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PROGRAM FOR DEVELOPMENT OF FLOOD RISK MANAGEMENT PLAN IN THE SAVA RIVER BASIN

Pilot Project on Climate Change Adaptation
Building the Link between Flood Risk Management Planning and Climate Change Assessment in the Sava River Basin

Contracting authority: the International Sava River Basin Commission

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ENVSEC Environment & Security

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1. Grounds for preparation of the Program for Development of the Flood Risk Management Plan for the Sava River Basin

Sava River Basin countries have had a long history of different activities in managing water resources, developing and building hydraulic structures, and protecting the Sava River from land base sources of pollution. By the Framework Agreement on the Sava River Basin[1] (hereinafter: FASRB), Bosnia and Herzegovina, Republic of Croatia, Republic of Serbia and Republic of Slovenia (hereinafter: the Parties) agreed to cooperate with the following common objective:

> ***The FASRB – Article 2: Objective of the Agreement***
>
> *1. The Parties shall cooperate in order to achieve the following goals:*
>
> *a) Establishment of an international regime of navigation on the Sava River and its navigable tributaries;*
>
> *b) Establishment of sustainable water management; and*
>
> *c) Undertaking of measures to prevent or limit hazards, and reduce and eliminate adverse consequences, including those from floods, ice hazards, droughts and incidents involving substances hazardous to water.*
>
> *2. For the purpose of carrying out the goals stated in Paragraph 1 of this Article, the Parties shall cooperate in the process of the creation and realization of joint plans and development programs of the Sava River Basin and harmonization of their legislation with EU legislation*

The key objective of the agreement is the transboundary cooperation for sustainable development of the region and one of the particular objectives is to prevent or limit floods and reduce their negative consequences.

The International Sava River Basin Commission (hereinafter: the ISRBC) is the international body charged with the implementation of the FASRB.

According to the Article 30 paragraph 1 of the FASRB, the Permanent Expert Group for Flood Protection of the ISRBC (PEG FP) prepared the Protocol on Flood Protection to the Framework Agreement on the Sava River Basin (hereinafter: the Protocol), which was signed by the Parties in June, 2010.[2]

1.1 Scope and objectives of the Protocol on Flood Protection to the FASRB

The scope of the Protocol, as stipulated in the Article 2, is to regulate the issues of sustainable flood protection caused by natural phenomena such as high river flows, ice jamming, artificial impacts like reservoir discharge, dam collapsing and inadequate handling of flood protection

[1] Framework Agreement on the Sava River Basin signed in 2002, ratified in 2004

[2] Protocol on Flood Protection to the FASRB, ratified by Bosnia and Herzegovina in 2011 and by Republic of Croatia in 2012

structures. Recognizing the recent issues and potential consequences of climate change on the water regime in the Sava River Basin, the Parties considered also the need of effective adaptation measures to deal with possible climate change impacts.

The Parties agreed to implement the Protocol in a coherent way and consistent with water resources policies in the European Union, as well as with the general provisions of water management policies in the Sava River Basin. In addition, the Protocol did not consider the flash flooding phenomena, although it may have significant impacts in the some areas of the Sava River Basin.

The Parties also recognized the need to promote the cooperation and implementation of joint activities aimed at creating the conditions for sustainable flood protection in the Sava River Basin.

The Protocol – Article 3: Grounds and principles of cooperation

1. *The Parties shall, in planning and implementation of measures, works and activities on sustainable flood protection in the Sava River Basin, cooperate on the basis of Directive 2007/60/EC, taking into account the Action Program for Sustainable Flood Protection in the Danube River Basin (hereinafter: the Action Program for Danube River Basin) and taking into account the good practices in cooperation in the field of flood protection in the Sava River Basin.*

2. *The Parties shall, in implementation of measures, works and activities on flood protection on their territories, as well as in conduction of activities in other sectors that may have negative impact on flood protection of other Parties, operate in accordance with "no harm rule" principle.*

The Parties agreed to cooperate on the following activities:

The Protocol - Article 4: Activities

With aim to achieve the objectives of this Protocol, and on the basis of documents as referred to in Article 3 paragraph 1 of this Protocol, the Parties shall cooperate on:

(a) Preparation of the Program for development of the Flood Risk Management Plan in the Sava River Basin;

(b) Undertaking of Preliminary Flood Risk Assessment;

(c) Preparation of Flood Maps;

(d) Development of Flood Risk Management Plan for the Sava River Basin;

(e) Establishment of the Flood Forecasting, Warning and Alarm System in the Sava River Basin;

(f) Exchange of information significant for sustainable flood protection;

(g) Implementation of all measures and activities of mutual interest, originating from planning documents or activities from items (a) to (f) above or other mutually agreed measures and activities.

In the Article 5 (see the box below) the Protocol requires a preparation of the Program for development of the Flood Risk Management Plan (hereinafter: the Program) for the Sava River Basin within six months after the ratification of the Protocol by all the Parties. This Program comprises all elements and activities necessary for development of the Flood Risk Management Plan (hereinafter: the FRMP) for the Sava River Basin with identifying responsible institutions and proposed realization deadlines.

The Protocol - Article 5: Program for development of Flood Risk Management Plan in the Sava River Basin

1. *The Sava Commission shall adopt a Program for Development of the Flood Risk Management Plan in the Sava River Basin (hereinafter: the Program), within six months as of the entry into force of this Protocol.*

2. *The Program shall comprise all elements relevant for development of the Flood Risk Management Plan in the Sava River Basin, including responsibilities of the Parties, mechanisms of the plan development, holders of the particular activities and their realization deadlines.*

The Program represents a further step in modes of cooperation defined in the Article 4 of the Protocol. The overall objective of the Program is to clearly establish common principles and methodologies that could be used in the final preparation of the Flood Risk Management Plan for the Sava River Basin.

All the Parties, presently, have not yet ratified the Protocol. However, at the Third Meeting of the Parties[3], they agreed to work on the Program even before the ratification, in order to speed up the procedure.

[3] Third Meeting of the Parties to the Framework Agreement on the Sava River Basin, Brdo (Slovenia), May 31-June 1, 2011

2. Preliminary Flood Risk Assessment (PFRA)

The Protocol prescribes the following:

> ***The Protocol - Article 6: Preliminary Flood Risk Assessment***
>
> 1. *Each Party shall undertake Preliminary Flood Risk Assessment for its part of the Sava River Basin, taking into account the Directive 2007/60/EC.*
> 2. *In the process of Preliminary Flood Risk Assessment, the Parties shall exchange all relevant data, in principle, through the Sava Commission or bilaterally, as appropriate.*
> 3. *In the case of bilateral exchange of the relevant data from paragraph 2 of this Article, the latter shall also be delivered to the Sava Commission, without delay.*
> 4. *Based on the Preliminary Flood Risk Assessment, each Party shall, on the part of the Sava River Basin on its territory, identify those areas for which it concludes that potential significant flood risk exists or might be considered likely to occur.*
> 5. *Each Party shall, through the Sava Commission, inform the other Parties on the identified areas from Paragraph 4 of this Article.*
> 6. *The Sava Commission shall coordinate the activities on harmonisation of the areas identified pursuant to paragraph 4 of this Article shared by two or more Parties, identified by the Parties as the areas of mutual interest for flood protection.*

According to the Article 4 of the Directive 2007/60/EC (hereinafter: EFD), the member states shall undertake a Preliminary Flood Risk Assessment (hereinafter PFRA) based on available or readily derivable information, such as records and studies on long-term developments, in particular impacts of climate change on the occurrence of floods, to provide the assessment of potential risks.

The impact of climate change on the very low probabilities of flood events may be analysed and considered by SRB riparian countries in assessing the future potential flood risks.

2.1 PFRA activities in the SRB riparian countries

According to the Article 6(1) of the Protocol, the Sava River Basin (SRB) riparian countries have developed PFRA methodologies inline with the EFD provisions. Each country has its own program and performs PFRA according to the adopted national legislative, rules and/or directives.

This section gives a short overview of the developed methodologies in all Sava countries. The overview was prepared using findings during the screening process and using countries' reports from the document "Preliminary Flood Risk Assessment in the Danube River Basins" prepared by the International Commission for Protection of the Danube River (hereinafter: the ICPDR), as a Summary Report to the EC on implementation of Articles 4, 5 and 13(1) of the EFD.

However, the SRB countries agreed to develop the joint PFRA document entitled ”Preliminary Flood Risk Assessment in the Sava River Basin" to be completed in March 2014 (Annex 1).

Slovenia

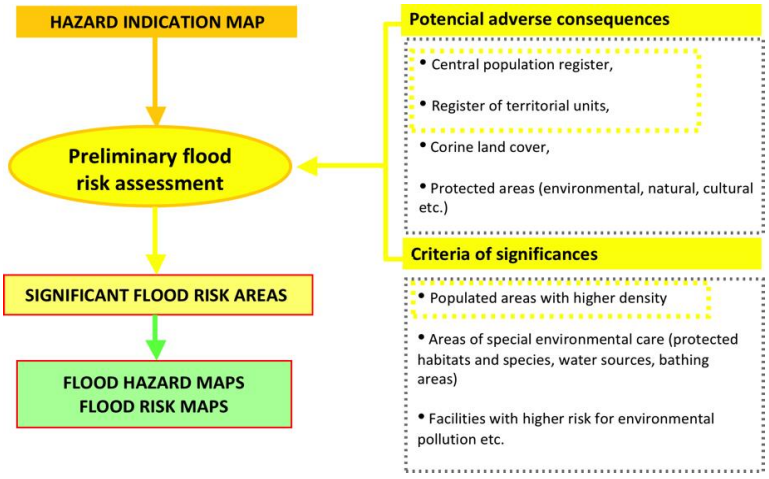

Figure 1: Slovenian PFRA methodology

In Slovenia the activities on the PFRA were conducted through the establishment of Hazard indication map, and by defining Potential adverse consequences, as well as the Criteria of significances (Figure 1).

PFRA was made for the whole Slovenian territory. Hazard assessment was realized using hazard indication map containing data from flood events and flood models, as well as data like: maximum water levels, flood return period, type of flood, date of commencement and duration of flood (days), type/degree of adverse consequences, etc. Additional area of flood hazard was defined based on the morphology of river network and expert consideration. The data were available for fluvial floods without any indication of possible significant pluvial floods, or groundwater floods, or floods from any artificial infrastructure sewerage systems. The flood defence infrastructure was not considered.

Croatia

The obligation of undertaking a PFRA is regulated by the Water Law. The PFRA includes the following: maps of the river basin districts including the borders of sub-basins, showing topography and land use; a description of floods which have occurred in the past; and an assessment of the potential adverse consequences of future floods. When undertaking the PFRA, the methodological approach is adjusted to the available data, and the basis for the assessment of a recipient, i.e. assessment of damage was based on the data from the CORINE Land Cover of 2006, statistics about the population and settlements from the 2011 Census[4], sites of major industrial plants and smaller settlements not visible on the CORINE Land Cover, the data base managed by Croatian Waters, and the available data about the locations of waste disposal sites.

According to the EFD, PFRA in Croatia includes four different types of floods: fluvial floods, pluvial floods - erosion and flash floods-torrents, as well as the artificial infrastructure failure. Account was also taken of the data concerning the floods recorded in the past. Data on groundwater floods was not available at the time. In the assessment all the watercourses

[4] The data from the 2011 Census has still not been processed, upon its publication, a revision of PFRA can be expected

within the national network of watercourses with a catchment area larger than 10 km^2 have been analysed, and, exceptionally, the watercourses with smaller catchment areas, particularly in the part concerning torrents.

Bosnia and Herzegovina

Republic of Srpska has completed the process of defining PFRA methodology and data collection. The problem related to the final payment of the consultant is the reason why the final data are not made available to the public. The principal activities that lead towards PFRA are:

- Data analysis - characteristic river flows, water levels, reliability of data, transformation of data into hydrographs;
- Documentation analysis - systematisation of relevant documentation, legislative, reports, plans, tuning with EFD.

From the latest information the Federation BiH has completed its PFRA. During the PFRA development process the Federation BiH developed the methodology of preliminary flood risk assessment for Sava River Basin for watercourses of II category, and I in 2010 - 2012. The 20, 100, and 500-year return period flood events are taken in the consideration.

Serbia

The provisions for PFRA are defined in Water Law. The official methodology for PFRA is defined in a rulebook published in the Official Gazette in January 2012 (Pravilnik o utvrđivanju metodologije za izradu preliminarne procene rizika od poplava, Službeni glasnik RS, 1/2012). According to the Water Law, PFRA was prepared for the whole territory of Serbia. The assessment was led by the responsible Ministry and with participation of other responsible institutions such as public water management companies, hydrometeorological service, relevant local self-government services and scientific institutes. The PFRA started in 2009 with the preparation of a questionnaire on floods that occurred after 1965. PFRA included risk caused by fluvial (river) floods.

The PFRA has been completed in 2011 and more detailed overview of PFRA for Serbia will be available (March 2014) in the joint report for SRB countries (Annex 1).

2.2 Exchange of information on the PFRA in the Sava River Basin

Ad Article 6(4):

Based on the PFRA, the SRB riparian countries are in the process of identification of areas with existing potential significant flood risk (APSFR) or by which the risk might be considered likely to occur. These areas shall serve for future flood mapping, flood risk assessment and development of the Flood Risk Management Plan (FRMP)..

Ad Article 6(5):

SRB riparian countries shall inform each other about APSFR through ISBRC, The countries will use the structure for APSFR-reporting, given in the Annex 1.

In order to comprise the national PFRA reports, the Secretariat of the ISRBC is preparing a Report on the PFRA on the Sava River Basin. It will set a basis for the assessment of the APSFR in the basin in the transboundary context. This report will include:

- Methodologies of the PFRA in the Sava countries,
- Historical floods in the Sava River Basin,
- Assessment of potential adverse consequences of future floods by the particular Sava countries,
- Methodologies for designation of the Areas of potential significant flood risk (APSFR).

Ad Article 6(6):
Based on the countries' reports, ISRBC shall start coordination on the activities on harmonisation of APSFR on transboundary areas. Harmonisation process should involve areas of mutual interest for flood protection identified by the countries.
Therefore, in accordance with the EFD, the PFRA for the Sava River Basin will include:

- Maps of the Sava River Basin, particularly transboundary flood areas, showing topography and land use, as well as other characteristics, including the position of watercourses and their general hydrological and geomorphological characteristics, floodplains as natural retention areas, existing manmade flood defence infrastructures, the position of populated areas, areas of economic activity and long-term developments.
- Maps of the areas delineated by the countries as the Areas of the Potential Significant Flood Risk (APSFR) in the Sava River Basin

Delineation of transboundary APSFR shall be done multi or bi-laterally through ISRBC. Maps for transboundary areas data should be homogenised for the purpose of their integration into unique spatial information system, Sava GIS. Common geo-reference system for Sava River Basin should be selected and official transformation from national to the selected system should be defined.

An outline of the proposed activities in the Sava River Basin regarding PFRA and expected timeline is given in the Annex 2, Table A1.

Status of the reporting on the PFRA and APSFR in the SRB countries

Since all countries are in the process of finalization of the PFRA following the Article 6(2) and 6(3) of the Protocol, the SRB riparian countries shall exchange all relevant PFRA data through the ISRBC (Annex 1).

When all the APSFR will be reported to the ICPDR (and consequently to the ISRBC), the SRB riparian countries, assisted by the ISRBC, should agree on the transboundary APSFR.

3. Flood Maps

The PFRA has been performed for catchments of various sizes, but for the flood mapping the Sava River Basin sub-catchments larger than 1000 km² will be considered (see the Table A5, Annex 4).
According to the Article 7(3)(4) of the Protocol, the SRB riparian countries shall adopt the methodology for mapping of the transboundary flood areas shared by two or more countries. The mapping methodology comprises development of flood hazard and flood risk maps as well as accompanied vulnerability and flood risk assessment procedures.

The Protocol - Article 7: Flood Maps

1. *Each Party shall prepare Flood Maps for the areas identified in the Preliminary Flood Risk Assessment as referred to in Article 6 of this Protocol for the part of the Sava river basin under its jurisdiction, taking into account the Directive 2007/60/EC.*
2. *Each Party shall, through the Sava Commission, inform other Parties on the Flood Maps prepared for its territory.*
3. *The respective Parties shall agree upon the methodology for mapping of the flood areas shared by two or more Parties, identified according to the Article 6 paragraph 4 of this Protocol, and, thereof, inform the Sava Commission.*
4. *The Parties may, for purpose of joint implementation of the activities from paragraph 1 of this Article, agree to develop a joint methodology for preparation of Flood Maps for the whole Sava River Basin.*
5. *The Sava Commission shall coordinate the development of the Methodology from paragraph 4 of this Article.*

Ad Article 7(1):
SRB riparian countries will prepare Flood Maps on its territory for areas identified during PFRA, following the Article 6 of EFD. According to the Article 6 (3), flooding scenarios for low, medium and, if appropriate, high probability should be taken into account. They will be shown in the maps of flood extent, and either water depths or water levels.

Ad Article 7(2):
ISRBC shall coordinate the development of the methodology for the Sava River Basin as defined in Article 7(5) of the Protocol. ISRBC coordinates information exchange and joint development of maps for the transboundary flood areas.

Ad Articles 7(3) and 7(4):
The SRB countries shall agree on the mapping methodology for the APSFR on transboundary areas identified during PFRA. The following sections (3.1 and 3.2) define common procedures for hazard and risk mapping including the vulnerability assessment. The methodology could be applied to the transboundary flood areas, but could also be accepted as a joint methodology for preparation of Flood Maps for the Sava River, or for the whole Sava River Basin according to the Article 7(4) of the Protocol.

The proposed hazard and risk mapping procedure is reached as a combination of existing legislation in Slovenia and good practice in other SRB riparian countries. Therefore, mapping procedure and vulnerability assessment were defined taking into account the following circumstances:

- Slovenia has legally defined a methodology in the Rulebook (Pravilnik o metodologiji za določanje območij, ogroženih zaradi poplav in z njimi povezane erozije celinskih voda in morja, ter o načinu razvrščanja zemljišč v razrede ogroženosti , Uradni list RS, št. 60/2007),
- Other SRB riparian countries are in the process of officially developing and legally defining methodologies and procedures for the flood hazard and flood risk mapping.
- Findings and proposals of on-going projects in Serbia (Annex 3);
- Findings and proposals of IPA project "Support to BiH Water Policy";
- Conclusions of several PFRA projects in Croatia (Annex 3);
- Findings and proposals of DANUBE Flood risk project.

Ad Article 7(5):
Based on countries' decision in case they agree to develop a joint methodology for preparation of Flood Maps for the whole Sava River Basin, ISRBC shall start coordination on the activities on harmonisation of mapping methodology.

3.1 Flood hazard maps

Hazard assessment should involve collection and analysing data and information to assess the hazard and to determine critical elements in the hazard assessment steps. Selection of flood event (e.g. Q_{100}) and computation of different parameters like depth and velocity provides a tool for analysing hazard. The areal boundaries of the selected flood event are fluvial water levels that will come from the hydrodynamic modelling. This forms the input to the hazard assessment step. There is different information, which should be shown in hazard maps, like extent of potential flood areas, water depth etc. Hazard maps show the danger of flooding as result of the coincidence of probability and intensity. They should be produced for all areas having significant potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity identified by the SRB riparian countries during PFRA.

According to the EFD, Article 6 (3), hazard maps for an extreme flow (low probability) and a ≥100-years scenario (medium probability) are requested. Where appropriate, a high probability scenario can be added. The mandatory elements for flood scenarios during hazard mapping procedure are: flood extent and either water depths or water levels. Where appropriate, flow velocity or water flow could be also used.

Within the SRB countries, Slovenia, Croatia and Serbia are considering 10, 100 and 500-year return periods for flood events, while BiH is currently using 20-year return period for the high probability flood event.

3.1.1 Flood hazard mapping methodology

The Program proposes usage of both water flow velocity and water depth for hazard assessment if available. Due to the lack of data in some SRB riparian countries, it is expected that the flow velocity (if available) and the water depth for hazard mapping will be calculated for the selected Q_{100} scenario (medium probability flow). In what follows, a method for determination of flood hazard based on parameters as flow velocity and water depth will be presented. Flood hazard maps can be produced from the outputs of hydraulic modelling by overlying the maximum velocity map on the maximum water depth maps. The hazard is suggested to be classified into three classes (Figure 2): high, moderate and low.

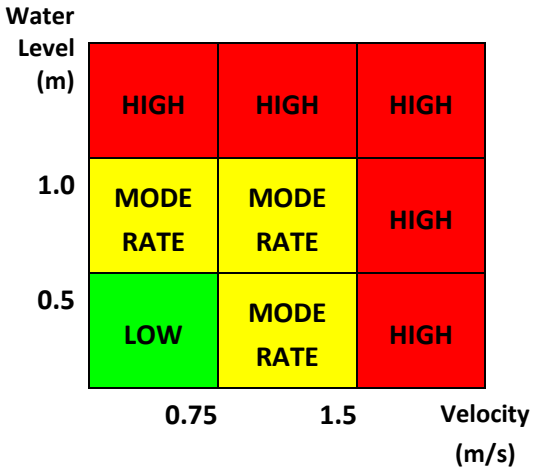

Figure 2: Flood hazard classification chart

The classes are defined according to the danger a flood could cause to the people. Adults are unable to stand in still floodwater with a depth of about 1.5 m or greater. Therefore, if children are considered, this limit should be lower, like 0.5 m. Water velocity enhances hazard, and 0.75 m/s is taken as first step towards more serious hazard. In many EU hazard assessment studies the product of water velocity and depth has been chosen to determine the hazard level. However, in this Program for the SRB we suggest an alternative approach (easier to be adjusted in national legislations). A table concept is proposed rather than a product. By setting 0.75 m/s and 1.5 m/s as thresholds for water velocity, a greater importance is given to the water depth. For example, with a water depth of 0.4 m and a velocity of 0.7 m, there is low hazard, but reversely, having a water depth of 0.7 m and a velocity of 0.4 m/s, there is moderate risk, even though the product is the same. Another option could be to put even thresholds for both, the water depth and water velocity for some river stretches where this can be justified.

3.1.2 Slovenian legislation related to the hazard assessment

Slovenia defined hazard mapping in the formerly mentioned Rulebook[5], flood hazard areas are classified into four classes on the basis of the following criteria:

[5] "Pravilnik o metodologiji za določanje območij, ogroženih zaradi poplav in z njimi povezane erozije celinksih voda in morja, ter o načinu razvrščanja zemljišč v razrede ogroženosti", Uradni list RS, št. 60/2007.

- High hazard is defined for Q_{100} when water depth is equal or higher than 1,5 m or product of water depth and water velocity is higher than 1,5 m^2/s;
- Medium hazard is defined for Q_{100} when water depth is equal or higher than 0,5 and lower than 1,5 m or product of water depth and water velocity is higher than 0,5 m^2/s and lower than 1,5 m^2/s;
- Low hazard is defined for Q_{100} when water depth lower than 0,5 m or product of water depth and water velocity is lower than 0,5 m^2/s;
- Very low hazard is defined when floods is caused by either unpredicted, sudden natural phenomena or human activities (like meteorological phenomena, damage/failure of flood defence or other type of structures).

3.1.3 Serbian experience related to the hazard assessment

Furthermore, Serbia developed a hazard mapping methodology through SoFPAS project (Study of flood prone areas in Serbia – phase 1, IPA 2007 - Annex 3) using flood depth as the only criterion. Consequently, the hazard is assessed using four depth classes:

- less than 0.5 m,
- between 0.5 m and 1.5 m,
- between 1.5 and 4 m,
- greater than 4 m.

3.1.4 Concluding remarks

For transboundary flood prone areas, the parties shall make a decision on the most appropriate methodology that will be used for hazard assessment:

- Simple combination of flood depth and water velocity as proposed herein (Figure 2),
- Multiplication of flood depth and water velocity, following Slovenian model,
- Using water depth only.

For the purpose of hydrologic modelling in Sava river basin, the SRB countries may consider the usage of HEC/RAS model, which has been successfully utilized in some previous studies coordinated by ISRBC.

The decision making process shall be conducted and supported by ISRBC while PEG FP is supposed to be the central body involved in the decision making process. Maps for transboundary flood prone areas shall be homogenised for the purpose of their integration into unique spatial information system, Sava GIS.

3.2 Flood risk maps

Following Article 7(1) of the Protocol, mapping procedure follows EFD and is based on comprehensive assessment of relevant elements. According to the Flood Directive, flood risk is defined as a combination of the probability of a flood event and of the potential adverse consequences (impacts) for human health, the environment, cultural heritage and economic

activity associated with a flood event. The probability of flood event is likelihood of occurrence of a hazard of certain intensity. The hazard impact could be expressed through a flood extent, water depths or water level, the flow velocity or the relevant water flow. Since the consequences are directly related to the vulnerability of the areas, describing their potential to be harmed, flood risk is commonly defined as:

Flood Risk = f (Hazard, Vulnerability)

Hazard and vulnerability will be estimated for floods with likely return period ≥ 100 years. Flood hazard maps will be prepared as defined in Article 6 Paragraph 3 of the Flood Directive.

For transboundary areas both, hazard and vulnerability shall be classified into minimum number of classes, as defined hereunder. Consequently, the flood risk classification shall be evaluated following a risk-chart. Flood risk maps will show the flood prone areas classified in accordance with flood risk classes and associated with chosen flood scenarios.

3.2.1 Risk assessment methodology

The Program proposes risk assessment using vulnerability and hazard maps. Vulnerability maps follows classification of flood prone areas as given in the chapter 3.2.1.1. Flood prone areas extent is defined in accordance with particular flood event (ex. Q_{100}).

3.2.1.1 Vulnerability assessment

Vulnerability analysis defines minimum requirements for vulnerability assessment in the Sava River Basin. Riparian countries could enhance and adjust a proposed scheme according to their own needs and priorities. This scheme primarily serves for transboundary areas as a minimum platform for further flood risk assessment.

Generally, the vulnerability assessment usually comprises a degree of awareness and preparedness before and during the floods, as well as resilience capacity during and after the floods. The vulnerability assessment defines the relation between flood characteristics and damage. This relation is different for different types of humans and goods, depending on their characteristics. It is suggested that SRB countries should develop the reference damage functions established theoretically or empirically based on flood damage data or for example loss of life or injury functions for people exposed to floodwaters.

For the purpose of flood risk management, and in accordance with EFD for flood risk maps, vulnerability is defined by suggested five criteria:

- Population density,
- Protected areas – nature,
- Cultural heritage,
- Economic activities,
- Special structures and objects.

Each criterion has three classes/levels defining vulnerability: high, moderate and low. Consequently, an overall vulnerability is classified as:

1. High vulnerability,
2. Moderate vulnerability,
3. Low vulnerability.

Criteria should be presented spatially. Since majority of the data are being derived from CORINE classification, the most practical approach to structure criteria values is a grid (for ex. 100 x 100 meters cells). Grid cells are classified according to each criterion, thus having five attributes: C1, C2, C3, C4, C5. For each cell vulnerability is calculated using the following rule:

$$\text{Vulnerability Level} = \max(C1, C2, C3, C4, C5),$$

where

$$\text{High} > \text{Moderate} > \text{Low}.$$

The cell vulnerability level is the maximum value among the criteria levels.

Population density

Population density over 500 inhabitants per square kilometre defines expected density for urban areas in SRB. For low populated areas it is expected to have less than 100 inhabitants per square kilometre. The classes are:

1. High vulnerability - greater than 500 inhabitants per square kilometre,
2. Moderate vulnerability - between 100 and 500 inhabitants per square kilometre,
3. Low vulnerability - less than 100 inhabitants per square kilometre.

Protected areas – nature

Categorization of the protected areas is developed in accordance with definition of protected areas by International Union for Conservation of Nature and Natural Resources. Special attention should be paid to potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) of EU Water Framework Directive (WFD), i.e. water designate for human consumption, recreation, bathing as well as protected habitats or species. The classes are:

1. High vulnerability – strictly protected areas where human visitation and impacts are rigorously controlled and/or limited (for ex. categories Ia, Ib and II, defined by International Union for Conservation of Nature),
2. Moderate vulnerability - protected areas cantered on particular natural feature, fragments of ecosystems or habitats (for ex. categories III and IV, defined by International Union for Conservation of Nature),
3. Low vulnerability - protected areas like cultural landscapes altered by humans, natural areas where biodiversity conservation is linked with sustainable use of the natural resources (for ex. categories V and VI, defined by International Union for Conservation of Nature).

Particular attention should be paid to the wetlands and marshes such that flood maps and above classification should be reported only for a low probability flood event.

Cultural heritage
Cultural heritage includes tangible culture such as buildings, monuments, landscapes, books, works of art, and artefacts, etc. This criterion also comprises the museums and similar facilities that store cultural heritage. The riparian countries shall define importance of their cultural heritage. The classes are:

1. High vulnerability - World heritage (UNESCO) or high national importance,
2. Moderate vulnerability - national or regional importance,
3. Low vulnerability - local importance.

Economic activities
This criterion is related to economic activities and their importance to economy: national, regional or local. The criterion has high level of abstraction. Therefore each riparian country has to define particular type of activities through land cover/use categorization and estimate importance to the economy. For transboundary areas a special attention should be paid to avoid eventual discrepancy in judgment. The classes are:

1. High vulnerability - areas with importance to national economy,
2. Moderate vulnerability - areas with importance to regional economy,
3. Low vulnerability - areas either without any importance or with importance to local economy.

Special structures and objects
This criterion concerns structures and objects that are either essential for functioning of society or economy especially during floods or could cause pollution and derogate health condition of the population in flooding conditions. Structures and objects that are either essential for functioning of society or economy are known as critical infrastructure (water supply systems, energy networks, telecommunication systems, major roads and railroads, etc.), structures and objects that could cause pollution according to the IPPC Directive Article 1, and listed activities in IPPC Directive Annex I. The classes are:

1. High vulnerability - structures and objects having national or transnational influence,
2. Moderate vulnerability - structures and objects having regional influence,
3. Low vulnerability - structures and objects having local influence.

If the parties have already classified sources of pollution separately, according to the IPPC directive, they could be easily combined with critical infrastructure objects into a single criterion. Alternatively, parties may decide to have sources of pollution as a separate class for specific sensitive areas having same classification as the criterion Special structures and objects.

3.2.1.2 Slovenian legislation related to the vulnerability assessment

Slovenia defined four vulnerability classes (Rulebook[6]): very low, low, moderate and high. The classification is presented in the Table 1.

[6] "Pravilnik o metodologiji za določanje območij, ogroženih zaradi poplav in z njimi povezane erozije celinksih voda in morja, ter o načinu razvrščanja zemljišč v razrede ogroženosti", Uradni list RS, št. 60/2007.

Table 1: Vulnerability classification (translated from Slovenian legislation)

Vulnerability class	Vulnerability elements
Very low	population density: up to 10 inhabitants per square kilometre
	smaller economic and non-economic activities having local importance
	sensitive objects
Low	population density: between 11 and 100 inhabitants per square kilometre
	economic and non-economic activities having local importance
	sensitive objects
	cultural heritage having local importance
	areas with special treatment according to the water management legislation
Moderate	population density: between 101 and 300 inhabitants per square kilometre
	economic and non-economic activities having regional importance
	sensitive objects
	object or installations that might easily cause pollution
	areas with special treatment according to the water management legislation
	cultural heritage having regional importance
High	population density: more than 500 inhabitants per square kilometre
	economic and non-economic activities having national importance
	object or installations that may easily cause huge pollution, especially if it is on the area with population density is between 101 and 500 inhabitants per square kilometre or on the special area according to the water management legislation
	cultural heritage having national or international importance
	sensitive objects

3.2.2 Flood risk assessment

The flood risk assessment methodology proposed by the Program defines spatial distribution of risk flood by overlaying vulnerability maps and flood hazard maps. Resulting polygons will be classified following flood risk chart (Figure 3). In order to keep classification scheme simple and flexible, the risk is also classified into three classes: high, moderate and low.

RISK		VULNERABILITY		
		HIGH	MODE RATE	LOW
HAZARD	HIGH	HIGH	HIGH	MODE RATE
	MODE RATE	HIGH	MOD ERATE	LOW
	LOW	MODE RATE	LOW	LOW

Figure 3: Flood risk classification chart

The classification assumes that hazard and vulnerability have equal importance and prefers uniform distribution of classes. Following proposed classification a flood risk maps should show extent of possible consequences on flood prone areas.

It is assumed that the analysis is performed for flood prone areas (Q_{100}) without manmade flood defence structures. Since the Sava river basin has flood defence system, it is important to properly include it in the hazard assessment. Based on the reliability of the flood defence system, the most likely locations of failure of the defence system need to be selected. The risk grade could be lowered for one degree if there is objective perception that manmade flood defence structures securely lower the hazard, i.e. that they are reliable and properly managed. The entire mapping procedure is shown on Figure 4. As previously stated, the risk analysis shall be performed for the flood with the medium probability (Q_{100}), as well as for the flood with low and high probability.

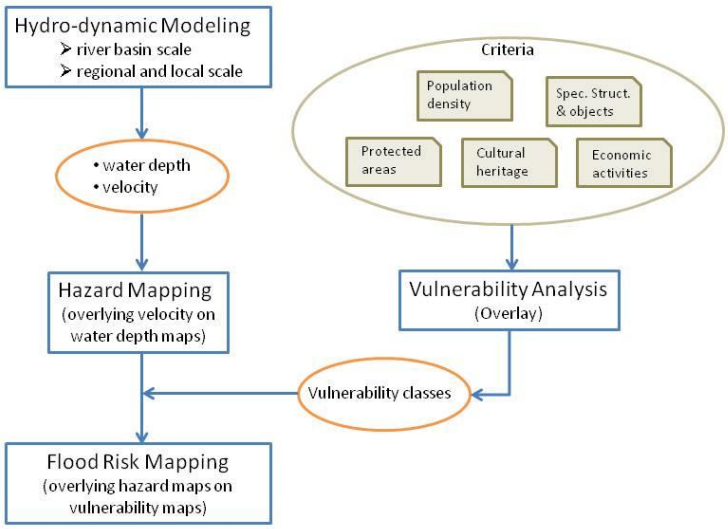

Figure 4: Mapping procedure proposed by the Program

3.2.2.1 Slovenian legislation related to the risk assessment

Slovenia defined three risk classes (Rulebook[7]): low, moderate and high. The classes are evaluated according to the chart shown in the Figure 5.

RISK		HAZARD			
		HIGH	MODERATE	LOW	REMAINING
VULNERABILITY	HIGH	HIGH	HIGH	MODERATE	LOW
	MODERATE	HIGH	HIGH	MODERATE	LOW
	LOW	HIGH	MODERATE	LOW	LOW
	VERY LOW	MODERATE	LOW	LOW	LOW

Figure 5: Flood risk classification chart - Slovenia

[7] "Pravilnik o metodologiji za določanje območij, ogroženih zaradi poplav in z njimi povezane erozije celinksih voda in morja, ter o načinu razvrščanja zemljišč v razrede ogroženosti", Uradni list RS, št. 60/2007.

3.2.3 Concluding remarks

For transboundary flood prone areas, parties shall make a decision on the most appropriate methodology that will be used for risk mapping. The decision making process shall be conducted and supported by ISRBC and PEG FP is supposed to be the central body involved in the decision making process.

Table 2 shows deadlines for flood hazard & risk maps and relevant documents, decrees, acts or laws that define the deadlines.

Table 2: Deadlines and relevant documents for flood hazard & risk maps in SRB riparian countries

Country		Deadlines	Document / Law (in original language)
Slovenia		22. Dec 2013, 22. March 2014 to EC	Okvirni program izvajanja Direktive o oceni in obvladovanju poplavne ogroženosti, (direktiva 2007/60/es) Za obdobje 2009-2015
Croatia		by the end of 2013	Plan izrade akata prema članku 249. Zakona o vodama s okvirnim planom izrade prvog plana upravljanja vodnim područjima
BiH	Federation BiH	by April 2015	Uredba o vrstama i sadržaju planova zaštite od štetnog djelovanja voda
Serbia		not defined	Zakon o vodama

An outline of the proposed mapping activities in the SRB and expected timeline is given in the Annex 2, Table A2.

Regardless of relatively high status of completion, Slovenia is considering revision for flood risk mapping methodology and will inform the ISRBC of new developments.

In general, it is expected that riparian countries should agree on the expert group meetings on a reporting methodology, how various spatial objects will be presented in GIS going from level A (ICPDR - predominantly presented as points) to level B (ISRBC – objects presented as points and lines) and to level C (country – objects presented as points, lines and polygons). All technical details regarding the object types and its presentation in Sava GIS are described in details in the document "Preparation of Implementing Documents for Establishment of the Sava GIS" (2010).

4. Flood Risk Management Plan (FRMP)

In accordance with Article 8 of the Protocol, the Program defines content of the Flood Risk Management Plan.

> ***The Protocol - Article 8: Flood Risk Management Plan***
>
> 1. *The Parties shall prepare the Flood Risk Management Plan for the Sava River Basin (hereinafter: the Flood Risk Management Plan), in accordance with the content defined by the Directive 2007/60/EC, and taking into account all relevant aspects of flood risk management.*
> 2. *The Flood Risk Management Plan shall, in particular, define the goals of the flood risk management of common interest on the Sava River basin level, measures to achieve these goals, mechanisms of coordination on the basin-wide level and a mode of joint cooperation of the Parties in flood defence emergency situations.*
> 3. *Taking into account the principle of solidarity and the no harm rule in accordance with the Article 9 of the FASRB, the Flood Risk Management Plan for the territory of one Party shall not stipulate measures that may, by their magnitude or impact, significantly increase the flood risk on the territory of the other Party, unless those measures are coordinated and agreed between the Parties concerned.*
> 4. *The Sava Commission shall coordinate the development of the Flood Risk Management Plan.*
> 5. *Flood Risk Management Plan shall be adopted by the Parties, upon proposal of the Sava Commission.*

Components of the first Flood Risk Management Plan are defined as follows:

a) Conclusions of the preliminary flood risk assessment including:

- Maps of the river basin district at the appropriate scale including the borders of the river basins, sub-basins showing topography and land use and delineating the areas which are the subject of the Flood Risk Management Plan;

Besides whole SRB and depending on the specific needs of the SRB parties on transboundary flood areas conclusions shall include an assessment of the potential adverse consequences of future floods for human health, the environment, the cultural heritage and economic activity, taking into account:

- Issues such as the topography,
- The position of watercourses and their general hydrological and geomorphological characteristics, including floodplains as natural retention areas,
- The effectiveness of existing manmade flood defence infrastructures,
- The position of populated areas,
- Areas of economic activity and long-term developments including impacts of climate change on the occurrence of floods.

b) Flood hazard maps

Flood hazard maps shall cover the geographical areas having significant potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity identified by the SRB riparian countries during PFRA according to the following scenarios: floods with a medium probability (Q_{100}), extreme event scenarios and floods with a high probability (Q_{20} or Q_{50}), if available, For each scenario the following elements shall be shown: flood extent, water level and water velocity, if available.

c) Flood risk maps

Flood risk maps shall show the potential adverse consequences associated with flood scenarios used for flood hazard maps and expressed in terms of both, flood vulnerability and hazard. Vulnerability is defined by five criteria: population density, economic activities, protected areas – nature, cultural heritage, special structures and objects. Catchments larger than 1000 km² will be considered (Annex 3, Table 5).

d) Description of the objectives of the Flood Risk Management

The objectives defined shall include and/or address:

- A necessity to deliver a single plan for the Sava River Basin,
- All aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems,
- Specific characteristics of the particular flood area,
- Reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity,
- Sustainable land use practices,
- Improvement of water retention, as well as the controlled flooding of certain areas in the case of a flood event,
- Potential reduction of the likelihood of flooding,
- Non-structural initiatives,
- Providing current and accurate floodplain information to the public and decision makers,
- Identification and assessment of flood hazards posed by aging of the flood damage reduction infrastructure,
- Public awareness and comprehension of flood hazards and risk,
- Capabilities to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the region.

e) Summary of measures and their prioritisation

FRMP must set out appropriate objectives for the management of flood risk within the SRB. The objectives must focus on reducing the adverse consequences of flooding for human health, the environment, cultural heritage and economic activity. In addition, the FRMP should focus on reducing likelihood of flooding including the structural measures.

In the SRB, which is shared by several countries, the *structural flood protection measures* should be planned as transnational effort, serving interests of multiple stakeholders subject to

multi-criteria strategic environmental impact assessment. The key in good effectiveness of the existing structural flood protection lies in continuous maintaining and monitoring.

For such a complex flood defence system like in the Sava River Basin and for the shared flood prone areas by several countries, *the non-structural measures* like flood forecasting and warning are an important prerequisite for successful mitigation of flood consequences. Sava riparian countries should work on further development of the system for timely and reliable flood warning, flood forecasting and information sharing, based on a synergy of all relevant national institutions in charge of water management.
Within the document "Sub-Basin Level Flood Action Plan – Sava River Basin" (ICPDR, ISRBC, 2009), the Parties have outlined detailed targets in flood protection planning and listed several structural and non-structural flood protection measures. They range from the local measures to the regional measures and some of them are already backed up with a national legislation.
The measures were grouped as following:

1. Regulation on land use and spatial planning,
2. Reactivation of former, or creation of new, retention and detention capacities,
3. Structural flood defences,
4. Non-structural measures (preventive actions, capacity building of professionals, raising awareness and preparedness of general public).

f) Flood conveyance routes and areas, which have the potential to retain floodwater, such as natural floodplains.

SRB riparian countries shall identify areas and conveyance routes that could retain floodwater. This particularly related to the transboundary areas where countries should cooperate during flood events.

g) Costs and benefits

Description of cost-benefit analysis used to assess measures with transnational effects.

h) Soil and water management, spatial planning, land use, nature conservation, navigation and port infrastructure.

While incorporating Flood Risk Management Plan into other plans, particularly spatial and urban plans, SRB riparian countries shall ensure a coordinated approach in land-use planning on transboundary flood areas as provisioned in Article 8(3).

This is particularly related to the need for some countries (Slovenia and Croatia) to undergo the development of **Strategic Environmental Assessment (SEA)** for implementation of FRMP according to SEA Directive 2001/42/EC.

i) Summary description of the methodology.

j) Flood defence emergency management including activities during and after floods, which need full support from early warning and alert system.

k) Description of the implementation of the plan:

- Progress in implementing the plan will be monitored,
- Summary of the public information and consultation measures/actions taken, mainly for transboundary areas,
- List of competent authorities and, as appropriate, a description of the coordination process within transboundary areas.

Table 3 bellow shows the deadlines for accomplishment of the national Flood Risk Management Plans and the relevant legal documents,

Table 3: Deadlines and relevant documents for Flood risk management plans in SRB riparian countries

Country		Deadlines	Law /Document (in original language)
Slovenia		to EC by Dec 2015	Uredba o vsebini in načinu priprave podrobnejšega načrta zmanjševanja ogroženosti pred poplavami Okvirni program izvajanja Direktive o oceni in obvladovanju poplavne ogroženosti, (direktiva 2007/60/es) Za obdobje 2009-2015
Croatia		by the end of 2015	Plan izrade akata prema članku 249. Zakona o vodama s okvirnim planom izrade prvog plana upravljanja vodnim područjima
BiH	Federation BiH	by April 2017	Uredba o vrstama i sadržaju planova zaštite od štetnog djelovanja voda
	Republic of Srpska	22. Dec 2015	Akcioni plan za održivo upravljanje poplavnim rizikom u slivu rijeke Dunav sa aplikacijom na podsliv rijeke Save područje Republike Srpske, planski period 2010. – 2021. God.
Serbia		by the end of 2017	Zakon o vodama

An outline of the proposed activities and/or deliverables regarding FRMP on the Sava River Basin level and expected timeline is given in the Annex 2, Table A3.

The need to coordinate and synchronise the FRMP with the River Basin Management Plan

(hereinafter: the RBMP), and to avoid double reporting, the reporting formats shall be coordinated. Within the RBMP, the Member States are requested to report on relevant and significant pressures and to establish a Programme of Measures (PoM) for each River Basin District, which could be of particular interest and importance for the FRMP. Therefore, a co-ordinated implementation of the Directive 2000/60/EC and the Directive 2007/60/EC should secure a synergy and benefit of proper information exchange.

5. Flood defence emergency situations and mutual assistance

Considering provisions of Protocol's Article 11, SRB riparian countries shall establish and maintain preparedness, as well as measures related to flood defence emergency situations, specifically including the measures for mitigation of transboundary impacts. A Hydrometeorological Information and Flood Forecasting/Warning System (HMIFFWS) (see item 7.1) should be a central information source during all emergency management phases.

The Protocol - Article 11: Flood defence emergency situations and mutual assistance

1. *The Parties shall undertake appropriate measures for establishment and maintenance of preparedness, as well as measures related to flood defense emergency situations. The Parties shall ensure that these measures also include the measures for mitigation of transboundary impacts.*

2. *In flood defense emergency situations, each Party shall undertake the measures mutually agreed upon in the Flood Risk Management Plan, including the water level monitoring as long as the emergency impacts exist, and, thereon, inform the Parties on whose territory the flood emergency defense situation has arisen.*

3. *In case of flood defense emergency situation, the affected Party(ies) may request assistance from other Parties, indicating the scope and form of assistance needed. The requested Parties shall, as soon as possible, consider such request and inform the Party requesting the assistance on its capacity to provide the required assistance, as well as on the scope and conditions of the rendering assistance.*

4. *For purpose of efficient assistance in case of flood defense emergency situations, the Parties shall agree in details on all necessary actions and activities in the Flood Risk Management Plan as referred to in Article 8 of this Protocol.*

In order to implement the Article 11 of the Protocol, SRB riparian countries should prepare Flood Contingency Plans for the transboundary areas, which systemically describe the actions required during a flood emergency and the authorities that are responsible for carrying out those actions. Key elements of Flood Contingency Plans shall be clearly elaborated in the FRMP. The actions should be coordinated between the countries and emergency procedures should indicate how the coordination would be realized. The plan should have an elaborated flood-warning system. As a start action, an exchange of information on the existing national contingency plans through the ISRBC is proposed. Further step for establishing basis for emergency coordination is evaluation of potential flood scenarios based on flood risk assessment.

SRB riparian countries should ensure that flood protection infrastructure is well maintained. In order to reduce the potential damage resulting from flooding structures situated on high-risk

areas according to the flood risk maps, they should be built/reconstructed as flood resistant. Evacuation routes on transboundary areas should be identified and plans/maps disseminated to the local communities. In the case of critical infrastructure related to essential services, actions to protect them should be undertaken.

Mutual assistance in the sense of Article 11(3) of the Protocol shall be performed through state directorates or similar national institutions in SRB riparian countries. ISBRC shall be a coordination body, taking care of establishment and revision of mutual assistance plans. According to the evaluated flood scenarios, national flood contingency plans should be prepared and a joint flood defence emergency management for the transboundary areas should be established. It will include the activities during and after floods, which need to be fully supported by the early warning and alert system.

6. Public participation and consultation

In accordance with the Article 12 of the Protocol, the SRB riparian countries shall continually inform public about the on-going activities elaborated in the Program, particularly concerning the PFRA, Flood Maps and the FRMP. As defined in the Article 12(2), the Parties shall foster efficient and active participation of the interested public in the process of development, review and up-date of these plans.

The Protocol - Article 12: Public information and consultation

1. *The public shall be informed about the implementation of this Protocol in a same manner as stipulated under permanent monitoring of the FASRB implementation.*

2. *The Parties shall ensure efficient public information concerning the Preliminary Flood Risk Assessment, Flood Maps and Flood Risk Management Plan and foster active participation of the interested public in process of development, review and up-date of these plans.*

Each issue that considers spatial planning should be set for public consultation. Considering transboundary areas, the information sharing and consultations should be performed through the ISBRC. The SRB riparian countries, sharing a flood prone area, should adequately inform public even during the mapping procedure and act with aim of raising the public awareness about joint efforts in flood management, particularly in the situation when the upstream country should sustain their activities, in order not to harm to the downstream parts of a flood prone area which lies in the other country.

An outline of the proposed information to public and public consultations during evaluation of FRMP is given in Table 4.

Table 4: Information to public and public consultation

Communication	Activity
Information to public	Upon elaboration of national and transboundary PFRA
Information to public	Upon definition of vulnerability
Information to public	Upon definition of risk maps
First public consultation	During definition of FRMP - evaluation of objectives
Second public consultation	During definition of FRMP - adoption of plan

7. Other Important activities related to the development of the FRMP in the Sava River Basin

7.1 Flood forecasting, warning and alarm system

The Article 9 of the Protocol prescribes a coordinated or joint Flood Forecasting, Warning and Alarm System in the Sava River Basin (hereinafter: the System).

The Protocol - Article 9: Flood Forecasting, Warning and Alarm System

1. *The Parties shall establish a coordinated or joint Flood Forecasting, Warning and Alarm System in the Sava River Basin (hereinafter: the System).*
2. *In order to establish the System, the Parties shall jointly undertake all necessary actions for establishment of the System, including the development of the project documentation.*
3. *The Sava Commission shall coordinate the activities on establishment of the System.*
4. *After the System is established, the Parties shall ensure its regular maintenance and performance control, as well as regular training of the engaged personnel, with application of joint standards.*

Through development of Hydrometeorological Information and Flood Forecasting/Warning System (HMIFFWS), the Sava River Basin riparian countries will ensure a timely exchange of meteorological and hydrological data, analyses and information important for flood protection, especially the timely forecast of high waters. The national hydro-meteorological services started this initiative in 2003, later supported by the ISRBC. The main outcomes of the planned HMIFFWS project are:

- Real-time hydrological and meteorological observing network,
- Common database,
- National Hydrologic Forecast Centres, with the capacity to use available hydrological models,

- Analyses and exchange of results of the hydrological models to forecast the flood risks.

Early warning systems should be composed of strongly interconnected elements: risk assessment, forecasting, monitoring, warning and alarm, dissemination and communication, and response capability. ISRBC shall have a coordination role between the Parties in establishment of the System.

The current conditions of flood forecasting and warning in the SRB differ in the frequency, methods and techniques used for monitoring and also in data collection and processing, where the solutions range from manual work to the automated and computerized procedures.

One of the core activities within forecasting module of future joint flood warning and alert system should be the simulation of different scenarios of the predicted flooding. The results of simulation will be characterised through the water depth, flow velocity and flood extent, which are input information for preparation of evacuation plans. With the establishment of the warning system, various aspects of alerting systems for population (mobile phones, social networks, etc.) should be taken into consideration.

An outline of the proposed activities and/or deliverables regarding flood forecasting, warning and alarm system in SRB is given in the Annex 2, Table A4.

7.2 Information exchange

Information exchange refers to the Article 10 of the Protocol and should ensure easy and transparent information flow and communication for all activities elaborated in the Program, especially considering potential transboundary impacts.

According to the Article 10(2), the SRB riparian countries should ensure timely exchange of meteorological and hydrological data, analyses and information important for flood protection, especially the timely forecast of high waters. HMIFFWS and the ISRBC web-based hydro-meteorological data module should be a base for further development.

The Protocol - Article 10: Information exchange

1. *In case of flood that induces or may induce transboundary impact, the Parties shall, without delay, inform the Parties that might be affected by this impact, through the System or any other appropriate manner in line with the agreed procedure for exchange of information important for flood defence.*

2. *The Parties shall, through the hydro-meteorological services and institutions responsible for flood protection, ensure timely exchange of meteorological and hydrological data, analyses and information important for flood protection, especially the timely forecast of high waters, in line with the agreed procedure.*

3. *The Parties shall inform each other on changes of their regulations and plans relevant to the flood protection in the Sava River Basin.*

Spatial data and information should be a part of integrated Sava GIS, managed by the ISRBC. In such a way, the data transparency and interoperability will be preserved.

7.3 Identification of adaptation measures due to the climate changes

Climate plays a central role in water resources management as it influences the hydrological variables at all scales. Water resources will be one of the most affected sectors by changes in climate. Thus, the future implementation of EU water related directives should be done in the face of climate impacts projections and associated uncertainties. The key example is the development of the FRMP as it considers future behaviour of river basins in terms of discharges and river flow elevations.

Therefore, the adaptation to climate change in the water resources is a challenging task that will require a paradigm shift in how we precede in future design and water resources management. Producing future climate scenarios and future impacts of climate change requires identification of adaptation measures to be implemented in FRMP.

The key objective, in the face of uncertainty, is to define and implement adaptation measures which both provide a benefit to current climate conditions as well as resilience to potential future climate changes. Some of them could be summarised in following:

- Adaptation options which reduce vulnerability to past and present climate variability,
- Modification to existing plans and designs,
- Adaptive and flexible management,
- Robust adaptation:
    - Adaptation measures that results in benefits, which exceed the costs,
    - Dynamic measures to allow changes or to with draw the adaptation,
    - Strategy as new climate change information evolve,
    - Robustness to uncertainty,
    - Strategies that can reduce climate change vulnerability by adding extra safety margins at low costs.

7.3.1 Identification of adaptation measures

For the development of the FRMP the following adaptation measures and adaptation action plan could be considered by the Sava riparian countries:

Project	Climate hazard	Vulnerability	Impacts	Adaptation measures
FRMP	• flooding event • increase of frequency and intensity • rising of groundwater • increased precipitation	• population density • economic activity • special structures • protected areas • cultural heritage	• damages to population • agricultural areas • soil erosion • water quality	• Retention and diversion of water • Dam, embankment, barage • Storage water for irrigation • Upgrading infrastructure • Spatial planning • Greening of urban areas • Environmentyal management

7.3.2 Adaptation action plan with measures - building adaptive capacity

Research and analysis:

- Aimed to reduce uncertainties prior to costly risk management measures,
- Better understand climate related factors,
- Develop higher resolution data on future climate variability,
- Develop cost-benefit analysis for risk management measures under uncertainty.

Data collection and monitoring:

- Monitor impacts of climate related factors on existing performance from remote sensing to in-situ data,
- Gain access to the new developments in climate change science (e.g., GEMS).

Changing standards and codes:

- Incorporate climate-resilience into countries procurment practice,
- Include climate-related risk mangement in Environmental Impact Assessment studies,
- Perform Strategic Environmental Impact Assessment within spatial planning documents.

7.3.3 Adaptation action plan with measures - delivering adaptation actions

Awarness raising:

- Undertake training and capacity building programmes,
- Organize workshops and public forums on climate changes.

Spreading of risk:

- Diversification of asset types and technologies for new development,
- Diversify locations of new developments,
- Use other financial options like Alternate Risk Transfer Mechanism including risk bonds and swap options.

Avoid negative impacts:

- Avoid locations where risks will be unmanegable in spatial documents,
- Require climate-resilient design standards in new developments,
- Implement changes to management and operating rules for existing projects,
- Implement engineering and technical solutions against climate change for existing developments,
- Build climate-related risks into contingency and disaster plans for new projects,
- Identify and develop new projects that are favored by future climate conditions.

8. Competent authorities and contact persons

In accordance with the Article 13 of the Protocol SRB riparian countries shall designate competent authorities, which shall be responsible for implementation of the activities elaborated in the Program. SRB riparian countries shall nominate one authority and corresponding contact person for official communication.

The Protocol - Article 13: Competent authorities and Contact Persons

1. *Each Party shall designate competent authority/authorities, which shall be responsible for implementation of this Protocol.*
2. *Each Party shall, among designated authorities from paragraph 1 of this Article, nominate one authority for official communication in implementation of this Protocol, on its behalf. Each authority responsible for official communication shall designate a contact person.*
3. *Each Party shall, no later than the entry into force of this Protocol, notify the Sava Commission of the designated authority/authorities from paragraphs 1 and 2 of this Article, as well as of the name and address of its contact person. Each Party shall, without delay, notify the Sava Commission of any changes of the designated authority, as well as of the name and address of its contact person.*
4. *For reasons of efficiency, the Parties may designate other authorities to be responsible for preparation or implementation of any activity stipulated under this Protocol and, thereof, notifies the Sava Commission.*
5. *The Sava Commission shall, without delay, inform the Parties of the notifications received under this Article.*

Table 5 shows responsible institutions for flood risk management in SRB riparian countries.

Table 5: Relevant institutions responsible for flood risk management

Country		Ministry	Executive agencies
Slovenia		Ministry of Agriculture and the and Spatial Planning	Institute for Water of the Republic of Slovenia
Croatia		Ministry of Agriculture	Croatian Waters
BiH	Federation BiH	Federal Ministry of Agriculture, Water Management and Forestry	Sava River Watershead Agency, Sarajevo
	Republic of Srpska	Ministry of Agriculture, Forestry and Water Management	Public institution "VODE SRPSKE", Bijeljina
Serbia		Ministry of Agriculture, , Forestry and Water Management	PWMC “Srbijavode”, PWMC “Vode Vojvodine” i PWMC “Beogradvode”

Annex 1: Preliminary Flood Risk Assessment in the Sava River Basin (prepared by the Permanent Expert Group for Flood Prevention) to be finalized on March 2014.

Aim and Objective of this report

Summary Report on implementation of Articles 4, 5 and 13(1) of the European Floods Directive had already done for the Danube River Basin District, under the umbrella of the International Commission for Protection of the Danube River (ICPDR).It was submitted to the European Commission in March 2012. In its nature it contains much similar information, which is provided by this report. Nevertheless, because of the specificities of the Sava basin, the PEG FP decided, on its 21st meeting held in January 2013 that the PFRA report should be prepared also for the Sava River Basin, whilst keeping in mind the commitments undertaken by the Protocol.

The aim and objective of undertaking a Preliminary Flood Risk Assessment are as follows:

- Summary of significant flood risk, based on available and readily derivable information, describing both the probability and harmful consequences of past and future flooding in the Sava River Basin based upon the Sava River Basin Analysis Report, national reports to the ICPDR in the process of preparation of the ICPDR PRFA and updated information from national sources and ongoing related projects;
- Identification of the areas of potential significant flood risk APSFR, which will require further investigation;
- Production of the basin wide APSFR map.

The following is the agreed the contents of the Report:

Table Contents

Annex 2: SRB riparian countries' activities and/or deliverables and deadlines

Table A1: SRB PFRA activities and expected deadlines

Activities of SRB riparian countries	The Protocol	EFD	Participating institutions
To start the PFRA for each SRB country's part according to the EFD.	Article 6(1)	✓	M, NEA
To exchange all relevant data, through the Sava Commission or bilaterally, as appropriate. In the case of bilateral exchange of the relevant data, the latter shall also be delivered to the Sava Commission, without delay.	Article 6(2) Article 6(3)		M, NEA, ISRBC
To identify the areas for which potential significant flood risk exists or might be considered likely to occur (APSFR)*.	Article 6(4)	✓	M, NEA
To exchange information with other SRB countries about APSFR through the Sava Commission.	Article 6(5)		M, NEA, ISRBC
To identify the areas of mutual interest for flood protection, within the APSFR, through Sava Commission.	Article 6(6)	✓	PEG FP, ISRBC

*Key milestones

** The joint PFRA for the SRB countries is under preparation with deadline of March 2014.

Abbreviations:
NEA - National Executive Agencies as listed in Table 7
M - Ministries as listed in Table 7

Table A2: SRB mapping activities and expected deadlines

Activities of SRB riparian countries	The Protocol	EFD	Expected deadlines	Participating institutions
To start the preparation of Flood Maps for the areas identified in the PFRA for the part of the Sava river basin under its jurisdiction, according to the EFD.	Article 7(1)	✓	September 2013	M, NEA
To agree upon the methodology for mapping of the flood areas shared by two or more Parties (APSFR), through the ISRBC or bilaterally providing information to the ISRBC*	Article 7(3)	✓	December 2013	M, NEA, ISRBC
In case of agreement, to deliver a joint methodology for preparation of Flood Maps for the entire Sava River Basin (coordinated by the Sava Commission).	Article 7(4) Article 7(5)	✓	June 2014	PEG FP, ISRBC
To inform to other countries on the Flood Maps prepared for its territory through the Sava Commission.	Article 7(2)	✓	June 2015	M, NEA, ISRBC

*Key milestones

Abbreviations:
NEA - National Executive Agencies as listed in Table 7
M - Ministries as listed in Table 7

Table A3: FRMP activities for SRB and expected deadlines

Activities and/or deliverables of SRB riparian countries	The Protocol	EFD	Expected deadlines	Participating institutions
Conclusions of PFRA	Article 6	✓	December 2013	M, NEA
Flood hazard maps	Article 7	✓	September 2015	M, NEA
Flood risk maps*	Article 7	✓	December 2015	M, NEA
To define objectives of flood risk management	Article 8(2)	✓	December 2015	M, NEA, ISRBC, PEGs
Measures to achieve objectives	Article 8(2)	✓	June 2016	M, NEA
To define and report the flood conveyance routes and areas, which have the potential to retain floodwater, such as natural floodplains.	Article 8	✓	December 2016	M, NEA
To evaluate and report the Cost-benefit analysis	Article 8	✓	December 2016	M, NEA
To asses the mutual impact from the planning documentation on soil and water management, spatial planning, land use, nature conservation, navigation and port infrastructure.		Art.7.3 (Art.4 WFD) ✓	December 2016	M, NEA
The summary description of the methodology*	Article 8	✓	June 2017	M, NEA, ISRBC, PEGs
To develop the flood defence emergency management, including activities during and after floods, which need full support from early warning and alert system.	Article 8	✓	To be defined by SRB countries	M, NEA, ISRBC, PEGs
Final document*	Article 8	✓	December 2017	M, NEA, ISRBC, PEGs

*Key milestones

Abbreviations:

NEA - National Executive Agencies as listed in Table 7

Ministries as listed in Table 7

PEGs - Permanent expert groups of ISRBC

Table A4: SRB Flood forecasting, warning and alarm system activities

Activities and/or deliverables of SRB riparian countries	**The Protocol**	**Participating institutions**
To assess the actual state of National Forecasting, Warning and Alarm systems	Article 9(1)	NEA, NAMH, M, ISRBC, *Ah* HM EG PEG FP
The completion of real-time hydrological and meteorological observing network (web-data exchange system).	Article 10 (1,3)	NEA, NAMH, M, ISRBC, *Ah* HM EG PEG FP
To analyse and exchange of results of the hydrological models to forecast the flood risks.	Article 10 (1,3)	NEA, NAMH, M, ISRBC, *Ah* HM EG PEG FP
To further develop the National Forecast, Warning and Alarm systems with capacities to use hydrological models to forecast flood risks.	Article 9 (1,2,3) Article 10 (2)	NEA, NAMH, M
To coordinate SRB Forecasting, Warning and Alarm System, with the capacity to use available hydrological models.	Article 9	NEA, NAMH, M, ISRBC, *Ah* HM EG PEG FP

Abbreviations:
NEA - National Executive Agencies as listed in Table 7
NAMH - National Agencies in charge for hydrological and meteorological forecasts
M - Ministries as listed in Table 7
PEGs - Permanent expert groups of ISRBC

Annex 3: Relevant supporting activities and projects

This chapter provides information about the projects addressing the transboundary issues of preliminary flood risk assessment and projects related to it activity in the Sava River Basin.

A3.1 Transboundary

Water and Climate Adaptation Plan (WATCAP) for the Sava River Basin

According to the last findings on climate change, the Sava River Basin is predicted to experience higher temperatures and more severe precipitation events and droughts. These changes will impact water resources management, water supply, hydropower, agriculture, navigation and flood control. Climate impacts will have significant consequences on investments in water systems associated with water services and managing water. There is a concern in the South Eastern Europe that recent growth in economic sectors and livelihoods of the population may be constrained by the climate change impacts. To fill the knowledge gap on the impact of climate change on water sector and to inform decision making sector (e.g. governments and other national authorities) how to increase the climate resilience of the critical water management infrastructure investments and integrated water resource management, the World Bank has initiated the project Water and Climate Adaptation Plans (WATCAPs) for selected river basins. The Sava River Basin is the first of these basins in SEE selected for this work.

The **main objective of** WATCAP project is:

- to fill the knowledge gap on the impact of climate change on the water sector in SEE, and to inform decision making by World Bank client governments and the development community on how to increase the climate resilience of critical water management infrastructure investments and of integrated water resource management in the region.

The project will combine general analysis on the river basin level with more detailed analysis on the investment of the World Bank in the region and the climate change adaptation measures needed.

The WATCAP will include a basin characterization through the development of a hydrologic model, an impact assessment for a number of climate change scenarios with that model, and appraisals of alternatives for adaptive management actions in water management sub-sectors, including: (i) navigation, (ii) hydropower, (iii) agricultural water use, (iv) flood protection, and (v) an economic analysis of the projects that the water management sub-sector studies are based on.

The **results** of the WATCAP project will be very important for the assessment of Programme of Measures and development of the Sava River Basin Flood Risk Management Plan.

Start: June 2009 **End:** December 2013

Building the link between the Flood Risk Management planning and climate change assessment in the Sava River Basin

Purpose of the Project is to:

- Address the issues of transboundary management of floods in the Sava River Basin, while taking into account the impacts of climate change under different scenarios and the perspective adaptation measures envisaged,
- Prepare the basis for the preparation of the first Flood Risk Management Plan for the Sava River Basin (Sava FRM Plan).

Agreement between UNECE and ISRBC on grant for the pilot project comprising eight project components:

- Preparation of an overview of already completed or ongoing activities and their findings regarding flood risk management planning in the Sava river basin
- Identification and assessment of existing legislation, strategies and plans related to FRM planning and climate change adaptation (transboundary and national)
- Compilation of various climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events
- Initial flood vulnerability assessment in the Sava River Basin and identification of the most vulnerable areas
- Assessment whether additional modeling of climate change impact on flood vulnerability is needed, preliminary identification and description of possible adaptation measures (costs, effectiveness, side effects, vulnerability reduction, feasibility of implementation, alternatives etc.), selection of a package of measures (long term, medium term and short term measures, prevention, preparedness, resilience, response and recovery measures)
- Preparation of a detailed Program for Development of the Flood Risk Management Plan in the Sava river basin
- Assessment of data and information needs for preparation of joint Sava FRM Plan, identification of data sources on national and international level, finding data gaps and defining strategy how to obtain the missing
- Exchange of experience on the implementation of the project with other projects in the programme of pilot projects under the Water Convention and dissemination of the results.

Three consultation workshops, with participation of various stakeholders from the Sava River Basin, are planned to be held in the course of the Project. First took place in May 2011, second in December 2012 and third is planned for April 2013.

Start: March 2011 **End:** December 2013

USACE Sava hydrologic/hydraulic models

The main aim of this effort is to foster multilateral cooperation and flood-hazard protection by the Parties to the FASRB by developing regional floodplain delineation and flood-risk mapping. The project was based on a single shared hydraulic model of the Sava River. The hydraulic model will be shared between the member countries, as will update information as it becomes available, and will be used to prepare the flood mapping, support the flood forecasting system, and for alternatives analyses of future flood protection projects.

Successful development of the joint Sava River hydraulic model will have a direct impact on international efforts to develop integrated flood hazard and risk maps, integrated data collection, flood forecasting, and flood warning systems, which will reduce vulnerability to natural, technological, and willful hazards.

Based on the **original scoping**, the USACE intended to leverage its technical experience with this nature of work to provide a package of products that directly support the needs outlined in the Protocol on Flood Protection to the FASRB.

The **main goal** of this project was to provide a fully georeferenced HEC-RAS steady hydraulic model of the Sava River that will ultimately support all of these needs. This model will not only serve to provide information along the Sava River, but will also serve as an instrument for training for future modeling in other areas of the Sava River Basin.
Additionally, it was planned that the project provides also:

- Guidance and Geospatial Products Supporting Flood Hazard and Risk Mapping,
- Hydraulic Structure Surveying and Inventorying,
- Product Transfer and Technical Training.

Products, which are delivered by the USACE, are as follows:

- Fully georeferenced HEC-RAS unsteady hydraulic model of the Sava River,
- In addition, a hydrologic HEC-HMS model for the whole Sava River Basin,
- GIS products including GeoHMS and GeoRAS models,
- Final report on the work, with guidelines and recommendations.

A3.2 National activities/projects

CROATIA

Development of flood hazard maps and flood risk maps in the Republic of Croatia

Overall Objective of the project reflects in contribution to the further harmonization and implementation of the EU water-related aquis communautaire specifically focusing on the Implementation requirements of EU Directive 2007/60/EC in the preparation of flood hazard maps and flood risk maps in the Republic of Croatia.

The activities described in this project need to lead to the following results:

- Project Implementation Plan and Methodology for the preparation of flood hazard maps and flood risk maps prepared.
- Minimum 2 pilot areas of adequate sizes selected.
- Data for the minimum 2 flood risks areas (identified as a result of the preliminary analysis) collected.
- Digital terrain models (DTM) for the minimum 2 flood risks areas(identified as a result of the preliminary analysis) prepared.
- Longitudinal and cross sections of watercourses for the minimum 2 flood risks areas (identified as a result of the preliminary analysis) prepared
- Hydrological data for the minimum 2 flood risks areas (identified as a result of the preliminary analysis) prepared and analyzed.
- Land use information for the minimum 2 flood risks areas (identified as a result of the preliminary analysis) prepared.
- Flood Hazard Maps and Flood Risk Maps for selected pilot areas (minimum 2 flood risks areas) prepared.
- Guidance Document on the technical aspects of the preparation of flood hazard maps prepared.
- Guidance Document on the assessment of flood risks and adverse consequences of floods prepared.
- Guidance Document on the integrated assessment of existing and planned civil engineering measures for flood protection prepared.
- Methodology for assessing potential impacts of climate change on flood risks prepared.
- Guidance Document on the participation of the public and stakeholders in flood risk management prepared.
- Guidance for Risk Management Plans prepared.
- Capacity of relevant institutions strengthened.

Start: 2013 **End:** 2015

EU IPA 2010 Twining project "Development of Flood Hazard Maps and Flood Risk Maps"

The purpose of the project is to implement requirements of the EU Floods Directive and to that end to prepare flood hazard maps and flood risk maps in eth Republic of Croatia.

Project components:

- Pilot areas and Pilot Project Implementation Plan,
- Mathematical hydraulic models,
- Flood Hazard Maps and Flood Risk Maps for the selected pilot areas,
- Guidance Documents on flood-related topics,
- Capacity of relevant institutions (Ministry of Agriculture and Croatia Waters) strengthened in order to improve implementation of the Floods Directive requirements.

Achievements obtained as of 15/10/2013:

- Selection of pilot areas (Kupa and Neretva),
- Project implementation plan and training needs analysis made,
- Broad involvement of Croatia Waters,
- Governmental stakeholders involved,
- Working structure established,
- Data collection achieved for modeling and hazard mapping,
- Modeling exercise almost finished,
- Legends of FHM and FRM prepared,
- Draft list of non-structural measures made,
- Guidance document on FRMP prepared.

BOSNIA AND HERZEGOVINA

Support to BiH water policy - Towards implementing EU Water Policy in BiH

Objectives:

- to ensure the protection and rational use of water resources in BiH in accordance with corresponding standards of the European Union;
- to support further development and implementation of Entity Water Laws in accordance with the principles of the European Union's Water Framework Directive and other EU water-related directives;
- to strengthen BiH capacities' for the coordination and implementation of international treaties/conventions to which BiH is party too.

Impact for the country:

- preparation of 1st water policy document tracing the main directions, which are harmonised and agreed among the main stakeholders, regarding water resources planning and development in BiH for the next 25 years;
- preparation of working material for 6 by-laws related to the Entity Water Laws;
- preparation of strategies for implementing EU "Drinking Water Directive", "Urban Wastewater Directive" and "Flood Risk management Directive".

The project has been completed in Dec 2011 and it is available on the web site of the FBiH Ministry of Agriculture, Water and Forestry.

SERBIA

SoFPAS project (Study of flood prone areas in Serbia – phase 1, IPA 2007)

Serbia developed slightly different approach to assess the vulnerability within SoFPAS project by defining risk receptors: population, infrastructure, economic activities, protected environment, sources of pollution and cultural heritage, and calculating potential adverse

consequences of floods to each receptor. Since the risk receptors typically correspond to the vulnerability classes it could be technically possible for the parties to use vulnerability classification for proposed vulnerability assessment.

Furthermore, Serbia developed a hazard mapping methodology through SoFPAS project using flood depth as the only criterion. Consequently, the hazard is assessed using four depth classes:

- less than 0.5 m,
- between 0.5 m and 1.5 m,
- between 1.5 and 4 m,
- greater than 4 m.

The SoFPAS project developed a risk mapping methodology. The methodology defines risk receptors, which were defined for the following classes: population, infrastructure, economic activities, protected environment, sources of pollution and cultural heritage. The risk is expressed as a probability of a flood event and potential adverse consequences of flood. Probability of a flood event was calculated taking into account probability of a flood and reliability of flood protection system. Potential adverse consequences of floods were assessed considering: value of a risk receptor, damage function (in relation to water depth) and exposure of risk receptor to flood. The overall risk was calculated by applying multi-criteria analysis to risk values for the specific classes: population, infrastructure, economic activities, protected environment and cultural heritage.

New maps based on methodology developed in SoFPAS project will be produced for Tamnava and Jadar in 2014.

Annex 4: Sub-catchments in the SRB larger than 1000 km^2

Table A5: List of the rivers in the Sava River Basin included in the Sava RBMP*

River name	River basin size (km^2)	River length (km)	Sava RB countries sharing the river basin	Tributary order	Confluence to the Sava/tributary L-left side R-right side
Sava	97,713.2	944.70	SI, HR, BA, RS, ME	-	-
Ljubljanica	1,860.0	40.00	SI	1st	R
Savinja	1,849.0	93.60	SI	1st	L
Krka	2,247.0	94.70	SI	1st	R
Sotla/Sutla	584.3	89.70	SI, HR	1st	L
Krapina	1,237.0	66.87	HR	1st	L
Kupa/Kolpa	10,225.6	118.3	SI, HR, BA	1st	R
Dobra	1,428.0	104.21	HR	2nd	R
Korana	2,301.5	147.62	HR, BA	2nd	R
Glina	1,427.1	112.22	HR, BA	2nd	R
Lonja	4,259.0	47.95	HR	1st	L
Česma	3,253.0	105.75	HR	2nd	L
Glogovnica	1,302.0	64.48	HR	3rd	R
Ilova (Trebež)	1,796.0	104.56	HR	1st	L
Una	9,828.9	157.22	HR, BA	1st	R
Sana	4,252.7	141.10	BA	2nd	R
Vrbas	6,273.8	235.00	BA	1st	R
Pliva	1,325.7	31.45	BA	2nd	L
Orljava	1,618.0	93.44	HR	1st	L
Ukrina	1,504.0	80.9	BA	1st	R
Bosna	10,809.8	272.00	BA	1st	R
Lašva	958.1	55,20	BA	2nd	L
Krivaja	1,494.5	74.3	BA	2nd	R
Spreča	1,948.0	147.28	BA	2nd	R
Tinja	904.0	88.10	BA	1st	R
Drina	20,319.9	335.67	ME, BA, RS	1st	R
Piva	1,784.0	43.50	ME	2nd	L
Tara	2,006.0	134.20	ME, BA	2nd	R
Ćehotina	1,237.0	118.66	ME, BA	2nd	R
Prača	1,018.5	62.67	BA	2nd	L
Lim	5,967.7	278.5	AL, ME, RS, BA	2nd	R
Uvac	1,596.3	117.70	RS, BA	3rd	R
Drinjača	1,090.6	90.00	BA	2nd	L
Bosut	2,943.1	132.18	HR, RS	1st	L
Kolubara	3,638.4	86.70	RS	1st	R

Source: SRBA Report 2009.

* Rivers with catchment area larger than 1000 km^2 or designated as of basin-wide importance