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PART 2/2

COMMISSION STAFF WORKING DOCUMENT

European Overview- 2nd Preliminary Flood Risk Assessments

Accompanying the document

REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

on the implementation of the Water Framework Directive (2000/60/EC), the Environmental Quality Standards Directive (2008/105/EC amended by Directive 2013/39/EU) and the Floods Directive (2007/60/EC)

Implementation of planned Programmes of Measures
New Priority Substances
Preliminary Flood Risk Assessments and Areas of Potential Significant Flood Risk

{COM(2021) 970 final} - {SWD(2021) 970 final}

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8 Transboundary co-operation

8.1 Information exchange and types of transboundary cooperation

In their reporting for the second cycle, Member States are required to provide information on the methodology for international information exchange relating to PFRAs and APSFRs that cross international boundaries. Article 4.3 of the FD states where international river basin districts or units of management exist which are shared with other Member States, exchange of relevant information relating to the undertaking of PFRAs shall be ensured between the Competent Authorities concerned. Further to information exchange during the PFRA phase, where an APSFR belongs to an international River Basin District or UoM shared with another Member States, the designation of these areas shall be coordinated between the Member States concerned.

There are 75 international River Basin Districts in the EU. International coordination mechanisms (agreements, working groups etc.) vary among the different international river basin districts. Based on their level of cooperation, four main categories were identified. An overview of different types of international cooperation is given in Table 12 below[1].

Table 12: Different categories of international coordination

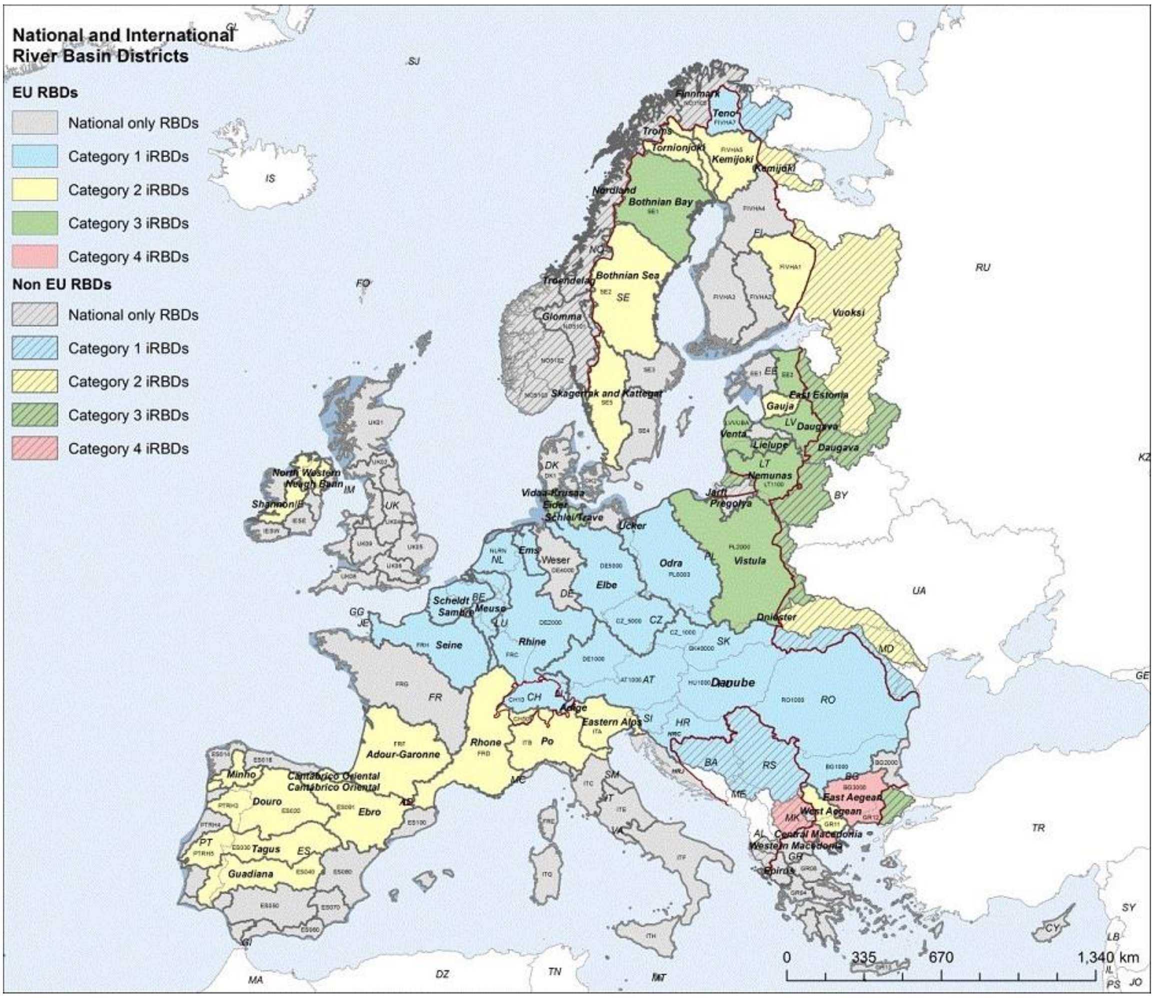
Category	Formal international agreement	International coordinating body	iRBMP produced
1	Yes	Yes	Yes
2	Yes	Yes	No
3	Yes	No	No
4	No	No	No

The international RBDs/UoMs are shown in Figure 49.

Member States were asked to report the mechanisms used for international cooperation and collaboration for the preparation of the PFRA (Figure 50) and in the designation of APSFRs (Figure 51). It should be noted that Member States are only required to report on the latter where transboundary APSFRs have been identified. It is clear that the International River Basin Commissions have an important role to play in co-ordinating the preparation of the PFRAs in international RBDs. However, when it comes to the designation of APSFRs bilateral co-operation seems to be the primary mechanism to ensure coordination.

[1] The table and map are for illustration only. The categories of the iRBDs were taken from the assessment of international coordination in the first cycle of the WFD. See: Vogel, B., et al. (2012): Transboundary Cooperation Fact Sheets. Comparative Study of Pressures and Measures in the Major River Basin Management Plans. available at: http://ec.europa.eu/environment/archives/water/implrep2007/pdf/Governance-Transboundary%20Fact%20Sheets.pdf
The circumstance in the River Commissions or the situation in the Member States may have changed since then.

Figure 49: Map of International RBDs/UoMs



Member States were asked to provide supporting information detailing the co-ordination mechanisms that are in place. An assessment has been made of whether it can be verified that international information exchange has taken place between Member States in the case of international RBDs or UoMs with a clear description of the methodology provided.

Table 13 shows which Member States provided strong evidence, some evidence or no evidence to support their claims, and Figure 52 shows the same information summarised in a chart. It can clearly be seen that most Member States presented some supporting evidence, but in a number of cases this information could have been stronger, particularly in relation to bilateral co-operation in the designation of APSFRs.

Figure 50: How information is exchanged in UoMs for the preparation of the PFRA as reported to the EIONET CDR in the second cycle

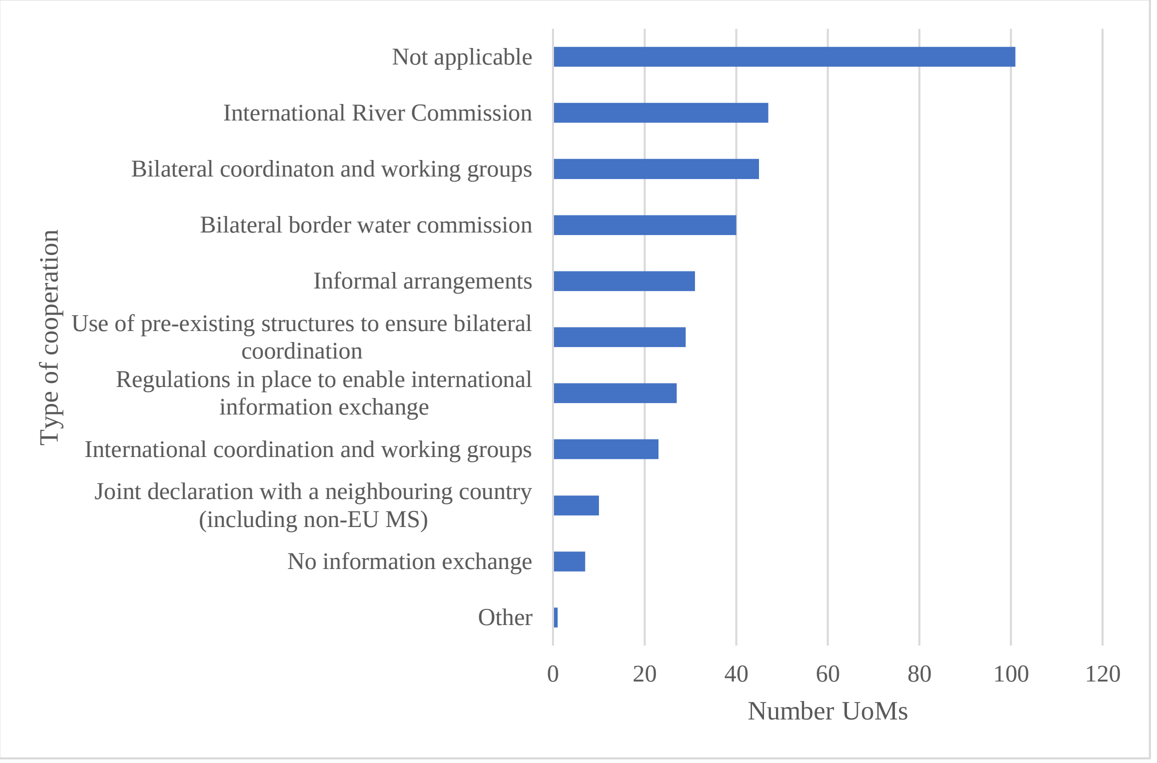


Figure 51: Type of cooperation in the identification of APSFRs as reported to the EIONET CDR in the second cycle

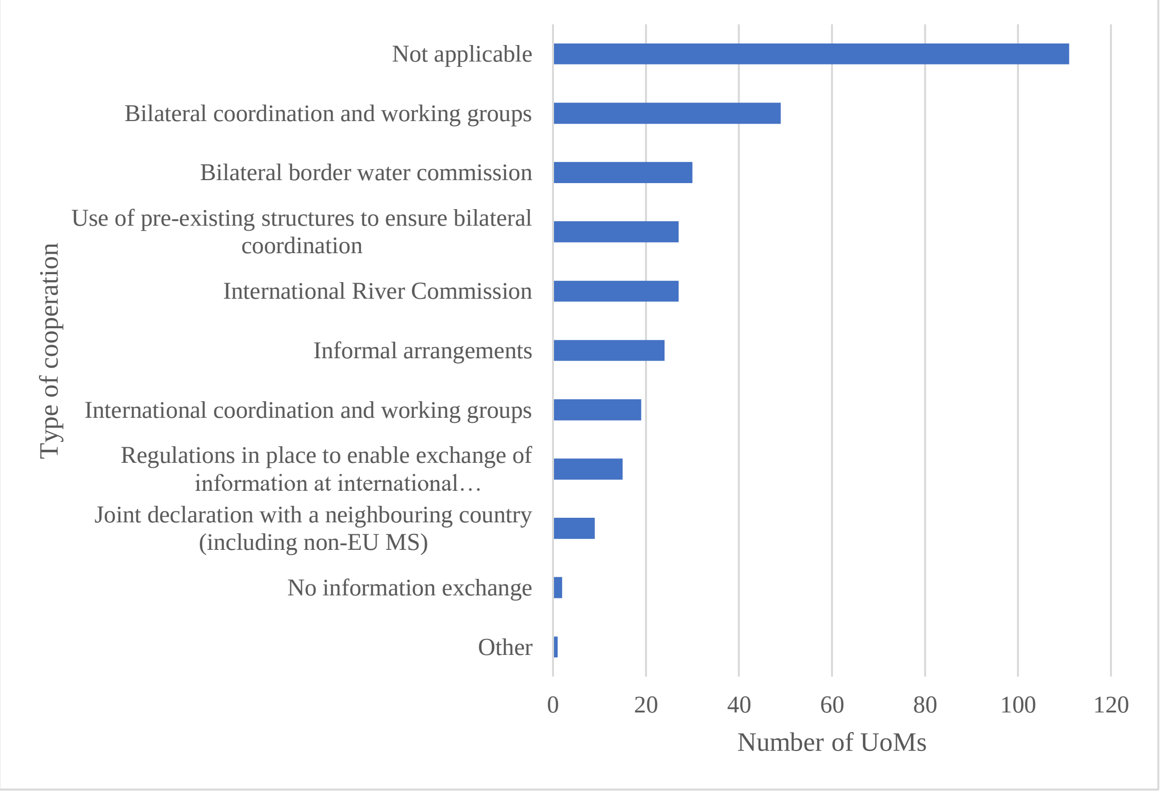


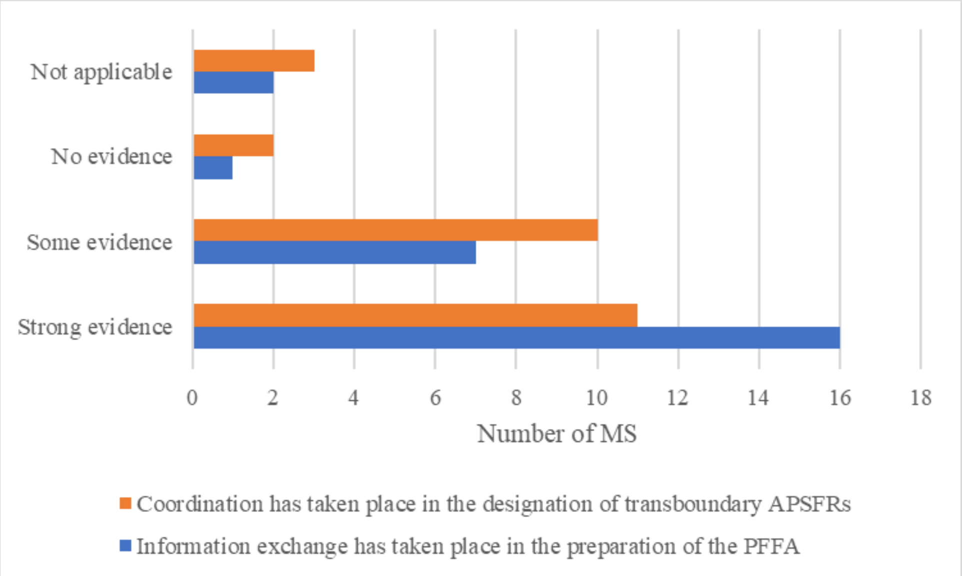
Table 13: Evidence presented to support whether information exchange has taken place, or not

MS	Information exchange has taken place during the PFRA assessment	APSFR methodology assessment
AT		
BG	Did not report in time for the Commission's assessment	
BE		
CY	No transboundary UoMs	No transboundary UoMs
CZ		
DE		
DK		No transboundary APSFRs
EE		
EL		
ES		
FI		
FR		
HR		
HU		
IE		
IT		
LT		
LU		
LV		
MT	No transboundary UoMs	No transboundary UoMs
NL		
PL		
PT		
RO		
SE		
SI		
SK		

Key:

Strong evidence
Some evidence
Not applicable
Data not reported

Figure 52: The evidence presented to support whether information exchange has taken place, or not



In order to confirm whether co-ordination is taking place at a bilateral level, some transboundary UoM's were selected and the data on the designation of APSFRs and the mechanism of co-operation reported was compared (Table 14). This showed inconsistencies between UoMs where the information reported would be expected to be the same. For example, in the Nemunas international UoM shared between Lithuania and Poland, Lithuania has reported nine transboundary APSFRs, but Poland has reported none. Whilst both Member States have reported that a bilateral border water commission is in place, Lithuania has also reported that bilateral working groups and the use of pre-existing structures (in place before the FD was adopted) to ensure bilateral co-operation. Similarly, in the Guadiana UoM shared between Spain and Portugal, Spain has reported no transboundary APSFRs, but Portugal has reported two. Both have reported that bilateral working groups are in place to ensure coordination, but Spain has reported that a bilateral border water commission is in place, which Portugal has not reported. On the other hand, Portugal has reported that regulations are in place to ensure bilateral co-operation. In the Danube international UoM, most of the Member States who are part of the International River Commission have reported no transboundary APSFRs (AT, DE, RO, CZ, SK). However, Hungary, has reported 109 cross-border APSFRs. It is therefore not clear whether these have been agreed with the other Danube countries.

The majority of these inconsistencies is likely a matter of neighbouring Member States coordinating better ahead of reporting to the Commission than symptoms of failing cooperation. However, the designation or not of cross-border APSFRs is an aspect that merits attention from the part of Member States and an area where synergies could be achieved, e.g. in the case of measures (and their funding) that have benefits extending beyond borders.

Table 14: Comparison of international coordination and number of transboundary APSFRs in selected international UoMs

International UoM	National UoM (MS)	Reported means of achieving coordination in preparation of PFRA	Number Cross-border APSFRs reported	Reported means of achieving coordination in designation of APSFR reported
Venta	LVVUBA (LV)	Informal arrangements (groups discussions and exchange of information)	0	Informal arrangements (groups discussions and exchange of information)
	LT2300 (LT)	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination Informal arrangements (groups discussions and exchange of information)	3	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination
Lielupe	LVLUBA (LV)	Joint declaration with a neighbouring country (including non-EU Member States) on cooperation on joint action	0	Joint declaration with a neighbouring country (including non-EU Member States) on cooperation on joint action
	LT3400 (LT)	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination Informal arrangements (groups discussions and exchange of information)	3	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination
Dauguva	LVDUBA (LV)	Joint declaration with a neighbouring country (including non-EU Member States) on cooperation on joint action	0	Joint declaration with a neighbouring country (including non-EU Member States) on cooperation on joint action
	LT4500 (LT)	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination Informal arrangements (groups discussions and exchange of information)	2	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination
Nemunas	LT1100 (LT)	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination Informal arrangements (groups discussions and exchange of information)	9	Bilateral border water commissions Bilateral coordination and working groups Use of pre-existing structures to ensure bilateral coordination

International UoM	National UoM (MS)	Reported means of achieving coordination in preparation of PFRA	Number Cross-border APSFRs reported	Reported means of achieving coordination in designation of APSFR reported
	PL8000 (PL)	Bilateral border water commissions	0	Bilateral border water commissions
Minho	ES10 (ES)	Bilateral border water commissions International working groups Bilateral coordination and working groups Informal arrangements (groups discussions and exchange of information)	2	Bilateral border water commissions International working groups Bilateral coordination and working groups Informal arrangements (groups discussions and exchange of information)
	PTRH1 (PT)	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level	2	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level
Duero	ES020 (ES)	Bilateral border water commissions International working groups Regulations in place to enable exchange of information at international level	0	Not applicable as no transboundary APSFRs
	PTRH3 (PT)	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level	2	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level
Tagus	ES030 (ES)	Bilateral border water commissions Bilateral coordination and working groups Regulations in place to enable exchange of information at international level	0	Not applicable as no transboundary APSFRs
	PTRH5 (PT)	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level	0	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level
Guadiana	ES040 (ES)	Bilateral border water commissions Bilateral coordination and working groups	0	Bilateral coordination and working groups
	PTRH7 (PT)	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level	2	Bilateral coordination and working groups Regulations in place to enable exchange of information at international level

8.2 Cooperation in international River Basin Commissions

The international River Basin Commissions have a key role to play in the co-ordination of flood risk assessment and management in transboundary river basins. For the Danube the ICPDR is a coordination platform for the implementation of the EU Floods Directive and for the preparation and update of the Danube Flood Risk Management Plan. A PFRA for the Danube was published in 2018, summarising the approaches and methodologies used in each Danube country, including the non-EU countries. The ICPR fulfils the same role for the Rhine and also published its PFRA in 2018. Due to differing legal and technical basis of flood protection in the different member states in the Rhine catchment there is no uniform approach to a preliminary flood risk assessment (PFRA), so the different national approaches are summarised. The PFRA for the Rhine includes details of the co-operation at national and sub-basin level between the member countries.

8.3 Examples of bilateral co-operation

For the Ems River basin, an agreement has been reached between the German Lander of Lower Saxony and North Rhine-Westphalia and the Netherlands that international co-ordination should focus on cross-border issues relating to the common goals and measures that are formulated. A document has been produced detailing how this cooperation will be achieved[2]. For the Meuse and the Sheldt river basins, Belgium and the Netherlands also produced a document explaining how coordination has been achieved[3].

Portugal and Spain participate in bilateral meetings with the Working Groups for Planning and Information Exchange of the Commission for the Application and Development of the Albufeira Convention. During such meetings, besides analysing all situations related to transboundary aspects related to floods (such as transboundary risk areas, measures with transboundary impact and exchange of data on these areas), more general methodological approaches on the subject are also discussed, including climate change in the Iberian Peninsula and strategies for data harmonisation and flood risk assessment. Italy and Slovenia are co-operating on a joint project for the Vipava/Vipacco river, VISFRIM, to develop common methodologies and technical instruments for the implementation of the PFRA, including joint risk modelling and mapping.

8.4 International cooperation developments since the previous assesssment

In the first cycle, among the most common mechanisms were the opportunities for coordination through an International River Commission, such as the International Commission for the Protection of the Danube River (ICPDR) and the International Commission for the Protection of the Rhine (ICPR). Bilateral border commissions were also relatively common, providing a formalised mechanism for two Member States to exchange information and coordinate flood risk management as well as other water management issues. Similarly, various international coordination and working groups had been established to carry out specific roles in flood risk management, including decision-making, the provision of advice, coordination of measures and the implementation of flood risk management measures.

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[2] See case study 30 at the end of this document.
[3] See case study 31.

There do not appear to have been significant changes in the mechanisms for coordination between the two cycles.

Annex A List of Member State Units of Management (River Basin Districts)

EUUOMCode	UOMName	International	InternationalName
AT1000	Danube	Y	Danube
AT2000	Rhine	Y	Rhine
AT5000	Elbe	Y	Elbe
BEEscaut_RW	Scheldt	Y	International river basin district of the Scheldt
BEEscaut_Schelde_BR	Scheldt	Y	International river basin district of the Scheldt
BEMeuse_RW	Meuse	Y	International river basin district of the Meuse
BEMaas_VL	Meuse	Y	International river basin district of the Meuse
BERhin_RW	Rhine	Y	International river basin district of the Rhine
BESchelde_VL	Scheldt	Y	International river basin district of the Scheldt
BESeine_RW	Seine	Y	No international institution formalised because of the small area concerned by the RBD in WR.
BG1000	Danube River Basin District	Y	
BG2000	Black Sea River Basin District	Y	
BG3000	East Aegean River Basin District	Y	
BG4000	West Aegean River Basin District	Y	
CY001	CYPRUS	N	CYPRUS
CZ_1000	Danube	Y	International river bazin district of Danube
CZ_5000	Elbe	Y	International river bazin district of Elbe
CZ_6000	Oder	Y	International river bazin district of Oder
DE1000	Deutsche Donau	Y	Danube
DE2000	Rhine River Basin District	Y	Rhine River Basin District
DE3000	Ems River Basin District	Y	Ems River Basin District
DE4000	Weser River Basin District	N	
DE5000	German Elbe	Y	Elbe
DE6000	Oder	Y	Odra
DE7000	Maas River Basin District (German Part)	Y	Meuse River Basin District
DE9500	Eider	Y	Eider

DE9610	Schlei/Trave	Y	Schlei/Trave
DE9650	Warnow/Peene	N	
DK1	Jutland and Funen	N	
DK2	Zealand	N	
DK3	Bornholm	N	
DK4	International (Vidå-Kruså)	Y	Vidå-Kruså
EE1	West-Estonian	N	
EE2	East-Estonian	Y	
EE3	Koiva	Y	
EL01	Western Peloponnese	N	
EL02	Northern Peloponnese	N	
EL03	Eastern Peloponnese	N	
EL04	Western Sterea Ellada	N	
EL05	Epirus	N	
EL06	Attica	N	
EL07	Eastern Sterea Ellada	N	
EL08	Thessalia	N	
EL09	Western Macedonia	Y	
EL10	Central Macedonia	Y	
EL11	Eastern Macedonia	Y	
EL12	Thrace	Y	
EL13	Crete	N	
EL14	Aegean Islands	N	
ES010	MINHO	Y	MINHO
ES014	GALICIAN COAST	N	
ES017	Eastern Cantabrian	Y	NORTE
ES018	Western Cantabrian	N	
ES020	DUERO	Y	DOURO
ES030	TAGUS	Y	International Tagus River Basin
ES040	Guadiana River Basin District	Y	Guadiana River Basin District
ES050	GUADALQUIVIR	N	
ES060	ANDALUSIA MEDITERRANEAN BASINS	N	
ES063	GUADALETE AND BARBATE	N	
ES064	TINTO, ODIEL AND PIEDRAS	N	
ES070	SEGURA	N	
ES080	JUCAR	N	
ES091	EBRO	N	
ES100	Catalan River Basin District	N	

ES110	BALEARIC ISLANDS	N	
ES120	GRAN CANARIA	N	
ES122	FUERTEVENTURA	N	
ES123	LANZAROTE	N	
ES124	TENERIFE	N	
ES125	LA PALMA	N	
ES126	LA GOMERA	N	
ES127	EL HIERRO	N	
ES150	CEUTA	N	
ES160	MELILLA	N	
FIVHA1	Vuoksi River Basin District	N	
FIVHA2	Kymijoki-Gulf of Finland River Basin District	N	
FIVHA3	Kokemäenjoki-Archipelago Sea-Bothnian Sea River Basin District	N	
FIVHA4	Oulujoki-Iijoki River Basin District	N	
FIVHA5	Kemijoki River Basin District	N	
FIVHA6	Tornionjoki IRBD	Y	Tornionjoki IRBD
FIVHA7	Teno, Näätämöjoki and Paatsjoki IRBD	Y	Teno, Näätämöjoki and Paatsjoki IRBD
FIWDA	Åland River Basin District	N	
FRA	L'Escaut, la Somme et les cours d'eau côtiers de la Manche et de la mer du Nord	Y	Scheldt
FRB1	Meuse	Y	Meuse
FRB2	La Sambre	Y	International Meuse River Basin District
FRC	Rhine	Y	Rhine
FRD	Le Rhône et les cours d'eau côtiers méditerranéens	N	
FRE	Les cours d'eau de la Corse	N	
FRF	L'Adour, la Garonne, la Dordogne, la Charente et les cours d'eau côtiers charentais et aquitains	N	
FRG	La Loire, les cours d'eau côtiers vendéens et bretons	N	
FRH	La Seine et les cours d'eau côtiers normands	N	
FRI	Les cours d'eau de la Guadeloupe	N	

FRJ	Les cours d'eau de la Martinique	N	
FRK	Les fleuves et cours d'eau côtiers de la Guyane	N	
FRL	Les cours d'eau de la Réunion	N	
FRM	Les cours d'eau de Mayotte	N	
HRC	Danube	Y	Danube
HRJ	Adriatic	Y	
HU1000	Hungarian part of the Danube River Basin District	Y	Danube River Basin District
IEGBNIIENB	Neagh Bann	Y	
IEGBNIIENW	North Western	Y	
IEROI	Republic of Ireland	N	
ITI012	Bradano	N	
ITI01319	Conca/Marecchia	N	
ITI014	Fiora	N	
ITI015	Fortore	N	
ITI017	Lemene	N	
ITI018	Magra	N	
ITI021	Reno	N	
ITI022	Saccione	N	
ITI023	Sangro	N	
ITI024	Sinni	N	
ITI025	Sele	N	
ITI026	Fissero-Tartaro-Canalbianco	N	
ITI027	Trigno	N	
ITI028	Tronto	N	
ITI029	Noce	N	
ITN001	Adige	N	
ITN002	Arno	N	
ITN003	Brenta-Bacchiglione	N	
ITN004	Isonzo	Y	Isonzo
ITN005	Liri-Garigliano	N	
ITN006	Livenza	N	
ITN007	Piave	N	
ITN008	Po	Y	Po
ITN009	Tagliamento	N	
ITN010	Tevere	N	
ITN011	Volturno	N	
ITR051	regionale Veneto	N	
ITR061	regionale Friuli Venezia Giulia	N	

ITR071	regionale Liguria	N	
ITR081	regionale Emilia Romagna	N	
ITR091	regionale Toscana Costa	N	
ITR092	regionale Toscana Nord	N	
ITR093	regionale Toscana Ombrone	N	
ITR111	regionale Marche	N	
ITR121	regionale Lazio	N	
ITR131	regionale Abruzzo	N	
ITR141	regionale Molise	N	
ITR151	regionale Campania Nord Occidentale	N	
ITR152	regionale Destra Sele	N	
ITR153	regionale Sinistra Sele	N	
ITR154	regionale Sarno	N	
ITR161I020	regionale Puglia/Ofanto	N	
ITR171	regionale Basilicata	N	
ITR181I016	regionale Calabria/Lao	N	
ITR191	regionale Sicilia	N	
ITR201	regionale Sardegna	N	
ITSNP01	Serchio	N	
LT1100	Nemunas	Y	
LT2300	Venta	Y	Venta
LT3400	Lielupe	Y	Lielupe
LT4500	Dauguva	Y	Dauguva
LU RB_000	Mosel	Y	Rhine
LU RB_001	Chiers	Y	Maas
LVDUBA	Daugava river basin district	Y	Daugava river basin district
LVGUBA	Gauja river basin district	Y	Gauja river basin district
LVLUBA	Lielupe river basin district	Y	Lielupe river basin district
LVVUBA	Venta river basin district	Y	Venta river basin district
MTMALTA	Malta	N	
NLEM	Ems	Y	
NLMS	Meuse	Y	
NLRN	Rhine	Y	
NLSC	Scheldt	Y	
PL1000	Danube River Basin District	Y	Danube River Basin District
PL2000	Vistula River Basin District	Y	Vistula River Basin District

PL3000	Swieza River Basin District	Y	Swieza River Basin District
PL4000	Jarft River Basin District	Y	Jarft River Basin District
PL5000	Elbe River Basin District	Y	Elbe River Basin District
PL6000	Oder River Basin District	Y	Oder River Basin District
PL6700	Ucker River Basin District	Y	Ucker River Basin District
PL7000	Pregolya River Basin District	Y	Pregolya River Basin District
PL8000	Nemunas River Basin District	Y	Nemunas River Basin District
PL9000	Dniester River Basin District	Y	Dniester River Basin District
PTRH1	Minho and Lima		
PTRH2	Cavado, Ave and Leca		
PTRH3	Douro		
PTRH4A	Vouga, Mondego and Lis		
PTRH5A	Tagus and West Rivers		
PTRH6	Sado and Mira		
PTRH7	Guadiana		
PTRH8	Algarve Rivers		
PTRH9	Azores		
PTRH10	Madeira		
RO1	BANAT HIDROGRAPHICAL AREA	Y	Danube River District
RO10	SIRET HYDROGRAPHICAL AREA	Y	Danube River District
RO1000	Danube	Y	Danube River District
RO11	PRUT-BARLAD HYDROGRAPHICAL AREA	Y	Danube River District
RO2	JIU RIVER BASIN	Y	Danube River District
RO3	OLT RIVER BASIN	Y	Danube River District
RO4	ARGES-VEDEA HYDROGRAPHICAL AREA	Y	Danube River District
RO5	IALOMITA-BUZAU HYDROGRAPHICAL AREA	Y	Danube River District
RO6	Danube Basin	Y	Danube River District
RO7	MURES RIVER BASIN	Y	Danube River District

RO8	CRISURI HYDROGRAPHICAL AREA	Y	Danube River District
RO9	SOMES-TISA HYDROGRAPHICAL AREA	Y	Danube River District
SE1	1. Bothnian Bay (Sweden)	N	
SE1TO	1. Bothnian Bay (International district Torne river - Sweden)	Y	1. Bottenviken (Int. dist. Torneälven - Sverige)
SE2	2. Bothnian Sea (Sweden)	N	
SE3	3. North Baltic Sea (Sweden)	N	
SE4	South Baltic Sea (Sweden)	N	
SE5	5. Skagerrak and Kattegat (Sweden)	N	
SI_RBD_1	Danube River Basin District	Y	Danube River Basin District
SI_RBD_2	Adriatic River Basin District	Y	Adriatic River Basin District
SK30000FD	Vistula	Y	Vistula
SK40000FD	Danube	Y	Danube

Annex B Definitions of Source, Mechanisms and Characteristics of floods[4]

Sources

Fluvial	Flooding of land by waters originating from part of a natural drainage system, including natural or modified drainage channels. This source could include flooding from rivers, streams, drainage channels, mountain torrents and ephemeral watercourses, lakes and floods arising from snow melt.
Pluvial	Flooding of land directly from rainfall water falling on, or flowing over, the land. This source could include urban storm water, rural overland flow or excess water, or overland floods arising from snowmelt.
Groundwater	Flooding of land by waters from underground rising to above the land surface. This source could include rising groundwater and underground flow from elevated surface waters.
Sea Water	Flooding of land by water from the sea, estuaries or coastal lakes. This source could include flooding from the sea (e.g., extreme tidal level and / or storm surges) or arising from wave action or coastal tsunamis.
Artificial Water-Bearing Infrastructure	Flooding of land by water arising from artificial, water-bearing infrastructure or failure of such infrastructure. This source could include flooding arising from sewerage systems (including storm water, combined and foul sewers), water supply and wastewater treatment systems, artificial navigation canals and impoundments (e.g., dams and reservoirs).
Other	Flooding of land by water due to other sources, can include other tsunamis.

Mechanisms

Natural Exceedance	Flooding of land by waters exceeding the capacity of their carrying channel or the level of adjacent lands.
Defence Exceedance	Flooding of land due to floodwaters overtopping flood defences.
Defence or Infrastructural Failure	Flooding of land due to the failure of natural or artificial defences or infrastructure. This mechanism of flooding could include the breaching or collapse of a flood defence or retention structure, or the failure in operation of pumping equipment or gates.
Blockage / Restriction	Flooding of land due to a natural or artificial blockage or restriction of a conveyance channel or system. This mechanism of flooding could include the blockage of sewerage systems or due to restrictive channel structures such as bridges or culverts or arising from ice jams or landslides.

[4] Reporting guidance, https://cdr.eionet.europa.eu/help/Floods/Floods_2018/index.html

Other	Flooding of land by water due to other mechanisms, for instance wind setup floods.

Characteristics

Flash Flood	A flood that rises and falls quite rapidly with little or no advance warning, usually the result of intense rainfall over a relatively small area.
Snow Melt Flood	Flooding due to rapid snow melt, possibly in combination with rainfall or blockage due to ice jams.
Other rapid onset	A flood which develops quickly, other than a flash flood.
Medium onset flood	An onset of flooding that occurs at a slower rate than a flash flood.
Slow onset flood	A flood which takes a longer time to develop.
Debris Flow	A flood conveying a high degree of debris.
High Velocity Flow	A flood where the floodwaters are flowing at a high velocity.
Deep Flood	A flood where the floodwaters are of significant depth.
Other	Other characteristics, or no special characteristics.

Annex C Case Studies from Member States

Case Study 1: Slovakia PFRA

Slovakia included detailed descriptions of past floods in both the national PFRA report, and the PFRA reports produced for each sub-basin. These included historic floods, as well as floods that have occurred during the second cycle (2012-2018). The information provided included a detailed description of the precipitation levels in each year, the conditions that led to flooding, and an overview of the consequences of each flood. The UoM reports also include information on the expenditure incurred for the purposes of flood security work, flood rescue work and flood damage (see machine translated table below for the Dunajec and Poprad sub-basin of the Vistula UoM. Note for the purposes of this case study only data for 2012-2018 has been shown)

Table 4.1. Overview of expenditures on flood protection work, flood rescue work and flood protection work damages in Slovakia in the period 1997 - 2017

Year	Floods Security work	Floods rescue work	Flood damage	Expenses and damages together
2012	460 624	369 427	2 435 268	3 265 319
2013	4 750 477	2 729 905	13 460 597	20 940 979
2014	11,912,949	5,657,451	36 959 006	54 529 406
2015	602 778	1 141 063	3 124 078	4 867 919
2016	1 270 825	843 174	12 670 107	14 784 107
2017	2 273 258	875 363	7 873 071	11 021 693

Case Study 2: Poland – Maps of retention areas

Poland produced maps of retention areas which were provided at national level, RBD level (for the Vistula and the Oder only) and at sub-basin level. The picture below is an example of this map at national level.

Case Study 3: Interactive portals

Twelve Member States provided links to specific flood related geoportals that allowed information directly related to the PFRA to be examined interactively.

BE (Flanders): https://www.waterinfo.be/kaartencatalogus

DE: https://geoportal.bafg.de/karten/HWRM_Aktuell/?tabs=on

DK: https://miljoegis.mim.dk/spatialmap?&profile=oversvoem2

EE: https://xgis.maaamet.ee/xgis2/page/app/yua

ES: https://sig.mapama.gob.es/snczi/index.html?herramienta=DPHZI

FI: https://www.ymparisto.fi/tulvakartat

IE: https://www.floodinfo.ie/map/floodmaps/

LT: https://potvyniai.aplinka.lt/map

LU: https://map.geoportail.lu/theme/eau?lang=de&zoom=10&X=683194&Y=6423615&version=3&layers=&opacities=&bgLayer=topo_bw_jpeg&rotation=0

NL: www.risicokaart.nl

SE: https://gisapp.msb.se/Apps/oversvamningsportal/index.html

SI:
https://gisportal.gov.si/portal/apps/webappviewer/index.html?id=11785b60acdf4f599157f33aac8556a6

Case Study 4 – Belgium (Wallonia)

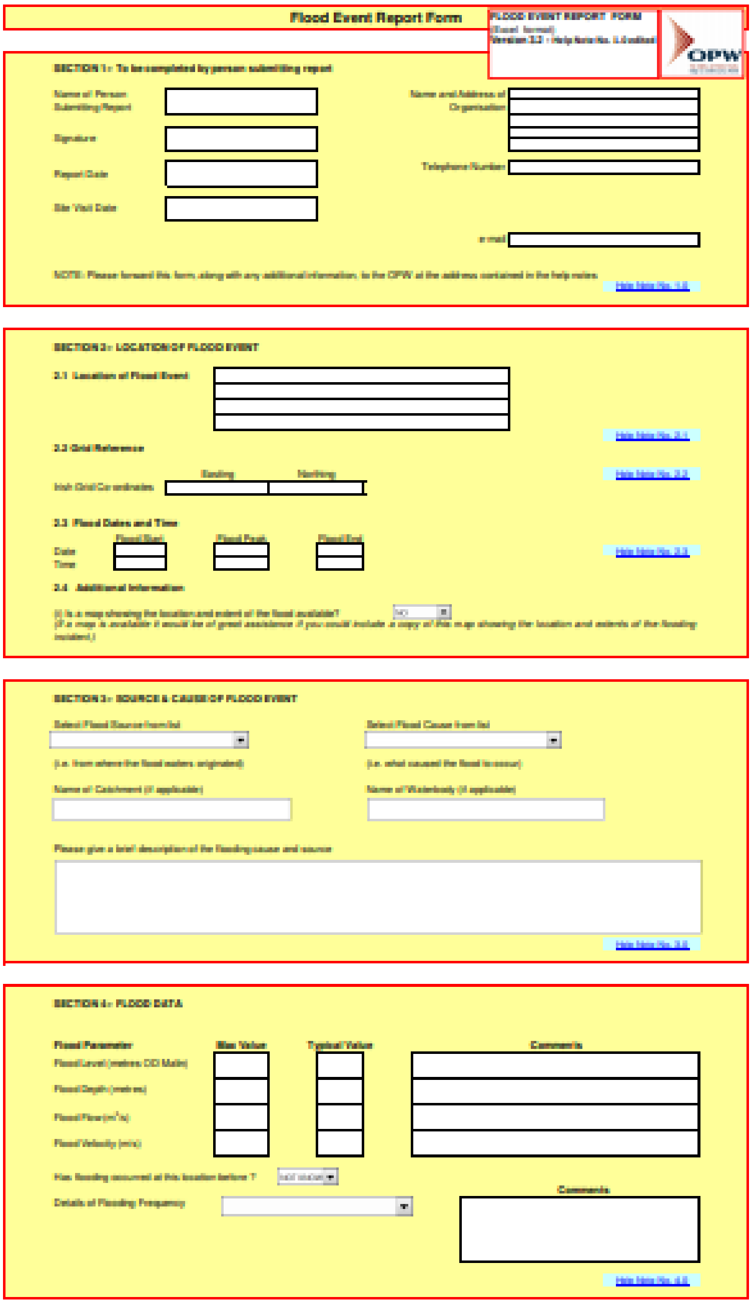
In 2017 Wallonia created an inventory of past floods (BRelI - Base de données des RELevés d'Inondations). Significant past floods are identified based on the information held within this inventory. The sources of information include:

- Flood markers;
- Photo database;
- Press sources (SPW press, Walloon Brabant press, press clippings);
- Flood report;
- Public calamities (supplemented by data from the Centre Régional de Crise(CRC));
- Insurance data (Assuralia);
- MRI data;
- Municipal surveys; and
- The Technical Committees by Sub-Hydrographic Basin (Comités Techniques par Sous-Bassin Hydrographique (CTSBH)).

Case Study 5 –The Republic of Ireland

The Republic of Ireland has introduced a data collection form[5] to allow for the collection and collation of more detailed information on the occurrence and impact of flooding in the second cycle. The form seeks information on a range of impacts, including numbers of residential and commercial properties that were flooded, the infrastructure and heritage affected and information on any environmental impacts.

[5] https://www.floodinfo.ie/static/floodmaps/docs/past_floods/Past_Flood_Event_Technical_Form_V3.2.pdf



Flood Event Report Form

SECTION 1 - To be completed by person submitting report

SECTION 2 - LOCATION OF FLOOD EVENT

2.1 Location of Flood Event

2.2 Grid Reference

2.3 Flood Dates and Time

2.4 Additional Information

SECTION 3 - SOURCE & CAUSE OF FLOOD EVENT

SECTION 4 - FLOOD DATA

Case Study 6 – Portugal Collection of Information on Historic Floods

To gather information on historic floods for the second cycle, Portugal collected the following information:

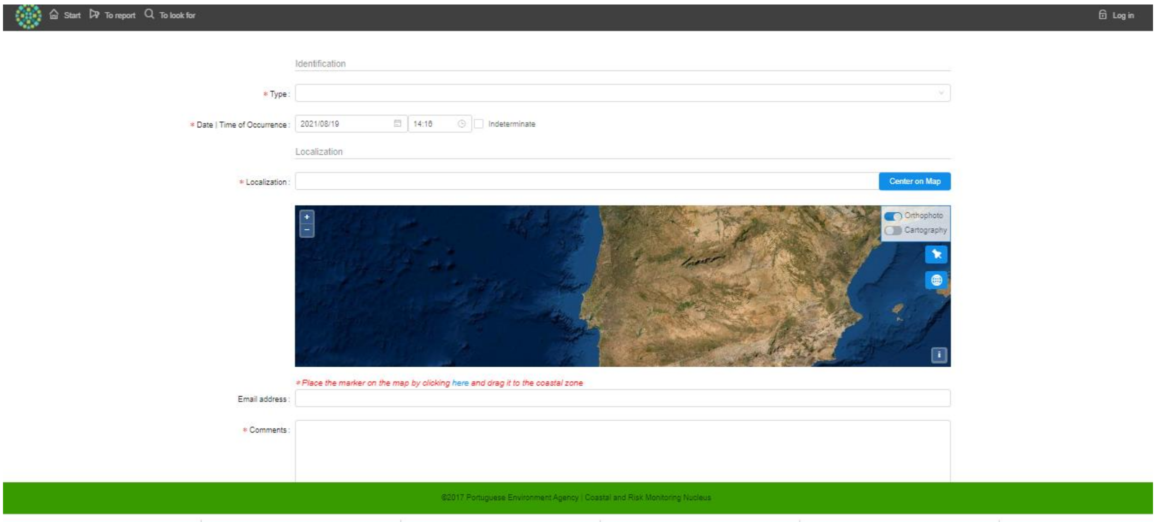
- An online form filled in by local and national authorities with competence in flood event management,
- Other sources of information and databases from the National Civil Protection Authority, the National Water Resources Information System, the Portuguese Insurance Association and COPERNICUS satellite images,
- Newspaper articles (especially on damage caused by flood events),
- Characterization studies in the scope of the Coastal Zone Planning/Programs,

- Specific technical studies and projects carried out in the context of coastal protection/defence interventions,

- Existing publications in academic and scientific articles, and

- Information produced in the context of previous local/regional monitoring projects/studies.

In addition, specifically in relation to coastal flooding, the recording of occurrences in the field has recently been optimized through the creation of an online platform (via PC or smartphone), which allows registration and communication in real time of the occurrence of flooding by the general public (see screen shot below).



Case Study 7: Romania

The shows an extract of the data reported to the EIONET CDR on the duration, area or length, and frequency of past floods for the UoM RO6.

UoM	Area	Date of Commencement	Duration of Flood	Length	Frequency	Name Of Flood Event	Flood Event Code
RO6		2016-06-01	1	2.43	40%	Inundatie 2016 iunie r. Luncaviţa - loc. Luncaviţa	RO6-14.01.050....-01-2016.06-L
RO6		2016-09-19	1	2.71	20%	Inundatie 2016 septembrie r. Taiţa - loc. Horia	RO6-15.01.003....-01-2016.09-L
RO6	1.00	2010-06-22	1		10%	Inundatie 2010 iunie - loc. Cernavodă, jud. Constanţa	RO6-60785-01-2010.06-L
RO6	10.38	2011-07-10	1		20%	Inundatie 2016 octombrie - loc. Constanţa, jud. Constanţa	RO6-60428-01-2016.10-L
RO6	2.22	2015-10-12	1		10%	Inundatie 2015 octombrie - loc. Corbu, jud. Constanţa	RO6-61522-01-2015.10-L
RO6	5.78	2010-06-25	1		10%	Inundatie 2010 iunie - loc. Tulcea, jud. Tulcea	RO6-159623-01-2010.06-L
RO6	5.78	2015-02	2		20%	Inundatie 2015 februarie - loc. Tulcea, jud. Tulcea	RO6-159623-01-2015.02-L

Case Study 8 - Hungary

In the last week of May 2013 and the first days of June, a cyclone developed in central Europe between the Atlantic Ocean and North-Eastern Europe. As a result of the process, a significant amount of precipitation fell in the upper catchment areas of the Danube, resulting in a significant flood wave. The floods of the Danube and the Inn met at Passau on 3 June, the water level peaked at 1 238 cm; the water level was about 2 m higher than the 2002 peak. Major Austrian tributaries (Traun, Enns, Ybbs) had peaks in several places exceeding previous peaks. In the Hungarian Upper Danube section, water levels approaching the highest water level ever recorded were expected to be reached in some places. The flood entered the country on June 7 and left the country seven days later, on June 14. With the exception of Mohács, the water level exceeded the previous highest observed water level (LLNV) at all major water monitoring stations. The exceedance of the LLNV was the highest in the case of Komárom station, here it exceeded the largest water level of 802 cm measured in 2002 by 43 cm. At Budapest, a peak water level of 891 cm, 31 cm above the LLNV, was registered. The water flow in Dévény, which characterizes the amount of water entering Hungary, exceeded 10,500 m^3/s. A total of 73 780 people took part in manning the defences against the flood, which involved raising and supporting the fortifications and building new fortifications. In addition, it became necessary to individually protect high-value facilities. The length of protection built exceeded 9.5 km, using more than 5 million sandbags. Due to the flood wave on the Danube between 7 June and 14 June 2013, 1 570 people had to be evacuated on 10 June. There was no personal injury or material damage resulting from the flood.

Case Study 9 – Czechia – Criteria for the identification of significant past floods

Czechia has developed a clear methodology for the assessment of past floods which incorporates several criteria for defining significant adverse impacts of past floods on humans, housing, society, the environment, cultural heritage and economic effects against a scale chosen to determine the degree of adverse effects of floods:

N - insignificant or unknown, 1 -– low, 2 -– high and 3 – extreme.

The criteria for individual types of various flooding situations are listed below:

1. River (fluvial) flood:
   - achieved at least a 100-year probability of recurrence (Q100)
   - observed in at least three specific profiles on watercourses
   - affected areas larger than 2 000 km^2
2. Flood from torrential rains:
   - claimed at least three human victims lives or the damage exceeded CZK 50 million
3. An accident on a waterworks or water management infrastructure:
   - if it did not occur as a result of natural floods, it claimed at least three human lives
   - if it occurred as a result of a natural flood, recurrence was increased downstream to at least 500 years and at least three human lives were lost.
4. Other types of floods (pluvial from groundwater):
   - damages exceeded CZK 250 million

Case Study 10 – The Netherlands

The PFRA report for the Netherlands includes an assessment of the impact of past floods on human health, measured by the number of fatalities and the number of evacuations carried out (both humans and livestock) and also an assessment of the economic impact in terms of the number of properties damaged, the value of livestock affected and the total damage (in millions of Guilders).

Tabel 3.1 Overzicht van historische overstromingen met significante negatieve effecten en een inschatting van het risico op herhaling

Hoofdwatersysteem

	Overstroming					Gevolgen		
nr.	Datum	Bron	Omvang van overstroming	Aard / route van overstroming	Indicatie van frequentie	Gezondheid van de mens	Economische bedrijvigheid[1]	Risico van herhaling
1	1916 januari	Noordzee, Waddenzee (stormvloed-A14)	Gebieden rond de toenmalige Zuiderzee	Groot aantal doorbraken (A22,A23,A38)	Zeer zeldzaam	19 slachtoffers	Schade aan dijken, grote schade aan houten huizen in Marken, scheeps-rampen	Nihil
2	1926 januari	Rijn en Maas (A11)	Grote delen van het rivierengebied	Groot aantal doorbraken (A22,A23,A38)	1: 100 jaar Hoogste gemeten afvoer van Rijn: 12.600 m^3/sec.	Geen slachtoffers	3.000 huizen zwaar beschadigd, 10 miljoen gulden schade	Nihil
3	1953 februari	Noordzee (stormvloed-A14)	1650 km^2 in Zuidwest-Nederland	Zeer groot aantal doorbraken (A22,A23,A38)	1:100 jaar	1.835 slachtoffers, 72.000 evacuaties	3.000 huizen en 300 boerderijen verwoest, 47.000 stuks vee verdronken,1,5 mil-jard gulden schade	Nihil
4	1993	Maas (A11)	180 km^2	Buiten oevers treden van rivier (A21,A35)	1:100 tot 1:200 jaar	Geen slachtoffers, 8.000 evacuaties	Ca. 250 miljoen gulden, nieuwbouw-wijken onder water	Nihil door uitvoering Maaswerken
5	1995 januari	Maas (A11)	180 km^2	Buiten oevers treden van rivier (A21,A35)	1:100 jaar	Geen slachtoffers, wel evacuaties	Directe schade geraamd op 150 miljoen gulden	Nihil door uitvoering Maaswerken
6	1995	Rijn en zijn	250 km^2	Overstroming van	ca. 1:100	Geen slachtoffers,	Nihil	Kleine kans op

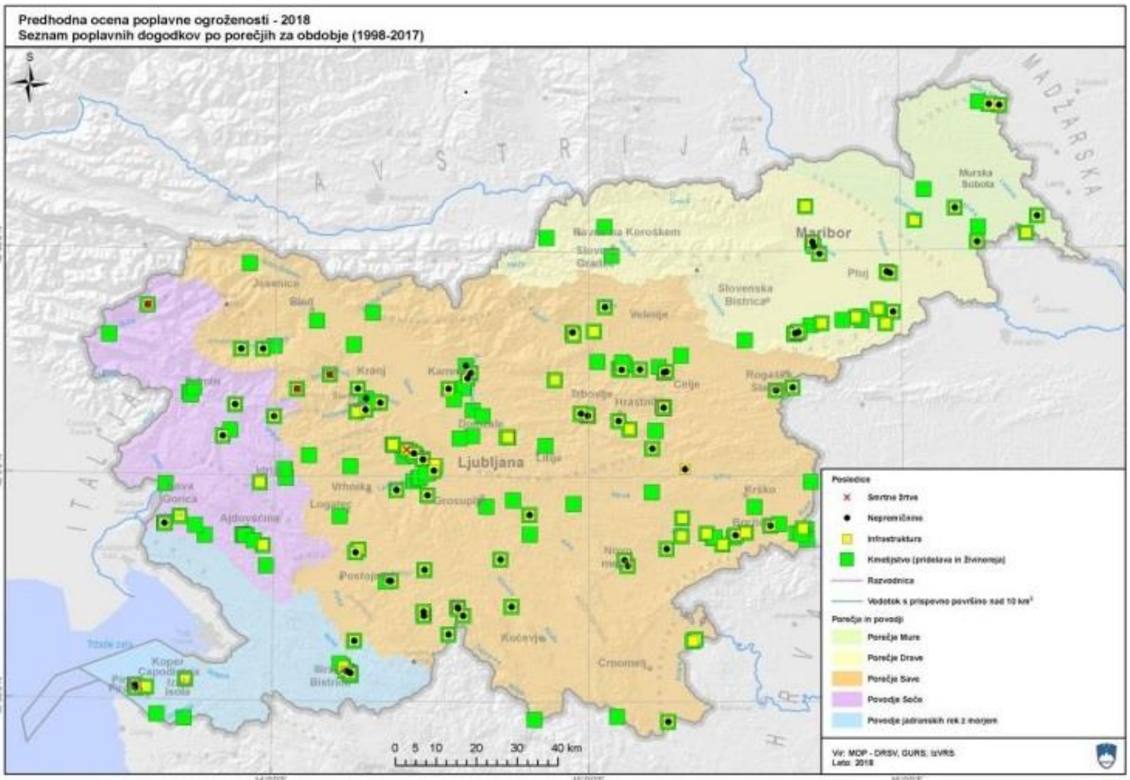
Case Study 11 – Latvia

For each significant past flood, Latvia has included a textual summary of the resulting damage and the level of financial assistance provided to repair the damage. An example (translated into English) is given below:

"The territory of Daugavpils city is exposed to the risk of floods, which is associated with both spring floods due to melting snow and rain, and ice congestion. Given that the city's residential districts are located on both banks of the Daugava River, and are partly in the river floodplain, it can be stated that in the last 10 years flooding has been observed every spring. However, in 2010 and 2013, the water level of the Daugava exceeded the "dangerous" mark of 93.43 m LAS (93.30 m BS), at which both the streets of Grīva district and several houses on the left bank of the river – from embankments to Nometņu Street were inundated. The floods of 2010 caused a loss of 124 969 lats (almost €180 000) to Daugavpils County Council of which €124 469 euro was allocated to road repairs. The spring floods of 2013 flooded about 700 houses and Daugavpils municipality received from the state budget only 4058 lats (€5774) for the payment of compensation for losses caused by floods. Daugavpils City Council was granted funding of €277 592 to prevent losses during the spring 2013 floods. At the end of 2013, a protective dam was built in Daugavpils, which protects the Grīva cemetery from flooding. In 2010, Ilūkste County Council received €176 895 for road repairs due to flood damage. In 2013, to Ilūkste municipality €116 403 was allocated for road repairs to cover expenses related to the spring flood."

Case Study 12 – Slovenia

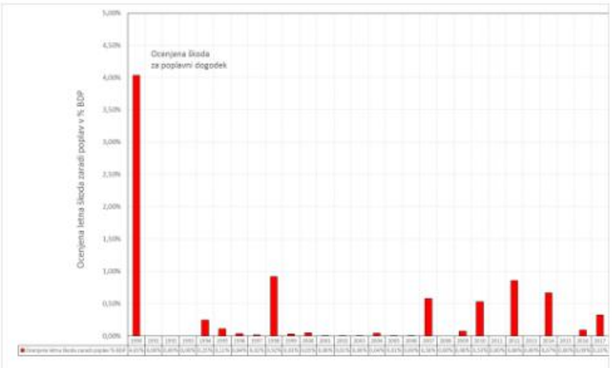
An example of one of the maps presenting areas of flood damage from the PFRA document.



Slika 15. Prikaz območij dogodkov glede na posledice za obdobje 1998-2017

Slovenia presentation of the yearly damage caused by floods in % of the GDP for the whole country for the years 1990 – 2017 in the PFRA document.

Predhodna ocena poplavne ogroženosti RS, junij 2019



Slika 16. Ocenjena letna škoda zaradi poplav 1990-2017

Leto	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Bruto domači proizvod (mio EUR)	13.674	10.271	9.688	10.849	12.162	15.704	16.345	17.456	18.761	20.240	21.288	22.505	24.108	25.344	26.764	28.244	30.453	34.562	37.280	35.311	35.416	36.896	36.076	36.239	37.615	38.837	40.418	43.278
Ocenjena letna škoda zaradi poplav (mio EUR)	551,7				30,3	18	6,16	3,48	173	6,1	10,2	0,43	2,26	0,37	11,4	2,22	0,21	200		27,4	188		310,9		251,2		36,8	143,1
Ocenjena letna škoda zaradi poplav % BDP	4,03%	0,00%	0,00%	0,00%	0,25%	0,11%	0,04%	0,02%	0,92%	0,03%	0,05%	0,00%	0,01%	0,00%	0,04%	0,01%	0,00%	0,58%	0,00%	0,08%	0,53%	0,00%	0,86%	0,00%	0,67%	0,00%	0,09%	0,33%

Case Study 13 – Portugal

Once information had been gathered on the impact of flood events, the UoMs on mainland Portugal classified each past flood events based on the severity of their impacts. This was done according to the use of selected indicators for the evaluation of significant impacts. The impact on the population was ranked qualitatively on a scale of 1 – 5 where 1 is low and 5 is very high. The number of people affected were ranked on a quantitative scale of 1 – 4 where 1 is <10 and 5 is >100. The impact on economic activities was ranked on a scale of 1-4 where 1 is low and 4 is very high, and the losses were ranked on a quantitative scale of 1 -6 from 1 being <$30,000 to 6 being > €1,000,000. The economic activities considered were listed as being private propriety, infrastructure, agricultural fields and industries and other economic activities. No information has been presented on the basis for the selection of these indicators.

The criteria for the selection of significant events were then combined with an equal weighting applied to those receptors on which the impact of flooding was considered to be most serious. Specifically, the following formula was applied:

(A> = 4) V (B> = 4) V (C> = 3) V (D> = 5)

where:

A = Impact on the population, B = Number of affected people, C = Impact on economic activities and D = Losses.

and

- Impact on the population - high (value 4, according to the classification presented);
- Number of people affected - 50 to 100 (value 4, according to the classification presented);
- Impact on economic activities - high (value 3, according to the classification presented);
- Losses - 500 000 to 1 000 000 Euros (value 5, according to the classification presented).

Those events that met the criteria in the formula above were then considered for designation as an APSFR. Events where there was not sufficient information to allow this assessment to take place, but where it could be demonstrated that there had been impacts on the environment or cultural heritage were also considered for designation as an APSFR.

Case Study 14 – Denmark

Assessment of the extent of flooding (English (machine) translation below)

OVERSVØMMELSE			'Udstrækning'
0	Ingen kilder, der oplyser om oversvømmelse eller sandsynliggør, at der har været oversvømmelse	Ingen eller ringe datarådighed	Ingen datarådighed, ingen eller ringe oversvømmelse, eller begrænset til havnearealer mv.
1	Oplysning om oversvømmelse, men ikke redegjort for omfanget på oversvømmede lokaliteter	Ingen samtidig kilde med angivelse af lokalitet og omfang. Fragmentarisk kildedækning.	Betydelig oversvømmelse er forekommet på en eller enkelte lokaliteter
2	Oplysning om lokaliteter, og kilder sandsynliggør, at omfang berører mennesker direkte	Oversvømmelsens udstrækning synes geografisk dækket, men med mangelfuld oplysning om omfang	Betydelig oversvømmelse er forekommet langs en længere kyststrækning
3	Uddybende beskrivelser fra flere lokaliteter af uafhængige kilder.	Oversvømmelsens omfang og udstrækning er dokumenteret for betydende lokaliteter	Betydelig oversvømmelse er forekommet vidt udbredt indenfor et eller flere farvandsområder

Scale	Data availability	Data quality	Phenomena
0	No flood reports or probabilities of flooding	No or little data availability	No data availability, no or little flooding, or limited to port areas, etc.
1	Information on flooding, but the extent of flooded sites is not explained	No simultaneous source indicating location and extent. Fragmentary source coverage.	Significant flooding has occurred at one or some localities
2	Information about localities and sources makes it probable that extent affects people directly	The extent of the flooding seems geographically covered, but with insufficient information on the extent	Significant flooding has occurred along a longer stretch of coastline
3	Detailed descriptions from several sites of independent sources	The extent and extent of the floods have been documented for significant localities	Significant flooding has occurred widely within one or more waters

Case Study 15 – Luxembourg

A combination of previously high levels of snowfall, and moderate rainfall, caused a rapid snow melt resulted in flooding in Luxemburg in January 2011. The Canadian satellite RADARSAT was scheduled for the evening of January 7, 2011, to cover the Alzette and Sûre valleys during the flight over on January 8, 2011 at around 6 p.m. (time winter). Thanks to the radar image obtained (example below), a detailed mapping of the flood fields could be carried out in just a few hours. The cartographic products produced will make it possible in the near future to produce hydraulic model calibration and validation operations in the sectors studied and at risk. In addition to the satellite images, many photos were taken on the ground, as well as by helicopter overflights, which also constitute so many additional sources of information for these modelling operations.

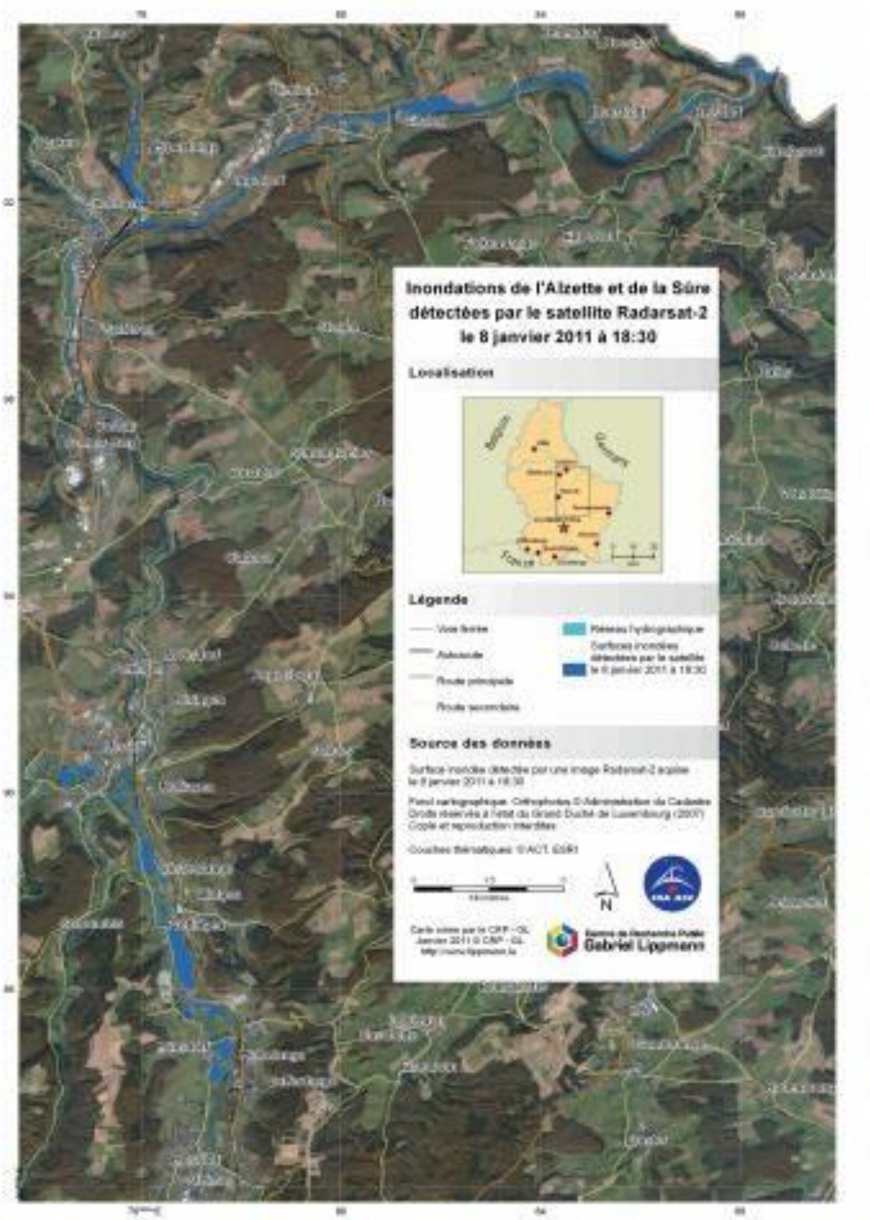


Figure 4.1. Champs d'inondation dans les plaines alluviales de l'Alzette et de la Sûre le 8 janvier 2011 à 18hrs30

Case Study 16 – Denmark: Vulnerability matrix

Denmark used a national approach, developed under an EU-project[6] for assessing potential adverse consequences of future floods. The same approach is used for stormfloods and fluvial flooding and is based on assessing and mapping the vulnerability of areas to flooding. It considers direct and indirect as well as tangible and intangible damages of flooding.

Denmark used the enumeration of potential adverse consequences of future floods provided in Article 4.2(d) of the FD as a point of departure to define criteria, which describe the adverse consequences of floods. The criteria are called "vulnerability indicators". To assure coherence of the approach used across all UoMs, the data sets which were used to describe the vulnerability indicators, had to be nationally available. The

[6] http://www.risckit.eu/

approach considers several vulnerability aspects (population density, type of land-use, cultural heritage, (transport) infrastructure, potentially polluting activities, emergency services, critical infrastructure, economic activity), which are understood to cover the aspects mentioned in Article 4.2 (d) of the FD. For each aspect its vulnerability is assessed/indexed separately on a scale from 1 to 5 (low to high) and later merged into one overall vulnerability index. In the indexing process mainly qualitative data (i.e. type of infrastructure) was used, except for population density and economic activity (described by number of employees), where absolute numbers were used for indexing. So potential future adverse consequences are not really quantified. In the process of indexing vulnerability indicators expert judgement from the CA (the Danish Coastal Authority) was used in cooperation with other relevant authorities.

Case Study 17 – Finland: Methodology for defining future floods[7]

In the seven mainland UoMs in Finland, the assessment of future flood risks is made using an altitude model and spatial data, which considers the location and hydrological and geomorphological characteristics of water bodies, the effectiveness of regulatory and flood defense structures and other available flood risk management measures, and long-term change of conditions, including climate change impacts. Data on the coverage and damage potential of future floods were obtained from flood risk maps. In the spatial data analysis, low, potentially flood-prone areas were identified based on topography and the location of water bodies and their hydrological properties. Flood hazard maps and the flood area of the preliminary flood risk assessment modeled as described above were combined with spatial data describing land use. Based on the number of inhabitants and floor area of the building and apartment register, the so-called flood risk boxes and flood risk areas were calculated. The spatial data produced, and the calculated damage potential indicators provided a tool for identifying flood risk areas or areas insignificant to flood risks. The following factors have been taken into account in assessing the harmful consequences of future floods: number of inhabitants, number of buildings that are difficult to evacuate, economic activities securing vital functions (e.g. ports and airports), infrastructure (e.g. lost connections), community activities (e.g. water, energy, and telecommunications outages), polluting installations/activities, adverse effect on the environment (e.g. deterioration of a water body and pollution of a protected area due to discharges), cultural heritage (e.g. damage to cultural environments or protected buildings, damage to archival and museum objects, etc.), frequency of flooding, the origin and nature of the flood, land use changes (e.g. zoning pressure) as well as regional and local conditions.

Case Study 18 – Slovenia: Assessment of future flood risk

Slovenia has significantly revised its methodology for the assessment of future flood risk for the second cycle PFRA, and has published details of this in a specific report[8]. Potential future floods are presented by means of a flood hazard potential map, which is compiled from the following flood records:

[7] Main PFRA document: http://wwwi9.ymparisto.fi/i9/fi/trhs/tulvariskien_alustava_arviointi_suomessa_vuonna_2018.pdf

[8] Methodology for the Amendment of the Preliminary Flood Risk Assessment (Determination of New or Additional Areas of Significant Flood Risk) https://www.gov.si/assets/ministrstva/MOP/Dokumenti/Voda/NZPO/e6c54974b8/PFRA_metodologija_IzVRS.pdf

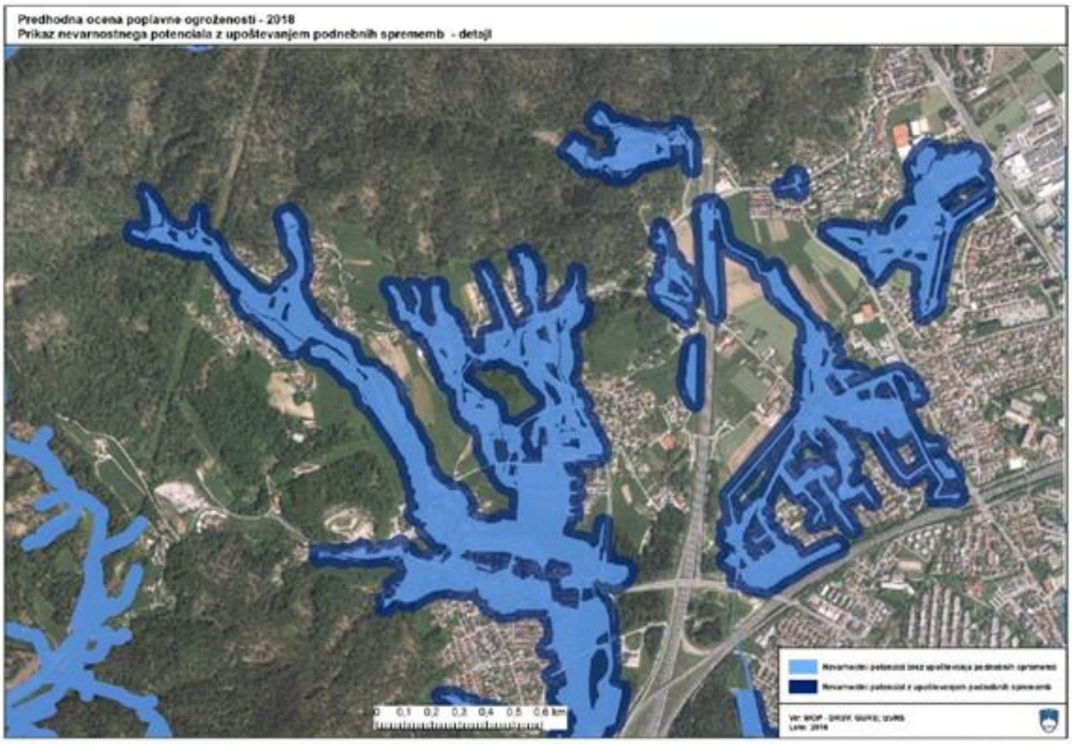
- Integral flood risk maps, a collection of results of studies investigating the flood risk in areas where urban development is anticipated. These studies use a common, nationally defined, methodology but do not cover all areas.

- A flood warning map which covers the whole country and shows the extent of flood areas according to the frequency of occurrence (frequent, rare and very rare).

- A database of past flood events that mainly contains data on the location where past flood events occurred.

- Maps of potential torrential flooding (all watercourses with an average inclination of the catchment area greater than 25% are included; the area in question is the water network of these watercourses with a 25 m offset on each side of the watercourse axis).

The final flood hazard potential map also takes the expected changes in water flow resulting from climate change into consideration. An example of the final map from the PFRA[9] is shown below. Other information, including flood risk maps, flood warning maps and the database of past flood events are available on the Slovenian map viewer[10].



Slika 43. Karta nevarnostnega potenciala (z upoštevanjem vpliva podnebnih sprememb) - detajl

Case Study 19 – Lithuania: Assessment of potential consequences of future flood risk

In Lithuania locations which are subject to future flood risk are identified by considering the location of significant past floods, topography, expected climate change impacts, location of water courses and their general hydrological and geomorphological characteristics. Once rivers or territories with future flood risks are identified, an

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[9] https://www.gov.si/assets/ministrstva/MOP/Dokumenti/Voda/NZPO/e56d7a6180/predhodna_ocena_poplavne_ogrozenosti_2019.pdf

[10] https://gisportal.gov.si/portal/apps/webappviewer/index.html?id=11785b60acdf4f599157f33aac8556a6

assessment of adverse consequences of future floods is performed. The assessment mainly relies on the land use analysis and results in estimates of potentially flooded agricultural and urban areas, infrastructure, affected inhabitants and protected areas.

The potential monetary damage of future floods is estimated with regard to economic activities (taking into account potential damage to property, infrastructure, losses of agricultural production). Damage estimates for different probability floods (0.1%, 1%, 10%,) are provided in the interactive flood hazard and risk map[11] for each grid cell. Based on the information provided on the webpage of the Lithuanian EPA[12], the consequences of future floods with respect to human health, environment, cultural heritage and economic activity are then assessed with the purpose of developing flood risk maps. The assessment is carried out by applying spatial analysis tools and combining the data on populated areas, inhabitant numbers, location of protected areas and cultural heritage and areas of economic activities with the information from flood hazard maps.

The consequences to human health are assessed in terms of numbers of potentially affected inhabitants whilst the assessment of damage to economic activity covers the assessment of:

- potential adverse consequences for property,
- potential adverse consequences for infrastructure (roads, buildings),
- potential adverse consequences for land use in rural areas (lost forest and agricultural production),
- potential negative consequences for economic activity (production, construction, services),
- other potential negative consequences (indirect economic and social costs, emergency costs).

Potential consequences for environment and cultural heritage are assessed in terms of numbers of the following present in the flood hazard areas:

- installations covered by Annex I of the IPPC Directive (96/61/EB) which in the case of flooding can cause accidental pollution,
- wastewater treatment plants,
- landfills and other waste management infrastructure,
- water abstraction sites and their protection zones,
- bathing sites,
- Natura 2000 sites, important for protection of birds and habitats,
- cultural heritage.

The potential social consequences are estimated based on statistical data on inhabitants' age, health status, income, unemployment rate, living conditions. Assessment results, expressed as a coefficient ranging from 0 (low risk) to 1 (high risk), are presented in the interactive flood hazard and risk map[13].

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[11] https://potvyniai.aplinka.lt/map
[12] http://vanduo.gamta.lt/cms/index?rubricId=6d87deab-3ecc-412a-9b66-7fd6361f26ba
[13] https://potvyniai.aplinka.lt/map

Case Study 20 – Latvia: Detailed methodology for calculating the potential consequences of future flooding, including a social index to express risks to social groups

In Latvia the methodology for the assessment of the consequences of future flood risk takes account of the following indicators:

1. Population in the flooded area;
2. Losses from economic activity and property;
3. Danger to social risk groups.

A special map is created for each indicator and then integrated into a combined map.

The damage to economic activity and property caused by the floods is monetary units for each type of land use (residential buildings, roads, agricultural land) per unit area (eg ha or m^2). The methodology includes formulae for the calculation of damage for each type of land use, for example for the calculation of damage to residential buildings the following formula is used:

$$Cost = S * V * F, \text{ where:}$$

S = area of the flooded building;

V = renovation costs per square meter;

F = damage factor value depending on the depth of flooding[14] (see table below)

Depth of flood, m	Damage factor
0	0
0 - 0.5	0.06
0.5 – 1	0.08
1 – 2	0.44
2 – 3	0.62
3 – 4	0.78
4 – 5	0.8
5 – 6	1

The threat to social risk groups is expressed using a social index related to the impact of the flood damage on the socially vulnerable groups in society.

The following statistical indicators are used in the calculation of social risk (% of total population in the administrative territory):

- population over 75 years of age,
- population under 15 years of age,
- population with chronic diseases,

[14] Taken from Kok M., 2001. Damage functions for the Meuse River floodplain. Internal report, JRC (Ispra)

- disability,
- jobseekers / unemployed,
- residents in families forced to give up a car,
- people in families facing economic problems,
- average monthly income of the population (gross), euro,
- land area per capita, m^2

To optimize data analysis, indicators or criteria are divided into two large groups (see table below) where "max" are criteria that increase social risk and "min" are criteria that reduce the risk.

Risk indicators of socio-political aspects of floods

No.	Indicator	Administrative unit of data compilation*	Group of data for analysis
1.	Population over 75%	n	max
2.	Population under 15%	n	max
3.	Population with chronic diseases, %	r	max
4.	Disability, %	r	max
5.	Job seekers unemployed,%	n	max
6.	Residents of families forced to give up cars, %	r	max
7.	Population in families facing economic problems, %	r	max
8.	Average monthly income of the population (gross), euro	v	min
9.	Land area per capita, m^2	n	min

* - administrative unit in which statistics are available - county (n), region (r) or country

An equal weighting is assumed for all indicators in the assessment of potential social risk. The data are restructured into a matrix in which the element $\mathbf{X}_{ij}$ indicates the **i**-th alternative to **J**-th criterion (**J**= 1, 2 ..., m and **i**= 1, 2, ..., n). The methodology analyses m = 9 criteria (indicators) and n = 119 alternatives (administrative units). The data is transformed using vector normalization:

$$\mathbf{X}^*_{ij} = \frac{\mathbf{X}_{ij}}{\sqrt{\sum_{i=1}^{m} X^2_{ij}}}$$

$\mathbf{X}^*_{ij}$ **=** normalized j-th criterion of the i-th alternative. This value has [0; 1] interval.

To calculate the social index for each administrative unit, the criterion of "max" the amounts must be deducted from the sum of the "min" criteria:

$$\mathbf{y}^*_{ij} = \sum_{j=1}^{g} x^*_{ij} - \sum_{g+1}^{n} x^*_{ij}$$

Where:

g = 1 .., m = criteria that increase social risk;

y^{*}_{ij} = aggregated social index.

The maximum value of the index indicates the largest loss in social terms.

The impact of floods on social risk groups is calculated using existing threats to the population in flooded areas and size of socio-political index:

$$S = \sum Pop\ (A, p) * \mathbf{y}^{*}_{ij}$$

Where:

S = number of people at social risk in the flooded area,

Pop (A, p) = population in the flooded area with area “A” in floods with “p” probability

Case Study 21 - Poland: Consideration of long term developments

Poland has assessed the effect of long-term developments on future flood risk by taking into account of two criteria: 1) the development of population density, 2) impact of spatial management with regard to the changes in built up areas (type of land use considered: rural, residential, industrial, transport infrastructure). The effect of long-term developments was assessed for fluvial floods with a mechanism of natural exceedance, for fluvial floods due to damage to flood prevention infrastructure, for pluvial floods, and for sea water floods. This type of analysis was not carried out for winter floods or for floods due to damage to damming infrastructure due to a methodology for such assessments not being available.

Case Study 22 - Poland: Assessment of flood risk as a result of damage to or destruction of a dam

An analysis of past floods resulting from the destruction or damage to dam structures was carried out which examined a total of 56 dams. It was concluded that historical floods resulting from damage to dams had not occurred. There is only one failure on record which took place during construction and it concerned the failure of a dyke and it was therefore concluded that its effects were not relevant to the analysis of floods resulting from the destruction or damage to damming structures. A further assessment of all dams was then carried out based on two criteria: the height of the dam is greater than 10 m; and a risk of flooding due to the failure of the dam has been identified in other projects. The extent of the likely flooding was assessed. Information for 25 reservoirs was obtained, and the number of buildings likely to be affected by the flooding was calculated and presented for each category of building. The analysis showed that in the areas at risk of failure of 26 dams, there are over 222 000.various types of facilities, of which

- 113 955 - buildings permanently inhabited by people,
- 83 345 - farm buildings,
- 12 192 - facilities employing people (enterprises, offices, etc.),
- 1 481 - schools, research institutions and hospitals,
- 1 294 - cultural facilities, museums and libraries,

- 898 buildings in which people temporarily live (hotels and guesthouses),
- 470 - historic and religious buildings (churches and archaeological sites)

Twenty six reservoirs were identified as areas of significant flood risk as a result of the assessment, with one further reservoir identified for further consideration in the third cycle PFRA.

Case Study 23 – France: Assessment of the flood risk from dams

Nombre de barrages « pondéré »

Les barrages et digues (créés par l'homme) sont recensés dans le Système d'Information sur les Ouvrages Hydrauliques (SIOUH).

Les retenues naturelles (lacs naturels, moraines, etc…) ne seront pas traitées par cet indicateur, mais dans le chapitre « autres types d'inondations » du guide (séquence 13).

Justification de l'indicateur

Une digue est construite dans le but de protéger des enjeux d'une inondation. On peut donc considérer la présence de digues dans un territoire comme un indicateur de présence du **risque** d'inondation.

Les digues et les barrages sont aussi des sources potentielles de risque d'inondation en cas de rupture de l'ouvrage.

Données en entrée

- «Tronçons de barrages » ponctuels issus de SIOUH, classés (garder A et B) et cartographiés sous forme de points à partir des coordonnées du centroïde de l'ouvrage,
- Table des pavés de calcul.

Détail de la méthode

- A partir des barrages :
  - Pavé par pavé, compter le nombre de barrages ponctuels par classe,
  - Pavé par pavé, mesurer et sommer les proportions de longueurs de barrage linéaire[11] par classe,
  - 2 colonnes résultats : NbA[12], NbB.
- Faire le calcul des 2 indicateurs « intégrateurs » au pavé :

N_BARRAGE = NbA * 10^3+NbB.

[11] proportion de longueur de barrage linéaire = longueur mesurée dans le pavé divisée par la longueur totale

[12] pour les barrages classe A : NbA = Nombre de barrages ponctuels dans le pavé + Somme des proportions de barrage linéaire dans le pavé

Machine translation:

Number of "weighted" dams

Dams and dikes (created by man) are listed in the Information System on Hydraulic Works (SIOUH).

Natural reservoirs (natural lakes, moraines, etc.) will not be treated by this indicator, but in the chapter "other types floods "in the guide (sequence 13).

Rationale for the indicator

A dike is built in order to protect the stakes of a flood. We can therefore consider the presence of dikes in a territory as an indicator of the presence of flood risk .

Dikes and dams are also potential sources of risk of flooding if the structure breaks.

Input data

"sections of dams" from SIOUH, classified (keep A and B) and mapped as points from coordinates of the centroid of the structure,

Table of calculation blocks.

Method detail

From the dams:

- Pavement by pavement, count the number of punctual dams by class,
- Block by block, measure and sum the proportions of linear dam lengths[11] per class,
- 2 results columns: NbA[12], NbB.

Calculate the 2 "integrating" indicators on the pavement:

N_BARRAGE = NbA * 10^3+ NbB .

11 proportion of linear dam length = length measured in the paving stone divided by the total length

12 for class A dams: NbA = Number of point dams in the block + Sum of the linear barrier proportions in the block

Case Study 24 – Italy: Po RBD (ITB) Methodology for selection of APSFRs

The Po RBD (ITB) set out a clear methodology for the selection of APSFRs in a specific document[15]. The document includes the flow chart below outlining the process, and goes on to explain how the process should be applied, including details of how the specific criteria used should be calculated.

15 http://www.adbpo.it/PDGA_Documenti_Piano/PGRA2015/Sezione_A/Allegati/Allegato_3/Allegato_3_Relazione_ordinamento_e_gerarchizzazione_aree_a_rsichio.pdf

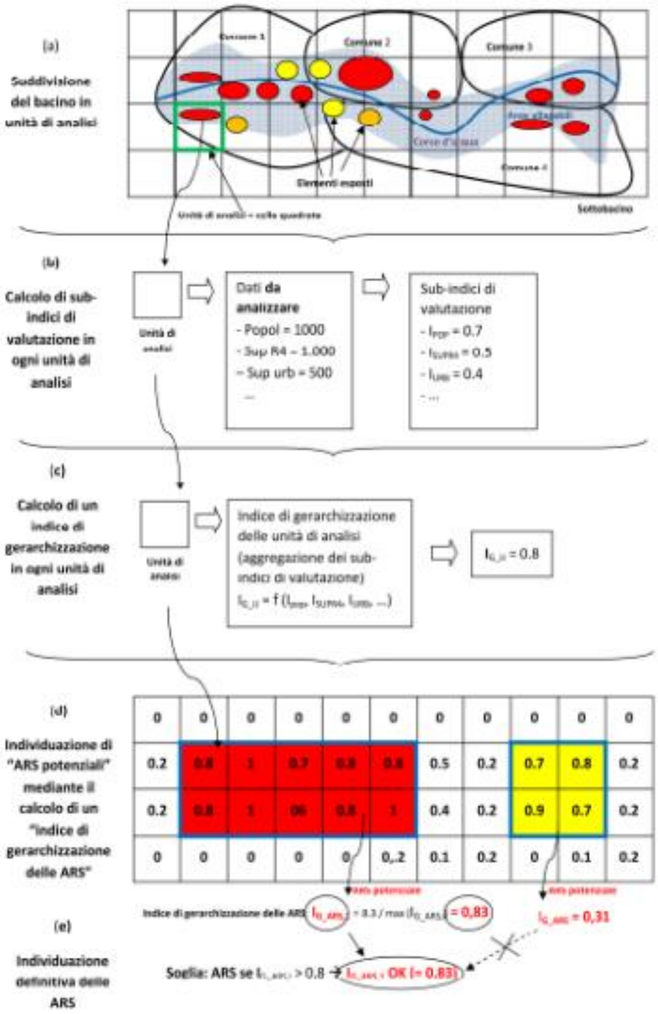


Figura 1 – Fasi della metodologia di lavoro per l'individuazione delle ARS: esempio relativo ad un sottobacino costituito da 4 Comuni, entro cui scorre un corso d'acqua che causa inondazioni, le quali vanno ad insistere su beni esposti a cui sono state attribuite classi di rischio (colori, nell'esempio) differenti. Nel caso in esame il sottobacino è stato suddiviso in unità di analisi costituite da celle quadrate appartenenti ad una griglia. Per ogni cella si calcola un "indice di gerarchizzazione delle unità di analisi" (IG_U). Le "ARS potenziali" sono individuate selezionando celle contigue il cui indice di gerarchizzazione IG_U è superiore ad una soglia stabilita (es. 0.7). L'individuazione definitiva delle ARS avviene calcolando un "indice di gerarchizzazione delle ARS" (IG_ARS) per ogni "ARS potenziale" e selezionando solo quelle il cui indice IG_ARS supera una soglia stabilita (es. 0,8).

Machine translation of figure title: Figure 1 - Phases of the working methodology for the identification of ARS[16]: example relating to a sub-basin consisting of 4 municipalities, within which flows a watercourse that causes flooding, which they insist on exposed goods to which risk classes have been assigned (colors, in the example) different. In the case in question, the sub-basin was divided into units of analysis consisting of cells squares belonging to a grid. For each cell a "hierarchy index of the unit of analysis "(IG_U). The "potential ARS" are identified by selecting contiguous cells whose indexIG_U hierarchy is higher than an established threshold (eg 0.7). The definitive identification of the ARS occurs by calculating an "ARS hierarchy index" (IG_ARS) for each "ARSpotential "and selecting only those whose IG_ARS index exceeds a set threshold (eg 0.8).

[16] ARS = APSFR

Case Study 25 – Austria: Criteria for the selection of APSFRs

Austria identified clear criteria and thresholds for the selection of APSFRs:

- impacted areas (populated or economically utilized) ≥ 60 ha;
- ≥ 200 impacted people per kilometre, on a length of at least 1.5 km, or fatalities solely due to the flooding event;
- damages (including infrastructure and cultural heritage) ≥ €5 million;
- disruption of drinking water supply through the contamination of protected areas for ≥ 1000 people; and
- significant ecological damages in protected areas ≥ 100 ha.

Case Study 26 – the Netherlands: Deltaprogramma

The Netherlands considered the IPCC scenarios for climate change impacts on flood risks. The outcomes of several projects that took into consideration these IPCC scenarios have been summarized under the so called 'Deltaprogramma'. This programme is an integral strategy to prepare the Netherlands for the consequences of climate change, higher and lower river discharges, changes in extreme precipitation, land subsidence and salinisation. The programme also takes into consideration socio-economic developments. The Deltaprogramma includes Delta scenarios on climate change, and these are used to identify and detect flood risks related to hydrological changes in an early stage. This is then further used in the cyclical evaluation of flood risk of infrastructures.

Case Study 27 – Croatia: Climate change modelling studies

The Croatian State Hydrometeorological Institute conducted a modelling exercise. The set of simulations was performed by the regional climate model for the period 1971 to 2070 at a spatial resolution of 12.5 km, and for the period 1971-2099/2100 at a spatial resolution of 50 km. The results of CMIP5 global climate models were used as boundary conditions: EC - EARTH, HadGEM2 - ES, CNRM - CM5 and MPI - ESM - MR. Until 2005, the global climate models and RegCM4 used measured greenhouse gas concentrations. For the period after 2005, two IPCC scenarios were used (RCP4.5 and RCP8.5) to simulate greenhouse gas concentrations. Simulations of the RegCM4 model were performed according to the recommendations and design of the CORDEX and EURO - CORDEX initiatives.

Based on the results of climate change modelling, it was concluded that the impact of climate change on flood risks is relevant throughout Croatia, and climate change should be carefully considered in all aspects of flood risk management. At the same time, the results of the model indicate that, in general, the adverse effects of climate change on flood risks increase: (1) from northeast to southwest and (2) on the coast where meteorological effects are superimposed with the effects of the sea level rise (which is also one of the predicted consequences of climate change). For the period 2011-2040 projections indicate possible warming in winter, spring and autumn from 1 to 1.3 ° C and in summer in most parts of Croatia from 1.5 to 1.7 ° C, and the results for the period 2041-2070 are even worse (1.7 - 2 ° C and 2,4 – 2.6 ° C). Further analyses of precipitation trends indicate a significant trend of increasing monthly precipitation for February in the whole of Croatia, and also a significant growing trend of maximum daily precipitation for February in HRJ.

The spatial presentation of the impact of climate change is systematized on the map "Impact of climate change on flood risks"[17]. As part of the already established cooperation between the State Hydrometeorological Institute and Hrvatske vode, work continues on improving the interpretation of all previous knowledge on climate change, which will provide a more reliable assessment of the impact of climate change on flood risk management.

Case Study 28 – Portugal: Climate change models

The trend for high intensity rainfall over shorter periods leading to a greater occurrence of extreme events is acknowledged to pose increased risks either in the context of floods originating either from rainfall, due to insufficiencies in drainage systems in urban environments or from river floods, due to insufficient capacity for land drainage or as a result of difficulties in the management of the upstream hydraulic infrastructure. In order to take account of these predictions in the PFRA, the Portuguese Institute of the Sea and the Atmosphere (IPMA) developed scenarios of climate change in the various regions Portugal based on the results of multiple sets of climate models. These scenarios led to the development of indicators which could then be applied to the analysis of past floods. No information on the exact methodology used for the development or application of these indicators is provided in the PFRA.

Case Study 29 – Sweden: Climate change modelling

Sweden has used advanced and detailed modelling to incorporate climate change into its assessments. Modelling for the river basins, including climate change scenarios for the 100-year flood, has been carried out. The calculations are based on a method described in a report from 2011 by the Swedish electricity industry research group (Elforsk)[18]. Two exceptions are for the Torne river and the Göte river which do not have climate change projected 100-year floods. In the calculations different models and scenarios have been used in so called ensemble modelling for river basins in different parts of Sweden and used to generate different scenarios. Statistical calculations have then been conducted for periods of 30 years and the future 100-year flood calculated for these until 2098, showing an expected situation in 2100. The assessment includes, and maps on a dedicated online flood map portal[19] show, the extent of the flooded areas for the 100-year flood for the climate of the future. In addition, the 200-year flood scenarios considering climate change are included in the online map portal.

Case Study 30: Bilateral co-operation between Germany and the Netherlands on the EMS

As part of an exchange of letters between the competent ministers of the Netherlands government and the German Lander concerned, it has been agreed that the implementation of the Flood Risk Management Directive will be conducted in the same way as the implementation of the Water Framework Directive. This means that the information exchange and coordination on cross-border issues will take place in the international

[17] HR PFRA 2018, Section 3.5.1., Figure 50, p. 80. https://www.voda.hr/hr/prethodna-procjena-rizika-od-poplava-2018

[18] https://www.svk.se/siteassets/3.sakerhet-och-hallbarhet/dammsakerhet/rapporter-och-yttranden/elforskrapport-11-25-dimensionerande-floden-for-dammanlaggningar.pdf

[19] https://gisapp.msb.se/apps/oversvamningsportal/avancerade-kartor/oversvamningskartering.html

steering group Ems (ISE) and the international coordination group Ems (IKE) that are already in place (see figure below).

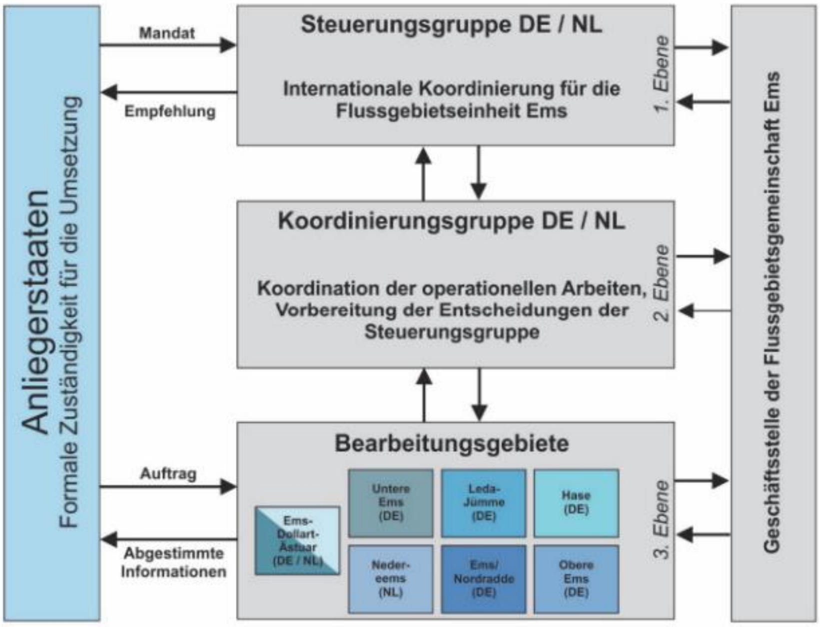


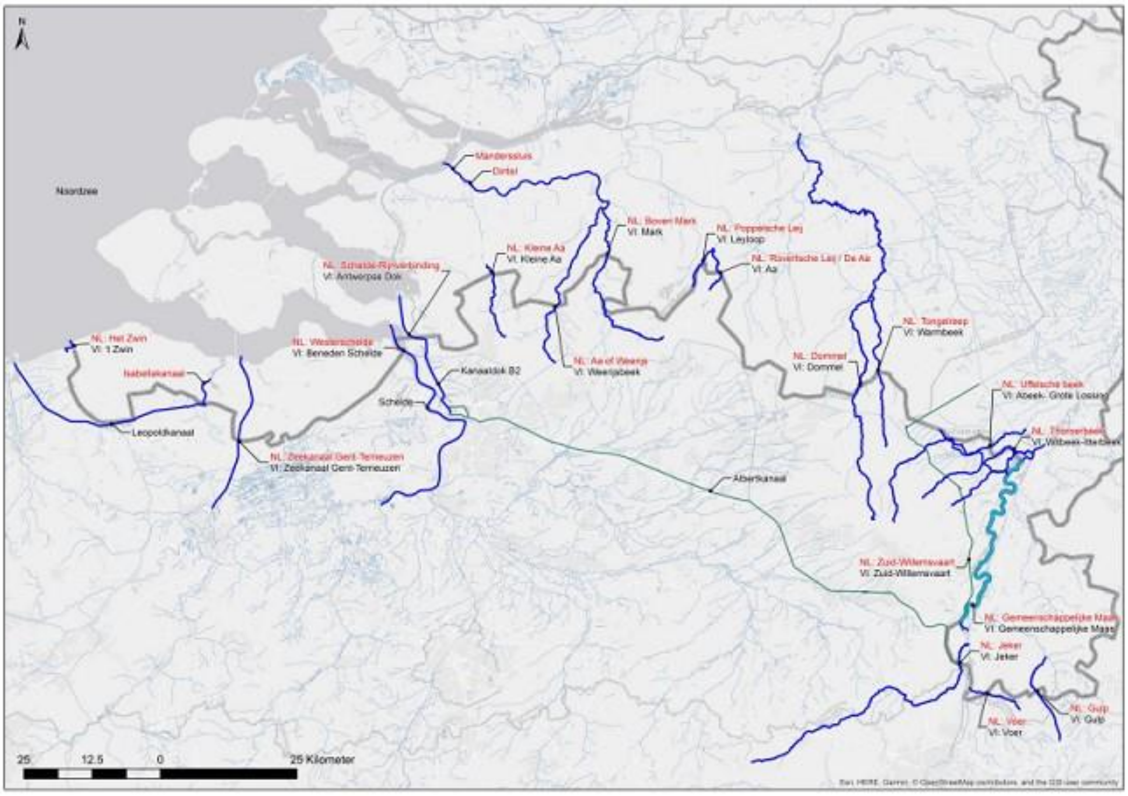
Abb. 3.1: Organisationsstruktur in der Flussgebietseinheit Ems

The ISE is responsible for the overall coordination and the general progress of work. This body makes the most important decisions on co-operation between the participating member states/federal states through meetings of the representatives of relevant ministries. The IKE consists of experts from the Netherlands, North Rhine-Westphalia and Lower Saxony. This body sets the fundamental resolutions of the inter-national steering group Ems and makes specific agreements about the joint implementation of the necessary operational work.

Case Study 31: Bilateral coordination between Belgium (Flanders) and the Netherlands on the Meuse and the Scheldt

Flanders and the Netherlands produced a short report describing how coordination has been achieved in the preparation of the PFRA and the identification of APSFRs. This includes a map showing the transboundary water bodies, and a table for each UoM showing where a flood risk is considered to exist.

Kaart 1. Grensoverschrijdenden waterlopen tussen Vlaanderen en Nederland.



Tabel 1 met Vlaams-Nederlandse grensoverschrijdende wateren die aan Vlaamse of Nederlandse kant onder de ROR/ORL (tweede cyclus) vallen. Met "X" is aangegeven of het water meegenomen wordt.

Stroomgebied van de Maas

Vlaanderen	ORL2	Nederland	ROR2	opmerking
Gemeenschappelijke Maas	x	Gemeenschappelijke Maas	x	
Gulp	x	Gulp	x	
Voer	x	Voer	x	
Jeker	x	Jeker	x	
Itterbeek	x	Thornerbeek	x	
Abeek - Grote Lossing/ Uffelsche beek	x	Uffelschebeek	x	
Zuid-Willemsvaart		Zuid-Willemsvaart	x	
Warmbeek	x	Tongelreep		
Dommel	x	Dommel		
De Aa	x	Rovertsche Leij / De Aa		
Leyloop	x	Poppelsche Leij		
Merkske	x	Merkske		
Mark	x	Boven Mark		
Grote Aa/ Weerijsbeek	x	AA of Weerijs		
Kleine AA/ Wildertse Beek	x	Watermolenbeek		