ICPDR Flood Risk Management Plan: ANNEX 2 Overview of measures

Overview of measures for achieving the objectives for the management of flood risks in the Danube River Basin District

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1 Introduction

Directive 2007/60/EC on the assessment and management of flood risks (European Floods Directive, EFD) requires that Member States on the basis of the flood hazard and flood risk maps shall establish flood risk management plans coordinated at the level of the river basin district.

Member States shall establish appropriate objectives for the management of flood risks for the areas identified under EFD Article 5(1) and the areas covered by EFD Article 13(1)(b), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding.

The flood risk management plans have to include a summary of the measures and their prioritisation aiming to achieve the appropriate objectives of flood risk management, including the measures taken in accordance with EFD Article 7, and flood related measures taken under other Community acts, including Council Directives 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (1) and 96/82/EC of 9 December 1996 on the control of major accident hazards involving dangerous substances (2), Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (3) and Directive 2000/60/EC.

In accordance with the EFD Article 7(2) the ICPDR agreed upon the following objectives for the Flood risk management plan for the Danube River Basin District:

- Avoidance of new risks
- Reduction of existing risks
- Strengthening resilience
- Raising awareness
- Solidarity principle

This overview of measures is structured in accordance with these basin-wide objectives.

This is a living non exhausting list of measures which could be amended if relevant.

2 Measures to avoid new risks

Aspects of flood risk management	Type	Description	Measures by countries
Prevention	Avoidance	Measure to prevent the location of new or additional receptors in flood prone areas, such as land use planning policies or regulation	GERMANY • Regional planning • Designation of floodplains • Area development planning • Adopted land use • Conceptions / studies / expertise • Information and training AUSTRIA • Compilation and update of hazard zone plans • Incorporation of hazard zone plans • Development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance • Compilation and incorporation of local and regional land use planning strategies • Definition of a framework for implementation and maintenance of flood protection and mitigation measures. CZECH REPUBLIC • Elaboration or update of the zoning plans (to define area without buildings) • Application of results of flood hazard maps and flood risk maps as a limits in zoning plans

			• Change of functional use in zoning plans • Raising of buildings and other structures resilience (technical regulations) SLOVAKIA • Incorporation of delineated flood prone areas into spatial planning HUNGARY • New regulations on the flood risk areas on land use planning (less valuable land use) • New regulations on the flood risk areas in the field of construction (water resistant constructions) SLOVENIA • Legal restrictions for public or private investments through conditions and limitations for constructions and activities on flood risk areas • Prevention of increasing the damage potential on flood hazard areas through municipal spatial plans and national spatial plans CROATIA • Continuation of activities on formal introduction of a special level of protection and maintenance of natural water retention and wetland areas and boundaries of the public water domain in the process of physical planning • Continuation of activities on registration of the public water domain in land registry • Monitoring of conditions on the public water domain SERBIA • Delineate “water land” and include this land category in land registries and municipal spatial plans • Implement results of flood hazard and flood risk mapping in spatial plans

			• Limit the increase of flood risk in the actually and potentially flooded areas through special conditions and permits, set in the law • Update the Erosion map of Serbia and designate erosion-prone areas, with conditions for their use and necessary works and measures for erosion and torrent control BOSNIA AND HERZEGOVINA • Inclusion of flood areas into the spatial plans and other planning documentation • Preparation of missing maps of flood hazards for rivers ROMANIA • Definition of a legal, organizational and technical framework for Flood Directive implementation (improving the legal framework on the implementation of the Flood Directive), preparation of studies, projects and programmes, including transfer of know-how and experience exchange to support implementation of the Floods Directive at basin and national level • Reviewing and updating plans for flood risk management (redefine/update APSFR, update hazard maps and flood risk, taking into account the flash-floods and climate change effects, review and update flood risk management plans at basin, sub basin and national level • Coordination of territorial planning strategies (developing plans at national, county, regional and urban plans with flood risk management plans) (implementation of a coordinated system of inspection and control of the application of legal and technical regulations on relocation, location, execution of the of existing and new construction in floodplains, coordinated update of the landscaping plans at national, local and county level by implementing flood risk management plans, implementation of a coordinated system of institutional collaboration for population relocation) BULGARIA • Legislative restrictions of the construction works in the floodplains • Prohibition of the construction in flood-prone zones. • Restrictive measures to the investment intentions in areas adjacent to the river's bed.

			MOLDOVA • Preventing location of new or additional receptors in flood prone areas UKRAINE • Compliance of approved flood areas • Compliance of legislative documents related to the territorial development
Preparedness	Emergency Event Response Planning / Contingency planning	Measure to establish or enhance flood event institutional emergency response planning	GERMANY • Emergence event response planning • Conceptions / studies / expertise • Information and training CZECH REPUBLIC • Flood inspection on rivers, water reservoirs and water structures HUNGARY • Renewal of the flood protection plans • Recalculation of design flood levels SLOVENIA • Renewal of national and municipal plans for flood protection and rescue (estimation of endangerment, measures and tasks, needed forces and equipment) • Update of discharge return periods and hydraulic consequences including climate change projections CROATIA • Updating of flood protection systems management plans and operative flood defence

			plans • Harmonization of operative flood defence plans with National civil protection directorate • Monitoring of data on flood events and effectiveness of flood protection measures SERBIA • Study of climate change impacts BOSNIA AND HERZEGOVINA • Preparing report on setting limits concerning surface water in municipal cadastres • Application of restrictions related to flood areas and surface waters. • Application of agro-technical measures, forests managing measures and land-use in accordance with the nature protection. ROMANIA • • Monitoring, forecasting and warning systems improvement • Ensuring human, financial and material emergencies and stimulate volunteerism (purchase/use of mobile flood protection systems, ensuring necessary human and financial resources for adequate management of emergency situations caused by floods BULGARIA • Elaboration or update of emergency action-plans for water systems and hydrotechnical facilities. • Develop of special flood-related action-plans for the “SEVESO” facilities

			MOLDOVA • Issuing of the DECISION NO. 1340 from 04.12.2001 of the Commission for Emergency Situations of the Republic of Moldova on undertaking specific tasks related to population and territory protection from emergency situations UKRAINE • Development and approval of yearly plans on emergence response • Application of plans and solutions of commissions on of technogenic and ecological secure and emergency • Confinement plans development

	Other preparedness	Other measure to establish or enhance preparedness for flood events to reduce adverse consequences	GERMANY
			• Insurance, financial precautions
			
			HUNGARY
			• Communication of flood risk
			• New regulation of the financial circumstances
			
			SLOVENIA
			• Identification and administrative protection of significant inundation areas
			
			CROATIA
			• Regulation of obligations of regular monitoring, analysis and reporting
			  ○ Conditions of flood protection structures and systems
			  ○ Data on flood events and effectiveness of flood protection measures
			  ○ Conditions on the public water domain
			• Establishment of a registry of legal entities certified for performing preventive and operational flood defence

			SERBIA • Permanent monitoring and inspection of erosion control and flood protection structures • Permanent monitoring of erosion processes and the state of torrential rivers ROMANIA • Develop and/or review of flood defence plans in conjunction with other management plans related emergencies • Flood exercises simulation with inter-institutional participation (simulation exercises involving all county institutions with responsibilities in the management of flood risks) BULGARIA • Monitoring and forecasting of rainfall / runoff in the river basins. Monitoring of the damsBroad access to the information and forecasts on water level, river-flow and ice conditions MOLDOVA • Communication on flood situation • Strengthening levees UKRAINE • Determination of potentially dangerous hydrotechnical structures • Modelling of the possible emergency situations
Protection			AUSTRIA • Improvement of retention capacity on catchment scale • Restoration of flood plains and sedimentation areas • Structural protection measures

		• Object oriented measures • Relocation and reallocation • Improvement of river inspection • Maintenance of protection and mitigation measures, river maintenance ROMANIA • Measures to restore retention areas (flood plains, wetlands etc.) (creating new wetlands, reconnecting and restoring floodplain, recreating watercourse meanders, to rehabilitate the banks of the watercourses (vegetative protection), restoring natural lakes • Natural water retention measures in urban/populated areas ("green" gutters and channels, drainage systems etc., collection and storage of rainwater in underground tanks, permeable paving, green roofs, bio retention areas, seepage canals, green areas etc.) • Natural water retention measures by changing or adapting land use practices in agriculture and forests management (maintaining areas occupied by meadows and pastures, cultivation practices to conserve soil, terracing slopes curtains shrubs for protection, improve management of forests in floodplains, afforestation mountain areas (in the upper basin), afforestation of additional area near reservoirs • Surveillance, monitoring the behaviour, expertise, strengthening interventions, rehabilitation and maintenance of watercourses and maintenance of hydraulic works (improving surveillance, works behavior and control, measures to modernize and strengthen the hydraulic works, maintenance existing flood protection infrastructure)
Other		GERMANY • Financial aid program BOSNIA AND HERZEGOVINA • Application of anti-erosion measures in the river basins and measures for torrents

		defence • Protection of objects against erosion and torrents CROATIA • Analysis of the climate change effects on the concepts of flood protection and flood risk management SERBIA • Update and apply principles and methods of flood-resilient construction • Update the Cadastre of erosion and torrents • Update the Cadastre of water structures • Include all data in Water Information System of Serbia BULGARIA • Flood-resilient design and construction of buildings

3 Measures reducing the existing risks

Aspects of flood risk	Type	Description	Measures by countries

management			
Prevention	Removal or relocation	Measure to remove receptors from flood prone areas, or to relocate receptors to areas of lower probability of flooding and / or of lower hazard	GERMANY • Removal/relocation • Information and training AUSTRIA • Incorporation of hazard zone plans • Relocation and reallocation CZECH REPUBLIC • Removal or relocation of buildings • Spend the rest of buildings and functional use life HUNGARY • Removal or relocation of dykes SLOVENIA • Setting a regulation on flood resilient construction SERBIA • Re-asses legalisation of illegally built structures on flood-prone areas • Remove structures illegally built on flood-prone areas BOSNIA AND HERZEGOVINA • Relocation of most endangered population based on risk map data • Relocation of any potentially dangerous industrial facilities away from the flood risk areas

			ROMANIA • Coordination of territorial planning strategies (developing plans at national, county, regional and urban plans with flood risk management plans) (implementation of a coordinated system of inspection and control of the application of legal and technical regulations on relocation, location, execution of the of existing and new construction in floodplains, coordinated update of the landscaping plans at national, local and county level by implementing flood risk management plans, implementation of a coordinated system of institutional collaboration for population relocation) BULGARIA • Removal of illegally built constructions, barriers, and other artificial obstacles located in the river's beds or in the gullies • Closure and reclamation of unused and abandoned industrial and contaminated sites MOLDOVA • Removal or relocation of buildings UKRAINE • Settling out of population from the flood hazard area • Change of land use
	Reduction	Measure to adapt receptors to reduce the adverse consequences in the event of a flood actions on buildings, public networks, etc...	GERMANY • Flood adapted planning, construction and renovation • Physical protection of buildings • Flood proof storage of water-hazardous substances • Conceptions / studies / expertise

			• Information and training • Research and development projects and best practice projects AUSTRIA • Object oriented measures • Definition of a framework for implementation and maintenance of flood protection and mitigation measures. CZECH REPUBLIC • Individual flood protection measures SLOVAKIA • optimisation of floodplains zoning with respect to existing infrastructure HUNGARY • training local defense leaders, municipality responsible groups • update or create local defense plans • update regional localization plans SLOVENIA • Adaptation of constructions to flood hazard intensity SERBIA • Local flood protection measures (on single or group of buildings), wherever possible • Reassessment and modification of vulnerable infrastructure (esp. road and railroad crossings on rivers)

			BOSNIA AND HERZEGOVINA • Capacity building on municipal level – organizing educational workshops ROMANIA • Natural water retention measures in urban/populated areas "green" gutters and channels, drainage systems etc., collection and storage of rainwater in underground tanks, permeable paving, green roofs, bio retention areas, seepage canals, green areas etc. • Measures to reduce water levels (increase transit capacity by resizing bridges, measures to ensure the drainage capacity, increase transit capacity of the minor riverbed: desilting works and reshaping riverbed, dikes relocation, restoration and increasing of the mitigation volumes in existing reservoirs and polders) • Measures for increasing population resilience (adaptation and implementation of protective measures at various objectives, wet flood proofing, dry flood proofing berms/local levees and floodwalls) • Adapting construction, infrastructure and existing defense structures in terms of climate change (recalculation design levels of current flood protection system, heightening of existing dikes, optimizing operation of existing reservoirs to increase retention/mitigation capacity BULGARIA • Assessment of the discharge and drainage of rainwater – especially via the sewage network • Construction /re-construction of drainage facilities • Construction of new sewerage networks with sufficient capacity

			UKRAINE: • Construction of flood protection structures in compliance with approved programs
	Other prevention	Other measure to enhance flood risk prevention (may include, flood risk modelling and assessment, flood vulnerability assessment, maintenance programmes or policies etc...)	AUSTRIA • Compilation and update of hazard zone plans • Compilation and incorporation of local and regional land use planning strategies CZECH REPUBLIC • Individual evaluation of flood risk and comparison with vulnerability • Programme to finance, to maintain and to check flood protection measures • Technical and safety supervision of water structures • Using of good agricultural practice principle (selection of plants, rotation of plants etc.) HUNGARY • Flood modelling • Land use changes on the catchment area • Education CROATIA • Assessment of status and updating (if needed) of concepts of the existing: o For the purpose of harmonization with the flood risk management objectives o For the purpose of compensation for an increase in the flood risks due to the use of natural water retention, wetland and floodplain areas for settlements and agricultural areas in the process of uncontrolled construction and urbanization of such areas o Assessment of functionality of the existing regulation and protection facilities

			SERBIA • Regular upgrade of the General Flood Defence Plan for the Republic of Serbia • Regular upgrade of the Annual Flood Defence Plans for the Republic of Serbia • Preparation and regular upgrade of the Annual Flood Defence Plans for municipalities • Update/preparation of technical documentation for all existing flood protection structures (incl. data on water estate) • Update/preparation of flood defence manual • Establish efficient bilateral cooperation with all neighbouring countries, including common actions on transboundary rivers during flood and ice defence • Plan and implement the ice control measures, economically feasible and tailored according to river specific conditions • Flood risk modelling • Flood vulnerability assessment BOSNIA AND HERZEGOVINA • Reconstruction measures for flood defence objects • Regular ongoing maintenance of existing flood defence objects • River training projects in the areas indicated by flood risk maps ROMANIA • Definition of a legal, organizational and technical framework for Flood Directive implementation (improving the legal framework on the implementation of the Flood Directive), preparation of studies, projects and

			programmes, including transfer of know-how and experience exchange to support implementation of the Floods Directive at basin and national level • Reviewing and updating plans for flood risk management (redefine/update APSFR, update hazard maps and flood risk, taking into account the flash-floods and climate change effects, review and update flood risk management plans at basin, sub basin and national level BULGARIA • Flood risk modelling and mapping MOLDOVA • Preparation of flood risk and flood hazard maps UKRAINE: • Elaboration of flooded areas • Elaboration of confinement plans • Development of automated monitoring and modelling systems
Protection	Natural flood management / runoff and catchment management	Measures to reduce the flow into natural or artificial drainage systems, such as overland flow interceptors and / or storage, enhancement of infiltration, etc and including in-channel , floodplain works and the reforestation of banks, that restore natural systems to help slow flow and store water.	GERMANY • Natural water retention in the catchment • Natural water retention in wetlands • Reduction of sealing • Natural water retention in settlement area • Recovery of floodplains • Conceptions / studies / expertise • Research and development projects and best practice projects • Information and training

			AUSTRIA • Restoration of flood plains and sedimentation areas • Definition of operating instructions for flood prone and flood influencing facilities CZECH REPUBLIC • Erosion protection measures in the river basins (complex land processing) • Support of rainfall infiltration • Interruption of trajectories of concentrated runoff (including forest roads) • Restoration of small retention areas • Restoration or revitalization of old amelioration structures • Protection and restoration of floodplains • Good management of alluvial plains to reduce runoff • Revitalization of rivers SLOVAKIA Measures to reduce (decelerate) run-off from river basin into the water courses, to increase retention capability of river basin or to support natural accumulation of water in the suitable areas – measures at agricultural soils, in forests and urban areas • operational erosion control measures (organisation of land with respect to erosion control, agro-technical erosion control measures, biological erosion control measures) • technical erosion control measures (erosion control trenches, terraces at hillslopes) • technical forestry measures to influence interception and transpiration of forest vegetation, improvement of infiltration properties of forest soils • measures to decrease storm water runoff • measures to control runoff and decrease water pollution (trenches and ditches, detention and retention ponds and reservoirs, retention soil filters,

			underground retention reservoirs) HUNGARY • divert the excessive water amount to surrounding sub-catchments if possible, to enhance storage capacity • increase the floodplain and riverbed storage capacity usage SLOVENIA • Natural water retention measures (restoration and reconnection of floodplains and meanders, upstream afforestation, adaptation of agricultural practices to improve infiltration potential and to decrease runoff and erosion, reduction of soil sealing in urban areas) CROATIA • Encourage selection of technical solutions that will ensure: o Retention of water in the watershed as long as possible and allowing room for watercourses to slow down the runoff o Preservation, restoration and enlargement of areas that can retain flood waters, such as natural water retention areas, wetlands and floodplains o Prevention of pollution of water and soil by harmful substances during flood events in areas reserved for flood water retention by land use restrictions and administrative measures o Continue creating lowland retentions in the areas of former floodplains for the purpose of flood flow reductions and flood protection of downstream areas o Usage of the existing lowland retention areas for meadows and grazing areas or for restoration of alluvial forests • Identification and preparation of protection and management programmes for floodplains and retention areas that could be used as natural water retention areas

			• Repair, reconstruction and construction of flood protection systems according to Multiannual programme of construction of water regulation and protection facilities and amelioration facilities (selected projects or project components) SERBIA • Sustain existing wetlands and inundated areas • Investigate the possibilities for economically feasible restoration or enlargement of natural retention areas • Sustain existing forests and afforest new areas, especially in hilly and mountain areas prone to erosion • Create green spaces in new urban areas, to enhance water infiltration • Revitalise drainage channels BOSNIA AND HERZEGOVINA • Re-forestation of deforested areas within the catchment ROMANIA • Measures to restore retention areas (flood plains, wetlands etc.) (creating new wetlands, reconnecting and restoring floodplain, recreating watercourse meanders, to rehabilitate the banks of the watercourses (vegetative protection), restoring natural lakes • Natural water retention measures in urban / populated areas "green" gutters and channels, drainage systems etc., collection and storage of rainwater in underground tanks, permeable paving, green roofs, bio retention areas, seepage canals, green areas etc. • Natural water retention measures by changing or adapting land use practices in agriculture and forests management (maintaining areas occupied by meadows and pastures, cultivation practices to conserve soil, terracing slopes curtains shrubs for protection, improve management of forests in

			floodplains, afforestation mountain areas (in the upper basin), afforestation of additional area near reservoirs BULGARIA • Restoration of the natural river beds, meanders and floodplains • Creation of polders and small buffer basins in the river terraces • Afforestation of the river banks and floodplains UKRAINE: • Cleaning of water draining systems, riverbeds and main channels • Elaboration and implementation of floodplain management plans • Application of soil chiseling on amelioration systems
	Water flow regulation	Measures involving physical interventions to regulate flows, such as the construction, modification or removal of water retaining structures (e.g., dams or other on-line storage areas or development of existing flow regulation rules), and which have a significant impact on the hydrological regime.	GERMANY • Planning and construction of flood retention systems • Operation, maintenance and reconstruction of flood retention systems • Conceptions / studies / expertise • Research and development projects and best practice projects • Information and training AUSTRIA • Improvement of retention capacity on catchment scale • Structural protection measures CZECH REPUBLIC • Construction of control structures for inundations • Improvement of existing water structures (raising of storage volume, increasing of discharge capacity, increasing of safety) • Update of operational rules and service regulations for water structure

			SLOVAKIA
			• measures which reduce flood peak discharge – construction, maintenance, repair or reconstruction of water structures
			  ○ dams and reservoirs
			  ○ dry or semi-dry reservoirs, polders
			  ○ bypass canals
			• optimisation of operational rules with respect to flood control and other purposes of reservoirs utilisation
			
			HUNGARY
			• Creating of polders for floods, flash floods and inland water
			• Operation of polders
			• Use of mobile protecting constructions
			• Optimization of reservoir operation
			• Relocation of dikes (space for the river)
			• Designation of natural retention areas where applicable
			
			SLOVENIA
			• Renewal and construction of dry and wet retentions and bypasses
			• Optimisation of operational rules for dams
			
			CROATIA
			• Repair, reconstruction and construction of flood protection systems according to Multiannual programme of construction of water regulation and protection facilities and amelioration facilities (selected projects or project components)

			SERBIA • Investigate possibilities for construction of dry flood-retention reservoirs on large international rivers (Danube, Sava and Tisza) in order to reduce pikes of extreme floods • Use existing reservoirs and retentions for flood management, according to specific regulation rules • Explore possibilities and construct new flood retention capacities on smaller rivers BOSNIA AND HERZEGOVINA • Defining the necessary storage volume and operation regime of the existing retention areas and reservoirs for flood defence • Consideration on construction of new multipurpose reservoirs and retention areas • Reconstruction and remediation of the flood defence system ROMANIA • Measures to reduce water levels (increase transit capacity by resizing bridges, measures to ensure the drainage capacity, increase transit capacity of the minor riverbed: desilting works and reshaping riverbed, dikes relocation, restoration and increasing of the mitigation volumes in existing reservoirs and polders) • Measures to improve capacity retention basin level by making polders and small lakes (made in the upper basin) • Measures to improve retention capacity at basin level by increasing safety awareness in the large existing construction/increase mitigation capacity of reservoirs face to design capacity (safety degree improvement of existing hydraulic structures (rehabilitation: upgrading, measures to limit infiltrations etc), maintenance work for the safe operation of existing hydraulic structures and related equipment

			• Structural protection measures (planning and realization) (construction of new reservoirs for flood peak mitigation, making derivation works, bed stabilization measures - recalibration of riverbeds, fences, shore defences, stabilizing the river bed, protection measures along watercourses through works of local dikes, measures to reduce runoff on slopes and torrents improvement • Adapting constructions, infrastructure and existing defence structures in terms of climate change (recalculation design levels of current flood protection system, heightening of existing dikes, optimizing operation of existing reservoirs to increase retention/mitigation capacity BULGARIA • Constructions for controlled inundation • Use of mobile flood-defence facilities • Efficient management of dams and retention structures • Removal of dangerous and/or inefficient dams and reservoirs MOLDOVA • Operation of water reservoirs UKRAINE • Construction of mountain storage reservoirs • Construction of polders
	Channel, Coastal and Floodplain Works	Measures involving physical interventions in freshwater channels, mountain streams, estuaries, coastal waters and flood-prone areas of land, such as the construction, modification or removal of structures or the alteration of channels, sediment	GERMANY • Adaption of dikes, dams, flood protection walls, dunes, beach ridges, mobile flood defences • Maintenance measures of static/mobile flood defence systems • Conceptions / studies / expertise • Research and development projects and best practice projects

		dynamics management , dykes, etc.	• Information and training AUSTRIA • Development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance CZECH REPUBLIC • Increasing of river discharge capacity • Construction of flood protection dikes • Construction of mobile walls • Evaluation of possible removal of transversal structures in the rivers (lowering of water level) • Increasing of discharge capacity of bridges, culverts, inundation structures etc.) • Construction of embankment walls • Grading in floodplains SLOVAKIA • measures which protect land from inundated water of water courses – technical river training works, flood protection dykes, walls, embankments, other linear flood protection structures • measures to ensure adequate flow capacity of the channels of water courses – maintenance of river channels and their vegetation, removal of deposits • reconstruction or maintenance of bridges to enhance their capacity during floods HUNGARY • removal of obstacles as debris masses, summer dikes, improperly placed artificial objects

			• protection of banks against erosion SLOVENIA • Renewal, construction and maintenance of flood and erosion protection structures • Maintenance of natural and artificial river channels, frequent obstacle removal and reconstruction of culverts • Development of concepts and plans on catchment scale to improve the water and sediment balance CROATIA • Repair, reconstruction and construction of flood protection systems according to Multiannual programme of construction of water regulation and protection facilities and amelioration facilities (selected projects or project components) SERBIA • Levee system on lowland rivers • Restoration of structures damaged during 2014 flood • Completion and reconstruction of flood protection structures • Upgrade of flood protection level of the most important areas, using combination of permanent structures and mobile protection • Implement sediment management measures to maintain river conveyance capacity BOSNIA AND HERZEGOVINA • River training works • Floodplain protection dykes (levies)

			• Torrent control barriers ROMANIA • Measures to reduce water levels Increase transit capacity by resizing bridges, measures to ensure the drainage capacity, increase transit capacity of the minor riverbed: desilting works and reshaping riverbed, dikes relocation, restoration and increasing of the mitigation volumes in existing reservoirs and polders • Measures to improve capacity retention basin level by making polders and small lakes (made in the upper basin) • Measures to improve retention capacity at basin level by increasing safety awareness in the large existing construction/increase mitigation capacity of reservoirs face to design capacity (safety degree improvement of existing hydraulic structures (rehabilitation: upgrading, measures to limit infiltrations etc), maintenance work for the safe operation of existing hydraulic structures and related equipment • Structural protection measures (planning and realization)Construction of new reservoirs for flood peak mitigation, Making derivation works, bed stabilization measures - recalibration of riverbeds, fences, shore defences, stabilizing the river bed, protection measures along watercourses through works of local dikes, measures to reduce runoff on slopes and torrents improvement BULGARIA • Expansion of the "bottlenecks" such as bridges, etc.., which obstruct the river flow. • Heightening and reinforcement of dykes • Terracing; • Reconstruction and maintenance of drainage channels • Maintenance of river-channels and gullies, ensuring adequate flow capacity

			of the channels of water courses UKRAINE • Increasing of soil-reclamation canals' capacity • Construction of falls and riffles on rivers and channels • Riverbed regulation • Construction of protective structures
	Surface Water Management	Measures involving physical interventions to reduce surface water flooding, typically, but not exclusively, in an urban environment, such as enhancing artificial drainage capacities or though sustainable drainage systems (SuDS).	GERMANY • Keeping clear flood discharge cross-sections in settlement area and wetlands • Keeping clear flood discharge cross-sections by maintenance measures and floodplain-management • Conceptions / studies / expertise • Information and training CZECH REPUBLIC • Infiltration structures to catch the rainfall water • Flood protection measures on sewerage system • Construction of retention storages on sewerage system • Creation of complex control systems on sewerage systems • Using of green roofs and rain gardens • Support of rainfall management in the urban areas SLOVAKIA • measures which protect land from inundated „inner waters" – installations (equipment) for pumping the „inner waters" SLOVENIA • Improving the capacity of urban drainage systems and opening of paved

			channels SERBIA • Prepare/update designs of second flood defence lines • Reconsider capacity of urban drainage systems ROMANIA • Measures to reduce water levels Increase transit capacity by resizing bridges, measures to ensure the drainage capacity, increase transit capacity of the minor riverbed: desilting works and reshaping riverbed, dikes relocation, restoration and increasing of the mitigation volumes in existing reservoirs and polders BULGARIA • Protective drainage channels in settlements • Reduction of sealing in urban areas • Management of rivers and channels in urban areas UKRAINE • Increasing of the storm sewage system capacity • Increasing of pumping stations' productivity
	Other Protection	Other measure to enhance protection against flooding, which may include flood defence asset maintenance programmes or policies	GERMANY • Information and training CZECH REPUBLIC • Inspection of the function of existing flood protection measures SLOVAKIA

			• mobile flood protection barriers SLOVENIA • Introducing the use of mobile barriers where possible CROATIA • Implementation of Programs of regular technical maintenance of watercourses, water domain and water structures in accordance with nature protection conditions. • Monitoring of conditions of flood protection structures and systems. SERBIA • Regularly maintain flood protection structures, as well as erosion and torrent control structures • Purchase and repair of machinery, tools, materials, equipment and communications need for flood defence units and emergency management units BOSNIA AND HERZEGOVINA • Developing guidelines for new reservoirs and retention work regime • Design and construction of new defence systems • Design and construction of new multipurpose reservoirs, barrages and retentions ROMANIA • Surveillance, monitoring the behavior, expertise, strengthening interventions, rehabilitation and maintenance of watercourses and maintenance of hydraulic works (improving surveillance, works behavior and control, measures to modernize and strengthen the hydraulic works, maintenance existing flood protection infrastructure)

			BULGARIA • Annual inspection of the technical and operational conditions of potentially dangerous water objects • Review and update of the regulations for maintenance and operation of small dams in order to guarantee the conduction of high water wave caused by flash floods UKRAINE • Support of favorable water regime for the water objects • Surface water monitoring • Elaboration and implementation of the programs on development and improvement
Preparedness	Public awareness and preparedness		GERMANY • Awareness-raising, preparation for emergency event SLOVAKIA • Awareness-raising about flood risk, possible flood protection measures, general public input into increasing flood protection at local level ROMANIA • Measures for improvement monitoring, forecasting and flood warning • Flood simulation exercises with inter-institutional participation • Ensuring human, financial and material emergencies and stimulate volunteerism (purchase/use of mobile flood protection systems, ensuring necessary human and financial resources for adequate management of emergency situations caused by floods) BULGARIA • Preparing the population for actions in case of flood

Other		GERMANY
		• Other measures)
		• Financial aid program
		
		CROATIA
		• Harmonization of interpretation of water fees as fees for covering costs of resources and costs of water environment and adjustment of water fees with 6-year planning cycle (financing issue)
		• Improvement to procedures of issuance of nature protection conditions for works of regular maintenance of watercourses, water domain and water structures (administrative issue, to enhance the efficiency of implementation of operation and maintenance measures)
		• Improvement to integrated water and flood risk management in the aspect of planning of measures of construction and maintenance of flood protection structures and systems through:
		  ○ Development of a methodology for establishment of ecologic potential of the heavily modified water bodies under the influence of flood protection structures and systems
		  ○ Establishment of a classification system for the ecologic potential of the heavily modified water bodies under the influence of flood protection structures and systems
		  ○ Monitoring of conditions of the heavily modified water bodies under the influence of flood protection structures and systems (according to the established classification system)
		
		SERBIA
		• Strengthening the capacity of professionals and institutions responsible for flood management and emergency management

4 Measures strenghtening resilience

Aspects of flood risk management	Type	Description	Measures by countries
Preparedness	Flood Forecasting and Warning	Measure to establish or enhance a flood forecasting or warning system	GERMANY • Flood information and forecast • Establish/improve local warning systems and information • Research and development projects and best practice projects • Studies in climate change AUSTRIA • Implementation of monitoring, forecasting, warning systems CZECH REPUBLIC • Revision and completion of forecast profiles and flood announcement limits • Construction of local warning and notification systems • Improvement of flood forecast • Creation of expert systems to analyse measured data SLOVAKIA • upgrade and enhancement of national flood forecasting and warning services

			by building new monitoring system (radar and precipitation stations) and new forecasting models for more water gauge stations • strengthening cooperation in the field of flood forecasting and warning – Danube basin-wide, international and bilateral agreements and systems HUNGARY • Renewal of the early warning system SLOVENIA • Improving the flood monitoring, forecast and warning information system • Improve and renew the existing alert system on individual and community level CROATIA • Improvement to the system for the flood alert and warning system with the goal of improvement of the efficiency of data transfer procedures. • Continuation of the development of the automatic delivery of meteorological data and their systematic dissemination on the internal web pages adjusted to the needs of the water management sector • Harmonization of the flood alert and warning systems in transboundary basins with the neighbouring countries • Modernization of the hydrologic data monitoring network and information systems • Development and implementation of hydrologic flood forecasting models • Harmonization of flood forecasts in transboundary basins with the neighbouring countries SERBIA • Improve the system of hydro-meteorological monitoring, forecast and early warning (more automated precipitation and gauging stations, use of radars

			and satellite imagery, contemporary forecast models) • Measured data available to relevant services in real time • Improve the alarm systems and systems for issuing timely warning to population at risk, especially on river basins without structural flood protection • Upgrade the international exchange of meteorological and hydrological data BOSNIA AND HERZEGOVINA • Improvement of meteorological and hydrological forecasting system connected with Water Information System (WIS) • Improvement of automatic forecasting station connected with WIS • International exchange of meteorological and hydrological data od flood defence operational measures ROMANIA • Measures for improvement monitoring, forecasting and flood warning BULGARIA • Building of early-warning systems addressed to flash floods • Improvement and modernization of the hydro-meteorological monitoring network • Improvement of the existing hydrological information system - real-time transfer of data for the entire river basin MOLDOVA • Improvement of flood forecasting UKRAINE • Provision of reliable maintenance of the automated information measuring

			system • Development and advance of the automated information measuring system • Construction of the new automated measuring stations • Introduction of the modeling systems • Introduction of the notification systems
	Emergency Event Response Planning / Contingency planning	Measure to establish or enhance flood event institutional emergency response planning	GERMANY • Emergence event response planning • Conceptions / studies / expertise • Information and training AUSTRIA • Compilation of emergency plans CZECH REPUBLIC • Update of flood protection plans (municipalities, companies, building owners, districts, regions) • Update of emergency and crisis plans (municipalities, companies) • Assignment of technical devices and materials for rescue activities during floods • Training and professional support of flood and crisis authorities SLOVAKIA • emergency flood equipment response measures – strengthening flood response capacities, improvement of cooperation between different sectors, institutions and professionals involved in flood management SLOVENIA • Exchanging knowledge and cooperation between prevention, intervention and

			recovery sector • Harmonizing the flood risk management plans and plans for protection and rescue CROATIA • Continuation of activities on formal introduction of a special level of protection and maintenance of natural water retention and wetland areas and boundaries of the public water domain in the process of physical planning • Continuation of activities on registration of the public water domain in land registry • Monitoring of conditions on the public water domain SERBIA • Preparation of plans for protection and rescue in emergency situations, including catastrophic floods on the state level, municipality level etc. BOSNIA AND HERZEGOVINA • Preparation, adoption and updating flood defence plans • Continuous data exchange between institutions in charge of flood defence • Strengthening the capacity of professionals and institutions responsible for flood management ROMANIA • Develop and/or review of flood defense plans in conjunction with other management plans related emergencies (review of the flood defense plans with multidisciplinary correlation) • Ensuring human, financial and material emergencies and stimulate volunteerism (purchase/use of mobile flood protection systems, ensuring necessary human and financial resources for adequate management of emergency situations caused by floods)

			BULGARIA • Establishment of a National Centre for real-time water management • Development and/or update of national regulations on prevention of emergency events and related recovery-activities, addressed to the state administrations, local administrations and business MOLDOVA • Preparation of plans for protection and rescue in emergency situations, including catastrophic floods on the state as well as municipality level. • Improvement of cooperation between different sectors, institutions and professionals involved in flood management UKRAINE • Development and approval of yearly plans on emergency response • Application of plans and solutions by commissions on technological and ecological security and emergency • Confinement plans development
	Public Awareness and Preparedness	Measure to establish or enhance the public awareness or preparedness for flood events	GERMANY • Awareness-raising, preparation for emergency event • Conceptions / studies / expertise • Consulting services CZECH REPUBLIC • Publishing of flood protection plans • Raining of individual public preparedness • Marking of flood risk areas on terrain HUNGARY

			• PR methods and education to increase the awareness of the population • Increase participation of inhabitants in flood prevention activities and concrete flood protection works on dykes during floods SLOVENIA • Detection of important risk areas, information and education of highly endangered inhabitants and other subjects of self-protective measures for vulnerability reduction before and during the event • Raising the awareness, preparation for emergency event and increase the level of community participation during the event CROATIA • Encourage public participation in the implementation of flood risk management plans and solution of problems caused by global climate changes • Establishment of a system for regular education of the public regarding flood risk management issues, especially in areas under significant flood risks • Continuation of activities on the system for informing the public on the activities and initiatives related to the flood risk management and activities during flood events SERBIA • Training exercises BOSNIA AND HERZEGOVINA • Public access to flood hazard and flood risk maps • Municipal authorities capacity building and training on data use • Implementation of flood insurance system

			ROMANIA • Adequate public information activities and promoting public participation • Active education/training of the population (brochures, leaflets, media communication) BULGARIA • Maintenance and update of water registers • Provision of updated information in appropriate format to the stakeholders • Training and information campaign MOLDOVA • Informing people about the flood risks through mass-media and local administration and placing warnings on the state hydro-meteorological Station web-site UKRAINE • Notification of municipalities concerning flood areas • Trainings for authorities and population
	Other preparedness	Other measure to establish or enhance preparedness for flood events to reduce adverse consequences	GERMANY • Insurance, financial precautions AUSTRIA • Ensure availability of facilities for emergency SLOVENIA • Renewal of national and municipal plans for flood protection and rescue (estimation of endangerment, measures and tasks, needed forces and

			equipment) • Building the new gauge stations for monitoring the discharges relevant for significantly endangered areas • Development of hydrologic models for flood prediction and setup of local alarm systems for significantly endangered areas SERBIA • Update/build scientific base for flood management • Preparation of studies and designs BOSNIA AND HERZEGOVINA • Improving international cooperation in flood management ROMANIA • Flood simulation exercises with inter-institutional participation • Implementing an adequate insurance policy BULGARIA • Implementation of insurance policies; promotion of flood-oriented insurance products UKRAINE • Determination of potentially dangerous hydro technical structures • Modeling of the possible emergency situations
Recovery and Review	Individual and societal recovery	Clean-up and restoration activities (buildings, infrastructure, etc) Health and mental health supporting actions, incl.	GERMANY • Assistance with post-flood repair, restoration activities, aftercare planning, elimination of environmental damage • Conceptions / studies / expertise

		managing stress Disaster financial assistance (grants, tax), incl. disaster legal assistance, disaster unemployment assistance Temporary or permanent relocation Other	AUSTRIA • Emergency response CZECH REPUBLIC • Assignment of technical devices and material for recovery activities SLOVENIA • Improving the realization of recovery plans and providing the financial assistance in possible relocation of damage potential • Financial aid and insurance schemas SERBIA • All enlisted measures BOSNIA AND HERZEGOVINA • Removal of buildings located in flood risk areas destroyed by war ROMANIA • Ensuring human, financial and material resources in case of emergency situations • Response in emergency situations (intervention measures to stabilize critical points, measures limiting the flooded area using secondary flood defence lines; measures to drain flooded areas, improving action and cooperation of the authorities involved in emergency management) BULGARIA • Elimination of pollution during and immediately after the flood-accident

			• Restoration work on roads, water supply facilities, sewage, power supply networks and other type of infrastructure • Restoration work for elimination of local damages on banks, embankments and other protective constructions. MOLDOVA • Assistance with post-flood repair, restoration activities, aftercare planning, elimination of environmental damage UKRAINE • Carrying out the after-flood examination and preparation of inspection certificate about the flood protective structures' technical status of hydrotechnical structures and buildings • Repair works on damaged hydrotechnical structures and buildings
	Environmental recovery	Clean-up and restoration activities (with several sub-topics as mould protection, well-water safety and securing hazardous materials containers) Other	AUSTRIA • Evaluation and repair of damages CZECH REPUBLIC • Financial support of environmental recovery • Preparation of materials for environmental recovery SERBIA • All enlisted measures ROMANIA • Damage assessment and restoration (improving damage assessment process-methodology, standards for cost, probability-damage curves, provisionally reparation all types of infrastructure affected by floods to ensure their minimum functionality, restoration/rehabilitation of damaged

			infrastructure and property (including water quality monitoring), offering medical and psychological assistance to people affected by floods) BULGARIA • Elimination of pollution in the water-supply safeguard zones • Stabilization of landslides caused/activated by flooding MOLDOVA • Evaluation and repair of damages UKRAINE • Assessment of damages • Recovery measures identification • Carrying out of recovery works
	Other recovery and review	Lessons learnt from flood events Insurance policies Other	GERMANY • Other recovery and review • Research and development projects and best practice projects AUSTRIA • Documentation and analysis CZECH REPUBLIC • Reports on floods and revision of recommendations • Register of flood damages SERBIA • Study of 2014 flood, reconsideration of flood management concept and proposal of new developments • Preparation of grounds for wider implementation of flood insurance

			ROMANIA • Documentation and analysis (improving the post event analysis - causes, development, effects etc, feedback – lessons learnt) UKRAINE • Analysis of the flood origin • Analysis of the actions during flood
Other			GERMANY • Other measures • Financial aid program AUSTRIA • Relocation and reallocation BULGARIA • Study on changes in the ecological status of surface water after flooding • Exchange of knowledge and experience • Recording of flood-events; assessment of the damages UKRAINE • Other measures

5 Awareness raising measures

Aspects of flood risk management	Type	Description	Measures by countries
Preparedness	Public Awareness and Preparedness	Measure to establish or enhance the public awareness or preparedness for flood events	GERMANY • Awareness-raising, preparation for emergency event • Conceptions / studies / expertise • Consulting services AUSTRIA • Information of public in an appropriate way • Improve participation • Educational activities • Implementation of monitoring, forecasting, warning systems • Compilation of emergency plans • Ensure availability of facilities for emergency CZECH REPUBLIC • Raising of public flood risk knowledge • Publishing of information regarding flood protection options SLOVAKIA • presentation of flood hazard and flood risk maps, flood management plans • raising public awareness

			• training campaigns focused at flood preparedness among municipalities HUNGARY • PR methods and education to increase the awareness of the population • • Increase participation of inhabitants in flood prevention activities and concrete flood protection works on dykes during floods SLOVENIA • Updating an information system for flood events data, hazard and risk maps and status of measures • Public information about flood hazard and risk conditions • Raising community awareness flood extent and intensity CROATIA • Encourage public participation in the implementation of flood risk management plans and solution of problems caused by global climate changes • Establishment of a system for regular education of the public regarding flood risk management issues, especially in areas under significant flood risks • Continuation of activities on the system for informing the public on the activities and initiatives related to the flood risk management and activities during flood events SERBIA • Introduction of water management issues into schools (from elementary school to university level) • Preparation of flood leaflet, film, TV broadcasts etc. • Flood hazard and flood risk maps available in WISS

			• Exercises BOSNIA AND HERZEGOVINA • Public awareness of flood life strategy • Production of fliers, movies, radio and TV shows ROMANIA • Flood simulation exercises with inter-institutional participation • Adequate public information activities and promoting public participation • Active education/training of the population (brochures, leaflets, media communication) BULGARIA • Educational activities • Public access to the flood hazard and flood risk maps. Public access to the annual reports on the status and operational conditions of dams and other MOLDOVA • Informing people about the flood risks through mass-media and local administration and placing warnings on the state hydro-meteorological Station web-site UKRAINE • Notification of municipalities concerning flood areas • Trainings for authorities and population
	Other preparedness	Other measure to establish or enhance preparedness for flood events to reduce adverse consequences	GERMANY • Insurance, financial precautions

			CZECH REPUBLIC • Flood exercises for flood and crisis authorities SERBIA • Continuous data exchange between institutions in charge for flood defence • Municipal authorities capacity building and training BOSNIA AND HERZEGOVINA • Municipal capacity building MOLDOVA • Continuous data exchange between institutions in charge of flood defence
Prevention/Protection			AUSTRIA • Compilation and update of hazard zone plans • Incorporation of hazard zone plans • Compilation and incorporation of local and regional land use planning strategies • Structural protection measures • Object oriented measures • Relocation and reallocation • Definition of operating instructions for flood prone and flood influencing facilities SLOVENIA • Detailed flood hazard and risk mapping through unified methodology (ongoing since 2007) • Renewal of flood hazard indication map every 6 years (ongoing since 2007)

		• Establishment of erosion hazard indication map UKRAINE • Determination of potentially dangerous hydrotechnical structures • Modeling of the possible emergency situations
Other		GERMANY • Financial aid program

6 Measures implementing the solidarity principle

Aspects of flood risk management	Type	Description	Measures by	Actions taken to avoid negative downstream effects
Protection	Natural flood management / runoff and catchment management	Measures to reduce the flow into natural or artificial drainage systems, such as overland flow interceptors and / or storage, enhancement of infiltration, etc and including in-channel , floodplain works and the reforestation of banks, that restore natural systems to help slow flow and store water.	GERMANY • Natural water retention in the catchment • Natural water retention in wetlands • Reduction of sealing • Natural water retention in settlement area • Recovery of floodplains • Conceptions / studies / expertise • Research and development projects	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: - § 5: Obligation of general diligence: Where activities can have an impact on a waterbody, everyone shall be obliged to exercise all dure required caution under the circumstances in order to 1. avoid adverse impacts on water properties, .. 3. preserve the vitality of natural water resources and 4. prevent the increase and acceleration of water run-off.

			and best practice projects • Information and training AUSTRIA • Restoration of flood plains and sedimentation areas • Definition of operating instructions for flood prone and flood influencing facilities CZECH REPUBLIC • Land use change (grassing, afforestation) • Raising of hydric function of forest SLOVENIA • Improvement of retention capacity on catchment scale • Adjusting the design flood levels on border rivers SERBIA • Establish efficient bilateral cooperation with all neighbouring countries, including common actions on transboundary rivers during flood and ice defence ROMANIA • Measures to restore retention areas (flood plains, wetlands etc.) (creating	- § 67 Principle on river development and construction of dykes, dams and coastal protection structures: Water bodies shall be developed in such a way that natural floodplains are preserved, the natural water run-off is not influenced significantly, species and biocoenoses typical for specific ecosystems are protected and any other negative impacts on the water properties are prevented. Otherwise compensation measures shall be taken. - § 68: plan approval procedure, planning license Planning approval shall only be granted, if 1. an impairment of the public interest is not to be expected, especially with regard to a considerable and permanent increase in flood risks that cannot be compensated or the destruction of natural flood retention areas, especially in riparian forests. § 77: Natural retention areas Natural floodplains shall be maintained. Former floodplains shall be restored as far as possible.

			new wetlands, reconnecting and restoring floodplain, recreating watercourse meanders, to rehabilitate the banks of the watercourses (vegetative protection), restoring natural lakes) • Natural water retention measures in urban/populated area ("green" gutters and channels, drainage systems etc, collection and storage of rainwater in underground tanks, permeable paving, green roofs, bio retention areas, seepage canals, green areas etc.) • Natural water retention measures by changing or adapting land use practices in agriculture and forests management (maintaining areas occupied by meadows and pastures, cultivation practices to conserve soil, terracing slopes, curtains shrubs for protection), improve management of forests in floodplains, afforestation mountain areas (in the upper basin), afforestation of additional area near reservoirs BULGARIA • Prohibition on felling of natural forest vegetation on the river banks and river islands • Creation of water retention areas; restoration of wetlands;	

			UKRAINE • Elaboration and agreement of the common measures on decreasing of the flood negative effect	
	Water flow regulation	Measures involving physical interventions to regulate flows, such as the construction, modification or removal of water retaining structures (e.g., dams or other on-line storage areas or development of existing flow regulation rules), and which have a significant impact on the hydrological regime.	GERMANY • Planning and construction of flood retention systems • Operation, maintenance and reconstruction of flood defence systems • Conceptions / studies / expertise • Research and development projects and best practice projects • Information and training AUSTRIA • Improvement of retention capacity on catchment scale • Structural protection measures CZECH REPUBLIC • Construction of dry reservoirs • Construction of water reservoirs HUNGARY • Adjusting the design flood levels on border rivers. ROMANIA •	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: - § 68: see above - § 75: Flood risk management plans (4): Flood risk management plans shall not include measures which, by their extent and impact, significantly increase flood risks in other countries

			• Measures to improve capacity retention basin level by making polders and small reservoirs (made in the upper basin) • Measures to improve retention capacity at basin level by increasing safety degree of the large existing construction/increase mitigation capacity of reservoirs face to design capacity (safety degree improvement of existing hydraulic structures (rehabilitation: upgrading, measures to limit infiltrations etc, maintenance work for the safe operation of existing hydraulic structures and related equipment) • Structural protection measures (planning and realization) (construction of new reservoirs for flood peak mitigation, making derivation works, bed stabilization measures - recalibration of riverbeds, fences, shore defenses, stabilizing the river bed, protection measures along watercourses through works of local dikes, measures to reduce runoff on slopes and torrents improvement) • Adapting construction, infrastructure and existing defense structures in terms of climate change (recalculation design levels of current flood protection system, heightening of existing dikes, optimizing operation	

			of existing reservoirs to increase retention/mitigation capacity UKRAINE • Agreement of the design flood levels on the boundary sections	
	Channel, Coastal and Floodplain Works	Measures involving physical interventions in freshwater channels, mountain streams, estuaries, coastal waters and flood-prone areas of land, such as the construction, modification or removal of structures or the alteration of channels, sediment dynamics management , dykes, etc.	GERMANY • Dikes, dams, flood protection walls, dunes, beach ridges, mobile flood defences • Maintenance measures of static/mobile flood defence systems • Conceptions / studies / expertise • Research and development projects and best practice projects • Information and training AUSTRIA • Development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance CZECH REPUBLIC • Relocation of river dikes (make more space to rivers) • Construction of diversion and lateral channels ROMANIA	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: § 67: see above § 68: see above

			• Measures to improve capacity retention basin level by making polders and small reservoirs (made in the upper basin) • Measures to improve retention capacity at basin level by increasing safety degree of the large existing construction/increase mitigation capacity of reservoirs face to design capacity (safety degree improvement of existing hydraulic structures (rehabilitation: upgrading, measures to limit infiltrations etc, maintenance work for the safe operation of existing hydraulic structures and related equipment) • Structural protection measures (planning and realization) (construction of new reservoirs for flood peak mitigation, making derivation works, bed stabilization measures - recalibration of riverbeds, fences, shore defenses, stabilizing the river bed, protection measures along watercourses through works of local dikes, measures to reduce runoff on slopes and torrents improvement) • Adapting construction, infrastructure and existing defense structures in terms of climate change (recalculation design levels of current flood protection system, heightening of existing dikes, optimizing operation	

			of existing reservoirs to increase retention/mitigation capacity UKRAINE • Agreement of the working projects and construction works for protective structures on the boundary territories	
	Surface Water Management	Measures involving physical interventions to reduce surface water flooding, typically, but not exclusively, in an urban environment, such as enhancing artificial drainage capacities or though sustainable drainage systems (SuDS).	GERMANY • Keeping clear flood discharge cross-sections in settlement area and wetlands • Keeping clear flood discharge cross-sections by maintenance measures and floodplain-management • Conceptions / studies / expertise • Information and training CZECH REPUBLIC • Infiltration structures to catch the rainfall water ROMANIA • Measures to reduce water levels (increase transit capacity by resizing bridges, measures to ensure the drainage capacity, increase transit capacity of the minor riverbed: desilting works and reshaping riverbed, dikes relocation, restoration and increasing of the mitigation volumes in existing reservoirs and polders)	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: § 77: see above

	Other Protection	Other measure to enhance protection against flooding, which may include flood defence asset maintenance programmes or policies	GERMANY • Other measures of protection • Information and training AUSTRIA • Restoration of flood plains and sedimentation areas • Definition of operating instructions for flood prone and flood influencing facilities • Improvement of retention capacity on catchment scale • Structural protection measures • Development of concepts, plans, projects, strategies on catchment scale to improve the water and sediment balance HUNGARY • Trans boundary cooperation with the neighbouring countries • Participation in international cooperation l • Participation in international projects, researches • Renewing the existing international flood management contracts (e.g. ice breaking) ROMANIA • Coordination of territorial planning strategies (developing plans at	

			national, county, regional and urban plans with flood risk management plans) (implementation of a coordinated system of inspection and control of the application of legal and technical regulations on relocation, location, execution of the existing and new construction in floodplains, coordinated update of the landscaping plans at national, local and county level by implementing flood risk management plans, implementation of a coordinated system of institutional collaboration for population relocation) UKRAINE • Agreement of the other measures in the frame of transboundary cooperation	
Preparedness				
	Emergency Event Response Planning / Contingency planning	Measure to establish or enhance flood event institutional emergency response planning	GERMANY • Emergence event response planning • Conceptions / studies / expertise • Information and training AUSTRIA • Compilation of emergency plans CZECH REPUBLIC • Construction and upgrade of rainfall and gauging stations with data	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream § 5: see above SLOVAKIA In Slovak Act No. 7/2010 Coll. on Flood protection in § 14 the process of providing information on hydrological situation on transnational rivers and the process on providing international help are codified.

			transfer online SLOVAKIA • strengthening of operational cooperation among the emergency response authorities in the international Danube basin, improvement of interoperability ROMANIA • Develop and/or review of flood defense plans in conjunction with other management plans related emergencies BULGARIA • Establishment of a mechanism for cooperation and coordination of flood-related activities in border areas UKRAINE • Elaboration of the joint plans of action during floods and confinement plans	
	Public Awareness and Preparedness	Measure to establish or enhance the public awareness or preparedness for flood events	GERMANY • Awareness-raising, preparation for emergency event • Conceptions / studies / expertise • Consulting services AUSTRIA	GERMANY In Federal Water Act (WHG) it is codified , that no measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: § 5: see above

			• Information of public in an appropriate way • Improve participation • Educational activities • Implementation of monitoring, forecasting, warning systems • Compilation of emergency plans • Ensure availability of facilities for emergency CZECH REPUBLIC • Update of documentations of special floods below water reservoirs SLOVAKIA • Information about flood event and warning between neighbouring countries based on bilateral commissions. • Using the outputs of EFAS - flood warning system among Danube´s countries ROMANIA • Adequate public information activities and promoting public participation • Active education/training of the population (brochures, leaflets, media communication)	SLOVAKIA In Slovak Act No. 7/2010 Coll. on Flood protection in § 14 the process of providing information on hydrological situation on transnational rivers and the process on providing international help are codified.

			BULGARIA • Informing the people and local administrations downstream the river as well as the neighbouring countries about the hydrological conditions and flood-event MOLDOVA • Informing people about the flood risks through mass-media and local administration and placing warnings on the state hydro-meteorological Station web-site UKRAINE • Experience exchange • Trainings for population	
	Other preparedness	Other measure to establish or enhance preparedness for flood events to reduce adverse consequences	GERMANY • Insurance, financial precautions ROMANIA • • Flood simulation exercises with inter-institutional participation UKRAINE • Other common measures	
Recovery and Review	Individual and societal	Clean-up and restoration activities (buildings,	GERMANY • Assistance with post-flood repair,	GERMANY In Federal Water Act (WHG) it is codified , that no

	recovery	infrastructure, etc) Health and mental health supporting actions, incl. managing stress Disaster financial assistance (grants, tax), incl. disaster legal assistance, disaster unemployment assistance Temporary or permanent relocation Other	restoration activities, aftercare planning, elimination of environmental damage • Conceptions / studies / expertise AUSTRIA • Emergency response CZECH REPUBLIC • Financial support of recovery of flood damaged areas ROMANIA • Ensuring human, financial and material resources in case of emergency situations • Response in emergency situations (intervention measures to stabilize critical points, measures limiting the flooded area using secondary flood defense lines; measures to drain flooded areas, improving action and cooperation of the authorities involved in emergency management) BULGARIA • Elimination of pollution during and immediately after the flood-accident UKRAINE	measures shall be taken within a river basin which significantly increase the risk of flooding upstream or downstream: § 5: see above

			• Mutual assistance during the recovery works fulfillment	
	Environmental recovery	Clean-up and restoration activities (with several sub-topics as mould protection, well-water safety and securing hazardous materials containers) Other	AUSTRIA • Evaluation and repair of damages ROMANIA • Damage assessment and restoration (improving damage assessment process (methodology, standards for cost, probability- damage curves), provisionally reparation all types of infrastructure affected by floods to ensure their minimum functionality, restoration/rehabilitation of damaged infrastructure and property (including water quality monitoring), offering medical and psychological assistance to people affected by floods) UKRAINE Common risks and damages assessment	
	Other recovery and review	Lessons learnt from flood events Insurance policies Other	GERMANY • Other recovery and review • Research and development projects and best practice projects AUSTRIA • Documentation and analysis CZECH REPUBLIC • Lessons learnt from past flood events and application of findings	

			ROMANIA • Documentation and analysis (improving the post event analysis (causes, development, effects etc.), feedback–lessons learnt) • Implementing an adequate insurance policy BULGARIA • Transboundary exchange of experience and data about flood-events, incl.”lessons learnt” UKRAINE • Other measures	
Other			GERMANY • Financial aid program	

7 List of transboundary projects supporting DFRMP

The projects or project proposals/ideas presented here were developed by the ICPDR and/or EUSDR PA5 and they shall i.a.:

- Reflect the objectives and priorities set in this Danube Flood Risk Management Plan;
- Have a transboundary character;
- Help to implement the needs listed i.a.in this Annex.

There is no ranking or prioritization of these projects, they are all considered as supportive to the implementation of the Danube Flood Risk Management Plan.

7.1 Danube Sediment Project

One of the main goals of the proposed project is to establish for the first time a Danube river basin sediment budget, identify reaches with surplus and deficit, river bed aggradation and degradation, sediment-related problems in flood risk management, drinking water production, hydropower generation, navigation, water quality and ecology, as well as gain knowledge and better understanding of sediment transport and morphodynamic processes in the Danube River.

The specific aims of the Danube Sediment Project are the following:

- Collect existing sediment data and analyse their quality
- Perform limited sediment transport monitoring at short but important reaches with significant data gaps
- Perform limited sediment transport monitoring and modelling in Pilot Reaches
- Identify the sediment quantity related issues at different space and time scale
- Identify reaches with sediment deficits and surplus and quantify the trends
- Quantify the role of major tributaries in the sediment transport of Danube River
- Develop a sediment balance for the whole Danube River and the input of major tributaries
- Discuss with stakeholders the sediment management problems and options associated with sediment transport
- Summarize and evaluate existing sediment management options
- Risk analysis related to sediment quantity
- Improve the knowledge on sediment transport mechanisms in Danube River
- Prepare a Danube Sediment Management Concept
- Policy recommendations

7.2 Danube Floodplain project

Overall objective of the proposed project is to reduce the flood risk through floodplain restoration along the Danube and other DRB rivers

The specific objectives include the following:

- to develop a common approach on restoring the water storage capacity of floodplains, from upstream to downstream sections;
- to develop best practice on using 'green infrastructure' for sustainable flood risk management in the Danube River Basin;
- to contribute to the more effective implementation of the EU WFD and Floods Directive with their Programmes of Measures;
- integrating the requirements and opportunities related to other EU policies, notably the Nature Directives, Biodiversity and Climate policy, and of the 2020 Strategy;
- to foster cooperation among Danube Basin countries in using restored floodplains for flood management;
- to demonstrate the feasibility of integrated flood management, including a combination of classical and "green infrastructure" in selected floodplain areas;
- to stimulate stakeholder involvement and cooperation in floodplain restoration / flood management planning and implementation.

The Danube Floodplain project should also include the project module "FORest TRaining in thE Danube floodplain":

- Based on existing land use data, discretization of important sections of the floodplain that are covered with forests, which are main conveyance lines and obstructed by the vegetation
- 2D modelling of the areas, development of the good modelling practices by pilot areas
- Initiative for long term maintenance of the forest to support the flood propagation

7.3 "DANICE" project

DANube river basin ICE conveyance investigation and icy flood management shall focus on:

- Report of recorded ice floods /events in the Danube basin
- Creating a database of registered ice observations and GIS-based map summary in the Danube basin
- Hydrologic and hydraulic investigation on the ice observation, conveyance and forecasting
- Discretization of stretches (Danube and tributaries), structures and certain sections that are frequently exposed to "freezing hazard"
- Listing monitoring stations, well placed observation points, webcams etc. that are suitable for tracing ice conveyance and ice coverage development along the river and its tributaries
- Definition of efficient observation methodology of floating ice plate conveyance on the Danube (e.g. satellite images), suggestions of monitoring development
- Setup of an online international tracking site for ice transport,
- Identification of 1D and 2D modelling capabilities of ice conveyance calculations, listing and evaluation of tools' capabilities
- Evaluation of different measures to open ice barriers or avoid their development,
- Measures and pilot areas

- Summarizing the ice breaker fleet in the Danube basin (synergies could be noticed with Newada and Newada Duo project, FAIRway), evaluation of international agreements
- Definition of good practices to avoid ice jams

7.4 "LAREDAR" project

Hazard and risk mapping, risk management planning of the LAkes and REservoirs in the DAnube River basin shall focus on:

- Inventory of potential flood-problematic lakes and reservoirs (L&R), realization of problems, GIS database and bed geometry data with supplying rivers (sub-catchments)
- Hydrologic assessment of the events that cause inundation around the lake or failure of defense system
- Hazard and risk mapping of the L&R, risk management strategies for L&R
- International consequences and conditions in the operation, good practice or agreements for the future

7.5 Coca-Cola - WWF "Partnership for a living Danube"

The Coca-Cola Company (TCCC) 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 will reconnect former floodplains to the river system by opening dikes and dams, as well as retaining water on the floodplains by working closely with relevant local authorities and stakeholders. At the same time, a regional movement is planned to be created for wetland conservation and restoration, as well as good water stewardship.

The plan is to restore wetlands in Hungary, Croatia, Serbia, Romania and Bulgaria, as well as a project in Austria. Over the restoration period, measures such as removing dikes and dams to reconnect former floodplains and improve flooding capacity, reconstructing the wetland habitats of six threatened and endangered species and building a fish pass will be executed.

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

7.6 Improvement of flood forecasting

Implementation step I: Inventory on the available data, information and exchange mechanism, designation of data needs by the national flood forecasting institutions and transnational instruments. Possible solutions is to create and operate national, bilateral, multilateral data exchange platforms for the national forecasting services of the Danube Region to provide them with the necessary data/information to improve their flood forecasting capabilities, taking into account the existing mechanisms and systems.

Implementation step II: Launch a research programme to improve the flood forecasting models by:

- Comparing the efficiency, accuracy, lead time etc. of the existing national, regional and Danube basin wide models
- Exchanging information on the national and trans-national Danube Basin forecasting models for better understanding of their outputs
- Further developing the national models or developing international models (like the Dráva-Mura forecasting model or the European Flood Awareness System)
- sharing models and/or methods

7.7 Information exchange on the operation of hydraulic structures

Flood forecasting and flood management need real time information and data on the operation of flow control structures. Pre-emptying the reservoirs of holding back water to fill up the reservoirs influence the precision of the flood forecasting and can endanger the flood management of the downstream stretches.

Implementation steps: The goal is to agree with the Danube countries and the operators of flow control structure to make their operational rules and real time data available for the national flood forecasting institutes and for the flood management organisations.

Elements of the cooperation have to:

- Identify relevant structures
- Make the real-time operational parameters available to forecasters,
- Make the operational rules (operational manuals) of the flow control structures available for flood forecasters and flood managers,
- Establish procedures and ICT infrastructure to warn flood forecasters when the pre-emptying or filling up of the reservoirs start (e.g. changes in discharge),
- Develop cooperation among the operators and flood managers to ensure that flood protection has got priority in the operation of flow control structures in peak periods (e.g. flood managers shall have the possibility to ask the operators to change the operational state if flood situation requires it),
- Prepare a unilateral framework agreement based on previous steps for the Danube Basin.

7.8 Coordination of operative flood management plans

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

Implementation steps: Coordinate the operative flood management and civil protection plans (evacuation plans and procedures, safeguarding people, goods, emergency rescue plans, etc.) considering the benefits of the civil protection mechanisms for the shared flood basins or stretches of common interest to better use the available resources.

7.9 Development of elements of flood risk management plans for trans-boundary sub-units of common interest

Implementation steps: Provide sub-units that need further support to meet the EUFD deadline on FRMP with resources and pilot projects developed under this Measure. Support the monitoring of the implementation and the review of the plan with planning the next FRMP for the sub-basin

7.10 Exchange of flood protection techniques, technologies and experiences

For the last decade a proliferation of new flood protection techniques and technologies could be seen. Some countries use mobile dams, some use mobile walls, some others prefer inflatable dams etc. The floods of the recent decade provided the opportunity to learn about advantages and/or disadvantages of these structures.

Proposal: collect and exchange information of the new equipment both from design and operational point of view. This can be done through a networking project by organising workshops and or seminars.

7.11 Develop an education/training network

Proposal: Develop an education/training network of universities/training centres to “train trainers” and develop curricula for training of flood managers.

7.12 Enhance coordination of operative flood protection methods and equipment

For risks that are common to a large number of countries in the region (i.e. floods) it is important to strengthen cross-border cooperation. To ensure that civil protection authorities have a good understanding of each other's systems. For instance available assets and potential gaps, working procedures, and that teams can also function smoothly in case of major emergencies involving bilateral, European, or international response. This measure will be developed also in close collaboration with the envisaged voluntary pool of European assets for disaster risk management as foreseen by the EU´s Civil Protection mechanism.

Task 1: Coordination of the regional disaster risk assessment / damage data recording methods and measures, taking into account the specific effects of the climate change phenomena in the region, for better disaster prevention.

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

Task 3: Establishment of the cooperation forum of the Danube basin municipalities and/or relevant institutions for better preparedness, awareness and data sharing during flood related interventions and other regional disasters.

7.13 Analysis of catchment reaction on different precipitation scenarios in the upper Danube including identification of retention sites

The 2013 flood in the Danube catchment evidenced the importance of flood storage polder. Therefore the Bavarian flood protection strategy focusses on natural and technical retention in the river catchments. The main objectives of this study of the upper Danube / Inn River catchment are:

- Identification of new retention sites in the whole Inn River catchment
- Analysis of the retention potential of the current barrages along the Inn River -> barrage management
- Statistical analysis of different precipitation scenarios with the Copula-method.

This project between Germany and Austria is supposed to run for three years and shall be finished by the end of 2018.

7.14 ProDaM – Protect Danube and Morava

The project objective is to optimize the joint flood management in the border area of the Danube and Morava between Austria and the Slovak Republic. The specific objectives include the following:

- Analysis of the residual risk at the river Morava
- Common understanding about residual risk and residual risk management
- Planning of the improvement of the common flood protection dam Wolfsthal-Petržalka

The overall objective and/or benefit of the project is to protect the border regions by means of coordinated flood measures.

7.15 DAMWARM project (Drava And Mura WAter and Risk Management)

Project focuses on better and more efficient Drava and Mura river basin and flood (and other) risk management. The Drava River is the fourth largest tributrary of the Danube and it's main course is full of hydropower plants and other large water management infrastructure. Floods, drought and other risk management without the full, swift and online cooperation and communication of water management authorities and hydropower plants' operators is nearly impossible. Large floods, droughts and different environmental issues in the past few years (especially the floods in year 2012) have shown that a better communication between water management and hydropower plant operators is needed.

Main activities of the project are:

- analysis and review of all the existing flow models & forecasting systems in both transboundary river basins;
- development of flow forecasting models for parts of both Drava and Mura river basins where they don't exist;
- thorough review and analysis of all the existing rules of operations for all existing hydropower plants and other water management infrastructure in both transboundary river basins;
- development of new set of hydropower plant and other water management infrastructure's operational rules incorporating newest flow and meteo forecasting knowledge and models, environmental objectives and other sustainability principles;

- operational set-up of the common flood forecasting system and platform for both transboundary rivers basins covering four countries;

The main results of the project include:

- development of the flow forecasting models for the Drava and Mura river basins where they don't exist;
- development of the ecologically sound, sustainable and effective (from the public interest point of view at the times of floods and droughts) rules of operation for the hydropower and other water management infrastructure in both river basins;
- development of joint flow forecasting platform integrating all the existing national and newly developed forecasting models and it's operational set up.

Partners in the project include responsible water management authorities from Austria, Slovenia, Croatia and Hungary and all hydropower plant operation public companies.

7.16 Common Slovenian and Croatian transboundary flood risk management project

The project addresses the flood risk at all of the Slovenian-Croatian borderline rivers (Kolpa/Kupa, Bregana, Sotla/Sutla, Drava, Mura and Dragonja rivers). All of these rivers are part of the Danube River Basin except for the Dragonja River. Any activities related to the flood risk management of these transboudary river basins without prior consent and harmonisation of the structural or non structural flood protection measures with the neighbouring country are not in line with the basic principles of flood risk (and river basin) management and can even increase the flood risk on one or the other side of the river (border).

Main activities of the project are:

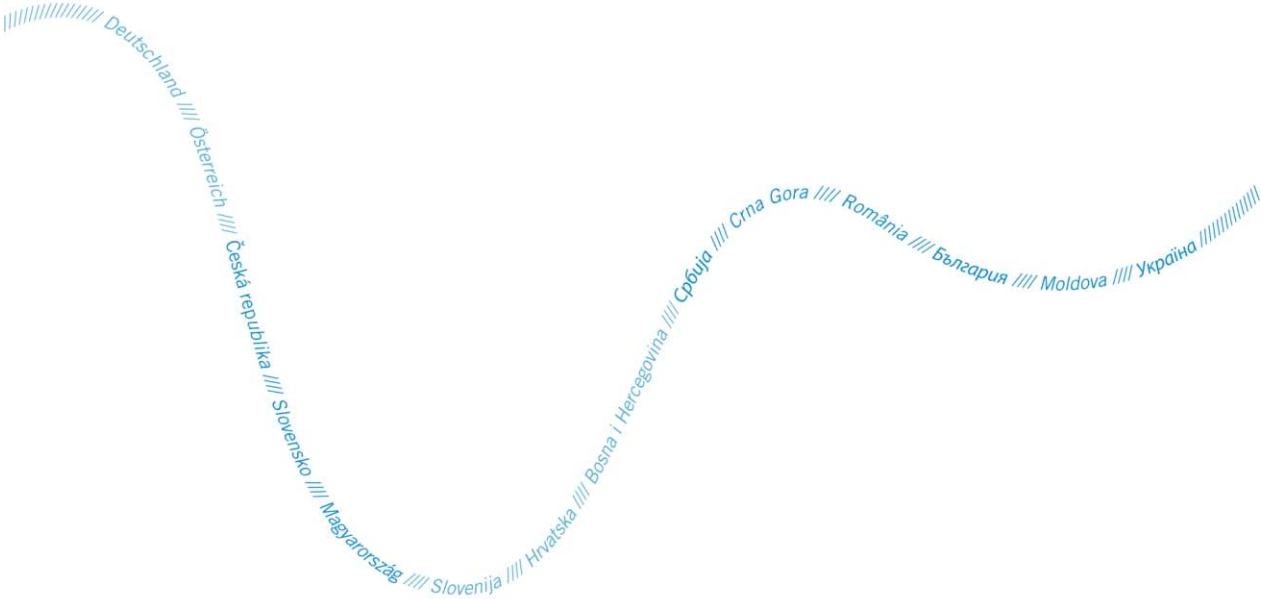
- collection and harmonization of all the relevant meteorological, geological, hydrological and other data related to the flood risk management of these transboundary river basins;
- development of the common hydrological and hydraulic models for all transboundary rivers;
- development of the flood forecasting models for the transboundary river basins where such models do not exist (no overlapping with other similar macro-regional or national projects will be allowed);
- harmonized and common flood hazard and flood risk mapping;
- common and bilaterally harmonized expert studies covering whole transboundary river basins identifying the most sustainable and effective structural flood risk reduction measures;
- pilot implementation of a few sustainable structural flood risk reduction measures.

Partners in the project include responsible water management authorities from Croatia and Slovenia.

Competent authorities

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

Annex 3 of the DFRM Plan



Austria
Federal Ministry for Agriculture, Forestry, Environment and Water Management
Stubenring 1
A-1012 Wien
Web link: www.bmlfuw.gv.at

Bosnia and Herzegovina
Ministry of Foreign Trade and Economic Relations
Musala 9
BiH-71000 Sarajevo
Web link: www.mvteo.gov.ba

Federal Ministry of Agriculture, Water Management and Forestry
Marsala Tita 15
BiH-71000 Sarajevo

Ministry of Agriculture, Forestry and Water Management of Republika Srpska
Milosa Obilica 51
BiH-76300 Bijeljina
Web link: www.vladars.net

Bulgaria
Ministry of Environment and Water
22 Maria-Luisa Blvd.
BG-1000 Sofia
Web link: www.moew.government.bg

Danube River Basin Directorate
60, Chataldzha str.
BG -5800 Pleven
Web link: http://www.bd-dunav.org/

Croatia
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Ulica grada Vukovara 220
HR-10000 Zagreb
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Czech Republic
Ministry of Environment
Vrsovická 65
CZ-10010 Praha 10
Web link: www.mzp.cz

Ministry of Agriculture
Tesnov 17
CZ-117 05 Praha 1
Web link: www.mze.cz

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Bavarian State Ministry
for Environment and Consumer Protection
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D-81925 München
Web link: www.stmug.bayern.de/

Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg
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Hungary
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József Attila utca 2-4.
H-1051 Budapest
P.O.box: 1903 Budapest, Pf.: 314.
Web link: www.kormany.hu

General Directorate of Water Management
Márvány utca 1/D.
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Web link: www.ovf.hu

Moldova
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Montenegro
Ministry of Agriculture, Forestry and Water Management
Rimski Trg 46
ME – 81000 Podgorica
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Romania
Ministry of Environment, Waters and Forests
12 Libertatii Blvd., 5th District
RO-04129 Bucharest
Web link: www.mmediu.ro

National Administration "Apele Romane"
6 Edgar Quinet St., 1st District
RO-010018 Bucharest
Web link: www.rowater.ro
National Institute of Hydrology and Water Management
97 Bucuresti-Ploiesti Blvd, 1st District
RO-013686, Bucharest
Weblink: www.inhga.ro

Serbia
Ministry of Agriculture and Environmental Protection (MAEP) –Directorate for Water
Bulevar umetnosti 2a
RS-11000 Beograd
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Slovak Republic
Ministry of the Environment of the Slovak Republic
Námestie L'. Štúra 1
SK-81235 Bratislava
Web link: www.enviro.gov.sk

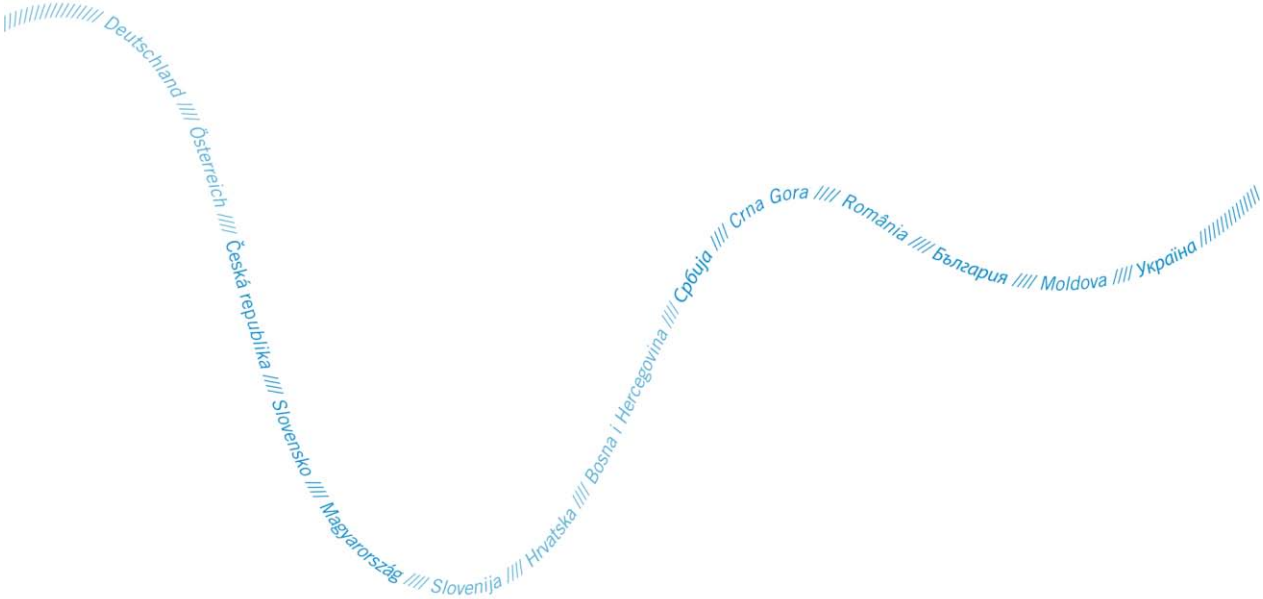
Slovenia
Ministry of the Environment and Spatial Planning
Dunajska 48
SI-1000 Ljubljana
Web link: www.mop.gov.si/en/

Ukraine
The State Emergency Service of Ukraine
55-a, O.Gonchara str.
UA-01601, Kyiv
Web link: www.mns.gov.ua
Ministry for Ecology and Natural Resources of Ukraine
35, Vasilya Lipkivs'kogo str.
UA-03035 Kyiv
Web link: www.menr.gov.ua
State Agency on Water Resources of Ukraine
8, Chervonoarmiyska Str.
UA-01601 Kyiv
Web link: www.scwm.gov.ua

Bilateral agreements on flood risk management in the DRBD

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

Annex 4 of the DFRM Plan



Austria

With Germany

Interstate treaty between the Republic of Austria on the one hand and the Federal Republic of Germany and the European Economic Community on the other hand on the cooperation regarding water management in the Danube River catchment (BGBl Nr. 17/1991).
The instrument of ratification signed by the Austrian Federal President and countersigned by the Austrian Federal Chancellor was exchanged on 14th December 1990 and referring to Art. 12 (2) came into effect on 1st March 1991.

Vertrag zwischen der Republik Österreich einerseits und der Bundesrepublik Deutschland und der Europäischen Wirtschaftsgemeinschaft andererseits über die wasserwirtschaftliche Zusammenarbeit im Einzugsgebiet der Donau (BGBl Nr. 17/1991)
Die vom Bundespräsidenten unterzeichneten und vom Bundeskanzler gegengezeichneten Ratifikationsurkunden wurden am 14. Dezember 1990 ausgetauscht; der Vertrag tritt gemäß seinem Art. 12 Abs. 2 mit 1. März 1991 in Kraft

With Republic of Slovakia

Agreement between the Republic of Austria and Czechoslovakian Socialist Republic regarding water management of transboundary rivers. (BGBl. Nr. 106/1970, idF. BGBl. Nr. 1046/1994 – Further application with Slovak Republic)
The instruments of ratification had been exchanged on 16th February 1970. The agreement came into effect by 18th March 1970 referring to Art. 22 (2).

Vertrag zwischen der Republik Österreich und der Tschechoslowakischen Sozialistischen Republik über die Regelung von wasserwirtschaftlichen Fragen an den Grenzgewässern
(BGBl. Nr. 106/1970, idF. BGBl. Nr. 1046/1994 - Weiteranwendung des Vertrages im Hinblick auf die Slowakische Repulik)
Die Ratifikationsurkunden zum vorliegenden Vertrag sind am 16. Feber 1970 ausgetauscht worden; der Vertrag ist somit gemäß seinem Artikel 22 Absatz 2 am 18. März 1970 in Kraft getreten.

With Czech Republic

Agreement between the Republic of Austria and Czechoslovakian Socialist Republic regarding water management of transboundary rivers. (BGBl. Nr. 106/1970, idF. BGBl. Nr. 1046/1994 – Further application with Czech Republic)
The instruments of ratification had been exchanged on 16th February 1970. The agreement came into effect by 18th March 1970 referring to Art. 22 (2).

Vertrag zwischen der Republik Österreich und der Tschechoslowakischen Sozialistischen Republik über die Regelung von wasserwirtschaftlichen Fragen an den Grenzgewässern
(BGBl. Nr. 106/1970, idF. BGBl. Nr. 1046/1994 - Weiteranwendung des Vertrages im Hinblick auf die Tschechische Repulik)
Die Ratifikationsurkunden zum vorliegenden Vertrag sind am 16. Feber 1970 ausgetauscht worden; der Vertrag ist somit gemäß seinem Artikel 22 Absatz 2 am 18. März 1970 in Kraft getreten.

With Republic of Slovenia / Mura River

Agreement between the Repbulic of Austria and the Federal People's Republic of Yugoslavia regarding the water management of the Mura River (BGBl. Nr. 119/1956, Republic of Slvenia Slowenien – further application, BGBl. Nr. 714/1993, Republic of Croatia – no further application, BGBl. Nr. 474/1996)
The instruments of ratification had been exchanged and came into force on/by 9th February 1956.

Abkommen zwischen der Republik Österreich und der Föderativen Volksrepublik Jugoslawien über wasserwirtschaftliche Fragen der Mur-Grenzstrecke und der Mur-Grenzgewässer (Mur-Abkommen)
Da der Austausch der Ratifikationsurkunden am 9. Feber 1956 vorgenommen wurde, ist das Abkommen gemäß seinem Artikel 11 am 9. Feber 1956 in Kraft getreten.

With Republic of Slovenia / Drava River

Governmental agreement between the Republic of Austrian and the Federal People's Republic of Yugoslavia regarding the water management of the Drava River. After approval of the governments the agreement came into effect by 15th January 1955.

„Regierungsübereinkommen vom 25. Mai 1954 zwischen Österreich und Jugoslawien über Wasserwirtschaftliche Fragen an der Drau" [HARTIG 1955]. „Nach Vorliegen der Genehmigung der Regierungen ist durch Notenwechsel festgelegt worden, dass als erster Tag der Wirksamkeit der 15. Jänner 1955 angesehen wird" [HARTIG 1955]

Hungary

Agreement between the Autrian Repbulic and the People's Repbulic of Hungary regarding the water management in the border region. (BGBl. Nr. 225/1959) The agreement came into effect by 31st July 1959.

Vertrag zwischen der Republik Österreich und der Ungarischen Volksrepublik über die Regelung der wasserwirtschaftlichen Fragen im Grenzgebiet (BGBl. Nr. 225/1959) Dieser Vertrag ist gemäß seinem Artikel 22 am 31. Juli 1959 in Kraft getreten.

Switzerland

Interstate treaty of between the Repbulic of Austria and the Swiss Confederation on the regulation of the Rhine from the Ill mouth to the Lake Constance. (StF: BGBl. Nr. 178/1955) The instruments of ratification had been exchanged and came into effect on/by 22nd July 1955.

Staatsvertrag der Republik Österreich mit der Schweizerischen Eidgenossenschaft über die Regulierung des Rheines von der Illmündung bis zum Bodensee
Da der Austausch der Ratifikationsurkunden am 22. Juli 1955 stattgefunden hat, ist der Vertrag gemäß seinem Art. 35 an diesem Tag in Kraft getreten.

Liechtenstein

Agreement between the Republic of Austria and the Princedom of Liechtenstein on the definition of common principles of the regulation of the Rhine from the Swiss-Liechtenstein boarder to the Ill mouth, as well as the regulation of the discharge of inland waters. (StF: BGBl. Nr. 333/1931) The instruments of ratification had been exchanged by 20th of October 1931. Referring to Art. 14 the agreement came into effect on 17th November 1931.

Vertrag zwischen der Republik Österreich und dem Fürstentume Liechtenstein über die Festlegung gemeinsamer Grundlagen für die Regulierung des Rheins von der schweizerisch-liechtensteinischen Staatsgrenze bis zur Mündung des Illflusses, sowie über die Regelung der Ableitung liechtensteinischer Binnengewässer auf liechtensteinischem und österreichischem Gebiete und über die damit zusammenhängende Regulierung des Spirsgrabens, des Frickgrabens und der Esche.
Der Austausch der Ratifikationsurkunden hat am 20. Oktober 1931 stattgefunden. Der Vertrag tritt daher gemäß seinem Artikel 14 am 17. November 1931 in Kraft.

Bosnia and Herzegovina

Type of document	Counterpart Country	Title	Issued (year)	Subject
Agreement	Republic of Serbia	Agreement between Council of Ministers of Bosnia and Herzegovina and the Republic of Serbia on cooperation in protection against natural and other disasters (ratified in 2011)	Official Gazette of BH no 8/11.	Transboundary Early warning system cooperation
Agreement	Montenegro	Agreement on Cooperation in protection from natural and other disasters, between Council of Ministers of B&H and Montenegro Government (signed in 2007 and ratified in 2008)	Official Gazette of BH no 2/08.	Transboundary Early warning system cooperation
Framework agreement	Multilateral	FRAMEWORK AGREEMENT ON THE SAVA RIVER BASIN among: Bosnia and Herzegovina, Republic of Croatia, Republic of Slovenia and Federal Republic of Yugoslavia[1]	Official Gazette of BH no 8/03.	Sustainable development of Sava river basin
Agreement	Republic of Croatia	Agreement between the Croatian Government and the Government of Bosnia and Herzegovina on the regulation of water management relations (signed 11 July 1996 in Dubrovnik)	Official Gazette of BiH no 6/96.	Transboundary water management
Agreement	Republic of Croatia	Agreement between the Council of Ministers of Bosnia and Herzegovina and the Croatian Government on cooperation in the protection of natural and manmade disasters	Official Gazette of BiH no 7/01.	Transboundary Early warning system cooperation
Agreement	Republic of Slovenia	Agreement between the Council of Ministers and the Government of the Republic of Slovenia on cooperation in the protection of natural and manmade disasters	Official Gazette of BiH no 3/12.	Transboundary Early warning system cooperation

[1] Federal Republic of Yugoslavia consisted at that time of republic of Serbia and Montenegro

Bulgaria

With Romania
Agreement between the Ministry of Environment and Water of the Republic of Bulgaria and the Ministry of Environment and Water Management of Romania on Cooperation in the Field of Water Management, signed on 12 November 2004 in Bucharest, entry into force on 15 March 2005.

With Serbia
A draft bilateral agreement with Serbia is at the final stage of preparation by Bulgarian competent authorities, to be proposed officially to the Serbian authorities via diplomatic channels. The proposed draft is entitled "Agreement between the Ministry of Environment and Water of the Republic of Bulgaria and the Ministry of Agriculture and Environmental Protection of the Republic of Serbia on Cooperation in the Field of Water Management".

Croatia

With Slovenia:
Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on regulation of water management relations
Agreement on cooperation for the protection of the Adriatic sea and the coastal area from pollution (Official Gazette of the Socialist Federal Republic of Yugoslavia – MP 2/1977)

With Hungary:
Agreement between the Government of the Republic of Hungary and the Government of the Republic of Croatia about the issues in cooperation in water management

With Bosnia and Herzegovina:
Agreement between the Croatian Government and the Government of Bosnia and Herzegovina on the regulation of water management relations (signed 11 July 1996 in Dubrovnik)
Agreement between the Council of Ministers of Bosnia and Herzegovina and the Croatian Government on cooperation in the protection of natural and manmade disasters

Multilateral:
FRAMEWORK AGREEMENT ON THE SAVA RIVER BASIN among: Bosnia and Herzegovina, Republic of Croatia, Republic of Slovenia and Federal Republic of Yugoslavia

With other neighbouring countries:
No bilateral agreements with the Republic of Serbia and the Republic of Montenegro. The responsible Ministry is involved in the formulation of agreements and the commencement of a negotiation process with neighbouring countries.

Czech Republic

With Slovakia:
Dohoda mezi vládou České republiky a vládou Slovenské republiky o spolupráci na hraničních vodách - podepsána dne 16. prosince 1999 a ve stejný den vstoupila v platnost
The Agreement between the Governments of the Czech Republic and the Slovak Republic on cooperation on transboundary waters

Směrnice pro předpovědní, hlásnou a varovnou službu na česko-slovenských hraničních vodních tocích
Implemantation for forecasting, reporting and warning service on the Czech-Slovak transboundary waters

With Austria:
Smlouva mezi Československou socialistickou republikou a Rakouskou republikou o úpravě vodohospodářských otázek na hraničních vodách ze dne 7. prosince 1967, platnou od 18. března 1970
Convention between the Czechoslovak Socialist Republic and the Republic of Austria on the settlement of water management issuies concerning transboundary waters signed on December 7, 1967 and came into force on March 18, 1970.

Směrnice pro varovnou službu na česko-rakouských hraničních vodách
Directive for warning service on Czech- Austrian transboundary waters.

Germany
With Austria

Interstate contract between the Republic of Austria on the one hand and the Federal Republic of Germany and the European Economic Community on the other hand on the cooperation regarding water management in the Danube River catchment (BGBl Nr. 17/1991).

The instrument of ratification signed by the Austrian Federal President and countersigned by the Austrian Federal Chancellor was exchanged on 14th December 1990 and referring to Art. 12 (2) came into effect on 1st March 1991.

Hungary

Name of the agreement			Date and place of the signature Date of coming to effect
AT	A Magyar Népköztársaság és az Osztrák Köztársaság között a határvidék vízgazdálkodási kérdéseinek szabályozási tárgyában	Agreement between the People's Republic of Hungary and the Republic of Austria about regulation of the water management issues in the border region	Vienna, 09/04/1956 31/07/1959
SK	A Magyar Népköztársaság Kormánya és a Csehszlovák Szocialista Köztársaság Kormánya között a vízgazdálkodás kérdéseinek szabályozásáról (magyar-szlovák viszonylatban)	Agreement between the Government of the People's Republic of Hungary and the Government of the Czechoslovak Socialist Republic about regulation of the water management issues	Budapest, 31/05/1976 28/07/1978 (new agreement accepted in Nov 2014, being published)
UA	A Magyar Köztársaság Kormánya és Ukrajna Kormánya között a határvizek védelme és fenntartható hasznosítása céljából folytatandó együttműködésről	Agreement between the Government of the Republic of Hungary and the Government of Ukraine about the cooperation purposing the protection and sustainable use of the rivers in the border region	Budapest, 11/11/1997 06/08/1999
RO	A Magyar Köztársaság Kormánya és Románia Kormánya között a határvizek védelme és fenntartható hasznosítása céljából folytatandó együttműködésről	Agreement between the Government of the Republic of Hungary and the Government of Romania about the cooperation purposing the protection and sustainable use of the rivers in the border region	Budapest, 25/09/2003 17/05/2004
RS	A Magyar Népköztársaság és a Jugoszláv Szövetségi Népköztársaság Kormánya között a vízgazdálkodási kérdések tárgyában (magyar- szerb viszonylatban)	Agreement between the Government of the People's Republic of Hungary and the Government of the Jugoslavian Federal People's Republic about the water management issues	Belgrade, 08/08/1955 19/05/1956 (new agreement is under discussion)
HR	A Magyar Köztársaság Kormánya és a Horvát Köztársaság Kormánya között a vízgazdálkodási együttműködés kérdéseiben	Agreement between the Government of the Republic of Hungary and the Government of the Republic of Croatia about the issues in cooperation in water management	Pécs, 10/06/1994 03/03/1995
SI	A Magyar Népköztársaság és a Szlovén Köztársaság Kormánya között a vízgazdálkodási kérdések tárgyában	Agreement between the Government of the Republic of Hungary and the Government of the Republic of Slovenia about the water management issues	Ljubljana, 21/10/1994 27/05/1995

Moldova
No information provided

Montenegro
No information provided

Romania

Bilateral cooperation Romania – Ukraine

Cooperation shall be conducted under the Agreement between the Government of Romania and the Government of Ukraine on cooperation in border water management (Galati, 30 September 1997), ratified by the Romanian Parliament by Law no. 16 of 11 January 1999.
Activities for implementing the Agreement shall take place within the next three working groups, one for each important river:
1. Working group to resolve issues of Tisza River and its tributaries in the border area.
2. Working group to resolve issues of Siret and Prut in the border area.
3. Working group to resolve issues of Danube on the common border area.

Bilateral cooperation Romania – Hungary

The first agreement in water field between Romania and Hungary was signed in Bucharest on 14 April 1924 and was in force until 1945. This was followed by 4 cycles of cooperation, 1945-1961, 1962-1965, 1965- 1970, 1970 to 1986, the agreement was renewed every time. On 25 June 1986 was signed in Bucharest Convention between the Government of Romania and the Republic of Hungary on the regulation of issues related to hydraulic structures on water which form or cross the border. The Convention entered into force November 20, 1986.
Currently, cooperation is performed under the Agreement between Romania and the Republic of Hungary on cooperation for the protection and sustainable use of water in the border region (Budapest, September 15, 2003), ratified by Government Decision no. 577/15.04.2004.
The agreement applies to the following rivers: Tur, Somes, Crasna, Barcau, Ier, Crisul Repede, Crisul Negru, Crisul Alb and Mures by hydrotechnical Romanian-Hungarian Commission.
For carrying out the agreement, the Commission has established the following standing Subcommittees areas:
1. Coordination and development cooperation Subcommittee;
2. Subcommittee on Water Management and Hydrometeorology;
3. Subcommittee on water quality;
4. Subcommittee on flood defence.
Subcommittees carry out the decisions of the Commission, the tasks resulted from regulations act independently within the provisions of the Regulations for measures to be taken immediately and assures the continuity of technical activity based on the Agreement.

Bilateral cooperation Romania – Serbia

Cooperation is achieved under the Agreement between the Romania and RPF Yugoslavia on hydraulic problems in hydraulic systems and watercourses that cross the border or are the border (Bucharest, April 7, 1955), ratified by Decree no. 242 / 06.17.1955.
The agreement applies to the following rivers: the Danube, Nera, Moravita, Aranca, Bega Veche, Bega Channel, Timis, Caras and Nera by hydrotechnical Romanian-Serbian Commission.
For carrying out the agreement, the Commission has established the following standing Subcommittees areas:
1. Subcommittee for water quality;
2. Subcommittee on hydrometeorology and quantitative water management;
3. Subcommittee on flood defence and ice.
Since 1998, the collaboration continued, but with some delays due to organizational changes produced in Serbia, resolving some issues regarding water management.
It is currently negotiating text of the new Agreement between Romania and Serbia on cooperation in the sustainable management of transboundary waters.

Bilateral cooperation Romania - Bulgaria

Cooperation is achieved under the Agreement between the Ministry of Environment and Water Management of Romania and the Ministry of Environment and Water of the Republic of Bulgaria on cooperation in the field of water management (Bucharest, November 12, 2004), ratified by Government Decision no. 2419 / 21.12.2004.
The agreement applies to the Romanian-Bulgarian Joint Commission through the following three working groups:
1. Working Group for river basin water management;
2. Working Group on Danube;
3. Working Group on the Black Sea.

Bilateral cooperation Romania – Moldova

Cooperation is achieved under the Agreement between Romania and the Republic of Moldova on cooperation for the protection and sustainable use of water - Prut and Danube (Chisinau, 28 June 2010) approved by Government Decision no. 1092/2.11.2010.
Application of the Agreement shall be made by the Intergovernmental Hydrotechnical Committee on subcommittees established for the following fields:
1. Subcommittee on operation and maintenance of hydraulic Stanca-Costesti reservoir;
2. Subcommittee on flood defence and ice;

3. Subcommittee on quantitative water management and hydrometeorology;
4. Subcommittee on water quality and biodiversity protection of water bodies.

Serbia

With HUNGARY:
The agreement between the governments of the FPR of Yugoslavia and the PR of Hungary regarding water management issues, entered into force on 8 August 1955.

With ROMANIA:

- The agreement between the governments of FPR of Yugoslavia and the PR of Romania concerning water engineering issues related to boundary and transboundary systems and watercourse, entered into force on 7 April 1955.
- Several agreements and conventions governing the construction, operation and maintenance of the Iron Gate Hydro Power and Navigation System Djerdap were entered into by Yugoslavia and Romania in 1963, 1964, 1967, 1976, 1977, 1987, and 1998.

With BULGARIA:
The agreement between the governments of the FPR of Yugoslavia and the PR of Bulgaria concerning water management issues, entered into force on 4 April 1958. The agreement is formally in force, but cooperation was discontinued in 1982.

With other neighbouring countries:
No bilateral agreements with Croatia, Bosnia & Herzegovina, Macedonia and Montenegro. The responsible Ministry has initiated extensive preparations for the formulation of agreements and the commencement of a negotiation process with neighbouring countries.

Slovak Republic
Bilateral cooperation of the Slovak Republic (SR) on the border sections of the rivers – valid intergovernmental treaties and agreements:

1. Treaty between Czechoslovak Socialist Republic and Republic of Austria on the regulation of water management issues at the border waters (signed 7.12.1967 in Vienna, valid since 18.3.1970, inherited with partners after the formation of the SR in 1993, Treaty between SR and Republic of Austria currently in the ratification process)
2. Intergovernmental agreement between Czechoslovak Socialist Republic and People´s Republic of Hungary on the regulation of water management issues at the border waters (signed 31.5.1976 in Budapest, valid since 31.7.1978, inherited with partners after the formation of the SR in 1993, Treaty between SR and Republic of Hungary currently in the ratification process)
3. Intergovernmental agreement between SR and Ukraine on the water management issues at the border waters (signed 14.6.1994 in Bratislava, valid since 15.12.1995)
4. Intergovernmental agreement between SR and Republic of Poland on the water management at the border waters (signed 14.5.1997 in Warsaw, valid since 6.12.1999)
5. Intergovernmental agreement between SR and Czech Republic on the cooperation at the border waters (signed 16.12.1999 in Zidlochovice, valid since 16.12.1999)

Slovenia

With AUSTRIA:
Agreement between the Government of the Federal People's Republic of Yugoslavia and Federal Government of Austria on water management issues of the Drava river (Official Gazette of Federal People's Republic of Yugoslavia – MP 1-8/1955)
Agreement between the Federal People's Republic of Yugoslavia and the Republic of Austria on water management issues of the border section and the border waters of the Mura river (Official Gazette of Federal People's Republic of Yugoslavia – MP 10-49/1956)

With HUNGARY:
Agreement between the Government of the Republic of Slovenia and the Government of the Republic of Hungary on regulation of water management issues (Official Gazette of the Republic of Slovenia – MP 2/95)

With CROATIA:
Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on regulation of water management relations (Official Gazette of the Republic of Slovenia – MP 23/97)
Agreement on cooperation for the protection of the Adriatic sea and the coastal area from pollution (Official Gazette of the Socialist Federal Republic of Yugoslavia – MP 2/1977)

With ITALY:
Agreement on the permanent Yugoslav-Italian commission on water management (Official Gazette of the Socialist Federal Republic of Yugoslavia – MP 9/80)
Agreement on cooperation for the protection of the Adriatic sea and the coastal area from pollution (Official Gazette of the Socialist Federal Republic of Yugoslavia – MP 2/1977)

The minutes of all Slovenian bilateral commission meetings/sessions are available at:
http://evode.arso.gov.si/index72dc.html?q=node/23

Ukraine
The Tisza River Basin Water Resources Directorate (of the State Agency of Water Resources of Ukraine) is engaged in implementation of the Bilateral Intergovernmental Water Management Agreements in partnership with the Upper-Tisza Water Directorate (of the General Directorate of Water Management of Hungary), Kosice Water Management Directorate (of the Slovak Water Management Administration) and Somes-Tisa Water Directorate (of the National administration "Romanian Waters"), based on:

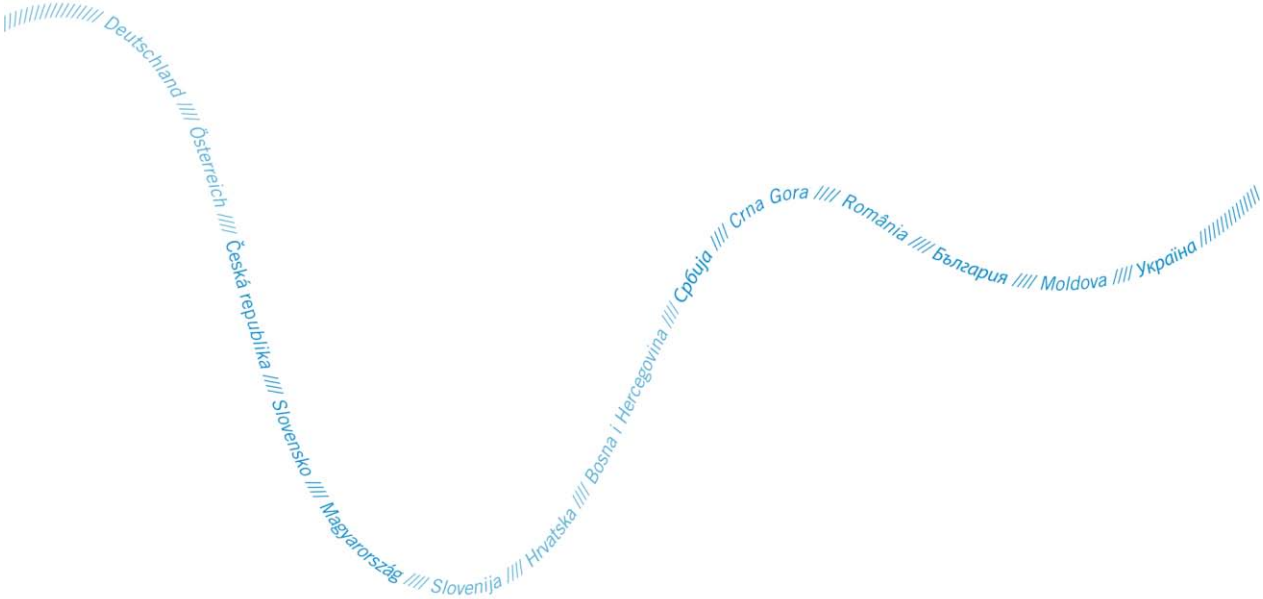
- the Agreement between the Government of Ukraine and the Government of Hungary on water management on boundary waters (Budapest, Hungary, 1997),
- the Agreement between the Government of Ukraine and the Government of Slovak Republic on water management on boundary waters (Bratislava, Slovak Republic, 1994),
- the Agreement between the Government of Ukraine and the Government of Romania on cooperation in the field of water management on boundary waters (Galati, Romania, 1997).

These bilateral agreements comprise the issues of flood protection, water resources management, water quality assessment and ecological monitoring, hydro-meteorological information exchange on boundary waters.

Resource Document "Economics and the Floods Directive"

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

Annex 5 of the DFRM Plan



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1 Introduction

In recent years, most notably in 2002, 2006, 2013 and in the summer of 2014, parts of the Danube River Basin District were being affected by very strong or extreme flooding events. These events, with return periods of up to 100 years and above, caused significant human and economic damages in the affected countries and communities. In 2006, 4 casualties were reported in the Czech Republic and Slovakia, and the costs and damages amounted to almost 600 million Euro in the whole basin. In 2010, there were 35 casualties, and damages of around 2 billion Euro occurred, a figure which was even surpassed in 2013 (2,3 billion Euro damages, mostly in Germany and Austria; additionally, 9 casualties were also reported from Austria and Romania). And, most recent, the Sava River Basin in Croatia and Bosnia and Herzegovina as well as Serbia was hit very hard in May 2014, effecting 2,6 million people, killing 79, and causing almost 4 billion Euros damage in the three countries[1].

Hence, floods and flood protection have an inherent economic aspect, which the Floods Directive (FD) takes into account through a number of references to the use of "economic analyses" in the flood risk management. However, these are not as pronounced as in other European water-related Directives, like the Water Framework and Marine Strategy Framework Directives.

There are explicit and implicit references to "economic analyses" in the FD:

The explicit reference of Article 7 §3 FD ("Flood risk management plans shall take into account relevant aspects such as costs and benefits…") basically point out that policy makers developing flood risk management plans should invest the limited resources available in an optimal way and guarantee a reasonable balance between benefits and costs in designing the measures and programs included in the plans. To this end, the flood risk management plans should be underpinned by information on advantages and disadvantages, likely to be expressed as costs and benefits.

Another explicit reference, included in Annex A.I.5 (as a component of the first flood risk management plans: "*When available, for shared river basins or sub-basins, a methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects*") obliges the Member States to describe the methodology for Cost-Benefit Analyses used to assess transboundary measures. The importance of economic assessments for evaluating transboundary aspect is also highlighted in the CIS WG Floods "Resource document on flood risk management, economics and decision making support", stating that economic assessments "could deliver mechanisms for compensation of transboundary effects related to the solidarity principle".

Beside the explicit references, the Floods Directive encompasses some implicit references to the use of economics, which are:

- The concept of flood risk as developed under Articles 2 §2, 6 §5 and referred to in other Articles throughout the Floods Directive.
- The definition of "flood risk" (Articles 2 §2 and 6 §5), which includes the definition of potentially adverse consequences (which need to be evaluated).
- The link to the WFD´s objectives and structures in Article 9 ("(…) for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of Directive 2000/60/EC"), automatically linking WFD economic analyses and approaches to the FD.

[1] ICPDR/International Sava River Basin Commission 2015: May 2014 Floods in the Sava River Basin - Brief overview of key events and lessons learned.

- The content of Article 7 §4 ("In the interests of solidarity, flood risk management plans (…) shall not include measures which, (…), significantly increase flood risks upstream or downstream of other countries (…)"), which necessitates an evaluation/assessment of the up- or downstream risk.
- In Annex A.I.4 ("a summary of the measures and their prioritization (…), and flood related measures taken under other Community acts (…)"), again a link to WFD economic analyses and approaches (priorization) is being established.
- The obligation of Annex A.II.1. ("a description of the prioritization and the way in which progress in implementing the plan will be monitored"), also necessitating an analysis encompassing economic elements.

2 What is a CBA - short theoretic introduction/description

Generally speaking, a Cost-Benefit Analysis aims at evaluating the economic efficiency (ratio of the economic cost of a measure/policy to the resulting economic benefits) of alternative options (e.g. measures, actions, programs). Thus, the benefits derived from an option are compared with the associated costs; the basis for this comparison are usually monetary units. The net benefit of each option results from the difference between the costs and benefits, and is called "Net Present Value" (NPV). Economic feasibility of an option is only given if the NPV that it generates is positive, i.e. >0 (beside the NPV, also the "benefit cost ratio" can be calculated by a CBA).

Hence, a CBA can serve as a systematic approach for evaluating and comparing alternative management and policy options. Ideally, all positive and negative effects of alternative options should be assessed. To this purpose, all benefits and costs should be translated into monetary terms, including where possible, environmental, social and other impacts (both negative and positive), and opportunity costs.

However, for many environmental, social and other impacts resulting from activities, actions and programs, there is no market on which they are traded, and therefore no market price is available which reflects their economic value (and which could be compared in the process of the CBA with the value of market goods and services resulting from the option). This leads to a distortion in the evaluation of the costs and benefits of different management and policy options, as non-marketed goods and many ecosystem services resulting from these options (or impacted by it) are often neglected. These usually encompass values such as the existence of wildlife and biodiversity (and the "cost" of losing such values in case of infrastructure development projects etc.), the opportunity to visit undisturbed areas, the provision of clean and fresh air and water, etc.

There are, however, several economic valuation methods which allow placing a value on such non-marketed goods and services[2]. This means that a wider range of goods and services can be explicitly recognised in the CBA process (see below for more details).

Depending on the extent of factors covered in the analysis, different types of CBA can be distinguished. Brouwer (2005) makes a fundamental distinction between financial and economic CBA:

- A financial CBA, also referred to as a cash-flow or a financial analysis, evaluates advantages and disadvantages of a policy measure in terms of the expenditures and

[2] See DEFRA (2007) for a comprehensive overview (in English), or COWI (2014): https://circabc.europa.eu/sd/a/95c93149-0093-473c-bc27-1a69cface404/Ecosystem%20service_WFD_FD_Main%20Report_Final.pdf.

earnings directly associated with its implementation. Originally devised for investment decisions, the tool can also be used to assess budgetary impacts of policies.

- An economic CBA evaluates the costs and benefits of a policy measure in a broader sense, taking into account the effects on the national economy as a whole.

- The costs and benefits addressed in an economic CBA may include indirect (second-order) effects and non-priced external effects (e. g. environmental effects). If such externalities are included in the analysis in monetary terms, it is, according to Brouwer (2005), also referred to as an "extended CBA". In the CIS WG Floods Resource Document on Economics, the term "extended CBA" is used differently, however: as a description of an appraisal method combining monetary/quantitative elements with non-monetary/qualitative elements.

In general, the following steps or stages can be identified for conducting a Cost-Benefit Analysis:

- Definition of the details of each feasible project, policy or management option including the business-as-usual ("do nothing") option.

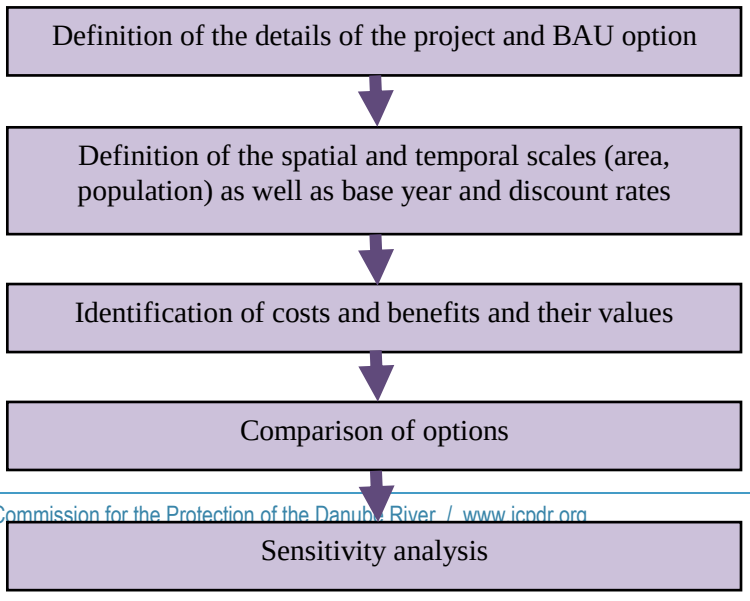
- Determination the spatial and temporal scales of the analysis, i.e. the area and population t appropriate for relating the costs and benefits to and the time period in which the costs and benefits arise (including discount rates).

- Identification of the costs and benefits and their monetary values. Monetary value may be based on the market value of a good or service or on its replacement cost (if that can be calculated), or, in the case of some environmental goods and services, by use of various valuation techniques (see footnote 2 above). To enable valid comparisons, all monetary values must refer to a common point in time – the base year – to give "present" values (e.g. some values might originate from the early 1990ies, others from 2015 - these have to be comparable by applying a "discount rate").

- The economic efficiency of various options are assessed through comparing either their "benefit-cost ratios", i.e. the present value of benefits divided by the present value of costs, or their "net present values", i.e. the present value of benefits less the present value of costs.

- A sensitivity analysis should be included within a CBA, to assess the impact on the benefit cost ratio and/or net present value of changes in the values of central parameters, e.g. the value of costs and benefits or the discount rate. By examining the impact that increasing costs (or reduced benefits) may have on the net present value, the breakeven point can be determined whereby the scheme would be no longer justifiable.

The following scheme depicts these steps graphically:



Carrying out a CBA often is an iterative and multi-disciplinary process, involving not only expertise from different fields, but also policy and decision-makers, whose input is essential when defining the objective which the assessed option is supposed to achieve, and when identifying the baseline and policy scenarios, including current policy objectives. One key role of economists in the process is to frame the issue and to set the CBA framework at the beginning.

In practice, government policies are often evaluated primarily on the basis of their financial (budgetary) costs, as these can be assessed relatively easily. The calculation of economic costs and benefits, and especially of non-market external effects, is a more difficult task. However, the economic/extended CBA is the more appropriate method for evaluating public policies than a simple financial CBA, since government interventions are often related to the provision of public goods and ecosystem services, which have an impact on society as a whole. Such impacts should consequently be evaluated from a societal perspective, not the perspective of the principal investor only (the government or a specific economic sector). In the case of environmental policy measures, an extended CBA will often be called for, as the main benefits of such policy measures usually consist of so-called external environmental effects (improvements) for which often no market prices exist.

Finding monetary information on the costs is fairly straightforward in most cases, as there is considerable experience with (at least the direct) financial costs caused by policy measures, and as market prices will often be available for the cost of implementing measures. The valuation of benefits is usually more demanding in terms of time, skills and resources: this requires that a monetary value be placed on the outcome of a policy decision. Also, data availability is often a great challenge, as studies describing benefits of environmental effects are rare and mostly tied to specific local circumstances. Non-monetised impacts, if relevant, can nonetheless be included in a qualitative discussion or in approaches that combine quantitative (monetized) and qualitative information (such as a Multi-Criteria Analysis).

A Multi-Criteria Analysis is a generic term for a number of methods that use multiple criteria - and not only monetary/quantitative ones - for evaluating alternatives/measures. The criteria are usually related to the objectives and points of attention of the policy makers and stakeholders, i.e. beside costs this could encompass data/information on visiting guests etc. All projects or alternatives considered get a value for the evaluation criteria considered. The importance of the different evaluation criteria is determined, usually in a participative process. Finally, a general score can be calculated or derived by means of a weighted summation of the values for the evaluation criteria. The scores for the different alternatives allow ranking the alternatives considered.

A combination of MCA and CBA can be used to evaluate policies or measures where monetary/quantitative information is available only for a part of the factors (i.e. for the costs, but only for a part of the benefits). Such an analysis is what the CIS WG Floods Resource Document on Economics refers to as an "extended CBA" (see above). Also, the Resource Document to "Support Policy Development for Integration of Ecosystem Service Assessments into WFD and FD Implementation" (COWI 2014; see footnote 2 above) contains information on scoring and MCA.

3 Cost-Benefit Analyses in other Directives and EU Guidance

3.1 WFD

The Water Framework Directive (Directive 2000/60; WFD) is a EU Directive which commits the Member States not to deteriorate the status of water bodies and to achieve "good" status of all surface water bodies (including transitional and coastal marine waters) and groundwater bodies by 2015. The objectives of non-deterioration and good status achievement are legally binding, although exemptions are possible under certain conditions (Article 4 WFD; see below for details) for which the CBA can become relevant.

Although the WFD was the first Directive to introduce mandatory "economic assessments" into the water governance of EU Member States, Cost-Benefit Analyses are not directly mentioned and, hence, are not an obligatory part of the Directive. The CBA is nevertheless a possible instrument/tool to inform decision makers on a variety of issues linked to WFD-implementation (see below). The WFD requires that Member States shall make judgments about the most cost-effective combination of measures to be included in the Programs of Measures (PoMs). Judging the cost-effectiveness of measures can be done by performing Cost-Effectiveness Analyses (CEA), which is also suggested by the non-binding advisory document of the CIS WATECO Group ("WFD CIS Guidance Document No. 1 - Economics and the Environment – The Implementation Challenge of the Water Framework Directive"). A CEA has certain similarities to a CBA, as it also encompasses analyzing the costs and benefits (in terms of impacts) of a measure/bundle of measures.

Additionally, assessments of costs and benefits can be of relevance in the context of exemptions: The WFD allows for an extended time to the achievement of objectives or the application of less stringent objectives if properly justified, inter alia, on the grounds of disproportionately expensive measures (Articles 4.4 and 4.5). According to the Directive, costs can be disproportionately high, firstly in relation to the financial ability to meet them, or secondly, compared to the benefits of meeting the objective - this second argument requires the MS to prove that the costs of the measure/bundle of measures are higher than the benefits that reaching GES would provide (it has to be noted that the results of a CBA do not question the general, legally binding objectives of the Directive). A similar passage is included in Article 4.7, on "new modifications": in case a new modification might deteriorate water status, according to this Article the respective MS has inter alia to demonstrate that the "…benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications… ". However, there was little information found on the details and the process of determining disproportionately expensive measures in the first RBMPs (or justifying new modifications), although the Water Directors agreed that a proportionate selection of the different analyses (cost-benefit analysis, benefits assessment, assessment of the consequences of non-action, distribution of costs, social and sectoral impacts, affordability, cost-effectiveness etc) is useful to inform decision making (CIS Guidance Document No. 20 on Exemptions to the Environmental Objectives). Hence, CBA is an option for reporting on methodologies used for the disproportional costs analysis/assessment (but not for the Article 4.7 assessment).

Assessments of costs and benefits of activities, actions and programs impacting (positively or negatively) the environment invariably need to consider the effects of the assessed measure on ecosystem services. Such assessments of ecosystem services are particularly relevant to the economic assessments, which are required by EU environmental Directives (WFD, but also FD and MSFD). Assessing effects on ecosystem services and included these into economic assessments (MCA, CEA or CBA, or any other form of economic analysis) strengthens the communication of the benefits of environmental measures, considers co-benefits in other policy areas (such as tourism, climate change

adaptation), and sharpens the view on who benefits and who loses from the implementation of the measure[3].

Reviews of cost and benefit information used in the first RBMPs, such as one performed in the frame of the "Pressures and Measures" project published in 2012, showed that only limited information on cost and benefit has been available. This was true in particular with respect to the benefits of WFD implementation: such information was rarely included in the RBMPs and in total, benefit information could only be found for 22 RBDs. This has been confirmed by the 2015 Commission Staff Working Document "Report on the progress in implementation of the Water Framework Directive Programs of Measures"[4], which states that for CEA "in general the methodologies used are often unclear or poorly reported" and that "various gaps in information availability did limit the use of a CEA".

Hence, it is not surprising that both CBA as well as CEA have not been used on a broader scale in the first RBMP planning and implementation cycle.

There are also many synergies between analyses and assessments in the WFD and the FD, e.g. between the Art. 5 WFD and Art. 6 FD. The CIS WG Floods Resource Document on Economics recommends strongly to maximise theses synergies and to take WFD aspects into account when performing FD economic assessments (hydromorphological measures and Natural Water Retention Measures are named as main examples).

3.2 MSFD

Similar to the Water Framework Directive, the Marine Strategy Framework Directive (Directive 2008/56; MSFD), commits EU Member States to achieve or maintain a "Good Environmental Status" (GES) in their marine waters. It also contains mandatory *economic requirements, of which the four key ones* are listed below:

- An "Initial Assessment" of a Member States´ marine waters, including an "Economic and Social Analysis" (ESA) of the use of those waters, and of the cost of degradation of the marine environment (Art. 8.1(c) MSFD).
- The establishment of environmental targets and associated indicators describing GES, including due consideration of social and economic concerns (Art. 10.1 in connection with Annex IV, no. 9 MSFD).
- The identification and analysis of measures needed to be taken to achieve or maintain GES, ensuring cost-effectiveness of measures and assessing the social and economic impacts including cost-benefit analysis (Art. 13.3 MSFD).
- A justification of exceptions to implement measures to reach GES based on disproportionate costs of measures taking account of the risks to the marine environment (Art. 14.4 MSFD).

Hence, contrary to the WFD, the MSFD does mention Cost-Benefit Analyses directly: in Article 13.3 on the Programmes of Measures (PoM), the Directive states that Member States shall give due consideration to sustainable development and, in particular, to the social and economic impacts of the measures envisaged by making sure that measures are cost-effective and technically feasible. Additionally, Member States have to carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure.

[3] For more information, see COWI (2014): https://circabc.europa.eu/sd/a/95c93149-0093-473c-bc27-1a69cface404/Ecosystem%20service_WFD_FD_Main%20Report_Final.pdf.

[4] Pressures and Measures Project (2012): http://ec.europa.eu/environment/archives/water/implrep2007/pdf/EU%20pressures%20and%20measures_Task_4b_Final%20report.pdf. COM http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/CSWD%20Report%20on%20WFD%20PoMs.pdf

The guiding paper of the CIS Working Group "Programmes of Measures", endorsed by the Marine Directors ("Programmes of measures under the Marine Strategy Framework Directive - Recommendations for implementing and reporting", draft final version as of 10th November 2014), acknowledges the role of CEA and CBA as "crucial requirements…for new measures" (and also offers a full definition of CBA, linking the MSFD CBA with the WATECO guidance of the WFD, highlighting the interactions and similarities between the two Directives), but also states that "*a common understanding and exchange of best practice is needed to better perform impact assessments of measures, including cost-effectiveness analysis (CEA) and, for new measures, cost-benefit analysis (CBA)*". Also, the possible role of ecosystem services as part of an economic analysis/CBA is similar to the WFD (and FD) (see section 3.1 above, and footnote 3).

The CIS guiding paper also explains that CEA and CBA can have different functions in the PoM development process, depending on each individual Member States´ decision-making process. Both CEA and CBA can be part of the prioritisation of measures process, in collaboration with stakeholders at various stages. It proposes that new measures can be ranked in accordance with their contribution to goal attainment (e.g. delivery against GES) and costs, "*starting with measures that bring the largest contribution at least cost. By combining cost-effective measures, the least costly PoM is found that will bridge the gap between current environmental status and GES. For any new measures, an impact assessment (including a cost-benefit analysis) is required. These tools can have different functionalities in the PoM development process*".

Hence, although a mandatory requirement of the MSFD, the exact role of CBA in the process of developing PoMs is not entirely clarified yet; this is also true for the role CBA can play in justifying exceptions due to disproportionate costs of measures – a challenge that has been and still is prominent in the context of the WFD[5].

4 CBA in the context of the FD - country approaches

The FD stipulates that when available, for shared river basins or sub-basins, a description of the methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects shall be provided in the flood risk management plan. In the following section, some selected approaches of countries in the Danube basin towards Cost-Benefit Analyses in the context of the Floods Directive are described, on the basis of the information included in the Danube FRMP, and as provided by the Danube countries.

4.1 Germany

Economic evaluations constitute a regular part of German flood risk management. This reflects the idea that the use of economic instruments, methods and procedures support an effective flood risk management, such as decision-making, vulnerability and risk assessment, the analysis and prioritisation of measures and the financing of FRM-measures. The process of identifying and selecting measures constitutes the basis to a successful FRM. In Germany, this process runs across several levels of water management. Hereby, various regulations and requirements are to be followed. Economic evaluations are in the wider sense an integral part of the framework and the key factors that influence the FRM-process.

[5] For examples of applying CBA (and other economic assessment techniques) see DG Environment´s "Background Document summarising Experiences with Respect to Economic Analysis to Support Member States with the Development of their Programme of Measures for the Marine Strategy Framework Directive", available on Circabc.

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

4.2 Austria

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

CBA in Austria is structured in 15 work steps as follows:

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

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

4.3 Czech Republic

No cost benefit analysis in flood risk management was applied as there was no methodology available for the evaluation of the benefit of the flood risk protection measures mentioned in the national Flood risk management plan for the Danube River Basin District.

For the purpose of evaluation of particular flood protection measures by strategic experts the efficiency ratio is calculated using the expected flood damages and the costs of the measures.

4.4 Slovakia

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

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

For the purpose of the measures prioritisation in the first cycle (2015) of Flood Risk Management Plans, the national methodology for the evaluation of flood damages for implementation, operation and maintenance of flood protection measures and their economic benefits was prepared by Slovak national Working Group on Economics, and then amended and adopted by the Slovak national Working Group on Floods in January 2014. The ranking of measures is based inter alia on their efficiency indices, which are calculated as the ratio between the estimated avoided potential flood damages and the estimated overall costs (for preparation, land purchase, implementation, operation and maintenance) of a given measure during its lifetime. The lifetime period of the flood protection measures/structures equals to 100 years in Slovakia.

Further information is presented as a Case Study (see Annex I).

4.5 Hungary

In the Hungarian FRMP great importance is given to the efficiency measurement of the flood risk management measures. To put this across a so called “planning assistant tool” has been developed which includes each measure which is associated with the aims and principles of flood risk management. It calculates the effect of both the structural and the non-structural measures and their investment costs. Calculation of the effects is based on the risk reduction results; the costs consist of the specific investment and maintenance costs. According to the Hungarian application of the FRMP, the measures and measure-groups are compared with each other and ranked with Multi-Criteria Analysis. The Multi-Criteria Analysis is divided into two groups, the economical and the non-economical evaluation, where the economical evaluation is the CBA (Cost-Benefit Analysis) itself. The non-economic effects are the impacts on human life and health, cultural heritage, ecological impacts, water-management planning and other aspects. Evaluation of these non-economic effects is done in two levels. The first level is a disqualifying or exhaustive level, where there are fixed conditions (minimum-terms) to keep, and when they are breached, the analysed plan-version is excluded from further investigation. The second level is an optimization task, where beyond keeping the minimum terms we compare, analyse and evaluate the economical and non-economic effects and calculate their efficiency.

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

The cost-benefit ratio of the measure will be acceptable, if it is above the fixed minimum demand, which is 110% in our case. It was an interesting experience to examine the efficiency of the planned flood risk management measures on the pilot area of Zagyva-Tarna in Hungary. According to the results of the CBA calculations of one of the plan-versions, there could be remarkable efficiency differences on partial water-catchments, when applying uniformly designed measures for the whole

water catchment. The efficiency on the partial water-catchments varied between 5-10% and 3-400%, although the calculated efficiency of the measure for the whole pilot area was 121%. These results came from the plan-version where the level of the existing, but – according to the present legal regulations – unsatisfactorily built dikes were uniformly raised to the legally specified level.

4.6 Serbia

Cost benefit analysis was not applied in Serbia.

4.7 Bosnia and Herzegovina

The application of partly modified cost- benefit analysis in flood risk management in the Federation BiH has begun through the creation of a strategic document entitled "Evaluation of the Current Flood Protection Level in the Federation of Bosnia and Herzegovina and Improvement Program Drafting " which was conducted end of 2002. In this document, 31 flooded areas in FBiH (major river valleys and karts' fields) were considered for which the economic and financial analysis have been implemented in order to define the costs and benefits. Benefit is presented by reducing the damages on certain flood area, and the costs include the funds needed for the construction of structures as well as their maintenance and other expenses that may arise during the use of the facility. Based on the defined costs and benefits, using the internal rate of rentability, the ranking of flood areas was carried out from the aspect of profitability of their investment in flood protection of these areas. The internal rate of profitability is defined as the rate of interest for which all the costs and benefits are equal and it represents the maximum rate for which the loan is profitable. After creation of the above ranking, no additional and separate cost-benefit analysis for the purpose of flood risk management was made. The necessity for such economic analysis is recommended by the adopted "Water Management Strategy of the Federation of Bosnia and Herzegovina 2010 - 2022". Recently, this method was used in the justification of investments in flood protection or in construction of flood control structures in relation to the value of the defended area.

4.8 Romania

Cost-benefit analysis aims to highlight the effects that the infrastructure will have for the beneficiary of the project. The effects can be divided into two main categories: financial effects (revenues and expenses generated/incurred by the beneficiary with the investment) and social effects (benefits and social costs made/induced by the infrastructure done by the project). Quantifying the benefit is achieved in case of several scenarios, depending on exceeding probability. Profitability and efficiency of the proposed investment (financial effects) result from B/C ratio by comparing the updated avoided damages, provided for each studied scenario, with total costs to date, necessary to mitigate flood risk. The economic analysis is based on an incremental approach, considering the economic benefits instead of financial ones. The net economic benefit of the project is equal to the difference between the amount of avoided damage due to project implementation and the economic costs of the project.

4.9 Slovenia

According to the Decree on establishment of flood risk management plans (Official Gazette of the Republic of Slovenia, No. 7/2010) flood risk management plans should take into account the aspect of costs and benefits. Cost-benefit analysis is an important element in the process of selection and prioritisation of measures of the flood risk management plan. CBA is already obligatory for public funded investments in flood protection exceeding 300 000 EUR according to the Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance (Official Gazette of the Republic of Slovenia, No. 60/2006 and 54/2010), and many different methods and approaches for the assessment of benefits of flood protection measures were applied in the past. A unified method for the assessment of benefits was developed in 2014 for the purpose of flood risk management plans. Benefits are assessed as a reduced value of expected annual damage after the implementation of certain measure or combination of measures. For the development of the method the data on damages during past flood events were taken into account. Benefits of the

measures for human health, environment, cultural heritage and economic activity are assessed in monetary terms. Besides direct and tangible values the monetary assessment includes also some indirect and some intangible values as well. Benefits, which are not assessed in monetary terms, are listed.

4.10 Croatia

For Croatia's draft Flood Risk Management Plan (FRMP), cost-benefit analyses (CBA) of individual measures have not been carried out. Costs of the structural measures are assessed in the *Multiannual programme of construction of water regulation and protection facilities and amelioration facilities*, which is the basis for implementation of the structural flood protection measures in Croatia. The overall potential damages for the high-probability, medium-probability and low-probability scenarios have been assessed for Croatia, but reductions of these damages due to implementation of individual measures (i.e. benefits) have not been assessed based on a consistent methodology and based on the current flood hazard and flood risk maps yet. There are ongoing studies for several river sub-basins in Croatia (Kupa, Krapina, Bednja and Karašica-Vučica in the Danube River Basin District), in which the alternative solutions for the flood risk management measures are evaluated, the optimal flood risk management measures are defined and evaluated by the CBA analyses for the purpose of securing the EU funding for implementation of these measures. It is planned to perform such CBA analyses during the first FRMP cycle (2016-2021) for all proposed measures in all sub-basins with potentially significant flood risks, which could lead to an economically-based prioritization of the measures for the second FRMP, due in 2021.

4.11 Bulgaria

The CBA analysis of the programmes of measures in FRMPs in Bulgaria will be performed according to a national methodology which is still under development. The elaboration of the CBA-methodology is one of the activities of the project, funded by the OP “Environment” and the development of the methodology was contracted through an open tender procedure. According to the terms of contract, the methodology shall be finalized by the end of June 2015. The main stages of the elaboration include: development of methods for financial and economic analysis; development of an approach for analysis of risk and sensitiveness; development of additional method for assessment of the effect of measures which is difficult to estimate in monetary terms; development of an approach for the assessment and selection of economically effective Programme of measures; elaboration of National Guidance for implementation of the Methodology.

4.12 Ukraine

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

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

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

5 Conclusions

The three major EU water Directives - the Water Framework, Floods and Marine Strategy Framework Directives - all make reference to "economic assessments" in some ways, some refer explicitly to Cost-Benefit Analyses (like Article 10 MSFD), some implicitly (like the WFD in case of exemptions); there are similarities, however, between the WFD and the FD in terms of economic assessments and CBA[6].

On the national scale, FRMPs "shall take into account relevant aspects such as costs and benefits", i.e. instead of prescribing a CBA (like in the MSFD), a relatively weak formulation was chosen, and there is no closer definition of what taking costs and benefits "into account" actually entails. On the international scale, performing a CBA is similarly not obligatory ("if available").

Nevertheless, it is recognized widely that economic assessments are a helpful decision-making support instrument, able to support the selection of appropriate activities, actions and programs or other decision-making processes towards reaching EU and national targets (also in their own interest). This is especially true in the case of measures of transboundary effects with regard to flood protection, to avoid shifting the risk up-or downstream. However, for this to be feasible, first a common definition of "measures with transboundary effect" would be necessary (because if analyzing a measure in a very detailed way, almost all measures will have some up- or downstream effect).

Furthermore, a CBA can be a useful tool to assess the costs and benefits of flood risk management measures more broadly and better linking the Floods Directive with the WFD, e.g. via the Economic Analysis, cost effectiveness, or disproportionate costs/affordability assessments.

Hence, it is recommended to work towards approaches to economic assessments (meaning CBA, CEA, exemptions) in a coordinated way between administrations responsible for floods risk management and water policy. The approaches should also respect the needs of policy-makers and administrations, i.e. approaches should be easy to handle, not too costly, and rely on data that is already or easily available. It can be expected that in the 3rd implementation cycle, more comprehensive methodologies need to be used (the data base and available information needs improved as well to be able to apply improved methodologies), so it would be beneficial to start already in the 2nd cycle to develop these.

Examples of how different Danube countries approached the topic can be found in chapter 4 above, as well as the Annex, describing three cases in more detail. Some insights can be drawn from these:

- In general, it seems that costs of flood risk management measures can be determined with some accuracy throughout the countries. Coordinated approaches would ensure a better comparability of the estimations of costs.
- Regarding benefits, most countries used a "damages avoided" approach, i.e. benefits were calculated on the basis of the damages avoided by new flood protection measures. In some cases, also approaches to include "wider" environmental and social benefits were applied.
- Hungary used an approach based on a Multi Criteria Analysis, which allows to incorporate such "wider" benefits into the assessment.
- For a detailed description of how potential damages of floods can be assessed, it is recommended to look at the examples in the Annex.

[6] Also see the "Linkage Document" on FD and WFD: https://circabc.europa.eu/sd/a/2e917bbb-abff-41ac-b6fc-0fc91bf0347d/inks%20between%20the%20Floods%20Directive%20and%20Water%20Framework%20Directive%20-%20Resource%20Document.pdf

Closely linked to the concept of "wider benefits", i.e. environmental and social benefits, is the concept of ecosystem services. A couple of recommendations can be extracted from the COWI Report[7] in this regard:

- Ecosystem service assessments need not be only quantitative in nature to provide valuable input for the decision-making process. Qualitative assessments such as MCA-related approaches can also provide valuable input to economic assessments. In some cases, simply the identification of all relevant ecosystem services will improve the level of knowledge and allow for better decision-making.
- Approaches to ecosystem service assessments should be aligned with the approaches applied for economic assessments, i.e. it should be clear how an ecosystem service assessment can be "linked" to the wider economic assessment in progress.

[7] https://circabc.europa.eu/sd/a/95c93149-0093-473c-bc27-1a69cface404/Ecosystem%20service_WFD_FD_Main%20Report_Final.pdf.

Annex I: Detailed Case Study Descriptions

Slovakia

The Cost-Benefit Analysis used within the frame of first Flood Risk Management Plans compilation was developed as the national methodology, than agreed and adopted by the Slovak national Working Group on Floods. In Slovakia the implementation of FD is coordinated by the Ministry of the Environment of the Slovak Republic (MoE of the SR) including the coordination with other sectors, institutions, academic sector, etc. The national methodology applied in the first Flood Risk Management Plans consist of following steps:

A. Estimation of flood damage:

The methodology for estimation of flood damage has been developed by Water Research Institute. The theoretical methodology was adjusted based on flood protection expert´s practical knowledge, following either their national experiences or their international experiences too. The methodology for estimation of flood damages is part of the Flood Risk Management Plans. Calculation of flood damages that could be caused by floods without realization of flood protection measures in particular geographical areas was elaborated by Slovak Water Management Enterprise, state enterprise. Estimation of flood damages consist of a number of following steps:

A. a) estimation and calculation of potential flood damages

Flood damages has been calculated for 4 categories of **direct flood damages** with some surpluses of **indirect flood damages** too. The national GIS inventory of objects Fundamental basis of GIS (ZBGIS, v2013.4, © ÚGKK) was used as the basis for determination of land use categories. Potential damages for following categories have been calculated:

1. Areas of civic amenities, housing areas, recreational areas, industrial areas, additional objects as immovable property. The damage for immovable property is calculated based on:
   a. damage function (international project CEframe), i.e. a function of flood depth and damage (%);
   b. unit prices (EUR/m^2) for infrastructure based on national Classification of construction 2012 (EUR/m^3). For simplifying the calculation, the universal high for one floor of any type of building was set to 3 m;
   c. ground plan area of building type (m^2). Surplus (lump-sum) of 50 % is added on top for indoor facilities. As by more frequent floods (Q_5, Q_{10}) people are better prepared for emergency situation, this surplus is added for scenarios Q_{50}, Q_{100} and Q_{1000} only.
2. Other areas (sidewalk, parking, courtyard). The damage is calculated based on:
   a. damage function (international project CEframe), i.e. a function of flood depth (less than 0,5 m and over 0,5 m) and damage (%);
   b. unit prices (EUR/m^2) for infrastructure based on national Classification of construction 2012 (EUR/m^3);
   c. ground plan area of particular area (m^2)
3. Transport and technical facilities (railways, roads). The damage is calculated based on:
   a. damage function (international project CEframe), i. e. a function of flood depth (less than 1,0 m and over 1,0 m) and damage (%).

   Furthermore the calculation is carried out separately for railways and roads, so:

railways: b. unit price (EUR/m of length); c. length of railways (m)

roads: b. unit price (EUR/m^2 of area); c. area of roads (m^2)

Additionally, 10,5 % surplus to the damage calculated for 3 above mentioned categories was added, as the value which represents the high of costs of rescue works and safeguarding works, taken from the state evidence of average flood costs and damages for the period 1996 until 2013. These are **indirect flood damages**.

4. Agricultural and forest landscape (forests, meadows, marshland, arable land, fruit grove, rocky land, grass land, vineyard, green crops, green fences). Calculation of the damage depends on the kind of crops grown, the duration of the flood and growing season. The annual statistical data (average values for the period 2009 - 2011) published by the Statistical Office of the Slovak Republic have been used. The approach was consulted with the experts from the Soil Science and Conservation Research Institute and the Research Institute of Agricultural and Food Economics (nowadays both operating under umbrella of the National Agricultural and Food Centre) the damage is calculated based on:

   a. gross agricultural production of gross turnover in EUR per productive agriculture field in hectare (EUR/ha);

   b. area of agricultural land (ha).

Additionally, 33% surplus was added to the damage calculated according above mentioned approach, which represents the damages caused on temporal accommodations, cars, distribution networks, damages caused by production disruption, extraordinary travel costs, and impact on public health.

Even a Statistical value of human life as a **direct flood damage** was taken into account. Based on the state evidence of fatalities and injuries caused by flood events, the average value was set to 0,9 Mio. EUR per year. This value was recalculated for all the geographical areas where potential flood risk was determined for the first planning cycle. Finally the amount of 1 610 EUR/year must be added to the overall damages.

Total potential flood damage equals to sum of all above mentioned damages calculated for given Q_n.

A.b) evaluation of potential flood damages

For the optimal proposal of flood protection measures it is necessary to evaluate the economical effectiveness of proposed measures, it means to evaluate the costs of flood protection measures and achieved benefits.

Method of numerical integration is used for calculation of the **average annual damage** (EUR/year) and is based on potential flood damages per each above mentioned category and designed discharges Q_5, Q_{10}, Q_{50}, Q_{100} and Q_{1000}. If any kind of flood protection measures already exists in the geographical area, this is taken into account too. It means, that the annual potential damage for Q_{1000} flood in the geographical area, where the flood protection measures against Q_{100} flood already exist, only the potential damage caused by Q_{1000} flood is calculated. The potential damages caused by Q_5, Q_{10}, Q_{50} and Q_{100} are not taken into account in such a case.

The difference between avenge annual potential damage for present status and average annual potential damage in the area with realized flood protection measures (e.g. for Q100) equals to **avoided annual** volume of potential **flood damages**.

This value multiplied by lifetime period of proposed measure equals to **total avoided potential damage** per measure lifetime.

As a next step, the calculation of total costs of flood protection measures was proceeded.

B. Calculation of total costs of flood protection measures

In general, the costs of flood protection measures are estimated prior to implementing the measure.

The costs and location of some technical flood protection measures have been determined based on the technical project documentation, as far as available.

If not available, the preliminary project documentation was prepared and costs have been calculated based on the average unit prices from Classification of construction 2012 (per structure unit, depending on the kind of structure which could be linear (e.g. dike), or m3 (e.g. dry reservoir)).

Additionally, 26,4 % was added to the cost calculated above as preparatory costs for all measures.

The expected costs of operation and maintenance are added too and are calculated according the Normative (the % differs according to the type of structure). As these are values per year, it is necessary to multiply the values by lifetime period of measure, which equals to 100 years.

Based on the data on forest area (ha) and unit prices (EUR/ha) provided by relevant authorities also the costs for measures necessary to implement in the forests were assessed. Costs of measures to implement in the forests maintained in normal regime for the planned period 2014 – 2021 were evaluated to 130,50 EUR/ha. Costs of measures to implement in the forests affected by areal calamity for the planned period 2014 – 2021 were evaluated to 1 440,00 EUR/ha.

Total costs of measures equal to sum of all above mentioned costs.

C. Economical effectiveness of proposed flood measures

Proposal and realization of flood protection measures is depending on calculation of economical effectiveness (efficiency index) of proposed measures. This implies that the economic efficiency of the proposed flood protection measures is represented by the ratio of the amount of total avoided potential damages and the total cost of the proposed measures of the Flood Risk Management Plans.

D. Prioritization of flood protection measures

The efficiency index is used as one out of several criteria in the process of prioritization of measures. Prioritization of flood protection measures proposed to achieve the objectives of Flood Risk Management Plan up to 2021, mainly according to the urgency of their implementation, has been carried out on the basis of the following criteria:

- number of affected population with Q100,
- number of economic facilities in the floodplain when Q100,
- number of objects IPPC, SEVESO, contaminated sites, and other objects that could cause during flooding an extraordinary deterioration of water quality and extraordinary threat of water quality in the floodplain when Q100,
- number of objects of cultural heritage or of cultural monuments and historic sites in the floodplain when Q100,
- number of measures in river basin management plans proposed for the implementation in the frame of measures of flood risk management plans (measures to mitigate or eliminate impact of hydromorphological pressures),
- total avoided damage in EUR,
- total costs for implementation of measures of the flood risk management plans in EUR,
- efficiency index of measures of the flood risk management plans.

Based on the above mentioned criteria the prioritization of measures was carried out according to the urgency of measures implementation within the territory of the Slovak Republic and ten hydrological sub-basins designated on the territory of the Slovak Republic belonging to two river basin districts (RBD), the Danube RBD and the Vistula RBD. Each of criteria was assessed individually, also cumulative effect of flood protection measure protecting more than one geographical area (e. g. dry polder) was taken into account. Based on the criteria assessment, the score was allocated to each of proposed measures. All the proposed measures have been ranked according the score. Based on the results of prioritization process the list of measures has been compiled which are proposed to be implemented up to 2021. Next the technical feasibility of realization of proposed measure up to 2021 was assessed. If it is technically unfeasible, than the measure is proposed for realization after 2021. The total volume of expected costs of measures must not exceed the amount of funds planned for the implementation of measures of the Flood Risk Management Plans by 2021.

Finally, all the proposed flood protection measures were divided into three priority groups:

1. Measures proposed in geographical areas of highest importance according FRMP;
2. Measures proposed in geographical areas of medium importance according FRMP;
3. Measures proposed in geographical areas of least importance according FRMP.

The methodology for prioritization of flood protection measures is part of the Flood Risk Management Plans.

E. Realization/implementation of flood protection measures

Implementation of flood protection measure is possible only after assessment according Art. 4.7 of WFD is proceeded for each proposed measure (description of national approach for assessment of new infrastructural project according Art. 4.7 of WFD for investors, form for investor on basic information on future infrastructure project, mandate for primary assessment for Water research Institute and general information on primary assessment), information are available at the webpage of the Ministry of the Environment of the Slovak Republic (http://www.minzp.sk/oblasti/voda/implementacia-smernic-eu/). Assessment according Art. 4.7 is a stepwise approach:

1. Primary assessment

If no impact on ecological status/ecological potential of water bodies after primary assessment is expected, then new infrastructure project could be implemented. But if any impact on ecological status/ecological potential of water bodies after primary assessment is expected, than step 2 is mandatory.

2. Secondary assessment

In the secondary assessment all the conditions required by Art. 4.7 of WFD will be assessed, whether:

- all practicable steps are taken to mitigate the adverse impact on the status of the water body (mitigation measures to the proposed flood protection measures),
- the reasons for modifications or alterations of water body are specifically set out and explained in the river basin management plan and the objectives are reviewed every six years,
- the reasons for modifications or alterations are of overriding public interest and/or the benefits to the environment and society of achieving the objectives set according Art. 4.1 of WFD are outweighed by the benefits of the new modifications or alterations to human health, to maintenance of human safety or to sustainable development, and
- the benefits of modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

Also appropriate assessment according Art. 6.3 and Art. 6.4 of Habitat Directive and assessments according requirements of EIA Directive must be proceeded too.

Hungary

Hazard maps

Hazard maps are prepared as being the base of risk calculations and preparation of flood risk maps on top of giving information about flood hazards for the public.

Hazard map is the areal distribution by raster cells of the probability of flood events, and their flood height.

The following factors have been taken into consideration:

- natural factors (different probability flood curves, runoff conditions, extreme runoff scenario)
- existing dikes (water protection dikes and localization lines),
- technical status parameters of dikes
- local weak points of dikes have been designated
- 2D hydro dynamical modelling

The flood hazard values have been determined with the consideration and calculation of the above mentioned factors. See below the current hazard categories for Hungary.

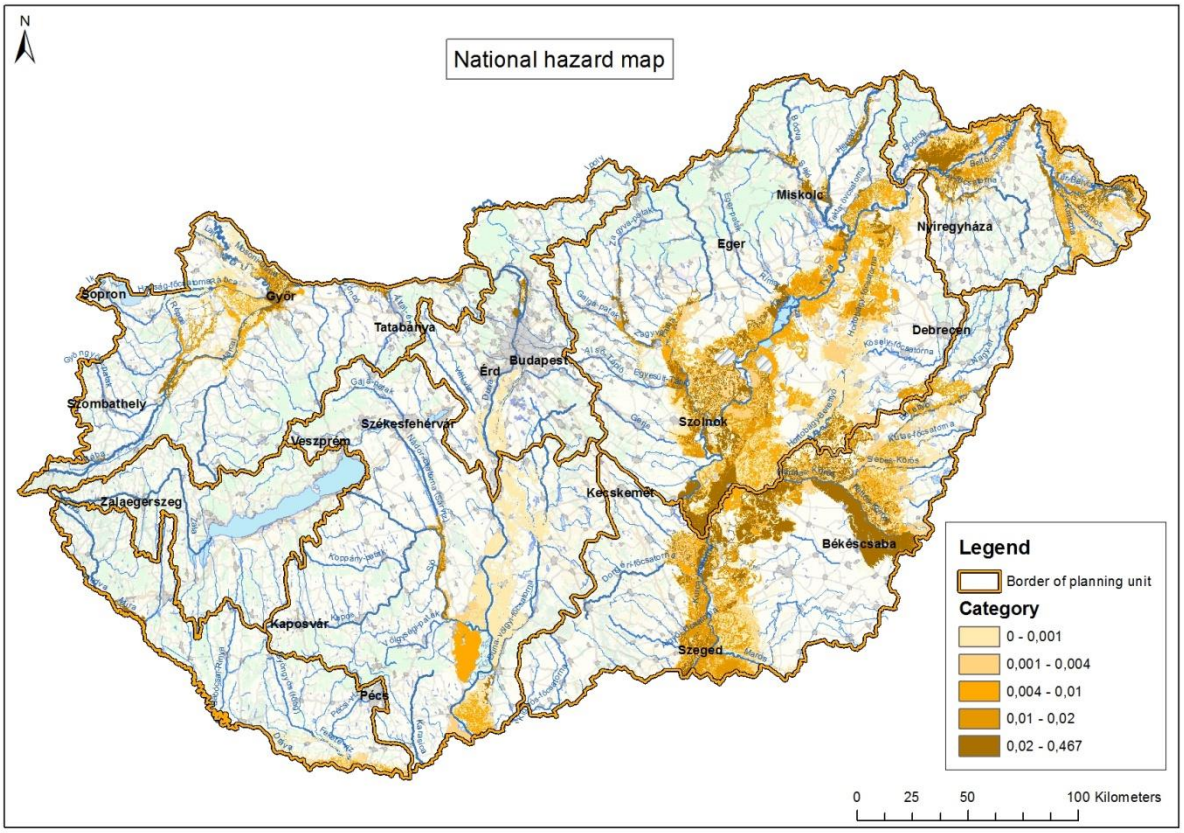


Figure H1: Hazard map of Hungary for the current state

Land use map

The base of the land use map was the 2012 Corine Land Cover (CLC), which was prepared in 1:100 000 scale (minimum area is 250 000 sqm). It contains 26 categories, which we have drawn together in 13 leading categories. For the improvement of the CLC scale, we have used the 2.3 version of DTA50 topographic maps, which scale is 1:50 000 (minimum area is 250 sqm). We have also developed the land use map with the maps of the county spatial plans, which also contain the projected build in zones. For regional planning a standardization were made for the settlements with five settlement categories. Altogether we have standardized the basic land use map in 17 categories.

For local planning the settlement structural plans were also digitized for the territory of the flood hazard, which contains 37 zones for the settlements.

The land use maps were made in 50x50 meter raster cells, which is the scale of the risk assessment.

Value	Categories

1.	Central role big city
2.	Central role city
3.	Incorporated town
4.	Village
5.	Dwellings with special function (e.g. touristic role dwellings)
6.	Road and rail networks and associated land
7.	Mineral extraction sites and dump sites
8.	Arable land
9.	Vineyards
10.	Fruit trees
11.	Natural grassland
12.	Complex cultivation patterns
13.	Land principally occupied by agriculture, with significant areas of natural vegetation
14.	Forest
15.	Shrub vegetation associations
16.	Wetlands
17.	Inland waters

The land use further developed and completed with the:

- road and railway-network
- POI objects (public institutions, heath care and education institutes)
- significant pollutant objects (IPPC, Seveso, EPRTR sites, land-fields)
- DTA industrial objects
- cultural heritage sites and objects

Each land use layer was rasterized in the 50x50 cell size. See below the national land use map.

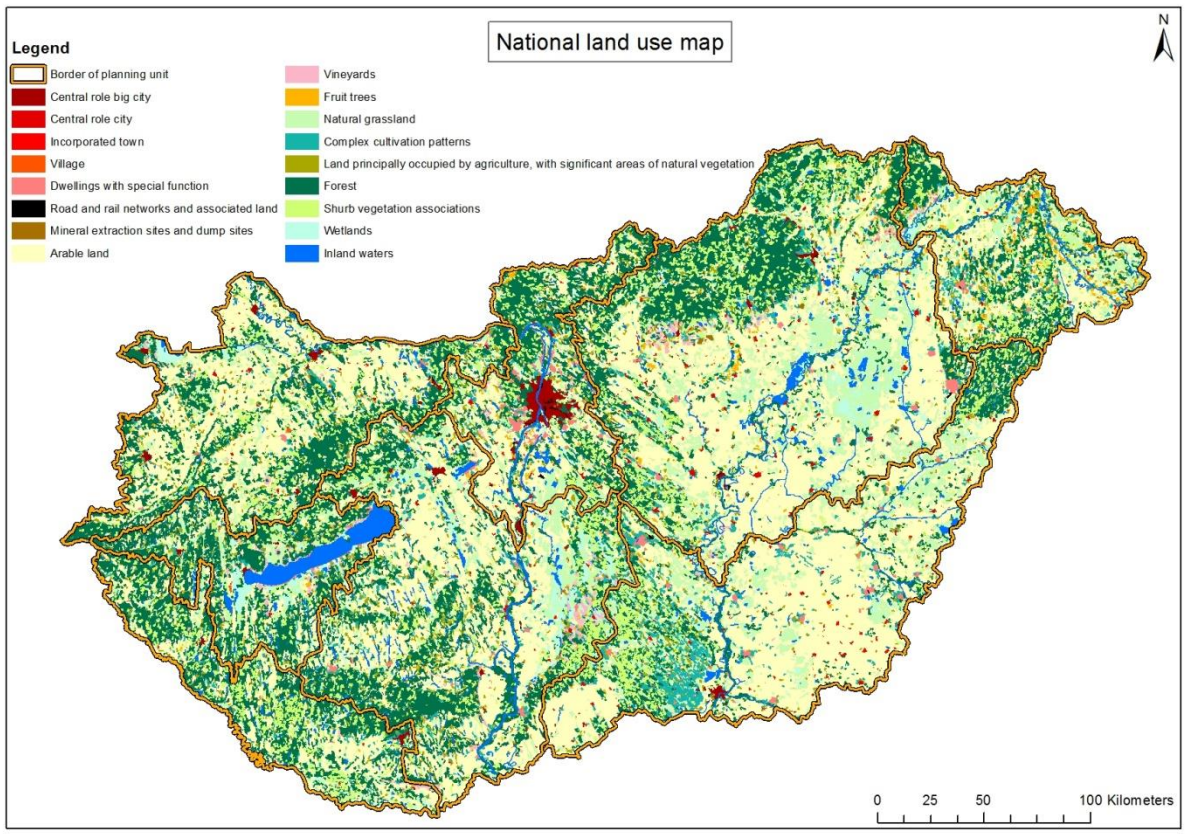


Figure H2: Land use map of Hungary

Damage curves for land use categories

For each land use categories damage curves are paired. We are using different damage curves for flat areas (flood basins) and for downhill areas (flash flood). Damage curves are nationwide uniform.

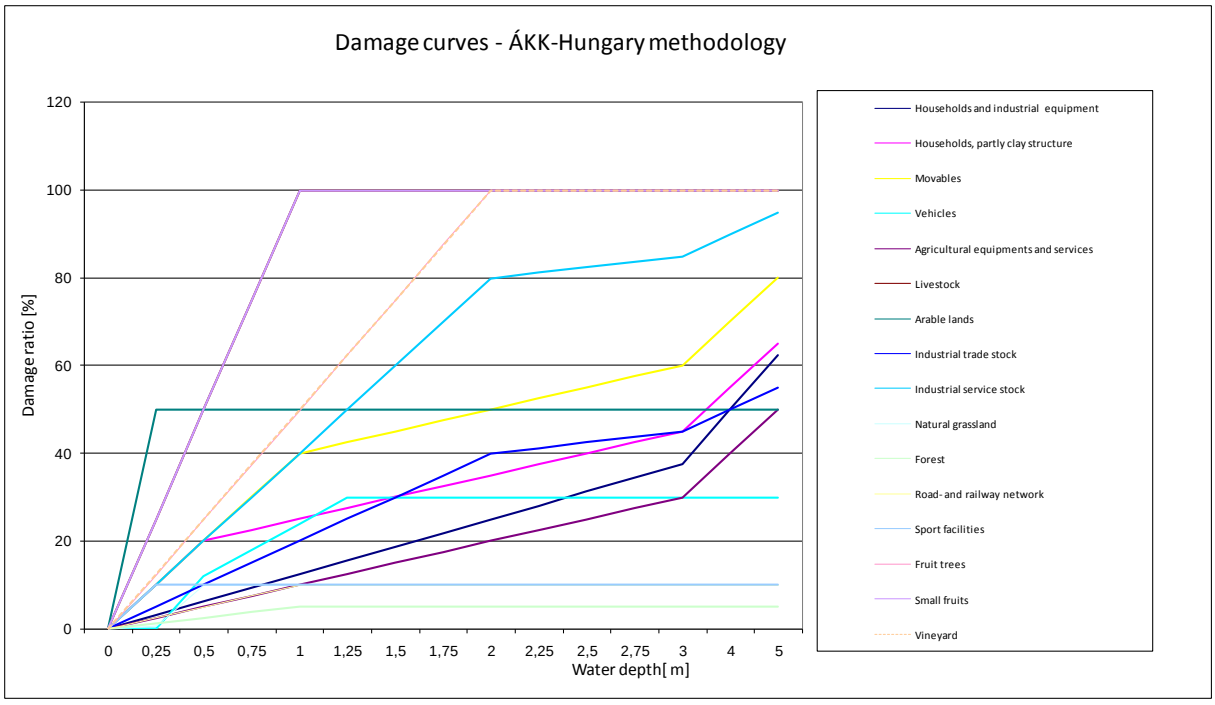


Figure H3: Damage curves.

Economic value of land use categories

The economic value of the different land use categories are estimated in consideration of the damage curves. Properties or goods are taken into account in the estimation if damage curve is defined for them.

In built-in area our land use categories are prepared for settlement types (from the highest population density to the lowest, as you can see shown categories from 1-5 at chapter Land use) where the proportion of different settlement zones are estimated. For example: 1st type so called Central role big city contains 3% big city zone, 6% small city zone, 25% suburban zone, 15% village zone, 25% industrial zone, and so on. For each type of settlement category the proportion of their settlement zones differs according to the population density and to the typical activities. We collected historical data from property market price statistics and we used estimation of installation and building ratio per hectare in order to calculate the value of the settlement zones.

	Land use categories	**Economic value (national average) HUF/m^2**
1	Central role big city	40 865
2	Central role city	38 505
3	Incorporated town	29 983
4	Village	22 100
5	Dwellings with special function (e.g. touristic role dwellings)	40 865

The economic value of the following land use categories from 6-17 is mainly based on national statistical data. The value of road and railway network is estimated based on historical investment benchmarks. The value of agricultural land uses, forestry and other type of activities are estimated based on net asset value and turnover data per square meter.

	Land use categories	**Economic value (national average) HUF/m^2**
6	Road and rail networks and associated land	17 338
7	Mineral extraction sites and dump sites	4 335
8	Arable land	116
9	Vineyards	359
10	Fruit trees	348
11	Natural grassland	2
12	Complex cultivation patterns	207
13	Land principally occupied by agriculture, with significant areas of natural vegetation	116
14	Forest	338
15	Shrub vegetation associations	170
16	Wetlands	0
17	Inland waters	0

For the estimation of economic value for industry, due to poor data availability we used estimation of asset necessity for production for different industry fields to prepare distribution in national industrial statistical data.

Land use categories	**Economic value (national average) HUF/m^2**
Energy industry	60 312

Production and processing of metals	43 080
Building material industry	34 464
Chemical industry	56 004
Waste treatment industry	25 848
Paper industry and wood processing	38 772
Textile industry	30 156
Leather industry	30 156
Food industry	51 696
Meat processing	25 848
Intensive livestock production	17 232
Machine production, metal processing	43 080
Mining	4 335
Other industrial activities	4 335
Dumps, tailing ponds	4 335
Landfills	4 335

As the statistical data were not detailed for prompt estimation for the area of each planning unit separately, we needed to use a regional correction factor on the national statistics based on effectiveness for a more appropriate economic values of each land use.

Flood risk mapping process - Economical flood risk maps

Flood risk mapping is a computation process in GIS database, and it is based on the following formula.

FLOOD RISK = FLOOD HAZARD * DAMAGE CURVE * VALUE, where:

- flood hazard (map) gives us the probability of flood event for different water depths
- damage graph gives us the damage ratio of different water depths for the land use categories considering properties and goods
- value gives the net monetary estimation of land uses considering properties and goods what can be damaged

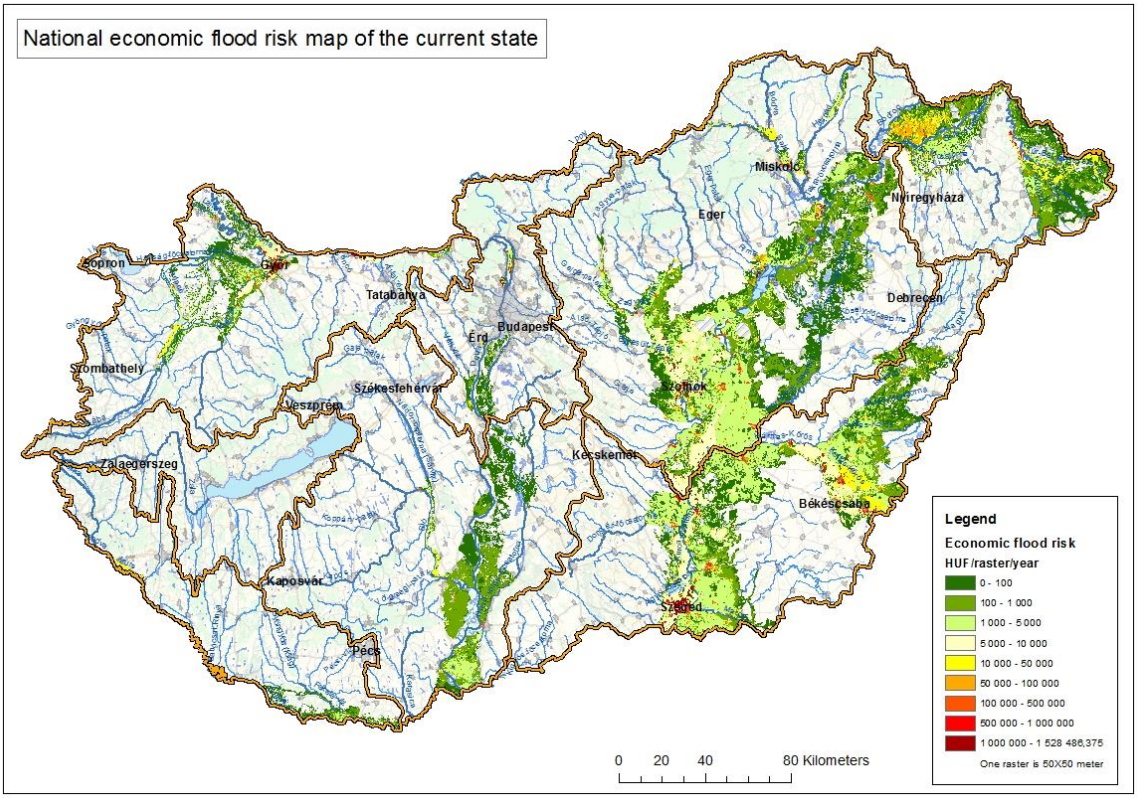


Figure H4: Economical flood risk in Hungary

Risk to human life

Risk to human life is assessed for urban, industrial and complex cultivation pattern areas. The calculation is based on the following formula:

$$K\ (\text{Risk}) = \sum [P\ (\text{probability}) * S\ (\text{population density}) * TO\ (\text{load class})]$$

Where load depends from the water depth and in case of flash floods, water depth and velocity.

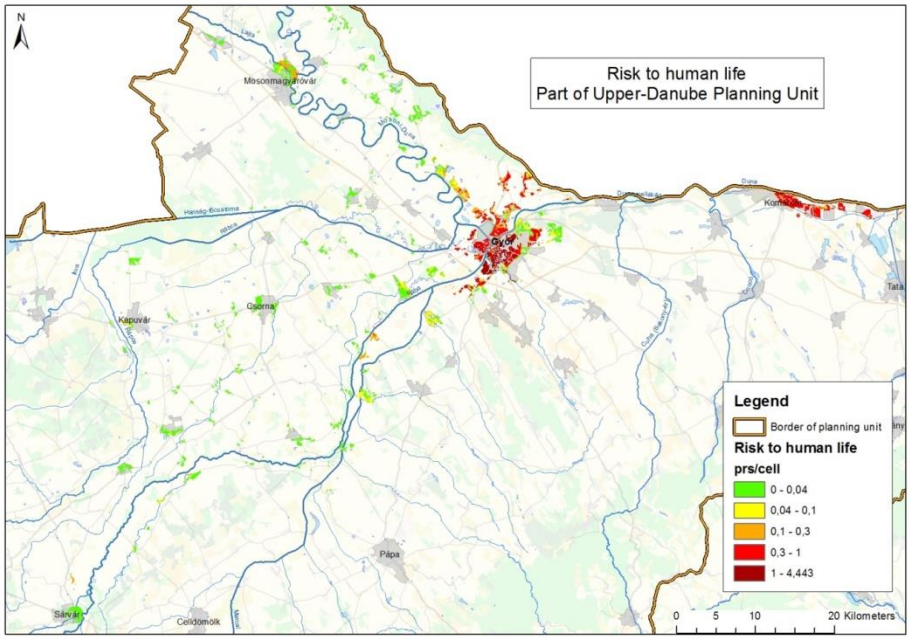


Figure H5: Risk to human life for the current state at the Upper-Danube

Ecological risk

Ecological risk focuses on Natura 2000 sites, where assessment is made for three different water-depth categories (0-0.5m; 0,5-3,0m; >3,0m) and the occurrence probability of the water-depth categories are examined. We considered the duration of the flooding as 1,5 months. Ecological risk maps were prepared for the possibly flooded Natura 2000 sites and a statistical assessment is also made for the same areas.

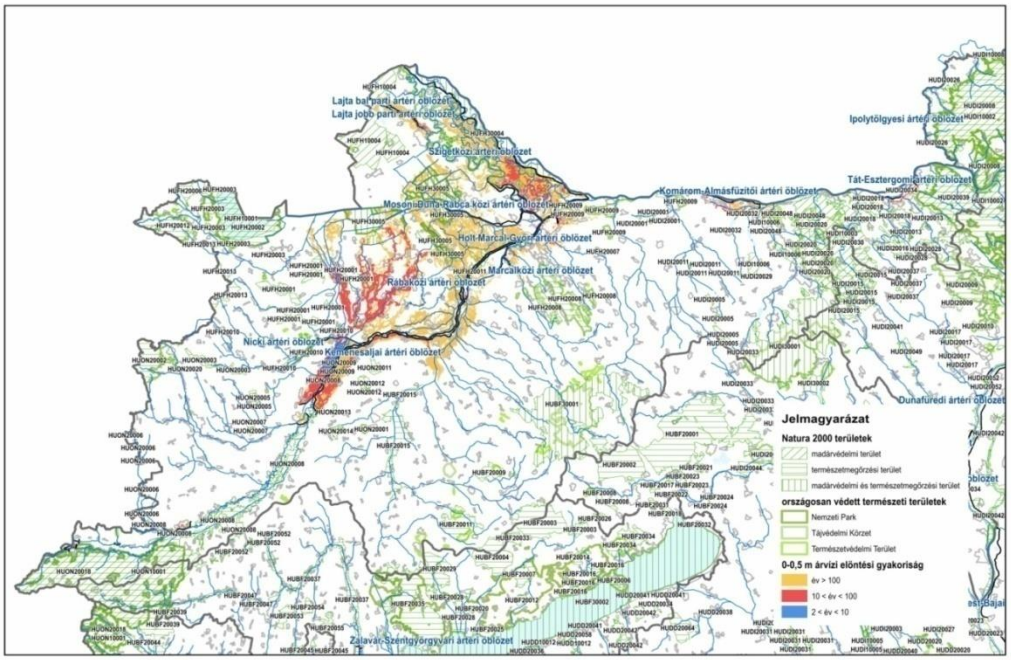


Figure H6: Ecological risk map for the Upper-Danube Planning Unit

Risk to cultural heritage

Regarding the cultural heritage objects and sites, probability distribution and flood depth were examined and mapped. According to which the probability of the inundation of an object and the considering flood depth can be defined. Probability of 0,05 or higher was defined as high-risk threshold.

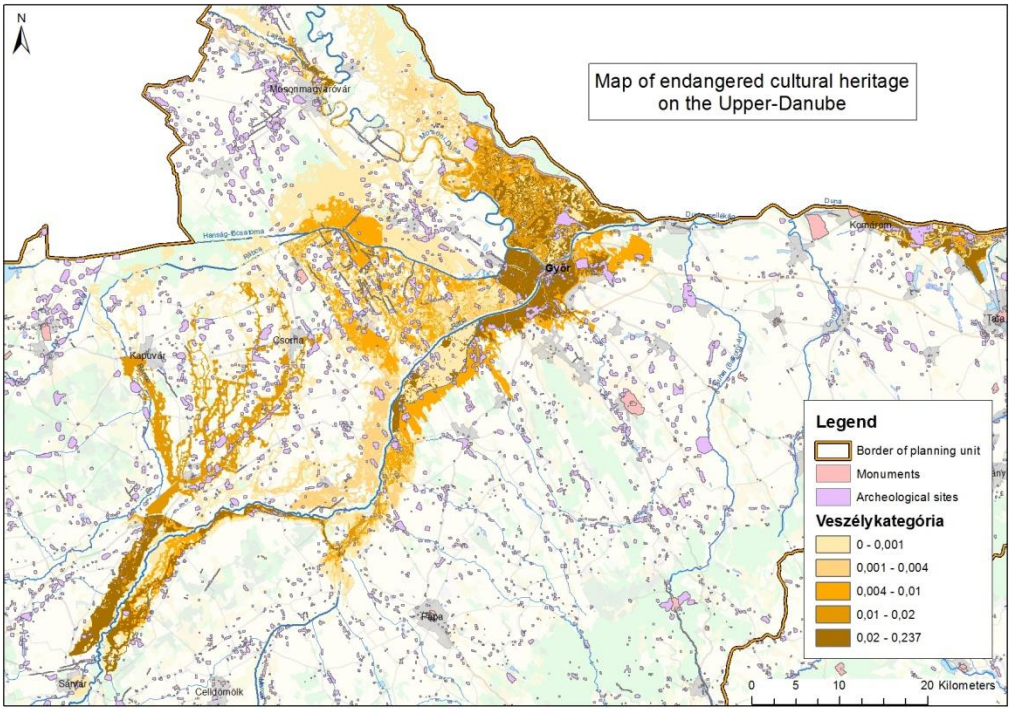


Figure H7: Map of endangered cultural heritage at the Upper-Danube Planning Unit

Significant industrial sites and public institutions

Assessment is prepared for the probability of the flooding of significant public institutions and industrial sites, including IPPC, Seveso and E-PRTR sites. Highly affected sites and institutions are determined and highlighted.

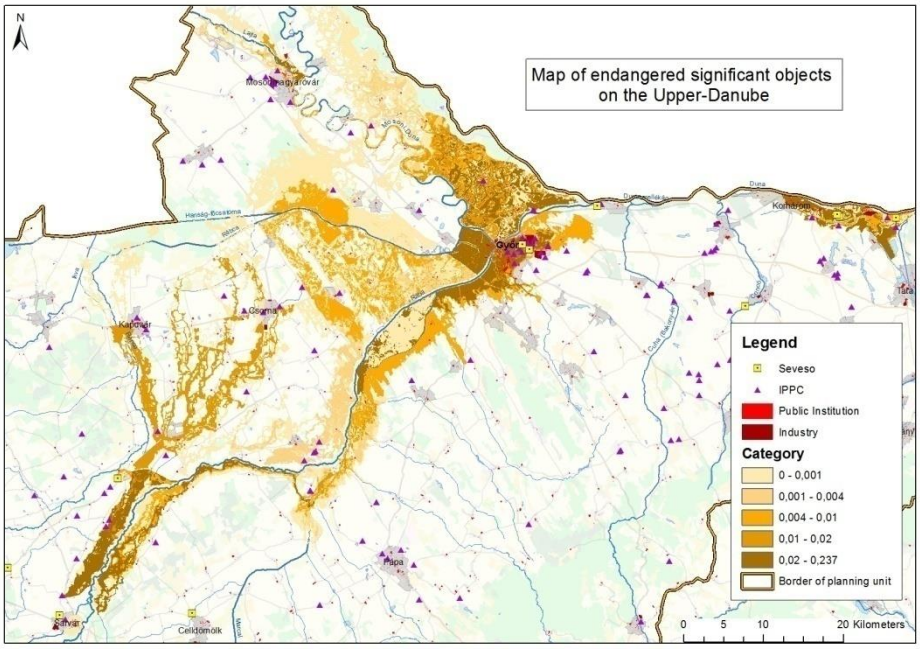


Figure H8: Endangered significant industries and institutions

Assessment of current flood risks

The current flood risk situation is assessed for the flood bays and small streams. This assessment is the base for the planning process and the evaluation of the alternatives. It is made by a statistical analyses of the risk maps and a threshold of high risk is determined, which defines the area and degree of flood reduction.

Determined statistical values are for example the maximum risk per raster cell, sum of risk, avarage of risk, risk-distribution and other criteria are also examined, like flood zones, which are basically connected with non-structural measures, etc.

Measurements for flood risk reduction

According to the final methodology at the phase of measurement identification for flood risk reduction, we calculated investment realization costs, and annual operation and maintenance costs in macro point of view. This way our methodology count costs regardless of the source of the amount.

In case of non-constructional measurements:

On agricultural area due to macro point of view:

1. we calculated the costs of realization of modifying the planting culture
2. we added subsidiary for the modification if there is regulation for that
3. we added loss of income and subsidiary, as the opportunity cost of giving up the previous planting method.
4. we added the surplus of operating and maintenance costs
5. we added annual subsidiary if there is regulation for that
6. we deducted the income from the harvest of the new plant

Our methodology differs 6 non-constructional measurements on agricultural area:

1. plough-land to meadow modification
2. plough-land to forest modification
3. plough-land to wet-land, or water
4. plough-land to fruit plant modification
5. meadow to forest modification
6. meadow to fruit plant modification

- On built-in area we defined 3 measurements
  1. risen floor level (max. 0,75 metres)
  2. risen constructional base-level (max 3 metres)
  3. use of flood proof building method

We estimated costs of realization for each measurement based on an average 10% building ratio and average households. No operating and maintenance cost were taken into account.

In case of constructional measurements: Constructional measurements, such as dike building, strengthening, heightening were estimated as the double of the need of volumetric earthworks.

- Structural alternatives are the followings:
  1. Elevation of the current dike level with 1 meter
  2. Differentiated dike elevation according to the defended value
  3. Strengthening of local “weak-points” of the dike-system
  4. Flood reservoirs (further modelling is required)
  5. Measurements taken on flood bed (further modelling is required)
  6. Dike elevation in case of limited financial resources (further modelling is required)
  7. Complex alternative (the optimum combination of measurements)

Risk reduction is based on comparing two different flood risk map reports on the same area. Different types of measures considered to have difference period of influence within the 30 years planning period (2015 – 2045). Theoretically, constructional measures are considered to have influence on risks from 2028. Non-constructional measures are considered to have linear influence from 0 – 100% between 2015 and 2045.

Flood risk map processing is done for 2015, 2028 and 2045. Risk reduction is calculated from comparison of the reports of these maps for the same flood basin or planning unit.

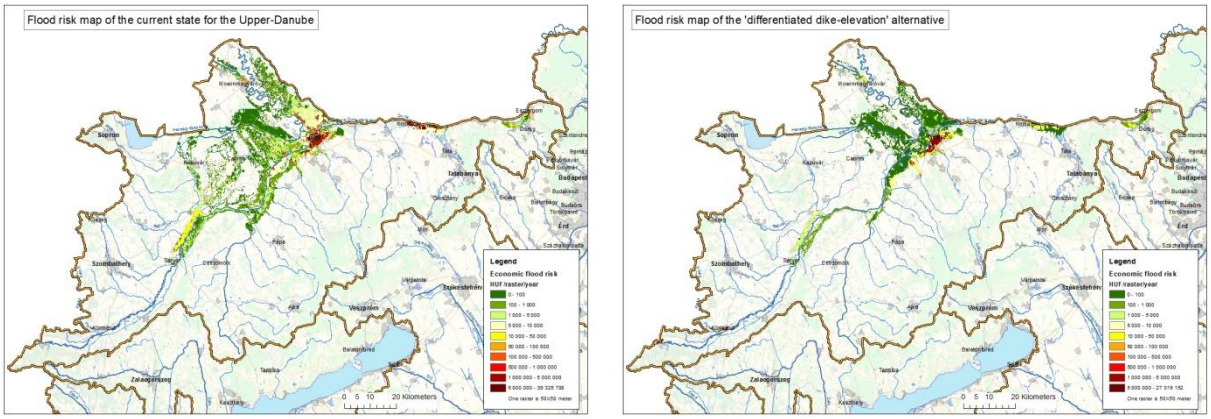
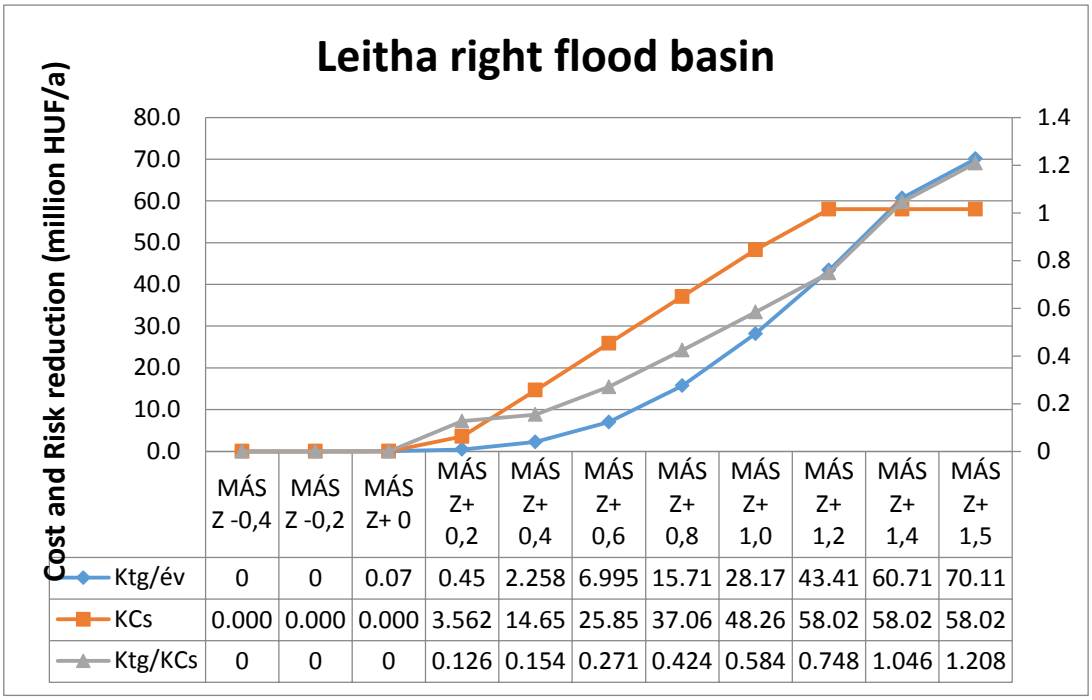


Figure H9: Economic flood risk map at the Upper-Danube for the current state and after the ‘Differentiated’ alternative

Planning support system

To help the planning of proper constructional measurements for each planning area a graph of cost effectiveness has been drawn. See below the cost / risk reduction graph, where the preliminary cost-effectiveness is drawn for each dike height (on top MÁSZ; the Hungarian National Designed Flood Level) on yearly base. This gives the opportunity to find the proper height for dike increasing taking into account the highest effectiveness and money allocation in one time.



	MÁS Z -0,4	MÁS Z -0,2	MÁS Z+ 0	MÁS Z+ 0,2	MÁS Z+ 0,4	MÁS Z+ 0,6	MÁS Z+ 0,8	MÁS Z+ 1,0	MÁS Z+ 1,2	MÁS Z+ 1,4	MÁS Z+ 1,5
Ktg/év	0	0	0.07	0.45	2.258	6.995	15.71	28.17	43.41	60.71	70.11
KCs	0.000	0.000	0.000	3.562	14.65	25.85	37.06	48.26	58.02	58.02	58.02
Ktg/KCs	0	0	0	0.126	0.154	0.271	0.424	0.584	0.748	1.046	1.208

‘Ktg/év’ – shows the annual cost dike building

‘KCs’ – shows the annual expected risk reduction, where you can see that after the improvement of +1,2 metres on top MÁSZ, the Hungarian National Designed Flood Level, no additional cost reduction can be reached.

‘Ktg/KCs’ – shows the Cost /Risk reduction ratio, where we can see the effectiveness of this measurement. When the ratio reaches and exceeds 1 this measurement becomes ineffective. The smallest is the ratio the more effective is this measurement, but altogether of course the risk has to be decreased some part.

The Planning Support System combines the evaluation of current flood risk maps and the survey of preliminary cost effectiveness of measurements, the Multi Criteria Analysis, and the Cost-Benefit Analysis.

CBA (Cost Benefit Analysis) is a benefit-cost ratio with the following formula:

$$\text{BCR (\%)} = \frac{\text{Discounted (Flood risk reduction + Externalities}^{8}\text{)}}{\text{Discounted (Investment cost + O\&M costs)}} * 100$$

MCA (Multi Criteria Analysis) is a computation which involves CBA ratio with a given weight next to other criteria, such as;

- Costs of measurement
- Ratio of the areas with high financial risk
- Ratio of the inhabitants effected by high probability inundation
- Ratio of the inhabitants effected by high life risk
- Ratio of the cultural heritage objects and sites effected by high probability inundation
- Ratio of the ecological sites effected by high probability and low level inundation (in this case it is positive)

The weights of these parameters need to be defined in a cooperative way of on interdepartmental stage. In the planning process three evaluation-goals were defined and according the chosen one (where our goal was to reduce the high risk areas to an adequate level in a cost-effective way), a suggested distribution was given.

On local scale (on the flood basins and small water courses as local planning units) we evaluated the different flood risk reduction alternatives and with the application of the Planning Support System we could choose the most optimal flood risk reduction measures, which results the complex plan for the achievement of the previously defined goals.

Croatia

In the Republic of Croatia, a Flood Risk Management Plan has been prepared as Chapter D of the 2nd River Basin Management Plan for the 2016-2021 programming period.

Clear EU and national regulation requirements regarding the activities on the preparation of the RBMP and FRMP enabled smooth transition in the Republic of Croatia from previous practices regarding the flood management risks to the concept of integrated water management. The Flood Risk Management Plan enables great flexibility on the one hand and a clear approach on the other hand, defined in three steps: obligatory time schedule of activities, results and reporting obligation.

[8]Not calculated due to the use of macro cost estimation.

The preparation of the Flood Risk Management Plan was preceded by several in-between steps in a form of comprehensive studies done either by Croatian Waters or external experts which served later as resource documents in the preparation of the FRMP.

Preliminary studies:

- Preliminary Flood Risk Assessment-. based upon available information defines a preliminary assessment of potential flood risk completed in January 2013 by Croatian Waters,
- Study Economic Aspects of Potential Flood Costs Assessment prepared in 2014 by SL CONSULT d. o. o. from Ljubljana, Republic of Slovenia.
- Multiannual Construction Program of water regulation structures, structures for protection from adverse water effects and amelioration structures.
- Operational Flood Defense Plan.

The data from the Preliminary Flood Risk Assessment served as a basis for the preparation Flood Hazard and Flood Risk Maps and Flood Risk Management Maps legally required being prepared with specific defined system of intervention measures in a case of flood occurrence as a part of the Operational Flood Defense Plan showing areas marked as areas of high flood risk potential. The same document also served as data base for the MapWindow GIS application program for the calculation of the potential flood damage costs created by SL CONSULT d. o. o. from Ljubljana, Republic of Slovenia. The Multiannual Program serves as an implementing document for the FRMP with clear annual activities schedule, annual investment and maintenance program and the Operational Flood Defense Plan gives clear instructions who does what and in which way in case of a flood occurrence.

Assessment of Potential Flood damage costs in Croatian FRMP

In the Republic of Croatia a CBA was not conducted for the national Flood Risk Management Plan.

The Assessment of potential flood damage cost was done based upon the methodology elaborated in the study Economic Aspects of Assessment of Potential Flood Damage Costs prepared in 2014 by SL CONSULT d. o. o. from Ljubljana, Republic of Slovenia.

In the study the authors have defined economic aspects of potential flood costs assessment and developed a MapWindow GIS application program for the calculation of the potential flood damage costs for the specific chosen area taking into account a water depth. The program uses data from international scientific literature, the Croatian Bureau of Statistics and CORINE Land Cover 2006.

In a category of housing value assessment the problem of non-existing register of real estate assessment occurred.

The flood damage costs have been classified in seven types determined by the general land use. Each land use is connected with appropriate data from CORINE Land Cover 2006 data base classified as follows:

- Urban areas
- Industrial or other business areas
- Infrastructure surfaces
- Agriculture surfaces
- Plantations
- Green surfaces
- Other surfaces

The parameters which influence the assessment of flood costs magnitude is the water depth in the first place, the type of endangered object, the velocity of water, duration of the flood event, concentration of the sediment, flooding water pollution, the efficiency of flood warning system and promptness and quality of rescue measures. At the same time specific requirements which potential flooded area might have and may have influence the assessment of flood costs magnitude and are interlinked with

necessary time for evacuation, period of flood event occurrence as well as period of its duration are taken into account using the correction factor F.

Table C1: Specific characteristics of correction factor F for the calculation of potential flood risk assessment

	F
EVACUATION TIME	
Damage in urban and industrial areas in a case of the two days alert in advance	0.65
Damage in urban and industrial areas in a case of the one day in advance alert	0.7
Damage in urban and industrial areas in a case of the six hours in advance alert	0.9
SEASON OF THE YEAR	
Damage on the agricultural surfaces in the winter	0
Damage on the agricultural surfaces in the summer months	1
DURATION OF THE FLOODING EVENT	
Damage in urban and industrial areas if the flooding event lasts at least 12 hours	1
Damage in urban and industrial areas if the flooding event lasts more than 12 hours	1.2

Figure C1: Overview of the land use classification

The potential flood costs assessment was done on the macro level based upon the Flood Hazard and Flood Risk Maps for those areas which have been determined as areas with great potential risks of flooding. The analyses have been conducted on total area of 30,000 km2 which means about 50% of total mainland area of the country.

The flood costs assessment was done for three main scenarios as envisaged by the Flood Hazard and Flood Risk Maps:

- High probability of flood occurrence
- Medium probability of flood occurrence
- Small probability of flood occurrence including accidental flooding caused by destruction of the levies on bigger water bodies or destruction of high water dams (artificially caused flooding),

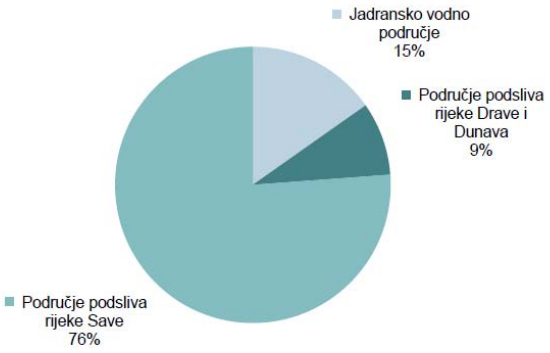
- and four water depth categories: <0.5m; 0.5-1.5m; 1.5-2.5m; >2.5m.

Since for the flood costs assessment the depth of the water is used as an input base parameter, the costs of damages have been calculated for all four classes of the previous mentioned depth of the water which finally gave a total amount of the flood damage costs for the certain area.

The flood damage costs have been calculated for three areas: the Adriatic river basin, the Sava River sub-basin and the Danube and Drava River sub-basins.

The results of analyses on the macro level show that for the flooding scenario of low probability of flood occurrence the flood damage costs are the highest since in such flood occurrence the area covered with water is also the largest. The highest flood damage costs are in the Sava River basin since big cities like Zagreb, Sisak, Slavonski Brod, Županja etc. are endangered in low probability of flood occurrence.

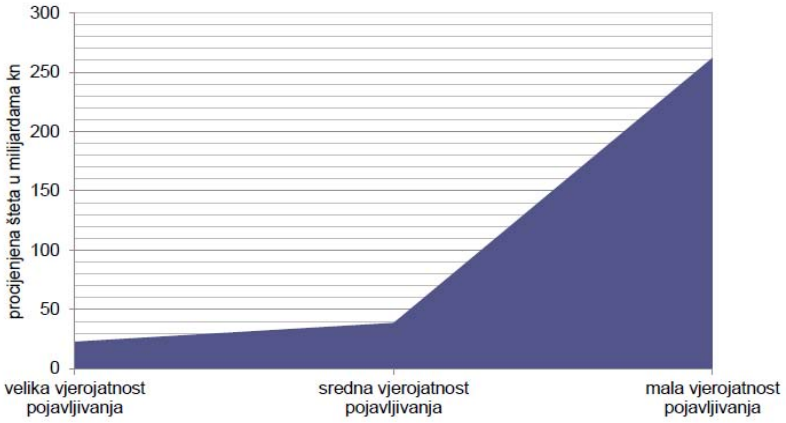
Figure C2: Calculated Ratio of the potential flood damage cost



Sl. D.16 Omjer proračunate potencijalne štete za malu vjerojatnost pojavljivanja

Potential flood damage cost on the national level of the Republic of Croatia caused by flooding occurrence of low probability of flood occurrence is significantly higher than potential damage cause by medium and high probability of flood occurrence and only direct damage costs have been assessed.

Figure C3: Flood damage cost according to probability of flood occurrence



Sl. D.17 Štete prema vjerojatnosti pojavljivanja na razini Republike Hrvatske

Part of the implementing measures for flood risk reduction are elaborated in more detail in the separate previously mentioned document Multiannual Construction Program of water regulation structures, structures for protection from adverse water effects and amelioration structures.

The program ensures:

- Increase of population with acceptable flood hazard and flood risk and increase of the area of acceptable flood risk
- Increase of flood defense systems with technical solutions based upon environmentally friendly approach

The implementation of investment activities in the sector of flood hazard protection (the construction of water regulation and protection structures) is planed according to:

- Multiannual Construction Program of water regulation structures, structures for protection from adverse water effects and amelioration structures;
- Regular maintenance activities implemented according to the Annual programs of regular maintenance of the water regulation and protection structures.

The projects are harmonized with previously mentioned Preliminary Flood Risk Assessment defining areas estimated by the flood risk criteria:

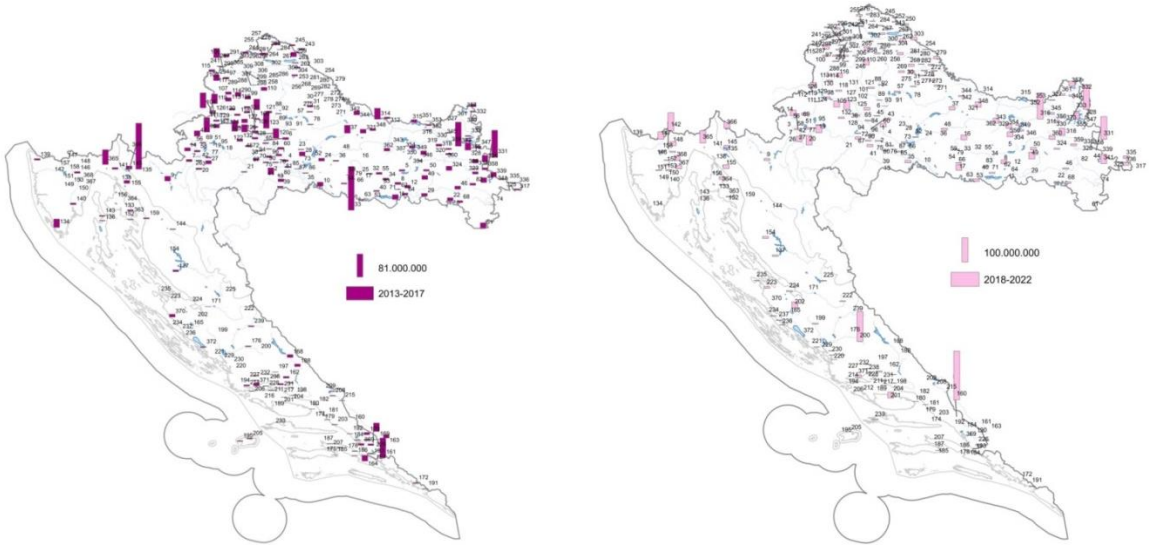
- Frequent flooding areas
- Potential flooding areas,
- Areas influenced by destruction of flood defense structures,
- Historically known flooding areas
- Flooding areas caused by torrents

Main goals of the program are preparation of the two groups of projects:

- Projects for construction of the structures for protection against the adverse effects of water (373 projects for protection against adverse effects of water grouped in 114 project units).
- Projects for construction for the irrigation purposes

For the construction of all projects a CBA and environmental impact assessment is required according to the legal requirements and will be conducted accordingly for each project.

Figures C4 and C5: Financial distribution of investments in protection from adverse effects of water in period 2013-2023



The projects will be financed from the national sources, international financial institutions (WB, EIB) as well as EU funds.

As a result of the Croatian Waters' previous activities many civil engineering projects/studies have been defined throughout Croatia which are focused on strengthening flood defense for the purpose of prevention against hazardous effects of water and reduction of flood risk, serving as the foundation for flood risk management.

The preparation of new projects includes the analysis of the FRMD requirements using the Flood Hazard and Flood Risk Maps (prepared in 2014-2015 and presented in a Draft of the RBMP for the 2016-2021) and proposal for best solution for the reduction of flood risk in those areas which require such reduction.

Initial solution options (projects from the Program) undergo the process of evaluation and improvement through a number of current studies/projects which will, after adoption of better/more suitable solutions, be included into the revised list of projects in the Program. The new approach is also determined by the RBMP for the 2016-2021. The new approach of the project selection has been implemented already on the river basin level (Kupa, Krapina, Bednja, Karašica-Vučica, Rječina and Donja Neretva) where as part of valorization of technical solutions preferring green infrastructure the non-construction measures have also been taken into account, especially natural water retention measures.

Slovenia

Methodology for the assessment of benefits of flood protection measures

According to the Decree on establishment of flood risk management plans (Official Gazette of the Republic of Slovenia, No. 7/2010) flood risk management plans should take into account the aspect of costs and benefits. Cost-benefit analysis (CBA) is an important element in the process of selection and prioritisation of flood protection measures.

CBA is already obligatory for public funded investments in flood protection according to the Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance (Official Gazette of the Republic of Slovenia, No. 60/2006 and 54/2010). Many different methods and approaches for the assessment of benefits of flood protection measures were applied in the past. A unified method for the assessment of benefits was developed in 2014 for the purpose of flood risk management plans. The method was prepared at the Institute for Water of the Republic of Slovenia in cooperation with the Ministry of the Environment and Spatial Planning[9].

Benefits of flood protection measures are assessed as a reduced value of expected annual damage (EAD) after the implementation of certain measure or combination of measures. EAD assessment takes into account **dimension**, **exposure**, **vulnerability** and **value** of elements at risk as well as **flood**

[9] More details in the report: Petelin, Š., Pergar, P., Kirn, T. (2014). Priprava ekonomskih vsebin načrtov zmanjševanja poplavne ogroženosti, Ljubljana, Institute for Water of the Republic of Slovenia. Available at: http://evode.arso.gov.si/direktive/FD_P/2014/2014_I_2_03_P_01.pdf

extent and in some cases even **flood intensity**. For the development of the method the data on damages during past flood events were taken into account.

Benefits of the measures for human health, environment, cultural heritage and economic activity are assessed in monetary terms. Besides direct and tangible values the monetary assessment includes also some indirect and some intangible values as well. Elements at risk, which are included in the monetary assessment of the benefits, are in the table below (Table SI1). Other benefits, which are not assessed in monetary terms, are recognized and listed.

Table SI1: Elements at risk, included in the monetary assessment of benefits

HUMAN HEALTH	ENVIRONMENT	CULTURAL HERITAGE	ECONOMIC ACTIVITIES
			  
Inhabitants with permanent or temporary residence	Water resources for water supply service (Water protection zones)	Immovable cultural heritage – areas	Buildings Separately for 3 groups of buildings: - Residential buildings, - Buildings for agriculture > 40 m^2 and - Industrial buildings, business buildings, business-residential buildings and other buildings > 40 m^2.
Employees at workplaces	Aesthetic value of environment and services dependent on biodiversity	Immovable cultural heritage – objects, parts of objects and groups of objects	Damaged equipment in residential buildings
Children in kindergartens, pupils at schools, high schools and students	Individual assessment for possible sources of greater pollution		Streams and belonging water infrastructure in selected area (not only in flooded area)
Patients in hospitals			State and local roads
People in road traffic			Water supply and sewage network
			Damage for companies (movable property, stocks)
			Damage for companies (loss of income)
			Agriculture – Land
			Agriculture - Crops

Location of each element at risk is determined according to spatial data from official data sources, such as:

- Central population register (Ministry of the Interior of the Republic of Slovenia)
- Building cadastre (The Surveying and Mapping Authority of the Republic of Slovenia)
- Real estate register (The Surveying and Mapping Authority of the Republic of Slovenia)
- Cadastre of public infrastructure (The Surveying and Mapping Authority of the Republic of Slovenia)
- Land use (Ministry of Agriculture, Forestry and Food)
- Register of Water protection zones (Slovenian Environment Agency)
- IPPC and SEVESO Registers (Slovenian Environment Agency)

- Immovable Cultural Heritage Register (Ministry of Culture).

Expected damage is assessed with spatial analyses taking into account actual location and **dimension** of elements at risk in flooded areas. Flooded areas (**flood extent**) at different discharges (Q10, Q100, Q500) from flood hazard maps are considered. Dimension is size or quantity of elements at risk in the selected area. It differs according to the element at risk (e.g.: number of inhabitants, surface area of buildings, length of roads, length of water supply and sewage network, area of agricultural land…). Example of these assessments is presented in the figure and table below.

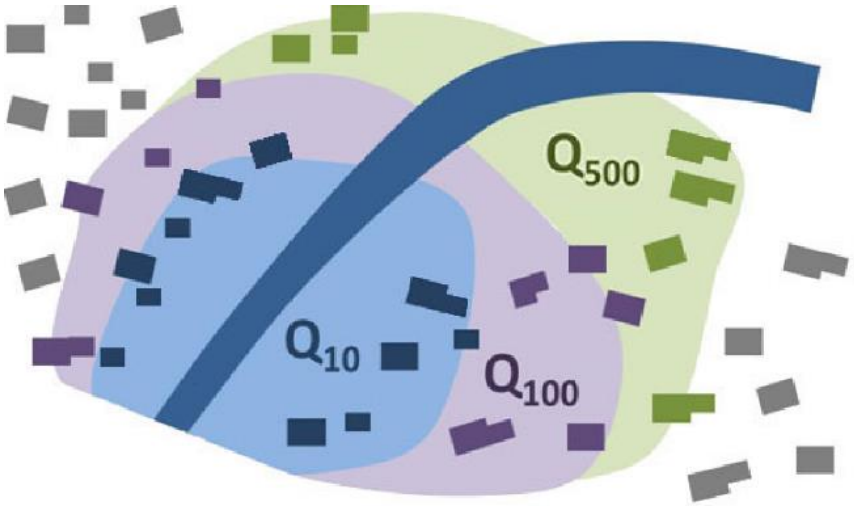


Figure SI1: Example of buildings in flooded areas at discharges of return period 10, 100 and 500

Table SI2: Example of surface area of buildings in flooded areas at discharges of return period 10, 100 and 500

Discharge	Surface area of buildings in flooded areas
Q10	700 m^2
Q100	1.400 m^2
Q500	2.000 m^2

Flood intensity (e.g. depth of water, velocity of water, product of depth and velocity of water) was only considered in the assessment of benefits for certain elements at risk. That was, when sufficient data from past flood events existed and it was possible to determine the dependency between flood damage and flood intensity.

Expected damage is calculated by multiplying the dimension of elements at risk in flooded area by exposure, vulnerability and value per unit. Exposure, vulnerability and value per unit were determined for all elements at risk from Table 1, when the method for the assessment of benefits was developed.

Exposure was determined as probability, that elements are present in selected area in certain period of time. For example, people are not present at their workplaces 24 hours per day, every day of the year. That is why exposure for employees at workplaces is lower than 1.

Data on damage during past flood events in Slovenia were taken into account for the assessment of **vulnerability** and **value** of elements at risk when the method was developed.

Actual damage is listed after every significant flood in Slovenia. According to the Decree on damage evaluation methodology (Official Gazette of the Republic of Slovenia, No. 67/2003, 79/2004, 33/2005, 81/2006, 68/2008) data on actual damage to buildings, streams and water infrastructure,

roads, water supply and sewage network, companies, agriculture and cultural heritage is recorded. Data on number of casualties in past flood events is also available.

With statistical analyses of the data on damage during past flood events vulnerability and value were assessed for different elements at risk (e.g. EUR/m2 surface area of residential buildings in flooded area, EUR/m of state roads in flooded area…).

Besides direct and tangible values, the monetary assessment includes also some indirect (loss of income) and some intangible values as well.

Intangible values for human health and environment were assessed with the use of benefit transfer. Benefits of prevented fatalities and injuries were assessed according to: Bočkarjova, M., Rietveld, P., Verhoef, E. (2012). Composite Valuation of Immaterial Damage in Flooding: Value of Statistical Life, Value of Statistical Evacuation and Value of Statistical Injury. Damage for aesthetic value of environment and services dependent on biodiversity was assessed according to: Markantonis, V., Meyer, V., Lienhoop, N. (2013) Evaluation of the environmental impacts of extreme floods in the Evros River basin using Contingent Valuation Method. Natural Hazards (2013). Both assessments were adjusted to Slovene conditions. Loss of water supply from flooded water protection zones was evaluated with the replacement cost method.

In that way, expected damage at flood events with discharge of return period 10, 100 and 500 can be assessed for all elements at risk and EAD can be calculated for all areas with flood hazard maps (Figure SI2).

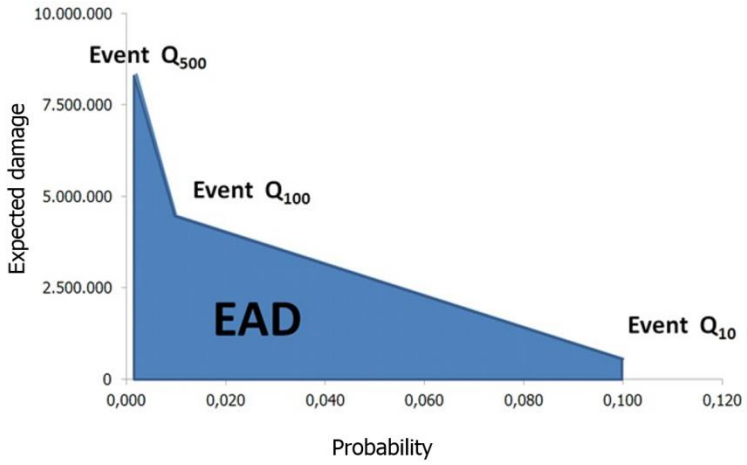


Figure SI2: Expected annual damage before the implementation of the measure

The method for the assessment of benefits was tested for five potentially significant flood risk areas:

- Ljubljana-south,
- Železniki,
- Škofja Loka,
- Laško and
- Vipava.

Calculated expected damage was compared to actual damage from past flood events (data not included in the development of the method). There are two examples of comparisons in Figure SI3. Calculated EAD and actual damage from past flood events are compared for buildings in Laško and for streams and water infrastructure in Škofja Loka.

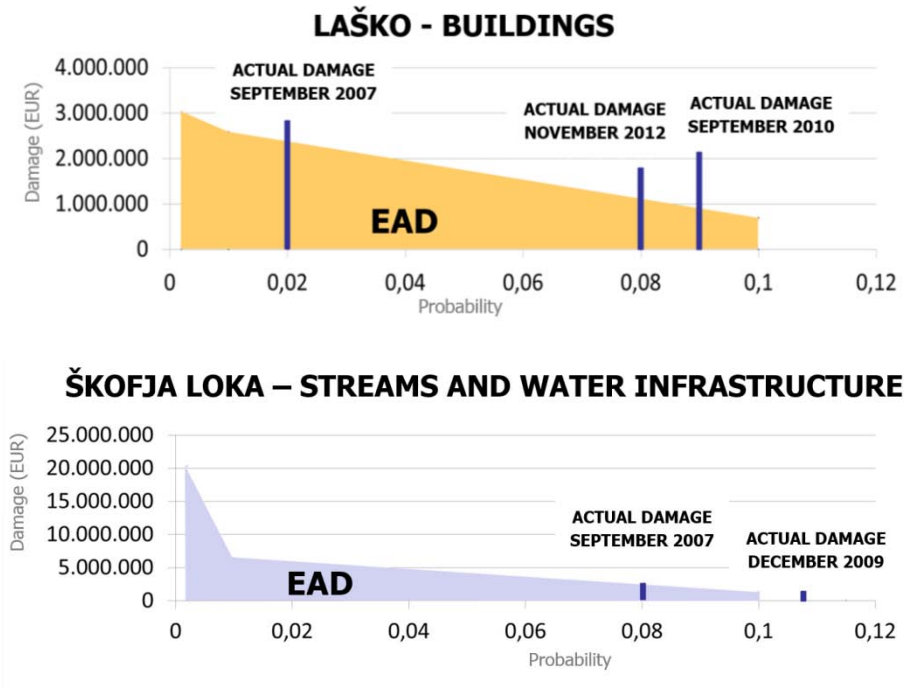


Figure SI3: Comparisons of calculated EAD with actual damage from past flood events in Laško and Škofja Loka

Application of the methodology

The aspect of costs and benefits is one of the criteria for selection of the best combination of flood protection measures. Methodology for the assessment of benefits of flood protection measures will be used in preparation of selection of structural flood protection measures along with the operational programme of implementation in 2016. Methodology could also be used for other measures, if effects of the measures are known.

According to the methodology EAD before and after the implementation of the measure (or combination of measures) is assessed. Example of elements at risk before and after the implementation of measure is presented in Figure SI4 and in Table SI3.

Figure SI4: Example of buildings in flooded areas at discharges of return period 10, 100 and 500 before and after the implementation of measure (flood protection dams: depicted by black lines)

Table SI3: Example of surface area of buildings in flooded areas at discharges of return period 10, 100 and 500 before and after the implementation of measure (flood protection dams Qx)

Discharge	Surface area of buildings in flooded areas before the implementation of measure	Surface area of buildings in flooded areas after the implementation of measure
Q10	700 m^2	0 m^2
Q100	1.400 m^2	1.400 m^2
Q500	2.000 m^2	2.000 m^2

Benefits of flood protection measures are assessed as a reduced value of EAD after the implementation of certain measure or combination of measures (Figure SI5).

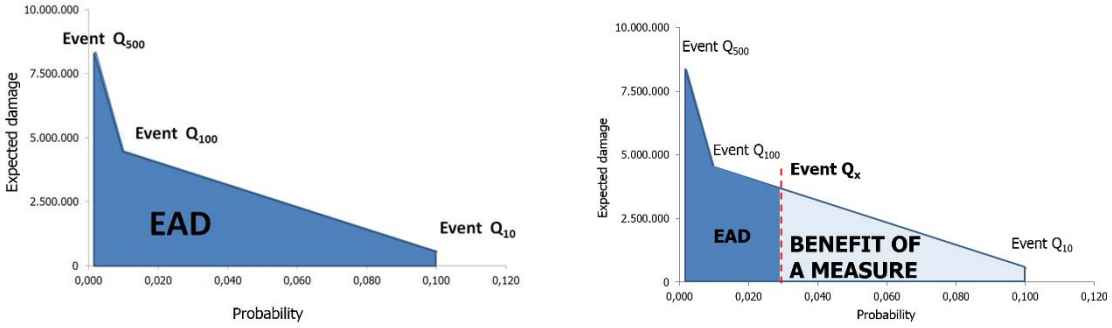


Figure SI5: EAD before and after the implementation of measure and benefit of a measure

More than one combination of flood protection measures is usually possible in certain river basin. For example:

Combination A: Flood protection dams (height 2m) on one side only, preservation of natural stream (distance between flood protection dam and natural stream 5 m), relocation of inhabitants and implementation of natural water retention measures on the other side of the stream

Combination B: Flood protection dams (height 5m), preservation of natural stream (distance between flood protection dam and natural stream 10 m).

Combination C: Flood protection dams (height 4m), modified stream (distance between flood protection dam and modified stream 5m)

Benefits can be assessed for different measures or combinations of measures (A, B, C), which would be appropriate in certain area (river basin). Best measure or combination of measures can be selected with the cost benefit analysis.

When choosing the best combination of measures, sensitivity analysis should be performed not only for costs, but for benefits of the measures as well due to significant uncertainties at benefits assessment (hydrologic, hydraulic and damage part of the model) (Figure SI6).

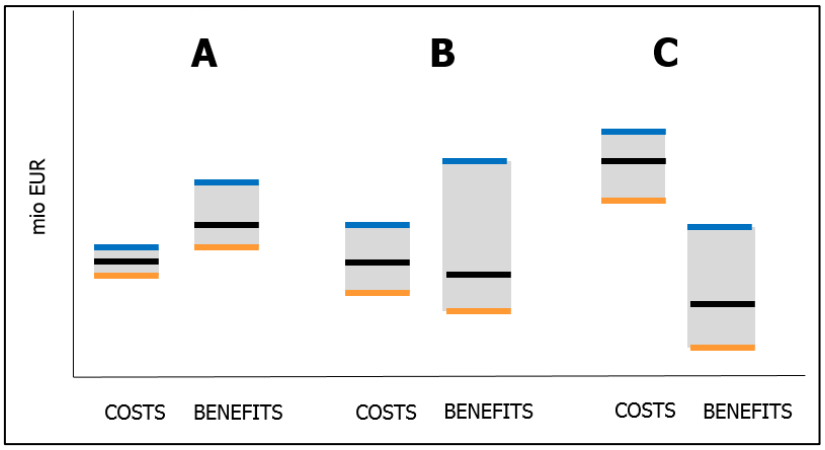


Figure SI6: CBA with remaining uncertainty for three combinations of measures (A, B and C) in certain area

Continual update of assessed values with new data from recent flood events is necessary for the future EAD calculations.