areas in each river basin district (as well as territories along flood prone watercourses) for which at least moderate potential significant flood risk already exists or might be considered likely to occur.

The analysis of past floods in the Danube River Basin and the level of emergencies and the probability of exceedance of absolute water level marks with adverse consequences allowed identifying the risks of potential flooding. Totally 47 APSFRs were identified in Danube RBD in Ukraine with total length 1993 km.

5.1.13 Moldova

For the determination of the flooded areas, the risk marking scheme is being used. The risk marks are set according to the previous floods. It is not clear when the APSFR data will be finalized in Moldova.

5.2 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.

The data on APSFR were agreed to be provided in the following geometry types:

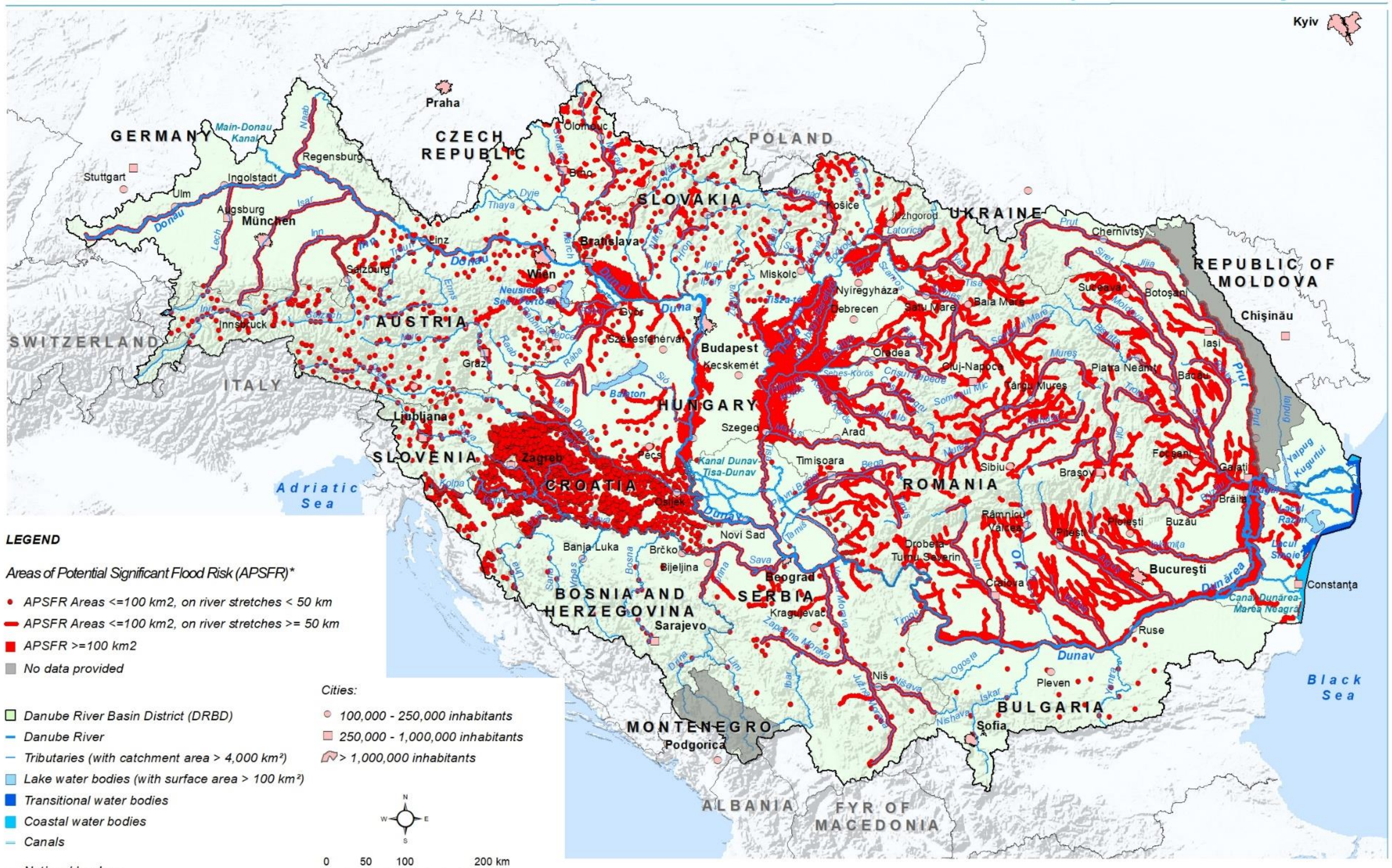
Polygon: Recommended for areas >= 100km^2

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 shows the status as of October 2019. Moldova and Montenegro did not deliver their APSFR data.

Danube River Basin District: Preliminary Flood Risk Assessment (PFRA) - 2019 data update



* The information about APSFR in Bulgaria is not final due to uncompleted activities on PFRA and APSFR designation.

This ICPDR product is based on national APSFR information provided by Contracting Parties to the ICPDR (AT, BA, BG, CZ, DE, HR, HU, RO, RS, SI, SK and UA). More details on the methodologies used for identification of APSFR at the national level and the definition of significance criteria are provided in the report "Preliminary Flood Risk Assessment in the Danube River Basin", chapter 5.1. National borders data was provided by the Contracting Parties to the ICPDR and CH; ESRI data was used for national borders of AL, ME, MK; Shuttle Radar Topography Mission (SRTM) from USGS Seamless Data Distribution System was used as a background layer; Data from the European Commission (Joint Research Center) was used for the outer border of the DRBD of AL, IT, ME and PL.

Vienna, January 2020

6 Revisions during the 2nd flood risk management cycle

6.1 Germany

According to the method, described in chapter “2.1. Germany”, the revisions during 2nd cycle brought the same result in the preliminary assessment of the Danube basin in Germany for A-level. Therefore, the water body network, considered to have a potential significant flood risk remains the same, compared to the result of the 1st cycle.”

6.2 Austria

The implementation of the FD in 6-years cycles allows a review of methods and decisions and, therefore, enables an update referring to lessons-learnt or new data availability where necessary. This approach shall increase and ensure the planning accuracy and acceptability. In the frame of the 1st cycle implementation in Austria the need for improvement referring to data accuracy and data availability was identified. Therefore, a process to improve the hazard data was initiated to ensure reliable flood hazard and risk maps. Further, the accuracy of exposure data increased significantly having real time object related data accounting for permanent and non-permanent residency at hand. This enables the authorities to assess potentially affected people in the inundation areas with higher accuracy.

Besides the assessment of fluvial flood risk, a focus in Austria was put on pluvial flood risk as well. For this purpose, a hazard indication map was elaborated and published. This primarily aims at increasing the awareness of people at potential risk but also decision makers on municipal level to take further actions if these indicated areas are to be developed.

Based on the assessment of potentially affected people numerous further information was provided to insure the inclusion of regional knowledge but, importantly, as well local expertise. Based on the improved data availability and accuracy as well as adapted methodology 416 APSFR had been delineated in Austria for further consideration in the frame of FD implementation.

6.3 Czech Republic

There was available information about flood extent for high and medium probability on other river stretches for the 2nd cycle. Percentage of inhabitants living in a potential flood risk with medium probability and the value of major types of properties being at risk have slightly declined (tenths of %).

APSFR methodology has not changed for the 2nd cycle in general. Only the threshold of affected properties /year has been increased to 3.3 million EUR. In the Czech part of the Morava river basin 684 kilometers of river sections were identified as APSFR. In the Czech part of the Vah river basin (Vlara catchment) 34 kilometers of river sections were identified as APSFR.

6.4 Slovakia

Slovakia has changed spatial view on APSFRs. The small isolated 1st cycle APSFRs have been aggregated into larger interconnected and more synergic 2nd cycle APSFRs. The 1st cycle APSFRs are called localities and these became a base group for evaluation. Altogether 588 1st cycle APSFRs were analysed. 70 localities were eliminated either due to already constructed measures or due to having been assessed as having insignificant flood risk. The rest of 518 localities remained for the 2nd cycle. Together with the newly identified localities they create 195 APSFRs of the 2nd cycle.

Overall methodology was revised, more parameters were taken into account and more detailed data were used. The hydraulic modelling was used for delineation of flood extent for most of APSFRs and the adverse consequences were calculated on a spatial basis and for all consequence groups.

6.5 Hungary

There were no changes during 2nd cycle in Hungary.

6.6 Slovenia

During the first cycle of implementation of the EU Flood Directive, the Republic of Slovenia prepared and adopted the Preliminary Flood Risk Assessment (PFRA) with identified areas of potential significant flood risk and prepared flood hazard maps and flood risk maps.

In 2016, it entered the second cycle of implementation of the EU Flood Directive, which, as the first of its activities, undertake the revision of PFRA. Revised PFRA in addition to the information from the first assessment (2011), also includes:

- new and additional records and flood events descriptions with different types of damage consequences (for the post-2011 flood period);
- upgraded analysis of maximum flows in the Republic of Slovenia;
- additional graphic material of recorded floods in the past;
- verification of the impacts of climate change on the occurrence of floods;
- verification and upgrading of the designation of APSFR)

In the middle of December 2018, the Ministry of the Environment and Spatial Planning presented a proposal for an updated document for the preliminary flood risk assessment in the context of a public consultation:

http://www.mop.gov.si/si/delovna_podrocja/voda/zmanjsevanje_poplavne_ozrozenosti/posvetovanje_z_javnostimi_2018/

Within the scope of this consultation, comments and suggestions were received. Based on the comments, improved data availability and accuracy as well as adapted methodology 86 APSFR (75 APSFR within the Danube RBD) had been delineated in the Republic of Slovenia for further consideration in the frame of FD implementation. The final version of PFRA with updated APSFR was published in June 2019 and is available on the following link:

http://www.mop.gov.si/si/delovna_podrocja/voda/zmanjsevanje_poplavne_ogrozenosti/predhodna_ocena_poplavne_ogrozenosti_republike_slovenije_2019/

6.7 Croatia

Application of upgraded methodology with more comprehensive set of data have resulted in minor increase of designated areas of potential significant flood risk. Regarding the Danube river basin in Croatia, in comparison to previous cycle, additional 13% of area inhabited with 10% population have been included and at the same time 2% of population occupying 5% of area have been excluded in the process of designation, resulting in overall increase of areas of potential significant flood risk for 8% of area and population.

6.8 Serbia

The preliminary flood risk assessment and the resulting areas of potential significant flood risk will be reviewed and if necessary updated by 1 December 2019.

6.9 Bosnia and Herzegovina

Bosnia and Herzegovina is currently in the phase of producing flood hazard maps and flood risk maps on basis of which the first flood risk management plan will be prepared.

6.10 Romania

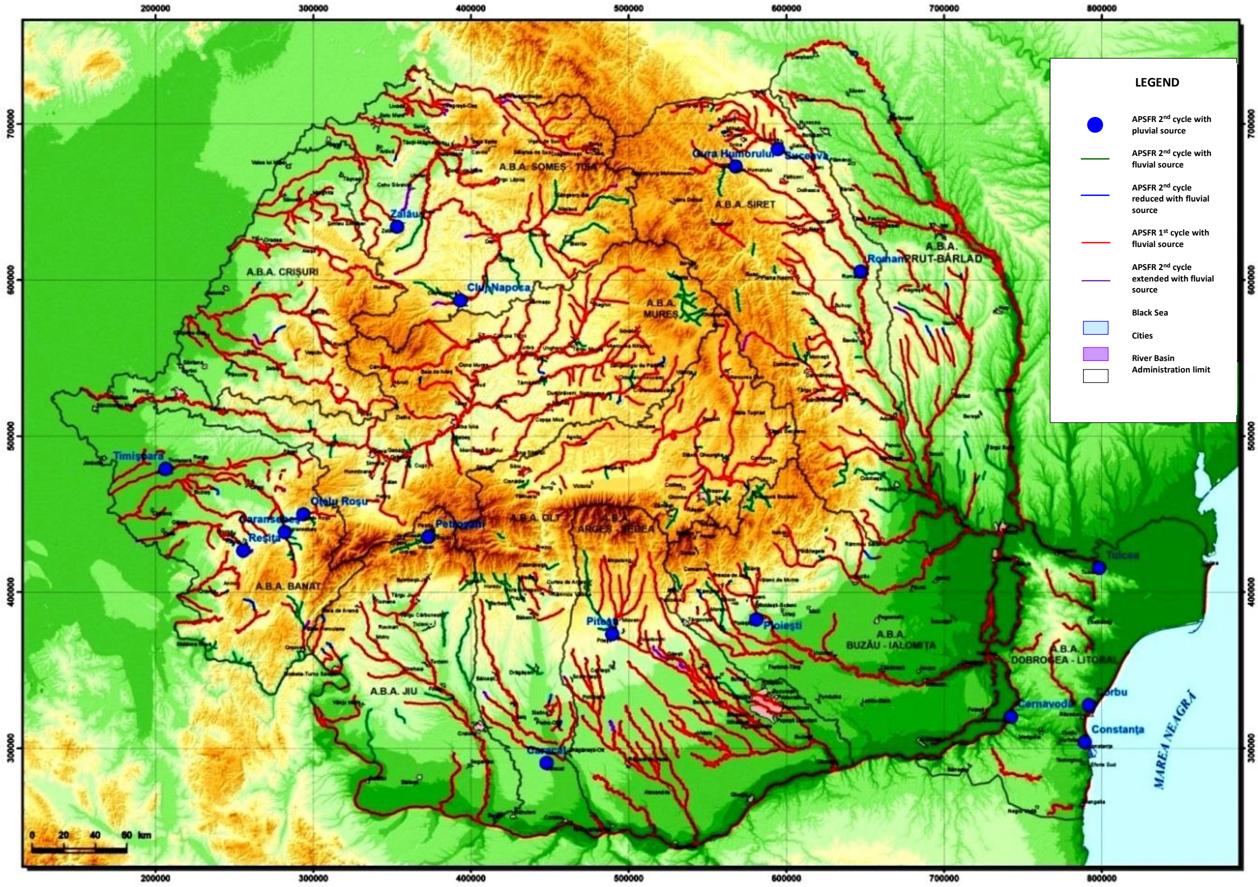
The application of the *Methodology regarding the designation of the areas with potentially significant flood risk (APSFR)* led to the identification in the 2nd FD implementation cycle of 153 areas with a significant potential risk to floods at national level, which was added to the 373 identified areas within the first Cycle, resulting in an increase by 41 %.

Within this stage of implementation of the Floods Directive, APSFRs from fluvial sources as well as from pluvial sources were identified. Thus, out of the 153 new areas, 136 are at potentially significant risk from river-type floods and 17 are at potentially significant risk from pluvial-type floods (localities). For this reason, from the point of view of the length of the sectors, the increase is 1962 km (around 10 %), from 17,520 km to 19,482 km).

The 136 new sections of APSFR have a length of 1,861.6 km.

In addition, during this reporting phase, the APSFRs designated in the first reporting cycle were re-analysed, and 69 APSFR zones have undergone modifications as follows:

- 36 APSFRs were extended by 273.2 km;
- 31 river sectors of river were reduced in length, resulting a decrease of 172.9 km in total;
- 2 areas were merged because they were located along the same river and had continuity.



7 Addressing the impacts of climate change

The FD established that the potential impacts of climate change shall be considered within the preliminary flood risk assessment from the second planning cycle, based on the available information. There are likely to be challenges and limitations on the degree of consideration of climate change in undertaking the preliminary flood risk assessment (PFRA), particularly in the first cycle, given the qualitative rather than quantitative information that may be available or readily derivable. This knowledge is foreseen to be improved in the second cycle (after the first flood hazard/risk maps and flood risk management plans).

To ensure climate change is properly considered in the reviews of the preliminary flood risk assessment, including the subsequent identification of areas of potential significant flood risk, WFD CIS Guidance Document 24 recommends to:

- always use latest available (yet robust) information;

- identify “climate change hot spots” which should be subject to more detailed checks and which can serve as trend detection areas and indicators of the vulnerability of certain regions. The need for reassessments shall be considered in each review period;
- exchange information between MS on climate change impacts, not just between MS sharing water courses but also at a wider scale, so as to raise awareness on changes noted.

To utilize the synergy between preliminary flood risk assessment activities and the investigation of impacts of the climate change WFD CIS Guidance Document 24 suggests following actions:

- Understand and anticipate as far as possible climate change impact on floods;
    - Monitor changes to flood patterns by gathering comprehensive information on past floods - consider development of a “past floods database at European level”;
    - Develop a structure for gathering information on past and new floods;
    - Improve trends detection, using the information gathered over the implementation cycles detecting trends of changing flood patterns;
- Use best available information;
    - Anticipate and improve readily available information;
    - Use monitoring under WFD on flows, physical modifications, pressures and impacts, etc.;
    - Consider what is "available and readily derivable information" today and what is foreseen to be "available and readily derivable information" in future;
    - Exchange information with the insurance industry, as well as land use and spatial planners;
    - Make the best use of review cycles of PFRA;
    - Continue further best practice exchange on how to incorporate climate change information in the PFRA at European level;
- Homogenize time series, and remove bias as far as possible;
    - Remove bias from time series and use time series that are as long as possible;
- Understand and anticipate as far as possible increased vulnerability and flood risk due to climate change;
    - Take climate change into account when assessing the effectiveness of existing man-made flood defense structures;
    - Be transparent in the use of “worst case” scenarios – take latest available climate change information into consideration;

The ICPDR developed its first “Strategy on Adaptation to climate Change” in 2012, which was based on a Danube climate change adaptation study, that summarized all of the relevant findings about climate change in the Danube River Basin until 2012.

In 2018, the ICPDR convened the Climate Change Workshop at which the updated study on “Integrating and editing new scientific results in climate change research and the resulting impacts on water availability to revise the existing adaptation strategies in the Danube River basin” was presented. Using the outcomes of the study and the Workshop the update of the “Strategy on Adaptation to Climate Change” has been elaborated and it has been adopted by the ICPDR in December 2018.

The ICPDR Strategy on Adaptation to Climate Change aims at offering guidance on the integration of climate change adaptation into ICPDR planning processes. Further, it promotes multilateral and transboundary cooperation action in the context of climate change adaptation and serves as a reference for national policy makers and other officials.

- ICPDR Climate change adaptation strategy highlights the following guiding principles for adaptation to climate change in the preparation of the preliminary flood risk assessment: Understand and anticipate as far as possible climate change impact on flood patterns.
- Use best available information and data.
- Homogenize time series, and remove bias as far as possible.
- Understand and anticipate as far as possible increased exposure, vulnerability and flood risk due to climate change, for establishing areas of potential significant flood risk

These principles are being followed by the ICPDR Contracting Parties when updating the preliminary flood risk assessment.

8 Transboundary coordination & information exchange

FD Article 4(3) stipulates that in the case of international river basin districts, or units of management referred to in Article 3(2)(b) which are shared with other Member States, Member States shall ensure that exchange of relevant information on the preliminary flood risk assessment takes place between the competent authorities concerned.

In accordance with the Article 5(2) the identification of areas of potential significant flood risk belonging to an international river basin district, or to a unit of management referred to in Article 3(2)(b) shared with another Member State, shall be coordinated between the Member States concerned.

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 below.

8.1 Germany

The coordination of the regions with a potentially significant flood risk was carried out bilaterally between the Republic of Austria and the Free State of Bavaria at the level of the Bavarian State Ministry of the Environment and Consumer Protection and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management by the Working Group of Experts under the title “Protection and Management of Waters” [Schutz und Bewirtschaftung der Gewässer] of the Standing Committee on Management of Water Resources based on the Regensburg Treaty. Coordination with the Czech Republic was carried out within the framework of the meetings of the Standing Bavarian Committee for the Bavarian Border Section of the German-Czech Transboundary Water Commission [Ständiger Ausschuss Bayern für den bayerischen Grenzabschnitt der deutsch-tschechischen Grenzgewässerkommission].

8.2 Austria

The exchange of relevant information and the coordination of the APSFR were mainly conducted at the level of the bilateral river commissions that already existed between the Republic of Austria and the neighboring countries: Slovenia, Hungary, Slovakia, Czech Republic and Germany. Mutual information was exchanged in the relevant Working Groups of Experts and/or in the Water Management Committees according to the relevant bilateral treaty.

8.3 Czech Republic

The Czech Republic shares its waters in the Danube River Basin with Austria, Germany and Slovakia. Bilateral border commissions were established to manage transboundary coordination and have discussed the implementation of FD including PFRA and APSFR and exchanged information during last two years. Besides those meetings, a trilateral conference was organized addressing the international cooperation in the water management and flood protection within the border area of Morava sub basin.

8.4 Slovakia

Cooperation, harmonization and data exchange on transboundary rivers is being carried out based on intergovernmental agreements with Czech Republic, Hungary, Poland and Ukraine and intergovernmental treaty with Austria through the International Border Water Commissions. Different Working Groups established within the frame of the International Border Water Commissions prepare and approve the directives and guidelines on data exchange and flood protection and specify and modify individual articles of intergovernmental agreements and intergovernmental treaty.

8.5 Hungary

The international cooperation is organized through pilot projects as well as by bilateral activities via transboundary river commissions.

In 2010, Romania was informed about the PFRA methodology & developments that took place in Hungary. An international conference was held in 2010 with participation of Austrian and Croatian experts. In 2011, an expert-level consultation was held with Austria on the preliminary flood risk assessment.

The initiatives are ongoing that the transboundary river commissions should make in bilateral agreements a record of the areas of common concern, for which the strategic flood management plans have to be jointly elaborated.

8.6 Slovenia

Information exchange of methods for PFRA and definition of APSFR took place at the level of:

- AT/SI and HR/SI commission for river Mura;
- Permanent SI/AT and SI/HR commission for Drava ;
- HU/SI bilateral commission;
- ICPDR and ISRBC meetings.

8.7 Croatia

Transboundary APSFRs in Croatia should be jointly identified for the Danube (Croatia, Hungary, and Serbia), Drava (Croatia, Slovenia, and Hungary), Mura (Croatia, Slovenia, and Hungary), Sava (Croatia, Slovenia, Bosnia and Herzegovina, and Serbia), Kupa (Croatia, Slovenia) and Una (Croatia, Bosnia and Herzegovina) rivers through the existing bilateral or multilateral commissions (ISRBC).

In this context, joint projects were initiated in the framework of bilateral commissions with Hungary and Slovenia on the Drava and Mura rivers, whereas joint projects in the Sava river basin are prepared and implemented in the framework of the ISRBC.

8.8 Serbia

APSFRs were identified at transboundary rivers: the Danube (being common with HU, HR and RO), Tisza (HU), Sava (HR and BA), Tamiš (RO), Drina and Lim (BA, ME), Timok and Nišava (BG).

PFRA information exchange with the countries in Sava river basin was done in the frame of ISRBC. Also, some projects as JoinTisza and Danube Floodplain were used as a platform for infomation exchange.

8.9 Bosnia and Herzegovina

Bosnia and Herzegovina has signed a bilateral agreement on cooperation in the area of water management with the Republic of Croatia. The activities on bilateral agreements with the Republic of Serbia and Montenegro are under preparation. In addition, the transboundary coordination is ensured through the activities of the international river basin commissions (ICPDR, ISRBC)

The examples of ongoing projects are as follows:

- Drina flood protection project,
- IPA 2014 Flood recovery – national component,

- IPA 2014 Flood recovery – Regional Programme for Bosnia and Herzegovina and Serbia,
- Flood hazard and flood risk maps project in Bosnia and Herzegovina,
- West Balkan Drina river basin management project,
- Support to water resources management in the Drina river basin,
- Technology transfer for climate resilient flood management in Vrbas River Basin,
- IPA FLOODS- The Programme for Prevention, Preparedness and Response to Floods in the Western Balkans and Turkey,
- FLOODS EMERGENCY RECOVERY PROJECT,
- Una-Sana early warning forecasting system.

The projects on

- Improvement of joint flood management actions in the Sava river basin - Component 1: Flood Risk Management Plan for the Sava River Basin,
- Improvement of joint flood management actions in the Sava river basin - Component 2: Flood forecasting and warning system for the Sava River Basin,

have been successfully completed.

8.10 Romania

The information exchange and transboundary coordination in water management sector is achieved through bilateral commissions established with the neighbouring countries as well as in the frame of the ICPDR through its Flood Protection Expert Group and international projects (i.e. Jointisza and Danube Floodplain)

Romania has adopted intergovernmental agreements on cooperation and sustainable use of transboundary waters with Hungary, Ukraine, Serbia, Bulgaria and Moldova.

8.11 Bulgaria

The areas with potentially significant flood risk in Bulgaria are in a process of being delineated. Steps regarding the information exchange with the neighboring countries are undertaken. For the Danube River Basin, the transboundary coordination is conducted mainly in the frame of the ICPDR activities and of the Joint Commission on Water Management between Republic of Bulgaria and Romania. Issues requiring a transboundary coordination will be dealt with in the Expert Groups in the frame of the Joint Commission.

8.12 Ukraine

At present, the identification of transboundary APSFR is not discussed. Information exchange on coordination of the APSFR identification with the neighboring countries is expected to be carried out by the Working Groups within the existing bilateral agreements with Slovakia, Hungary and Romania.

8.13 Moldova

Because the Prut River flows through the territory of Ukraine, Romania and Moldova, there is a cooperation agreement on information exchange between these countries. At present, the identification of transboundary APSFR is not discussed. Information exchange on coordination of the APSFR identification with the neighboring countries is expected to be done by the Working Groups within the existing bilateral agreements with Ukraine and Romania.

9 Supporting transboundary activities

This chapter provides not only examples of pilot projects addressing the transboundary issues of preliminary flood risk assessment but it informs on the international activities addressing wider aspects of flood risk management at the regional and basin-wide level. Information on bilateral activities is provided in the national reports.

9.1 Danube Floodplain

During the last decades, Europe suffered major catastrophic floods along the Danube. Therefore, the Flood Directive asks for adequate and coordinated measures to reduce flood risk without conflicting WFD objectives. The main objective of the project is improving transnational water management and flood risk prevention while maximizing benefits for biodiversity conservation. The expected change is improved knowledge, among the countries located within Danube River Basin, related to integrative water management through restoration of floodplains, combination of classical and green infrastructure, natural retention measures, involving all related stakeholders. The main activities of the project are: updating the floodplain areas inventory and their ranking using the Floodplain Evaluation Matrix-FEM; assessing, by using the pre-selected pilot areas, of the efficiency of floodplain projects in the Danube District and developing tools for increasing the knowledge and cooperation of experts, practitioners, decision makers and stakeholders on floodplain restoration.

The Project will develop the following tools: 1) The Danube basin wide floodplain restoration and preservation manual addressed mainly to practitioners; 2) A DRB Sustainable Floodplain management Strategic Guidance summarizing the key findings of the manual targeting a wider audience; 3) A DRB Roadmap comprising agreed next steps towards realizing floodplain projects. The ICPDR which is the major platform for cooperation in flood risk management and river basin management in the DRB, through its experts will be supportive to this project in helping to achieve its goals and also in transferring the outputs. The main project target groups are ministries, river basin authorities, practitioners and stakeholders.

9.2 Danube Sediment

The main objective of this project is to improve Water and Sediment Management as well as the morphology of the Danube River. To close existing knowledge gaps, sediment data collection will be performed providing information to the sediment data analysis and will lead to a handbook on good practices of sediment monitoring methods. Furthermore, a baseline document on the Danube Sediment Balance will be prepared, which explains the problems, which arise with sediment discontinuity negatively influencing flood risk, inland navigation, ecology and hydropower production. Possible answers to these problems will be provided by a catalogue of measures. The main outputs of the project are the first Danube Sediment Management Guidance comprising measures to be implemented and a Sediment Manual for the stakeholders consisting of approaches how to implement the measures, which deliver key contributions to the Danube River Basin Management Plan and the Danube Flood Risk Management Plan.

Project duration is 01/2017-06/2019 (30 months). Project Budget is 3.56M EUR. The Lead Partner is Budapest University of Technology and Economics. ICPDR is an Associated Strategic Partner (ASP) in this project. The official kick-off meeting took place on 11 April 2017.

The Internal Handbook, Communication Plan and stakeholder mapping have been completed. Internal & external newsletters have been produced. WP3 on sediment data collection has been finished. Comparative analysis of suspended sediment sampling has been carried out. Handbook on Good Practices in sediment monitoring has been issued. Sediment balance has been assessed under WP4. DPSIR concept has been developed under WP5. It includes sediment - flood risk management link. Danube Sediment Management Guidance and Sediment Manual have been elaborated.

The project video is online:

http://www.interreg-danube.eu/news-and-events/project-news/3734

ICPDR is an Associated Strategic Partner (ASP) in this project.

9.3 DAREnet

The DAREnet project is to support flood management practitioners across the Danube River region and from different disciplines to deepen and broaden their Research, Development and Innovation related collaboration (=RDI). DAREnet will build a multi-disciplinary community of practitioners, operating in a network of civil protection organisations, and supported by a broad range of stakeholders from policy, industry and research. Together they will build a transnational and interdisciplinary ecosystem to foster synergies, innovation and its uptake.

ICPDR will provide DAREnet with the technical and political feedback on the project deliverables from the flood risk managers and experts in the Danube countries. ICPDR will make use of the DAREnet outcomes in order to contribute to the Danube Flood Risk Management Plan update 2021.

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

The Coca-Cola Foundation, Coca-Cola system and WWF are working in a seven year partnership to restore vital wetlands and floodplains along the River Danube and its tributaries. The project aims to restore 53 km² of wetland habitat in the Danube region by 2020. The ICPDR is observer in the Steering Group of the partnership.

The partnership is working closely with local stakeholders and relevant authorities to connect river stretches, side-branches or other floodplains areas to the river system by mainly opening dams, installing or modernising sluices for water retention, improving water supply channels or building fish-pass. At the same time, a regional movement is being created for wetland conservation and restoration, as well as good water stewardship.

The regional program includes nine restoration projects in six countries covering Hungary, Croatia, Serbia, Romania and Bulgaria, as well as a project in Austria. Until 2018, projects have been completed at three sites at Neusiedler See in Austria, on Danube tributaries in Bulgaria and Siroki Rit in Serbia, another six are in various stages of development.

The partnership was introduced to the ICPDR and officially launched in the frame of the 12th Standing Working Group Meeting in June 2014.

9.5 DAREFFORT – Danube River Basin Enhanced Flood Forecasting Cooperation

The project shall create a system that would be not possibly to be established without a common project in the catchment. The end product has multi-layer relevance:

- Nation-wide benefits for forecasting
- Cross-border issues can be solved via the system
- Basin wide unified system would be created
- EU Flood Directive measure is applied at once along the Danube

The project will result in a cheaper, easier and flexible data exchange system and long-term sustainability is guaranteed through the ICPDR. The project would use the existing tools and materials, not much new purchases are needed (mainly IT).

The main goal of the project is to enhance the access to the recorded data and to provide coherent distribution to all countries in the Danube catchment. The aim is to support the development of the DanubeHIS (ICPDR) and provide a long-term development perspective for the sufficient conditions of proper basin-wide hydrological forecasting.

9.6 FRISCO

The common Slovenian and Croatian transboundary flood risk management project addresses the flood risk at all Slovenian-Croatian borderline rivers (Kolpa/Kupa, Bregana, Sotla/Sutla, Drava, Mura and Dragonja rivers). Project duration was April 2016 – April 2019. All of these rivers are part of the Danube River Basin except for the Dragonja River.

More information is available at: https://frisco-project.eu/en/

9.7 GoMURa

The project goMURra is the continuation of many years of cooperation and joint activities of the official institutions of Slovenia and Austria in the field of water management, which operate under the bilateral commission for boundary waters. With the implementation of the project, the border Mura River will be visibly transformed into a river that connects. The work packages of the project include harmonized measures for the improvement of water management and flood protection – on a strategic level by developing a cross-border management plan of the border Mura River until 2030 and on local level with the implementation of flood protection measures. These measures will be supported by a targeted publicity and information campaign. The aim is to strive to improve the living environment and life situation of people living next to and on the river and thereby promoting joint life of neighbours on both sides of the Mura River. More information is available at http://www.si-at.eu/en2/gomurra/

9.8 Copernicus European Flood Awareness System EFAS for the Danube

The aim of EFAS is to support preparatory measures before major flood events strike, particularly in the large trans-national river basins such as the Danube. EFAS is the first operational European system monitoring and forecasting floods across Europe. It provides complementary, added-value information (e.g. probabilistic, medium range flood forecasts, flash flood indicators or impact forecasts) to the relevant national and regional authorities. Currently 21 national or regional authorities from the Danube river basin have access to EFAS forecasts and receive the Danube wide EFAS warnings. Furthermore, EFAS keeps the Emergency Response Coordination Centre (ERCC) of the European Commission informed about ongoing and possibly upcoming flood events across Europe. Since 2012 EFAS is running fully operational as part of the Copernicus Emergency Management Service.

More information is available at: https://www.efas.eu/en

9.9 CROSSRISK

Risks related to rain and snow belong to the key challenges in the SI-AT programme region. This has been demonstrated by floods in September 2010, large avalanches in February 2009, or snow load damages in spring 2016. However, forecasts and warnings related to such events are currently not harmonised across the Austrian-Slovenian border and the warning institutions partly lack financial and personal resources to sufficiently develop their tools to the current state-of-the-art. Since both countries face similar challenges and since weather processes, natural hazards, and human activities don’t stop at national borders, the proposed project CROSSRISK will pool expertize and foster joint development in the field of forecast and warning of rain- and snowfall-related risks. Consequently, synergistic effects will be exploited and high cost-efficiency will be achieved on both sides of the border. The general goal is to improve safety of population and to better protect infrastructure in the programme region. In addition, tourism will be supported by raising awareness of opportunities and risks, e.g., by improved communication of safety information for backcountry tourists, or by improved forecasts of technical snow production potential. Consequently, many target groups (local/regional/national authorities, companies, NGOs, citizens, and tourists) will benefit from the project. Major project outputs are improved forecasts and warnings concerning rain, floods and snow, their cross-border harmonization and the improvement of their comprehensibility, availability and dissemination. In addition, the information flow between relevant institutions in both countries will be improved and the qualification of their experts will be raised. The innovative aspects of CROSSRISK are novel and harmonised warning tools as well as innovative dissemination and education concepts, which will lead to better awareness of risks and chances in the target groups and consequently to more safety.

10 Conclusions

This report presents the preliminary flood risk assessment in the Danube River Basin District and shows on a map the areas where potential significant flood risk exists. This is the first practical outcome of a key basin-wide activity in flood risk management that follows the provisions of the Danube Declaration adopted in 2016 by the Danube Ministers. This Declaration recognized that 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. The preliminary flood risk assessment is thus an important step towards a sound flood prevention, protection and mitigation through appropriate measures in accordance with the EU Floods Directive.

The report presents information on major flood events that occurred in the Danube River Basin District focusing primarily on the last two decades. It summarizes 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 EFD 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 provides 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 are 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 sets 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 provides the public and stakeholders with an important evidence that the areas with potential vulnerability to flood hazards in the Danube River Basin are being taken care of for the benefit of all inhabitants and countries of the Danube River Basin.