University of *Ljubljana*
Faculty of *of Civil and Geodetic Engineering*

PILOT PROJECT ON CLIMATE CHANGE:
BUILDING THE LINK BETWEEN FLOOD RISK MANAGEMENT PLANING AND CLIMATE CHANGE ASSESSEMENT IN THE SAVA RIVER BASIN

COMPONENT A5: ASSESSMENT WHETHER ADDITIONAL MODELLING OF CLIMATE CHANGE IMPACT ON FLOOD VULNERABILITY IS NEEDED, PRELIMINARY IDENTIFICATION AND DESCRIPTION OF POSSIBLE ADAPTATION MEASURES, SELECTION OF A PACKAGE OF PREVENTION, PREPAREDNESS, RESILIENCE, RESPONSE AND RECOVERY MEASURES

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Participated in the study:

Prof. Mitja Brilly, PhD, BSc (Civil Eng.)

Assist. Prof. Mojca Šraj, PhD, BSc (Civil Eng.)

Andrej Vidmar, MSc, BSc (Civil Eng.)

Katarina Kavčič, BSc (Civil Eng.)

List of Abbreviations

CC – Climate change
BiH – Bosnia and Herzegovina
EOBS – European observation – European daily high-resolution gridded data set
FEMA – Federal Emergency Management Agency
ICPDR – International Commission for the Protection of the Danube River
INC – Initial National Communication
ISRBC – International Sava River Basin Commission
MOP – Ministry of the Environment and Spatial Planning of Slovenia
MOPP – The Ministry of Environment and Spatial Planning of Serbia
MPPO – Ministry of spatial planning and environment of Montenegro
MZOIP – Ministry of Environmental Protection, Physical Planning and Construction of Croatia
PMF – Probable Maximum Flood
SHMZ H – Hidrološki godišnjak, Savezni hidrometeorološki zavod, Beograd.
SHMZ MII – Meteorološki godišnjak II (padavine), Savezni hidrometeorološki zavod, Beograd
TI – Transboundary impact
UNECE – United Nations Economic Commission for Europe
UNFCCC – United Nations Framework Convention on Climate Change
US – University of Split
WS – water station

Contents

1. Introduction

The report should support the Program for development of the Flood Risk Management Plan in the Sava River Basin. The assessment of impact of possible climate change on floods was derived in the previous two parts of the report. This, Part Three of the report, deals with action A5(Assessment whether additional modelling of climate change impact on flood vulnerability is needed, preliminary identification and description of possible adaptation measures, selection of a package of prevention, preparedness, resilience, response and recovery measures) climate change adaptation measures for flood protection according to results of action A3 (Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events) (UL FMF 2013[1] and UL FGG 2013[2]) and action A4 (Initial flood vulnerability assessment in the Sava river basin and identification of the most vulnerable areas) (US 2013)[3]. Characteristics and size of flooding, the state of facilities for flood protection and organization of flood defences, are described in detail in the report »Sava River Basin Analysis Report – International Sava River Basin Commission (ISRBC, 2009)[4]«. The Sava River flood plains are characterized by karst poljes in the head part of the watershed and large inundation areas along the main stream in the middle and lower part of the Sava River. Downstream of the border between Slovenia and Croatia, inundation plain substantially expands up to the inflow into Danube. The main stream of the Sava River flows through a wide inundated plain area. As a consequence of large flood protection works that are not yet completed, the flooding extent has largely decreased, but it has also increased the risk of flooding downstream. Thus, the water level at the water station Sremska Mitrovica rose by 1 meter in the past hundred years, (ISRBC, 2009). However, it should be noted that the flow of the Sava River at the mouth is under the influence of the Danube River and the Đerdap Hydro power (HP) Dam backwater.

In the International Commission for the Protection of the Danube River (ICPDR 2012)[5] study, based on the United Nations Framework Convention on Climate Change (UNFCCC) communication, flood measures are addressed in the whole Sava River basin, except for Slovenia where floods are not addressed. Adaptation measures are suggested only in the Serbian national communication; for other countries such the information is not available. Within the UNFCC C communication, flood measures are not addressed only by Slovenia; all other Sava River countries have recognised the flood protection measures as a part of the climate change strategy.

[1] UL FMF, 2013 Pilot project on climate change: Building the link between flood risk management planning and climate change assessment In The Sava River Basin, COMPONENT A3: Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events, Part 1: Report on meteorological part of development of climate projections for The Sava River Basin, University of Ljubljana, Faculty for mathematics and physics

[2] UL FGG, 2013 Pilot project on climate change: building the link between flood risk management planning and climate change assessment in The Sava River Basin, COMPONENT A3: Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events, Part 2: Climate change impact on flood discharge of The Sava River, hydrology report, University of Ljubljana, Faculty of civil engineering and geodesy

[3] US 2012, Report on vulnerability analysis, Pilot project on climate change adaptation Building link between Flood Risk Management planning and Climate Change Assessment in the Sava River Basin.

[4] ISRBC, 2009, Sava River Basin Analysis Report

[5] ICPDR, 2012, Danube Study – Climate Change Adaptation

The report developed by the University of Split (US 2012)[6], Report on Vulnerability Analysis, provides an overview of data on the vulnerability of the flood-prone areas based on data from various sources, including Land Cover 2000 data. The vulnerability analysed in highly detailed manner. The criteria that are considered are the following:

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

The conclusion of the report (University of Split, US 2012)[7] is:
»As expected, the most vulnerable zones are those flood prone areas that coincide with big settlements with high population density and economic activities. Some parts between Zagreb and Slavonski Brod, as well as some eastern parts of the Basin are vulnerable due to protected natural habitats. Almost 50% of flood area is classified as moderate vulnerability, a neglected part hasn't got any grade of vulnerability, and other 50% is almost equally distributed between high and low vulnerability. Areas with high vulnerability are mainly those around Zagreb, Belgrade and areas on the mouth of Drina River into the Sava River. The objective of the vulnerability analysis performed for this pilot project is only an indication to the SRB riparian countries. The countries shall perform detailed analysis, with particular respect in the transboundary areas. The countries may introduce weights to the criteria, but this process should be undertaken very carefully, not jeopardising either population rights, or safety. It is recommended that the weights should be common to the entire Sava River Basin and evaluated by consensus.«

Sensitivity was analysed only within the Q_{100} flood zone, but not beyond. Historical events like the Drina River 1896 flood, almost Probable Maximum Flood event and extremely high water downstream on the Sava River, need some special treatment. The question is also how will vulnerability change in the future and what will be the change in population density. In the report, the sensitivity about the possible ecological disasters caused by floods is not treated. The same holds for the exposed Krško Nuclear Power Plant, and for other major chemical facilities in inundated areas.

There is also the process of reforestation, which has a strong impact on the water balance and discharge decrease. In Slovenia, the area covered by forest increases by almost 1% each year. In Bosnia and Herzegovina, on the contrary, drastic deforestation has taken place.

[6] US, 2012, Report on Vulnerability Analysis
[7] US, 2012, Report on Vulnerability Analysis

2. Assess and compare the results of the initial flood vulnerability assessment in the Sava River Basin and the climate change impact on the hazard of flooding and draw conclusions related to the extent of the climate change impact on flood vulnerability

In the Introduction section, the report provides an interesting overview of historical floods and an overview of flood protection measures. The vulnerability report A4 is elaborated on the basis of EU recommendations, using the CORINE database. Vulnerability maps were produced, showing vulnerability in relation to population density per km2, economic activities and critical infrastructure. In relation to population density, two classifications were elaborated (Tables 4.8, US 2012). The analysis was performed only within the 100-year return period flood zone, but not beyond. In the first classification, the vulnerability grades are defined in a way that the first grade covers the densities 1–100 inhabitants/km2, the second one 101–500 inhabitants/km2, and the third one population densities of over 500 inhabitants/km2.

In the second classification, the first vulnerability grade is the same, the second one is for a population density of 101–300 inhabitants/km2 and the third one is for a population density above 500 inhabitants/km2. The vulnerability of economic activities is also divided into grades. Most of the economic activities are classified as 'not vulnerable'. The 'low vulnerability' grade was assigned to agricultural areas mixed with natural vegetation, the 'moderate vulnerability' grade was assigned to vineyards, orchards and complex cultivation patterns and 'high vulnerability' was assigned to urban areas, industrial areas, areas devoted to the exploitation of mineral resources and agricultural land. Special structures and objects are excluded, i.e. as areas of moderate vulnerability: building sites, and as areas of high vulnerability: roads, railways, airports and waste disposal sites.

The weaknesses of the vulnerability report are associated with to the groundwork for the elaboration of the report. For example, the vulnerability assessment is determined only for flood-prone areas with a 100-year return period. Vulnerability beyond the given range is not analysed nor shown. The work was based on the data from the CORINE database on land use, in a grid of 100 × 100 m. However, the CORINE database does not contain any data on the type of activities present and/or the potential of flood-induced ecological disasters. Also, the CORINE database does not provide data on the critical infrastructure, which is, indeed, a particularly important element of any vulnerability analysis. There are also no data on the vulnerability regarding the housing of population. Notably, the danger of loss of life in a flood-prone area with stable, solid, multi-storey concrete buildings is much smaller than in an area with wooden low-rise buildings. Furthermore, CORINE as a raster database does not contain data on important linear critical infrastructure such as: railways, roads, gas pipes, pipelines, water supply installations, means of telecommunications, sewerage installations, electrical wires etc. The vulnerability analysis should take into consideration the future, long-term development in the relevant areas. Also, the issue of the continuing depopulation of rural areas in the river basin areas remains (ISZD; 2014)[8].

The report on climate change impacts to floods is elaborated in two parts. The first part investigates the meteorological studies and calculations based on the simulations of effects of climate change

[8] ISZD, 2014, Dobna struktura hrvatskih općina i gradova http://iszd.hr/2014/01/dobna-struktura-hrvatskih-opcina-i-gradova/?lang=hr

based on scenario A1B and the data on observed precipitation E-OBS, collected for the 1961–2010 period. Based on 16 different simulations of climate change effects, the average of projected maximum daily precipitation values with an event probability of 20- and 100-year return periods, i.e. for each season, was elaborated. The projections of temperature increase were also elaborated. The calculations were made for the periods 1961–2010, 2011–2040, 2041–2070, and 2071–2100. The accuracy of projections is estimated at 30%.

The hydrological analysis of climate change was derived based on the hydrological model, which helped to capture the basic characteristics of the Sava River Basin hydrological system. The model was calibrated for one of the biggest flood events (1974), which affected the entire river basin. The 1974 event was chosen because it was one of the last events that was not the result of the anthropogenic effects due to the extensive river engineering works of the 1970s. The model and meteorological projection data were used to elaborate a hydrological analysis which gave probability distributions of maximum discharges for the individual forecasting periods for the water stations along the main stream of the Sava River. For the individual tributaries, only the percentages of the increase of precipitation events with 20- and 100-year return periods are given. The analysis has suggested a major impact of climate change, particularly in mountainous areas where it is predicted that the return period of events will decrease by ten times – 100-year return period events would become 10-year return period events. In plain areas of the river basin, i.e. in its lower stream, the climate change impacts to floods would be much smaller.

The main weakness in the calculations of climate change impacts to floods lies in the incompleteness of the E-OBS database. In the database, there are no data available on precipitation in the Sava river basin in Montenegro; also the water stations in other countries, i.e. with the exception of Slovenia, are extremely scarce, and the orographic effect of the Dinaric Alps to the precipitation distribution in the river basin is not captured well. The hydrological model provided an overview of the impacts, particularly in the most sensitive area along the main stream; however, it did not produce a detailed enough analysis of major tributaries and their parts. Flood event scenarios due to snowmelt and precipitation are also not considered. Here, we should draw attention to the flood of 1896 in the Drina river basin.

3. Assess the reliability of the results of the activities A3 and A4, and conclude whether additional modelling of climate change impact on flood vulnerability in the Sava River Basin is needed to obtain more reliable results

Both reports (UL FGG 2013[9] and US 2012[10]) provide a good view on the most sensitive flood areas along the main stream of the Sava. The increased vulnerability is present particularly in the upper Sava river and along the right tributaries, which drain water from the Dinaric Alps areas. The effect to the tributaries from the left bank area and in the lower Sava is much smaller. The effects cannot be neglected and must be considered in the planning and implementation of protection against floods in the river basin.

As mentioned before, the databases which provided the grounds for the elaboration of both reports (UL FGG 2013 and US 2012) are incomplete. Particularly the E-OBS database should be updated with the necessary data as soon as possible. An investigation into the accuracy of the meteorological simulations based on the revised E-OBS database should then be performed. For the river basin, a more detailed hydrological model should be produced, which would define the climate change effects to individual major tributaries and their parts, such as: Ljubljanica, Savinja, Krka, Sotla, Kolpa, Una, Bosna, Vrbas, Bosut, Drina and Kolubara. The aforementioned model could determine the impacts to smaller parts of the river basin, the impact of the structures to floods, and their role in mitigating climate change impacts. Furthermore, we should discuss the scenarios of climate change impacts to snowmelt and intensive precipitation.

The vulnerability analysis should be expanded to the entire area where floods are feasible. This would help to assess the scenarios of climate change and other anthropogenic changes to floods. Furthermore, the analysis should include the critical infrastructure, especially linear structures for transport, water supply and energy sources supply . An analysis on the reliability of the vulnerability data is also necessary.

Climate change impacts are relatively large and must not be neglected in flood safety analyses. Notably, the impacts are not the same throughout the river basin. In the headwater part, i.e. in the Alps, the impacts are somewhat greater than in the central and lower river reaches.

[9] UL FGG, 2013 Pilot project on climate change: building the link between flood risk management planning and climate change assessment in The Sava River Basin, COMPONENT A3: Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events, Part 2: Climate change impact on flood discharge of The Sava River, hydrology report, University of Ljubljana, Faculty of civil engineering and geodesy

[10] US 2012, Report on vulnerability analysis, Pilot project on climate change adaptation Building link between Flood Risk Management planning and Climate Change Assessment in the Sava River Basin.

4. Possible flood protection measures

For the purposes of water management planning in the Danube River Basin, ICPDR commission developed a report entitled DANUBE STUDY – CLIMATE CHANGE ADAPTATION – Study to provide a common and basin-wide understanding towards the development of a Climate Change adaptation strategy in the Danube River Basin (ICPDR 2012)[11]. The project has produced an overview of the studies and projects related to climate change and water resources management. On average, for each country some 40 to 50 studies were made. Despite the many studies, only the general conclusions of guidelines of EU Directives were presented. The general conclusion on floods in the middle part of the Danube River Basin is »High uncertainty in flood projections; no clear picture can be drawn about possible changes of flood conditions«. The general guidelines are highlighted for the use of wetlands as water retention and for development of spatial planning adapted to the needs of nature. Possible recommended measures are extensively listed in the report by ICPDR 2012 and presented in ANNEX 1 of this report.

Floods are not specifically mentioned in Slovenia's Fifth National Communication under the United Nations Framework Convention on Climate Change, developed by the Ministry of the environment and physical planning (MOP 2010)[12]. Also, no specific adaptation measures against floods are listed in the Second, Third, Fourth and Fifth National Communications of the Republic of Croatia under the United Nations Framework Convention on Climate Change by the Ministry of Environmental Protection, Physical Planning and Construction (MZOIP 2006)[13].

However, adaptation measures related to flood protection are mentioned in the section on physical planning and future development of urban areas, i.e. in the Initial National Communication (INC) of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change (BiH 2009)[14].

In the Initial National Communication of the Republic of Serbia under the United Nations Framework Convention on Climate Change (MOPP, 2010)[15], several adoptive measures are predicted for flood protection:

– Develop vulnerability map and map of flood risk
– Determine the need for widening and deepening riverbeds and their additional cleaning
– Estimate ability of dams and other constructions, as well as city channel systems for flood control
– Improve flood resistance systems
– Adopt flood control, including financial needs for its implementation
– Adopt a special plan for flood managing
– Improve hydrological observation network
– Improve early warning systems for climate and hydrological extreme events
– Establish a data base on extreme meteorological and hydrological events and disasters

[11] ICPDR, 2012, Danube Study – Climate Change Adaptation
[12] MOP (2010) Slovenia's fifth national communication
[13] MZOIP (2010), Fifth National Communication of the Republic of Croatia
[14] BiH (2009) Initial National Communication (INC) of Bosnia and Herzegovina
[15] MOPP (2010) Initial National Communication of the Republic of Serbia

– Improve research in area of numerical modelling of hydrological processes (precipitation/snow–runoff for different time intervals)

Large number of measures structured in ICPDR 2012[16] as:

1. Preparation measures for adaptation
2. General measures
3. Ecosystem based measures
4. Behavioural /managerial measures
5. Technological measures
6. Policy approaches

The problem is that the measures are collected from many reports, i.e. some measures are listed several times in slightly different wording, or they overlap.

In addition, the EU has derived numerous researches for flood risk management planning and implementation. A review of practice in individual EU countries was produced (Delft Hydraulics, 2007)[17]. Based on these studies, we can conclude that:
The Sava countries, Parties to the Protocol on Flood Protection to the FASRB, agreed on the hundred-year flood (Q_{100}) as the flood with medium probability, according to the Flood Directive. Nevertheless, the Flood Directive requires also the production of maps for higher discharges. In the past, Zagreb, Bratislava and New Belgrade are defended against the onset of Q_{1000}. Vienna is protected against the flooding of the Danube River of $Q_{10,000}$. The Krško Nuclear Power Plant is protected against the occurrence of the Probable Maximum Flood (PMF).

The implementation of structura measures is long and lasts for decades, and it enables and marks the spatial development of urban agglomerations, such as Vienna and New Belgrade. The Vienna flood protection scheme started in the 1970s and in New Belgrade in the 1950s, while the full urban development of these areas has been implemented recently.

Freeboard of embankments over the designed flood level varies in the practice of individual countries. In Slovenia it is 0.5 m, along the Sava River it is 1.2 m (Polytechna-Hydroprojekt-Carlo Lotty, 1972) [18], on the Danube River and in the Netherlands it is 2.0 m.

In determining the flood risk, the Flood Directive also requires the determination of appropriate water velocity. Slovenia has banned construction in areas where the depth of water exceeds 0.5 m by flood of a 100-year return period (Uradni list Republike Slovenije – URLS, 2008)[19]. Austria takes into consideration the depth of water and velocity, Figure 1.

[16] ICPDR, 2012, Danube Study – Climate Change Adaptation
[17] Delft Hydraulics, 2007, Atlas of Flood Maps, Examples from 19 European countries, USA and Japan
[18] Polytechna-Hydroprojekt-Carlo Lotty, 1972, Study for the Regulation and Management of the Sava River in Yugoslavia
[19] URLS 2008, UREDBA o pogojih in omejitvah za izvajanje dejavnosti in posegov v prostor na območjih, ogroženih zaradi poplav in z njimi povezane erozije celinskih voda in morja

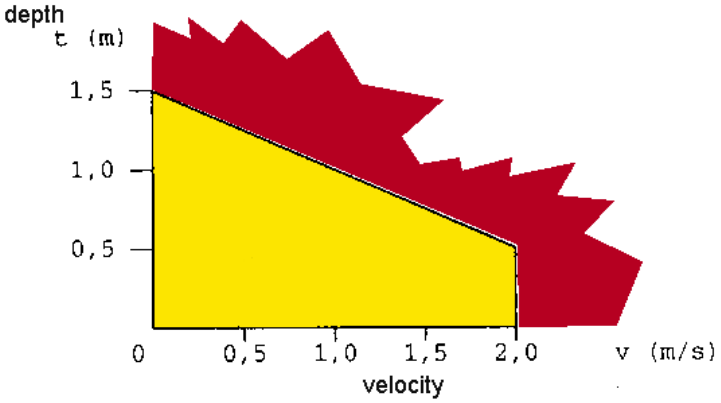

Figure 1: Criteria that determine medium and high flood risk by using flow depth and velocity in Austria (Delft Hydraulics, 2007)[20]

Through the already widely accepted concept »more room for river«, the efficient flood risk adaptation measure has been developed in the Netherlands (Klijn and Schweckendiek, 2012)[21], http://www.ruimtevoorderivier.nl/meta-navigatie/english/publications/. The Dutch *Room for the River Programme* started in 2007 and will be completed by 2015. With the goal to give more room to the river to manage the higher water levels, at more than 30 locations, 2.3 billion EUR measures are being taken. The nine measures used to provide more room for river are the following:

1. Deepening summer bed. The river bed is deepened by excavating the surface layer of the river bed.
2. Water storage. The Volkerak-Zoommeer lake provides for temporary water storage when exceptional conditions result in the combination of a closed storm surge barrier and high river discharges to the sea.
3. Dike relocation. Relocating a dike land inwards increases the width of the floodplains.
4. Strengthening dikes. Dikes are strengthened in areas in which creating more room for the river is not an option.
5. High-water channel. A high-water channel is a diked area that branches off from the main river to discharge some of the water via a separate route.
6. Lowering of floodplains. Lowering (excavating) an area of the floodplain.
7. Lowering groynes. Groynes stabilise the location of the river and ensure that the river remains at the correct depth.
8. Depoldering. The dike on the river side of a polder is relocated land inwards and water can flow into the polder at high water levels.
9. Removing obstacles or modifying them in the river bed where possible, increases the flow rate of the water in the river.

United Nations Economic Commission for Europe (UNECE) published the Guidance on Water and Adaptation to Climate Change, 2009[22]. Among other suggestions, in Table 2 of the report, instructions are given for selection and prioritizing of adaptation measures. Some of the criteria

[20] Delft Hydraulics, 2007, Atlas of Flood Maps, Examples from 19 European countries, USA and Japan
[21] Klijn and Schweckendiek, 2012, Comprehensive Flood Risk management, Research for policy and practice
[22] UNECE, 2009, Guidance on water and adoption of climate change

related to the transboundary impacts, promoted by UNECE[23], but not published in the report, are listed in Table 1 below.

Table 1: Criteria for transboundary impact assessment

No.	Criterion	Questions to be asked
1	Side-effects	Does the measure have potentially negative impact effects on other riparian countries?
2	Efficiency / costs and benefits	Is the measure beneficial for the basin as a whole? Is this measure taken at an effective and efficient location considering the entire basin?

[23] UNECE unpublished workshop paper

5. Existing measures for flood risk management in the Sava River Basin

The flood protection measures in the Sava River Basin are based on STRATEGY B: »modify flooding«, particularly using dikes, levees and high flow diversions (FEMA 1992, ANNEX 2)[24], as planned in the project by Polytechna-Hydroprojekt-Carlo Lotty, 1972[25]. Large and complex systems of levees, detention ponds and alternate flood channels were constructed. Other measures are well developed on the national level.

Some flood protection measures are in full design development in Slovenia. Structural measures with water storages will be implemented in the Savinja River and on the Sava River stream to supplement the development of hydropower plants. All those measures will have some impact on the floods downstream. The environmentally friendly maintenance of the river corridor has increased the hydraulic resistance of stream flow and caused serious floods in the past few years. Proper maintenance and regular vegetation cutting in the stream corridor will produce some impacts on the downstream floods, too.

After the serious flood in the area of the City of Zagreb in 1964, the construction of major flood protection works commenced in Croatia (US 2012)[26]. Until today, only 40% of the construction of the complex system, consisting of the large detention ponds and high flow diversion channels and hydraulic structures, has been finished. Part of the inundation between the border with Slovenia and Zagreb is not protected yet. Zagreb is protected against 1000-year return period events. Between the town of Sisak and the mouth of the Una River, a system of eight detention ponds was constructed. The system reduces areas inundated during a Q_{100} event by 65%. The downstream part of the large inundated areas has just been foreseen for reconstruction.

The inundated area on the right bank of the Sava River, between the Una River mouth and the Drina River mouth, in a total length of 332 km, is in the responsibility of Bosnia and Herzegovina. The very fertile area is protected by several independent systems of levees and pumping stations (23 in total). The area is also affected by right-side tributaries. Major tributaries are: Una, Vrbas, Bosna and Drina River. The areas on the mouth of the tributaries are affected by high water in the Sava River and in the tributaries. The hazard rate depends on the coincidence of high flows. There is no data on the return period for which the particular areas are protected (ISRBC 2009). On the mouth part of the tributaries, flood hazard should be integrated with the ground water regime. The floods in tributaries are affected by storage and reservoir operation of the HP facilities. For hazard risk analysis, the 1896 flood event on the Drina River that was estimated as a PMF event is of great importance.

The lower part of the Sava River, downstream of the mouth of the Drina River on the right bank, and downstream of the border with Croatia, which is upstream of the mouth of the Bosut River on the left bank, belongs to the Republic of Serbia. There are large inundated areas affected by the Sava River and its tributaries. Major tributaries are: Drina River, Bosut River and Kolubara River. The complex systems of levees and pumping stations have been constructed in the past with different

[24] FEMA, 1992, FLOODPLAIN MANAGEMENT IN THE UNITED STATES
[25] Polytechna-Hydroprojekt-Carlo Lotty, 1972, Study for the Regulation and Management of the Sava River in Yugoslavia
[26] US, 2012, REPORT ON VULNERABILITY ANALYSIS

protection level, i.e. from Q_{1000} at New Belgrade and up to Q_{100} on other systems. The lower part of the Sava River is under impact of the Danube River. The climate change impact on the lower part is related to the coincidence of floods in the Sava River and the Danube River.

The Sava River is quite winding in its midle and lower parts. Also, it was not heavily modified in the past and major inundation areas are also in function today.

The legal and administrative framework for integrated flood risk management in the Sava River Basin is well established by the Protocol on Flood Protection to the Framework Agreement on the Sava River Basin (hereinafter: the Protocol). The Protocol is based on the Framework Agreement on the Sava River Basin (FASRB). By the Protocol, the Parties commit themselves to undertake the following actions:

- Program for development of the Flood Risk Management Plan in the Sava River Basin;
- Preliminary Flood Risk Assessment;
- Preparation of Flood Maps;
- Flood Risk Management Plan in the Sava River Basin;
- Flood Forecasting, Warning and Alarm System in the Sava River Basin.

The actions are now fully in development.

6. Recommendation for climate change adaptation measures for flood protection

The optimal solution for complex flood management is in a multilevel integrated approach. In doing so, we capture the essential factors, which are different on a case-by-case basis (Brilly, 2000)[27]. »Implementing integrated water resources management supports adaptation« is strongly recommended by UN 2009 and European Environmental Agency, Laaser, 2009[28]. The Recommendation for adaptation of flood management to the possible climate change should be developed according the Protocol on flood protection to the Framework Agreement on the Sava River Basin. The main actions are accepted in the Protocol and are in development.

Flood risk management is the integration of hazard or geophysical phenomena that produce floods and vulnerability or anthropogenic activity that cause victims and damage. Estimations of risk depend on hazard and vulnerability. The recommendation for adaptation of flood management to the possible climate change should be developed according to the Protocol on Flood Protection to the Framework Agreement on the Sava River Basin. The main actions are accepted in the Protocol and are in development.

The hazard of flooding is presented by hazard maps of events with certain return periods. The Flood Directive asks for the following maps: (a) floods with a low probability or extreme event scenarios; (b) floods with a medium probability (likely return period ≥ 100 years), and (c) floods with a high probability, where appropriate. The Flood Directive is not so strict in relation to mapping, but in future we should produce hazard maps for PMF (Figure 2). As assessed in the second part of the report, climate change will increase flood discharges in:

- head and midle parts of the watershed (Water Station WS) Čatež – WS Županja), where the flood discharges with medium probability will be discharges with high probability
- on the lower part of the Sava River stream (WS Sremska Mitrovica) where the probability of discharges will not change as much (from a 100-year return period to a 50-year return period).

Climate change will take time, i.e. decades in which vulnerability will change, that will have a strong impact on risk estimation. Some facilities should be protected against PMF: nuclear power plants and critical infrastructure, Figure 2. The action is supported by the ICPDR 2012 report in items 1.2, 1.3 and 6.1 (Annex 1).

Integration flood risk management with spatial planning will shift development out of the hazard areas, establish areas without protection and with local mitigation measures and derive appropriate regulations. Action is supported by ICPDR in items 1.4, 2.3, 2.4 V, 2.5, 3.1, 3.2, 3.3, 3.5, 4.2, 4.3 ii v–viii x, 4.4 ii, 4.5, 6.2 and 6.10 (Annex 1) .

[27] Brilly, 2001, The integrated approach to flash flood management
[28] Laaser, 2009, Report on good practice measures for climate change adaptation in river basin management plans

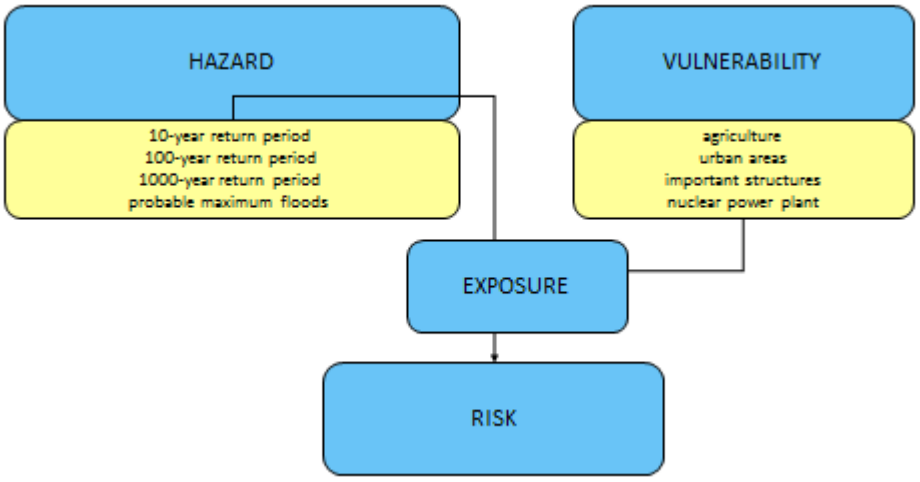

Figure 2: Components of the flood risk analysis

Develop up-to-date monitoring of water regime, like the one established in the BOBER project (Better Observation for Better Environmental Response) in Slovenia. Numerous water stations with sensors for water level measurements, sensors for water velocity measurements, multisensory probe for water quality measurements could be established also with low funding. Probes are equipped with memory and are capable to pick up data in a short period of time. The data are necessary for hydrology models, calibration of unsteady hydraulic models and estimation of impacts of structural measures. The 3D velocity meters are capable to pick up the data on the 3D velocity in a short distance along the profile, which is highly important for the understanding of water flow in inundated areas and the back water impact on the tributaries. Areal precipitation could be measured by weather radar. Also, snow cover measurements are crucial for flood forecasting in the Sava River basin. The measurement will also strongly support the action in the Protocol Flood Forecasting, Warning an(Annex 1)d Alarm System in the Sava River Basin. Monitoring is supported also by the ICPDR Study in item 1.5 .

The collected data will give the possibility of development and calibration of hydrological and hydraulics models. Technology now allows us to develop relatively accurate predictions of precipitation, including three days in advance. Also, models for hydrological forecasting allow us to quite reliably predict floods three to four days in advance. That gives the possibility to implement a range of other measures presented in strategies A and C. The solution is in the multilevel integration of measures adapted to the dimensions of risk, vulnerability and currently available funding. The action is supported by ICPDR item 1.1, 2.4 i–iv (Annex 1) .

Increase protection of heavily urbanised areas and critical infrastructure by structural measures are in development. The measures are supported by ICPDR in item 5 (Annex 1) .

Increase of flood protection on special vulnerable areas. It is necessary to prepare different solutions to protect major cities and critical infrastructure (sensitive technological facilities, highway, railway, pipeline etc.) against floods with high return periods and including flood events up to PMF. According to their safety based on structural measures, it is necessary to prepare other measures: zoning, emergency plans, and regulations for flood hazard areas, building codes, flood proofing,

redevelopment, permanent evacuation and other regulatory tools. Actions as »room for river« and similar are supported by ICPDR: items 1.8, 2.2, 2.4 ii v, 2.5, 4.3 ix, 4.4 iv, 4.7 and 5 (Annex 1).

Prepare plans of actions at the level of the river basin and develop monitoring of cross-border impacts on flood risk. Take care of maintenance of flood protection measures of common interest. Develop manuals and regulations for construction of buildings and infrastructure that are resistant to flooding. Information development, education, presentation examples of good and bad practices should be derived. The actions are supported by ICPDR, item 6 (Annex 1).

It is necessary to define the effects of measures for protection against flooding and construction of hydropower facilities, on the development of flood waves along the Sava River and its tributaries. Hydrological measurement data after 1970 are burdened with these effects and do not show the natural water regime. There are also different trends across the watershed, including process of afforestation of abandoned agricultural land. We propose to produce a natural flow pattern of the Sava River and its tributaries from 1970 to the present. With such a sample, we could perform a proper probabilistic analysis and define the probability of flood flows.

A vulnerability analysis should cover a wider area than just that of Q_{100}, i.e. at least the area up to the PMF hazard. We propose to take into account the area with an altitude of 5 m above the present water level of Q_{100}. Special attention should be given to industrial facilities that could produce an ecological catastrophe, as well as transport infrastructure, especially roads and highways. Last year in Slovenia, an increasing number of people lost their lives by driving their cars in high water.

Establish more accurate EOBS data and repeat the calculations of the impact of climate change on precipitation in the basin.

Implementation of structural measures requires a lot of time. Measures for flood protection provided in the Central Posavina region, with plans drawn up in the early 1970s, have not been fully developed to the present day. The same applies to other actions in certain areas. Do the requirement to reduce risks and objectives always stay the same, or do they change? And, last but not least, what is the perspective in the coming decades: will our actions today guide the development in the coming decades (as the current state of flood risk is due to the development in the past decades)?

Taking into account climate change and further dynamic development, flexibility is an essential characteristic of the measures that will be implemented. Even today, we make plans to meet the highest security standards, which will be implemented in the future. Above all, there is the need to reserve the space in which the water could overflow and reduce the pressure on the highly protected areas. The paradigm oriented in abstraction of space from rivers for the purposes of development and various anthropogenic activities, should be shifted into a more intensive and safe use of space, leaving more room for the river and nature in order to achieve the objectives of sustainable development.

The 3rd Consultation Workshop on the Pilot project on climate change adaptation: Building the link between the Flood Risk Management planning and climate change assessment in the Sava River Basin was held in Zagreb, 5–6 June 2013[29]. There were 36 participants from the countries of the Sava River Basin, international agencies and observers. After the presentation of the results of the project,

[29] http://www.savacommission.org/event_detail/8/22/295/1

in the group discussion several conclusions were drawn. Also, the participants were requested to complete two questionnaires.

In the first questionnaire (the table in annex 1), the participants were asked to prioritise the measures in terms of high, medium and low importance. High importance was given to the following measures:

1. **Regulation on land use and spatial planning**, especially: development of flood hazard and hazard class maps, creation of missing maps of flood hazards for rivers of category I and II and application of agro-technical measures, forest managing measures and land in accordance with nature protection.

2. **Reactivation of former, or creation of new retention and detention capacities,** especially: through water acts, defining the necessary storage volume and operation regime of the existing retentions and reservoirs for flood defence, reconstruction measures for flood defence existing objects, consideration of possibilities for construction of new multipurpose reservoirs and retentions, design and construction of a new flood defence system on the Sava River tributaries, regular, on-going maintenance, reconstruction and remediation of existing objects for flood defence and regular, on-going maintenance of regulated waterway sections.

3. **Non-structural measures,** especially: creation of agreed methodology for the production of flood hazard maps and vulnerability maps, creation of vulnerability maps, flood hazard maps and flood risk management plans, preparation, adoption and updating of flood defence plans, continuous data exchange between institutions in charge of flood defence, support to scientific and educational projects related to flood aspects, professional expert training for application of water resources, integral management principle, improvement of automatic forecasting stations and water-measuring stations with the possibility of adequate data displaying in ISV, improvement of meteorological and hydrologic forecasting systems, with data displaying in ISV, improvement of the system for advance informing, warning and alerting the people under the flood hazard, international exchange of meteorological and hydrological data, as well as data on flood defence operational measures, improvement of public awareness on floods and improvement of international cooperation in flood management.

7. Programme for climate change adaptation measures for flood protection

The Flood Protection Expert Group of ISRBC produced a report with a list of measures for flood protection in different countries in the basin, ICPDR-ISRBC, 2009. The table, with the list of provided measures collected from the countries, is presented in the report. There are measures for maintenance and improvement of existing flood protection structures, improvement of flood protection by construction of multipurpose hydropower dams, changes in spatial planning and institutional strengthening. The list of measures is in Annex 3, equipped by comments on climate change and trans-border impacts.

Climate change will significantly increase the flood hazard along the main stream and over the watershed. Indeed, climate change will influence, directly or indirectly, more or less, all of the measures provided in Annex 1. Some of the measures, mainly structural, could have a significant impact on the flood hazard downstream with trans-border impacts; a flood risk assessment study downstream, before the implementation, is required.

Program to mitigate the impact of climate change:

1. Institutional strengthening of the organizations responsible for the collection and exchange of hydrological data; updating equipment for water level measuring; purchase of new state-of-the-art equipment (meteorological radars, snow cover water content, and infiltration rate); use of satellite images for hydrological monitoring; development of models for the prediction of rainfall and runoff; the installation of additional water stations on the Sava River and their transboundary tributaries. Institutional strengthening is fundamental for development of an up-to-date hydrological forecast and warning system.
2. Determination of cross sections for monitoring changes in the morphology of the river bed along the main stream of the Sava River and the tributaries on the border: The Kolpa/Kupa River, the Sotla/Sutla River, the Una River, the Bosut River and the Drina River. Special attention should be on the sections of the intake of major tributaries in the Sava River main stream. The profiles should be labelled with permanent geodetic points on the ground and the measurements should be repeated every 2 or at least 10 years. Erosion or sedimentation could have a significant impact on the water level. The river bed erosion of the Sava mainstream in the areas of Ljubljana and Zagreb municipalities has significantly increased flood protection in the areas. Sedimentation of river bed will increase inundation and decrease flood protection. Morphology data are also essential for successful hydraulics model calibration and validation.
3. The development of hydrologic models for the prediction of flood flows, including assessment of land use and changes in the biosphere. Development of hydraulic models for calculating water levels along the Sava River and the tributaries to forecast water levels and determine the effects of various interventions for flood protection in downstream areas. A well calibrated and maintained hydraulics model is essential for good flood forecasting and determination of flood measures on flood protection along the Sava River. The model will be developed using the results of tasks 1 and 2.
4. Increase of the level of protection of major cities along the Sava River: Belgrade, Zagreb and Ljubljana. The impact of provided solutions should be determined by hydraulics model.

Similar protection should be developed for critical infrastructures: highways, railroads, industrial and health care buildings.

5. The protection of other cities and populated areas along the Sava River depends on long-term spatial planning and future development. Zoning should be integrated with spatial planning. Giving more space to rivers, by deepening and widening of the river channel; increasing the floodplains by lowering the surface and the movement of dams; removal of structures that impede water flow; and similar with special attention to river front development.
6. Protection of agricultural areas should be kept on today's level or even at a lower level, in order to mitigate the effects of additional protection of urban areas. Those areas should be equipped with proper warning systems.
7. Integration of flood protection measures with water management, Water Framework Directive and sustainable development.

8. Analyze the suggested measures related to the costs, effectiveness, side effects, vulnerability reduction, feasibility of implementation and alternatives

The first three measures, as foreseen in the previous chapter relate to the improvement of the information basis for flood risk management in the Sava River Basin. This also provides the basis for collection and processing of reliable information on flood events, their forecasting and, last but not least, identification of effects of operation of different structures in the river basin. The models produced in Action 3 will be the basis for estimate of cross-border impacts of different flood protection measures and their remediation.

In Slovenia, an on-going research project »Upgrade of the system for monitoring and analyzing the water environment in Slovenia« covers the tasks foreseen under the first three items. The costs of the project is 33 million EUR. For the elaboration of a similar project for flood protection in the entire Sava River Basin an additional 100 million EUR would be necessary. The project can be carried out in cooperation with interested economic sectors, i.e. hydropower electricity generation, agriculture and navigation. The programme could be implemented in stages, according to the funds available. The programme is also the basis for implementation of all other flood protection measures and for establishing their efficiency.

The measures foreseen under items 4, 5 and 6 are long-term measures to be implemented in the following decades. The estimated costs will be up to three billion EUR. Currently, the estimated costs of works for protection against floods in Slovenia, co-financed by the Cohesion Fund until 2015, are 185 million EUR. The planned works can be implemented gradually, in cooperation with different economic sectors. Presently, the projects on energy exploitation of the Sava River in Slovenia and in Croatia to Sisak are being drafted. Under the design projects, the flood safety of the City of Zagreb will be addressed. There are also preparations to address the hydropower development of the Drina River, which will include the installation of flood-storage into reservoirs.

Possible alternative solutions include in-depth analyses of spatial development along the river between Sisak and the inflow of the Sava into the Danube. Certain alternative measures for the Middle Sava have been prepared, with revisions of initial projects of flood protection for the Middle Sava. Similar solutions and initiatives have been developed in other areas along the river.

9. Select a package of measures (long-term, medium-term and short-term measures, prevention, preparedness, resilience, response and recovery measures)

Based on previous analyses and extensive materials provided in Annex 3, packages of short-term, medium-term and long-term measures for the Sava River Basin have been elaborated. Actions should integrate water management, spatial planning and sustainable development in order to assure the production of synergistic effects and the optimum use of funds. Some of the actions are listed in more detail in the table, ANNEX 3.

Phase A: The short-term measures, which will take place in the next years, include the development of a flood warning system based on institutional strengthening, hydrologic and hydraulics modelling, and renovation of construction of existing flood protection structures. The short term measures are:

1. Institutional strengthening of the organizations responsible for the collection and exchange of hydrological data:
   - updating of equipment for water level measuring;
   - use of satellite images for hydrological monitoring;
   - development of models for the prediction of rainfall and runoff;
   - the installation of additional water stations on the Sava River and their transboundary tributaries.

2. Determination of cross sections for monitoring the changes in the morphology of the river bed along the main stream of the Sava River and its tributaries. The profiles should be labelled with permanent geodetic points on the ground and the measurements should be repeated every 2 or at least every 10 years.

3. The development of hydrologic models for the prediction of flood flows, including assessment of land use and changes in the biosphere. The hydrologic model is essential for the flood warning system development.

4. Development of hydraulic models for calculating water levels along the Sava River and the tributaries to forecast water levels and determine the effects of various measures for flood protection in downstream areas. A well calibrated and maintained hydraulics model is essential for good flood forecasting and determination of the impact of flood measures to flood protection along the Sava River. The models will be developed using the results of tasks 1 and 2.

5. Preparation and development of flood risk maps including uncertainty and climate change impacts for the entire Sava River Basin. Preparation works for flood risk management measures ask for delineation of water estate solving of property right relations to the water estate and flood protection structures.

6. Maintenance and renovation of construction of existing flood protection structures in the Sava River Basin and its mechanical equipment (gates and pumping stations).

Based on experience and costs of similar EU projects, the costs are estimated at 50 million EUR. Items 1–4 will take approx. 2 million EUR, item 5 will take approx. 3 million EUR and item 6 will take the rest of the funding.

Phase B: The medium-term measures include the continuation and completion of works in the phase A and the execution of works related to flood protection of the capital cities of Ljubljana, Zagreb, Belgrade and Sarajevo.

The medium-term measures, collected from individual segments (in the following fifteen years), are:

1. Institutional strengthening of the organizations responsible for the collection and exchange of hydrological data. Purchase of new state-of-the-art equipment as: meteorological radars, measurement of snow cover water content and soil moisture.

2. Increase of the level of protection of major cities along the Sava River: Belgrade, Zagreb and Ljubljana. Similar protection should be developed for critical infrastructures: highways, railroads, industrial and health care buildings.

3. The protection of other cities and populated areas along the Sava River depends on long-term spatial planning and future development. Remuving the obstacles for flood flows. Zoning of areas should be integrated with spatial planning.

Based on experience and costs of similar EU projects, the costs are estimated at at **1 billion EUR**.

Phase C: The long-term measures will be implemented in the following 50 years. The long-term measures include the continuation and completion of works in the all of segments.

The long-term measures, derived from future needs and other mesures listed in Annex 3 which will be implemented according to Water Framework Directive and Flood Directive.

Based on experience and costs of similar EU projects, the costs are estimated at projects **2 billion EUR**.

10. References

Brilly, M., 2001, The integrated approach to flash flood management. GRUNTFEST, Eve (ed.), HANDMER, John W. (ed.). Coping with flash floods, (NATO science series. 2, Environmental security, v. 77). Boston: Kluwer Academic Publishers, 2001, 2001, pp. 103–113

Delft Hydraulics, 2007, Atlas of Flood Maps, Examples from 19 European countries, USA and Japan, prepared for RWS – RIKZ (http://www.arhiv.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/okolje/pdf/vode/atlas_primerov__kartiranja_poplavne_nevarnosti_ogrozenosti.pdf)

FEMA, 1992, FLOODPLAIN MANAGEMENT IN THE UNITED STATES: an assessment report - Volume 2: Full Report

ICPDR 2012, DANUBE STUDY – CLIMATE CHANGE ADAPTATION "Study to provide a common and basin-wide understanding towards the development of a Climate Change adaptation strategy in the Danube River Basin", Department of Geography, Chair of Geography and Geographical Remote Sensing, Ludwig-Maximilians-Universität Munich, Germany

ICPDR-ISRBC, 2009, Sub-Basin Level Flood Action Plan, Sava River Basin, Flood protection Expert Group

ISRBC – INTERNATIONAL SAVA RIVER BASIN COMMISSION, 2009, Sava River Basin Analysis Report

ISZD, 2014, Dobna struktura hrvatskih općina i gradova http://iszd.hr/2014/01/dobna-struktura-hrvatskih-opcina-i-gradova/?lang=hr

Jansen, P., Van Bendegom, L., Van den Berg, J., De Vries, M., Zanen, A., 1979. Principles of River Engineering. Pitman

Klijn, F., Schweckendiek, T., 2012, Comprehensive Flood Risk management, Research for policy and practice, CRC Press, Taylor and Francis Group, A Balkema book, 2012

Laaser, C., Leipprand, A., de Roo, C., Vidaurre, R., 2009, Report on good practice measures for climate change adaptation in river basin management plans. European Environmental Agency, European Topic Centre on Water, 2009

Polytechna-Hydroprojekt-Carlo Lotty, 1972, Study for the Regulation and Management of the Sava River in Yugoslavia

UL FMF, 2013 Pilot project on climate change: Building the link between flood risk management planning and climate change assessment In The Sava River Basin, COMPONENT A3: Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events, Part 1: Report on meteorological part of development of climate projections for The Sava River Basin, University of Ljubljana, Faculty for mathematics and physics

UL FGG, 2013 Pilot project on climate change: building the link between flood risk management planning and climate change assessment in The Sava River Basin, COMPONENT A3: Compilation of various existing climate change scenarios for the region, their expected impacts on water cycle and more specifically on frequency and magnitude of extreme flood events, Part 2: Climate change impact on flood discharge of The Sava River, hydrology report, University of Ljubljana, Faculty of civil engineering and geodesy

UNECE 2009, Transboundary flood risk management, Experiences from the UNECE region, United Nations Economic Commission for Europe, United Nations New York and Geneva, 2009

UNECE, 2009, Guidance on water and adoption of climate change, United Nations Economic Commission for Europe, United Nations New York and Geneva, 2009

UN 2009, Guidance on Water and Adaptation to Climate Change, Economic Commission for Europe, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, United nations, New York and Geneva, 2009

URLS 2008, UREDBA o pogojih in omejitvah za izvajanje dejavnosti in posegov v prostor na območjih, ogroženih zaradi poplav in z njimi povezane erozije celinskih voda in morja, Uradni list RS, št. 89/2008 z dne 19. 9. 2008

URLS 2010, UREDBA o vsebini in načinu priprave podrobnejšega načrta zmanjševanja ogroženosti pred poplavami, Uradni list RS, št. 7/2010 z dne 29. 1. 2010

US 2012, Report on vulnerability analysis, Pilot project on climate change adaptation Building link between Flood Risk Management planning and Climate Change Assessment in the Sava River Basin, University of University of Split, Faculty of Civil Engineering, Architecture and Geodesy.

ANNEX 1. Possible recommended measures listed in the report by ICPDR 2012

1. Preparation measures for adaptation

1.1 Development of a Danube-wide flood forecasting system
i) Assessment of existing national and international flood forecasting
ii) Development of a system for timely and reliable flood forecasting and information based on the relevant regional and national systems
iii) Improvement of existing systems and their interconnection, e.g. by the implementation of mathematical models and radars, which can give a quantitative forecast of precipitation, by provision of additional information to national and regional flood-forecasting authorities, by including plans for early warning evacuation
iv) Further development and testing of Flood Alert System
v) Implement forecast for flash floods

1.2 Implementation of a flood risk assessment for the identification of areas exposed to floods

1.3 Establishment, use and regular adaptation of flood hazard, risk and vulnerability maps and databases including uncertainty related to climate change impacts (e.g. support the Danube FLOODRISK project) in order to increase public awareness of the areas at risk from flooding, to provide information of areas at risk to give input to spatial planning and to support management and the reduction of the risk to people, property and the environment.

1.4 Development of Strategies and Plans
i) National Protection and Rescue Strategy for emergencies and design of protection and rescue plans
ii) Contingency, confinement and possibly evacuation plans of trans-national flood areas (floodplain basins) should be worked out jointly by the interested countries
iii) Drafting and implementation of a Water and Climate Adaptation Plan for River Basin (fill the knowledge gap on the impact of climate change on water sector and 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)
iv) Preparation of working plans for the sub-basins
v) Establishment of incorporated concepts for the protection of torrents in order to assess the risk of flood and define precautions

1.5 Monitoring
i) Of changes of flood patterns by gathering comprehensive information on past floods
ii) Development of a »past floods database at European level«
iii) Development of a monitoring network with modern measuring equipment at stations and software packages for the assessment of the intensity of precipitation, with the use of radar imaging systems
iv) Development methodologies on monitoring of the condition of flood defence structures incl. remote sensing techniques

1.6 Improvement of information systems
i) Planning and implementation of informatics system supporting the planning process and utilisation of digital contingency and confinement plans in DS in order to enhance flood protection
ii) Organisation of flood and reporting services, flood recording and documentation

iii) Creation of forums for exchange of expert knowledge
iv) Upgrading confinement planning in digital format, enabling digital archiving and the utilisation of their information and data base in DSS
v) Making sure that best available information is taken into account when flood scenarios are reviewed regularly
vi) Implementation of effective public communication systems for managing crisis situations
vii) Enabling influencing the communication specific mass audience should be able to influence
viii) Improvement and increase of information exchange

1.7 Re-evaluation of flood protection and water structures taking into account climate change impacts

1.8 Updating flood design values

2. General measures

2.1 Promotion and extension of insurance systems for protection of goods and persons against damages from floods.

2.2 Considering both, use and protection in supporting new infrastructure

2.3 Implementation of integrative flood prevention programs to support flood-prevention measures with retention

2.4 Improvement of resistance
i) Strengthening existing protection
ii) Increase the resilience of civil protection and disaster management infrastructure in view of climate change
iii) Development and strengthening emergency organisations and their cooperation
iv) Raising preparedness and emergency response capabilities
v) Increase the level of flood protection for cities and settlements along major water streams, by enlarging and rehabilitating existing systems

2.5 Prevention of accidental pollution during floods affecting the storage facilities of dangerous substances

3. Ecosystem based measures

3.1 Using synergies of flood protection and biodiversity conservation, e.g. in the renaturation of rivers and riparian systems in order to create additional flood plains and habitat for rare ecological communities and to buffer run-off peaks

3.2 Protection and restoration of water retention areas, including natural reservoirs
i) Creation or restoration of retention areas to increase water retention properties of the landscape
ii) Use water retention capacity of wetlands
iii) Provision of further information on natural retention (e.g. the appropriate strategy consists of three steps: retaining, storing and draining; therefore protection and restoration of infiltration areas in the upper parts of the catchment and conservation and restoration of wetlands are crucial for the water retention)

iv) Increasing natural retention and storage capacity (e.g. construction of artificial side channels, reconnection of old river arms and increasing water transport and retention capacity of floodplains): the storage effect of vegetation, soil, ground and wetlands has an important mitigating effect particularly in minor or medium-scale floods; each of these storage media is capable of retaining certain quantities of water for a certain length of time; a large natural storage capacity results in slow rises in water levels, thus reducing the flood wave, and enables sustaining or contributing to the restoration of self-purification capacity of water

3.3 Regional planning

i) Making extensive use of all available potentials to achieve a considerable expansion of retention areas and to provide effective long-term protection against the flood risks
ii) Improvement of the opportunities for rainfall to soak away naturally by reducing new land take of open spaces for settlement and infrastructure
iii) Provision of planning support for restoration, unsealing, restoration
iv) Reservation of areas for flood control (going beyond the designation of flood control areas required by water legislation), in order to safeguard existing discharge and retention areas and preparation of their necessary expansion
v) Spatial planning and construction activities in the context of climate change and increased threats of floods

3.4 Reintroduction of alternative and more sustainable measures, such as widening the area between dikes, creating accumulation polders for capturing flood waves instead of permanent reservoirs, revitalizing streams and increasing natural retention capacities

3.5 Preparation of an overview of the implementation of future measures to achieve the WFD environmental objectives while ensuring an appropriate level of flood protection

4. Behavioural /managerial measures

4.1 Awareness raising, training and education of the general public

i) Raising awareness and ensuring the preparedness of the general public through dissemination of printed materials on floods risks and prevention organization of public meetings and training
ii) Including climate change related flood risk changes in on-going education initiatives to improve flood risk awareness and preparedness
iii) Professional consultation on flood prevention
iv) Information through mass-media
v) Using informal networks for information dissemination
vi) Establishment of community self-protection teams promoting self-reliance among residents and businesses to minimize the risk to personal safety and property damage during a flood event
vii) Building ability to »live with floods«
viii) Carrying out public awareness and information in order to encourage citizens to behave in suitable ways before, during and after the passage of the floods and to take their own precautions
ix) Establishment of a training program for dyke defence
x) Organisation of regular defence exercises on local, regional, national and trans-national level to test preparedness and co-operation between water authorities, disaster and rescue services, leaders of public administration and local governments, police, road administration, military forces, hydropower companies and local industry

4.2 Adaptation of floodplain systems

i) Establishment of new floodplain areas
ii) Increasing the size of existing floodplain areas
iii) Removing of hydraulic obstructions
iv) Conservation, effectively protection and restoration of floodplains
v) Promotion of transnational conservation of the remaining floodplains along the entire length of the Danube by completing existing initiatives and promoting new ones
vi) Avoiding possible negative effects on agriculture, rural settlements and water pollution from contamination due to intensive use of chemicals on agricultural lands in planning the reactivation of protected floodplains
vii) Delimitation of inundation zones for safe passage of major floods through affected territory

4.3 Adaptation of flood management

i) Implementation of proper flood control practice
ii) Implementation of appropriate floodplain management to explore the benefits of flooding
iii) Implementation of so-called non-structural means of flood control, such as organisational tasks
iv) Involvement of local stakeholders
v) Concentration on the reduction of current vulnerabilities to extreme events
vi) Highlighting floodplains in river basin management when designating areas for restoration and flood control
vii) storage
viii) Combination of non-structural and structural measures of flood risk management
ix) Increasing river basins protection by means of both passive safety measures and active river regulation
x) Correlation of the territorial development and improvement plans with the strategy and the risk management plans in the case of floods
xi) Improvement of bilateral and multilateral cooperation in planning enhancements, especially in contingency planning
xii) Integration of flood risk management into land use planning

4.4 Sustainable agricultural practices

i) Introduction of flood-tolerant species
ii) Following nature conservation and flood control requirements
iii) Using agricultural practices such as avoiding bare soil during precipitation season, minimise plough land on the slopes of hills
iv) Improvement of drainage
v) Support runoff reduction by agronomic practices like no-tillage and cropping systems

4.5 Changing land use and adaptation of land use management

i) Replacement or complementation of the prevailing intensive agriculture dependent on flood levees and drainage in order to balance hydrological processes
ii) Enabling natural ecosystems to return to their former territories through the rehabilitation of naturally flooded areas
iii) Ensuring a coordinated approach in land-use planning (through this action synergy effects between river basin management and flood risk management could be used)
iv) Afforestation in upper basin areas and on broad floodplains along the river to increase the water retention capacity of the river basin
v) Maintenance and expansion of the forest population in river basins by semi-natural reforestation, particularly in mountain and hilly ranges
vi) Maintenance of the vegetation edging waterways to support biodiversity of these environments, and help against risk of flood damages
vii) Implement land use regulation to preserve and enhance natural retention across the river basin

4.6 Capacity building: raising preparedness of the organisations responsible for flood mitigation

4.7 Adaptation of flood management concerning the water infrastructure
i) Regulation of the flow regime by increasing the flow capacity of the channels of water courses
ii) Increasing the safety of water works
iii) Increasing the capacity of safety overflows
iv) Change the operation of reservoirs and lakes
v) Creation of accumulation polders for capturing flood waves instead of permanent reservoirs
vi) Cutting a flood carrying clearance, a corridor, within the floodplain, in the dense vegetation

5. Technological measures

5.1 Structural flood protection / adaptation of urban infrastructure
i) Adaptation of stream canalization
ii) Improvement of existing drainage systems and capacity, including the separation of sewage, sewer relief from flood waters by offsite pumping and other solutions
iii) Installing pumps for water extraction at the floods events
iv) Installation of non-return valves in all building connections to the public sewage network
v) Construction of removable or modifiable structures e.g. bridges, which can be moved out of the water's way
vi) Modification of transport infrastructure, including the development of appropriate pavements to provide the infiltration of the rain water at pedestrian platforms, for parking and for storage
vii) Implementation of artificial infiltration and retardation to reduce impermeable areas
viii) Creation of local storages (ponds, building storages, groundwater cisterns)
ix) Roof planting
x) Construction of new protection structures e.g. tidal barriers
xi) Construction and renewal of polders
xii) Keeping spaces for emergency overflow free as a emergency storage

5.2 Creation / adaptation of dams and dykes (Challenges: in some countries maybe none of these (high-cost infrastructural projects like dam building, the construction of dykes and stream channelization) are an optimal solution; considerable external funding would be needed for these measures to be successful)
i) Dam building and the construction of new dykes including the possibility to modify the height of the dam later
ii) Development of plans for restructuring, displacing or removing the so called "summer dikes" of floodplains (internal dikes protecting objects within floodplains)
iii) Widening the area between dikes
iv) Construction of temporary dams
v) Implementation of measures to maintaining dam safety

5.3 Elaborating new design standards of the protection works against floods
i) New building codes and regulations
ii) Precautionary construction planning: building resilience precaution in constructions
iii) Building resilient housing

5.4 Introduction of a climate change adaptation factor on dams and dykes (example Bavaria) Challenge: due to no projected increase in future flood magnitude no climate change adaptation factors (AT)

5.5 Creation / adaptation of reservoirs (Besides objectives related to downstream flood control, reservoirs can be also used for other purposes such as municipal and industrial water supply, agricultural irrigation, navigation, fisheries, recreation, and water quality control and salinity control Challenges: a very important note on reservoir systems is that using them will highly influence the quantity of available water in downstream countries (in case of transboundary catchments), therefore these methods also require improved international regulation and water policy between the affected nations)

i) Building new reservoirs like emergency flood reservoirs and multi-purpose reservoirs, which serve as an adaptation measure for both floods and droughts
ii) Reconstruction and modification of existing water reservoirs
iii) Creation of a series of reservoirs in order to reduce flood-peak height significant
iv) Using lowland floodplains for flood relief reservoirs, which can be used as multipurpose areas, adjusted to floods
v) Construction of a second flood channel

5.6 Technological development to improve the efficiency of emergency interventions to raise the capacity of defences during floods

6. Policy approaches

6.1 Implementation of the Floods Directive including the impacts of climate change on the management of floods arising from surface waters and in coastal areas; the six-yearly risk analyses, hazard/risk maps and flood management plans, are regularly adapted to take account of the latest state of knowledge

6.2 Legal legitimating the creation of retention areas

6.3 Development of a strategy for flood protection

6.4 Use the EU Floods Directive as a legal framework for a coordinated approach to assess and manage flood risks

6.5 Institutionalization of civil protection system as a part of protection and rescue in emergency situation

6.6 Strengthening operational cooperation between the emergency response authorities in the Danube countries and improve the interoperability of the available assets in order to reduce damages, protect citizens and ensure an appropriate response to emergencies

6.7 Establishment, maintenance and updating of agreements upon procedures for mutual assistance among riparian countries in critical situations, including arrangement of formalities to facilitate the travel of flood response personnel from abroad and interoperability of emergency services' equipment (whether by plane, boat or on land) during flood events

6.8 Further investment and provision of financial aid

i) Further investments in flood defence
ii) Establishment of a national fund for assistance in the case of natural disasters
iii) Implementation of various ex ante measures such as reserve funds, contingent credit schemes for disaster loss financing
iv) Implementation of subsided loans for risk adjustments and ex post measures such as external borrowing and loan conversions

6.9 Improvement of institutional awareness of potential climate change related impacts on flood risk, for instance ensure that authorities responsible for climate change adaptation and flood risk management coordinate with river basin management

6.10 Consequent implementation of restrictions of development in risk areas like in riverside belts and floodplains and areas of high groundwater level as well as restrictions on storing materials, substances and objects that could be washed away.

ANNEX 2. Strategies and tools for flood loss reduction

US Federal Emergency Management Agency made an extensive report “FLOODPLAIN MANAGEMENT IN THE UNITED STATES”, which include the possible flood protection measures.

STRATEGY A: MODIFY SUSCEPTIBILITY TO FLOOD DAMAGE AND DISRUPTION

1. FLOODPLAIN REGULATIONS
a) State Regulations for Flood Hazard Areas
b) Local Regulations for Flood Hazard Areas
1) Zoning
2) Subdivision Regulations
3) Building Codes
4) Housing Codes
5) Sanitary and Well Codes
6) Other Regulatory Tools
2. DEVELOPMENT AND REDEVELOPMENT POLICIES
a) Design and Location of Services and Utilities
b) Land Rights, Acquisition and Open Space Use
c) Redevelopment
d) Permanent Evacuation
3. DISASTER PREPAREDNESS
4. DISASTER ASSISTANCE
5. FLOODPROOFING
6. FLOOD FORECASTING AND WARNING SYSTEMS AND EMERGENCY PLANS

STRATEGY B: MODIFY FLOODING

1. DAMS AND RESERVOIRS
2. DIKES, LEVEES AND FLOODWALLS
3. CHANNEL ALTERATIONS
4. HIGH FLOW DIVERSIONS
5. LAND TREATMENT MEASURES
6. ON-SITE DETENTION MEASURES

STRATEGY C: MODIFY THE IMPACT OF FLOODING ON INDIVIDUALS AND THE COMMUNITY

1. INFORMATION AND EDUCATION
2. FLOOD INSURANCE
3. TAX ADJUSTMENTS
4. FLOOD EMERGENCY MEASURES
5. POST FLOOD RECOVERY

ANNEX 3. Measures to Achieve Targets with climate change (CC) adoption

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	4.1. Regulation on land use and spatial planning						
SI	**Target 1: Spatial plans must consider limitations and conditions (*Decree on conditions and limitations for constructions and activities on flood risk areas*)**	flood indication map - information of existing data	Adm.	MOP	Cont.	Preliminary maps prepared on local data	There is no climate change (CC) impact and no transboundary impact (TI)
		flood hazard and hazard class map	Adm.	MOP	Cont.		Maps should incorporate CC impact on flood hazard **– no TI**
		conditions and limitations for constructions and activities on flood hazard areas	Adm.	ARSO	Cont.		Measures should be adapted to the CC impact on flood hazard areas– **no TI**
		detailed designation of boundary of waterside land	Adm.	MOP	Cont.		Maps should incorporate CC impact on flood hazard **– no TI**
		conditions and limitations for defined waterside land	Adm.	MOP/ARSO	Cont.		Measure should be adapted to the CC impact on the flood discharges– **no TI**
HR	**Target 1: Solving problems related to the water estate**	Drafting and adoption of regulations (criteria for identification, zoning of the terrain and gradation of limitation restrictions in the use of the water estate)	Adm.	MRDFWM, HV, MEPPPC			Used maps and zoning should incorporate CC impact on flood hazard **– no TI**
		Delineation of the water estate, entry into land registers and physical plans	Adm.	MRDFWM, HV, MEPPPC			Used maps should incorporate CC impact on flood hazard **– no TI**

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Solving property-right relations to legalise flood protection structures (repurchase of real estate, getting location and construction permit)	Adm.	MRDFWM, HV, MEPPPC	Cont.		Flood protection structures should be adapted to CC, no TI
		Systematic monitoring of the status of ownership on the water estate.	Adm.	MRDFWM, HV, MEPPPC			There is no impact of CC and no IT
	Target 2 Provide information of areas at risk to give input to spatial planning	Introduction of flood risk maps and flood damage maps for the entire country, and their presentation to the interested public	Adm.	MRDFWM, HV, MC	Unc.		Maps should incorporate CC impact on flood hazard **– no TI**
		Introduction of appropriate indicators and systematic monitoring of the efficiency of flood and erosion control measures	Adm.	MRDFWM, HV, MC	Unc.		Indicators should incorporate CC impact. No TI
		Preparation and systematic maintenance of: the Inventory of water bodies, water estate and water structures, the Inventory of extreme hydrologic phenomena (floods, storms and droughts) and the Inventory of the status of erosion and anti-erosion measures taken	Adm.	MRDFWM, HV DHMZ, HS	Cont.		No CC and No TI
BA	**Target 1: Inclusion of flood areas into the spatial plans**	Inclusion of determined flood areas into the spatial plans and other planning documentation	Adm.	EMPŠV, EAVP EMPUGE, EMULS	Cont.		Flooded areas should incorporate CC impact on flood hazard, no TI

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Creation of the missing maps of flood hazards for rivers of I and II category	Adm.	EMPŠV, EAVP	Cont.	According to the level of vulnerability of area defended against flood	Flooded areas should incorporate CC impacts on flood hazard maps, no TI
	Target 2: Introducing the water surfaces to the municipal cadastre plans	Creation of the Report for determination the limits of water surfaces in the municipal cadastre along tributaries of the I and II order	Adm.	EMPŠV, EAVP, MPUGE	2011	According to the level of vulnerability of area defended against flood.	Flood areas should incorporate CC impacts on flood hazard, no TI
	Target 3: Determination of limitation related to the flood surfaces use	Application of limitations related to the flood areas and water surfaces along the tributaries of the I and II order	Adm.	EMPŠV, EAVP, EMPUGE, EMULS	Cont.	According to the level of vulnerability of area defended against flood.	Flood areas should incorporate CC, impacts on flood hazard, no TI
		Application of agro-technical measures, forests managing measures and land in accordance with the nature protection.	Adm.	EMPUGE, EMULS, EMPŠV, EAVP	Cont.		Measure should adapt to the CC impact. TI is positive.
RS	**Target 1: Spatial plans of municipalities contain flood hazard maps and flood risk maps**	Defining water estate	Adm.	MAFWM-RDW, PWMCies	Cont.		Measure should incorporate CC and enlarge water estate, no TI
		Introduction of flood maps into spatial plans of municipalities	Adm	MESP			Flood maps should incorporate CC, no TI.
	Target 2: Limitations related to land use in flood prone areas are defined	Preparation of instructions for limitations on land use	Adm	MAFWM-RDW, MESP			Used flood maps should incorporate CC, no TI
		Land use limitations applied	Adm	LRSG			Used flood maps should incorporate CC, no TI
		4.2. Reactivation of former, or creation of new, retention and detention capacities					

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Deadline	Comment	Climate change adaptation
SI	**Target 1: Restricting the aggravation of the high water regime due to man-made activities** (***The compensation measures must be performed***)	Improvement of efficiency of existent or/and creation of new retention and detention capacities	Scien.	MOP/ARSO/ IZVRS	in progress	Reducing flood risk on southwest of Ljubljana. Detention reservoirs are planed on areas which are flooded today.	Measure should incorporate CC, possible small TI
						The similar principle (several detention reservoirs on already flooded areas) is planned on Savinja River basin reducing flood risk in Celje and some smaller settlements near the Savinja River and tributary Bolska River. The similar principle (detention reservoir) on Sora River basin is reducing flood risk in Železniki.	Measure should incorporate CC, possible TI Measure should incorporate CC, possible positive small TI

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
HR	**Target 1: Preserving and improving natural retention capacities**	Existing large lowland retention storages in the Sava River basin are preserved	Adm.	MRDFWM, HV	Cont.	Lonjsko polje, Mokro polje, Zelenik, Kupčina and Jantak (total volume of 1.590 hm^3)	Measure should incorporate impact of CC, TI
		Existing multipurpose reservoirs are used for flood attenuation	Adm.	MRDFWM, HV	Cont.	Coordinated operation of existing multipurpose reservoirs (total volume of 73 hm^3)	Measure should incorporate CC, TI will be positive.
		Existing mountain retention storages are used for flood attenuation	Adm.	MRDFWM, HV	Cont.	Coordinated operation of existing mountain retention storages (total volue of 2,5 hm^3)	Measure should incorporate impact of CC, TI small and positive.
		Design and construction of new mountain retention storages	Tech.	MRDFWM, HV	started		Measure should incorporate impact of CC, TI will be positive and small.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Introduction of restoration measures of preventive flood protection: - reduction of flood wave peak flows by reactivating former floodplains and restoring watercourses; - Implementation of the Best Practices of Flood Prevention Protection and Mitigation in land use management	Adm.	MRDFWM, HV, MC, MEPPPC, LRSG, OTHER	Cont.		Measure should incorporate CC impact, strong positive TI

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
BA	**Target 1: Preservation and control of existing retention areas for flood defence**	Through the Water acts, defining of the necessary storage volume and operation regime of the existing retentions and reservoirs for flood defence	Adm.	EMPŠV[30], AVP	Cont.	Coordinated management of existing retentions in Central Posavina and hydropower reservoirs at Drina, Lim and Piva River, with the aim of decreasing the peak of the flood wave on the Drina River. (joint plan and coordination at the level of HR-BA-RS-ME).	Measure should incorporate CC impact and has strong TI

[30] Letter E in front of the institution means Entity institution

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Reconstruction measures for flood defence existing objects.	Adm. – tech.	EMPŠV, AVP	Cont.	Planned only the maintenance, reconstruction and levelling the embankments up to the projected height levels, as well as reconstruction of the lateral and drainage channels.	Measure should incorporate CC impact and should be integrated with physical planning, TI
	Target 2: Creation of new retention areas (large and small multipurpose reservoirs)	Consideration of possibilities for construction of new multipurpose reservoirs and retentions	Technical	EMPŠV, AVP, EMPER	2015	Planned construction of reservoirs HPP Buk Bijela, compensational HPP Foča and HPP Banja Luka niska. It is necessary to agree and coordinate on the level HR-BA-RS.	Measure should incorporate CC impact with strong TI

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Design and construction of new multipurpose reservoirs, as well as the barrages and retentions on the Sava River tributaries in BA	Technical	EMPŠV, AVP, EMPER	Cont.	Planned construction of the number of Small HPPs on the Sava River tributaries in BA. It is necessary to provide information to the downstream basin countries.	Measure should incorporate CC impact on discharges, small TI
		Creation of guidelines for new reservoirs and retention work regime	Administrative – technical	EMPŠV, AVP, EMPER	2015	Coordination at the Sava Commission level.	Developed procedure should incorporate implementation of CC impact. TI is positive.
		Design and construction of a new flood defence system	Technical	EMPŠV, AVP	Cont.	Planned on the Sava River tributaries and tributaries of the II order in Derventa area (Ukrina), Prijedor area (Sana and Gomijenica River), Bosna River (Doboj – Šamac area).	Measure should incorporate CC impact on discharges. TI is small.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
RS	**Target 1: Existing – natural retention areas along the Sava and the Lower Drina River are preserved**		Adm. /Tech.	PWMCies	Cont.	New levees along the Sava and Drina River will not be erected. Old "summer" dike Provo-Orlača at Sava River, which protects agricultural land, will not be reconstructed. If within Hydropower project on Lower Drina River new levees are planned, new retention capacities should be considered for flood attenuation.	Measure should incorporate CC impact, study of should be done. TI
	Target 2: Protection of densely populated areas by new detention capacities (or small single or multipurpose reservoirs)	Design and building	Tech.	PWMCies	Start.	Planned at small tributaries in the Belgrade region (Topčiderska i Barička reka)	Measure should incorporate CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Preparation of Operation manual	Tech.	PWMCies		Only in case of reservoirs, not for retentions.	
	Target 3: Large hydropower reservoirs at the Drina, Lim and Uvac River are used for flood attenuation	Common study of possibilities	Scien.	MAFWM-RDW, PWCies, EPS + bilateral commission + ISRBC		Coordinated operation of the existing hydropower reservoirs at Drina, Lim and Uvac River with aim to attenuate peak of the Drina flood wave (common plan and coordination with BA)	Measure should incorporate CC impact, TI could be beneficial.
		Preparation/update of Operation manual	Adm./ techn.	MAFWM-RDW, PWCies, EPS + bilateral commission + ISRBC			Measure should incorporate CC impact, TI is positive.
	Target 4: Coordinated operation of hydropower reservoir at Drina and Middle Sava retentions	Common study of possibilities	Scien.c	MAFWM-RDW, PWCies, EPS + bilateral commission + ISRBC			Measure should incorporate CC impact, TI is positive.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Preparation of Operation manual	Adm. / techn.	MAFWM-RDW, PWCies, EPS + bilateral commission + ISRBC		Coordinated operation of hydropower reservoir at the Drina and the Central Posavina retentions (common plan and coordination with BA and Croatia are needed)	Measure should incorporate CC impact, TI is positive.
	4.3. Structural flood defences						
SI	**Target 1: Provide flood protection for existing settlements on lower section of the Sava River due to construction of hydropower plants**	improvement of existing dikes and creation of new ones	Scien. /Techn.	MOP/ARSO		depending on time-table of building of hydropower stations	Measure should incorporate CC impact, TI could be negative.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
HR	**Target 1: Achieving the 100% functionality of the flood protection systems**	Gradual implementation of repair and reconstruction works on about 5000 km of protective systems	Techn.	MRDFWM, HV, HEP, OTHER	2038	It is anticipated that 87-percent functionality of the flood protection systems will be achieved by the end of 2023 and 100-percent functionality by the end of 2038.	Measure should incorporate CC impact, TI could be significant. Measure should incorporate CC

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Design and construction of 270 km of protective systems	Techn.	MRDFWM, HV, HEP, OTHER	2038	From the point of view of health, safety and environment, the priorities of first order in preventive flood protection are the areas of large and larger towns with more than 30,000 inhabitants, potentially at risk from major rivers – the Sava and Kupa River. The priorities of second order are other towns and settlements along the Sava, Kupa and Una River.	impact, TI could be significant.
		Regular maintenance of watercourses, water estate, and water structures; systematic technical monitoring of key water structures	Techn.	MRDFWM, HV	Cont.		Frequency of monitoring could increase due to CC.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Finishing the construction of the Lonjsko polje retention - reconstruction and partial construction of the existing Southern levee of the Lonjsko polje retention - construction of Palanjek weir	Techn.	MRDFWM, HV	2012	Priority works related to the further development of the Central Posavina system – one of the main objectives of Inland Waters Project co-financed by World Bank funds The Project has been implemented in the period 2008-2012.	Measure should incorporate CC impact, TI could be beneficiary.
		Support to solving flood protection problems within multi-purpose systems for the regulation and use of water and land	Techn.	MRDFWM, HV, HEP, OTHER	Cont.		Measure should incorporate CC impact, TI could be significant.
BA	**Target 1: Providing the flood defence for adopted floods of the 100-years period along the Sava River area**	Regular on going maintenance of existing objects for flood defence	Adm.-tech.	EMPŠV, EAVP, EVP	Cont.	This measure is of the highest priority range.	Measure should incorporate CC impact, Cost of maintenance could increase.
		Reconstruction and remediation of the flood defence system objects along the Sava River area in FBA.					

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Reconstruction and remediation of the flood defence system objects along the Sava River area in Republika Srpska.					
		Reconstruction of 14.0 km right Sava River embankment in Kozarska Dubica municipality area.	tech.	MPŠV- AVORSS, VP	2015	1. priority task. Embankment levelling (app. 1.0 m) up to the designed height level - 100-year rang flood.	Measure should incorporate CC impact, TI could be negative.
		Reconstruction of 5.0 km right Sava River embankment in Bijeljina municipality area.	tech.	MPŠV- AVORSS, VP	2015	2. priority task. Embankment levelling (approx.1.0 m) up to the designed height level - 100- year range flood.	Measure should incorporate CC impact, TI could be negative.
		Reconstruction and repair of 16 existing pumping stations for flood defence. 10 PS in Kozarska Dubica and Gradiška, 2 PS in Brod and 4 PS in Bijeljina.	Tech.	MPŠV- AVORSS, VP	2015	3. priority task. Activities of reconstruction and repair of the object PS include construction, machine and electro-phase.	Measure should incorporate CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Landslide sanation at Sava River embankment (right bank) in Lijevče polje area. Total 1.7 km of landslide.	tech.	MPŠV- AVORSS, VP	2015	4. priority task. Activities of landslide sanation include embankment slope stabilization at the sections of landslides appearance.	TI could be positive.
		Periphery channels repair of total length 193 km.	tech.	MPŠV- AVORSS, VP	2015	5. priority task Activities implicit cutting the vegetation and cleaning the sludge from channels with partial repair of river banks and embankments along the periphery channels	Measures supported CC adoption, but could in conflict with WFD.
		Reconstruction and repair of flood defence system objects along the Sava River area in Brčko District.					

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Reconstruction of Sava embankment in Brčko District area, in total length of 8.25 km.	tech.	VBD	2015	6. priority task Activities implicit landslide sanation, existing embankment levelling and construction of new embankment section.	Measure should incorporate CC impact, TI could be negative.
		Regulation of Brka and Zovičica River, in the length of 2.6 km (regulation sequence) – Brčko District.	tech.	VBD	2015	7. priority task Activities implicit embankment construction and river bed regulation	Measure could incorporate CC.
		Regulation of Teka River (Tinja River regulation sequence) – Brčko District.	tech.	VBD	2015	8. priority task Activities implicit embankment construction and river bed regulations.	Measure could incorporate CC.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	Target 2: Providing the flood defence for adopted floods of 100-years period for the areas along the tributaries to the Sava River of the I and II order	Regular on going maintenance of regulated waterway sections	Adm. tech.	EMPŠV, EAVP, EVP	Cont.	This measure is the highest priority measure.	
		Designing and construction of existing objects for flood defence in the area along the rivers of I and II category, according to the vulnerability rang and significance of the protected area.					
		Prijedor urban area, Sana and Gomijenica River regulation (reconstruction of existing objects and construction of new embankments)	tech.	EMPŠV, EAVP, EVP	2020	9. priority task Activities implicit the reconstruction of existing and construction of new embankments and river bed regulation.	Measure should incorporate CC impact. TI is small.
		Derventa urban area , Ukrina River regulation (regulation sequence, construction of new embankments)	tech.	EMPŠV, EAVP, EVP	2020	10. priority task Activities implicit the reconstruction of existing and construction of new embankments and river bed regulation.	Measure should incorporate CC impact, TI is small.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	Target 3: Sediment management and torrent regulation	Application of anti-erosion measures in the basin and measures for torrents control.	Adm. – tech.	EMPŠV- EAVP, EVP, EJPŠ, EMPER, EMULS, EOST	Cont.	Optimal measures combination (biologic, biologic – technical and technical).	Measure should incorporate CC impact,
		Maintenance of objects for erosion and torrents defence	tech.	EMPŠV, EAVP, EVP	cont		Measure should incorporate CC impact,
		Application of anti-erosion measures in the basin – Republika Srpska					
		Eroded river banks reconstruction on the Sava River tributaries: Vrbas River, 9 locations,5.1 km Bosna River, 4 locations, 1.5 km Drina River, 4 locations, 2.1 km	Tech.	MPŠV- AVORSS	2015	11. priority task Reconstruction includes the construction of river bank supports with the aim of agricultural land erosion defence, as well as the protection of the traffic corridors.	Measure should incorporate CC impact,
RS	**Target 1: Provide protection for the adopted design 100-year flood along the Sava**	Reconstruction of key walls on the Sava left bank in New Belgrade (6.2 km)	Tech.	PWCies + city of Belgrade		First and urgent task	Measure should incorporate CC impact

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	River	Reconstruction of 13 km of levees on the left bank of Sava (Lower Srem)	Tech.	PWC Vode Vojvodine			Measure should incorporate CC impact.
		Reconstruction of 2.1 km long levee near Hrtkovci	tech.	PWMC VV			Measure should incorporate CC impact
		Reconstruction or sluice and pumping station Bosut	Tech.	PWC Vode Vojvodine + bilateral commission with Croatia		Adopt bilateral agreement related to sharing costs for evacuation of high waters through RS territory	Measure should incorporate CC impact. TI is significant.
		Reconstruction of key walls on the Sava right bank in Belgrade (4 km)	Tech.	PWCies + City of Belgrade		First and urgent task	Measure should incorporate CC impact.
		Reconstruction of right bank levees between Belgrade and Kolubara mouth (approx. 9 km)	Tech.	PWCies + City of Belgrade			Measure should incorporate CC impact.
		Reconstruction of levees in the Macva region (31.3 km) with sluices and pumping stations	Tech.	PWC Srbijavode	Star.		Measure should incorporate CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Deadline	Comment	Climate change adaptation
	Target 2: Provide flood protection of first-order priority areas within the Sava River basin	Carry out reconstruction or construction of flood protection structures	tech.	PWC Srbijavode	Cont.	Protection of flood cells with more than 20,000 inhabitants, large and significant industrial and other facilities. Required safety level for a certain area depends on technical, economic, ecologic, social, political and other criteria, conditions and limitations and may be changed in time.	Measure should incorporate CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Deadline	Comment	Climate change adaptation
	Target 3: Provide flood protection of second-order priority areas within the Sava River basin	Carry out reconstruction or construction of flood protection structures	Technical	PWC Srbijavode	Cont.	Protection of areas with 5,000 to 20,000 inhabitants, medium industrial and other facilities, significant drainage and irrigation systems or water-supply sources. Required safety level for a certain area depends on technical, economic, ecologic, social, political and other criteria, conditions and limitations and may be changed in time.	Measure should incorporate CC impact. TI

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	Target 4: Provide adequate measures for sediment management and torrent control	Apply anti-erosion watershed management and torrent control measures	tech.	PWC Srbijavode, PCSS	Cont.	Optimal combination of biological measures (forestation, forest melioration, pasture melioration, etc.), bio-technical measures (contour trenches, terraces etc.), and technical measures (check dams and river-bed training).	Measure should incorporate CC impact.
	Target 5: Provide permanent preparedness of the flood defence system	Maintenance of flood protection structures	tech.	MAFWM-RDW, PWMCies, LRSG, OTHER	Cont.	According to specific standards and norms.	Standards should incorporate CC impact.
		Maintenance of erosion and torrent control structures	tech.	MAFWM-RDW, PWMCies, PCSS, LRSG, OTHER	Cont.	According to specific standards and norms.	Measure could incorporate CC.
		Maintenance of dams, retention basins and reservoirs used for flood protection	tech.	MAFWM-RDW, PWMCies, EPS	Cont.	According to specific standards and norms.	Measure should incorporate CC impact. TI

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Purchase and repair of machinery, tools, materials, equipment and communications	tech.	MAFWM-RDW, PWMCies,	Cont.	According to specific standards and norms.	CC could increase needs for machinery.
4.4. Non-structural measures (preventive actions, capacity building of professionals, raising awareness and preparedness of general public)							
SI	**Target 1: Preventive actions**	Flood indication map - information on existing data	Adm./ Scie.	MOP	Cont.		Measure should incorporate CC impact
		Improvements in flood forecasting and warning (forecasting hydrological events and launching flood warnings)	Adm./ Scie.	ARSO/ Notification Centre of the Republic of Slovenia	Cont.		
	Target 2: Capacity building of professionals	Workshops: enforcement of prevention principle for reducing the risk instead of assuring of certain degree of safety	Adm./ Scie./ tech.	MOP/ARSO/ IZVRS	2015	probably will continue after 2015	Measure should incorporate CC impact
		Workshops: on harmonisations of elaboration of hazard and risk maps	Scien.	MOP/ARSO/ IZVRS	2015	probably will continue after 2015	Measure should incorporate CC impact
		Workshops: for administrative professionals which are involved in spatial planning	Scien.	MOP/ARSO/ IZVRS	2015	probably will continue after 2015	
	Target 3: Raising awareness and preparedness of	flood indication map - information of existing data	Adm./ Scie.	MOP	Cont.		Measure should incorporate CC impact on hazard.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	general public	workshops on implementations of Flood directive	Adm./ Scie.	MOP/ARSO/ IZVRS	Cont.		Measure should incorporate CC impact on hazard.
		flood forecasting and warning (workshops, public campaigns, demonstrations	Adm./ Scie.	MOP/ARSO/ IZVRS/ MO	Cont.		Measure should incorporate CC impact on hazard.
		adoption and execution of regulations for adaptation of construction in flood risk areas	Adm./ Scie.	MOP/ARSO/ IZVRS/ MO	2010, Cont.		Measure should incorporate CC impact on hazard.
	Target 4: Spatial plans must include restricting measures of enlargement on flood hazard areas in order to prevent and mitigate the water pollution due to floods	flood indication map - information of existing data	Adm.	MOP	Cont.		Measure should incorporate CC impact
		flood hazard and hazard class map	Adm.	MOP	Cont		Measure should incorporate CC impact
		conditions and limitations for constructions and activities on flood hazard areas	Adm.	ARSO	Cont		Measure should incorporate CC impact for estimation of hazard.
HR	**Target 1: Reduce flood damage risk**	Implementation of operative flood defence measures	Tech. / Organi.	MRDFWM, HV	Cont		Measure should incorporate CC impact on hazard.
		Managing and coordinating the operation of multipurpose reservoirs and water distribution structures during high water periods	Tech. / Organi	MRDFWM, HV, HEP, OTHER	Cont.		Measure should incorporate CC impact

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	Target 2: Increase the efficiency of operative flood defence measures	Improving the system of automated weather stations and gauging stations, and making the measured data available to relevant services in real time	Tech. / Organi	MRDFWM, HV, DHMZ	Cont.		Measure will improve knowledge about CC impacts.
		Improving the system of hydrological and weather forecasting, and making the created forecasts available to relevant services; establishment of local forecasting centers and application of the latest technologies in forecasting - monitoring and water information system	Tech. / Organi	MRDFWM, HV, DHMZ	Cont.		Measure will improve knowledge about CC impact. Positive TI.
		Improvement of alarm systems and systems for issuing timely warning to population at risk; organizing improved operations of the police and fire fighting forces during floods; organizing evacuation of population, if needed; organizing life on damaged areas by providing humanitarian aid, organizing medical services, and emergency recovery of essential infrastructure	Tech. / Organi	NPRD	Cont		Measure will help in adaptation to CC impact. TI will be positive.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Improvement and formalizing of international basin wide on line flood related meteorological and hydrological data exchange	Adm.	HV, DHMZ	Cont.		Measure will help in adaptation to CC impact. TI will be positive.
		Improvement and formalizing of international basin wide on line operative flood defence information exchange	Adm.	HV, NPRD	Cont		Measure will help in adaptation to CC impact. TI will be positive.
	Target 3: Increase the capacity building and raise the level of preparedness	Preparation, adoption, and regular updating of the National Flood Defence Plan	Adm.	MRDFWM, HV	Cont		Measure will help in adaptation to CC impact.
	Target 4: Build capacity of professionals and institutions	Support of scientific and educational projects related to all aspects of floods.	Adm.	HV, MSES, MRDFWM	Cont		Measure will help in adaptation to CC impact.
		Professional education of scientific personnel to perform the tasks of integrated water resources management. It is necessary to create new interdisciplinary plans and programs of education.	Scien.	HV, MSES, MRDFWM	Cont		Measure will help in adaptation to CC impact.
	Target 5: Introduce principles of EU Floods directive	Continue action in the framework of international multilateral and bilateral agreements.	Adm.	MRDFWM, HV MFAEI, MEPPPC, MC	Cont		Measure will help in adaptation of CC impact. TI will be positive.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Bring into force the laws, regulations and administrative provisions complied with Flood Directive	Legal/ Adm.	MRDFWM, HV	26 Nov. 2009		Measure will help in adaptation of CC impact.
		Decision on units of management	Legal/ Adm.	MRDFWM, HV	26 May, 2010		
		The Preliminary flood risk assessment	Scien. / Techn.	MRDFWM, HV	22 Dec., 2011		Measure should incorporate CC impact on flood hazard and risk.
		Preparation of flood hazard and flood risk maps	Scien. / Techn.	MRDFWM, HV	22 Dec., 2013		Measure should incorporate CC impact on flood hazard.
		Preparation of Flood risk management plan	Scien. / Techn.	MRDFWM, HV	22 Dec., 2015		Measure should incorporate CC impact on flood hazard and risk. TI
	Target 6: Raise awareness and preparedness of the general public	Presentation of flood risk and flood damage maps to the interested public	Adm.	MRDFWM, HV, MC	Cont.		Measure will help in adaptation to CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Introducing the principle of covering uncovered flood damage risks through insurance policies	Adm.	MRDFWM, HV, MF	Cont.		Measure will help in adaptation to CC impact.
	Target 7: Prevent and mitigate pollution of water caused by floods	Recovery of the current sources of pollution on the areas potentially at risk	Adm.	MRDFWM, HV, MEPPPC, MHSW, LRSG	Cont.		Measure should incorporate impact of CC on flood hazard. Measure will help in development of actions for adaptation to CC impact.
BA	**Target 1: Flood risk reducing**	Implementation of operative flood defence measures defined by flood defence operational plans	Techn. /Organ.	EMPŠV- EAVP, EVP, EUCZ EMPER, EMULS, EOST	Cont.		Measure will help in adaptation of CC impact.
	Target 2: Introducing the principles of EU flood directive	Creation of agreed methodology for the production of the flood hazard maps and the vulnerability maps	Scien. / Techn.	EMPŠV, EAVP	2010	The following will be used: Common approach of the Sava countries (ISRBC PEG-FP), agreed with ICPDR approach	Measure should incorporate CC impact on flood hazard. TI will be positive.
		Creation of preliminary estimation of flood hazards	Adm.	MVTEO, EMPŠV, EAVP	2014		Measure should incorporate CC impact on flood hazard.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Creation of vulnerability maps and flood hazards maps	Adm.	EMPŠV, EAVP	2015		Measure should incorporate CC impact for creation of flood hazard maps.
		Creation of the flood risk management plans	Adm.	EMPŠV, EAVP	2016		Measure should incorporate CC impact on flood hazard and risk maps.
	Target 3: Build the capacity of professionals and institutions responsible for flood management	Preparation, adoption and updating the flood defence plans	Adm.	EMPŠV- EAVP	2016	Entity level. Necessary compliance at entity level and Sava Commission level.	Measure should incorporate CC impact to estimation of flood risk.
		Continuous data exchange between institutions in charge for flood defence.	Adm.	EMPŠV- EAVP, EHMZ, EUCZ, MULS	Cont.	At all levels	Measure will help in adaptation to CC impact. TI will be positive.
	Target 4: Strengthening the capacity of professionals and institutions responsible for flood management	Support to the scientific and educational projects related to the flood aspects	Adm.	EMPŠV, EAVP, EMOT, EUCZ	Cont.	Measured data available to the institutions in charge in real time at entity and BA state level.	Measure will help in adaptation to CC impact. TI will be positive.

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Professional experts training for application of water resources integral management principle	Adm.	EMPŠV, EAVP, EHMZ, EUCZ	Cont.	Int roduction of modern technologies at state and entity level.	Measure will help in adaptation to CC impact. TI will be positive.
	Target 5: Improvement of the monitoring system, data collecting, forecasting and warning.	Improvement of automatic forecasting stations and water-measuring stations with the possibility of adequate data displaying in ISV	Techn./ Organ.	EMPŠV, EAVP, EHMZ, EUCZ	Cont.		Measure will help in adaptation to CC impact. TI will be positive.
		Improvement of meteorological and hydrologic forecasting systems, with data displaying in ISV	Techn./ Organ.	EMPŠV, EAVP, EHMZ, EUCZ	Cont.	Entity associations of civil protection are in charge for the organisation of the evacuation of population, as well as for providing help to people under the flood hazard.	Measure will help in adaptation to CC impact. TI will be positive.
		Improvement of the system for beforehand informing, warning and alerting the people under the flood hazard.	Techn./ Organ.	EMPŠV, EAVP, EHMZ, EUCZ	Cont.		Measure will help in adaptation to CC impact. TI will be positive.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		International exchange of meteorological and hydrological data, as well as data on flood defence operational measures.	Adm.	MVTEO, EMPŠV, EAVP, EHMZ, EUCZ	Cont.	Coordination at the Sava Commission level	Measure will help in adaptation to CC impact. TI will be positive.
	Target 6: Improvement of public awareness on floods	Presentation and providing of public access to the flood hazard and the flood vulnerability and the flood hazards maps.	Adm.	EMPŠV, EAVP	2012	Common approach of the Sava countries will be applied (ISRBC PEG- FP), in compliance with the ICPDR approach	Measure will help in adaptation to CC impact. TI will be positive.
		Implementation of flood insurance system	Adm.	EMPŠV, EAVP	2016		Measure will help in adaptation to CC impact.
		Public awareness of the flood life strategy	Adm.	EMPŠV, EAVP	Cont.		Strategy should incorporate CC and measure will help in adaptation to CC impact.
		Creation of fliers, movies, radio and TV shows	Adm.	EMPŠV, EAVP	Cont.		Measure will help in adaptation to CC impact. TI will be positive.
	Target 7: Improve international cooperation in flood management	Participation in ICPDR work	Adm.	MVTEO, EMPŠV, EAVP	Cont.		Measure will help in adaptation to CC impact.
		Participation in Sava Commission work	Adm.	MVTEO, EMPŠV, EAVP	Cont.		Measure will help in adaptation to CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Signing the bilateral agreement with Serbia and Montenegro	Adm.	MVTEO	Cont.		Measure will help in adaptation to CC impact.
RS	**Target 1: Reduce flood risk**	Implementation of operative flood defence measures	Techn./ Organ.	PWMCies, LRSG	Cont.		Measure will help in adaptation to CC impact.
	Target 2: Introduce principles of EU flood directive	Preparation and adoption of new Water Law	Legal/ Adm.	Republic of Serbia, MAFWM-RDW	2010		Measure will help in adaptation to CC impact.
		Preparation of bylaws according to new Water Law	Legal/ Adm.	MAFWM-RDW	2011		Measure should incorporate CC impact for flood estimation and it will help in adaptation to CC impact
	Target 3: Build capacity of professionals and institutions responsible for flood management	Regular upgrade of General and Annual Flood Defence Plans for the Republic of Serbia	Adm.	MAFWM-RDW	Cont.	State level – increased efficiency of operative flood defence	Measure will help in adaptation to CC impact.
		Preparation and regular upgrade of General and Annual Flood Defence Plans for municipalities	Adm.	LRSG	Cont.	Municipality level – increased efficiency of operative flood defence.	Measure should incorporate CC impact for flood hazard definition and it will help in adaptation to CC impact.
		Characterisation of current situation	Techn.	MAFWM-RDW, PWMCies	2009	Finished partially	Measure should incorporate CC impact for flood hazard definition.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Update/preparation of technical documentation for all existing flood protection structures (incl. data on water estate)	Techn.	PWMCies		Finished partially.	Measure will help in adaptation to CC impact.
		Update/preparation of flood defence manual	Techn.	MAFWM-RDW	2010		Measure will help in adaptation to CC impact.
		Preparation of bylaw for establishment and management of cadastre of water structures	Adm.	MAFWM-RDW	2010		Measure will help in adaptation to CC impact.
		Preparation of cadastre of flood protection structures	Techn.	PWMCies, LRSG	Cont.		Measure will help in adaptation to CC impact.
	Target 4: Upgrade flood monitoring, forecast and warning	Improvement of the system of automated weather and gauging stations	Tech./ Organ.	RHMSS, MAFWM-RDW	Cont.	Measured data available to relevant services in real time.	Measure will help in adaptation to CC impact.
		Improvement of the system of hydrological and weather forecasting	Tech./ Organ.	RHMSS, MAFWM-RDW	Cont.	Introduction of the latest technologies in forecasting. Forecasts available to relevant services through WMISS and by other IT.	Measure will help in adaptation to CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Improvement of alarm systems and systems for issuing timely warning to population at risk	Tech./ Organ.	RHMSS, MAFWM-RDW	Cont.		Measure will help in adaptation to CC impact.
	Target 5: Introduce regulations for emergency situations response (natural disasters)	Preparation of strategic, tactical and operative disaster management plans for catastrophic flood	Tech./ Organ.	MAFWM-RDW, PWMCies, MI, LRSG		- Criteria for declaration of an emergency; - Information routes - Methods of public warning - Evacuation routes - Preparedness of public services	Measure should incorporate CC impact for flood risk definition and it will help in adaptation to CC impact.
		Training exercises	Public partic.	PWMCies, LRSG, MI	Cont.	- Organizing operations of the police and fire fighting forces as during floods; - Organizing evacuation of population; - Organizing life (medical services, and emergency recovery)	Measure will help in adaptation to CC impact.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Deadline	Comment	Climate change adaptation
	Target 6: Prepare Flood risk management plan	Preliminary flood risk assessment	Scien.	MAFWM-RDW	2011	Activities started. Required harmonization with neighbouring countries.	Measure should incorporate CC impact to flood risk assessment.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Preparation of methodology for flood risk mapping	Scien. /Techn.	MAFWM-RDW	2011	Standard hydrological and hydraulic models should be revised or new should be developed for computation of reference high water levels. Also, methodology for digital mapping should be developed according to standard specifications. The following results/conclusions will be used: - Common position on flood risk mapping (ICPDR); - Flood risk project; - Tamnava project (Swedish Rescue Service and MAFWM-RDW). Common approach of Sava countries (ISRBC PEG FP	Measure should incorporate CC impact to flood hazard mapping.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Adoption of bylaw on methodology for flood risk mapping	Adm.	MAFWM-RDW	2011		Measure should incorporate CC impact to flood risk definition and mapping.
		Preparation of flood hazard maps	Scien. /Techn.	MAFWM-RDW, PWMCies	2013	Due to the extent of this activity and required high investments, project is supported by ISRBC PEG FP – Initial common hydraulic model for the Sava RB in cooperation with USACE.	Measure should incorporate CC impact to flood hazard maps.
		Preparation of flood risk maps	Scien. /Techn.	MAFWM-RDW, PWMCies	2013	Supported by ISRBC PEG FP – Initial common hydraulic model for the Sava RB in cooperation with USACE.	Measure should incorporate CC impact to flood risk maps.
		Preparation of draft Flood risk management plan	Techn./ Organ.	MAFWM-RDW, PWMCies	2014	Sava countries will prepare an integrated plan or a plan coordinated on the level of the Sava River basin. Support: Tamnava project (Swedish Rescue Service and MAFWM- RDW)	Measure should incorporate CC impact to flood risk definition and management.

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
		Public information and consultation on draft Flood risk management plan for the Sava River basin in Serbia	Public partic.	MAFWM-RDW, PWMCies	2014 - 2015	Flood risk management plan and Flood risk maps should be discussed in public. The results, benefits and consequences of preparation of the flood risk maps as a legal act should be presented to a broad public.	Measure will help in adaptation to CC impact.
		Bring into force Flood risk management plan for the Sava River basin in Serbia	Adm.	MAFWM-RDW	2015		Measure should incorporate CC impact for flood risk estimation and it will help in adaptation to CC impact.
	Target 7: Improve awareness of stakeholders on floods	Introduction of flood insurance	Adm.				Measure should incorporate CC impact to flood risk estimation.
		Introduction of water management issues into schools	Public partic.		Cont.	From elementary school to university	Measure could help in adaptation to CC impact.
		Preparation of flood leaflet, film, TV broadcasts etc.	Public partic.				Measure should incorporate CC impact on floods and it Measure will help in adaptation to CC impact...

Flood protection and climate change adaptation measures

Targets		Measures	Type of intervention	Institution in charge	Dead line	Comment	Climate change adaptation
	Target 8: Update/build scientific base for flood and ice management	Preparation of studies and design	Scien.	All	Cont.		CC impacts and adaptation should be incorporate in studies.
	Target 9: Improve international cooperation in flood management	Bring into force bilateral agreement with Croatia, Bosnia&Herzegovina and Montenegro and establish bilateral commission	Legal	Republic of Serbia	2010		Measure will help in adaptation to CC impact.
		The Sava River basin wide on-line flood related meteorological and hydrological data exchange	Adm.	Republic of Serbia + RHMSS bilateral commissions	2010	Improvement and formal agreement.	Measure will help in adaptation to CC impact.
		The Sava River basin wide online operative flood defence information exchange	Adm.	Republic of Serbia + bilateral commissions	2010	Improvement and formal agreement.	Measure will help in adaptation to CC impact.
		workshops on implementations of Flood directive	Adm./ Scien.	MOP/ARSO/ IZVRS	Cont.		CC impacts should be part of workshop.
		flood hazard and hazard class map	Adm.	MOP	Cont.		Measure should incorporate CC impact for flood management..
		conditions and limitations for constructions and activities on flood hazard areas	Adm.	ARSO	Cont.		Measure should incorporate CC impact for flood hazard maps and it will help in adaptation to CC impact.