E.C.O. Institut für Ökologie

"Sava.Restore - Connecting the Floodplains for a healthy alluvial forest"

Feasibility Study for Spačva - Bosut Forests Restoration

Final Technical Report

Client:

EuroNatur Foundation

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Sava.Restore - Connecting the Floodplains for a healthy alluvial forest" Feasibility Study for Spačva - Bosut Forests Restoration

Final Technical Report

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Table of Contents

List of Figures

List of Tables

1 PREFACE

Contributing towards restoring the Sava River floodplain in such a huge area like the alluvial Spačva - Bosut Forests which is the largest complex of old lowland oak forest in Europe is a delighting task for our company. The feasibility study highlights the vision of renaturing one of the biggest ancient oak forests in Europe.

The project team would like to thank EuroNatur Foundation and all local project partners for their engaged and open project support. The input and information received are very rich, the discussions were fruitful, and the resulting information encompass a wealth of data.

Especially we would like to mention the technical contributions of Radenko Ponjarac who did the hydrostatic modelling and Alen Kis from Institute for Nature Conservation of Vojvodina Province (Serbia), who contributed local ecological knowledge and many photos of the area. Alens' local knowledge in habitats and forest management contributed in developing restoration scenarios, together with Tibor Mikuška from Croatian Society for Birds and Nature Protection. We also want to thank Zoran Galić from Institute of Lowland Forestry and Environment (Serbia) who contributed by digitalization of dataset from river gauging stations). At this stage, we also want to thank all the stakeholders in this project who provided useful data like Croatian Waters and Forests and Environmental Department, among others.

The study was carried out under the challenging circumstances of the prevailing global COVID-19 restrictions. Unlike planned, field trips, workshops and feedback loops could happen only partially on site and personally due to current COVID-19 travel restrictions in 2020.

Therefore, the contractor could just participate at the first stakeholder meeting in Croatia on the 29th of September 2020 and at a final meeting in September 2021. Field trips to the study area were limited to a very short period. The first stakeholder meeting in Serbia on the 30th of September 2020 was held as an online session. All following workshops happened online, too. A field trip to Serbia took place in September 2021.

Nevertheless, this has had no great influence on the project processing. The exchange of questions and information with some of the major stakeholders were possible by virtual means. However, it cannot replace sufficiently face to face meetings with important local stakeholders and decision makers and especially the extensive fieldtrips would have supported the interpretation of the data.

Based on extensive prior studies and reports in the area, the project team could manage to come up with a feasible range of possible scenarios, which should be further developed in a participative stakeholder process. We see our result as a starting point for a process towards restoring as much forest area as possible to ensure the ecological, and socio-economic functionality of the floodplain. We hope that our result will contribute to reconnect the Sava River to its alluvial forest.

2 INTRODUCTION

2_1 Project information and context

The EuroNatur Foundation is campaigning together with its partners for a Europe with free-flowing rivers, ancient forests and a rich variety of cultural landscapes. A main action field of EuroNatur Foundation is the "Blue heart of Europe" – the protection of the Balkan rivers.

In the framework of the project "Freedom for Sava" EuroNatur Foundation and its partners want to boost the implementation of river and floodplain restoration projects in the Sava River basin triggered by successfully conducted feasibility studies at selected pilot sites and to further strengthen SavaParks network – a network of GOs and NGOs committed for the protection of Sava River and its river basin as well as its transnational cooperation, name recognition and reputation in the region. Both purposes are interlinked and have a mutually reinforcing effect.

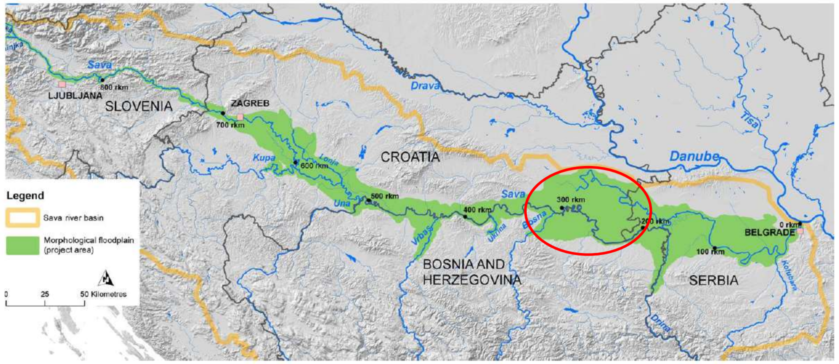


Figure 1: Sava River and its morphological floodplain within the Sava River basin.

In red the study area. Sava White Book. The River Sava: Threats and Restoration Potential. (Source: SCHWARZ 2016A).

The Sava River has a length of 926 km and has a catchment area of over 97,800 km². The Sava River is the largest tributary of the Danube by discharge. The number of hardwoods amount to 63,302 ha in the active floodplain and another approximately 78.270 ha outside the flood dikes. The morphological floodplain area was as large as 8.943 km² (Figure 1). Nowadays 2.067 km² of the morphological floodplain is still flooded. This means, that 77% are inactive and have been lost. With restoration measures additional 184.289 ha can be flooded. But there are regional differences. In Croatia, from Sisak to Gradiška, 60% of the morphological floodplain are still active. At the Bosna water mouth 85% of the floodplains are cut-off from the river. (SCHWARZ 2016a)

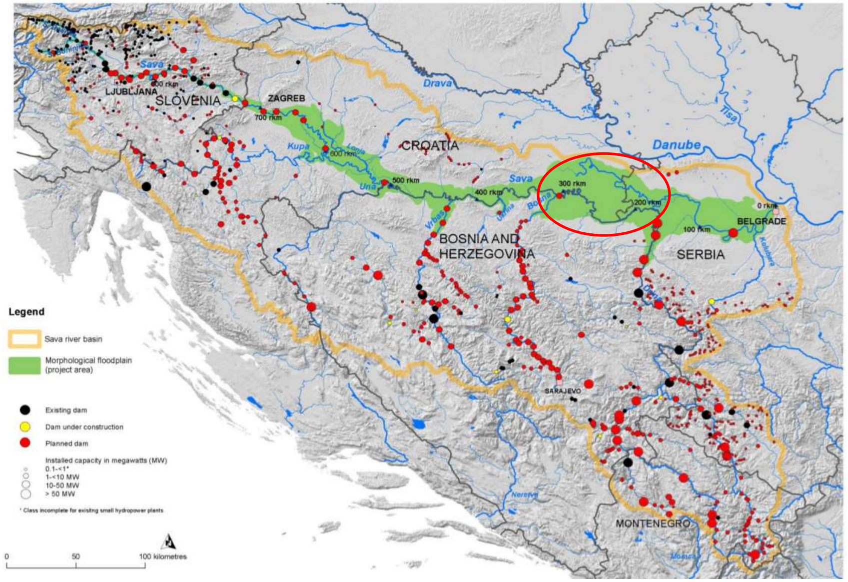


Figure 2: Existing and potential Hydropower plants in the Sava basin (231). Sava White Book. The River Sava: Threats and Restoration Potential. (Source: SAVE THE BLUE HEART WEBPAGE, 2020).

Besides dikes, which cut-off a lot of floodplain areas from the river, the greatest source of pressure on the river are the hydropower projects in the Sava River basin (Figure 2). Fortunately for ecological point of view, within the study area no power plants exist at the moment or are under construction. Furthermore, dredging and sediment exploitation and the plans for the construction of multi-purpose Danube-Sava Channel are great threats for the river, habitats and species along the river (SCHNEIDER-JACOBY 2002).

Along the river Sava a significant number of protected areas are located. 36% of the morphological floodplain (322.875 ha) and 64% of the Sava River course (excluding headwaters) are designated as protected areas. The most established are the Lonjsko Polje Nature Park in Croatia and the Obedska Bara Nature Reserve in Serbia. Large stretches of the Sava and tributaries in Croatia as well as some stretches in Slovenia are Natura 2000 sites. (SCHWARZ 2016a). To preserve these protected areas networks, cooperation and partnerships like the SavaParks network with 21 members (EuroNatur Foundation and further NGO's, administration of protected areas) coordinated from EuroNatur Foundation and Riverwatch or Wetlands International has been established in the past.

Figure 3: Sava River near Jaruge.
(Source: E.C.O. 2020).

2_2 Objective and scope of the feasibility study

This feasibility study aims to assess and analyse the possible options for an ecological floodplain restoration plan and promotes the idea of integrated land use and forest management at the Sava River stretch at the Spačva Forest (Croatia) and Bosut Forest (Serbia). The final report will be used to inform stake holding authorities about the restoration potential and synergies and to lobby the study outcomes among decision makers to carry out restoration measures. Main tasks for the Spačva-Bosut floodplain forest restoration as proposed in the Terms of References are:

- Pros and cons analysis of floodplain restoration - considering forestry operation activities, nature protection objectives and flood protection needs.
- Assessment of restoration costs and a cost-benefit analysis.
- Scenarios of optimal ecological and highest acceptable flooding potential which would not destabilize the business sector and environmental objectives. Setting up optimum spatial-temporal flooding for the habitat mosaic. Defining pessimism thresholds in height, length and season of flooding for the key species and habitats.
- Define how the integrated solutions for the floodplain restoration is bringing added values in business and environmental issues (nature-based solutions, climate buffer etc.)

The feasibility study is built up on two reports:

A technical report which contains the documentation of the status quo, a stakeholder assessment, scenario definition, a cost-benefit-analysis, an assessment of the impact of the different scenarios on social structure and ecology.

Second, the final report includes results and findings of stakeholder involvements, where also a joint roadmap and recommendations for the management of the river section will be constituted.

The purpose of the general "Freedom for Sava" project is to conduct a feasibility study at selected pilot sites that have a mutually reinforcing effect on the region. This feasibility study within the Bosut and Spačva forests is interlinked with a second feasibility study about the Sava River stretch between Brežice (Slovenia) and downstream Zagreb (Croatia), which foresees to provide a nature-based solution to current floodplain developments and promotes the idea of an ecological alternative to current spatial planning.

The following table shows exemplarily the potential of nature-based solutions projects in Croatia and Serbia for the Spačva-Bosut forests related sites within the study area. 1 – very high potential/priority, 2 – high potential/priority, 3 – moderate potential/low priority (SCHWARZ 2018).

Table 1: Potential of nature-based solutions projects in Croatia and Serbia within the study area. 1 – very high potential/priority, 2 – high potential/priority, 3 – moderate potential/low priority (Source: SCHWARZ 2018).

Country, Name and river	1 Retention capacity	2 Cost effectiveness (only for dike reloca-tion)	3 Feasibility (land ownership)	4 Opportunities, local support	5 Biodiversity benefits	Nature based solution priority
HR Bosut-Spačva north, Sava	1	3	2	-	1	2
HR Spačva northern forest west, Bosut	2	3	1	-	1	2
HR Spačva northern forest east, Bosut	3	3	1	-	1	2
HR Bosut-Spačva south, Sava	1	3	2	-	1	2
RS Bosut forest Bosut-Spačva south and Sremska Rača, Sava	1	2	2	1	1	1

Figure 4: Bosut River near Morović. (Source: ALEN KIS).

Figure 5: Mosaic of forest and marsh. (Source: ÁBEL MOLNÁR).

3 PROJECT DESCRIPTION AND METHODOLOGY

3_1 Project structure and execution

3_1_1 Milestones and workflow

The feasibility study is split in two phases:

- Phase 1: technical study
- Phase 2: stakeholder involvement

The subject of this report is phase 1.

Project steps for this phase build up on the data acquisition, where the project team assessed all relevant documents, reports and studies with regards to the rivers Sava (e.g., GIZ ESAV study, Interreg project "EcoWet", BFN study "Nature Based Solutions for Risk Management in SEE"). The analysis of the collected data shows the status-quo and reflects the provided data.

With available GIS-data out of prior projects a SAVA-GIS project was set up. This includes an elevation model for the immediate area next to the river, a habitat map, a land use map, mapping of ownership and infrastructure.

Based on the data analysis we generated a stakeholder map and organized a virtual kick-off meeting with local experts and EuroNatur (20.05.2020).

We also defined in coordination with the local experts and EuroNatur three flooding scenarios according to the needed intervention measures, the area affected by flooding and the flooding duration/frequency. This was presented to key stakeholders in September 2020 in Zagreb. A side visit was combined with this meeting.

With the cost-benefit analysis, we outlined roughly the construction costs (and associated compensation cost) and identified the most important ecosystem services.

Finally, we assessed the social and ecological impact of the two scenarios and compared the ecosystem service value of each scenario.

In the course of this feasibility studies, we defined the following miles stones for the first phase

- Kick-Off Meeting
- Internal workshop to define the targets and relevant objectives.
- Field visit
- Stakeholder meetings

3_1_2 Processing team

E.C.O. as the consortium leader has 20 years of experience in environmental and social impact assessment and the management of protected areas, specifically regarding the interaction between human livelihoods and the protection of natural resources. E.C.O. has a pool of experts for all possible aspects that might be relevant in this project such as forest ecology or land-use. E.C.O. looks back on more than 20 years of experience in vegetation ecology and conservation issues. The organisation and implementation of large-area vegetation and habitat mapping and monitoring as well as biodiversity and human impact assessments are among the key services of the Institute. The expert team responsible for the feasibility study consist of team members with various experience and competences. This includes vegetation ecologist, a zoologist, an external eco-hydrologist with experience in all aspects of hydropower development, including planning, construction, operation, rehabilitation and environmental aspects, GIS-experts, a landscape planner, a lawyer and experts for conception and implementation of participatory, inter- and transdisciplinary projects.

3_2 Delimitation of the study area

The study area of the feasibility study covers the Sava River stretch with the Spačva Forest (Croatia) and Bosut Forests (Serbia) (Figure 6). The highway A3, which cuts through the forest and induce north-south fragmentation of the Spačva forest and a barrier effect. The highway is the second-longest highway in Croatia and the longest in the west-east direction. It runs in the Sava plain from Bregana on the Slovenian border via Zagreb to Lipovac on the Serbian border and is currently the only continuous and completed transit highway in Croatia. Therefore, it is of high importance for transnational relations. The western border of the study area is formed by the Sava-Bosut irrigation channel near Jaruge village in Croatia, that is envisaged to become Danube-Sava channel. The northern part is delineated by the Bosut River, while the eastern border is formed by the area where Bosut River enters the Sava River in Serbia. The southern border of the study area is reflected by the Sava River that also forms the border to Bosnia and Herzegovina. The map on the next page shows the land use. The study area is made up of land principally occupied by forests which is the target area for restoration. Around this central forest, there are agricultural areas and settlements. Roads and other infrastructure systems, like the railway Vinkovci-Brčko, intersect the area of interest.

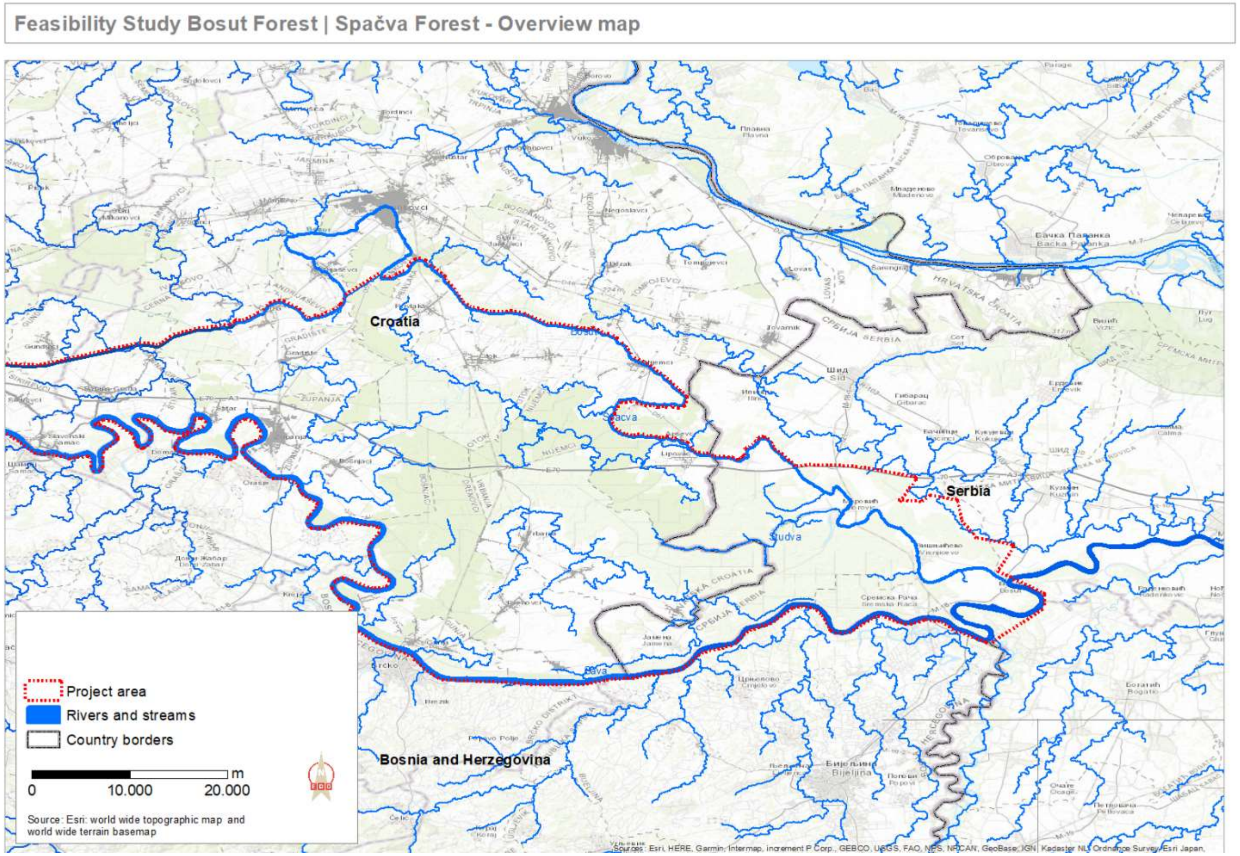


Figure 6: Overview of the study area with forest, main rivers and its tributaries. (Source: E.C.O. based on google map).

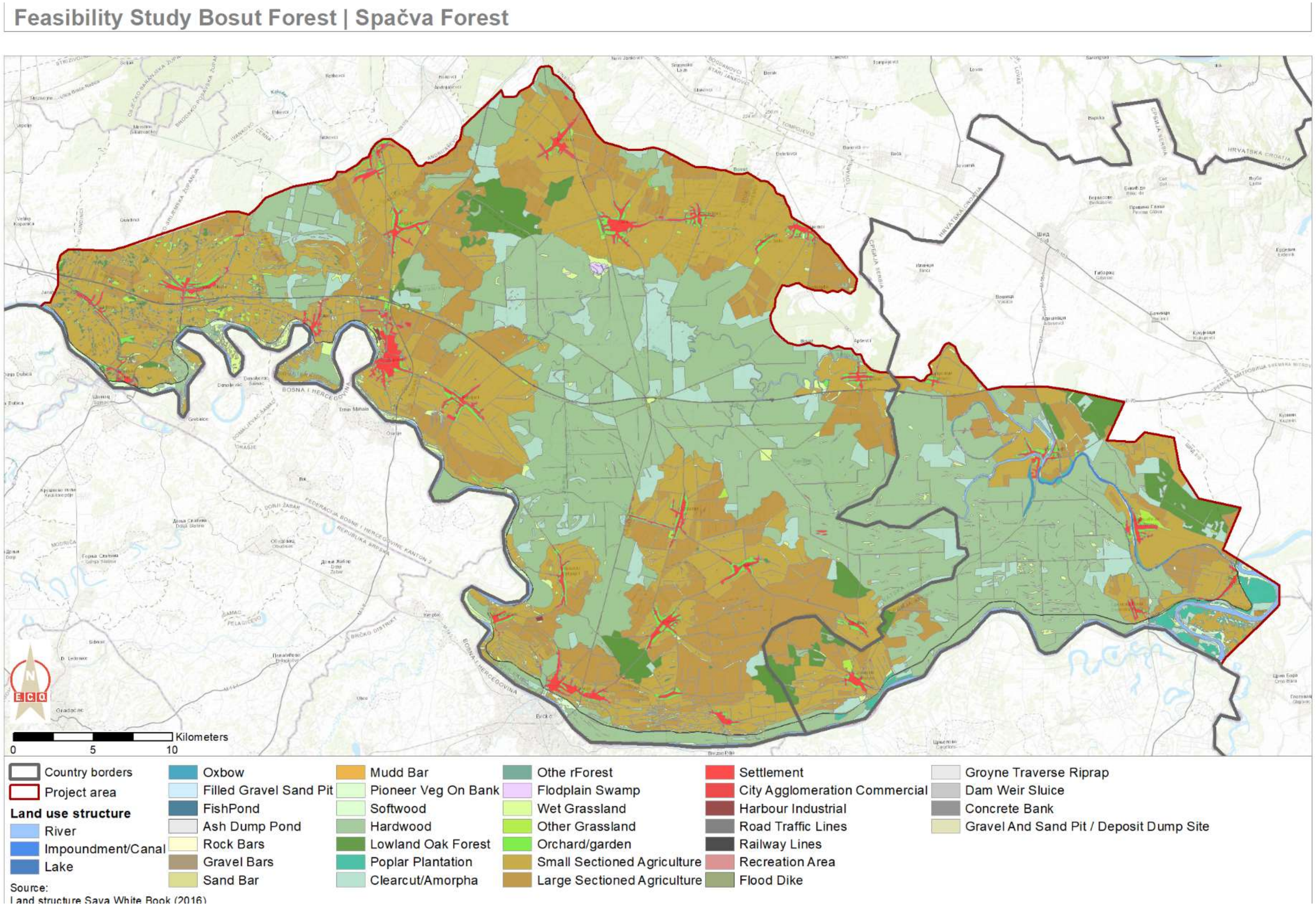


Figure 7:Land use in the study area.

(Source: E.C.O. based on SCHWARZ, 2018).

3_3 Methodology

The base for the study is literature review and hydrostatic modelling. Various studies and data of prior projects were screened and the findings summarized. A qualitative comparison with the historic data was done. Relevant GIS data of those studies were provided by EuroNatur and local partners and institutions. For the hydrological analysis gauging data from different stations along the Sava River and the Bosut River were used and interpolated for the study area river strech.

3_3_1 Modeling

At the start of the project, there was limited access to relevant GIS data, especially with regards to LIDAR data. They are crucial for the scenario definition. With help from EuroNatur, LIDAR-data which cover the Serbian site quite well were provided by ISRBC under the framework of a prior project that cover Sava River and Bosut forest quite well.

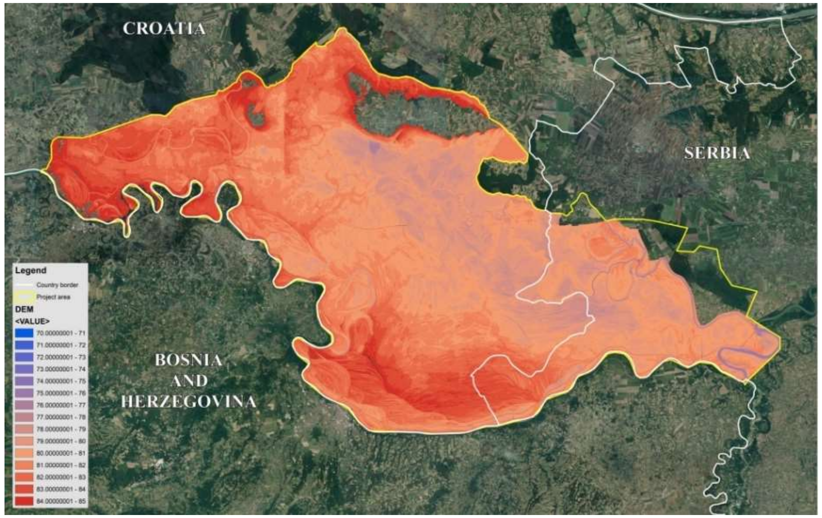


Figure 8: Digital Elevation Model, showing the forest as the deepest part (blue 70 masl, red 84 m.a.s.l) (Source: Radenko Ponjarac).

With a second DEM from the Croatian geoportal, we could complete the rough picture. The height is shown on 1 m steps and the range of possible areas for flooding is between 75 m and 80 m approximately (all green and greenish areas). Rivers and drainage channels are clearly visible (darker greens areas). With the help of water levels and the DEM we were able to point out flooding areas. In November 2020, additional high-resolution data were provided for the Croatian part originating from the FORRET project. Therefore, the study uses different level of accuracy in the elevation model for different areas. However, most important parts of the floodplains and Spačva-Bosut forests were covered by high-resolution LIDAR data, provided by the Sava River Commission. The following map highlights the different data quality within the study area. A hydrostatic water model was then calculated and contributed by Radenko Ponjarac.

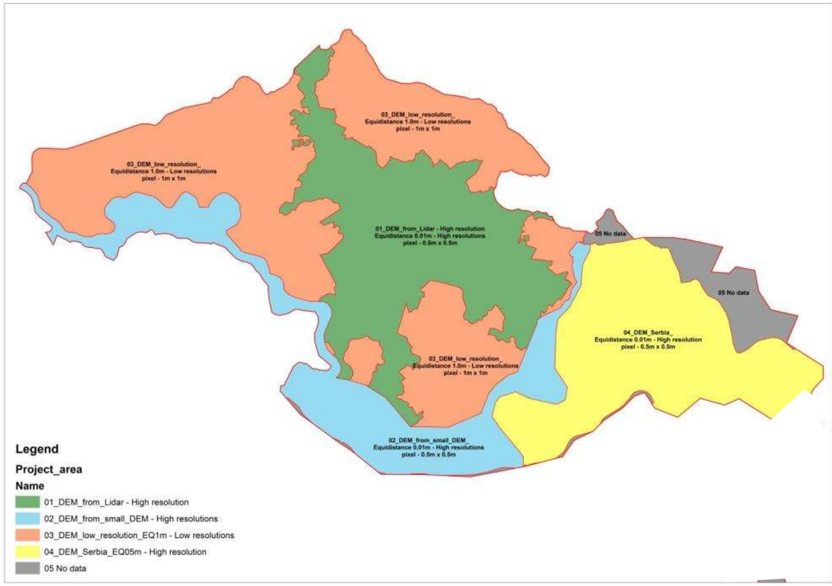


Figure 9: Different data quality for elevation model: For the orange and the grey area high resolution data were not available. (Source: RADENKO PONJARAC)..

Based on the study area which covers 151.270 ha the maximum possible extend of the temporarily flooded area in Croatia and Serbia for reconnection the river with its floodplain was calculated for the minimum and the maximum scenario. To analyse the area the grid calculation method was used due to the size of the study area and the high number of polygons. For the calculation, the programs ArcGIS Desktop 10.7 Version and MS Access were used. The analysis was based on following shapefiles: Country borders, Land Structure Sava White Book (2016), Natura 2000 sites (Croatia) and Forest Types and Natura 2000 Types (Serbia); Shapefiles were converted into grid layers with a cell size (X and Y) of one meter. The extend corresponds to the grid layers of the Scenario Water level 79 m a.s.l. and Scenario Water Level 80.5 m a.s.l. which have also a cell size of one meter. For the grid analysis all layers were aggregated with the grid calculator (Spatial Analyst) and exported to a personal geodatabase to calculate the maximum extend of temporarily flooded area (in hectare) for each scenario.

3_3_2 Feasibility

The feasibility of a restoration project can be structured in four dimension:

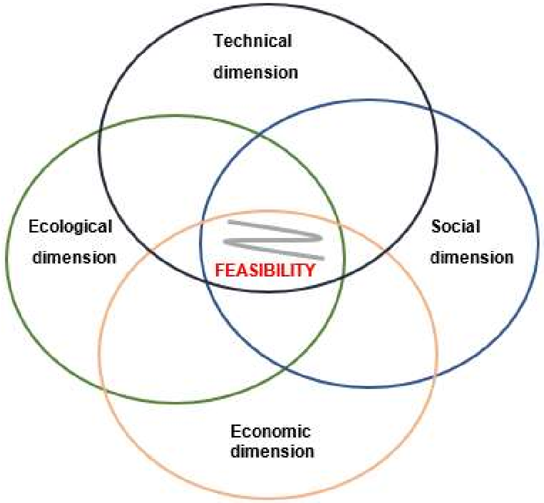


Figure 10: Dimensions to be considered when it comes to decide over the feasibility of a scenario.

Besides ecological, social and economic dimension, the idea of linking the riverine forests bears also technical dimension. In the history of Sava River the riverbed was changed through dike construction a long time in the past. The riverbed changed the elevation, and besides of cost and benefit consideration first of all it must be technically feasible to bring the water back to the forest. Settlements and agriculture within the observation area have changed the landscape over time, and there might be technical limitations.

3_3_3 Stakeholder Assessment

A final delimitation proposal for the implementation of measures can only be progressed in a subsequent participatory process, in coordination with the decision makers, with the involvement of the landowners and any relevant stakeholders. There are also further professional and pragmatic aspects that need to be considered as the effect on rights of use, the effect on legal framework, the impact on the biodiversity objects habitats, plant species and animal species. To identify potential partners, beneficiaries or opponents a stakeholder map was created which formed the basis to contact the stakeholder regarding stakeholder meetings.

3_3_4 Scenario definition

Three scenarios were defined, elaborated and described:

- Scenario 1: business as usual
- Scenario 2: minimal flooding
- Scenario 3: maximal/optimal flooding

The technical approaches of the assessment were developed in cooperation with local experts.

Each scenario was described according to the area affected by temporarily flooding, the water volume and the intervention measures needed. The actual result based on the elevation/hydrostatic model gives a basic idea. It must be modelled with a hydrodynamic model in detail as a next step, to calculate the waterflow and the flood duration in the specific areas. These indicators are relevant for the cost estimate, the habitat conditions and the land use options.

3_3_5 Assessment of impacts

Considering the pre-defined key questions, the feasibility study consists of three levels of consideration with connected sets of criteria, which are developed and evaluated step by step. Based on the widespread concept of sustainability dimensions, the long-term feasibility is determined by three subject areas:

- Ecological dimension
- Social dimension
- Economic dimension

Ecological dimension

The floodplains and riverine forests within the study areas have a great potential to boost the ecological treasure of the area. Almost 40 % of the study area lay within Natura 2000 sites: A favourable conservation status needs to be developed according to the EU habitat and bird directives. Additionally, almost the whole area on the Serbian side is declared as ecological important area for the national ecological network. Priority habitat types and strictly protected species recorded in the area have conservation targets as well.

Social dimension

To connect the people with the river and natural floodplain dynamics can be a social target as well. Recreational use, fishing, hiking and cycling and the identification with the riverine landscape is important for the connection to nature and can also support the local identity.

The question of landownership and support of the respective land owners and land users is part of the consideration for the feasibility, as well as the political will to support changes.

Economic dimension

Besides extensive forestry use of the alluvial forests, Sava River is used for hydropower and with the policy to brake climate change, CO2 neutral energy will be supported in the future. On the other hand, an intact river system can trigger nature tourism and support regional development. Fishing, recreation with hiking and cycling might be economically important in the future. Flood protection and groundwater stabilisation are other factors to be considered. They are the base for the economic welfare of the residents.

In addition to the content-related dimensions of sustainability, a fourth level was added, which considers the technical aspects. Opportunities to reconnect the floodplain via use of current water levels are evaluated.

To assess the impacts of each scenario an intersect with the habitat maps for ecological impact and an intersect with the land use map was done. The following subject areas are described for each scenario along the ecosystem services.

Ecosystem services (ESS) -

The impacts as mentioned in Table 3 were described and calculated using the concept of the Ecosystem services. It allows to consider positive and negative impact.

In the course of the feasibility study, the essential ESS's were pointed out and described. The rough calculation is based on the output of the ESS study for the Serbian part (INCVP, 2018) amended by own price research and results of the study "Evaluation of the ecosystem services of the Austrian Federal Forests (ÖBf): Values of nature: Modelling the scenarios and evaluating the management options" from the technical university of Vienna and E.C.O. Institute of Ecology (GETZNER ET AL., 2019).

For the conclusion only quantified ecosystem services were considered. Therefore, the benefits and compensation expense were calculated for forestry, agriculture, potential animal husbandry, potential fisheries and retention capacity. Additionally, the construction costs to implement the retention capacity and the flood mitigation for the settlements were added to the conclusion of both scenarios.

Forestry

Based on the case study in Bosut Forest (INCVP, 2018), timber production is expected to increase by 30-50% by reconnection with the river via temporarily flooding. In the period between 2007 and 2013 20.39

m³/ha Pedunculate oak was harvested, which corresponds to an annual harvest of approximately 4.2 m³ per hectare. For both scenarios, the flooded area for the land use type lowland oak and hardwood (GIS results of Sava Whitebook SCHWARZ, 2016) were considered and an increase of 30% of wood production for this area was calculated. The monetary value of the increased timber volume was determined with prices for wood from the Austrian Chamber of Agriculture (LWK ÖSTERREICH, 2021). It was estimated that 30 percent of the increased volume is firewood and 70 percent is roundwood.

Table 2: Assumptions for Forest production.
Percent of total Volume Upper limit, Source: LWK ÖSTERREICH (2021).

	Percent of total Volume	Upper limit € per hectare	Mean € per hectare	Lower limit € per hectare
Roundwood	70%	380	285	190
Firewood	30%	62	58.5	55

Agriculture

The compensation expense due to flooding in agriculture was assumed to be a loss of the annual land renting price for arable land (104 €) and permanent grassland (52 €) in Croatia (EUROSTAT, 2019). As arable land the land use types “small sectioned agriculture” and “large sectioned agriculture” were used (SCHWARZ, 2016). The area for permanent grassland was determined on the land use type of “other grassland”.

Potential Animal husbandry

To calculate the benefit of traditional pig herding on the floodplain of the Sava river the case study in Bosut Forest (INCVP, 2018) was used. Due to flooding the exploitation of capacity per area increases. The increase of the meat production was then estimated for the land use types clearcut/amorpha, hardwood, floodplain swamp and wet grassland (SAVA Whitebook, SCHWARZ, 2016). The annual increase of meat in euro per hectare for ranged between 54 € and 58 €. Traditional pig herding also reduce the annual costs of pond habitat maintenance of 100€ per hectare. The saved financial resources due to the increase of pig farming was estimated with the mean ratio of ponds per hectare farming area for the Scenario B (11%).

Potential Fisheries

Based on the case study in Bosut Forest (INCVP, 2018), an increase of 30 – 60 kg Carp per hectare was estimated in case of environmental flooding in the Bosut Forest area. To calculate the potential increase of fisheries an average annual value 45 kg/ha for the flooded area of the land use types Impoundment/Channel and Oxbow (SAVA Whitebook, SCHWARZ, 2016) were used.

Retention Capacity

GETZNER ET AL. (2019) calculated production costs for retention basins which would have to be built without retention capacity of the landscape. The technical lifetime of those retention basins was set at 50 years. The annual costs per m³ retention capacity was about 0.384 € in Austria (based on 2017 prices). To calculate the retention costs the water volume was multiplied with this factor for both scenarios.

Construction Costs

The estimated construction costs of this project include the preparatory costs and the construction cost to ensure the retention capacity of the landscape and the flood mitigation of settlements and areas close to settlements. The construction costs are a rough estimate at this stage and mainly consider costs for an additional sluice-gate north of Zupanja, and dike construction measures for selected areas.

To calculate annual construction costs also a technical lifetime of 50 years was assumed.

Table 3: Essential ecosystem services regarding to forest and floodplain within the study area. (cf. GETZNER ET AL. 2019, INCVP 2018).

Provisioning services	Supporting services	Regulating services	Cultural services
Wood production	Protection of biodiversity - habitats (improvement, quantity, quality, (FFH) habitats, naturalness…) **Natura 2000 restoration (area restored)**	**Flood protection (flood retention volume)**	Recreational use (leisure activities, tourism, nature observations, connection to nature…)
Game and fish for commercial use	Protection of biodiversity - species (richness, endangered species, population size…Bird directive)	Storage of carbon (reduction of CO2 emissions…) - Climate change adaption	Further benefits (education for sustainable development, participation opportunities, recognition of area, connection to nature…), signalling effect and funding
Production support through pollination	Improvement of protected areas (connection with river… improvement of ecological status)	Water quality	
	Importance for European wildlife corridor	Ground water storage (keeping sufficient water in the area)	
	Agricultural use/ **Traditional pig farming**		

A valuation is done for following factors in the frame of this study for the minimum and the maximum scenario (text highlighted in black in the table above). The influence on the other services is described but not validated.

Table 4: Validation Criteria for ESS calculation

Production	**Unit**	**Upper limit €**	**Mean €**	**lower limit €**	**Scenario**	**Result € upper limit**	**Result € mean**	**Result € lower limit**
70 % of ha of roundwood (Hardwood and Oak forest) +30% increase divided by annual average harvest value of 4.2 m³ per ha	m³/year		Average roundwood price		m³ timber per year and ha x 70 % of ha forest flooded	m³/year x price	m³/ha x price	m³/ha x price
30 % of ha of firewood (Hardwood and oak forest) +30% increase divided by annual average value of 4.2 m³ per ha	m³/year		Average firewood price		m³ timber per year and ha x 30 % of ha forest flooded	m³/year x price	m³/ha x price	m³/ha x price
Arable Land (Compensation after flooding)	ha/year		Minus average rental price		ha affected		ha x minus rental price	
Other grassland (Compensation after flooding)	ha		Minus average		ha affected		ha x minus rental price	

Production	**Unit**	**Upper limit €**	**Mean €**	**lower limit €**	**Scenario**	**Result € upper limit**	**Result € mean**	**Result € lower limit**
			rental price					
Potential Animal husbandry (pigs)	Meat € per year per ha	Meat price	Meat price	Meat price	Potential animals per ha forest	Price x animals	Price x animals	Price x animals
Potential Fisheries (carp)	kg	Price per kg	Price per kg	Areas ponds x kg fish	Scenario x price			
Pond habitat maintenance cost avoided	ha		Minus Costs per ha		ha ponds x cost			
Total:Production							sum	
Retention	**Unit**	**Upper limit €**	**Mean €**	**lower limit €**	**Scenario**	**Result € upper limit**	**Result € mean**	**Result € lower limit**
Retention value	m³/year		Yearly retention costs per m³		Water volume per scenario		Water volume x retention costs	
Preparatory costs (yearly)	€	minus lump sum	minus lump sum				minus lump sum	
Construction costs (yearly)	€	minus lump sum	minus lump sum				minus lump sum	
Total: Retention value	€						sum	
Total ESS:							**Sum of production and retention**	

:

3_3_6 Cost-benefit analysis

Simplified methodology for cost and benefit analysis (CBA) has been proposed by EPTISA (2018). Especially in situations when certain measures are part of technical preparation, most commonly of a feasibility study this approach is applied. There are two types of costs that should be addressed within a CBA (EPTISA 2018):

- direct costs: capital, operational and maintenance costs
- indirect costs: e.g. salaries of people responsible for the implementation of measures.

This analysis considers estimated costs for preparatory works, planning and design and the costs for the construction of the necessary structures and facilities and some protective measures.

Compensation costs are calculated for arable land in the impact description.

3_3_7 Methodological limitations

COVID-19 Adaptations

Due to the current situation regarding COVID-19, the team was forced to limit all field trips as indicated in the original proposal to a minimum. One visit in the Croatian part of the study area connected to a stakeholder meeting took place in Zagreb in September 2020. Due to COVID-19 regulation, the Serbian side could not be visited during that trip like originally planned.

As an alternative, Skype/ZOOM meetings were held to adequately discuss and reflect the perspectives of the different stakeholders. As a consequence, trust creating face to face meetings and personal introduction of the project team to relevant stakeholders were not possible.

In September 2021 the study was presented during a field trip to Serbia and at Sava Parks meeting in Croatia.

4 DATA ANALYSIS

4_1 Evaluation of studies and reports

The following paragraphs explain the most important studies in the study area more detailed.

4_1_1 Sava White Book

The Sava White Book (SCHWARZ, U. 2016a, b) was developed by the Consultant Engineer for Geography FLUVIUS in cooperation with EuroNatur and Riverwatch as well as the SavaParks network as part of the campaign “The Blue Heart of Europe”. For the study data and facts about the Sava River and its tributaries were compiled and satellite images were evaluated. The White Book describes in a compressed form the ecological importance and the acute threat to this unique river through the expansion of flood dams, hydropower projects, navigability and gravel extraction for the first time. It specifically shows the possibilities of how flood protection can be improved, and the Sava River can be preserved as a lifeline.

The study examines the restoration potential for river and flood areas. Based on landscape structure, hydro morphology, protection status, retention capacity, ownership structure and 143 areas that are suitable for restoration measures were pointed out.

For the actual study area, the Sava White Book shows for Croatia one area north-west of Gunja with very high restoration potential and one area south of Zupanja with high restoration potential. Additionally, the river stretch north of the mouth of the Bosut River in Serbia is considered to have high restoration potential (Figure 11).

All stretches with high river restoration potential lie with more than 70% of the stretch within a protected area (SCHWARZ 2016a).

Parameters used for the assessment:

- Length
- Space for lateral development
- Protected areas
- Connection to potentially restored floodplain

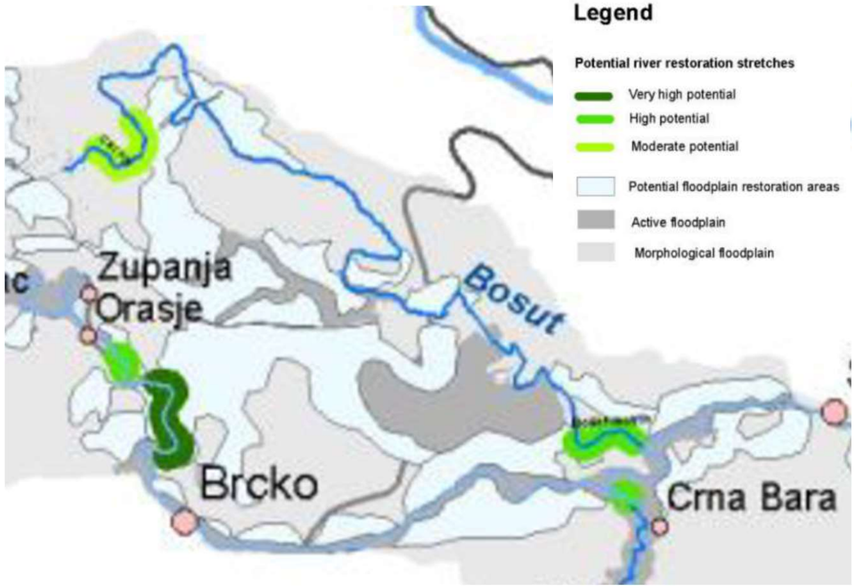


Figure 11: Potential river restoration stretches within study area. (Source: Schwarz 2016b).

The assessment of potential floodplain restoration areas points out mostly high potential for restoration. For the area between the Bosut mouth and Strošinci (Sremska Rača floodplain) even high potential Figure 12. Here the proportion of typical remnants of natural floodplain elements is for 30-70%, more than 70% of the land is aggregated into large plots, >70% of the floodplain lies within a protected area.

Parameters used for the assessment:

- Land structure
- Hydromorphological conditions
- Retention capacity
- Dike relocation potential

- protected areas
- Land ownership

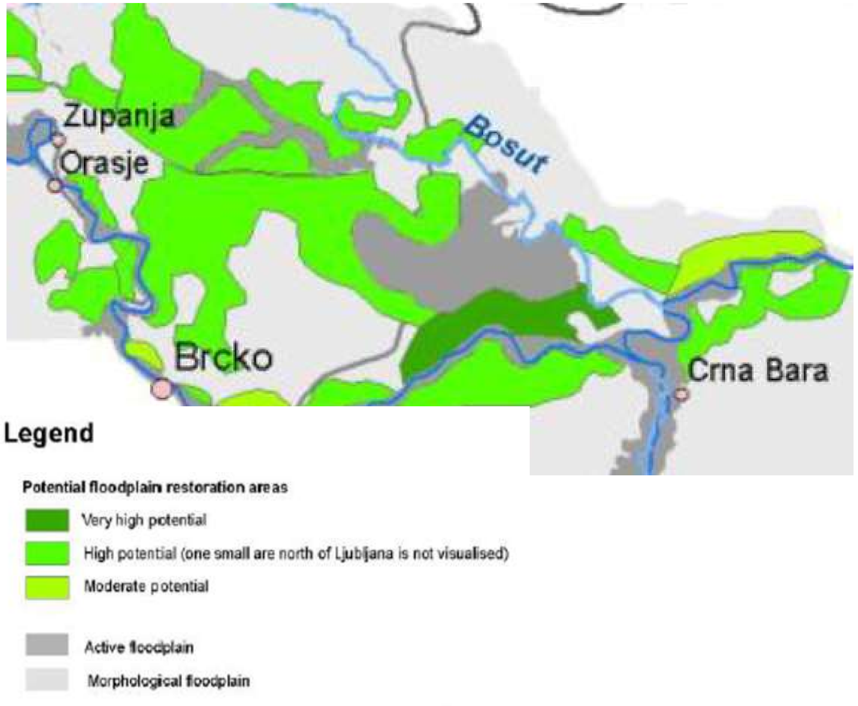


Figure 12: Potential floodplain restoration areas within the study area. (Source: Schwarz 2016b).

One of the ten areas with the highest restoration priority class is the floodplain area Sremska Rača in Serbia. This is by far the largest potential floodplain restoration area. To the north, it borders the central Bosut-Spačva forest, and at present, it is partially flooded by the backwater of the Bosut when the Sava weir at the Bosut confluence is closed. There are plans in Serbia to make this area a flood polder with a retention capacity of approximately 130 million m³. (SCHWARZ 2016a). Figure 13, Figure 14 and Figure 15 show the hydromorphological assessment of Sava River stretch within the study area. Although few areas are classified as near natural (southwest of Zupanja), most parts are only slightly modified and the overall assessment over the river stretch in large parts is also classified as slightly modified. The floodplain as moderately modified to extensively modified.

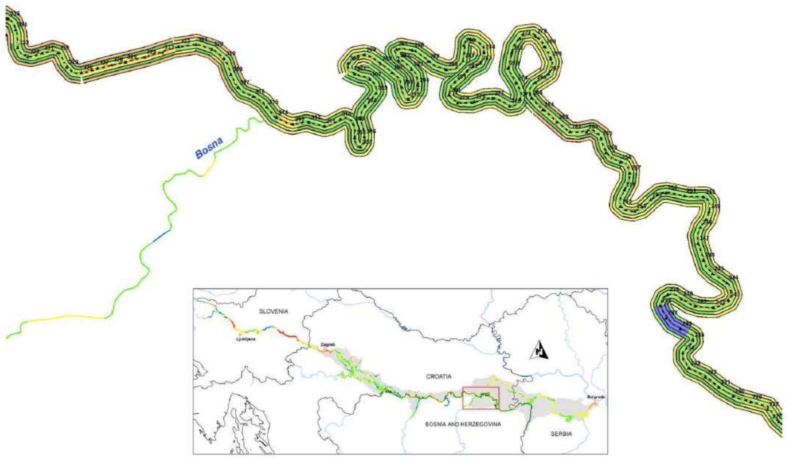


Figure 13: Hydromorphological assessment of Sava River stretch within the study area. (Croatian site)
Blue = near-natural, green= slightly modified, yellow=moderately modified, class 4=extensively modified, class 5=severely modified. Most parts of the Sava River stretch are slightly modified. (Source: SCHWARZ 2016B).

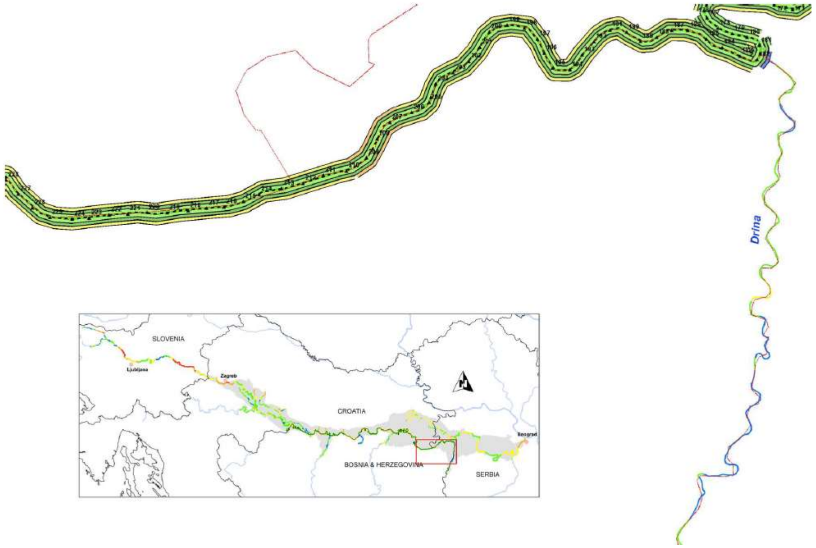
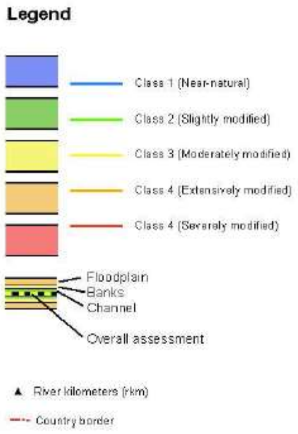


Figure 14: Hydromorphological assessment of Sava River stretch within the study area (Croatian and Serbian site). (Source: SCHWARZ 2016B).



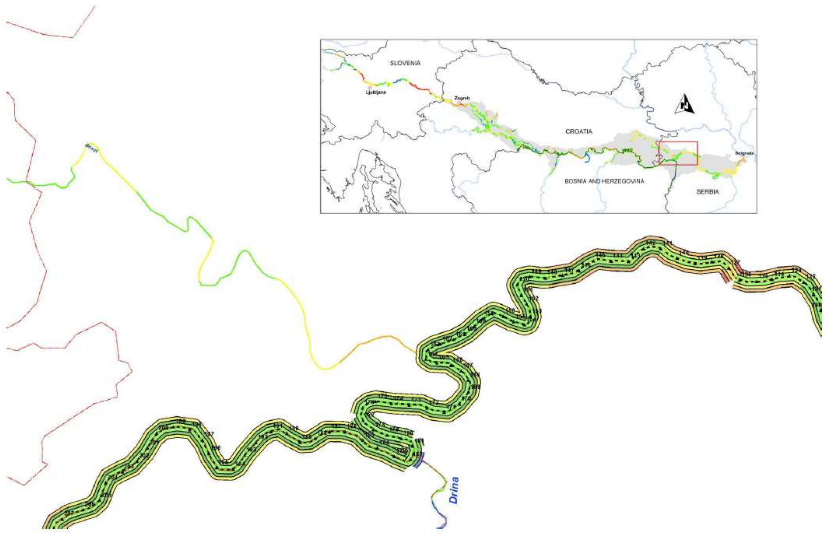


Figure 15: Hydromorphological assessment of Sava River stretch within the study area (Serbian site). (Source: SCHWARZ 2016B).

4_1_2 Case Study: Advocating ESAV in Bosut Forests area - integrating biodiversity and ecosystem services in natural resource uses and management (INCVP 2018)

The scope of the case study was to evaluate four ecosystem services or “benefits from nature” that are crucial for flood protection, steady profits, nature conservation, and local population welfare in the Bosut Forests area: wood production, flood prevention, meat production and biodiversity.

Through panel discussions with stakeholder from the fields of forestry, water management, traditional animal husbandry and nature conservation beneficiaries’ needs and improved cooperation in utilisation and management of Bosut Forests area were discussed.

In the framework of the study two scenarios have been calculated: (1) continuation of ”business as usual” and (2) “integrated management” approach.

Regarding to the case study the integrated management approach which foresees a multipurpose utilisation of the area pursues the following objectives:

- The establishment of a protected area with the reception of flood waves in half of the Nature Park
- environmental flooding of the forest complex in order to increase forest vitality and maintain the existent habitat mosaic
- the application of traditional animal husbandry as the most economical method of habitat maintenance
- increasing yields and profits in the area.

4_1_3 Nature-based solutions for flood risk prevention in South-Eastern Europe (Schwarz et al. 2018)

The purpose of the study is to raise awareness about nature-based solutions (NbS) for flood risk prevention in Southeastern Europe. The objective was first to analyse the current situation (floods and flood management in those countries) and second identifying natural water retention areas and proposing specific projects for NbS. The restoration of the former floodplain between the rivers Sava and Bosut is one the identified areas, where the lack of flooding and the lowering of the groundwater, caused by increased riverbed erosion at the Sava, affect all species that are related to wetlands and lowland forest habitats, too (Schwarz et al. 2018). Flood risk for the wider region, severe droughts and groundwater depletion are further threats (BAUER 2013, GALIC´ 2009 and 2010).

The proposed solutions are (SCHWARZ ET AL. 2018)

- Geodetic measurements necessary to deliver a digital elevation model of the area;
- Additional collection of spatial data on selected indicator species and habitat types;
- Construction of a new dike around the forest complex between the existing dike on Sava River and the settlements (Jamena, Morović, Višnjićevo) in order to keep the floods within the forest, achieving water dynamics in favour of forest vitality. The surface of the proposed retention area (see map below) enclose approximately 9.000 ha. The approximate length of the new dike would be 25 km, with heights from 1 to 4 m, following the micro relief of natural levees. The final retention area and the dike location would be defined according to a digital elevation model.
- Inlet/outlet structures on the existing dike on Sava River.
- Additional drainage on arable land close to the retention area (small in extent);
- Monitoring of the effects of the hydrological changes, both on the biodiversity (selected species and habitat types) and on the forest

Numerous reasons for restoration were mentioned in the study. This includes the economical, ecological and social needs, flood risks or impaired conservation status of the habitat types and species. Another rationale is that material for the dike constructions is available at the site.

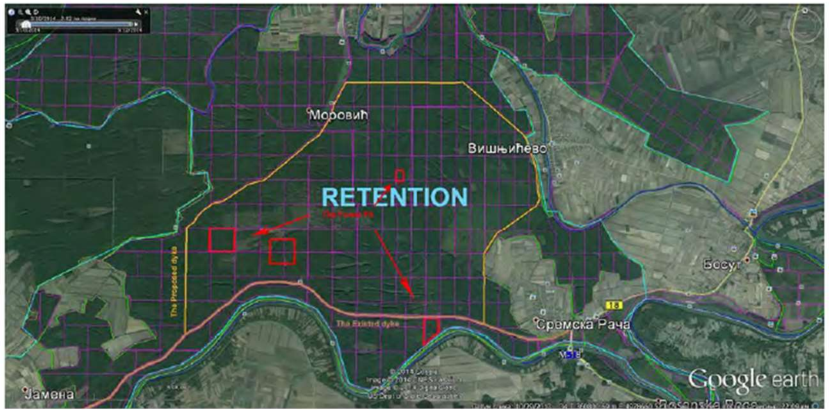


Figure 16:Bosut forest, potential area for reconnection with the lower Sava. (orange marked area north of the flood dike). (Source: SCHWARZ 2018).

4_1_4 Wetlands Ecosystem Services Assessment (EcoWET) in Croatia-Serbia cross border region (Interreg 2020a)

The Interreg-project EcoWET project is an ongoing project (Lead partner Nature Conservation Movement of Sremska Mitrovica) and it provides a solution for the degradation of wetland ecosystems caused by human activities and the limited capacity to deal with these consequences. Also, low awareness about the importance of wetlands is a priority in the project. To achieve that, the ecosystem's importance will be assessed and innovative methods for their conservation will be developed.

The main objective of the project is to develop Guidelines on ecosystems mapping and assessment (tested on pilot areas in the cross-border area), educational events and the ecosystem processor for wastewater purification (ASSOCIATION FOR NATURE AND ENVIRONMENT PROTECTION GREEN OSIJEK 2020).

4_1_5 Protection of Biodiversity of the Sava River Basin Floodplains - Identification of sites in need of restoration and preparation of small scale pilot restoration plans (KITNAES ET AL. 2009)

Restoration Plan for Bosutsko-Morovićke šume

Although the study area Bosutsko-Morovićke šume is in good condition, replacing of natural forest with poplar plantations and drainage of wetlands water management can harm species and habitats and their conservation status. Due to the low economical value of alluvial forests, that forests were systematically replaced with economically more valuable forest (KITNAES ET AL. 2009).

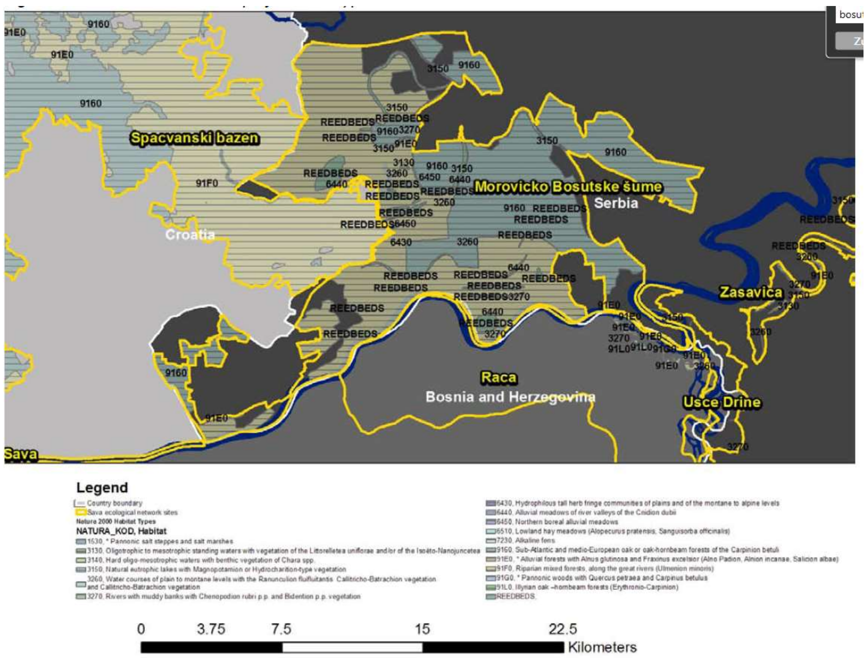


Figure 17: Study area Bosutsko-Morovićke šume and habitat types. (Source: Kitnaes et al. 2009).

Proposed Restoration Actions for Management (KITNAES ET AL. 2009):

- Evaluate how important is the site as a water retention.
- Develop water management plan which would consider conservation of water dependent habitats.
- Adapt forest practices to mitigate negative impacts (especially invasive species in alluvial forests).
- Plan stepwise replacement of poplar plantings within core areas and around larger wetland habitats.
- Develop a plan for restoration of wetlands within forest complex.
- Develop plans for alluvial forest restoration.

- Support extensive cattle breeding in order to maintain open habitats.
- Promote area as an ecotourism destination (together with Spačva in Croatia the largest oak forest).

Proposed Restoration Actions: Protection (KITNAES ET AL. 2009):

- Elaborate study for legal protection of the site.
- Define zones and regimes of protection.
- Precisely define and prioritize locations in need of restoration (wetland & forest).
- Develop action plans for most important species (black stork, white-tailed eagle etc.).
- Minimize hunting and disturbance during reproduction period (spring, summer)
- Use mowing and grazing where possible, to maintain wet meadows and similar open habitats.
- Clean (extract mud and vegetation) the most important marshes and bogs within forest complex.
- Develop measures to control favourable water levels (dikes, dams, ditches).
- Clean channels for influx of water, control efflux of water in periods of low waters.
- Restore and maintain transitional zones between forests and wetlands.
- Secure leaving of old trees and dead trunks in forests.

Spačvanski bazen

The main threats for the site are drainage, the current forest management, channelisation, removal of dead and dying trees, modification of hydrographic functioning, reduction of underground water level modifying structures of inland water courses (KITNAES ET AL. 2009).

Recommendations for management and protection (KITNAES ET AL. 2009):

- Capacity building for County Administration of protected areas to ensure management plan implementation.
- Educate local people on the high biodiversity value and its protected species and habitat types.
- Integrate water management with nature protection needs and prevent changes in water level in wet forest habitat types, and if possible, improve water regime for the lowland wet forests.
- Manage forests sustainable and introduce close-to-nature forestry to secure the quality and diversity of flora and fauna.
- Ensure incentives for extensive livestock and stimulate traditional farming and extensive livestock farming.
- Conduct restoration of wet grassland habitat types in the site.

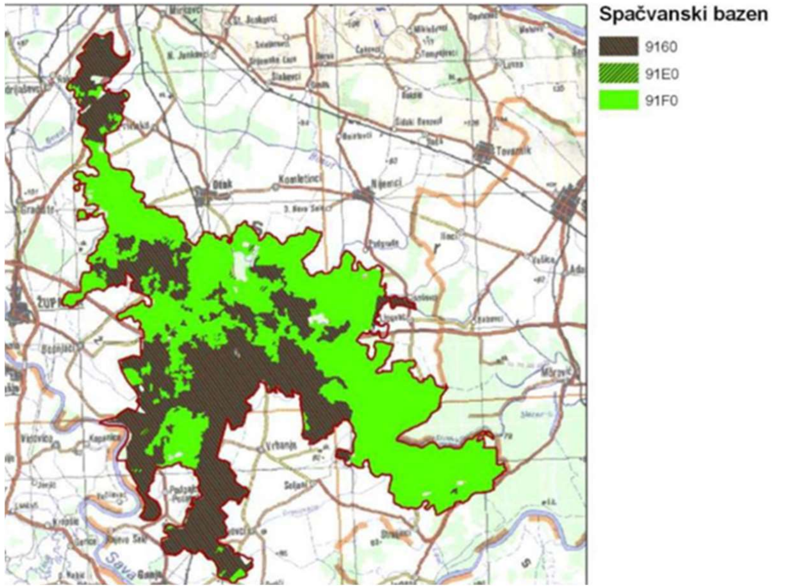


Figure 18: Study area Spačvanski bazen and habitat types. (Source: KITNAES ET AL. 2009).

4_1_6 Integrated Cross-Border Monitoring and Management Systems for Flood Risks, Environmental and Biodiversity Protection and Forestry Through Transboundary Forest Retentions and Other Measures (INTERREG 2020b)

The objective of the project was the development of transboundary forest retention measures for integrated flood risk, environmental and forestry management.

This project focused on the reach of the Sava River from Županja in Croatia to Sremska Mitrovica in Serbia.

Further the aim of the study was to determine the optimal measures and prepare a feasibility study for the green infrastructural measure(s) that will be implemented in the future from other sources of funding. Unfortunately, the project was cancelled before gathering data.

4_1_7 SPAČVA BASIN Proposed Natura 2000 Site DRAFT MANAGEMENT PLAN (RAMBOLL & NATURE BUREAU, 2013)

Connected with the preparation for joining the European Union, Croatia designated several natura 2000 sites to fulfil obligations of the FFH-directive and the birds directive. The SPAČVA BASIN draft management plan was one of the products from the EU-funded Natura 2000 Management and Monitoring Project (Natura MANMON), implemented by Ramboll of Denmark and Nature Bureau of the United Kingdom between 2011 and 2013. Specialists from the Ministry of Environmental and Nature Protection, State Institute for Nature Protection, County Public Institutions, research bodies, Croatian Forests, Croatian Waters, as well as local land users and many experts from different EU countries were brought together in order to build national and regional capacity for preparing draft management plans at six proposed Natura 2000 sites. The plan highlights physical characteristics of the area and habitats and species of European importance and includes the evaluation of their conservation status. Goals and management objectives were formulated, to ensure a favourable conservation status for the following ten years. The status was defined as good at that time for the Natura 2000 habitats including the forest. Following vision was developed together with all stakeholders "*Spačva forests represent the largest and best preserved complex of riparian oak forests in Central Europe where unhindered ecological processes and functions (including the processes of natural regeneration, succession and aging), sustainable economic use of natural resources through forest and water management, as well as sustainable tourism, recreation, hunting and fishing are enabled. The role of the Spačva forests as the greatest natural Sava floodwater retention basin should be permanently secured*". Objective 1 means to maintain forests and all their functions in favourable status, in detail a total area of intact natural forest was defined with at least 43.548 ha, and with patches of at least 0,5 ha of old forest in each 56 ha regeneration plot and with at least 40% of stands over 80 years old, reflecting the harmonisation of forestry goals with Nature 2000 goals. Objective 2 means to maintain waters and aquatic ecosystems in favourable status and Objective 3 means to preserve the populations and distribution of target species in good conservation status. The objectives were connected with target areas and target populations. (RAMBOLL & NATURE BUREAU, 2013). A monitoring plan for target species was developed.

4_1_8 Summary and Findings

In the last years, several studies have been carried out in connection with the Sava River basin. Preliminary work was done also for the study area. It can be emphasized that the study area is of high interest for the implementation of river restoration projects. All studies mention the importance of the area and the danger that the forest dries up without any restoration, flood or management measures to supply forests with water and thereby promoting the ecosystem, habitats, plants and animal species that belong to the forests.

The Sava White Book (SCHWARZ 2016 a, b) shows for Croatia one area north-west of Gunja with very high restoration potential and one area south of Županja with high restoration potential. Additionally, the river stretch north of the mouth of the Bosut River in Serbia is considered to have high restoration potential (Figure 11). The assessment of potential floodplain restoration areas points out mostly high or very high potential for restoration, as for the area between the Bosut mouth and Strošinci (Sremska Rača floodplain) (Figure 12).

The Case Study "Advocating ESAV in Bosut Forests area – integrating biodiversity and ecosystem services in natural resource uses and

management" (INCVP 2018) evaluated that with an integrated management wood production in the Bosut area would benefit in 30-50% less forest dieback and salvage cuttings related to water depletion, with proportionally higher quality yield in timber. The approach will promote a great variety of animal species and habitat types.
The restoration of the former floodplain between the rivers Sava and Bosut is one of the identified areas, where the lack of flooding and the lowering of the groundwater, caused by increased riverbed erosion at the Sava River, affect all species that are related to wetlands and to lowland forest habitats, too (SCHWARZ ET AL. 2018). Flood risk for the wider region, severe droughts and groundwater depletion are further threats (BAUER 2013, GALIC´ 2009 and 2010).

KITNEAS ET Al. (2009) show that the replacement of natural forest with poplar plantations and drainage of wetlands water management can have a negative impact on species and habitats and their conservation status. In the study, they identified Bosutsko-Morovićke šume and Spačvanski bazen as sites in need of restoration and prepared small-scale pilot restoration plans for management and protection actions. RAMBOLL & NATURE BUREAU, 2013 developed the management plan for the Natura 2000 sites within the area and defined ambitious targets for conservation status of forests and wetland habitats.

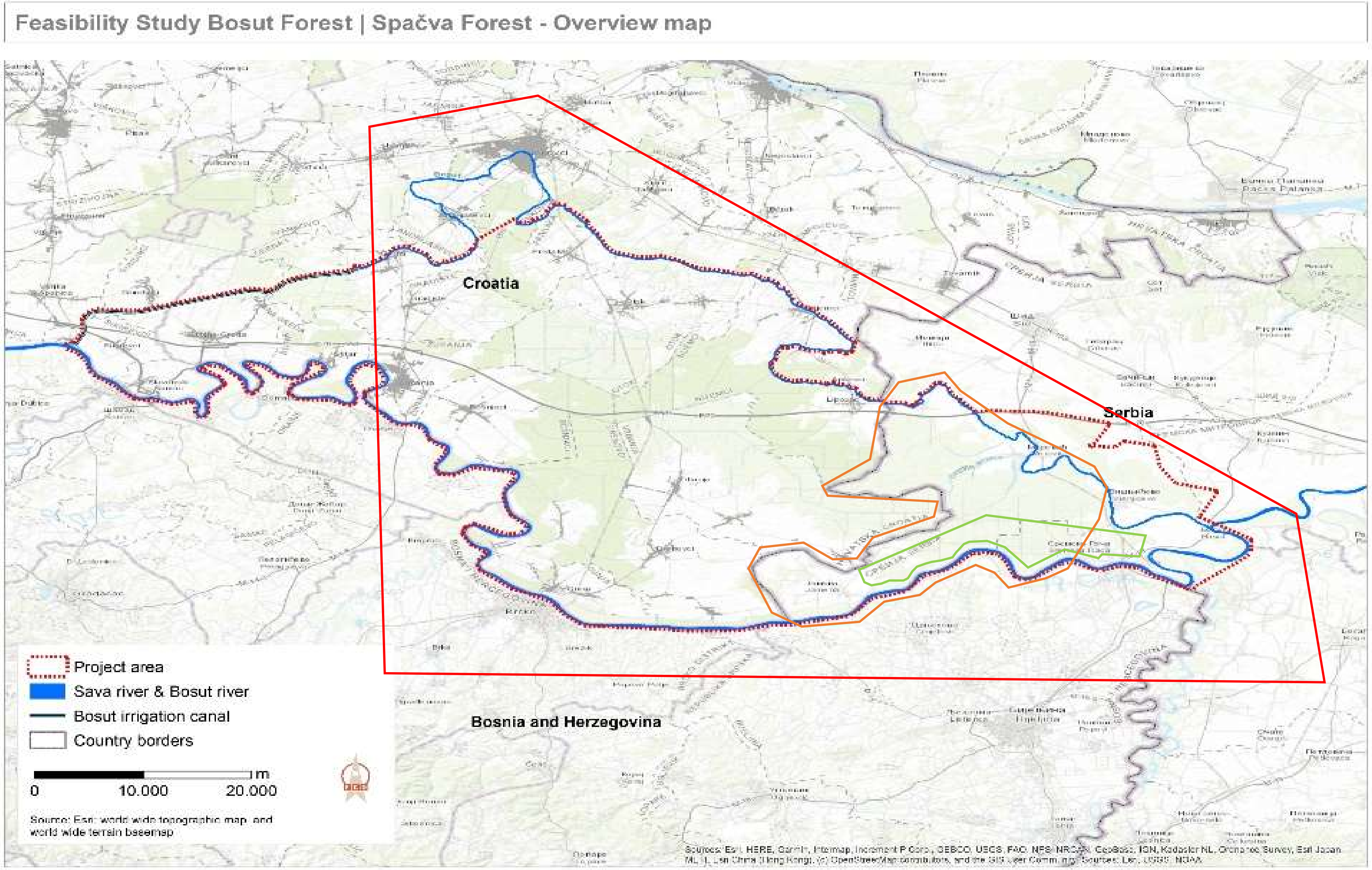


Figure 19: Overview about studies and their spatial reference.

Red =: Potential river restoration stretches, Potential floodplain restoration areas, hydro morphological assessment (Sava White Book), Nature-based solutions for flood risk prevention in South-Eastern Europe (SCHWARZ ET AL. 2018); green = one of ten areas with the highest restoration priority class in Sremska Rača (SCHWARZ, 2016); orange = Case Study: Advocating ESAV in Bosut Forests area - integrating biodiversity and ecosystem services in natural resource uses and management (INCVP 2018), Protection of Biodiversity of the Sava River Basin Floodplains - Identification of sites in need of restoration and preparation of small scale pilot restoration plans (KITNAES ET AL. 2009).

4_2 Analyses of Status Quo

4_2_1 Land use

The study area in Croatia consists of a forest area with representative flooded forests of Pedunculate oak, Black alder and Ash and is combined of areas of different age. For the last part of the Zagreb-Belgrade highway passes a significant part of the forest complex has been cut down without any compensation. The forest area is surrounded by intensively used arable land (KITNAES ET AL. 2009).

The study area in Serbia is situated in the lowland on the left bank of the Sava River. As described in KITNAES ET AL. (2009) it is a mosaic-like landscape dominated by mixture of old lowland Pedunculate oak-ash-hornbeam forests, with mosaics of marshes and waterlogged areas overgrown with willows, representing a natural mosaic of high biodiversity value. Within wetland complexes there are small grassland patches situated. These patches are at different stages of succession. The subarea is surrounded by arable land from north and east.
The landscape is dominated by lowland forest and the largest part of the area is protected by a dike along the Sava River. The water management in the area is implemented through a dam in the Bosut River. Flooding do not regularly occur and depend on the needs of agriculture and flood protection of settlements and towns. You can find a well-developed network of roads (dirt roads, asphalt roads). Despite the building of a dike in 1930s, due to low altitude and strategic importance of oak forest, the site remained in close to natural state (KITNAES ET AL. 2009, ZINGSTRA ET Al. 2010).

Forestry

The study area is covered by an enormously large area of forest. In Croatia 48.648 ha is covered by forest while on the Serbian site 19.407 ha of forest exist. In total, 45% of the project area is covered by forests.

The soil types reflect the alluvial character of the forests. In Croatia (Spačva Basin) there is mainly eugley, humogley and alluvium (fluvisol). There is great variation in the horizontal and vertical soil profiles, expressed in modified layers of different grain sizes. The soils are temporarily to permanently wet in part or whole of the profile (RAMBOLL & NATURE BUREAU 2013).

Table 5: Share of forest within the study area.
(Source: GIS-data Vojvodinashume (Serbia), GIS-data Sava White book (Croatia)).

Country	ha forest in study area	%
Croatia	48.648 ha	71
Serbia	19.407 ha	29
Study area	68.055 ha	100

Croatia

The Spačva basin with a flooded pedunculate oak forest is one of the largest forest complexes in Croatia. It is not only the largest oak forest in Croatia but also one of the largest oak forests in Europe and extends over an area of 48.000 hectares between the Sava and Danube rivers (BUDEN-HOSKINS ET AL. 2013; DUBRAVAC AND DEKANIĆ 2009).

The forests in the Spačva Basin are a complex of lowland forests in the region of Slavonia (eastern Croatia). Regarding the publication of CESTARIĆ ET AL. (2016) the present state of the forests is strongly influenced by intensive exploitation and hydro-ameliorative activities carried out in the past. The study indicates that all vegetation types are becoming floristically more similar and there is a general trend of moisture reduction among all communities. They also showed that due to less of flooding and lack of water the frequency and cover of flood intolerant woody species (such as *Carpinus betulus, Cornus sanguinea, Tilia tomentosa,* and *Acer tataricum*) increase and vernal species related to wet habitats decrease. Because vegetation types are becoming floristically more similar, the mosaic community pattern characteristic of lowland alluvial forests are getting more and more lost (CESTARIĆ ET AL. 2016).

The natural condition of the forest is reflected through quite a diverse species composition (Table 6). The main species are (RAMBOLL AND NATURE BUREAU 2013):

- Oak *Quercus robur* (about 65% of the growing stock),
- Ash Fraxinus angustrifolia (14%)
- Hornbeam *Carpinus betulus* (13%).

Field elm *Ulmus minor*, which once had a large proportion in the forests, has almost disappeared because of Dutch elm disease.

Table 6: Tree species composition in Spačva basin forests. (Source: Ramboll and Nature Bureau 2013).

Tree species	Share	Tree species	Share	Tree species	Share
Pedunculate oak	67.65%	Fruit bearing sp.	0.30%	White willow	0.04%
Narrow-leafed ash	14.10%	American ash	0.18%	Other softwood sp.	0.03%
Hornbeam	13.31%	Poplars	0.14%	Black walnut	0.02%
Field maple	1.61%	Black alder	0.07%	Field elm	0.01%
Linden	1.30%	Native poplars	0.07%	Cherry	0.01%
European white elm	0.74%	Black locust	0.06%	Spruce	0.00%
Other hardwood sp.	0.31%	White poplar	0.05%		

In the late 19th and early 20th centuries, the forest management was divided into compartments of 100 cadastral acres (57,50 ha) and grouped into management units. Management plans for every forest unit are made for a period of 10 years and are regularly updated (RAMBOLL AND NATURE BUREAU 2013). The forest within the Spačva Basin is divided into 12 forest management units which differ somewhat in habitat conditions, stand structure and permitted cut (Table 7).

The draft of the Management Plan for the Natura 2000 Spačva Basin (RAMBOLL AND NATURE BUREAU 2013) indicates, that the average overall growing stock is 326 m³/ha, ranging from 116 m³/ha in Dubovica, up to 413 m³/ha in Kragujna.

Table 7: Spačva forest management units. (Source: Ramboll and Nature Bureau 2013).

Management unit	Total area (ha)	Forest area (ha)	Type 9160 / G10 (ha)	Type 91F0 / G20/30 (ha)	Type 91E0 / G40 (ha)	Growing stock (GS, m³/ha)	Final felling %	10-year Cut / GS
Desićevo	2603	2494	2140	292	61	297	0.57	0.21
Debrinja	5334	4884	1494	3390	0	357	0.52	0.22
Dubovica	1434	1385	155	1230	0	116	0.73	0.14
Kragujna	3838	3637	1879	1758	0	413	0.48	0.19
Narače	1682	1612	225	1387	0	322	0.34	0.18
Otočke šume	2591	2507	384	2126	0	314	0.35	0.17
Topolovac	3460	3280	255	3059	0	386	0.23	0.13
Vrbanjske šume	8283	7867	5202	2651	14	378	0.52	0.17
Kunjevci	2582	2582	1508	1074	1	298	0.48	0.16
Kusare	3054	2927	309	2618	0	304	0.24	0.15
Trizlovi Rastovo	1995	1897	1090	807	0	363	0.45	0.17
Slavir	8623	8220	7873	221	126	367	0.52	0.17
Total	45479	43292	22514	20613	202	326	0.45	0.17

According to RAMBOLL AND NATURE BUREAU 2013 the planned harvest is 69% of the growth (or 17% of the growing stock within 10 years), the growing stock should increase over time. With some 14 million m³ of standing trees, the forests provide a sustainable annual harvest of 320.000 m³ of valuable timber and firewood. Recent harvest data shows that if current management practice would continue, the amount of old growth forest would decline to only 12% of total cover by 2061 GRLJANIIČ & GREGOROVIČ, 2003 in TOMIK & GRGIČ, 2020.

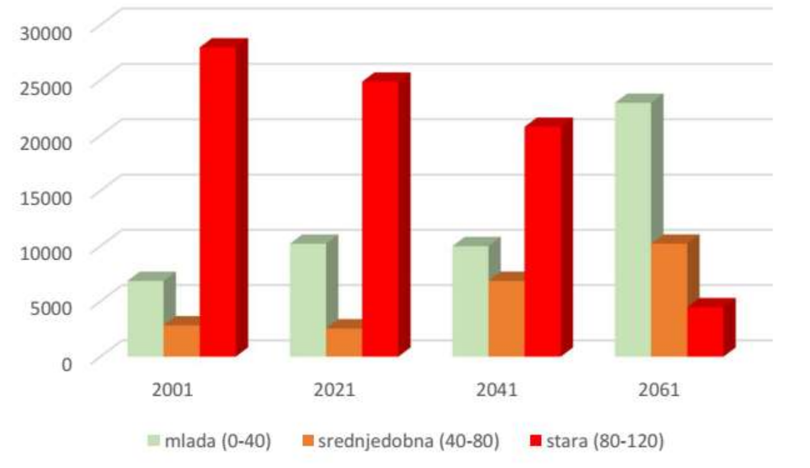


Figure 20: Prediction of decline of old forest.
(Source: Grljaniič and Gregorovič, 2003).

The age structure of forest stands is reflected in Figure 21. It shows that very old forest stands are quite scarce within the different forest types of Spačva forest and that there already quite extensive areas with very young forest stands and also clear cuts. The old forest stands are especially valuable for nature conservation.

Among the main occupations of local people are of course forest management and wood processing, although to a declining degree over the last twenty years. The utilisation of non-timber forest products includes grazing and browsing, collecting mushrooms, fruits, seeds, medicinal and ornamental plants, collection and removal of bushes and branches for livestock feed and beekeeping (RAMBOLL AND NATURE BUREAU 2013).

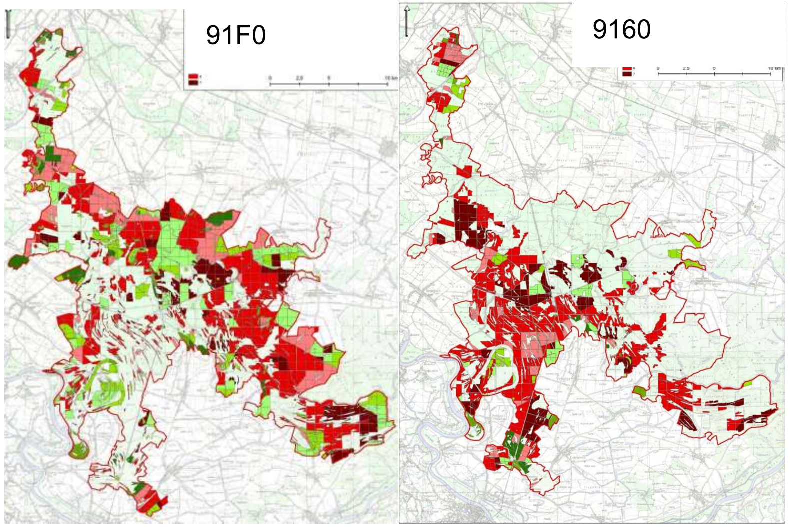


Figure 21. Age structure of forest type 91F0 (dark red = very old) light green (young) white (0)
(Source: Ramboli and NatureBuerau, 2013).

The Zagreb-Lipovac highway passes through Spačva Basin, as well as railway infrastructure, country and state roads. Recreational opportunities of local people are restricted to protected natural areas within Spačva Basin due to strict hunting regulations (RAMBOLL AND NATURE BUREAU 2013).

Serbia

The following information is taken from the Conservation study of INCVP (2016) and translated from Serbian to English by Alen Kis.

Thanks to the large forest cover, primarily autochthonous hardwoods (*Q. robur, F. angustifolia, C. betulus,* etc.) forestry is the most spatially represented type of use of natural resources. Forest management planing in "Ravni Srem" (Sava lowlands) has a tradition of more than 250 years (PE "Vojvodina Forests", 2008), which largely determined the manner of use and restoration of forests in the ecological conditions of the entire area. Forest users at the time of valorisation of the area and preparation of this study, according to the real estate cadastre are: PE "Vojvodinašume" (75.89% of forests in PA), PE for Water Management "Vode Vojvodine" (0.02% of forests in the PA) and Military Institution „Morovič" (3.59% of forest in the PA).

During the last few centuries there have been significant changes in forest management and general use of space in the area of Ravni Srem. The specifics of the forest area, which are conditioned by the development of technology and social needs with regards to use shaped the structure and modified the composition of the vegetation. Industrialization and the increase in the possibility of transporting wood soon led to a drastic reduction of old-growth oak stands in the area.

Figure 22: Oak hornbeam forest.
(Source: ALEN KIS).

Already at the time, leading experts in forestry pointed out the negative consequences of deforestation/reforestation on large areas (KOZARAC, 1896; 1898), and in this regard ERDEŠI (1971) points out that the overpopulation of bogs was recorded only after the first extensive felling. During the export of "oak planks" for the production of wine barrels (XIX and the first half of the 20th century), there was an intensive use of the highest quality oak forests. In the period from 1861 to 1901, over 17 million cubic were cut for French planks. For two centuries, grazing and forest grazing were an important part of the forest management practice, very efficient and from today's aspect a type of integrated forest management. Under the conditions of military service, the border guards used privileges and "law enforcement" in the forests for more than two centuries, which was reflected in free acorn grazing for a certain number of pigs, firewood and technical wood for the household. At that time, the forests were still regularly flooded. The use of forests of higher hydrographic positions was more pronounced.

In accordance with the forest management plans, in the forests of autochthonous hardwoods of Ravni Srem (*Q. robur, F. angustifolia, C. betulus, etc.*) the use of forest assortments has been realized in the last few decades by silvicultural fellings (thinning and sanitary) and renewal in a short rejuvenation period within the system of `moderate stand management`.

The development of modern technologies for directing the growth and structure of young forest stands, the use of mechanization and appropriate pesticides to combat invasive and parasitic species, the control of fast-growing competitive species, has enabled the successful renewal of the oak as edificatory species.

Nowadays the dominant land use in the area of Bosutsko-Morovićke is still forestry. Natural or semi-natural mixed deciduous forests cover 19.281 ha (88,2%). Most of this area is moderately managed. Only waterlogged willow and autochthonous poplars forests in foreland, managed by Public Enterprise for Water Management “Vode Vojvodine are extensively managed. Since small watercourses, fragmented grassland patches and forest infrastructure belonging to forest management units, they are included into “forestry “. 830 ha (4%) of the site is covered by intensively managed poplar plantations. (KITNAES et al. 2009).

The period of more intensive utilization and rejuvenation of the old-growth stands occurs during the last two decades, and with the further maturation, it will intensify in the following decades. Softwood plantations in the area are not significantly represented, and they are mostly monocultures of hybrid poplars ("I-214", "Pannonia", "Bora"). Those plantations require the so-called "Complete technology", including ploughing, herbicides, parasite control which reduce their role as habitats of wild species significantly. The characteristics of forest lands, the great ecological, economic and social importance of mixed pedunculate forests as well as the possibility of their multipurpose use, indicate the need for sustainable management of existing forests and forest cultures of autochthonous tree species.

Figure 23: Oak forest and old oak.
(Source: ALEN KIS).

All forests of the lowland area are often expressed in forestry practice as: hardwood forests (Q. *robur, F. angustifolia, C. betulus, U. minor, U. effusa, A. campestre, A. tataricum*, etc.) and soft forests (*Populs sp., Salix sp.*). Stands of indigenous species are represented as much as 97% in the total forest cover. The spatial dominance of "hundred-year-old" forests indicates ecologically extremely valuable habitats for species specialized to old oak forests.

In the forest area where forest regeneration is carried out, grazing of domestic animals is prohibited, but it happened that domestic pigs came to feed on areas rich in acorns. Thus, for the successful regeneration of oak forests, it is necessary to protect the surfaces with an appropriate fence during the first decade of young stand, and in some cases even longer. This fencing in the area of Bosut forests is often done with a fence of several rows of wire through which electrical impulses are released intermittently, repelling large animals.

Agriculture

Croatia

According to SCHWARZ, (2016b) the biggest share of the total study area in Croatia (116.589 ha) outside the forest is composed by small sectioned agriculture (30%). This agricultural land is located mainly close to villages.

Large sectioned agriculture and agroindustry, which includes fruit/wine production) has the second biggest share (17%). Grassland, orchards, wet grassland only have together less than 6% share of the study area in Croatia. Wet grassland are wet meadows and pastures inside and outside the active floodplain (includes dense mosaic of grasslands and forests, forest fringes and wet succession areas). With Other grassland other meadows and grasslands mainly outside the active floodplain, also within settlements and traffic infrastructure are meant. The orchards and gardens are located mostly close to villages.

Table 8: Agricultural structure in Croatia (study area) according to Sava White Book land use data.
(Source: Schwarz 2016b).

Agricultural structure Croatia	Share
Small Sectioned Agriculture	29,5%
Large Sectioned Agriculture	17,6%
Other Grassland	2%
Orchard/garden	1,8%
Wet Grassland	1,6%
Total	ca. 53%
Total Area = 100% (Croatia)	e.g. 116.598 ha

Serbia

The Bosut area is particularly sensitive to intensive agricultural production. Thanks to the fertile soils, the favourable climate and the abundance of water, along the Sava, Bosut and Studva Rivers developed an intensive agricultural production with a long tradition. Here it is especially important to establish a balance between nature and human activities. Agrochemicals, nitrates, and phosphates from fertilizers caused by excessive fertilization or improper manure disposal and uncontrolled use of pesticides contaminate rivers and groundwater (INCVP 2016).

Figure 24: Forest farmer in Bosut forest.
(Source: Ábel Molnár).

In the area of Šid, the most profitable crops are corn and soybeans. Because of the good water supply and fertile soil in this area they provide good yields. In addition to corn, soybeans are also used differently Crops such as sugar beet, barley, sunflower, tobacco etc. are grown (INCVP 2016). In addition, livestock production has a long tradition. From Šid Township were some of the best producers of fattening pigs and cattle in Srem (INCVP 2016). Pig grazing in the Bosut forests is practiced for more than two millennia.

Figure 25: Traditional farming contributes to habitat diversity.
(Source: A. MOLNAR).

This type of extensive pig farming is still practiced throughout Posavina today (INCVP 2016). Some families have been doing this for generations and passing their skills on to their offspring (ZINGSTRA 2010).

Table 9: Agricultural structure in Serbia (study area) according to Sava White Book land use data.
(Source: Schwarz 2016b).

Agricultural structure Serbia	Share
Small Sectioned Agriculture	17,4%
Large Sectioned Agriculture	14,5%
Other Grassland	1,2%
Orchard/garden	0,8%
Wet Grassland	1,4%
Total	ca. 35%
Total Area = 100% (Serbia)	ca. 45,054 ha

In addition to pigs in the woods in the pasture there were sheep, cattle, horses and, more rarely, goats. Within 60-70 days a pig eats 818 hectoliters of acorns, which corresponds to 345 kg of maize.

The grazing of the oak forests has several advantages. For example, it helps to maintain biodiversity in forest, and it reduces pollution of watercourses (INCVP 2016). Agriculture is still one of the main occupations of the population in the whole area. The cultivation of wheat, corn, barley, soybeans, sugar beets and sunflowers are of paramount importance.

There exist management plans for forest, water bodies and agriculture. The agriculture management plan contains only guidelines, and it is prepared by the local government (ZINGSTRA 2010).

Game management / Hunting

In Serbia and Croatia red deer *Cervus elaphus*, wild boar *Sus scrofa* or roe deer *Capreolus capreolus* are hunted the most. Game populations are much higher than the carrying capacity, in both the Spačva and Bosut forests preventing natural rejuvenation. In case of clear cuts these areas must be fenced in to protect the new plantings from being grazed or destroyed by game. The following paragraphs show the structure of hunting and game management in each country.

Croatia

Within the Spačva forest there are several hunting grounds, mainly state-owned and managed by Croatian Forests (Vinkovci Administration), (RAMBOLL AND NATURE BUREAU 2013). Additionally, communal hunting grounds (managed by local hunting society) exist.

Serbia

According to the Conservation study for Bosutske šume (INCVP 2016) the forest is administered by three hunting areas: "Bosutske šume", "Kućine" and "Vranjak". All are part of the Public Company 'Vojvodinašume' which has been established and set up on the area of 108,988.00 ha, which accounts for 5.06% of the total surface area of hunting-grounds established in Vojvodina (2.152.635,60 ha). Hunting area "Bosutske Forests" covers an area of 1,912 ha. The main species of large game are wild boar and deer. The hunt is mostly carried out with high checks but also takes place in organized groups.

Figure 26: Hunting lodge on Studva river near Morovic. (Source: Alen Kis).

The hunting ground of "Kućina" is also a state owned hunting ground with a total area of 1.986 ha, 1.403 ha are fenced. The main species are wild boar and deer. It has an easy to access geographical location and good transport links. Group hunts for wild boar are organized in this hunting area (INCVP 2016).

"Vranjak" hunting area is a fenced-in hunting area with an area of 544 ha. The primary focus is wild boar, also roe deer (INCVP 2016). Is provides valuable habitat conditions and quality game.

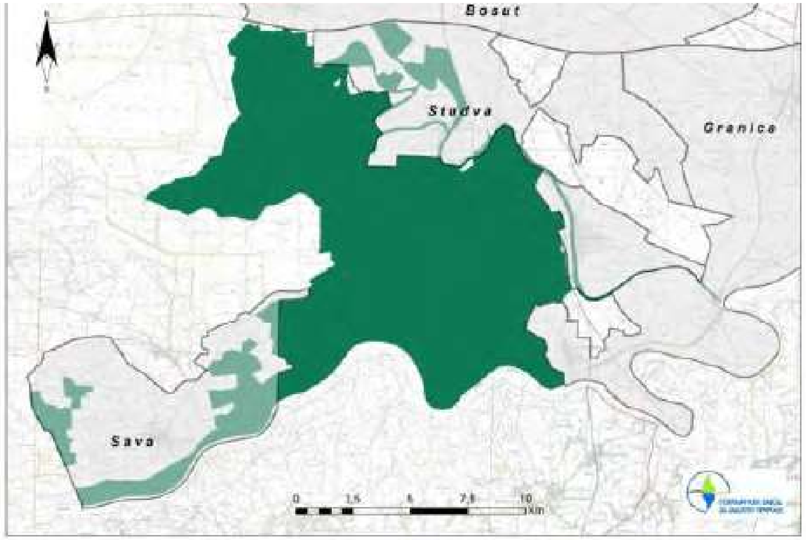


Figure 27: Hunting areas withing the area Bosutske šume. (Source: INCVP 2016b).

Fishery

Croatia

Commercial fishing is allowed on Sava River downstream Jasenovac to the Croatian/Serbian border with very few licenses at the moment, but there is a potential for development.

However, with the implementation of the project flooding can be improved and dramatically enlarge the spawning area for fish species that would enter from Sava River. With more fish in the system importance of fishing in the Spačva and Bosut area would grow.

Serbia

In the area of the Bosut forests, next to the Morović settlement, there is a "Slezen" pond, built in 1956 with an area of 54 hectares. 40 hectares are usable. He represents the former meander of Bosut. The pond belongs to PE "Vojvodinasume" and is rented to the Veterinary Institute "Subotica". The main purpose is breeding economically important species such as carp, silver carp and grass carp. The water is taken from the Bosut. A mechanical barrier is built in at the inlet that prevents migration of fish from the pond into the river. Since 2008 the rights to the Sava are incumbent "Vojvodinašume". Based on a management program both recreational and commercial fishing is allowed. The program regulates the protection and the sustainable use of water as a natural resource. The same applies to the rivers Bosut, Studva and Smogva but they are mainly used by local sport anglers. The issue is that Bosut River and its tributaries have stagnant water levels due to sluices that prevent water flow at the moment.

Figure 28: Geese flock In Morović. (Source: ALEN KIS).

Tourism

The Bosut and Spačva forest have the potential to develop and sustain transboundary eco-tourism area. The Ramsar Convention held in Bucharest in July 2012 enacted a Resolution XI.7 on Tourism, recreation and wetlands, which confirms that "sustainable tourism and recreation can bring economic opportunities for securing wetland conservation and wise use and the maintenance of key socio-economic wetland values and functions, both in Ramsar Sites and in other wetlands" (ISRBC 2013).

Figure 29: Traditional forest-farmers cottage, built of sprouts, mud and hay. (Source: *ALEN KIS*).

Croatia

On the Croatian side, the rural areas around the forest are getting abandoned and more and more depopulated. Much of the area is degrading. Nevertheless, at the border of the forested areas, tourism offers are developing. Nature tourism and especially bird watching has a big potential according to TOMIK & GRGLĆ, 2020. Ranger programmes, excursions and guided tours to place of interest for nature conservation should be organised and developed together with local stakeholders. The development of ecotourism is a chance for regional development also, if benefits from nature conservation are combined with income generating activities. Nature education leads to valuing the natural treasure. The Spačva-basin in Croatia hosts a unique fauna and flora within Europe and provides the opportunity to experience old oak forest stand. Bird watching offers combined with canoe tours through the alluvial forest can contribute to expand the international tourism season in Croatia especially from April to June or during migration or alternative during hibernation. Croatia host 400 different birds, and many of them can be watched in the Spačva-basin.

On a global scale there are millions of Bird watchers, especially in USA and UK, Germany, Netherlands, Scandinavia and France and there is a chance to enter this tourism market.

Serbia

The geographical location of the Bosut forest is favourable due to the distance to the next larger settlement areas (approx. 100 km from Novi Sad, approx. 115 km from Belgrade, Šid 15 km and Sremska Mitrovica 35 km). Proximity to major cities and good transport connections guarantee easy access for visitors. Anyway, tourism plays a subordinate role. Until the 1990's hunting tourism was a lot more important than it is nowadays. However, there is still great potential for sustainable hunting and fishing. Within the hunting and fishing area VU Morović there are hotels and few bungalows. Other facilities are not available.

Figure 30: Traditional landscape and Bird watching can be an attraction for nature tourism.
(Source: ALEN KIS).

The most common forms of tourist movements are excursions, hunting tourism and fishing tourism.

4_2_2 Habitats and species

The study area and especially the Spačva - Bosut Forests with its alluvial forest habitats and old oak forest stands, lowland rivers and streams (tributaries to Sava River) and temporary wetlands is an area of very high ecological value and of high importance for international nature conservation.

Within the study area there are various nature conservation areas, like Natura 2000 sites, special protected areas, important bird areas and nature reserves listed. These protected parts of the study area are important feeding and breeding grounds, retreat areas, migration areas for a big number of endangered species, especially birds, amphibia, reptiles but also invertebrates of over-regional importance.

Figure 31: Bosut in Morović Summer floating Lemna and Spirodela. (Source: ALEN KIS).

Figure 32: Old uprooted oak, 430 age and a person standing aside. (Source: ALEN KIS).

Figure 33: Wetland meadow. (Source: A. MOLNAR).

Croatia

Natura 2000

Four Natura 2000 areas are situated in the Croatian part of the study area, all of them are of immense international importance for the European Natura 2000 network:

- HR2001311 Sava nizvodno od Hrušćice, confirmed 2014-12 (SCI)
- HR2001414 Spačvanski bazen, confirmed 2014-12 (SCI)
- HR2001415 Spačva JZ, confirmed 2014-12 (SCI)
- HR100006 Spačvanski bazen (covers the whole area 43.549 ha) classified as SPA /1/2013

The habitat types which are present at the Spačva and Bosut area and have been assessed within the project "Protection of Biodiversity of the Sava River Basin Floodplains - Sites Important for Biodiversity along the Sava River (KITNAES 2009) are listed in the table below. They are combined with data from the Spačva basin draft management plan (RAMBOLL & NATURE BUREAU, 2013) and data of Bioportal (https://bioportal.hr/gis/).

Table 10: Important habitat types and main characteristics

Code	Habitat	Area [ha] Croatia	Area (ha) Serbia
3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoeto-Nanojuncetea ELLMAUER (2005): The habitat type includes bank and mud floor corridors that are temporarily covered with water. The locations experience a change due to fluctuating water levels of three phases: littoral phase (up to 2 meters flooded, not flooded but completely saturated with water phase) and terrestrial phase (soil dried out). The habitat type appears scattered and always covers only small areas.	0	22.83
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation ELLMAUER (2005): The habitat type includes naturally nutrient-rich (meso- to eutrophic) standing waters (ponds, lakes, oxbows) with floating leaf or aquatic vegetation. According to Ramboll & NatureBureau 2013 plants like Salvinia natans, Azolla filiculoides, Hydrocharis morsus-ranae, Lemna minor, Stratiotes aloides, Potamogeton lucens, P. perfoliatus and P. gramineus nare found in the study area.	128	334
3260	Watercourses of plain to montane levels with the *Ranunculion fluifluitantis* Callitricho-Batrachion vegetation and Callitricho-Batrachion vegetation ELLMAUER (2005): The decisive ecological factor for the vegetation is the flow velocity (especially the flow extremes). The habitat type is found in slow (10-25 cm/s) to rapid (> 25 cm/s) flowing water. The habitat type preferentially occurs in low to moderately polluted rivers (water quality class II). Dense vegetation can slow down the water, what leads to the deposits of smaller fractions (e.g. silt or organic material). Conversely heavy floods destroy plant communities.	2	0
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation. ELLMAUER (2005): Pioneer societies on muddy river banks of near-natural rivers. The flow velocities are very low in these areas so that sedimentation of fine particles (sand, silt, clay and organic particles) occurs. The sites are regularly exposed through flooding and overflow. Only under these conditions, it is guaranteed that the habitat type will remain. Would this regime be interrupted,	622	33.92

	perennial plant species can establish very quickly, which transfers the habitat type to tall perennial and reed communities.		
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels. ELLMAUER (2005): This habitat type includes species-rich, lush, tall herbaceous and high grass corridors. They grow on moist nutrient-rich soils and on sand and gravel banks. This habitat type occurs naturally in floodplains, where it is subject to a cyclical disturbance regime.	42	25.86
6440	Alluvial meadows of river valleys of the *Cnidion dubii* ELLMAUER (2005): This Meadows result from alternately moist to alternately dry site conditions and from occasional occurring floods and the associated overflow. If the flooding dynamics are prevented (e.g. by damming) the type-specific species composition disappears.	0	102.46
6450	Northern boreal alluvial meadows	0	19.27
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli* ELLMAUER (2005): The habitat type occurs on moist to waterlogged locations, which due to their air and water balance are unfavourable for the European beech. In the study area Oak-hornbeam forests are found on moist soils (having high water tables e.g. valley bottoms, depressions or near riparian forests). In Spačva, natural mixed forests are composed mostly of Quercus robur, Acer campestre and (on drier ground) Carpinus betulus, with an understorey of Corylus avellana, Ligustrum vulgare, Cornus sanguinea, Euonymus europaeus and Crataegus species. According to RAMBOLL & NATURE BUREAU, 2013 the conservation	15.510 (14.371) GIS analyses	8.148
	status was described as good. It it is the commonest forest type in the Spačva Basin. Stands aged 100 to 120 years old are the most frequent (38%), while middle-aged stands (40 to 80 years old) are underrepresented.		
91E0	* Alluvial forests with Fraxinus angustifolia ELLMAUER (2005): The habitat type covers a wide range of different forest communities of flood and pressurized water meadows, which have a relatively high level of oxygen-rich groundwater, which has periodic fluctuations. Natural softwood meadows are extremely dynamic habitats. Terrain formation, soil formation and vegetation development are closely linked to the water flow of rivers. Through erosion and accumulation, habitat areas are destroyed and created in another place again in a different place. At the new, more stable locations succession takes place in which the typical woody plants such as willows, poplars or alders quickly take control. By changing the hydrology (regulation of rivers, damming of alluvial forests, damming the water, etc.) there is a loss of land. Deadwood usually plays a major role in near-natural softwood meadows, but it is in abundance and quality very dependent on the respective community. In the study area these forests of Fraxinus excelsior and Alnus glutinosa, with an understorey of Frangula alnus and Prunus padus, occur on heavy soils rich in alluvial deposits, periodically inundated by the annual rise of the river level, but otherwise well-drained and aerated during low-water periods. According to RAMBOLL & NATURE BUREAU, 2013 the conservation status was described as good. Occupy 79 ha of Spačva, of which more than half are middle-aged (40	79 (240 GIS analyses)	82

	to 80 years old) stands and 30% old (80 to 120 years old) stands.		
91F0	Riparian mixed forests, along the great rivers (*Ulmenion minoris*) ELLMAUER (2005): Hardwood alluvial forests occupy the least flooded areas of the floodplain, whereby deep-rooted deciduous trees still partially reach the flowing groundwater. The woods are only affected by episodic floods or in their highest elevations reached by disaster floods. The hardwood forests are very diverse in terms of structure and stand structure. In natural hard alluvial forests, dead wood usually plays a major role. The dynamics of the hardwood meadows are influenced by a variety of anthropogenic or semi-natural influences. The most important factor is the change in the river hydrology through regulations or energy management use, whereby the stocks either are flooded less often or not at all or the groundwater levels sink. This leads to a change in the soil and development towards other deciduous forest communities (e.g. oak-hornbeam forest, beech forest, etc.). According to RAMBOLL & NATURE BUREAU, 2013 thy type was classified as good. With a total area of 24,381 ha, it is the commonest forest type in the Spačva Basin. Stands aged 100 to 120 years old are the most frequent (38%), while middle-aged stands (40 to 80 years old) are underrepresented.	24.381 (25.948 GIS analyses)	10.280

According to the standard data form of the protected area, the Sava nizvodno od Hrušćice site is one of only four sites in Croatia for the habitat type 3270. It is also an important site for the habitat type 91E0.

Within the study area, but outside of the alluvial forest, there are additional 1885 ha of the FFH-Type 6510 Lowland hay meadows in Croatia. They are outside of the target area for flooding scenarios.

Table 11: Species of European importance within Spačva and Spačva SW pSCIs (Source RAMBOLL & NATURE BUREAU, 2013).

Feature	Population	Threats and trends	Status
Otter Lutra lutra	Estimated to be around 27 individuals, which is less than 2% of the national population.	Stable	Good
Barbastelle bat Barbastella barbastellus	Not available	Stable; increased felling of old trees could affect the population level	Good
European pond terrapin *Emys orbicularis*	Not available	Stable	Good
Fire-bellied / yellow-bellied toads *Bombina bombina x B. variegata*	Not available	Stable	Good
Danube / Italian crested newt Triturus dobrogicus x T. carnifex	Not available	Stable	Good
Stag beetle Lucanus cervus	Not available	Stable; increased felling of old trees could affect the population level	Good
Great capricorn beetle *Cerambyx cerdo*	Not available	Stable; increased felling of old trees could affect the population level	Good

The fish species *Aspius aspius, Cobitis elongatoides, Eudontomyzon vladykovi, Gymnocephalus schraetser, Romanogobio vladykovi, Zingel streber* and *Zingel zingel* profit from the designation as Natura 2000 area. up to

45% of the total Croatian population of the fish species *Cobitis elongata* inhabitant. It is also an important site for *Rutilus virgo*. This fish species inhabited the site with up to 30% of the total Croatian population.

Moreover, Sava nizvodno od Hrušćice host a very large population of *Ophiogomphus cecilia* and is important for the conservation of *Unio crassus* in the Continental Biogeographical Region.

Spačvanski bazen is an important site for *Emys orbicularis*, for the amphibian species *Bombina bombina* and *Triturus dobrogicus*. The area is considered to support a significant presence of *Lutra lutra*.

According to the standard data form the Natura 2000 area, Spačva JZ is important site for the European pond terrapin *Emys orbicularis*, for amphibian species *Bombina bombina* and *Triturus dobrogicus,* and for the otter *Lutra lutra.* The Spačva site is located at the lowest part of Posavlje so the flow of surface water and groundwater is very intense, and it enables the development of rich and lush vegetation. It is located at 82 meters above sea level.

Together with area Spačvanski bazen it represents big oak forest complex of Spačva and together with forests of Odransko and Lonjsko polje it is an important habitat for saproxylic beetle species *Cerambyx cerdo* and *Lucanus cervus* in continental biogeographical region in Croatia. Furthermore especially for the bat species *Barbastella barbastellus* Spačvanski bazen is an essential feeding site.

The SPA Spačvanski bazen complements the above mentioned with an impressive bird list.

Table 12: Current conservation status of birds in Spačva SPA (Source: Ramboll & Nature bureau, 2013)

Species	Population	Threats and trends	Status
Black stork *Ciconia nigra*	8-12 pairs, representing 2-15% of the national population.	Stable; disturbance and increased felling of old trees could affect the population level	Good
White-tailed eagle *Haliaeetus albicilla*	8 pairs, representing 2-15% of the national population.	Stable; disturbance and increased felling of old trees could affect the population level	Good
Lesser spotted eagle *Aquila pomarina*	1-2 pairs, representing less than 2% of the national population.10 – 12 areas register in 2019, were observations area regularly.	Stable; disturbance and increased felling of old trees will affect the population level	Good
European honey buzzard *Pernis apivorus*	4-8 pairs, representing less than 2% of the national population, 2019: 10 areas of observation	Stable; disturbance and increased felling of old trees could affect the population level	Good
Middle-spotted woodpecker *Dendrocopos medius*	2013:1,300-2,000 pairs, representing 2-15% of the national population. 2020: 122 pair register, estimation: 1400 – 2000 p	Stable; increased felling of old trees could affect the population level, Danger: increased habitat loss due to removal of dead wood	Good
Black woodpecker *Dryocopus martius*	Estimated population 25-40 pairs, representing less than 2% of the national population.	Stable	Good
Grey-headed woodpecker *Picus canus*	Estimated population 200-300 pairs, representing less than 2% of the national population.	Stable	Good
Collared flycatcher *Ficedula albicollis*	Estimated population 2,000-6,000 pairs, representing 2-15% of the national population.	Stable; increased felling of old trees could affect the population level	Good

According to the standard data form it hosts one up to two breeding pairs of the rare and endangered lesser spotted eagle *Aquila pomarine* and around 5 pairs of the white-tailed eagle *Haliaeetus* albicilla, the European honey-buzzard *Pernis* apivorus (4-8 p), black kite *Milvus migrans,* as well of 8 up to 12 pairs of black stork *Ciconia nigra*, the woodpecker species *Dendrocopos medius (*around 1300 p*), Dryocopus martius* (25 p) *and Picus canus* (90 p) and the singing birds *Ficedula albicollis* (2000 p), *Lanius collurio* (200 p).

The habitat for those birds of European importance is basically covering the whole forest part of the study area in Croatia. The habitat is described as 81 % covered with alluvial oak forests.18 % are described as shrubland, which reflects abandoned meadows and clear-cuts. The rest is covered by waterbodies, arable land and human infrastructure according to the standard data form. Lithostratigraphic units represented in this area are pleistocene marsh loess and holocene marsh deposits (clay and clayey silt). Spačva covers the part of the river Sava holocene alluvial Bosut lowlands, which gradually rises to the south of the river and in the north to the Vukovar Plain. The entire area is rich with groundwater, but also a significant inflow of surface water. The soil types are hydromorphic and consist of mollic gleysols according to the the standard data form.

Figure 34: There is a rich population of white collard flycatcher in the Area. It is an indicator of old forests. (Source: ALEN KIS)

Additionally, there are two forest protected areas within Spačva forests:

- Lože Special forest reserve (109 ha),
- Radiševo Special forest reserve (4,17 ha)

The international nature conservation organization Birdlife also mentions the Important Bird Area (IBA) Spačva Basin HR047 as an important forest for birds of prey and Black Stork. They consider the pastures and meadows, which are important for feeding as very scarce. This leads to a limited number of breeding pairs. According to BIRDLIFE, 2020 the area suffers from intensified forest management and changes in water level in wet forest due to drainage.

The Natura 2000 sites in Croatia within the study area are of enormous interest for nature conservation at European level. A favourable Conservation status needs to be reached for the habitat types of the SCIs but also for the whole forest area with the old tree stands, dead wood, water bodies, wet meadow in its function as high quality habitat for endangered bird species (SPA) in their life cycle.

Ecological threats

Following threats are seen to influence a favourable conservation status are described as abandonment/lack of mowing of seminatural wetland habitats, the abandonment of pastoral systems and the lack of grazing, forest exploitation without replanting or natural regrowth, hunting and the modification of the hydrographic function in general.

TOMIK AND GRGIĆ, 2020 mention especially intensive clear cuts as threats for the favourable conservation status of the bird species *Aquila pomarine*, *Pernis apivorus* and also for *Dendrocopos medius*. Final cut practise of old forest stands leads to habitat fragmentation and habitat loss. Since the draft management plan of RAMBOLL & NATURE BUREAU, 2013 the rotation period is shorter than the original 140 years and old forest stand have been cut down.

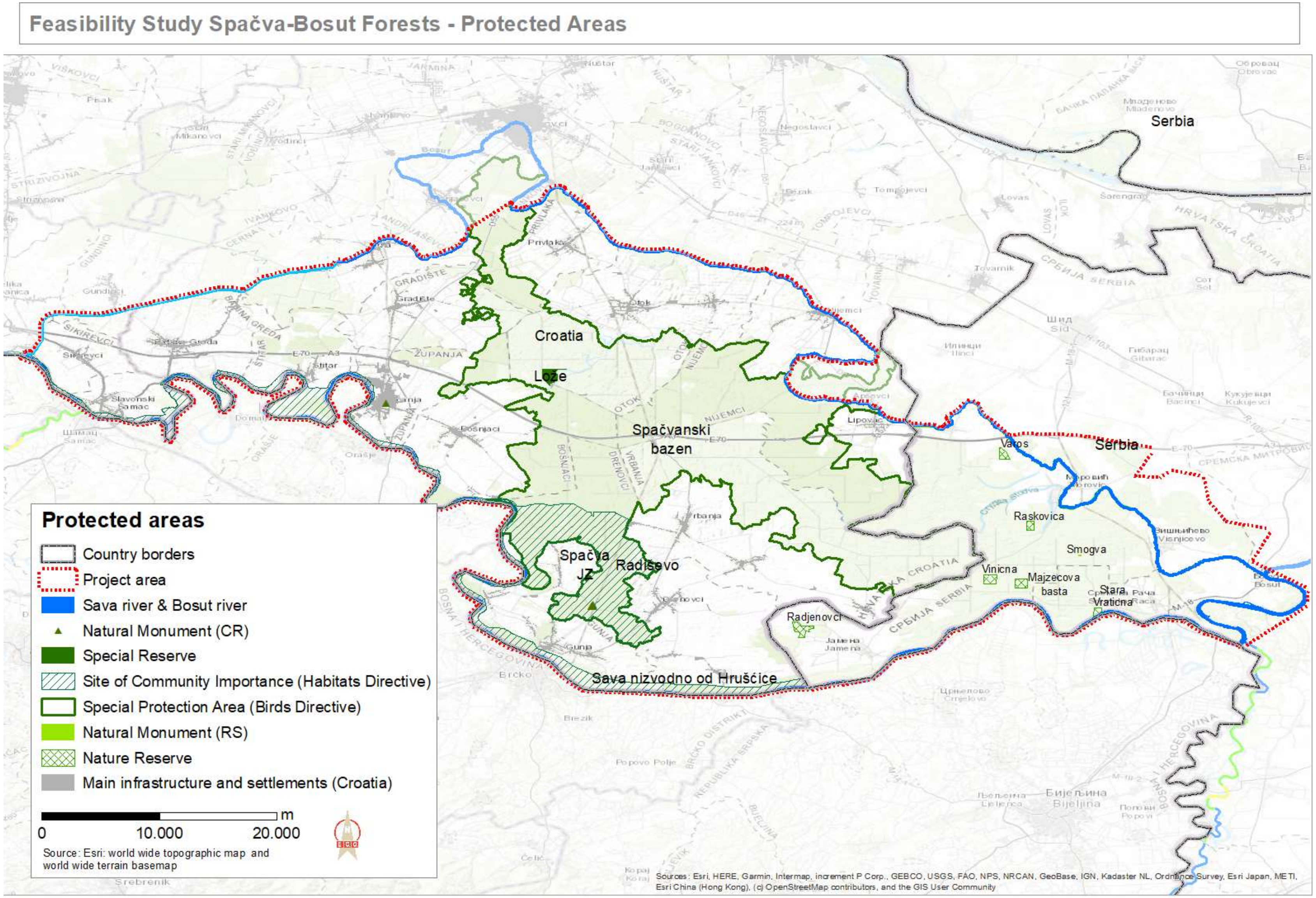


Figure 35: Protected areas within the study area.

Serbia

In the alluvial plain of Bosut, Studva and Sava River, you can find the largest, oldest and best preserved pedunculate oak forest (Quercus robur L.) in Serbia. It is located in the area southwest of Srem and it is also one of the largest complexes of pedunculate oak forests in south-eastern Europe and the Pannonian Plain on the border to Croatia.

These forests were formed in the network of lowland watercourses (Sava, Bosut and Studva) and represent a functioning forest, wetland and water habitats between the countries Serbia, Bosnia and Herzegovina and Croatia. The forest provides habitat for wild species that depend on old forests (INCVP 2016).

The Bosut Forests are recognized as an ecologically significant area. It is inhabited by numerous animal species. According to the study from INCVP (2016), a total of 12 strictly protected higher plants, 14 strictly protected invertebrates, 4 strictly protected fish species, 8 strictly protected amphibian species, 5 strictly protected reptile species, 156 strictly protected bird species and 8 strictly protected mammal species were found.

With over 85%, the forest category dominates in the area southwest of Srem. Open wetlands (ponds) and alluvial land only make up a smaller proportion (4%). Almost all of the forest is owned by the state. The largest part is incumbent on PE "Vojvodinašhume". The remaining parts are managed by VU "Morović" and JVP "Vode Vojvodine" (INCVP 2016).

Two state roads and one railway line run through the forestry area. The area has good transport links to all settlements in the vicinity but also to larger city centres such as Šid, Sremska Mitrovica, Novi Sad and Belgrade. A railway line runs through the north-eastern part from Bijeljina via Bosut, Višnjićevo and Morović to Šid, but it is not electrified and has not been operational in recent years. The Sava and the dike at Sremska Rača near Jamena in the border area with Bosnia and Herzegovina are of great importance for the transport connection. (INCVP 2016)

Wetlands have the largest area along the floodplains and river terraces. Oxbows represent no longer connected meanders of the rivers.

The largest part of the area is the alluvial plain of the Sava, Bosut and Studva River, which was formed by the deposition of materials (sand, gravel and mud) from the Sava River during the Holocene.

In the area itself, there is higher terrain in the alluvial plain, which is not flooded area (Grabova greda and Raškovica). They were of strategic importance for the formation of settlements and traditional activities such as livestock breeding, hunting, fishing. Land drainage and irrigation is a major problem for people. The land was used as pasture for steppe cattle, but over time it was converted into arable land.

On the Serbian side of the study area, there are Nature reserves and Important Bird Areas listed.

Figure 36: Rosalia alpina is one of the FFH-Species occurring in the study area. (Source: ALEN KIS).

Nature reserves Serbia

On the Serbian site you can find several smaller national nature reserves:

- Nature reserve Vinicna (0,26 km²)
- Nature reserve Majzecova basta (0,27 km²)
- Nature reserve Radjenovci (0,87 km²)

- Nature reserve Stara Vraticna (0,1 km²)
- Nature reserve Raskovica (0,34 km²)

The intention of the nature reserve is to protect fauna, flora, habitats and landscapes. There are no habitat types or species listed, whether from the European environment agency nor from protected planet.

Important Bird Area (IBA) Bosutska forest in Serbia RS007

(BIRDLIFE INTERNATIONAL 2020) mentions the IBA Bosutska forest as largest area in the country covered with native pedunculate oak forests. It is built up on around 20.000 ha of lowland and almost every year the lower parts of the area are flooded by subterranean waters. The area borders with the Sava River in the south and further forest areas in the west (Spačva forest, Croatia). Northern borders motorway Belgrade-Zagreb and east of the area there is agricultural land of Sremska Mitrovica municipality.

Figure 37: Some of the important species which occur in the study area. (Source: INCVP 2018).

Key species to be considered

A number of endangered species are found and protected at the Serbian part of the study area. They represent the typical species of the floodplains, and the alluvial forest. The following table outlines species which need to be considered when planning nature conservation measures in Serbia (INCVP 2018). Some of these species (e.g., all birds) are already listed in SPA Spačvanski bazen Natura sites.

Table 13: Listed indicator/umbrella species in GIZ-study (INCVP 2018).

Scientific name	English name
Armoracia macrocarpa	*False indigo-bush*
Elatine triandra	Longstem waterwort
Hottonia palustris	*water violet*
Stratiotes aloides	Water soldier
Marsilea quadrifolia	*Four-leaf clover*
Fraxinus angustifolia	Narrow-leafed ash
Quercus robur	Penduncluate/Euroean oak
Leucojum aestivum	*Summer snowflake*
Lindernia palustris	*Prostrate False pimpernel*
Lutra lutra	Eurasian otter
Haliaeetus albicilla	White tailed eagle
Ciconia nigra	Black stork
Ficedula albicollis	Collar flycatcher
Rhodeus amarus	European Bitterlin
Cyprinus carpio	Common carp
Triturus dobrogicus	Danube crested newt
Lycaena dispar	Large copper

Ecological Threats in Serbia

The following threats are mentioned in the conservation study (INCVP 2016) for the Bosut area, some of these threats can also be applied to the other part of the study area on the Croatian site.

Change in the general habitat characteristics of the area

The habitat conditions in the study area have changed fundamentally since the beginning of the construction of flood protection dikes along Sava River (in the 18th century). Those measures led to the separation of the floodplain from the river. Due to the lack of proper floods of the alluvial forest and due to further drainage of the area via drainage channels (that are causing a decrease of groundwater level and forest drying) natural floods do not occur anymore in the floodplain. The forest vegetation is cut off its natural dynamics. Additionally, the construction of pumping station and weirs on the Bosut river, that prevents natural flow and makes the river stagnant led to a fundamental change in the hydrological regime. Surface and groundwater levels in the study areas are low, the soil moisture decreased, no flooding or excessive flooding occurs in a big part of the alluvial forest.

Following threats are seen to influence a favourable conservation status: They are described as abandonment/lack of mowing of seminatural wetland habitats, the abandonment of pastoral systems and the lack of grazing, forest exploitation without replanting or natural regrowth, hunting and the modification of the hydrographic function in general.

TOMIK AND GRGIĆ, 2020 mention especially intensive clear cuts as threats for the favourable conservation status of the bird species *Aquila pomarina*, *Pernis apivorus* and also for *Dendrocopos medius*. Final cut practise of old forest stands leads to habitat fragmentation and habitat loss. Since the draft management plan of RAMBOLL & NATURE BUREAU, 2013 the rotation period is shorter than the original 140 years and old forest stand have been cut down.

Effects of water regime changes on forest vegetation (INCVP 2016)

- Changes in the water regime of surface and groundwater have a great impact on forests and wetlands. Forests are drying out and loss of income is recorded. The forest microclimate changed, and the low water supply could entail a change in management.

Influence on the vegetation of ponds and wet meadows (INCVP 2016)

- The regulation of the Sava River led to changes in the structure of all plant communities, which is reflected in the decline of certain species of the wetter habitat types that directly depend on seasonal fluctuations.

Effects on fauna (INCVP 2016)

- Changes in the water regime and hydro-morphological changes in watercourses have a negative effect on the fauna of birds, mammals, amphibians, reptiles, fish and insects by reducing the suitable habitat for those species, which are water depended in their life cycle. The habitats are less in quantity and also suffer in their quality: alluvial wetlands and forest communities depend on periodical disturbance to maintain the typical habitat mosaic of pioneer vegetation and old growth stands. If it dries out open habitats get overgrown by bushland and the tree composition is changing. The habitat structure changes.
- The fish fauna for example is very negatively affected by cutting off the floodplains via embankments due to lack of spawning sites. Swamp and pond habitats get supplied with less and less water. The swamps and ponds are at risk of drying out and consequently important habitat and feeding grounds for birds of prey getting lost.
- Habitats of amphibians are getting smaller or drying out completely.

Biotic factors

Invasive species

Invasive species are one of the most important factors contributing to the loss of biodiversity. Various anthropogenic influences deteriorate habitats and accelerate the spread of invasive species. According to the Convention on Biological Diversity, Serbia and Croatia are obliged to prevent it from spreading. If necessary, measures are taken to contain invasive species. In Serbia a total of 23 invasive taxa have been recorded in the area of the Bosutske Šume Nature Park: *Amorpha fruticosa* (false indigo bush), *Oxalis stricta* (yellow woodsorrel), *Asclepias syriaca* (common milkweed), *Solidago gigantea subsp. Serotina* (tall goldenrod) and species of the genus *Xanthium* (X. *spinosum*, X. *strumarium* agg., *cocklebu*r) were among the most frequently identified. (INCVP 2016). Same species causing pressure on the natural vegetation in Croatia.

Allochthonous and invasive species (INCVP 2016)

- Various anthropogenic influences affect natural habitats (structure and vegetation, hydrological conditions, lighting conditions, land cover) and promote the spread of invasive species.
- Invasive species can have negative economic, social, and environmental consequences
- Humans play an important role in the spread of invasive species like *Asclepias syriaca* or *Amorpha fruticosa*, as species are particularly well established on forest trails, clearings and impaired areas.
- With the spread of invasive plants, rare species of forest communities are disrupted and pushed back. Therefore, they represent a threat to the development of, for example, slowly growing native tree species like oaks and endanger the stability of the forest.

Big game and domestic cattle (INCVP 2016)

- The vegetation in forests, wet meadows and in some places in swamps it is also negatively affected by wild boars and other large game, which are abundant in Bosut forests, for example. Their populations are kept above forest carrying capacity for hunting purposes, thus preventing natural forest rejuvenation.
- The influence of domestic pigs in the forest is mainly concentrated in the area around the barn and pond in close proximity.

Other anthropogenic influences

Pollution (INCVP 2016)

- Settlement pollution
- Municipal sewage pollution
- Landfill pollution
- Agriculture and forestry pollution

Effects of pollution (INCVP 2016)

- The effects of pollution are reflected in impaired plant, fungal and animal communities in aquatic, wet and terrestrial habitats.
- Pesticides in agriculture and forestry, and especially rodent poisoning, endanger rare and strictly protected bird species.
- The use of chemical pesticides (insecticides, fungicides or herbicides) to control harmful organisms in forest ecosystems also poses a major problem for insects.
- Mammal species struggle with pollution of the water and wetlands.

Transport infrastructure (INCVP 2016)

- Transport infrastructure is a significant barrier and threatens large numbers of species.
- Road networks cross and fragment both habitats and migration routes of amphibians.
- The increased mortality of reptiles on the streets is often the

result of their thermoregulation since body temperature is dependent on the ambient temperature. They use open areas, including streets, to warm up and sunbathe.

- There are also navigation plans for Sava River (supported by ISRBC) willing to create navigation class IV in the project area.

Forest management

Lowland oak forests and poplar plantations are the most intensively managed forest types in the downstream parts of the Sava River, both in Serbia and Croatia. The plantations mostly substitute less economically favourable natural willow and poplar forests. The forming of plantations goes on the account of the animal and bird species. However, these intensive disturbances (ploughing, pruning pesticide spraying, etc) are creating favourable circumstances for invasive plant species, which are more resistant than autochthonous (INCVP 2016).

According to TOMIK & GRGIĆ 2020 who monitored the target species *Aquila pomarina, Pernis apivorus*. and *Dendrocopos medius* the actual forest management (intensive and large size clear cuts) and especially the speed of cutting old forest stands means a thread for those species. They are dependent on the availability of a larger area of old oak forest. The most important measure for the conservation of the population of these species is a change in the current way of managing the forests of Spačvanski basin.

The basic problem of today's way of managing the forests of the Spačva basin is a "one-time mode" of management whereby the trees of the desired species (oak, ash, etc.) are inside one department and section of approximately the same age. The so-called "Cutting maturity" will be reached at the same time, and thus the whole department (750 x 750 m) will be completely cut ("Final cut").

With the felling of large areas of forest, habitats for species that are dependent on old forests disappear and thus a significant part of the Biodiversity of this area, especially the priority species of the Natura 2000 areas. (HORVATIĆ et al. 2020)

If the forest management continues this way, old forest stands will disappear within the next 20 years to an extent of only 10 % of the actual distribution (GRGLJANIĆ & GREGOROVIĆ 2003 in HORVATIĆ et al. 2020).

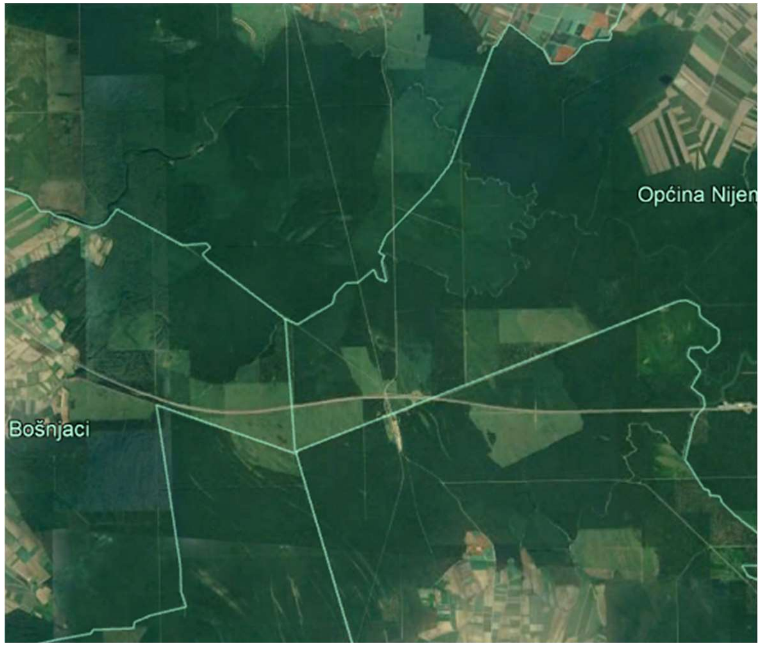


Figure 38: Visible Clear cuts on Google earth. Light green parts in the Google earth picture
Represents the cutting sections that are most visible in the northwestern part and along the Zagreb-Lipovac motorway. (Source: Google earth 2020, cf. HORVATIĆ ET AL. 2020).

The figure above shows deforestation sizes of old forests in the Spačva basin. Light green parts in the Google earth picture represent the sections that are most visible in the northwestern part and along the Zagreb-Lipovac motorway. It is very easy to see the departments (red on the maps) that are now completely cut down.

*Figure 39:Street view on clear cut close to Spačva Highway.
(Source: Google map street view).*

Effects of forestry on amphibians and reptiles (INCVP 2016)

- Negative effects of forestry on amphibians and reptiles through deforestation and drainage of the forest.
- Negative effects of forestry on birds through loss and change of their habitat.
- Negative effects of forestry on insects, especially on the oak dependent stag beetle.

*Figure 40: Wet meadow within Bosut forest.
(Source: ALEN KIS).*

*Figure 41: Typical forest road with ditch.
(Source: ALEN KIS).*

4_2_3 Significant historic and potential future floods

According to the draft of the Flood Risk Management Plan for the Sava River Basin (EPTISA 2018) 28 historic flood events on the Sava River and its tributaries are described

Year	Water course	Year	Water course
1896 October/November	Drina	1998 October/November	Upper Sava
1932 April	Sava	1998 November	Kupa
1933 October	Sava	1999 May	Tamnava, Ub and Gračica
1939	Kupa	2001 June	Kolubara, Jadar and Ljubovida r.
1944 November	Sava	2006 March	Tamnava, Ub and Gračica
1964 October	Sava	2006 April	Sava
1966 December	Sava, Kupa	2007 September	Upper Sava
1968 December	Bosna	2009 March	Tamnava, Ub and Gračica
1970 January	Sava and Bosut	2009 December	Upper Sava
1972	Kupa	2010 May/June	Middle Sava
1974 November	Sava, Krapina, Kupa and Una	2010 September	Middle Sava
1989 June	Krapina	2010 December	Drina, Kupa and Una
1990 October/November	Upper Sava	2014 February	Kupa
1996	Kupa	2014 May	Middle and Lower Sava, Una, Vrbas, Bosna, Drina, Bosut, Kolubara

Figure 42: Significant flood events in the Sava River Basin (Source: EPTISA 2018).

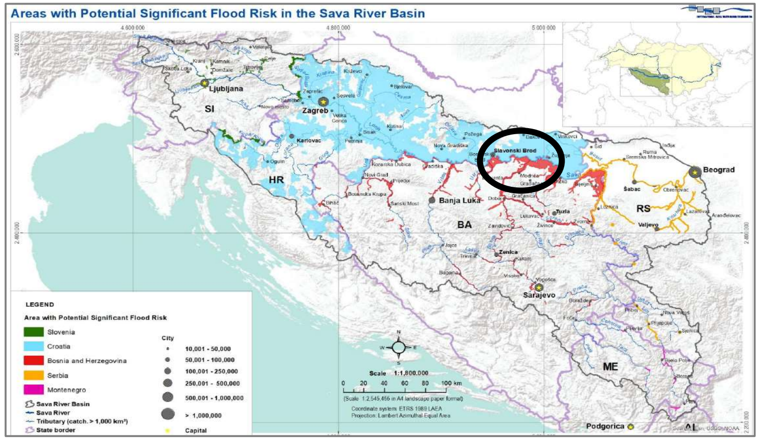


Figure 43: Areas with Potential Significant Flood Risk (APSFRs) in the Sava River Basin. Black circle = study area (Source: EPTISA 2018).

The report stressed that the Sava River Basin is prone to flooding, mainly in lowlands along the Sava River and on the confluence of larger tributaries into the Sava.

Also SCHWARZ 2018 lists flood events since 2010, and stresses, that damages were high.

Country	Year	Description	Damage in € / number of fatalities
AL	2/2015, 12/2017	Riparian flood, lower Vjosa	20 Million (mainly in agri-culture)
AL	1/2010	Riparian flood, Shkodra (Drin/Buna)	Several 100 million, city of Shkodra flooded
BA	2014	Riparian flood, flash flood with landslides: lower Sava tributaries and Sava	2 Billion (15 % of GDP) / 25 fatalities
HR	2014	Riparian flood, lower Sava	300 Million / 3 fatalities
KV	2013	Flash floods, Drini Bardhe and tributaries	
ME	2010	Riparian flood, entire country, Drina and Bojana catchments	43 Million
MK	3.8.2015 and 6.8.2016	Flash floods in Polog area (2015) and in the vicini-ty of Skopje (2016)	22 fatalities in the 2016 event
MK	2015	Flooding in the Bitola region (Pelagonia)	25 Million
RS	2014	Riparian flood, flash flood with landslides: lower Sava tributaries and Sava, Velika Morava	1.53 Billion / 51 fatalities

Figure 44: Examples of flood events since 2010. (Source: Schwarz et al 2018).

According to (INCVP 2016). the region is very sensitive to natural disasters. The Jamena settlement suffered major damage during the floods in May 2014 when the Sava dike broke and the area good flooded. 80% farmland of the area close to Jamena has been destroyed, in a village where 95% of the local population lives exclusively from agriculture. The water got locked in this area and could not go back to the river because of the dike. The figures below show the flood event of 2014. It reflects the area flooded.

It also shows the necessity of taking into account the large potential of the historic alluvial forest as retention area. Flood events occur, and the forest restoration project has a big potential to contribute to flood protection by taking away the flood peak. Instead of mitigating the damage after catastrophic flood events, a paradigm change and a joint effort towards controlled flooding to defined alluvial forest areas allows dealing with the water volume. With the funds spent for mitigating the damages of uncontrolled flooding, the basic structure to allow controlled flooding could be funded.

Figure 45: Close-Up of flooding 2014 between Vidovice (BIH) and Jamena (Serbia).
(Source: NASA Earth Observatory).

5 RESULTS

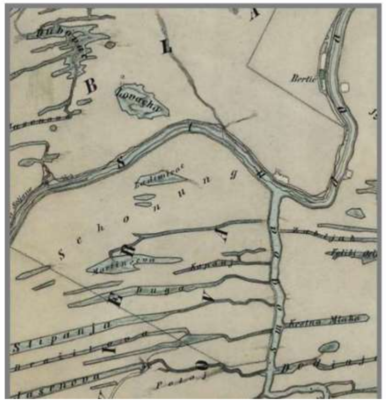
5_1 Comparison between historic river course and actual river course

The hydro morphological situation of the study area changed fundamentally within the last century. The project area is part of the Sava/Bosut floodplain that was connected and regularly flooded by those rivers in former times. Three phases of hydro-meliorative activities are responsible for the transformation of the alluvial forest:

- The construction of dikes along Sava River prevents natural floods nowadays and disconnects the river from its floodplain.
- With the construction of the sluice and the pump at Bosut mouth, the natural hydrology of the Bosut River was disrupted. Floods from Sava River are hold back and cannot enter the Bosut River.
- The third process influencing the natural hydrology was the construction of draining ditches for agricultural land reclamation.

As described in ANDRÁSFALVY (1989) in former times floods came with more or less water in the danube water system. The water emerged from the river bed, and if possible, it flooded the deeper, less often the higher parts of the flooded area, the meadows, the willow bushes, the forests and orchards. The flooding was no problem for forest and orchards if the water did not stay for a long time and did not become submerged due to heating. However, if the floods failed to appear, or warmed up and sank, the trees dried out or died because the roots did not receive enough air or oxygen. The historical maps from the 19th century show nearly the full range of historical land use. Only data for the areas south of the Sava River are not available. In comparison with the historical maps from the 18th century, this map shows the course of the Sava River and Bosut River more detailed, including its floodplains, riparian forests, settlements and their names. In the 18th and 19th centuries, the study area (and beyond) shows a network of natural depressions and artificial channels, connecting the Sava, the tributaries Bosut and Studva and most ponds and oxbow lakes into an integral hydrological network (Figure 46, cf. INCVP 2018).

Map from 19th Century

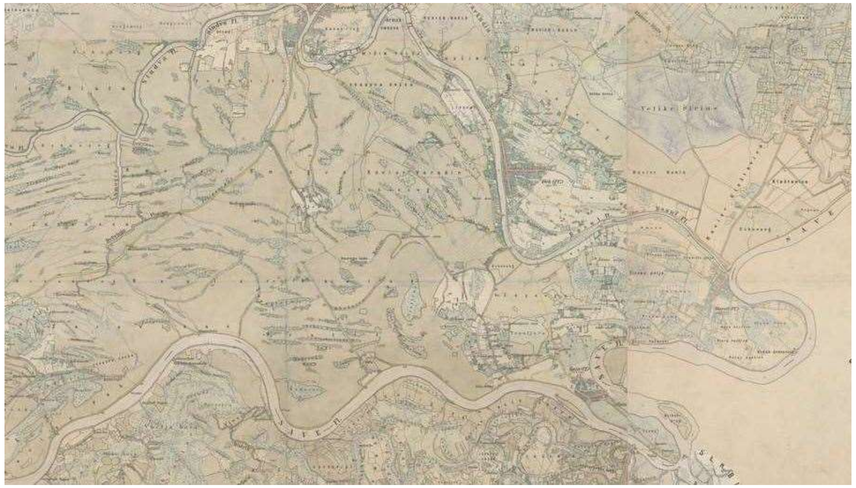


Map from 18th Century

Figure 46: Oxbows, wet depressions and channels south of the confluence of the Smogva and Studva Rivers on the maps from 1782-1785; 1865-1869 compared to google hybrid 2020. Case Study: Advocating ESAV in Bosut Forests area - integrating biodiversity and ecosystem services in natural resource uses and management. (Source: INCVP 2018).

In the actual situation reflected on Google hybrid the channels are still existing. The forest in this part of the area is characterized by extensive clear-cuts of 56 ha squares. The course of the Studva River did not change.

Map from 19th century



Map from 18th century

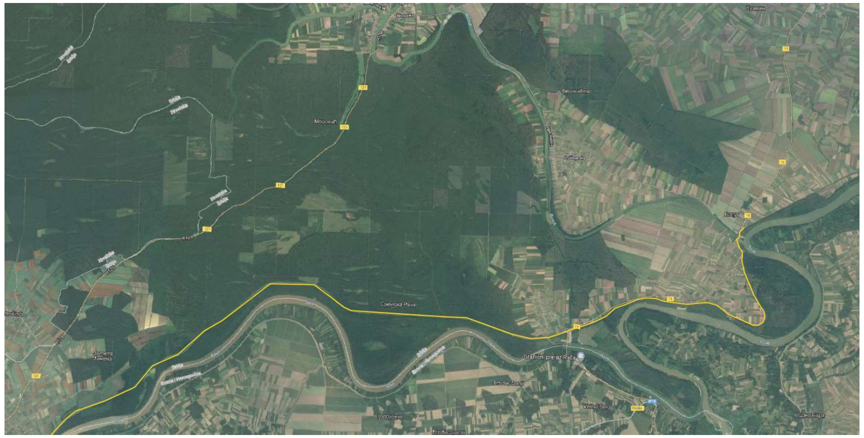
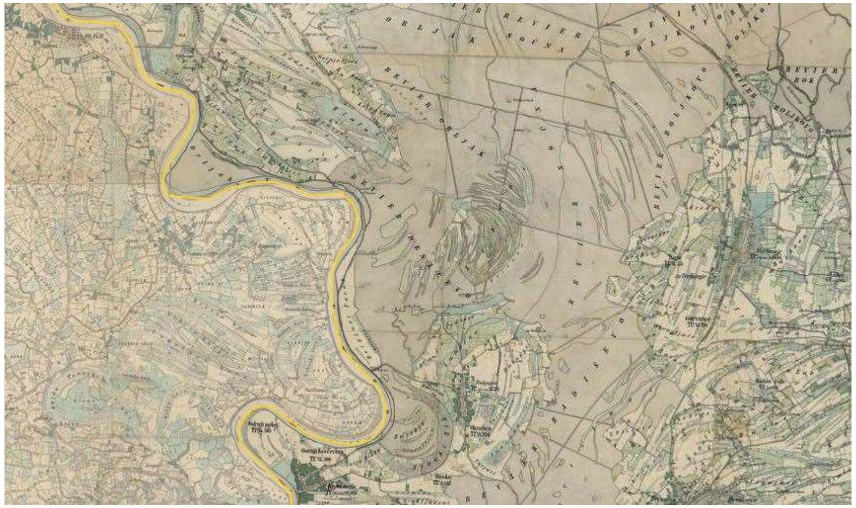


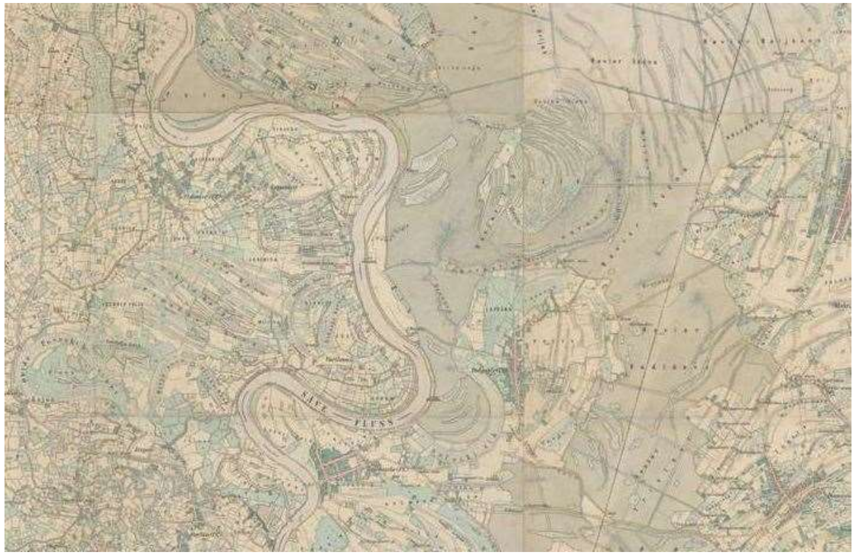
Figure 47: Oxbows, wet depressions and channels between Sava River and Bosut River in Serbia on the maps from 18th century and 19th century (left) and nowadays (above) (Source: MAPIRE - HISTORICAL MAPS (HTTPS://MAPIRE.EU/DE/ AND GOOGLE HYBRID 2020).

Compared to the historic situation the eastern part of the study area changed especially in terms of infrastructure. Roads and the dike were built, and the area used for agriculture increased into the floodplain. Large clear-cuts are now visible within the forest.

However, part of the agricultural land between the two rivers was already mentioned as “polje” in the 18th century, which proves the historic flood plain adapted agricultural use of this area.



Map from 19th Century



Map from 18th Century

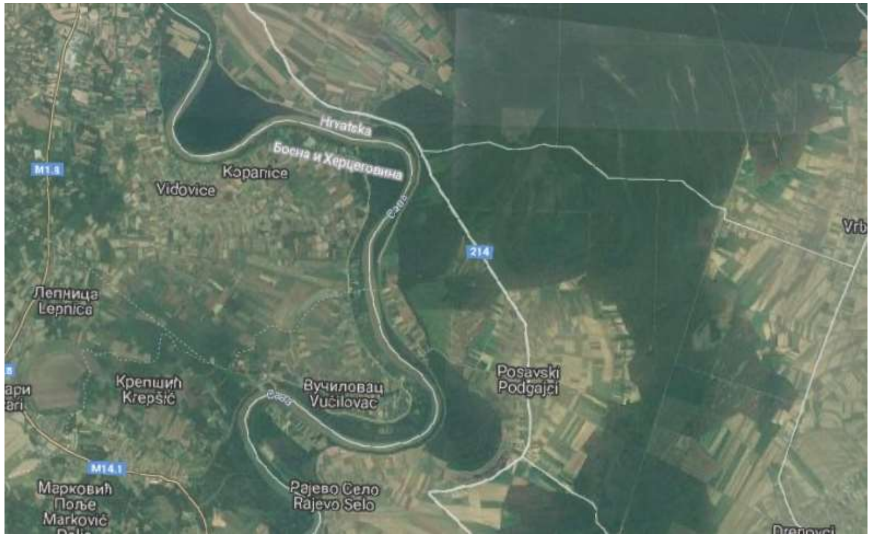


Figure 48: Oxbows, wet depressions and channels southwest of Zupanja on the maps from 18th century and 19th century (left) and from Google hybrid (2020).

(Source: MAPIRE - HISTORICAL MAPS (HTTPS://MAPIRE.EU/DE/), GOOGLE-HYBRID).

Compared to the historic situation the south western part of the study area changed especially in terms of land use and infrastructure. Roads and the Sava dikes were built, and the area used for agriculture increased into the floodplain. The Sava River main course did not change fundamentally. However, some of the agricultural land around Podgajci and next to Sava River were already visible on the map of the in the 19th century.

Today's river course of the Sava River and those of the Bosut River did not change fundamentally. The river morphology is partly changed: within the study area large parts of both rivers are near natural or just slightly modified (Figure 49). The last part of Bosut before it reaches the Bosut mouth is classified as moderately changed. A short part south of Zupanja is classified as pristine.

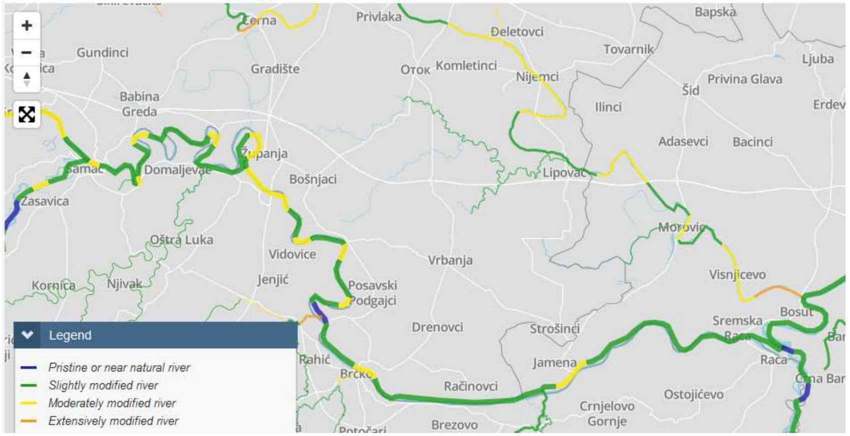


Figure 49: Hydro morphology of Sava and Bosut River within the study area.

(Source: HTTPS://BALKANRIVERS.NET/VMAP?LAYERS=M0&MENU=MA).

The Bosut River follows basically the natural gradient. The river is free flowing till mouth Sava but there are dam constructions along the river and obstacles in order to retain, to slow down and to impound the water. The tributaries from the Bosut River, which have its source originally in the area of natural forest are mostly original.

However, the construction of dams had influenced the dynamic of the river (Figure 55). Sidearms have been more developed and more numerous before construction. Flood events occurred more frequently. That's why older settlements are often found at higher altitudes in this region.

A major change to the region and the Spačva forest brought the construction of the Bosut irrigation channel near Jaruge, which was built for irrigation/drainage purposes only (Figure 50 and Figure 52). At the beginning of the channel, there is a pumping station located. The water then goes towards Bosut River by following the natural gradient from Sava to Bosut. The alluvial forest is developed at the deepest part. After the construction of dikes, settlements were established in those areas which originally were exposed to higher flood risks.

Figure 50: Bosut irrigation channel near Jaruge village, Croatia.
(Source: E.C.O. 2020).

Figure 51: The Sava levee.
(Source: ALEN KIS).

Figure 52: Sluice of Bosut irrigation channel near Jaruge.village, Croatia. (Source: E.C.O. 2020).

Figure 54: Pumping station Lipac near Jamena. Additional pipes over dike after the flood in 2014. (Source: ALEN KIS).

Figure 53: Bosut irrigation channel near Nozice. (Source: E.C.O. 2020).

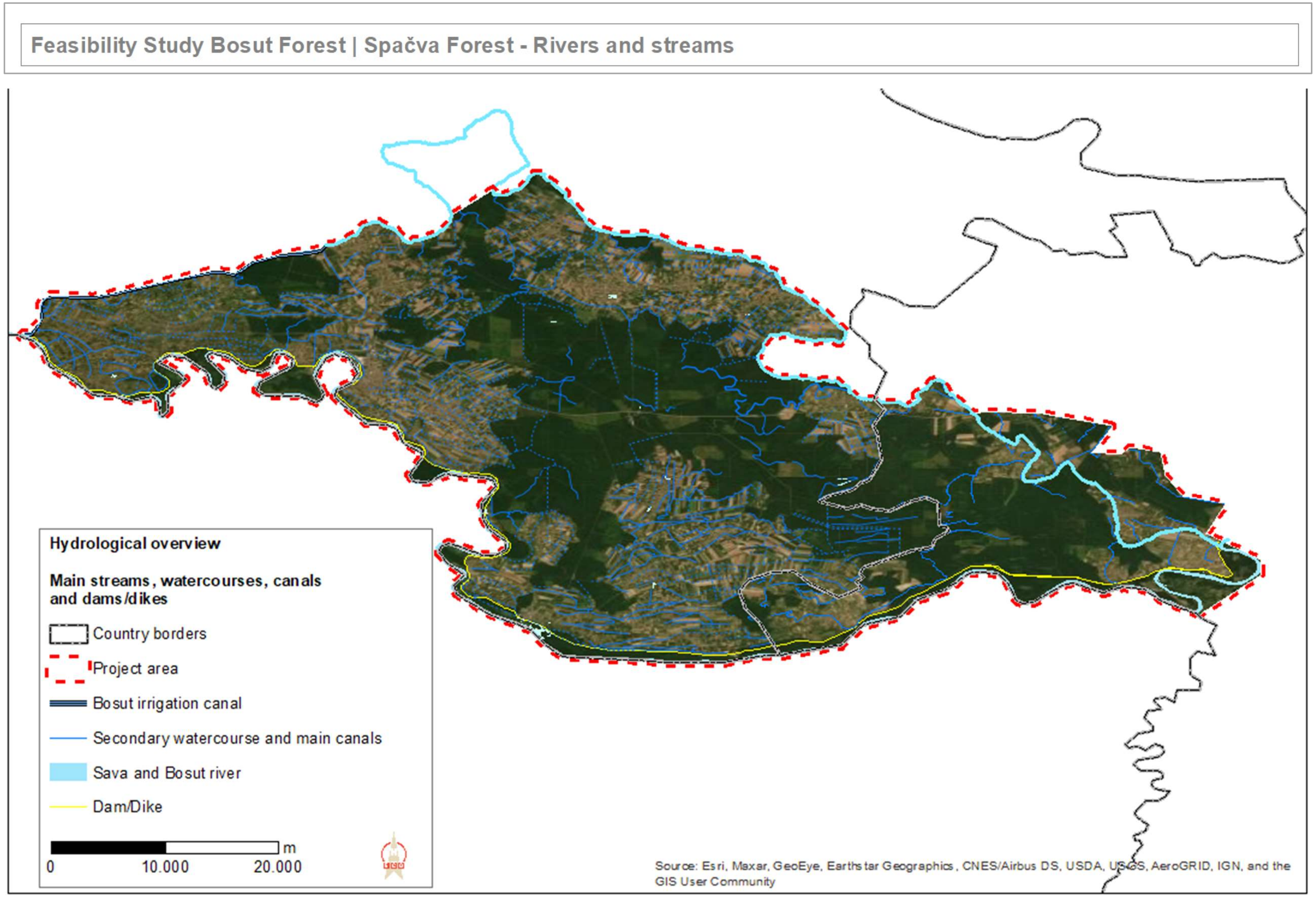


Figure 55: Main streams and dams/dikes within the study area.

The study area in Serbia is situated in the lowland on the left bank of the Sava River. As described in KITNAES ET AL. (2009) it is a mosaic-like landscape dominated by mixture of old lowland Pedunculate oak-ash-hornbeam forests, with mosaics of marshes and waterlogged areas overgrown with willows, representing a natural mosaic of high biodiversity value. Within wetland complexes there are small grassland patches situated. These patches are at different stages of succession. The subarea is surrounded by arable land from north and east.
The landscape is dominated by lowland forest and the largest part of the area is protected by a dike along the Sava. The water management in the area is implemented through a dam in the Bosut River. Flooding do not regularly occur and depend on the needs of agriculture and flood protection of settlements and towns. You can find a well-developed network of roads (dirt roads, asphalt roads). Despite the building of a dike in 1930s, due to low altitude and strategic importance of oak forest, the site remained in close to natural state. (KITNAES ET AL. 2009, ZINGSTRA ET AL. 2010).

The study area in Croatia consists of a forest area with representative flooded forests of Pedunculate oak, Black alder and Ash and is combined of areas of different age. For the last part of the Zagreb-Belgrade highway passes a significant part of the forest complex has been cut down without any compensation. The forest area is surrounded by intensively arable land (KITNAES ET AL. 2009).

Fok-system

The river with its annually repeating high water levels was the so-called Fok. The following explanation of the Fok-system is extracted from a written message from Alen Kis (INCVP 2020).

The Fok is an archaic word used in the early Austro-Hungarian monarchy for a natural/seminatural or man-made channels cutting through the natural level (high river bank consisting of sediment deposited at high water levels) and connecting the riverbed with the floodplain. They belong to the traditional system of wetland management. The traditional wetland management, where the channels connecting main river and oxbows were maintained by local families after which the channels were given names, was the utmost pragmatic land use at that time. Such channels had fretwork gate for fishing (usually after the fish had finished breeding in the wetland and were retrieving back to the river). The channels/depressions with other marshlands have been used (and maintained) by extensive farming (pasture), particularly in dry seasons. The system increased and fastened water incharge-discharge into floodplain, thus also increasing biomass productivity, particularly in the famous 'Slavonian oak-elm-ash' forest type.

Figure 56: The main Fok in Vinicna is still in place. (Source: ALEN KIS).

The key point from the conservation perspective is that the traditional Fok system of integrated land use has diversified the natural habitats, the species richness, the habitat patchiness, by multiplying the natural ecological niche and the ecotones. The biodiversity, flood safety and people's livelihood were linked to the practice. Flood waves could come in, pass through the landscape and retrieve.

The role of these still existing channels in a restoration project has to be taken into account when it comes to further planning.

Figure 57:Historical Fok-system near Čurug (outside study area). (Source: MAPIRE 2020).

5_2 Hydrography and Hydrology

The hydrographic network in the area consists of natural watercourses and numerous artificial channels. The largest natural watercourse that flows through this area is the Sava River. Effect on the surrounding space through which it flows depends mainly on the phenomena and processes that take place upstream (INCVP 2016). The Sava has often changed course in the past. Its bed made numerous meanders, which sometimes made it difficult to record water runoff or ice movement in winter. Work to regulate the Sava and its valley began a relatively long time ago (1870). For example, from then until 1945, 103 km of dikes were built (Jamena-Sr. Mitrovica 53 km, Jarak-Ušće 50 km). Until the dike was built, the Sava River regularly flooded the alluvial plain (INCVP 2016).

The Sava River in the project area receives only a few tributaries, most of which are short and small. The only significant tributary on the left side is the Bosut River (INCVP 2016).

Regarding to the Management Plan draft for Natura 2000 Spačva Basin (RAMBOLL AND NATURE BUREAU 2013) the main watercourse in the Spačva forest is the Spačva River (length 40 km), which runs through the middle of the site. The Spačva river with tributaries Brižnica, Koritanj, Ljubanj, Virovi, Rabra and Drenova and the Studva River with tributaries Smogva and Smogvica form two sub-basins. Both rivers flow into the Bosut. In 1932 the construction of a dike along the River Sava on the Croatian site was finished and the natural flood cycle of the area was lost. This had a significant impact on the surface and groundwater levels. Because of that large parts of the forests nowdays are flooded only rarely, such as in the years 2005, 2006 and 2014.

Table 14: Hydrological features of the Spačva Basin. (Source: Ramboll and Nature Bureau 2013).

Spačva River System	Length (km)	Catchment Area (km²)	Storage Capacity (m³)
Bistra-Spačva	8.1	19	18.842.250
Virovi	18.2	39	46.496.000
Brižnica	33.0	82	63.457.250
Ljubanj	13.2	92	114.517.250
Spačva (without tributary)	33.9	70	92.615.250
Studva River System	Length (km)	Catchment Area (km²)	Storage Capacity (m³)
Jasenova	6.1	13	11.951.750
Veliki pašt	3.1	18	18.537.250
Studva (without tributary)	20.0	80	142.531.250

The water regime of the Bosut River and its tributaries depends on several factors, most notably precipitation and evaporation. Other main factors are vegetation cover or river network density (INCVP 2016).

The Bosut River, which draws most of its waters from the territory of the Republic of Croatia, has, with other channelized watercourses, very little influence on the Sava River water regime, but significant effects on the groundwater and surface water regime of Srem and the area southwest of Srem (INCVP 2016).

The Bosut River always carried little water and the inflow was further reduced with the construction of a side channel. The Bosut River slopes very gently (0.014% on average), which means that the water speed is very low and has no transport power. There are no river islands in the riverbed and the slopes of the bank are even. Bosut's highest average water levels occur in all three spring months. It is lowest in all three autumn months with a minimum in September. The waterflow of the Bosut are often dormant and often flows in the opposite direction (upstream) when the water level is low as a result of water level fluctuations in the Sava (INCVP 2016).

The flow and water level regime of the Bosut is largely regulated with the help of a dam near Vinkovci (Croatia) and a pumping station at the dam at the mouth near the village of Bosut (Serbia). The confluence of the Bosut and Sava Rivers is today 200 m to the west, upstream of the earlier natural mouth (INCVP 2016).

Anthropogenic factors have a negative impact on oak forests in the lower reaches of the Sava River in Ravni Srem. In addition, the influence of anthropogenic factors will significantly change the water regime and its quality. However, this also has an impact on water management, agriculture and forestry. An analysis of the groundwater level at locations covered by the survey shows that the water level during the drought period in 2012 was so low that the root system of the pedunculate oak was not supplied with water. During the wet year 2010, for most of the growing season, the groundwater was so high that trees were supplied with water (INCVP 2016).

Amount of precipitation

Over the past 50 years, the average annual rainfall in the Bosut area was 635,6 mm. The lowest annual precipitation was recorded in 2000 (298,2 mm), while the maximum annual precipitation was recorded in 1974 (903,0 mm). The month with the highest rainfall is June (86,4 mm), while the lowest levels of rainfall were recorded in February (36,3 mm). When the rainfall per decade is considered, the highest rainfall is recorded for the second decade (1974-1983), with an annual average of 715,45 mm. The average annual rainfall (570,46 mm) was measured in the decade 1984-1993. Over the past decade, the average annual rainfall has been 631,39 mm (INCVP 2016).

Figure 58: Average monthly precipitation (mm) (Sremska. Mitrovica, 1964-2013). (Source: INCVP 2016).

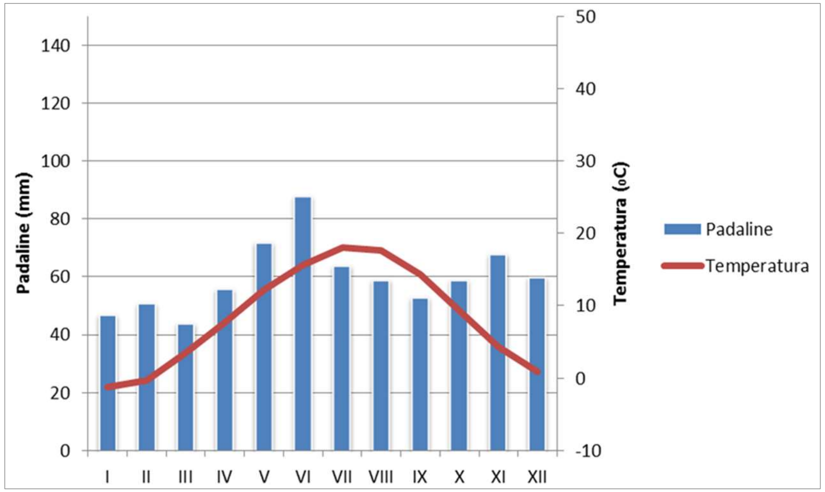


Figure 59: Mean annual precipitation and temperatures at Spačva Basin. (Source: Ramboll and Nature Bureau 2013).

The rainfall in the Spačva region is low with the annual average of 720 mm, relatively evenly distributed throughout the year, though the driest period is in winter (RAMBOLL AND NATURE BUREAU 2013).

5_2_1 Hydrological analysis

This study is addressing the hydrological and hydraulic situation and the different options and scenarios to bring water from the Sava River into the restoration area during high flows and back into the Sava River as flows are receding again. The detail of technical information for this report was limited. It should therefore be seen as a preliminary analysis of how large areas of the central forest could be inundated similarly to the historic condition.

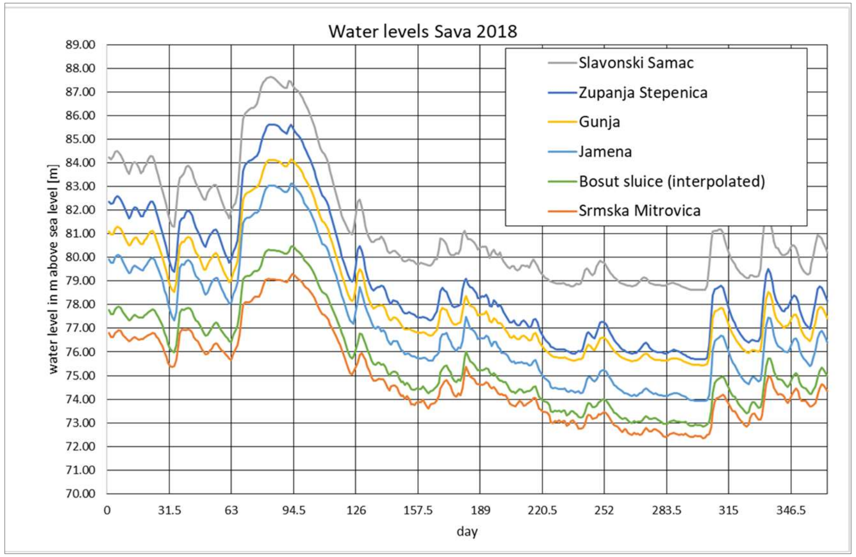


Figure 60: Water level elevations at different gauging stations along the Sava River in 2018 (Source: Klaus Jorde/ECO, 2020; Database: Croatian Hydrometeorological Institute).

For the hydrological analysis gauging data from different stations along the Sava River and the Bosut River could be used. The stations along the Sava are shown in Figure 60. The comparison of water level elevations of all five gauging stations for the year 2018 shows that the data from the gauges are of good quality, consistent and realistic. Where data from one gauging station are missing they can be interpolated from the other gauges and in addition the water levels at the so-called Bosut sluice could be interpolated, see Figure 60. The Bosut sluice is a control gate at the confluence of the Bosut with the Sava that controls the flow from the Bosut River into the Sava and vice versa.

Depending on the water levels in the Sava and the Bosut Rivers and the operation of the sluice gate, the water in the Bosut River can flow in both directions, upstream when Sava water levels are high, and downstream in the normal flow direction when water levels in the Sava are lower. The water levels show that during high flows the water level at the Bosut irrigation channel intake which is approximately 10 km upstream of the Slavonski Šamac gauging station is roughly 8 m higher than it is at the confluence with the Bosut River. This is the head which is available to convey the water into and through the floodplain which at the end drains via Bosut River back into the Sava River.

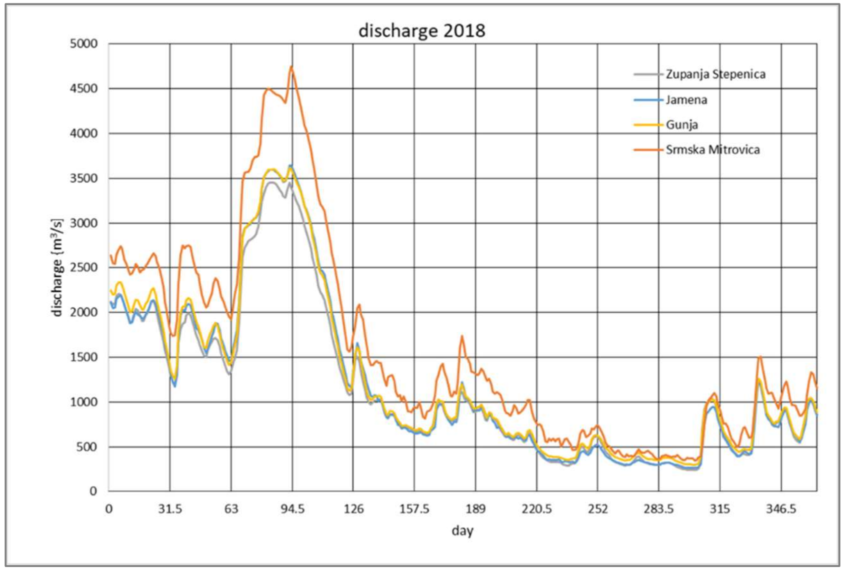


Figure 61: Discharge in the Sava River at different stations during the year 2018 (Source: Klaus Jorde/ECO, 2020; Database: Croatian Hydrometeorological Institute).

Figure 61 shows the discharge in 2018 along the Sava River. The discharge does not change significantly among the upper three gauging stations whereas the confluence with the Drina upstream of Sremska Mitrovica ads up to 1000 m³/s during the highest flows. This is an indication that in the situation shown here for 2018 the Drina carries flood flows simultaneously with the Sava. A comparison with the water levels in Figure 60 shows that the possibility of flooding the forest for restoration starts approximately when the discharge in the Sava (before Drina enters) exceeds appr. 2000 m³/s.

The year 2018 is an average hydrological year and data from 2018 will therefore be used for this analysis.Figure 63 shows a comparison for the year 2018 between the water level elevations in the Sava and the Bosut/Spačva system. A comparison between the water levels at Bosut sluice represented by the red line and the two gauges at the lower Bosut (Nijemci) and the Spačva (Ljubani) River (they have almost identical water levels) represented by the yellow line shows several things:

- the water level in the Bosut system is largely independent from the Sava and fluctuates not more than 50 cm throughout the year. This is a result of the closed sluicegate, which prevents water from Sava River to flow into Bosut River system.
- In the lower Bosut the water levels during the floods in the Sava do slightly correspond with water levels in the Sava by rising approximately 1 m. (Bosut sluice is shut!)
- The head in the Sava at the Bosut sluice is only to 1 to 2 m higher than in the Bosut River. This head is available to convey water via the Bosut sluice upstream into the Bosut River and its tributaries Spačva and Studva River.
- The head in the Sava River at the intake for the Bosut irrigation channel (approximated by Slavonski Šamac gauging station) is approximately 8 m higher than the water levels in the upper catchments of the Bosut represented by Biđ-Cerna gauging station.
- In the lower Bosut the water levels during the floods in the Sava do slightly correspond with water levels in the Sava by rising approximately 1 m.

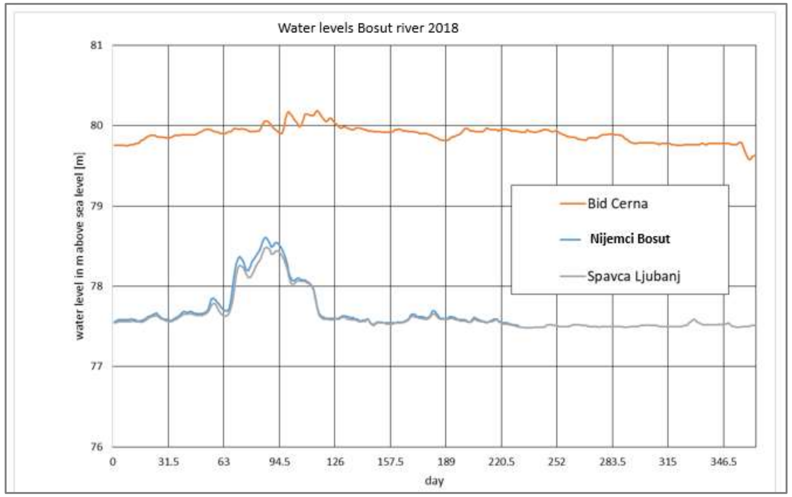


Figure 62: Water levels at different gauging stations along Bosut River (Source: Klaus Jorde/ECO, 2020; Database: Croatian Hydrometeorological Institute).

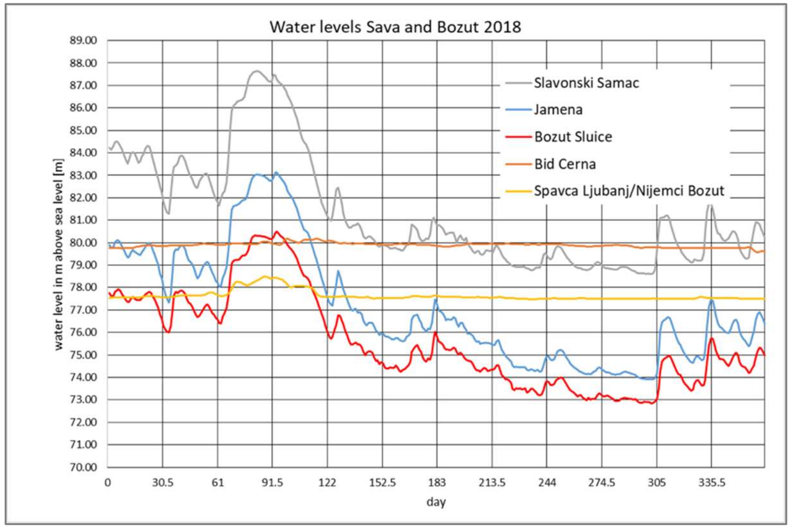


Figure 63: Water levels in the Sava River at different stations during the year 2018 (Source: Klaus Jorde/ECO, 2020; Database: Croatian Hydrometeorological Institute).

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This has a number of consequences for possible flooding scenarios:

- The flow of water that can be conveyed via Bosut sluice upstream and through the tributaries Studva and Spačva into the forest restoration area is limited to a water level elevation of around 79 masl during average floods observed in the years 2009 – 2018.
- The head available to convey water from the Sava via the Bosut irrigation channel into the forest is significantly higher and water levels over 82 m can technically be reached in the restoration areas.

Finally, a longer period of 10 years, from 2009 two 2018, was studied to understand the inter-annual variations of the discharge and water levels in the Sava River and the tributaries in the Bosut forest. Several things can be observed:

The Sava River carries flood flows almost every year of the observation period with an exception of 2011. Some years show several individual floods during different seasons such as the years 2010 or 2013. The magnitude, the duration and the timing of the floods are not very regular but vary from year to year. The only rather consistent pattern that can be observed is that the summers are dry and no flood events occur during the late summer months. Other than that floods appear to occur in all seasons but most of all and rather consistently they occur in the months of March and April.

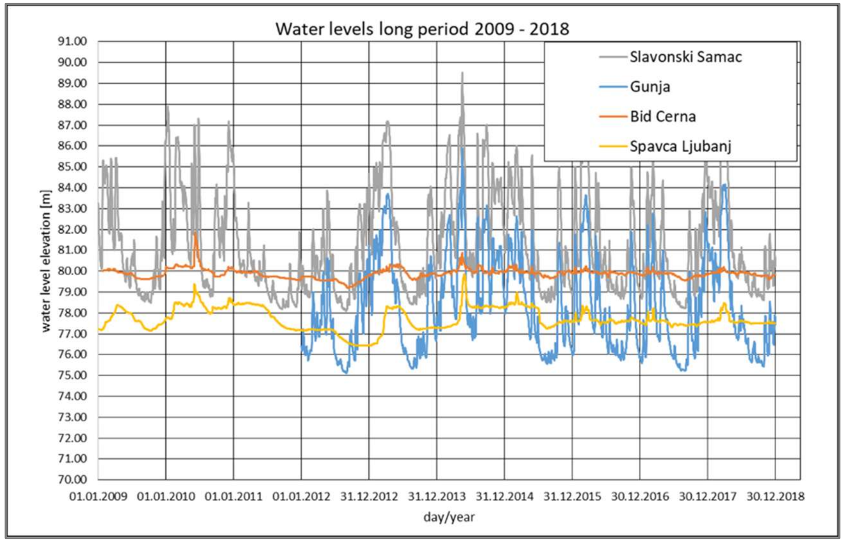


Figure 64: Discharge in the Sava River at different stations between 2009 and 2018.
(Source: KLAUS JORDE/ECO, 2020).

For possible flooding scenarios this means that the level of flooding that can be enabled is not perfectly consistent and may vary from year to year. A certain level of flooding should be possible almost every year but may be very short in dry years. Most likely flooding is possible during March, April and May whereas floods in other seasons are less consistent and occur more randomly.

5_3 Flooding Scenarios

The flooding scenarios studied for this purely technical component of the project are based on an analysis of the digital terrain models in combination with water levels and conveyance capacities in the Sava River, the Bosut irrigation channel and the Bosut sluice and river.

The pathways of how water from the Sava River is conveyed into the floodplain forest are as follows:

The most direct and simplest way is to open the Bosut sluice as soon as the water levels in the Sava are higher than in the Bosut River. The flow of water can be controlled by the gates in the sluice and water enters the Bosut and moves upstream. It eventually enters the Studva river and from there it moves into the various tributaries and drainage channels in the floodplain forest and starts filling it up from the bottom. Water will also eventually flow into the Spačva River and its tributaries and drainage channels connected to those. This pathway of bringing water into the floodplain forest works up to a water level of approximately 79 masl. For higher water levels the available head at the Bosut sluice and the limited conveyance capacity of the Bosut River are limitations. There is also an artificial embankment dam (possibly with embedded culverts) crossing the Bosut River upstream near Lipovac just below the confluence with the Spačva River. This may form an additional bottleneck.

The second pathway to convey large quantities of water into the floodplain forest is via the Bosut irrigation channel. The water from the Sava River would follow the irrigation channel into the upper Bosut River. From there it can be released into the floodplain forest approximately 2 km upstream of the village of Andrijaševci where a shortcut channel is cutting off from the Bosut and crossing a part of the forest. The water entering the floodplain forest in this area may have to be guided by a new channel or by small dikes to direct the water where it should go and to protect areas of the forest where flooding is not desired. This will have to be analyzed in detail at a later stage.

The Bosut irrigation channel itself has a high conveyance capacity since it was originally designed for a possible upgrading for navigation. However, there is a considerable number of road crossings consisting of small embankment dams with two box culverts embedded. The culverts have a cross-section of two times 2,0 m * 3,0 m. The conveyance capacity of these culverts is a function of the water level difference before and after the culvert. The water level difference cannot exceed certain values because of the stability of the embankment and also because only a certain head will be available for the entire length of the channel. The maximum capacity of the culverts is therefore assumed to be around 40 m^3/s (corresponding to around 60 cm of water level difference), but this will have to be studied in more detail in the next steps. If the capacity of the Bosut irrigation channel should be used to convey higher flows of water, it would be necessary to take out the culverts in the channel and replace them by road bridges.

Finally, there is the possibility of breaching the dike of the Sava River approximately 4 km downstream of the village of Bošnjaci where the forest is directly adjacent to the river dikes. A sluice gate would have to be built to allow a controlled flow of water from the Sava River into the floodplain forest. Most likely some small dikes would also have to be built to keep the water from flooding areas where this is not desired and convey it towards the restoration areas. This breach and sluice has to be designed according to the necessary conveyance capacity. Possible flow rates could be fairly high in comparison to the capacity of the Bosut irrigation channel and the Bosut sluice and river.

Based on these general options to bring water to the central part of the floodplain forest a number of simple scenarios has been developed. The scenarios assume horizontal water levels across the entire area in comparison with the digital elevation data representing the land surface. Wherever the water level is higher than the land surface, the area is flooded. Flow paths and the propagation of the water through the floodplain forest are not considered in this simplified approach. Some of the wetted area as shown may be inundated by surface water flowing through the existing network of channels and the forest itself, some of the areas, particularly isolated patches of water, may get inundated by rising groundwater and some areas will not be inundated at all.

In reality the water surface of the inundated areas is not horizontal. Instead, it is a wave that is slowly moving through the restoration area with water levels slowly increasing as water is entering the floodplain forests and decreasing again towards the end of the flood when the water is leaving the floodplain towards the lower Bosut and Sava River.

A more detailed analysis of how the water will be flowing through the restoration area and inundate various areas at different depths would require a hydrodynamic simulation model which should be developed in a next step. Such a model can also be used to analyze where dikes and levees or shallow channels would have to be built to guide the water to where it should go.

The following figures are showing the extension of inundated areas at different water surface elevation levels.

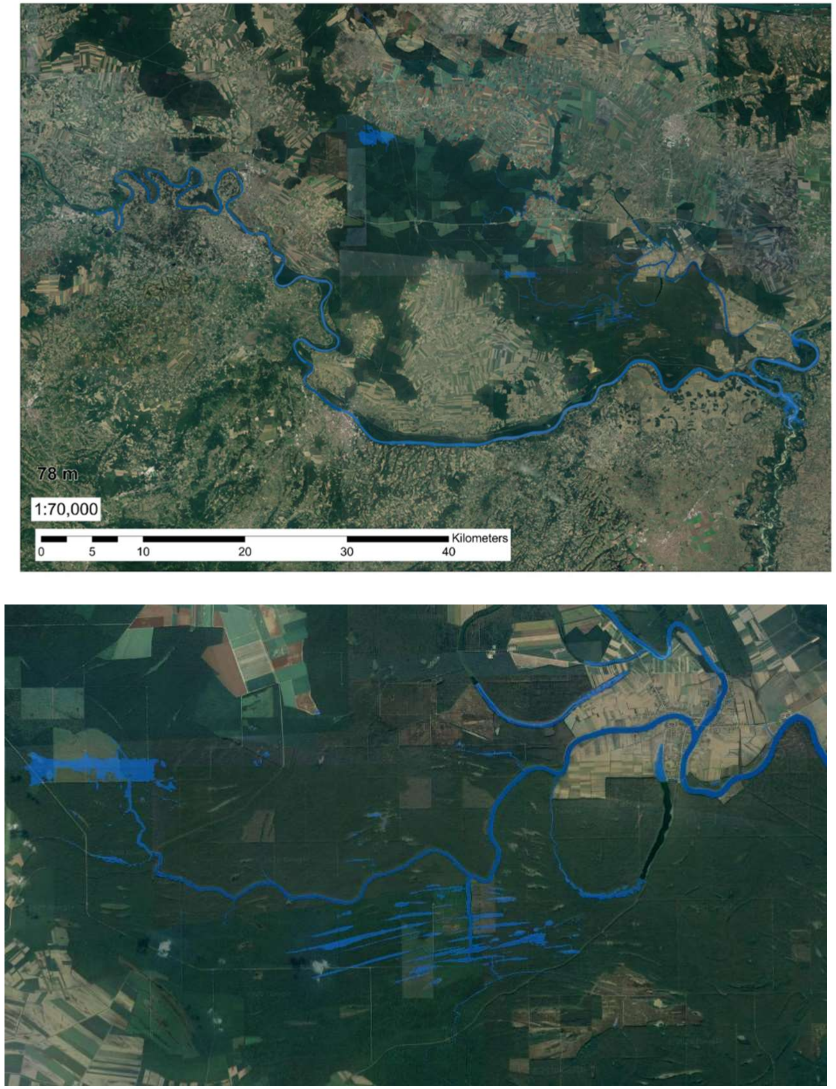


Figure 65: Temporary inundated areas with water levels at 78.00 masl.

Simulation of water levels at 78 m (Figure 65) reveals that areas flooded in this scenario are extremely small. This level of flooding can be reached by allowing water from the Sava to enter the Bosut River and the Studva. The forest will be inundated from rising groundwater levels and through the existing network of drainage channels and small natural streams. In addition, surface water from rainfall will help filling up these depressions.

This might be the situation called business as usual.

Water levels around 79 masl as shown in Figure 66 would cause a flooding of minor areas and the water could be provided from the Bosut sluice and via the Studva River.

The scenario could probably be implemented with the existing structures and the operation of the Bosut sluice. No additional construction works would be required based on this simplified analysis. However, there is always a possibility that small local protection measures such as small dikes or levies will have to be built to prevent the inundation of areas where this is not wanted. This scenario will be handled as minimum scenario in terms of floodplain restoration.

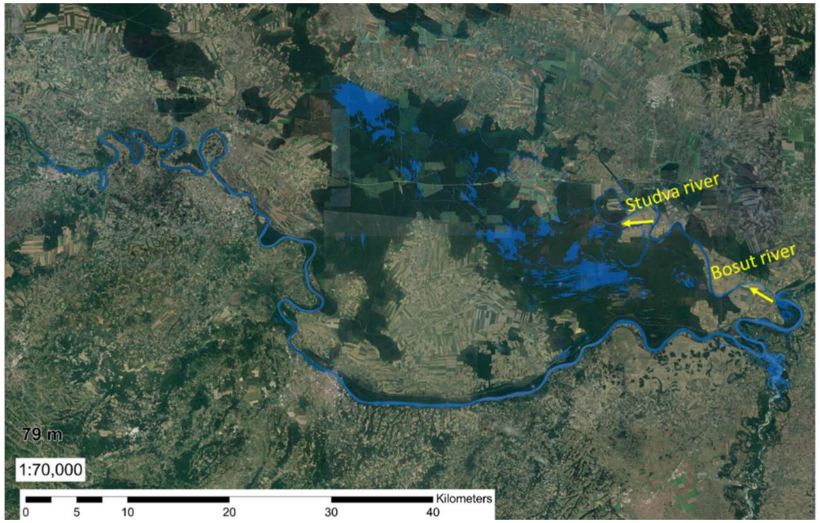


Figure 66:Temporary inundated areas with water levels at 79.00 masl.

Water levels in the floodplain around 80 m as shown in Figure 67 are causing significant areas to be temporary flooded. It remains to be studied how much of the required flow of water can be provided via the Bosut sluice and the Studva and Spačva Rivers. The conveyance capacities might be limiting. It is not clear yet which adaptations (construction works) would be required for such a scenario, possibly not too much. The conveyance capacity of the small dam (possibly with submerged culverts) across the Bosut River near Lipovac and just downstream of the Spačva confluence is not known and might be limiting.

Generally, not all areas shown as inundated on these pictures will actually be flooded. For example, the areas along the Sava River now shown as flooded will not necessarily be inundated because they have no connection to the flooded areas in the forest. The visualization is based simply on a digital terrain model in combination with a horizontal water level. More detailed and accurate the visualizations would require an analysis based on hydrodynamic simulations which is not available at this stage of the project.

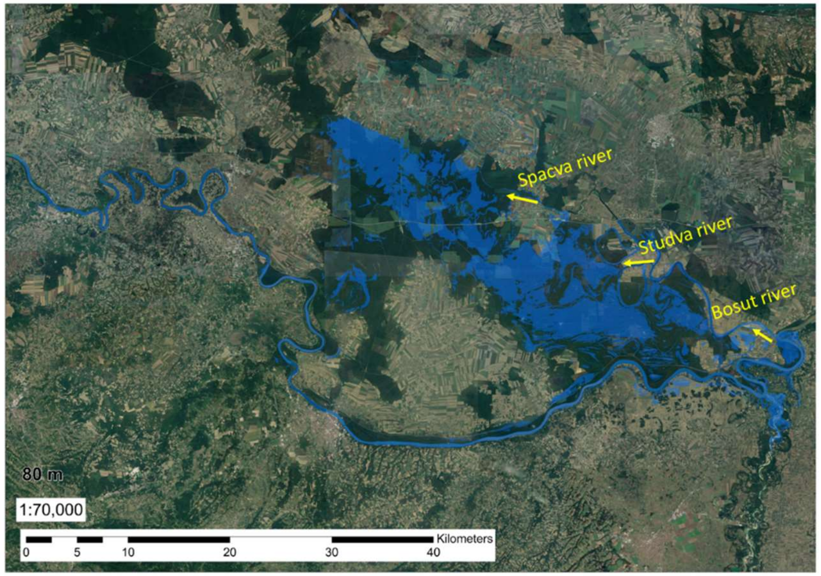


Figure 67: Temporary inundated areas with water levels at 80.00 masl.

Figure 68 shows a scenario where a water level of 80.5 masl was simulated. Regarding the flooded area it differs significantly from the 80.0 m scenario. This appears to be the highest water level to be considered and it may provide an enormous potential for restoration of the floodplain forest over a large area. The volume of water, as will be described later, required to enable this level of inundation can only be brought into the floodplain forest if all available pathways are being used at the same time. The main flow direction will be from northwest to southeast but flooding in the southeastern and lowest part of the forest will also start from the Bosut sluice. The water will therefore enter the floodplain forest from three directions until the desired water levels are reached and then drain towards the Bosut River and back into the Sava. This scenario will be further handled as maximum scenario in terms of restoring the alluvial forest in this study. The optimum scenario might be something in between 80 and 80.5 masl when considering maximal retention potential and maximal forest restoration effect.

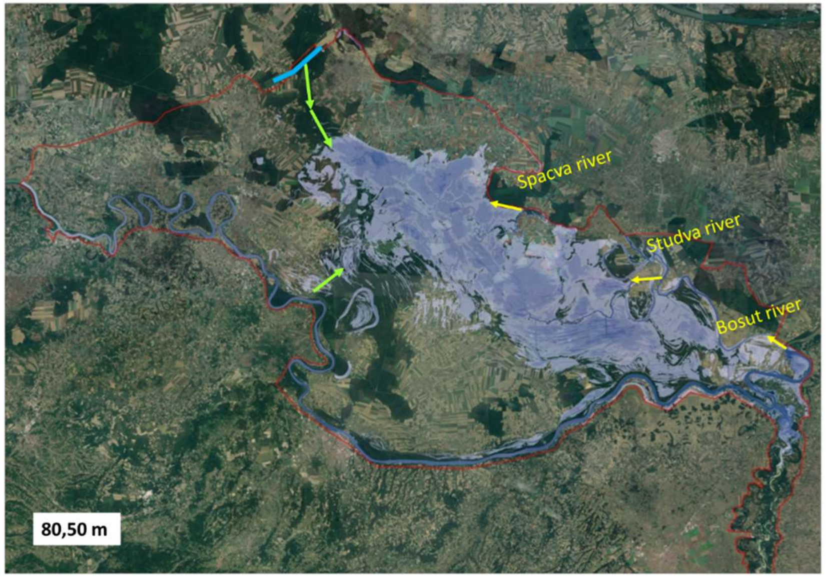


Figure 68: Temporary Inundated areas with water levels at 80.50 masl.

The scenario is also assuming that the existing network of highway, roads, railways and other infrastructures is equipped with culverts and other structures which allow the full permeability of water moving through the floodplain.

It remains to be studied in more detail how exactly such a level of inundation could be reached and how the different flood waves and volumes of water would realistically move through the floodplain. What kind of inundation in terms of local water depths and the duration of the inundation can be achieved has to be simulated in details. This also depends on the shape and the peak values of the flood wave that is moving down along the Sava River which differs from one year to another. It may not be possible to achieve such a level of inundation every year, but the general possibility is considered realistic.

Quite obvious such a level of inundation would require the protection of certain areas where inundation is not desired. This can mostly be done by small dikes and levees. There is also a possibility that some forest roads would be flooded temporarily.

Such a scenario also requires additional construction works to convey the water from the Sava River to the restoration areas. The volume of water required for this scenario is very high and it is questionable if this volume of water could be conveyed into the floodplain by the existing network of channels, riverbeds, and drainage channels. In particular, the conveyance capacities of the culverts in the Sava irrigation channel are probably too small. The scenario would also require the construction of an additional channel leading from the Sava irrigation channel/upper Bosut towards the forest to be flooded (see green arrows in figures). The conveyance capacity of the Bosut irrigation channel may be insufficient because of the culverts. If the culverts are not replaced the main flow of water into the restoration area has to come directly from the Sava River by a new sluice gate that has to be built into the dike. This will be a major concrete structure with movable steel gates to allow a controlled flow of water from the Sava River towards the forest restoration area.

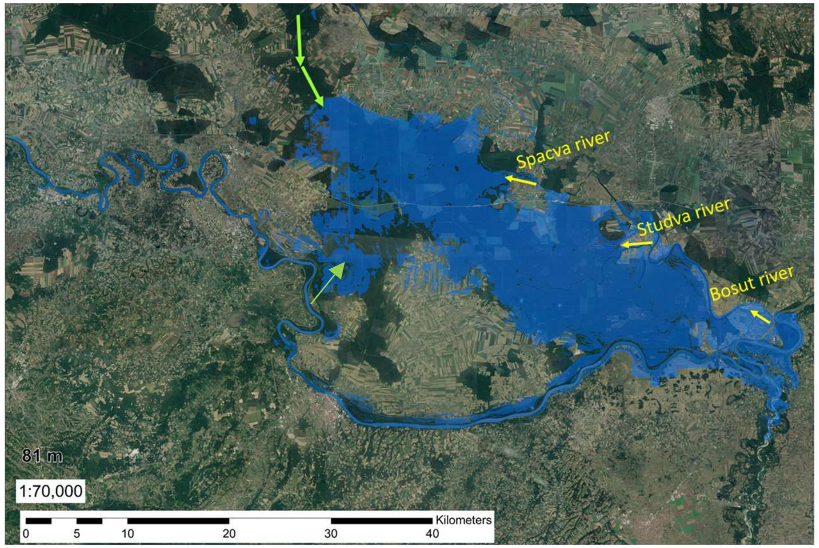


Figure 69: Inundated areas with water levels at 81.00 masl.

The highest scenario investigated is putting a water level in the flooded areas at 81 m (Figure 69). This would already affect some areas used for agriculture and rural settlements. Dikes and levees would have to be built to protect such areas. This scenario is not considered any further and would obviously require similar measures as the previous one but to a larger extent.

A completely different option, the smallest possible scenario for flooding minor areas would be along the Sava River, see Figure 70. Water levels at 81 m show some areas adjacent to the river to be flooded. Most of these areas are now separated from the river by dikes. In order to reactivate this portion of the floodplain a second row of dikes would have to be built around the areas to be reconnected with the river. The existing dikes along the Sava would have to be equipped with gated outlets which could be opened during high flows to release water into the restoration areas. Once these are filled to the desired level the gates to the Sava would be closed again. Once the water level in the Sava has dropped the gates could be opened again to allow the water to flow back into the Sava River. The construction of a series of secondary dikes along the river and the construction of gated concrete structures as outlets into the main dikes would be costly while the restoration area would be comparably small.

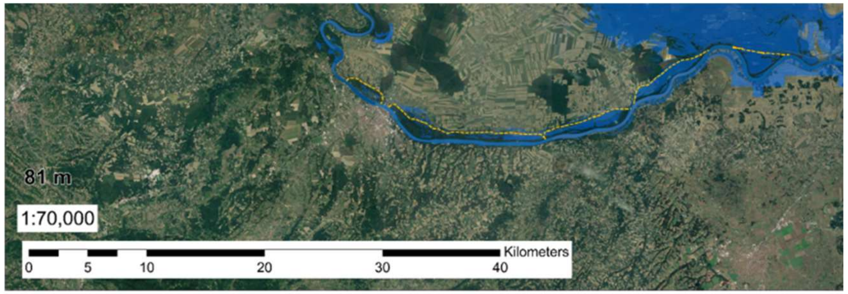


Figure 70: Water levels at 81.00 masl with small restoration possibilities directly along Sava River.

*Figure 71: Studva River south of the highway A3, Croatia.
(Source: E.C.O. 2020).*

*Figure 72: Mouth of Spačva River (left) into Bosut River north of Lipovac, north of the Highway A3, Croatia.
(Source: E.C.O. 2020).*

*Figure 73: Brežnica River, Croatia.
(Source: E.C.O. 2020).*

5_3_1 Ecological conditions for restoration scenarios

Ecological conditions that will develop in the floodplain as a consequence of different flooding scenarios will depend on the timing, duration and water depth caused by the actual water release into the floodplain. These parameters will vary spatially and they will be transient. Certain types of floodplain vegetation usually correlate with certain durations and frequencies of inundation and the water depth reached by the inundation. Also, the timing is highly relevant.

To develop meaningful restoration scenarios, it is required to describe the physical conditions or the range of conditions that certain types of floodplain vegetation require. This can be called habitat suitability criteria. The processes relevant for these criteria can then be simulated in an iterative approach to analyze where the proper conditions occur as a consequence of a certain flow release into the floodplain. Numerical hydrodynamic models, so called computational fluid dynamics (CFD) models, in combination with the floodplain topography and certain points where water is conveyed into the floodplain will allow to simulate how the water is moving into, through and out of the floodplain over a period of several days, weeks or even months. The input data for such simulations will be the timing, duration and flow rates where water is entering the floodplain either from the Sava irrigation channel or from the Bosut River via the Studva and Spačva Rivers. The simulations will be numerically quite complex and require several days of computer runtime. The output of such a simulation will be the spatial distribution of water level elevations, water depths and flow velocities for time steps of let's say one hour, for example. This data can then be used to compare it with the physical conditions required by certain types of floodplain vegetation to see how good the physical conditions match the habitat suitability criteria. This process can be described as floodplain vegetation habitat modeling. The underlying assumption in such a process is that in areas where suitable physical habitat conditions are achieved the vegetation will follow and develop accordingly. Parameters outside of the physical habitat conditions may be limiting as well but are not considered in such an approach. If the suitability criteria are not achieved sufficiently or the area where they are reached is too small, the input parameters into the CFD models can be adapted and another simulation performed until the desired level of suitable habitat is reached. The models are also necessary to determine the operational rules for the sluice gates and other control structures.

All possible flooding scenarios depend on the flows and water levels occurring in the Sava River. The shape, duration and peak value of any flood wave propagating down the Sava River will influence the possibilities of conveying water via different pathways into the floodplain. It is therefore obvious that it is not possible to mimic the same flooding event year by year. There will be wetter years and drier years and the timing and duration of the flooding cycles are also differing.

5_3_2 Technical Feasibility of the Flooding Scenarios

Table 15 shows a comparison of the water volumes for the different water level elevations based on a comparison between the land surface elevation and the water table. The volumes are ranging from 100 Mio m^3 if the water level is at 78 m to approximately 1000 Mio m^3 if the water level is at 81 m (as a comparison, Lake Wörthersee near Klagenfurt, Austria) has volume of 820 Mio m^3).

Table 15: Results of Elevation Model Analysis (Source: Radenko Ponjarac)

	Water depth	AREA (ha)	Water (m3)	Duration in Weeks	1	2	3	4	5	6
81 m	0-1 m	30.711,85	243.891.941,27							
	1-2 m	19.047,52	329.277.170,27							
	2-3 m	6.028,90	162.938.290,52							
	3-4 m	1.944,91	73.772.263,18							
	4-5 m	2.148,35	102.746.472,21							
	5-6 m	1.336,06	76.486.887,72							
	6-7 m	317,43	22.153.188,14							
	SUM	**61.535,02**	**1.011.266.213,31**	Inflow [m3/s]	1.672	836	557	418	334	279
	water depth	**AREA (ha)**	**Water (m3)**	**Duration in Weeks**	**1**	**2**	**3**	**4**	**5**	**6**
80,5 m	0-1 m	28.988,73	138.124.804,50							
	1-2 m	15.695,04	223.541.333,63							
	2-3 m	3.563,62	86.501.734,48							
	3-4 m	2.092,73	72.950.979,13							
	4-5 m	931,00	41.398.715,61							
	5-6 m	673,56	35.604.680,64							
	6-6.27 m	0,50	30.853,06							
	SUM	**51.945,18**	**598.153.101,05**	Inflow m3	989	495	330	247	198	165
	water depth	**AREA (ha)**	**Water (m3)**	**Duration in Weeks**	**1**	**2**	**3**	**4**	**5**	**6**
80 m	0-1 m	19.045,05	138.791.581,29							
	1-2 m	6.028,05	102.637.543,09							
	2-3 m	1.944,76	54.319.581,34							
	3-4 m	2.148,05	81.252.193,31							
	4-5 m	1.335,89	63.118.624,69							
	5-6 m	317,43	18.978.824,16							
	SUM	**30.819,23**	**459.098.347,87**	Inflow m3	759	380	253	190	152	127
	water depth	**AREA (ha)**	**Water (m3)**	**Duration in Weeks**	**1**	**2**	**3**	**4**	**5**	**6**
79 m	0-1 m	7.599,41	28.060.713,76							
	1-2 m	2.384,40	36.039.470,56							
	2-3 m	1.410,96	35.012.144,84							
	3-4 m	869,53	31.657.621,90							
	4-5 m	6,76	278.097,25							
	SUM	**12.271,07**	**131.048.048,30**	Inflow m3	335	167	112	84	67	56
	water depth	**AREA (ha)**	**Water (m3)**	**Duration in Weeks**	**1**	**2**	**3**	**4**	**5**	**6**
78 m	0-1 m	1.944,76	15.424.310,84							
	1-2 m	2.148,05	38.291.236,31							
	2-3 m	1.335,89	36.400.890,19							
	3-4 m	317,43	12.630.188,66							
	SUM	**5.746,13**	**102.746.625,99**	Inflow m3	170	85	57	42	24	28

The right side of the table shows a brief analysis on the required flow rates [m^3/s] in order to convey this volume of water depending on the number of weeks of duration of the inflow. In order to reach a water level of 81 m it would for example be necessary to convey 279 m^3/s over a period of six weeks into the floodplain. This would require on one side flood water levels in the Sava River that are high enough over such a long duration. Secondly it would require sufficient conveyance capacities in the Sava irrigation channel and/or the additional new sluice gate for this flow rate. In reality the required water volume would be even higher because some of the water will percolate into the ground and refill the groundwater. The table also summarizes which areas are reaching certain maximum inundation depths which in return can be related to the maximum water depth that is favorable or acceptable for certain types of vegetation.

5_3_3 Flood Retention

Flood retention capacity obviously differs for the various scenarios presented above. The overall volume of water which can be stored temporarily in the floodplain is quite significant. However, the required flow rates to bring these waters into the floodplain within a relatively short period of time are extremely large, almost 1700 m^3/s to fill the retention volume up to a level of 81 m within one week. For comparison, in 2018 the highest flows in the Sava River reached almost 5000 m^3/s in an ordinary year. The possible retention would therefore be a highly significant reduction of the discharge in the Sava River to shave of the highest peak even in the case of a significantly higher flood wave during the maximum flows of one week. But it would require the construction of the conveyance structures, particularly the breaches in the existing dike, the sluice gates to open the breach and the additionally required dikes, levies and channels to guide the water towards the floodplain forest at very high flow rates. Such high flow rates are not necessary for the ecological restoration of the floodplain but they are needed for an effective contribution to flood retention.

It is concluded that the restoration has also a very significant potential to contribute to flood retention and to significantly shave off the peak of a flood wave in the Sava River. But only if 1) a restoration scenario relying on a water level as high as possible is chosen and 2) if this flood retention aspect is considered in the general design of the structures and facilities that have to be built to support the restoration efforts.

The whole project must be therefore designed as a multi-purpose project including both, floodplain forest restoration and flood retention.

5_4 Implementation Costs

Costs can only be roughly estimated at this stage. This analysis considers estimated costs for preparatory works, planning and design and the costs for the construction of the necessary structures and facilities. Costs for operation, land use, compensation for land owners etc. are not considered in this chapter.

First of all, in the next stage it will be necessary to study and simulate the different flooding scenarios in more detail. A hydrodynamic model has to be developed which covers the entire restoration area and the different pathways of how the water is conveyed into the restoration area. In addition to the digital elevation model all hydraulic structures such as dikes and levees, ditches and channels, road embankments, culverts etc. must be captured in a certain detail. A two-dimensional numerical hydrodynamic model has to be developed. Flooding scenarios have to be set up which are based on a representative flood wave moving down the Sava River, the existing and possibly intended new structures (dam breaches, new sluice gates) in combination with specific operating rules (when and how to open and close the gates) and it has to be clarified what the desired inundation patterns are in terms of inundation depths and duration during a certain Sava flood event. The model is then run to simulate these different scenarios to show how the water is actually moving through the floodplain in a real event. This has to be done in unsteady modeling, compared to the simplified steady-state consideration done for this study.

The hydrodynamic model simulates local water depths and flow velocities and can show where the water will be at any point in time and for what duration. This purely physical information can be combined with vegetation habitat suitability functions which describe, for example, which water depth and for how many days is preferable or acceptable for a certain type of floodplain vegetation. Some examples of similar studies under the supervision of the author of this report here are attached and can demonstrate the potential of such studies. The results of the hydrodynamic model in combination with the floodplain vegetation model could be able to specifically design the restoration efforts in order to support specific types of floodplain vegetation in certain zones of the restoration area.

The results of the models will also help to determine exactly if and what kind of additional hydraulic structures must be built and how they have to be operated in the case of a flood wave in the Sava River.

Table 16: Rough Cost estimates – Preparatory and construction costs.

Item	Estimated cost range [* 1000 Euro]
Additional data collection for hydrodynamic model development	10 - 20
Hydrodynamic model development	20 – 30
Scenario development and simulation, depending on scenarios	5 - 50
Design and construction of Scenario 79.0 m (no significant new construction needed), local flood protection measures might be needed though	10 – 100/1 000
Design and construction of Scenario 80.0 m (some dikes and levees, shallow channels, culvert replacement, possible dike breach and sluice gate)	1 000 – 5 000
Design and construction of Scenario 80.5 m (dikes, levees, channels, culvert replacements, dike breach and several sluice gates)	5 000 – 15 000

The next stage would be the preparation of the technical design and construction drawings. The construction itself can be implemented once all permits and licenses have been granted. The construction costs depend very much on the restoration scenario that is targeted for and how much the options for flood retention or considered in the design of the multipurpose project. A preliminary cost estimation is given in Table 16.

Figure 74: Culvert at Bosut irrigation channel near Jaruge, Croatia. (Source: E.C.O. 2020).

Figure 75: Culvert at Bosut irrigation channel near Jaruge, Croatia. (Source: E.C.O. 2020).

Figure 76: Dam at Bosut River shortcut near Andrijaševci, Croatia. (Source: E.C.O. 2020).

Figure 77: Overflow barrier at Bosut River north of Lipovac, Croatia. (Source: E.C.O. 2020).

5_5 Evaluation of Ecosystem services (ESS)

There are many different concepts addressing ecosystem services of floodplains and alluvial forests. Preparatory for the impact assessment of the different scenarios, the ecosystem services of the alluvial forest will be highlighted based on respective studies (GETZNER ET AL. 2019, INCVP 2016).

Provisioning services

Wood production

In the context of sustainable use of wood, which is primarily limited by the wood increment, it is also useful to determine the wood growth that is available for use and can contribute directly to welfare as a sustainable resource. It should be noted that wood production is directly related to the use of renewable energy sources (including biomass) and the storage of carbon in biomass (plants, soil); further connections arise with a lot of other ecosystem services (e.g., biodiversity, recreational and leisure use, tourism, erosion protection).

The Case Study "Advocating ESAV in Bosut Forests area - integrating biodiversity and ecosystem services in natural resource uses and management" (INCVP 2018) assessed that wood production would benefit in 30-50% less forest dieback and salvage cuttings related to water depletion, with proportionally higher quality yield in timber. To make this more apparent, the improvement is shown with the Vinčina-Žeravinac-Puk management unit. Salvage yield (sanitation cutting because of dieback) of 60.771m³ is reduced by the estimated value (30-50%), which is from 18.213 m³ to 30.385 m³ in terms of volume. Calculations for the scenarios are presented in the chapter impact assessment.

Water quality

Floodplains can significantly reduce the entry of nutrients from the surrounding area into waters. The benefits associated with higher water quality (e.g., savings in drinking water treatment) can be enormous. For instance, by relocating the dike at the Elbe, floodplains would be created, which could hold back nutrients worth up more than € 480 million[1] (GROSSMANN 2012). Tourism and recreational fishing can also benefit from higher water quality (NEFO O.J.).

Production support through pollination

With this ecosystem service (ESS), the pollination performance by insects of near-natural forest habitats in adjacent crops can be estimated and evaluated.

Fish for commercial use

The ESS concepts focus on that part of the traded animal products that is not preceded by specific breeding and keeping of the animals. Several indicators can be defined to describe this ecosystem service, including the amount of fish caught. Calculations for the scenarios with regards to fish are presented in the chapter impact assessment, based on INCVP 2018.

Supporting services

Protection of biodiversity

The existence of natural diversity at the level of species, genes, ecosystems and landscapes can be seen as a final achievement of the forest areas because it establishes existence or legacy values. This ecosystem service is not a classic, use-related ecosystem service in the actual sense.

[1] Net value over a period of 90 years at a discount rate of 3%. The costs relocation of the dike is not taken into account in this example.

Various input parameters can be used to record and represent the ecosystem service of protecting biological diversity and to model the closeness to nature ("closeness to nature/biodiversity index"). Parameters such as “protected area index”, “biodiversity potential species”, “biodiversity potential structure” and the “forest road index” (degree of fragmentation) can serve as input parameters.

Different moisture tolerant habitat types, plankton communities and plants and animal species selected will be improved in their ecological status, number, population, and area of occupancy. Improvements are expected to take place not only for them but for most of the other species present in the area as well since they are indicators and umbrella species (cf. INCVP 2018). Also, traditional uses support the typical habitat mosaic of the marshes.

Figure 78: The pannage system supports species like Marsilea quadrifolia (Source: ALEN KIS).

Cultural services

Pig farming

Pig grazing in the Bosut forests is practiced for more than two millennia. Some families have been doing this kind of farming for generations and passing their skills on to their offspring (ZINGSTRA 2010). Today this type of traditional use is still maintained in Serbia; in Croatia forest grazing is not common anymore in the Spačva forests area.

Figure 79: Traditional pig farming in the marshes of Serbia. (Source: ALEN KIS).

Within 60-70 days a pig eats 818 hectolitres of food which corresponds to 345 kg of maize. The pastoring of the oak forests has several advantages. For example, it helps to maintain biodiversity in forest, and it reduces pollution of watercourses (INCVP 2016). Calculations for the scenarios are presented in the chapter impact assessment.

Recreational use

The recreational performance can be described by several indicators. These include the number of people who visit forest areas for recreation, information about the length of hiking and riding trails, the area of FFH areas or the number of people who use forest areas without noise.

Nature observation

Nature observation activities can be recorded in terms of the number of visitors who specifically observe animal and plant species in forest areas.

Natural and cultural landscapes for commercial use in tourism

Natural and cultural landscapes can be viewed in many ways as “green infrastructure” (see EUROPEAN COMMISSION 2014) for tourism. In this sense, the protection of the landscape and the landscape is a prerequisite for the perceived attractiveness of the landscape. Vacationers visit because of the attractiveness of the landscape. This creates added value for tourism, which is based on the spending of holiday guests, among other things: for accommodation, meals, transportation, and various consumer goods and services based in the vacation region. This ecosystem service includes the various natural and cultural landscapes that are either actively used by tourists (e.g., holiday activities) or serve as a backdrop for personal relaxation.

Regulating services

Storage of carbon (reduction of CO2 emissions)

The binding of carbon (C) in the biomass, especially through the growth of plants, reduces the CO2 concentration in the atmosphere (Federal (UMWELTBUNDESAMT 2015) or slows down the further accumulation of CO2. This ecosystem service thus describes the capacity of forests to absorb carbon in the form of CO2 and store it as hydrocarbons. In this way, a contribution to climate protection is made with a net increase in biomass. The change in the carbon stocks (C stocks) in the ecosystems (biomass, especially wood and soil) and in the wood products (sawn timber, panels and paper) results in either a net carbon sink (the C stocks in the Biomass stock increases), or to a net emission (C stock in the biomass stock decreases) (GUSTAVSSON ET AL., 2006). In addition, the substitution of fossil raw materials and products made from other materials with biomass reduces CO2 emissions. In this way, Croatia’s greenhouse gas balance can be improved.

The ESS can be described by the following indicators: Change in the wood product stock pool based on the wood used by forest management, thermally used forest biomass and finished wood products.

Flood protection (protection provided by areas that are flooded or can hold back water)

Climate change in conjunction with diverse anthropogenic interventions in ecosystems and spatial development (infrastructure and settlement planning) has an impact on hydrological processes and thus also on the flood regime and the dangers and risks of flooding. In general, flood risk is increased by barriers and sealing (APCC 2014). One consequence of climate change can be the increased occurrence of heavy rain events. This, but also general water-ecological reasons, make it necessary, in the sense of integrated flood protection, to create retention areas to an increasing extent or to restore the previously existing ones (UMWELTBUNDESAMT 2015). The retention capacity of surfaces describes the ability to retain water and solids. With the increasing probability of a flood event, the provision of retention areas is more and more important.

The ecosystem service flood protection can be described based on three indicators: floodplains in the area of the Spačva and Bosut forests, which can serve for retention, potential retention areas, the ability of the forests to retain rainwater.

The calculation of the elevation model showed a range between 100 Million m^3 (water level 78) and 600 Million m^3 (water level 80,5) retention potential (see also table 15).

Local climate regulation

The factor climate change also plays a role in the consideration of feasibility and is cross-cutting all dimensions. In connection with mitigation of negative climate change effects, like desertification and high risks of high floods, a healthy natural floodplain with the potential to keep water in the wet forest as long as possible has various positive effects also as retention area for floods and to keep the groundwater level of the whole area stable.

For Serbia Vojvodinašume specified that there are severe oak diebacks reported, which are affecting management planning, requiring changes in annual plans and are expected to imply the Strategic Plan of Forestry as the highest level of forest management planning. Forest pest outbreaks and heavy storms are linked to climate change and sanitation cuttings are more often and increasing in timber volume. One of the adaptation measures of silviculture in dense forest is stronger thinning, so the competitions among the trees is lessened.

The Ministry of Economy and Sustainable Development – Institute for Environment and Nature Protection (MESD – IENP) pointed out that the negative impact of climate change can be felt especially on groundwater levels. These forests are also very important as sink for CO2. Thus, one needs to look at the area from that perspective, too, how to increase the carbon uptake in the future. This is also important because of the aspired carbon neutral agenda to be reached by 2050.

Figure 80: Species like Calitrichae palustris benefit already from Scenario 79. (Source: ALEN KIS).

The ecosystem service “local climate regulation” can be described using the indicator (number of ÖBf (Austrian state forest) areas in hectares according to GETZNER, 2019. As a guide, those forest areas can be considered that are within a 10 km radius of communities with> 5,000 inhabitants. This indicator can be used to determine the number of inhabitants who benefit from local climate regulation through the forests.

Figure 81: The use of the huge retention potential of the alluvial forest can contribute to reduce the flood risk. (Source: ALEN KIS).

Figure 82: Usurpations of riverbanks in Morovic. (Source: ALEN KIS).

6 IMPACT ASSESSMENT

6_1 Ecological impact

The importance of floodplains determined JURIŠIĆ, B. & VIDICKI, B. (2014) in their study. The result of the geospatial analysis of species richness indicates that flooding duration strongly affects species richness. The highest values of species richness were recorded in the intermediary zone of the hydrological gradient. This indicates that the pattern of species richness increases with the duration of flooding (the highest in the range of 60 to 70 days of inundation in Serbia). Further increase of the gradient leads to a reduction in species richness.

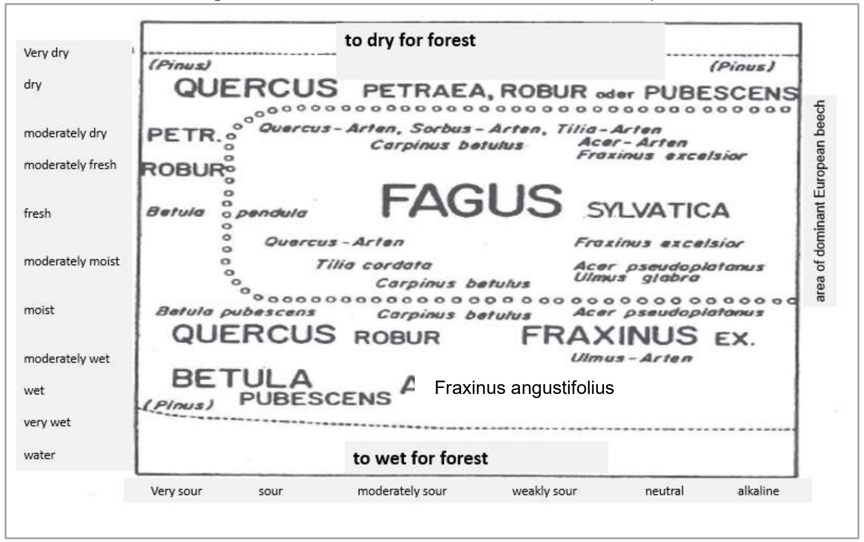


Figure 83: Ellenberg's ecogram (adapted).
The size of the font roughly expresses the degree of participation in the tree layer from what would be expected as a result of natural competition. Parenthesized only in some areas. In the study area Alnus glutinosa is replaced by Fraxinus angustifolia. (Source: ELLENBERG 1986).

Figure 83 shows Ellenberg's ecogram (ELLENBERG 1986) the dependence of different trees of water. It is important to remember that the species are differently water/drought resistant. *Quercus robur, Fraxinus angustifolia,* will be replaced by species such as *Fagus sylvatica* or *Acer spp.* when flooding disappears. As a result, forest communities typical of the region are being lost. The aim should therefore be to promote these species by temporarily flooding.

In the following table you can find short characteristics and the flooding duration that is necessary that the respective type can develop and become more established.

Table 17: Most important forest habitat types, water compatibility and necessary floods events for expression.

Code	Habitat type	Short characteristics (Ellmauer 2005, Willner & Grabherr 2008)	Flooding duration (Willner & Grabherr 2008)
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	Soil damp to waterlogging locations, which due to their air and water balance are unfavorable for the European beech; influenced by groundwater, often in the contact area with riparian forests;	extremely rarely flooded, but oaks can stand flooding without harm up to 90 days according to Reif et al. 2016.
91E0	* Alluvial forests with Fraxinus angustifolia	relatively high standing oxygen-rich groundwater, which has periodic fluctuations; stocks in the immediate flood areas along rivers are characterized by regularly acting floods; with their roots all year round in contact with the groundwater;	According to Margl (1972), the alluvial willow zone is between approx. 30 cm to 1.5 meters above mean groundwater level. This zone is flooded on about 30 days in average. The white willow can withstand an overflow in the root area for up to six months without being damaged. Allluvial poplar zone on locations which are flooded at about two to three year intervals - according to Margl

			(1972) on average every 2 years for 8 days. The locations can partially fall completely dry, eliminating ash and alder.
91F0	Riparian mixed forests, along the great rivers (Ulmenion minoris)	Hardwood alluvial forests occupy the least flooded areas of the floodplain, whereby deep-rooted deciduous trees still partially reach the flowing groundwater. The woods are only affected by episodic floods or in their highest elevations, only reached by disaster floods. The floods are lower in duration and height than in the softwood alluvial forests;	wet riparian forest: adjoins the alluvial willow zone and the water that remains after episodic floods can usually not run off and seeps away or evaporates. fresh riparian forest: the locations are flooded every 2-5 years on 8-4 days (Margl 1972). dry riparian forest: only rarely - every 5-10 years - flooded

6_1_1 Scenario 1: Business as usual – Water level 78

All Natura 2000 habitat types mentioned above have in common that they are dependent on high water availability; all types apart from 9160 need periodic flooding and waterlogging and type 9160 is typical located on clay rich, moist soils for optimal development. Therefore, any change in the hydrological system in the study area has a dramatic impact on the habitat types. Changing the hydrology (regulation of the rivers, building damns and dikes, etc.), changing the level dynamics of the flowing waters at a consistently low or high level (e.g., dams, flood protection measures) or change of the groundwater level leads to a massive conversion of the ecosystem.

- Without natural flooding regime, shade-tolerant and flood-intolerant tree species (*Carpinus betulus, Acer campestre*) would take the dominant role in the canopy and the shrub layer (INCVP 2018).
- Due to the lack of water protected mud-layer after flooding, some species will disappear, and tall marshland vegetation, like the reed and Typha beds and tall sedge communities, will overgrow the muddy surfaces (INCVP 2018).
- Homogenization of the microhabitat-diversity of the woodlands increase and key species of ponds like plant species *Hottonia palustris* will be threatened (INCVP 2018).
- Traditional pig farming on the Serbian site will disappear on the long run. This is a disadvantage for some species, because it contributes to maintain biodiversity in marshlands.
- Decline of characteristic species of the wetter habitat types that directly dependent on seasonal fluctuations will progress.
- Swamp and pond habitats will insufficiently be supplied with water. The swamps and ponds are at risk of drying out and consequently important habitat getting lost.
- There is a risk that habitats of amphibian getting less.
- Invasive species can establish themselves further and claim larger areas and thus displace native flora and fauna factors.With the spread of invasive plants, rare species of forest communities are disrupted and pushed back. They therefore represent a threat to the development of, for example, slowly growing native tree species like oaks) and endanger the stability of the forest (INCVP 2016).
- Droughts will become more frequent, and this promotes the establishment of parasites and pathogens.
- Lack of water has an impact on groundwater and in the consequence forest (FFH 9160) which develop in mostly terrestrial conditions. This forest type is less depending on flood but need specific ground water supply.
- If flooding does not take place anymore the forest type 91E0 and the ponds will disappear and the forest type 91F0 will be replaced by the type 9160 Sub-Atlantic and medio-European

oak or oak-hornbeam forests of the *Carpinion betuli* and one of Europe's largest alluvial forests will disappear.

- Population and distribution of fauna of birds, mammals, amphibians, reptiles, fish and insects which depend on the characteristic mosaic of habitats with different water regimes will decrease.
- Spawning grounds for fishes like the carp (*Cyprinus carpio*) or the European bitterling (*Rhodeus amarus*) will get less.

Figure 84: Typical alluvial forest plant will reduce if the habitat dries up. (Source: ALEN KIS).

Table 18 shows, that with water level 78 masl half of the FFH-Type Oligotrophic to mesotrophic standing waters, two third of 3150 - Natural eutrophic lakes and just 1 % of 3270 of the Serbian part of the study area are connected to the natural dynamics of the floodplain. This represents the status quo. The rest of this type in the area will suffer from insufficient water supply and is endangered to dry out in future. Populations of amphibians and reptiles, which depend on lakes and standing waters like Fire bellied toad, Danube crested newt or European pond terrapin will suffer from shrinking habitats.

For the Croatian part of the study area, there are no data on those types available; they are integrated in the forests types.

With regards to forest types, 27 ha of the type 91 E0, mainly within the dike close to Sava are still connected by this scenario.

Only 2 % of the target habitat 91F0 Riparian mixed forests along the great rivers, which depends on rare but periodic flooding is connected to natural dynamics with this scenario. The rest of the approximate 32.000 ha will on the long run be transformed to another habitat type (e.g., 9160) with the absence of flooding.

With the status quo scenario the FFH-Type 9160 (24.671 ha within the study area) will most likely suffer from drought and sinking groundwater levels without measures. Without periodical flooding and improving the hydrology by reconnecting the habitats to the river, the conservation status of those FFH-Type cannot be improved.

Natura 2000 Habitats are not restored by implementing scenario water level 78.

Table 18: Forest Natura 2000 Habitat Types affected with Scenario 78 masl (Status quo)
Total temporary flooded area within the study area at water level 78 masl: 1.324 ha (602ha in Croatia and 722 ha in Serbia).

Code Habitat Type	Name of Natura 2000 Habitat Type	Area (ha) flooded in HR	Area (ha) flooded in RS	Total area flooded in study area	Area of habitat types within study area [ha]	% of flooded area from the total area
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	45	26	71	24.671	0
91E0	* Alluvial forests with Fraxinus angustifolia	25	2	27	227	12
91F0	Riparian mixed forests, along the great rivers (Ulmenion minoris)	657	177	834	33.264	2

Table 19: Other Natura 2000 Habitat Types affected with Scenario 78 masl (Status quo)
Total temporary flooded area within the study area at water level 78 masl: 1.324 ha (602ha in Croatia and 722 ha in Serbia).

Code Habitat Type	Name of Natura 2000 Habitat Type	Area (ha) flooded in RS	Area (ha) flooded in RS	Total area flooded in study area	Area of habitat types within study area [ha]	% of flooded area from the total area
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea	0	12	12	23	52
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	67	222	289	462	63
3260	Watercourses of plain to montane levels with the Ranunculion fluifluitantis Callitricho-Batrachion vegetation and Callitricho-Batrachion vegetation	1	0	1	22	5
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation	23	1	24	656	4
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	0	0	0	68	0
6440	Alluvial meadows of river valleys of the Cnidion dubii	0	2	2	97	2

6_1_2 Scenario 2: Minimum flooding – Water level 79 masl

As already mentioned above, all Natura 2000 habitat types in the study area have in common that they are moisture-dependent, and their favourable conservation status is connected to optimal hydrology.

By reaching water level 79 masl some areas will be temporary filled up with water for short periods every year or every second year, depending on high water levels on the Sava River. Especially the depressions and channels will receive more water. In total around 10,600 ha will be maximally flooded in this scenario. 7.100 ha in Croatia and 3.500 ha in Serbia. Out of this, 5.500 ha in Croatia are mapped as Natura 2000 Forest Habitat types. Wetlands and streams will also be temporary flooded.

- Regularly flooding up to water level 79 will secure some natural dynamics for the habitat types 3130 Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (20 ha) in Serbia and 3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation (around 300 ha) in Serbia and 100 ha in Croatia.
- More than 88 % of the mapped standing waters will be regularly flooded in this scenario and could be hold in a favourable conservation status. Populations of amphibians and reptiles, which depend on lakes and standing waters like Fire bellied toad, Danube crested newt or European pond terrapin can at least be stabilized in their conservation status.
- Water birds which depend on sufficient availability of food will also profit. Herons for example or white Storks mainly feed on amphibian, mouse, and fish.
- Also 55 ha of the type 6440 Alluvial meadows of river valleys of the *Cnidion dubii* in Serbia will regularly get flooded. Additional areas of the above-mentioned types are included in the data for Croatia (see table Table 21), where in total around 7.000 ha are affected by this scenario within forested area.

Table 20: Area analysis of the temporary flooded forest habitat types within the study area regarding the minimum scenario.

Total flooded area within the study area at water level 79 masl: 10.600 ha (7.100 ha in Croatia and 3.500 ha in Serbia).

Code Habitat Type	Name of Natura 2000 Habitat Type	Area (ha) flooded in HR	Area (ha) flooded in RS	Total area flooded in study area	Area of habitat types within study area [ha]	% of flooded area from the total area
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea	0	20	20	23	87
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	111	294	405	462	88
3260	Watercourses of plain to montane levels with the Ranunculion fluifluitantis Callitricho-Batrachion vegetation and Callitricho-Batrachion vegetation	2	0	2	22	9
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation	64	1	65	656	10
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	0	1	1	68	1
6440	Alluvial meadows of river valleys of the Cnidion dubii	0	55	55	97	57
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	122	367	489	22.519	2
91E0	* Alluvial forests with Fraxinus angustifolia	69	5	74	366	20
91F0	Riparian mixed forests, along the great rivers (Ulmenion minoris)	5.329	967	6.296	41.304	15

- The effect of Scenario Water level 79 is limited on forest habitats. Only 20 % of the Forest type 91E0 can be restored. Part of it is already located close to Sava inside the dike already gets flooded without additional measures.
- The bigger effect of this scenario will be on the type 91F0 Riparian mixed forests, along the great rivers (Ulmenion minoris): This scenario will allow around 5.329 ha in Croatia and 967 ha in Serbia getting regularly and temporally flooded for some days, during Sava River high water level. This is important for stabilizing this alluvial forest type. However, from the total area on this FFH Habitat just a maximum of 15 % can be restored if this scenario is realized. Part of this forest in Croatia could be just reached via Spačva River, and it is not yet clear, if it is possible to get that much water in the area. This must be clarified by calculating a hydrodynamic model.
- In total a maximum of 489 ha of the Habitat type 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli can be restored in this scenario. This means that just 2 % of this target habitat in the study area will be positively affected.
- According to this calculation maximal 10 % of the total area of the forest habitat types in the study area will be flooded. This could be a starting point and pilot areas should be defined. A good conservation status for at least 10 % of the flood depended habitats can be stabilized and will have a positive effect on the conservation status of the connected species.
- Depending on flood duration and frequency, it can be expected that the lowest parts of the forest type 91F0 will be transformed to forest type 91E0. However, Natura 2000 Habitat protected areas are not restored.

The following table shows in detail the forest types (combined with soil types) which would be flooded in the minimum scenario 79 masl. The calculation is based on exact forest data, which were available for the Serbian part. It shows that the biggest effect will be on non-forest habitats followed by ash and pedunculate oak forest of different soil types and poplar on alluvial semigley and fluvisol forest type.

Those habitat types depend on periodical flooding for developing a good habitat condition. The effect of this scenario for restoration of the forest is limited, it mainly affects wetland, standing water and alluvial meadows.

Table 21: Result of intersect of Flooding scenario 79 masl with forest and soil data of Serbia.

Forest type including Soil type	Corresponding FFH Type	Area_(ha) flooded_RS
Forest not specified (Croatian part) and wetland habitats (including standing waters, alluvial meadows) inside of the forest of Serbia.	Various types	2136
Ash and pedunculate oak forest type (Fraxineto-Quercetum typicum) on moderately moist humogley	91F0	123
Ash and pedunculate oak forest type (Fraxuneto-Quercetum typicum) on drier variants humogley	91F0	644
Ash and pedunculate oak in ocassionally flooded part of Gornji Srem forest type (Fraxineto-Quercetum roboris subinundatum) on semi-gley soils (meadow chernozem alluvial pararendzina)	91F0	2
Ash and pedunculate oak with Deschampsia caespitosa forest type (Deschampsio - Fraxineto - Quercetum roboris) on loess - pseudo gley	91F0	1
Ash and pedunculate oak with field maple and Tatar maple and rich shrub layer in unflooded part of Gornji Srem forest type (Fraxineto-Quercetum roboris aceretosum) on driest variants of humogley and on meadow chernozem with signs of	9160	190

Forest type including Soil type	Corresponding FFH Type	Area_(ha) flooded_RS
loess process		
Grey willow forest type (Salicetum cinareae) on alpha - and alpha/beta-gley	91E0	1
Narrow-leaved ash with grey willow forest type (Salicetum cinereae - Fraxinetum angustifoliae) on alpha/beta-beta gley	91E0	146
Pedunculate oak and hornbeam forest type (Carpino- Quercetum roboris) on cambisol to loess-cambisol in unflooded area	9160	
Pedunculate oak and hornbeam forest type (Carpino- Quercetum roboris) on non-carbonated meadow chernozem in unflooded area	9160	
Pedunculate oak in depressions (Quercetum roboris caricetosum remotae) on pseudo gley – gley	91F0	1
Pedunculate oak, hornbeam and ash forest type (Carpino - Fraxino-Quercetum roboris typicum) on cambisolin unflooded area	9160	8
Pedunculate oak, hornbeam and ash forest type (Carpino- Fraxino-Quercatum roboris inundatum) on meadow chernozem in flooded area	91F0	
Pedunculate oak, hornbeam and ash forest type (Carpino- Fraxino-Quercetum roboris caricetosum remotae) on meadow chernozem in unflooded area	91F0	25
Pedunculate oak, hornbeam and ash forest type (sometimes with Turkish oak) (Carpino-Fraxino-Quercetum roboris typicum) in unflooded area on loess cambisols - loess pseudo gley soils	91F0	
Pedunculate oak, hornbeam and Turkish oak forest type (Carpino-Quercetum roboris cerretosum) on loess to pseudo gley meadow chernozem	9160	
Pedunculate oak, hornbeam and Turkish oak with lime forest type (Carpino - Quercetum roboris tilietesum) on cambisol to loess-cambisol	9160	
Pedunculate oak, hornbeam and Turkish oak with rich ground layer forest type (Caripino - Quercetum roboris cerretosum) on cambisol to loess-cambisol	9160	2
Poplar on alluvial semigley and fluvisol forest type	91E0	128
Poplar on humogley and reef humogley forest type	91E0	37
Poplar on meadow chernozem and reef meadow chernozem forest type	91F0	32
Poplar forest type on semi-gley and gley soils.	91E0	4
Poplar forest type on buried meadow blackberries on wood alluvium.	91F0	4
White willow forest type (Salicetum albae) on beta-gley	91E0	31

Forest type including Soil type	Corresponding FFH Type	Area_(ha) flooded_RS
Total area flooded		3.515

6_1_3 Scenario 3: Maximum/Optimum flooding

All Natura 2000 habitat types within the study area have in common that they are dependent on moisture. All types apart from 9160 need periodic flooding or waterlogging for their expression, and the type 9160 needs moist soils. Therefore, the maximum scenario, where a major part of the Bosut and Spačva forest is periodically temporarily flooded for some days can be considered as optimum flooding from ecologic perspective. The maximum area that will be flooded for some days within a year or every few years will be 49.000 ha in total (32.000 ha in Croatia and 16.000 ha in Serbia). The scenario is connected to hydro-constructive measures and can be realized fully with very high floods at Sava River for a maximum of 6 weeks. With this scenario around 65 % of the alluvial forest habitats can be restored. Approximately 60 % of area will reach maximum water levels of 0 – 1 m, flowing through the area and filling up the depressions. 30 % will reach water levels up to 2 m.

- Looking into Natura 2000 habitat types, the biggest share is allocated to the habitat type 91F0 Riparian mixed forests, with is the target habitat of restoration measures. A maximum of 19.000 ha in Croatia and around 7.000 ha in Serbia mapped as this type will be positively affected by this flooding scenario. 63 % of the FFH-Type within the study area would benefit from water levels up to 80.5. Parts of it, especially those in depressions, will develop to the FFH-habitat type 91E0, if the water stays for more than 8 days within a year.

Table 22: Mapped Natura 2000 Habitat types intersected with Maximum scenario 80.5 masl

Code Habitat Type	Name of Natura 2000 Habitat Type	Area (ha) flooded in HR	Area (ha) flooded in RS	Total N.2000 area flooded in study area	Mapped Area of habitat types within study area [ha]	% of flooded area from the total area
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea	0	23	23	23	100
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	124	333	457	462	99
3260	Watercourses of plain to montane levels with the Ranunculion fluifluitantis Callitricho-Batrachion vegetation and Callitricho-Batrachion vegetation	2,3		2,3	22	10
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation	248	20	268	656	41
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	6	26	32	68	47
6440	Alluvial meadows of river valleys of the Cnidion dubii	0	84	84	97	87

9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	6.186	4.065	10.251	.	46
91E0	* Alluvial forests with Fraxinus angustifolia	188	52	240	366	66
91F0	Riparian mixed forests, along the great rivers (Ulmenion minoris)	19.205	6.944	26.149	41.304	63

- Forest allocated to the type 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli will also be affected by this scenario. It generally covers the higher levels and during flood periods water will slowly run through and fill up the groundwater storage. 6.168 ha of this type in Croatia and 4.065 ha of this type in Serbia (10.251 ha which is 46 % of the type within the study area) will be affected and restored, depending on the flood duration and height. Parts of this forest of this type in lower elevations and in depressions might develop to the FFH Type 91F0.

66 % of the Alluvial forests with Fraxinus angustifolia will be restored. In some areas, especially in the depressions, an increase of this habitat type 91E0 might happen, depending on flood duration and frequency. The cover of flood intolerant woody species (such as Carpinus betulus, Cornus sanguinea, Tilia tomentosa, and Acer tataricum) will decrease.

A hydrodynamic model combined with habitat types should be calculated for more detailed information.

- Additionally, all wetland habitat types within the depressions and channels will be restored, 87 % of wet meadows will be flooded and the ground water level of the whole area can be filled up during flood periods. 100 % of the watercourses, of the types 3130 and 3150 will be filled up with water periodically. Also 40 to 50 % river bound herb communities of the types 3270 and 6430 will be restored.
- Populations of amphibians and reptiles which depend on lakes and standing waters like Fire bellied toad, Danube crested newt or European pond terrapin can be stabilized in their conservation status.
- Water birds that depend on sufficient availability of food will benefit and can stabilize their population.
- Fish populations, spawning in alluvial ponds and oxbows will benefit also, depending on the management of the old Fok system.
- Generally, the conservation status of the FFH habitat types and associated species will be stabilized and secured for the future. The alluvial forest will become reconnected to Sava River and its dynamic.
- While flooding will help to avoid some invasive species like *Asclepias syriaca* or *Amorpha fruticose*, the possibility of spreading seeds of other invasive species (e.g., *Acer negundo*) through parts of the forests, which are not yet affected might happen. Depending on the species, specific measures need to be taken into account.

The following table shows in detail the forest types (combined with soil types which would be flooded with the maximum scenario 80.5 masl). The calculation is based on exact forest data, which were available for the Serbian part. It shows that the biggest effect will be on non-forest habitats followed by Ash and pedunculated oak forest of different soil types and Poplar on alluvial semigley and fluvisol forest type. The figures shown for Croatian site are a result of grid calculation along the boundary. Those habitat types depend on periodical flooding for good habitat condition. The effect of this scenario for restoration of the forest is immense.

Table 23: Result of intersect of Flooding scenario 80.5 masl with forest data of Serbia.

Forest type	Area (ha) flooded RS-flooded
Forest not specified (Croatian part) and wetland habitats (including standing waters, alluvial meadows) inside of the forest.	5.030
Ash and pedunculate oak forest type (Fraxineto-Quercetum typicum) on moderately moist humogley	435
Ash and pedunculate oak forest type (Fraxuneto-Quercetum typicum) on drier variants humogley	2.102
Ash and pedunculate oak in ocassionally flooded part of Gornji Srem forest type (Fraxineto-Quercetum roboris subinundatum) on semi-gley soils (meadow chernozem alluvial pararendzina)	170
Ash and pedunculate oak with Deschampsia caespitosa forest type (Deschampsio - Fraxineto - Quercetum roboris) on loess - pseudo gley	43
Ash and pedunculate oak with field maple and Tatar maple and rich shrub layer in unflooded part of Gornji Srem forest type (Fraxineto-Quercetum roboris aceretosum) on driest variants of humogley and on meadow chernozem with signs of loess process	4.757
Grey willow forest type (Salicetum cinareae) on alpha - and alpha/beta-gley	1
Narrow-leaved ash with grey willow forest type (Salicetum cinereae - Fraxinetum angustifoliae) on alpha/beta-beta gley	405
Pedunculate oak and hornbeam forest type (Carpino- Quercetum roboris) on cambisol to loess-cambisol in unflooded area	0
Pedunculate oak and hornbeam forest type (Carpino- Quercetum roboris) on non-carbonated meadow chernozem in unflooded area	
Pedunculate oak in depressions (Quercetum roboris caricetosum remotae) on pseudo gley – gley	16
Pedunculate oak, hornbeam and ash forest type (Carpino - Fraxino-Quercetum roboris typicum) on cambisolin unflooded area	245
Pedunculate oak, hornbeam and ash forest type (Carpino- Fraxino-Quercatum roboris inundatum) on meadow chernozem in flooded area	21
Pedunculate oak, hornbeam and ash forest type (Carpino- Fraxino-Quercetum roboris caricetosum remotae) on meadow chernozem in unflooded area	2.276
Pedunculate oak, hornbeam and ash forest type (sometimes with Turkish oak) (Carpino-Fraxino-Quercetum roboris typicum) in unflooded area on loess cambisols - loess pseudo gley soils	18
Pedunculate oak, hornbeam and Turkish oak forest type (Carpino-Quercetum roboris cerretosum) on loess to pseudo gley meadow chernozem	4
Pedunculate oak, hornbeam and Turkish oak with lime forest type (Carpino - Quercetum roboris tilietesum) on cambisol to loess-cambisol	1
Pedunculate oak, hornbeam and Turkish oak with rich ground layer forest type (Caripino - Quercetum roboris cerretosum) on cambisol to loess-cambisol	23
Poplar on alluvial semigley and fluvisol forest type	436
Poplar on humogley and reef humogley forest type	59
Poplar on meadow chernozem and reef meadow chernozem forest type	86
Poplar forest type on semi-gley and gley soils.	9

Forest type	Area (ha) flooded RS-flooded
Poplar forest type on buried meadow blackberries on wood alluvium.	19
White willow forest type (Salicetum albae) on beta-gley	88
Total	16.245

6_2 Socio-economic Impact

After highlighting the ecological impact of those scenarios, the socio-economic effects must be considered as well. The optimum scenario will be a trade-off between ecological and socio-economic impacts. After a century of conducting hydro meliorative measures to improve the floodplain for economic purpose, a paradigm change happens throughout European countries. Looking for synergies in terms of flood protection and ecological restoration reflects nowadays approach and becomes status quo in the big river basins. Using the retention capacity of floodplain areas is considered a promising option.

6_2_1 Scenario 1: Business as usual

Water level 78 represents the average water level at Bosut River and its tributaries, as well as the existing channels of the ancient Fok system and additional channels. Depressions are partly filled with water. The scenario calculation of the elevation model shows around 6.000 ha of land within the study affected. This is mainly within the rivers, channels, standing waters and swamps.

Hydromeliorative activities in the past including embarkments to protect from flooding helped to increase the arable land in the former floodplain.

The system of channels provide water for agricultural use. The systems include a network of channels for draining agricultural land with pumping stations, and also a network of channels for draining swamps within the forest areas, connected to channels dug by forest roads. These anthropogenic impacts, along with climate change, have led to lower levels of groundwater (INCPV, 2018).

Traditional animal husbandry plays a limited role nowadays, and especially in Croatia traditional big farming stopped some decades ago.

With regards to forestry timber is generated in form of numerous extended clear cuts. Through effects of climate change, drought has led to an increase of forest dieback, so sanitation cuttings are likely to increase (INCVP 2018). Also, the regeneration of young forest in the clear-cuts has become difficult, due to drought and invasive species.

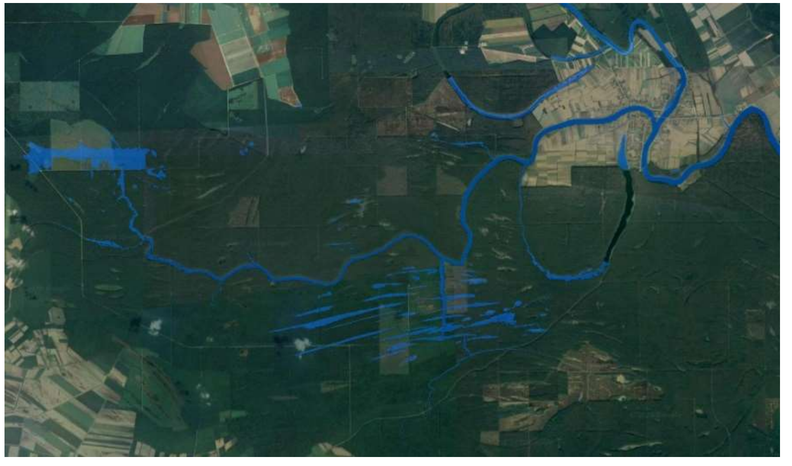
Another threat is drought due to high temperatures and sinking ground water level. Without adaptive measures, there is a risk that the whole area will dry up in the future. A stable groundwater level in the whole area will provide water for economic activities (Agriculture and Forestry).

The settlements within and close to the former floodplain are protected through the dike from average floods at Sava River. However, big flood events like in the year 2014 are threatening settlements and flood prevention measures are needed in the Sava River basin in future (EPTISA SERVICIOS DE INGENIERÍA S.L., 2018) because extreme heavy rain will lead to more frequent flooding events in future due to climate change. The historic floodplain was cut off the river and as a result the huge potential retention room is not functional.

Therefore, continuation of business as usual is not a recommendable option on the long run and will lead to some negative effects in future if the impact of climate change is taken into consideration.

One option for the future is the potential of the study area as retention room in case of high floods. Floods (e.g., those of 2014) have shown, that the existing dike and flood prevention measures are not effective enough to avoid flooding at very high water levels and generally there is a need to consider adaption measures. Using the alluvial forest as retention room (130 Mill. up to 1.000 Mill m^3 according to table 15) (can be one solution for this problem, it is a "soft" alternative to constructive flood prevention measures.

Figure 85 below: Scenario 78 mainly affects the waterbodies and some swamps and channels. There are hardly any forest areas affected.



6_2_2 Scenario 2: Minimum flooding – Water level 79 masl

Though the biggest share of the study area is covered by forest, it also contains some other land use types and critical human infrastructure, where protective measures must be set. The intersect of the land use data with the flooding scenario of water level 79 masl shows, which land use type is maximal possible affected by reaching this water level during Sava high floods. The scenario is calculated based on a hydrostatic model, so the effect is theoretical and does not take into account the dynamic flow.

The following table shows the area of different land use types which would be maximally touched with the scenario Water level 79 masl, if not protected measures are set. The percentage shows the share of area affected compared to the total occurrence of the type within the study area.

Table 24: Land use type most likely affected with water level 79 masl.

Land use type	Ha flooded at 79	HR_79	RS_79	total within study area	% of total	Remark
Dam Weir Sluice	0,0	0,0	0	0,1	0,4	Not affected
Recreation Area	0	0	0	6,3	0,0	Not affected
Harbour Industrial	0	0	0	31,7	0,0	Not affected
City Agglomeration Commercial	0,0	0	0	71,1	0,0	Not affected
Flood Dike	1,2		1,2	376,2	0,3	Not affected, the dike is higher than the targeted water level.
Railway Lines	5,9	3,8	2,1	177,2	3,3	The Railway line is not functional at the moment. Local affection must be considered. There might be a need for local protection or compensation
Road Traffic Lines	7,9	5,0	2,9	744,4	1,1	Roads or Traffic lines lie partly within the affected area, but their dams are generally higher. Local protection (permeability) must be considered.

Land use type	Ha flooded at 79	HR_79	RS_79	total within study area	% of total	Remark
Settlement	15,6	1	1,6	3.262,9	0,08	With water level 79 masl some settlements close to Bosut, Spačva or Studva River and their tributaries (0,1 % of all Settlements like Morovic, Višnjićevo, Bosut might need local protection measures; the channels of the historic Fok system might be closed.
Groyne Traverse Riprap	4,5	4,0	0,6	17,0	26,6	Not affected
Orchard/garden	22,6	6,5	16,1	2.425,4	0,9	Some areas close to the settlements above mentioned need protection or compensation
Other Grassland	96,5	81,6	14,9	2.759,0	3,5	Minor parts of grasslands are partly flooded, which limits application of machinery and the intensity of cultivation. Generally, grassland can be cultivated on flooded areas, but a (potential) reduction in productivity needs compensation.
Large Sectioned Agriculture	105,5	63,0	42,5	24.299,0	0,4	Most crops grown on agricultural land are sensitive to flooding. Additionally, agricultural land needs more frequent access with machinery that grassland or forests and flooding and wet soil limits this accessibility. The minor areas affected by flooding (less than 1%) need local protection or compensation measures
Other Forest				32,4	0,0	Not affected
Lowland Oak Forest	33,6	33,5	0,1	5.670,4	0,6	Hardly affected, might need local compensation depending on flood duration
Poplar Plantation	170,4		170,4	974,4	17,5	Poplar is a species which can deal with long flooding periods
Softwood	380,7	66,2	314,5	1.656,0	23,0	Restoration effect 23 %
Clearcut/Amorpha	1.007,6	870,3	137,3	9.248,7	10,9	Needs to be checked if there is a harm on young seedlings. no/limited negative effect expected
Hardwood Forest	5.453,1	4.222,8	1230,4	53.192,8	10,3	Restoration effect 10 %
Wet Grassland	433,4	266,9	166,5	2.567,7	16,9	Restoration effect 16 %
Fish Pond				1,3	0,0	hardly affected
Filled Gravel Sand Pit	0,0	0,0		14,2	0,1	Restoration effect 0,1 %
Pioneer Veg on Bank	0,2	0,2		3,2	5,3	Restoration effect 5 %
Gravel Bars	0,7		0,7	0,7	100,0	Restoration effect 100 %

Land use type	Ha flooded at 79	HR_79	RS_79	total within study area	% of total	Remark
Mudd Bar	1,6	1,1	0,5	4,9	33,2	Restoration effect 33 %
Gravel and Sand Pit Deposit Dump Site	2,3	0,1	2,2	122,8	1,8	Might not be affected negatively
Sand Bar	2,8	2,5	0,4	10,9	25,8	Restoration effect 26 %
Floodplain Swamp	156,7	95,5	61,2	259,9	60,3	Restoration effect 60 %
Oxbow	168,3	61,1	107,2	209,7	80,3	Restoration effect 95 %
Impoundment/Channel	175,1	0,4	174,7	178,4	98,1	Restoration effect 98 %
River	2.277,2	1.272,5	1.003,5	2.545,7	89,5	Restoration effect 89 %
Total area affected	10.612,4	7.082,6	3.514,6	151.268,9	7,0	7 % of the study area is maximal affected

The table above shows that a raise of water level up to 79 masl will have a local effect on some land use types. In total 7 % of the study area lies within the modelled minimum scenario. Around 7.000 ha in Croatia and 3.500 ha in Serbia will be most likely affected by temporary flooding if the scenario is realized. Considering human infrastructure, the settlements Morovič, Višnjićevo and Bosut in the area close to Bosut River and Studva river mouth will possible need local flood protected measures, if they are not yet in place. The table also shows settlement areas in Croatia close to Bosut tributaries, where protection measures might be already in place. The old, and actual not functional railway is situated in the eastern part of the study area and has to be considered. Roads or Traffic lines laying partly within the affected area, but their embankments are generally higher. Local protection (permeability) must be considered.

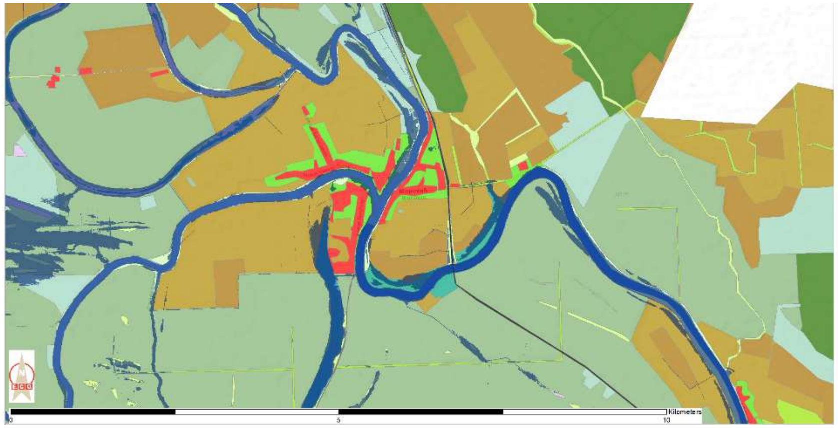


Figure 86: Local Flood protection measures must be considered in Morovič.

Arable land is hardly affected in this scenario, there are 22 ha of orchard/garden, 105 ha of the type large sectioned agriculture and 60 ha of grassland, where protection or compensation measures might be needed, depending on flood frequency, duration and season. Forestry is affected in some parts, so in this scenario 4.223 ha of hardwood in

Croatia (if water levels can be reached also north of the highway) and 1.230 ha of hardwood in Serbia can be positively affected by temporary flooding. The restoration effect of this scenario is 10 % of the total forest of this type in the study area. A negative effect might be discussed for 870 ha of clear-cuts in Croatia and 137 ha of clear-cuts in Serbia, also depending on flood duration and season. However, FRYE & GROSSE (1992) have shown that flooding had no negative impact on hight growth of seedlings of *Quercus robur*, but positive impact on diameter growth. The tree species from the adequate forest type will be able to regenerate according to the given flooding regime. For in total 10 % of the clear-cuts within the study area compensation measures might be needed if the flood duration on site extends more than three weeks. 23 % of the total softwood in the area can be rehabilitated by applying this scenario. 66 ha of softwood in Croatia and 314 ha in Serbia will benefit from regular controlled flooding. However, the biggest areas of this type mainly lie behind the dike, close to Sava River. Therefore, the restoration effect is limited.

Figure 87: Local Flood protection measures might be considered in Višnjićevo.

17 % of the total Poplar Plantations will be within the flooded area, but also: depending on the flood duration they will not be harmed, because the species can deal with flooding. Only a marginal share of 0,6 % of Lowland Oak Forest will be flooded in Croatia. As this forest type is stable to short term flooding, no significant impact is expected.

The biggest effect of the minimum scenario will be on waterbodies and wetland habitats: 16 % of the wet grassland, 60 % of the floodplain swamp, 95 % of the oxbows and 98 % of the channels will be restored by this scenario. Additionally, the different sediment habitats receive some dynamics.

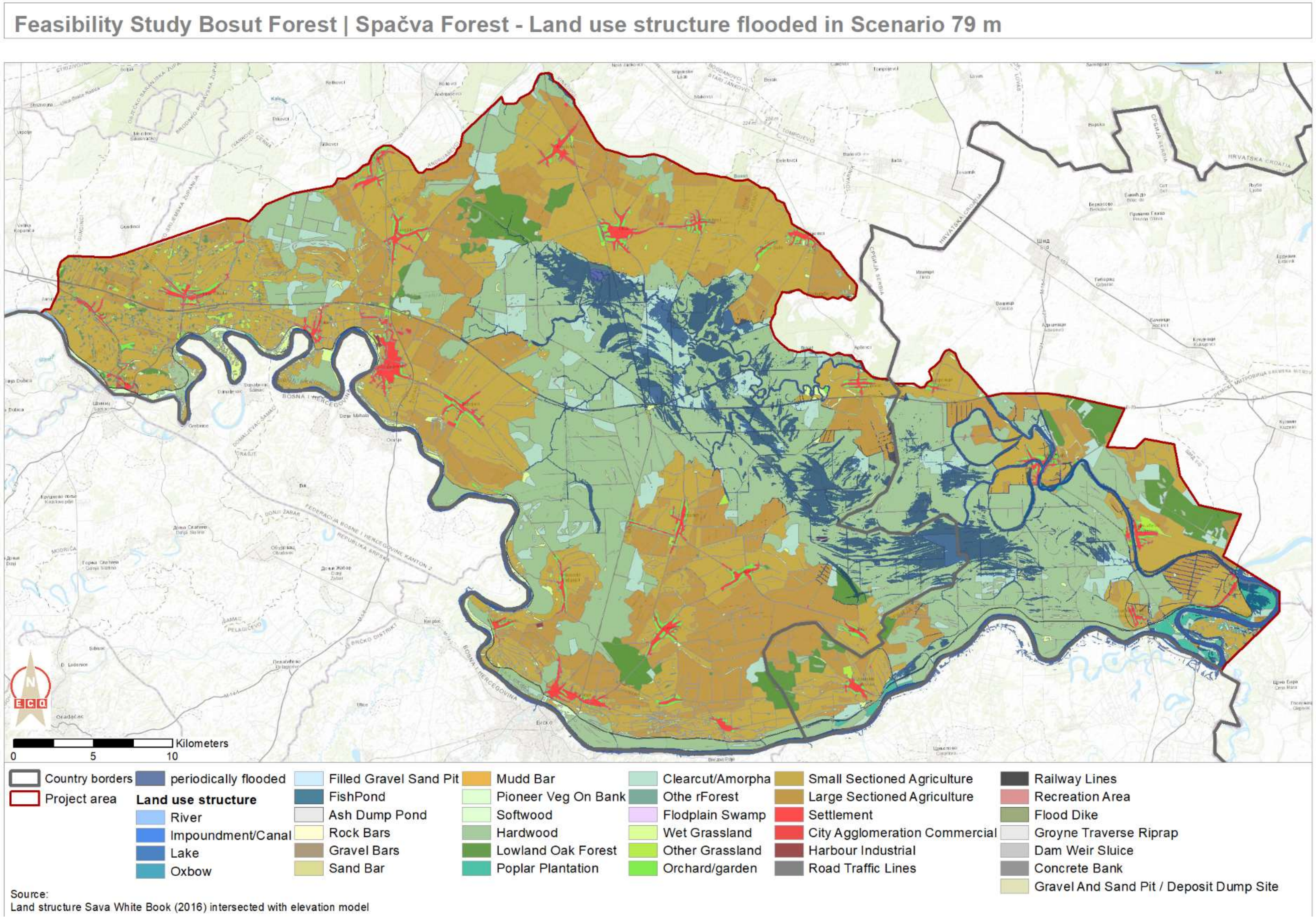


Figure 88: Land use map (SCHWARZ, 2016) intersected with temporary controlled flooding Scenario 79 masl (in blue). (Source: E.C.O).

Table 25. Ecosystem services for Scenario 79
(Source: E.C.O. landuse intersect (Schwarz, 2016), Calculations based on assumptions of INCVP, 2018 and GETZNER ET AL, 2019).

		€	€	€	Scenario	79			
Production	**Unit**	**Upper limit**	**mean**	**lower limit**	**Scenaro 79**	**Upper limit**	**mean**	**lower limit**	**Remark**
Roundwood (Hardwood and Oak forest) +30%	m^3 per year	380	285	190	4.839	1.838.820	1.379.115	919.410	Increase of 30 % production with yearly 4,2 m^3 per ha, 70 % roundwood, on 5.486,7 ha hardwood and lowland forest. Price source: https://www.waldverband.at/wp-content/uploads/2021/01/Preistabelle-J%C3%A4nner-2021.pdf
Firewood (Hardwood and oak forest) +30%	m^3 per year	62	58,5	55	2.074	128.588	121.329	114.070	Increase of 30 % production with yearly 4,2 m^3 per ha, 30 % firewood, on 5.486,7 ha hardwood and lowland forest. Price source: https://www.waldverband.at/wp-content/uploads/2021/01/Preistabelle-J%C3%A4nner-2021.pdf
Arable Land (Compensation after flooding)	ha		-104		194		-20.243		Land renting price for one year by region (Eurostat, 2019)
Other grassland (Compensation after flooding)	ha		-52		97		-5.044		Land renting price for one year by region (Eurostat, 2019)
Potential Animal husbandry (pigs)	Meat € per year per ha	62	58	54	7.051	437.162	408.958	380.754	10 to 14 x more. Source: INCVP, 2018; for Scenario B calculated (wet meadow)
Potential Fisheries (carp)	kg	10	7	5	15.452	154.520	108.164	77.260	Source: INCVP, 2018 x 2 (for additional area in Croatia), Channel and Oxbow
Pond habitat maintainance cost avoided	ha		100		444		44.400		INCVP, 2018
Subtotal:							**2.036.679**		**Total production value**
Retention									
Retention value	m³/year		0,4		131.050.000		50.323.200		Source: Million m^3, Calculation from lidar

									elevation model (200 Mill m³ and 7. Mill € were calculation with less accurate elevation model)
Preparatory costs (yearly)	€						-1000		Breakdown of 50 years
Construction costs (yearly)	€						-2000		Breakdown of 50 years
Subtotal:	**€**						**50.320.200**		**Total Retention value minus project costs**
Total ESS:	**€**						**52.356.879**		**Production minus retention**

The table above shows the calculation on ecosystem services for the minimum scenario 79 masl in Euro. It highlights that production values are most likely to increase if the forest and wetland habitats are restored and forestry, traditional pig farming and fish production will benefit if the scenario is applied (see also INCVP, 2018). The benefits overweigh compensation costs for arable land and the project costs, which include protection measures for settlements. If the retention value is taken into account (see also GETZNER ET AL, 2019) the benefits are many times higher than the costs. The total ESS value is calculated with 52 Million Euro, which represents a minimum, because many factors like the tourism potential, increased recreational value, spiritual value, aesthetic value, ground water retention, climate change mitigation and other prior described ESS factors like N2000 favourable condition (habitats and species) and international corridor functioning are not calculated in the frame of the current study.

6_2_3 Scenario 3: Maximum flooding – Water level 80,5

The third scenario handled in this study is water level 80.5 masl. It represents the maximal feasible controlled flooding scenario from a technical and an ecological point of view, aiming to cover and to restore the forested area as much as possible without affected parts of crucial infrastructure and big parts of agricultural land. To reach this scenario fully will not be possible every year, but just in those years of higher water levels in Sava River. Considering other criteria, the optimum flooding will be determined as a trade-off between ecological impacts and socio-economic limitations.

A hydrodynamic model will help to define the most feasible flooding options. The enormous impact of increasing the water level by just half a meter requires more detailed investigation. The optimum scenario will most likely lie somewhere between water level 80 and water level 80.5 masl. It will be defined as the situation where the alluvial forest can be restored and used as retention area without affecting human infrastructure like settlements and large areas of arable land.

The table below reflects the maximum area of different land use types which would be affected if the scenario 80,5 is realized. The results per country are shown separately. The percentage shows the share of area affected compared to the total occurrence of the type within the study area.

Table 26: Land use type most likely affected with water level 80.5 masl

Name	total area of type (ha)	Area max flooded (80.5)	Area max flooded in HR	Area max flooded in RS	% from total area	Remark
Human infrastructure						

Name	total area of type (ha)	Area max flooded (80.5)	Area max flooded in HR	Area max flooded in RS	% from total area	Remark
City Agglomeration Commercial	71,1	0,0			0,0	Not affected
Harbour Industrial	31,7				0,0	Not affected
Settlement	3.262,9	81,6	44,5	37,1	2,5	Some areas need protection or are currently protected
Road Traffic Lines	744,4	61,2	42,4	18,7	8,2	Some might need protection or compensation/permeability check
Railway Lines	177,2	27,5	11,2	16,3	15,5	Not functional, needs protection or compensation
Recreation Area	6,3	0,1		0,1	1,4	Hardly affected, needs local protection with 80.5 masl
Flood Dike	376,2	12,5	1,9	10,6	3,3	Not affected, dike is higher
Dam Weir Sluice	0,1	0,0	0,0		0,0	The area below might need local protection with 80.5 masl
Groyne Traverse Riprap	17,0	6,0	5,5	0,6	35,5	Needs a check
Agriculture						
Orchard/garden	2.425,4	149,6	70,0	79,6	6,2	Needs local protection or compensation
Large Sectioned Agriculture	24.299,0	3.249,7	2.543,3	706,5	13,4	Needs local protection or compensation
Small Sectioned Agriculture	40.402,6	2.816,1	1.807,6	1.008,5	7,0	Needs local protection or compensation
Other Grassland	2.759,0	583,2	451,1	132,0	21,1	Needs compensation
Forestry						
Other Forest	32,4				0,0	Not affected
Lowland Oak Forest	5.670,4	310,4	309,1	1,3	5,5	Should not be negatively affected, depending on flood duration
Hardwood	53.192,8	31.158,9	21119,0	10.039,9	58,6	Restoration effect 58 %
Clear-cut/Amorpha	9.248,7	5.049,0	3.783,6	1.265,5	54,6	Limited/no negative impact expected
Poplar Plantation	974,4	592,0	0,0	592,0	60,8	Limited/no negative impact expected
Softwood	1.656,0	701,1	179,0	522,1	42,3	Restoration effect 42 %
Filled Gravel Sand Pit	14,2	7,8	7,8		55,3	Dynamics for 55 %
Gravel And Sand Pit Deposit Dump Site	122,8	19,0	15,5	3,5	15,5	Needs check
Gravel Bars	0,7	0,7		0,7	100,0	Dynamics 100 %

Name	total area of type (ha)	Area max flooded (80.5)	Area max flooded in HR	Area max flooded in RS	% from total area	Remark
Sand Bar	10,9	8,6	8,2	0,4	78,6	Dynamics 78 %
Mudd Bar	4,9	3,5			71,5	Restoration effect 71 %
Fish Pond	1,3	0,4		0,4	33,4	Hardly affected/ depending on permeability
Floodplain Swamp	259,9	235,6	146,5	89,1	90,7	Restoration effect 90 %
Impoundment/Channel	178,4	177,4	0,7	176,7	99,4	Restoration effect 99 %
Wet Grassland	2.567,7	1.075,2	654,8	420,5	41,9	Restoration effect 42 %
Oxbow	209,7	200,0	87,5	112,5	95,4	Restoration effect 80 %
Pioneer Veg On Bank	3,2	0,3	0,3		9,3	Restoration effect 9 %
River	2.545,7	2.477,8	1.466,6	1.009,6	97,3	Restoration effect
not specified	2,1		3,0	0,5	0,0	no impact
Total	151.268,9	49.005,1	32.759,0	16.244,5	32,4	32 % of the study area affected

The table above shows that a controlled raise of water level up to 80.5 masl within the floodplain during high flood periods in the Sava River will have local temporary effects on some land use types, also outside of the forest area. In total 32 % of the study area lies within the maximum scenario. Around 33.000 ha in Croatia and 16.000 ha in Serbia are situated inside of this flood scenario.

Considering human infrastructure, 82 ha (2,5 %) of the settlements lie within the maximum scenario 80.5 masl. Local protection measures will be needed there. It must be evaluated if such measures are already in place. Closing structures for the local channels which connect the forest with the settlements and the arable land (Fok system) must be put in place and are an intrinsic part of the scenario.

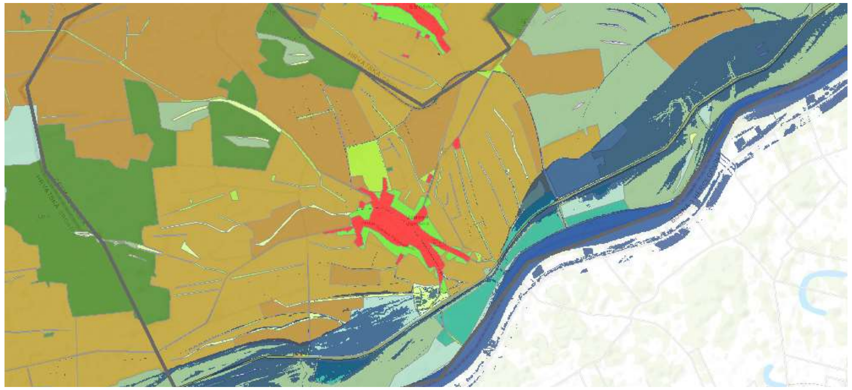


Figure 89: Jamena is not directly affected by Scenario 80,5. But there is a need to check if water comes up directly from Sava River by the channels.

The settlements where local protection measures are most likely to be realized are Morovic and Batrovci, Sremska Raca, Bosut, Višnjićevo and Bosut in Serbia. Jamena lies outside the scenario, however there might be a need to close the channels from side of the Sava River.

In Croatia the settlements of Bosnjaci and Vrbanja will most likely need flood protection measures if they are not in place yet. Zupanja will not be affected, but probably there is a need to protect surrounding orchards.

In some places there will be a need to close the old Fok system channels during high floods like in Gradiste and Cerna, Strošinci and in Soljani.

The old, and actual not functional railway is situated within the flood scenario area. Roads lie partly within the affected area, and it is necessary to check if permeability (culverts) is given with the targeted water level. In most cases their embankments should be higher. Local protection (permeability) must be considered.

Arable land is partly affected with scenario 80.5 masl. Some ha of orchard/garden, large sectioned agriculture and some ha of grassland lie within the area and compensation measures or local protection measures will be needed, depending on flood duration and season. 6 % of the total orchard/garden like those of Nijemci, Donje and Novo Selo need protection measures.

3.250 ha (13 %) of the total large agriculture is affected. For example, the area east of Zupanja or the areas north of Soljani and Strosinci are most likely affected. However, protective measures area intrinsic part of the scenario. The settlements of Gradiste and Cerna are not affected, but connecting channels need to be considered and large agriculture in the surroundings lie partly within temporary flooded areas. Depending on flood duration and season, protection or compensation measures must be put in place.

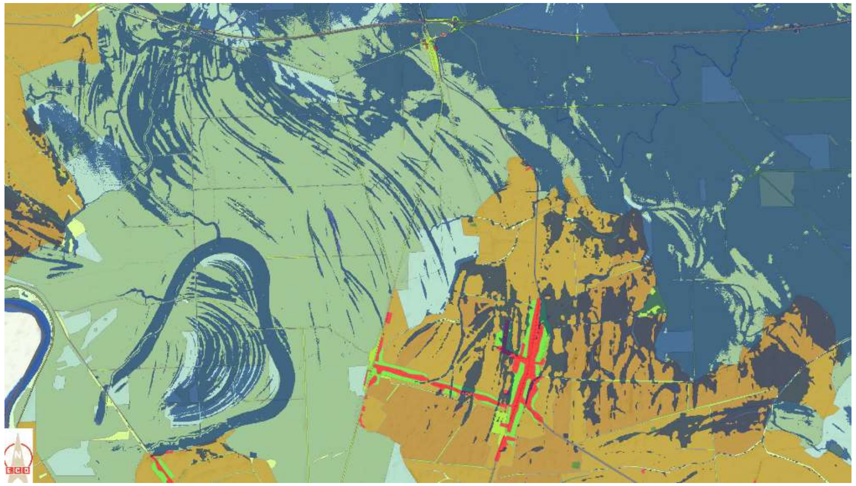


Figure 90: The area around Vrbanja must be protected when reaching water level 80.5.

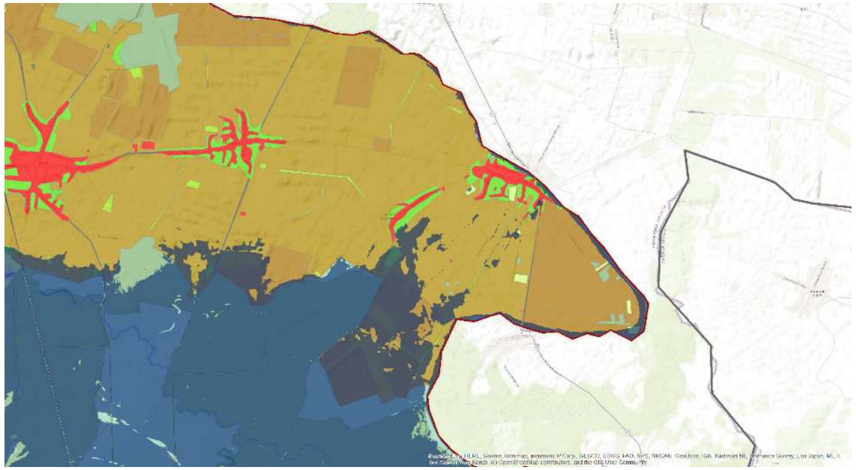


Figure 91: Orchards and arable land affected with scenario 80.5 masl around Nijemci.

The settlements in the southern part of study area between the forest and Sava River are not directly affected but water might come up via channels – there is a need to control if they are locked during controlled flooding and high water level periods.

Around Podgarski there is a need to protect the fields, compensation or flood protection measures must be considered.

In total 7 % of small scale agriculture is affected and 21 % of the type other grassland. Compensation measures and protective measures might be needed.

Looking inside of the forest, with scenario 80.5 masl a big share of different forest types can be reached.

5 % of the Lowland Oak Forest within the study area are situated in the scenario, evenly distributed in Serbia and Croatia. It is expected that lowland oak forest will benefit from flooding and raise of ground water level.

59 % of the hardwood forest can be temporarily flooded in this scenario. This type of forest is the target habitat and can deal with temporary high water levels very well. In total around 21.000 ha of hardwood in Croatia and 10.000 ha of hardwood in Serbia can be restored in this scenario.

54 % of clear-cuts/amorpha in the area also lie in flooded area of the scenario. Generally, no or limited effects are expected, because according to REIF ET AL, 2016 oak seedlings are even positively affected by flooding. Depending on the actual vegetation, the flood frequency and duration and also seasonal aspects it must be investigated locally if this can be verified or if compensation measures in some cases are needed.

60 % of the Poplar Plantations will be theoretically affected in this scenario. They are mainly located close to Sava River and inside of the dike, so they are anyway flooded during high water periods.

43 % of the softwood will be within this scenario. They are mainly located close to Sava River and inside of the dike, so they are anyway flooded during high water levels.

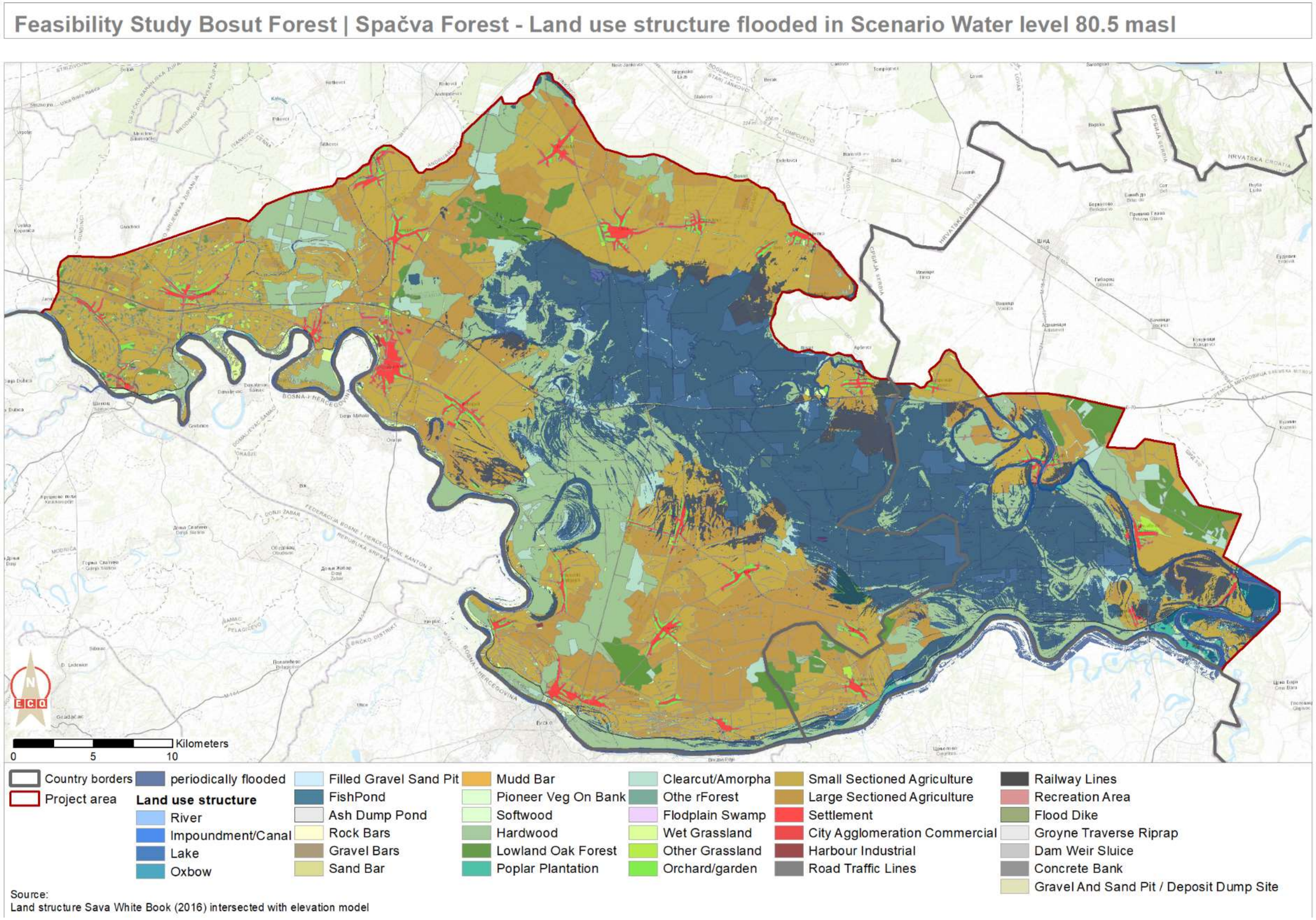


Figure 92: Land use map (Schwarz, 2016) intersected with temporary controlled flooding of Scenario 80.5 masl (in blue). (Source: E.C.O).

Table 27: Ecosystem services for scenario 80.5
Source: E.C.O. land use intersect (SCHWARZ, 2016), Calculations based on assumptions of INCVP, 2018 and GETZNER ET AL, 2019).

		€	**€**	**€**	**Scenario**	**80.5**			
Production	Unit	Upper limit	mean	lower limit	Scenario 80.5	Upper limit	mean	lower limit	Remark
30 % increase of Roundwood (Hardwood and Oak forest)	m^3 roundwood yearly	380	285	190	51.744	19.662.720	14.747.040	9.831.360	Increase of 30 % production with yearly 4,2 m^3 per ha, 70 % roundwood, on 58.863 ha hardwood and lowland forest, Price source https://www.waldverband.at/wp-content/uploads/2021/01/Preistabelle-J%C3%A4nner-2021.pdf
30 % increase of Firewood (Hardwood and oak forest)	m^3 firewood yearly	62	58,5	55	22.176	1.374.912	1.297.296	1.219.680	Increase of 30 % production with yearly 4,2 m^3 per ha, 30 % firewood, on 58.863 ha hardwood and lowland forest, Price source https://www.waldverband.at/wp-content/uploads/2021/01/Preistabelle-J%C3%A4nner-2021.pdf
Arable Land (Compensation after flooding)	ha		-104		6.066		-630.864		land renting price for one year by region (Eurostat, 2019)
Other grassland (Compensation after flooding)	ha		-52		583		-30.316		land renting price for one year by region (Eurostat, 2019)
Potential Animal husbandry (pigs)	Meat € per year per hectare	62	58	54	37.519	2.326.178	2.176.102	2.026.026	10 to 14 x more. Source: INCVP, 2018; calculated for Scenario B (it includes forest and wet meadow)
Potential Fisheries (carp)	kg	10	7	5	16.982	169.820	118.874	84.910	Source: INCVP, 2018 x 2 (for additional area in Croatia), Channel and Oxbow
Settlement/Orchard									(Included in project costs)
Pond habitat maintenance cost avoided	ha		100		2.364		236.400		INCVP, 2018
Subtotal:							**17.914.532**		Sum of production values

		€	€	€	Scenario	80.5			
Retention value	**m³/year**		**0,38**		**600.000.000**		**230.400.000**		Source: Retention volume in m³ (Table 15 Calculation from elevation model), Getzner et al.
Preparatory costs (yearly)							-2.000		Breakdown of 50 years
Construction costs (yearly)							-30.0000		Breakdown of 50 years
Subtotal:							**230.098.000**		**Total Retention minus Project costs**
Total ESS:							**248.012.532**		**Total sum Production and Retention value**

The table above shows the calculation of ecosystem services for the maximum scenario 80.5 masl in Euro. It highlights, that production values are most likely to increase many times when the forest and wetland habitats are restored, and forestry, traditional pig farming and fish farming will have multiple benefits assumed (see also INCVP, 2018) the potential is also utilized. The benefits overweigh compensation costs for arable land and the project costs, which include protection measures for settlements. If the immense retention value is taken into account (see also GETZNER ET AL, 2019) the benefits are many times higher than the costs. The total ESS value is calculated with 248 Million Euro, which represents a minimum, because many factors like the tourism potential, recreational value, spiritual value, aesthetic value, ground water retention, climate change mitigation and other prior described ESS factors like N2000 favourable condition (habitats and species) and International corridor functioning are not calculated in the frame of the current study.

Figure 93: Morovic is one of the settlements where flood protection measures must be considered.
(Source: ALEN KIS).

Figure 94: The permeability of the Fok system must be controlled.
(Source: ALEN KIS).

Figure 95: The sluice-gate between Sava and Bosut River plays a major role for the scenario development.
(Source: ALEN KIS).

6_2_4 Scenario evaluation

The full range of attributes for the ecological and the socio-economic impact of the minimum and maximum scenarios are compared in this chapter as a base for further discussion and to give an overview for decision makers. The disadvantages for the status quo were already mentioned before, it is not a recommendable option to continue in this way. The current status is connected with a number of problems due to sinking ground water levels and a general lack of water in the alluvial system.

The comparison of the minimum and the maximum (ecological optimum) scenarios shows following results (see also Table 28):

Ecological impact:

Compared to the minimum scenario water level 79 masl nearly four times more area will be temporarily and periodically controlled flooded by applying the maximum scenario water level 80.5 (12.000 ha vs 42.000 ha). This would cover three quarter of the alluvial Bosut Forest and Spačva Forest and lead to a big restoration effect for the ecosystem (FFH Types 91F0, 91E0 and 9160 and its related and depending rare and endangered species) in the area.

6 times more hardwood forest (31.200 ha vs 5.500 ha) and 12 times more lowland oak forest (410 ha vs 33 ha) would benefit from controlled periodically/occasional flooding when water levels in Sava River are high.

Concerning water habitats (200 ha vs 178 ha) and wetland habitats like wet grassland (1.000 ha vs 400 ha), Softwood (701 ha v 380 ha) and swamp (235 ha vs 156 ha) the ratio of the restoration effect is lower (1 or 2). By applying of the maximum water level scenario 80.5 up to 100 % of the water- and wetland habitats can be restored, and groundwater storage will be filled. However, the Natura 2000 area HR2001415 Spačva JZ will need even higher water levels for full restoration.

Socio-economic impact:

While the socio-economic impact of scenario water level 79 is low, some critical land use types might be affected within the scenario water level

80.5 without. Therefore, protective measures and compensation measures are an intrinsic part of the scenario. This limits the idea of going beyond water level 80.5.

12 settlements (instead of 3) and its surrounding orchards will need protective measures by applying the maximum scenario. Large scale agriculture on those areas, where hydro-meliorative activities in the past allowed agricultural production in the former floodplain will require protective measures or compensation in case of applying the maximum scenario (6.799 ha of arable land versus 314 ha).

The comparison of the calculated ecosystem services (ESS) shows that the positive effects of both scenarios overweigh the project costs significantly (see Table 28) by triggering production and by avoiding other flood protection measures.

With regards to the forestry sector there will be mainly positive affects in terms of production: By optimizing the water supply to the alluvial forest types by controlled flooding, 30 % more yearly production in the hardwood forests can be expected (see also INCVP, 2018). This leads to an increase of around € 14 Million by application of the maximum scenario compared to an increase of € 1.380.000 for oak roundwood just via improving forest health and avoiding forest dieback. The increase of the returns on firewood would be € 1,3 Million yearly by applying scenario water level 80.5 instead of around € 123.000 by the application of scenario water level 79.

Compensation costs for arable Land (Compensation after flooding) area calculated with € -630.851comparead to € -20.243 for the minimum scenario, and compensation costs for grassland (type other grassland) are calculated with -30.324 by applying the maximum scenario compared to € -5.019 for the minimum scenario.

The sector of animal husbandry, especially big farming in a traditional way could benefit a lot, if the potential is utilized. Yearly € 2 Million could be gained if the maximum scenario of water level 80.5 is applied compared to € 400.000 with the minimum scenario. As a side effect, pond habitat maintenance costs can be avoided up to around € 200.000 with the maximum scenario and € 44.000 by applying the minimum scenario via pig farming.

Another potential for the area is fisheries: If the maximum scenario is applied, a mean value of 190.000 € would be possible by keeping high water levels in the channels and depressions, compared to € 108.000, if the minimum scenario is applied.

However, the biggest effect lays in utilization of the enormous retention capacity of the alluvial Bosut Forest and Spačva Forest. Compared to the minimum scenario water level 79 masl four to five times more water volume can be temporarily stored by applying the maximum scenario water level 80.5 (600.000.000 m^3 vs 131.000.000 m^3[2]) in a controlled way and slowly released after big flood events into Sava River. If it is utilized fully, it will help to protect numerous settlements downstream and help to save costs for protective measures.

The ecosystem service retention potential was calculated with around € 230 Million by applying the maximum scenario compared to around 50 Million € for the minimum scenario.

Compared to these benefits, the project costs of € 10 – 100.000 for the minimum scenario (around € 3.000 yearly costs) and € 5- 15 Million (€ 302.000 yearly) are definitely lower.

[2] 200.000.000 m^3 were calculated by the use of less accurate elevation data

Table 28: Comparison of effects of the minimum and the maximum scenario.
Source: E.C.O – Method explained in the method section

Effect	**80.5**	**79**	**Difference**	**Remark**
Area periodically controlled flooded (ha)	42.000	12.000	30.000	GIS analyse of elevation model
Restoration effect				
Natura 2000 Habitat improvement	100 % of 3130 99 % of 3250 45 % of 3160 10 % 3260 41 % 3270 47 % 6430 87 % 6440 46 % of 9160 63 % of 91E0 66 % of 91F0	87 % of 3130 88 % of 3250 9% of 3260 10 % of 3270 1 % 6430 57 % 6440 2 % 9160 20 % of 91E0 15 % of 91F0	13 %3130 12 % 3250 36 % 3160 1 % 3260 31 % 3270 46 % 6430 30 % 6440 44 % 9160 43 % 91E0 51 % 91 F0	Calculation based on habitat data from Bioportal and Data provided by INCVP. Habitat type Codes used for Natura 2000 habitat types.
Area of Habitat restoration (ha of Hardwood)	31.200	5.500	25.700	Area calculation based on Land use data
Area (ha) of Wet grassland	1.000	400	600	Area calculation based on Land use data
Area Habitat restoration (ha of Softwood)	701	380	321	Area calculation based on Land use data
Ha of Swamp	235	156	79	Area calculation based on Land use data
Ha of Lowland oak forest	410	33	377	Area calculation based on Land use data
Ha Water habitats	200	178	22	Area calculation based on Land use data
Ha of Clear cuts	5.050	1.007	6.485	Area calculation based on Land use data
Ha of arable land flooded	6.799	314	9	Area calculation based on Land use data /Protection measures or compensation needed
Water Volume/Retention capacity in m^3	**600 000.000**	**131.000.000/ up to 202.000.000**	**400.000.000/up to 469.000.000**	**GIS analyse of elevation model (different values depending on accuracy of data)**
Protection of settlements needed	12	3	9	Number of settlements most likely touched by scenario

Effect	80.5	79	Difference	Remark
Area periodically controlled flooded (ha)	42.000	12.000	30.000	GIS analyse of elevation model
ha settlement affected	81	15	66	Area calculation based on Land use data /Protection measures needed
ha human infrastructure	183	31	152	Area calculation based on Land use data /Protection measures needed

ESS - Production	**80.5**			**79**				
Type	Upper limit	mean	lower limit	Upper limit	mean	lower limit	Delta	Type
Roundwood Production (Hardwood and Oak Forest) increase of 30%	19.662.720	14.747.040	9.831.360	1.838.820	1.379.115	919.410	13.367.925	Roundwood Production (Hardwood and Oak forest) increase of 30%
Firewood Production (Hardwood and oak forest) increase of 30%	1.374.912	1.297.296	1.219.680	128.588	121.329	114.070	1.175.967	Firewood Production (Hardwood and oak forest) increase of 30%
Arable Land (Compensation after flooding)		-630.864			-20.243		-610.621	Arable Land (Compensation after flooding)
Other grassland (Compensation after flooding)		-30.316			-5.044		-25.272	Other grassland (Compensation after flooding)
Potential Animal husbandry (pigs)	2.326.178	2.176.102	2.026.026	437.162	408.958	380.754	1.767.144	Potential Animal husbandry (pigs)
Potential Fisheries (carp)	169.820	118.874	84.910	154.520	108.164	77.260	10.710	Potential Fisheries (carp)
Avoided costs							0	Avoided costs
Pond habitat maintenance cost avoided		236.400			44.400		192.000	Pond habitat maintenance cost avoided
Subtotal:		17.914.532			2.036.679		15.877.853	Sum Production
ESS Retention								
Retention value		230.400.000			50.323.200		180.076.800	Retention value (result for accurate lidar elevation

ESS - Production	80.5			79				
Type	Upper limit	mean	lower limit	Upper limit	mean	lower limit	Delta	Type
								data)
Project Costs								
Preparatory costs (yearly)		-2000			-1000		-1.000	Preparatory costs (yearly)
Construction costs (yearly)		-300000			-2.000		-298.000	Construction costs (yearly)
Subtotal Retention		230.098.000			50.320.200		179.777.800	Retention value minus costs
Total ESS:		248.012.532			52.356.879		195.655.653	Total ESS:

7 CONCLUSIONS AND RECCOMENDATIONS

The first task of the project was to provide a pros and cons analysis of floodplain restoration - considering forestry operation activities, nature protection objectives and flood alleviation needs. The study results show that a multipurpose floodplain restoration project will address many problems of the status quo scenario. By applying a feasible range of controlled periodically flooding and by integration of the needs of all sectors (operation of forestry, nature protection and flood alleviation needs) positive effects can be gained for all. The study confirms the high restoration and retention potential of the Sava River basin mentioned in many prior studies (e.g. SCHWARZ, 2016, INCPV, 2018, EPISTA SERVICIOS DE INGENIERA, 2018) and also highlights the range of the area feasible for restoration of the alluvial Bosut and Spačva forest.

The second task was to elaborate scenarios of optimal ecological and highest acceptable alleviation potential which would not destabilize the business sector and environmental objectives. Setting up optimum spatial-temporal flooding for the habitat mosaic and defining pessimism thresholds in height, length and season of flooding for the key species and habitats. In the frame of this study, a range of water levels between 79 masl and 80.5 masl can be recommended for the study area for wetland and forest restoration purpose.

Scenario water level 79 masl can be considered as minimum scenario which could be applied every year and will at least help to restore some standing water and wetland habitats. From ecological point of view, it does not have a significant effect on the alluvial forest habitat types, because just 15 % of the habitat 91F0 and 20 % von 91E0 could be restored. Water level 79 masl can easily be achieved every year by changing the operation of the Bosut Sluice gate aiming to restore the standing water and marsh habitat.

Scenario water level 80 masl basically lies within the forest area and hardly affects arable land and critical infrastructure. However, the restoration effect on the forest habitat is limited, because not all parts of alluvial forest will be included by controlled flooding. Limiting factors are related to the process of regeneration of pedunculate oak forests and the sensitivity of other key species to flooding. In the planning of controlled temporary flooding, it is necessary to take care that the flooded water is kept on the rejuvenated surfaces as short as possible (up to a month) and with the lowest possible height of the flood wave. The flooded water height on rejuvenation plots during the vegetation period should be less than the young trees height. If, due to the flood defence of the settlement the waters in retention became higher than the tolerance of edifying tree species, as well as protected wildlife species, revitalization and compensatory measures need to be carried out. The effects of this scenario are not analysed in detail at this stage. There is a big step from water level 80 until 80.5 masl with regards to the size of the flooded area, water volume and the impact.

The results of the hydrostatic model allow to recommend an optimum scenario between water level 80 and 80.5 masl, which could be reached in years of higher water levels at Sava River. In terms of restoration effect, the maximum scenario water level 80.5 must be considered as the optimum scenario from an ecological point of view. Up to 65 % of the Natura 2000 forest habitat types could be restored and nearly 100 % of wetland habitats would be connected to floodplain dynamics fully. However, the Natura 2000 area HR2001415 Spačva JZ, (SCI) is not yet restored at this water level and would require water levels up to 81 masl. Beneficiaries are a big list of rare species of European importance like White tailed eagle, Black stork, Collar flycatcher, Eurasian otter, Danube crested newt, Fire-bellied toad, European pond terrapin, Large Copper as well as European bitterling and other fish species among others.

From a technical point of view, Scenario 80.5 also reaches the most feasible entry point from Sava River to the alluvial forest north of Zupanja, where it could be connected directly. The maximum scenario 80.5 requires higher water levels at Sava River for around 6 weeks. A certain level of flooding should be possible almost every year but may be very short in dry years. To restore the target habitats fully (especially FFH-habitat 91F0) periodic flooding every 2 – 5 years for around 4 – 8 days will be needed. Half of the flooded area in this scenario will deal with water levels up to a maximum of 1 m. Water should mainly run through the forest and remain in depressions with standing water, swamp areas and marshes.

However, it involves some socio-economic impact on arable land and critical infrastructure, were hydro-meliorative measures have been set in the past. Protective measures are intrinsic part of the scenario and will help to avoid temporary flooding of those areas.

The third task of this project was to define how the integrated solutions for the floodplain restoration is bringing added values in business and environmental issues (nature-based solutions, climate buffer etc.)

Considering ecosystem services as well as socio-economic impact scenario 79 masl can be a starting point for increasing various benefits in terms of productive and regulative services. Climate change mitigation measures like filled groundwater levels, and healthy forest growth will support the productive sector.

By reaching higher water levels of just 1,5 m in the study area in a controlled way, the restoration effect will increase significantly. Though the maximum scenario with water levels at 80.5 masl, will lead to higher compensation or local protection measures when it comes to potential flooding of arable land, especially large-scale agriculture it is overweight by the higher production volume of forestry, animal husbandry and fishing. The arable land which might be affected without protected measures is situated in the former floodplain, which was transformed and affected by hydro-meliorative activities in the past. However, mitigation measures, which are part of the scenario costs will avoid negative effects.

Wood production (timber and firewood, especially from oak) will increase by 30 % by restoring the forest hydrology to an optimum. The advantage will prevail outage caused by limited access to some areas for a short periods. Fish production and Meat production have a potential to increase by a factor 10 for the minimum scenario and by the factor 23, if the potential is utilized fully.

The comparison of the minimum and the maximum feasible scenario is interesting in terms of comparison of ecological impacts and provision of ecosystem services with the project costs. Scenario 79 masl reaches already a starting point for habitat restoration of some habitat types, without high negative effects on the current land use. However, the restoration effect on the alluvial forest and the Natura 2000 forest habitats and its species is limited.

Scenario 80,5 would be a step back to nature for the whole area; with various positive effects for habitat and forest health. Though parts of the arable land is affected by this scenario, it could be either protected by dams or compensated in case of controlled temporary flooding. The best option is a controlled scenario, where the optimum water level can be influenced by operation of the existing and the additional sluice-gates.

The convincing argument for the maximum scenario is the provision of an enormous retention capacity. The calculated ecosystem services for this scenario of 248.012.532 € highlights the high value of this retention capacity. This will be enough to take away the flood peak of Sava River and can help to protect the settlements downstream and avoid severe flood damages.

The last task of this project was the assessment of restoration costs and a cost-benefit analysis.

The valuation of ecosystem services showed results which allow to consider scenario 79 as a starting point for various benefits in terms of productive and regulative services, which increases exponential with scenario 80.5, if the potential is fully utilized.

There is a significant range between the socio-economic impact and the costs of each scenario. Starting with costs up to 100.000 € for scenario 79 masl (depending on the capacity of the culverts, the actual permeability and the local flood protection measures for settlements and orchards) the costs are roughly estimated from 5 up to 15 million € for water level 80.5 masl. The big scenario goes in line with several constructive measures in terms of flood regulation (construction of a new sluice gate north of Županja, channels and dikes as well as local flood protection measures for around 12 settlements, if they are not yet in place).

The biggest benefit from ecosystem services is the retention capacity. The advantage of providing a retention capacity of a minimum of 130 Million m^3 with Scenario 79 up to 600 Million m^3 with Scenario 80.5 or valued in Euro 50 Million or 230 Million € overweight the project costs significantly.

With regards to implementation, it is recommended to consider Water level 79 masl a starting point, where habitat restoration can be achieved for wetland habitats and for some forest parts within the floodplain. It will most likely be accepted by various stakeholders.

To fulfil the aim of restoring the Natura 2000 sites and to achieve a favourable conservation status for the forest habitats fully as well as to utilize the retention potential of the floodplain, a higher water level scenario must be chosen. Water levels from 80,2 masl up to 80,5 masl most likely reflect the optimum scenario in terms of sufficient flood retention and to respond to the Natura 2000 requirements. Many positive side effects in terms of ecosystem services will arise from this optimum scenario.

7_1 Next steps recommended

The results prepared for this study offer a first analysis of the different scenarios that should be developed iteratively and studied in more detail. A feasible range of temporary water levels in the floodplain via controlled temporary flooding has been shown.

The visualizations provided by the hydrostatic analysis based on the elevation model are a simplification of the real conditions that will develop depending on where from the water is released into the floodplain, at what flow rate and for how long. The real range of possibilities how such flooding scenarios could be implemented depends on the shape of the natural flood wave which is propagating along the Sava River and which is differing in its magnitude, duration and shape from one year to another. The real situation is therefore not a horizontal water table as shown in the figures but in reality, a wave of water will be propagating not only down the river but also into and out of the floodplain.

For a better identification of the restoration scenarios that should be analyzed it is recommended to develop a set of habitat suitability criteria for different types of floodplain vegetation, relevant for this project, and to identify areas where these criteria can be fulfilled based on knowledge and input from all contributing stakeholders.

More detailed technical data (like the capacity of the culverts, the location of existing flood protection measures and the proper functioning of the historic Fok system and its channels can be taken into account.

It is recommended to proceed with the development of a hydrodynamic simulation model which will help to analyze the possible restorations scenarios in more detail and to analyze which accompanying measures are required. The model can be linked with habitat suitability criteria for different desirable types of floodplain vegetation to identify which areas will be suited for certain types of floodplain forest under each of the restoration scenarios.

An additional step during the next stage would be the preparation of the technical design and construction drawings. The construction itself can be implemented once all permits and licenses have been granted. The construction costs depend very much on the restoration scenario that is targeted for and how much the options for flood retention or considered in the design of the multipurpose project.

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