Ulrich Schwarz, Sanja Pokrajac, Kathrin Bockmühl and Gisela Stolpe

Nature-based solutions for flood risk prevention in South-Eastern Europe

Federal Agency for Nature Conservation

BfN-Skripten 511

2018

Nature-based solutions for flood risk prevention in South-Eastern Europe

Final report

Ulrich Schwarz
Sanja Pokrajac
Kathrin Bockmühl
Gisela Stolpe

Federal Agency for Nature Conservation

Cover picture: Livanjsko Polje, Bosnia and Herzegovina (© U. Schwarz**)**

Editing: Alexander Zinke, Vienna

Authors' addresses:

Ulrich Schwarz
FLUVIUS, Floodplain Ecology and River Basin Management
Hetzgasse 22/7, 1030 Vienna, Austria
E-Mail: Ulrich.Schwarz@fluvius.com

Sanja Pokrajac
Independent Expert
Svetozara Markovica 27a, 11000 Belgrade, Serbia
E-Mail: sanja.pokrajac@gmail.com

Kathrin Bockmühl
Gisela Stolpe
German Federal Agency for Nature Conservation
Branch Office Isle of Vilm
International Academy for Nature Conservation Isle of Vilm
18581 Putbus, Germany
E-Mail: kathrin.bockmuehl@bfn.de; gisela.stolpe@bfn.de

This publication is included in the literature database "DNL-online" (www.dnl-online.de)

BfN-Skripten are not available in book trade. A pdf version can be downloaded from the internet at: http://www.bfn.de/0502_skripten.html.

Publisher: Bundesamt für Naturschutz (BfN)
Federal Agency for Nature Conservation
Konstantinstrasse 110
53179 Bonn, Germany
URL: http://www.bfn.de

Printed by the printing office of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Printed on 100% recycled paper.

ISBN 978-3-89624-248-8

DOI 10.19217/skr511

Bonn, Germany 2018

Table of contents

Figures

Tables

Abbreviations

AL	Albania
a.s.l.	Above sea level
AT	Austria
BA	Bosnia & Herzegovina
BfN	Federal Agency for Nature Conservation, Germany
CBD	UN Convention on Biological Diversity
CCA	Climate Change Adaptation
CCAWB	Climate Change Adaptation in Western Balkans
CEN	European Committee for Standardisation
DE	Germany
DRR	Disaster Risk Reduction
EbA	Ecosystem-based Adaptation (to Climate Change)
EC	European Commission
ECRAN	EU Environment and Climate Regional Accession Network
EEA	European Environment Agency
Emerald	Ecological Network of Areas of Special Conservation Interest
ESS	Ecosystem Services
EU	European Union
EUFD	European Union Floods Directive
EUHD	European Union Habitat Directive
EURED	European Renewable Energy Directive
EUWFD	European Union Water Framework Directive
FRMP	Flood Risk Management Plan (EUFD)
FYROM	The Former Yugoslav Republic of Macedonia
GEF	Global Environment Facility
GIZ	German Society for International Cooperation
HR	Croatia
HV	Hrvatske Vode, management body under the Croatian Ministry of Agriculture
ICPDR	International Commission for the Protection of the Danube River
ICSRB	International Commission for the Sava River Basin
IPA	EU Instrument for Pre-Accession Assistance
IUCN	International Union for the Conservation of Nature
KV	Republic of Kosovo (recognized as a state e.g. by 23 EU memberstates)
ME	Montenegro

MEA	Millenium Ecosystem Assessment
MK	Macedonia (FYROM, The Former Yugoslav Republic of Macedonia)
NbS	Nature-based Solutions
NGO	Non Governmental Organisation
NWRM	Natural Water Retention Measures
RBMP	River Basin Management Plan (EUWFD)
RS	Republic of Serbia
SDGs	UN Sustainable Development Goals (Agenda 2030)
SEE	South-Eastern Europe
SI	Slovenia
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WBIF	Western Balkan Investment Framework
WWF	World Wide Fund for Nature

Acknowledgements

- Alan Kis, Institute for Nature Conservation of Vojvodina, Novi Sad, RS
- Luka Basrek, Green Ring Public Institution of Zagreb, HR
- Peter Sackl, Johanneum Universalmuseum Graz, AT
- Borut Stumberger, ornithologist, wetland researcher, Cirkulane, SI
- Gabriel Schwaderer, Euronatur, Radolfzell, DE
- Ulrich Eichelmann, RiverWatch, Vienna, AT
- Marina Babic-Mladenovic, Jaroslav Cerni Institute, Belgrade, RS
- Arno Mohl, WWF Austria, Vienna, AT
- Dimitrija Serkovski, UNDP Macedonia, Skopje, MK
- Goran Gugic, GIZ Albania, Tirana, AL
- Klodian Zaimi, Institute for Geoscience, Energy Water and Environment, Tirana, AL
- Boris Erg, Regional Office for Eastern Europe and Central Asia, Belgrade, RS
- Azra Babic, Federal Hydrometerologcial Institute, Sarajevo, BA
- Renata Barutovska, Ministry of Environment and Physical Planning, Skopje, MK
- Osman Fetoshi, Ministry of Environmental and Spatial Planning, Rahovec, KV
- Igor Kovacic, Hydrometerorological Service of the Republika Srpska, Banja Luka, BA
- Jana Ikovic, Center for Protection and Research of Birds, Podgorica, ME
- Bernd Neukirchen, German Federal Agency for Nature Conservation, Bonn, DE
- Bernd Hausmann, German Federal Agency for Nature Conservation, Bonn, DE

Preface

Flood risk on the Balkan peninsula in Southeastern Europe ranks among the most significant natural hazards and is becoming even more important with increasing climate change during future decades. Recent extensive flood events, such as those of 2014 in the lower Sava basin, those in 2012 in the lower Drin/Bojana/Buna catchments as well as many local flash flood events (e.g. in the Skopje region 2016), partially combined with landslides, all causing numerous casualties and extensive economic damage, give evidence to this trend.

Therefore, in recent years huge investment plans and programmes were established to improve flood defences and to properly implement the EU Floods Directive in the region.

Besides structural measures such as conventional flood defence construction and river regulation and non-structural measures, which include flood forecasting and flood preparedness, only very few nature-based solutions (NbS) are envisaged or even implemented. Those NbS measures focus on the near-natural water retention (reduce, retain or divert flood water) within the catchment and floodplains, are complementary to structural measures and often more cost-effective. Furthermore, they offer many synergies and wider benefits: NbS measures can significantly improve the ecological status, as required by the EU Water Framework and Habitat Directives (EUWFD, EUHD). They also maintain or even increase other valuable ecosystem services, such as nutrient retention and carbon sequestration.

To foster and support the planning and implementation of those nature-based solutions, the German Federal Agency for Nature Conservation (BfN), encouraged by the Regional Office for Eastern Europe and Central Asia (IUCN ECARO) of the International Union for Conservation of Nature (IUCN), jointly commissioned the study "Natural solutions for disaster risk reduction (DRR) and climate change adaptation (CCA) with a focus on flood prevention in Southeastern Europe (SEE)".

The aim of this study is to promote the implementation of NbS for disaster risk reduction and climate change adaptation across the SEE region. An integral part of the study is an analysis of flood risks, of the opportunities and the status of implementing nature-based solutions in different SEE countries. Relevant stakeholders and existing constraints and barriers were also identified and criteria for the selection of priority sites for pilot nature-based flood prevention measures developed. The study serves finally to form the foundation for targeted and essential follow-up activities, such as policy reforms, pilot projects, capacity building and wider awareness raising.

Boris Erg, Director of the IUCN Regional Office for Eastern Europe and Central Asia

Beate Jessel, President of the German Federal Agency for Nature Conservation

Executive Summary

Flood risk is one of the most important natural hazards in Western Balkan countries, even more severe under the ongoing climate change conditions, which in the southern Mediterranean part are pronounced by a temperature increase of nearly two degrees in the past century and lead to both an increase of moisture capacity and heavy precipitation and to longer dry seasons. Results of these climatic changes are extensive riparian inundations as well as flash flood events in most of the SEE countries. Today, about 13 % (35.170 km²) of the entire study area is prone to extensive floods and another 15 % prone to landslides.

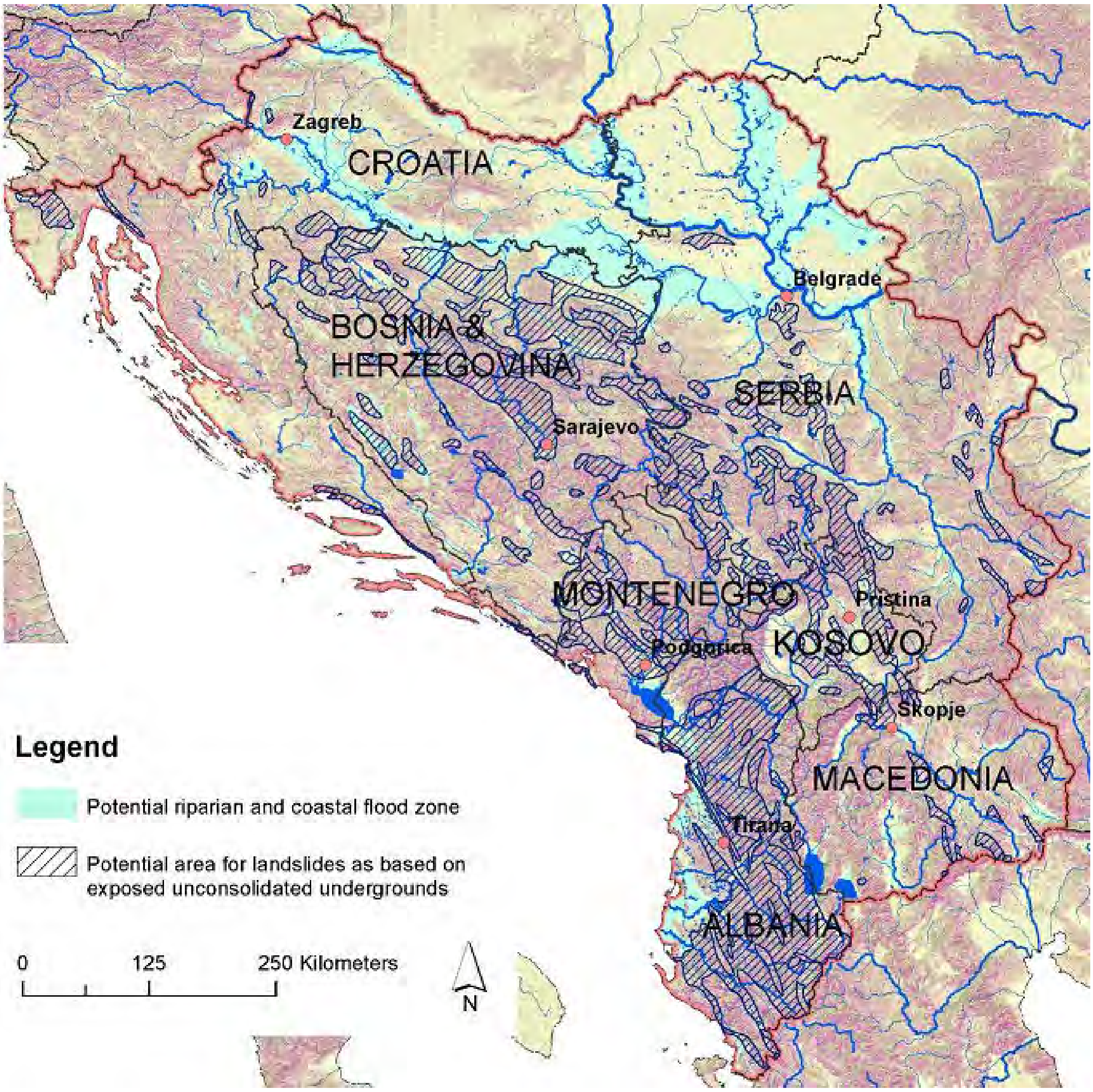


Fig. 1: Geographical overview showing the most affected flood zones and areas with potential landslide risk.

The concept of NbS as a tool to near-naturally mitigate the increasing natural hazards is defined and presented in the framework of current international policies at global (UN SDGs) and EU scale. It is defined as “actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits." (IUCN, COHEN-SHACHAM, et al. 2016).

The concept of NbS for flood protection is illustrated by one of the most prominent examples in place, the upper Posavina flood system along the Sava river in Croatia, capable to store about 1.5 billion m³ of water for several weeks, reducing discharges by 1,000 m³/s and lowering therefore the water level along adjoining cities considerably. This NbS in the Sava basin is even praised as a world-wide example generating several co-benefits (UN WORLD WATER DEVELOPMENT REPORT 2018). The Balkan region is still rich in wetlands of European importance, essential for natural water retention and biodiversity, for all types of rivers (deep gorges in the Balkan mountains, braided rivers when approaching huge floodplains in the northern lowlands or deltas at the Mediterranean Sea), outstanding lakes such as Skadar, Ohrid and Prespa, unique flooded karst poljes (Serbo-Croatian name for a large plain or agricultural field), and extended coastal wetlands. To protect those areas and to maintain their natural and economic functionalities for biodiversity, flood retention, food production and other ecosystem services, it must be a priority and fundament to plan and implement NbS in the region. Some of the best preserved "nature-based solutions" are already in place, such as the regularly flooded Kopački Rit at Danube-Drava confluence, the Skadar lake shared by Montenegro and Albania or the Livanjsko polje in Bosnia & Herzegovina. The upper Posavina flood system on the Sava in Croatia with the Lonjsko polje nature park in its heart can be seen as one of the best functioning semi-natural retention systems across Europe. It is important to keep these unique areas and to understand and to value their functions, cost effectiveness and multiple benefits. This study is the first to provide an entire overview of these important areas in the western Balkans, presenting 77 larger areas across all countries with a combined retention capacity of about 5 billion m³. Any flood management strategy in the region should incorporate NbS at these important areas as a priority.

Tab. 1: The largest existing natural retention areas serving as NbS examples.

Country, water body and name	**Category**	**Retention capacity in m³**
AL Lake Skadar shore	Coastal floodplain	100-200 Million (Mil)
AL Devoll delta	Coastal floodplain	50-100 Mil
AL Lower Vjosa Pocem-Mifol	Coastal floodplain	50-100 Mil
AL Erzen delta	Coastal floodplain	50-100 Mill
AL Bojana-Buna delta	Coastal floodplain	50-100 Mil
AL Vjosa delta	Coastal floodplain	100-200 Mil
AL Lake Skadar shore	Lake floodplain	50-100 Mil
AL Lower Vjosa Pocem-Mifol	River floodplain	50-100 Mil
BA Duvanjsko polje	Karst polje floodplain	50-100 Mil
BA Livanjsko polje	Karst polje floodplain	200-500 Mil
BA Bardaca, lower Vrbas and Sava	River floodplain	100-200 Mil
BA Lower Bosna Odzac-Samac	River floodplain	100-200 Mil
BA Lower Drina	River floodplain	100-200 Mil
HR Kupa east of Banska Selnica	River floodplain	100-200 Mil
HR Lower Drava	River floodplain	200-500 Mil

Country, water body and name	Category	Retention capacity in m³
HR Middle Drava	River floodplain	100-200 Mil
HR Sava East of Slavonski Brod	River floodplain	100-200 Mil
HR Sava Lonjsko polje	River floodplain	500-1000 Mil
HR Sava Mokro polje	River floodplain	200-500 Mil
HR Sava Odranjsko polje	River floodplain	200-500 Mil
HR Sava Sunjsko polje	River floodplain	200-500 Mil
HR Upper Sava	River floodplain	50-100 Mil
HR Wider Kopački Rit area	River floodplain	500-1000 Mil
KV Prishtina field Plemetin	River floodplain	10-50 Mil
KV Drini i Bardhe Zllakuqan	River floodplain	10-50 Mil
ME Skadarsko Jezero	Lake floodplain	200-500 Mil
ME Middle Zeta river	River floodplain	10-50 Mil
MK Middle Bregalnica Grdovtsi	River floodplain	10-50 Mil
MK Upper Pelagonia	River floodplain	50-100 Mil
MK Upper Vardar Polog	River floodplain	50-100 Mil
RS Apatin-Bogoljevo	River floodplain	100-200 Mil
RS Danube Backa Palanka - Novi Sad	River floodplain	100-200 Mil
RS Danube Novi Sad -Tisa confluence	River floodplain	200-500 Mil
RS Lower Tamis Pancevo -Glogonj	River floodplain	100-200 Mil
RS Lower Tisa Zrenjanin	River floodplain	100-200 Mil
RS Lower Velika Morava Pozarevac	River floodplain	100-200 Mil
RS Sava Bosut forest	River floodplain	100-200 Mil
RS Sava wider Obedska bara area	River floodplain	200-500 Mil

Flood risks and vulnerability were assessed for the study area (compare Figure 1) by analysing several databases such as the potential flood risk areas under the EUFD, datasets of the riparian zones, own data on the delineation of active and morphological floodplains as well as geological maps and national risk inventories estimating the landslide risk in combination with hill slope. Regarding land and mudslides, the high mountain rock-dominated highlands with strong slopes are not the most risky region but rather the more densely settled hilly regions with unconfined undergrounds and soils.

For any flood protection strategy it is essential to understand human pressures or any land use of areas that are prone to natural hazards. Most of the flood-prone areas are used for agriculture (66 %), except for grasslands which are adapted to regular inundation. Settlements and infrastructure cover only 5 %, which is less than one would expect (in comparison to Western Europe). But the whole region is rather rapidly developing, despite of still ongoing political tensions and some years or periods of stagnation. Road and hydropower construction, but also the modernisation of infrastructure, are abundant today. The pressure on river valleys and therefore the reduction of floodplain and retention areas is a serious process. It is necessary to prevent further losses by halting unlimited development and protecting the remaining natural flood protection areas. An example estimate made for the wetlands of Skadar/Bojana-Buna (ME/AL), Neretva Delta (BA/HR) and Livanjsko polje (BA) indicates a loss or strong deterioration of 5-10 % of these areas between 2005 and 2017. In general, these areas are already drastically reduced in size and capacity (an overall 75 %

loss). On the other hand, more than 20 % of flood-prone areas are still covered by wetlands, wet forests or grasslands, which is approximateley the double value than for Western Europe. The study recommends that, in the upstream river reaches and catchments, the existing but often inefficient flood defences within settlements or areas with highest damage potential must be renewed and strengthened combining structural and non-structural measures in strong conjunction with nature-based solutions. Here, illegal housing and the uncoordinated growth of settlements as well as the missing spatial planning must be addressed from the beginning. Unfortunately in practice, the integrated planning approaches required by the EU policies (e.g. Flood Directive) and many international legal agreements are not taken into account. Too often, funding only focuses on single, isolated projects. When reviewing various flood projects (e.g. a wish list of flood protection projects over 1,5 billion Euros until 2020 prepared by the WBIF) it becomes clear that in most of the cases, NbS do not play a substantial role yet.

Regarding the implementation of the EU Floods Directive all countries made significant steps forward and, by about 2020, in most countries at least the legal basis, the first flood risk assessments as well as initial flood risk management plans will exist. The Sava Commission strongly fosters the development of climate change adaptation strategies, which are aligned to commitments for transboundary cooperation (which is anyway essential in case of riparian flooding and of needed mutual support in case of major events). Therefore, now is the right time and need to incorporate NbS into the planning of concrete flood management measures.

The overlay of flood- and landslide-prone areas with the inventories of wetlands and NbS projects allow, together with assessing the vulnerability (potential damage in settlements and agriculture), a very first raw assessment and prioritisation of projects. Few afforestation and catchment-based retention projects were also accounted for on a very low, conservative basis: they are more relevant for small catchments and regular precipitation events. Finally, pilot NbS projects are suggested which illustrate in an exemplary way how nature-based solutions can be implemented across the region.

In total, 264 potential areas for NbS were delineated and, based on available data, analysed and ranked by priority. In addition, eigth pilot sites are presented in more detail. Altogether, the 264 NbS comprise an area of 399.322 ha with a potential retention capacity of approximately 6 billion m³. Out of the 264 potential NbS, 24 are ranked within the highest priority class, 151 in the second and 69 in the third category of low priority.

In the future, NbS and green infrastructure concepts should be much more considered and valued in the region for strengthening the capacities and functions of natural and near-natural retention measures in-between reaches with settlements and infrastructure. The intensive agricultural and forestry use in the catchments has to be respected and partially excluded from or adapted to flood- and landslide-prone areas. Better spatial planning must prevent uncontrolled landuse in floodplains, such as the rapid expansion of commercial areas in those areas. A consequent application of NbS should be introduced in every Programmes of Measures for the national and international flood risk planning and climate change adaptation activities under the EUWFD and EUFD (to reach the environmental objectives such as the good ecological status of rivers). The multiple benefits and ecosystem services of functioning nature-based retention solutions should - economically - not be underestimated, as they are serving not only for retention at flood events but being an integral part of the water cycle (flood buffering, surface waters filtering and recharge of groundwater), these areas also serve as nutrient and carbon sinks, provide biomass (timber, hay, fish etc.) and for many other functions such as agriculture, recreation or tourism.

Finally the listed pilot projects should be further developed and considered by Balkan countries, as is already the case on the Sava or in some coastal wetlands in Albania. The further development of national guidances for the implementation of NbS would be useful.

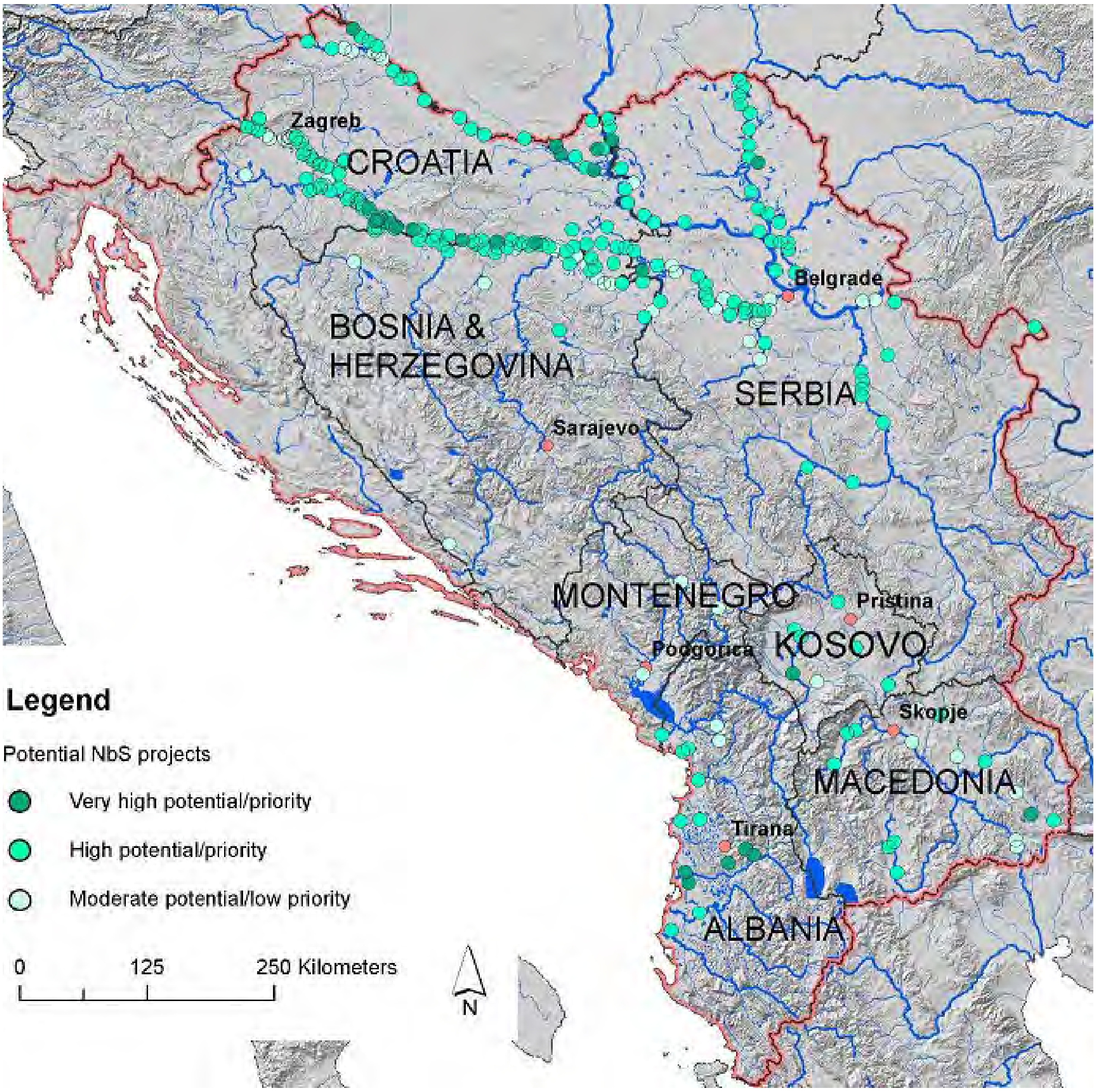


Fig. 2: Map with 264 potential NbS in the whole study area.

1 Introduction

This study aims at raising awareness about nature-based solutions (NbS) for flood risk prevention in Southeastern Europe by first analysing the current situation (floods and flood management in those countries), and by then identifying natural water retention areas and proposing specific projects for NbS. The Balkan region still hosts outstanding examples of natural water retention areas and biodiversity, for all types of rivers from the high mountains to the plains, including extended floodplains in the northern lowlands and some deltas into the Mediterranean Sea, various lakes, flooded karst poljes[1] and coastal wetlands. It is important to protect those special riverine areas and to maintain their natural functionality in terms of the local water household (flood retention and dynamic) and many ecosystem services.

The study area comprises the entire western Balkan region, which includes from northwest to southeast the countries Croatia, Bosnia & Herzegovina, Serbia, Montenegro, Kosovo, Macedonia (FYROM) and Albania. Geographically, the area is characterised by high mountain ridges and large uplands in its central part receiving high precipitation in the upper catchments of many south- and north-bound rivers. As a result, the large plains in the northern part (the rivers Danube, Sava, Velika Morava) and the coastal plain of Albania receive a lot of flood waters. The densely settled hill region that lays on non-consolidated soils and geological undergrounds is often subject to flash floods and associated mud- and landslides.

In a first step, the study area was characterised and mapped regarding its flood risk, including an observed worsening of natural flood retention by the multiple cutting off of natural floodplains or by river regulations. In a second step, all countries were reviewed regarding their application of the respective administrative and legal framework for flood risk management and climate change adaptation. In the third and last step, proposals for measures and pilot areas were formulated to foster the application of NbS.

1.1 Flood risk prevention by Nature-based Solutions (NbS)

There are various terms and approaches dealing with flood management by NbS at EU and global levels that should be explained in this study.

Floods and flood management

Floods are defined as a natural process within the global water cycle, beginning with the ability of the atmosphere to take up and transport huge amounts of humidity across sea and land surfaces. Due to the atmospheric pressure differences and the orography (e.g. mountain ridges near the coast), large and intensive rain zones can develop. Rain water is firstly retained in the vegetation cover (interception) before it reaches the soil and the groundwater. Depending on climate and regional weather conditions (snow, frost), the water saturates faster or slower all soil capillaries and water cannot further infiltrate. Surface water run-of will then be collected in streams and rivers. As soon as the river banks are overtopped by the increasing discharge and water levels (bankfull discharge) the flood waters spread over the floodplain. Surface water infiltration from the wider river areas raises also

[1] Karst poljes are extensive depressions (plains) with a flat floor and steep hillslope but no outflowing surface stream. They are typical for the Western Balkan. Many poljes are regularly inundated; their in- and outflow is regulated by intermittent karst springs and ponors (sinkholes).

the groundwater level. Depending on the valley form and morphology of rivers and their floodplains small or large areas are inundated. Flooding is a natural process that occurs at more or less frequent intervals with probabilities of once in a year to once in 100 years or at even rarer intervals (e.g. once in 500 or 1000 years). After the flooding the water slowly returns from the floodplains into the river beds and the aquifer also exfiltrates water into the river. The inundation time and duration depends on the hydrological regime (e.g. based on snow melt or seasonal heavy rains) and the size of the catchment. Further, floods can be differentiated into *flash floods* occurring locally after heavy precipitation, *riparian floods* regularly occurring along an entire river continuum, and *coastal floods* that are often combined with storm surges and typical for narrow coastal zones or extending into estuaries. Rivers and their floodplains naturally host a high biodiversity, large biomass production and fertility (fine sediments) that are supporting human land uses, notably agriculture, and allow the development of prosperous cultures across the entire globe.

Floods as a natural process may become a natural hazard with a high damage potential if exceeding a certain magnitude (water level peak and duration). They endanger human activities and settlements, namely when they overtop or destroy flood protection dikes. Due to their immediate impact on nearby human development zones along rivers (and coasts, often in combination with storm surges), floods count worldwide together with (tropical) storms to the most frequent and dangerous natural hazards and disasters.

Over the last 150 years, many settlements have grown rapidly, therefore rivers became more and more regulated and floodplains, but also forests across the catchments, are being more intensively used. This is leading to a loss of natural flood retention capacity and to an increase of damaging and even disastrous flood events. Therefore, land developers started to construct many dikes to protect settlements, infrastructure and other valuable land use zones. Over time, an organised flood management has been established, and many more flood protection structures, such as reservoirs and dams, have been constructed. But flood hazards and impacts still exist worldwide and thus also in SEE. The again increasing flood events of the past two decades, primarily triggered by systematic regulations of rivers and the loss of active floodplains, but not necessarily triggered mainly by climate change, has been leading to a growing consensus for a more comprehensive and even transboundary flood management. In Europe, for instance, it took until 2007 to agree on a Union-wide flood management approach, the EU Floods Directive (2007/60/EC).

Contemporary flood management can be subdivided basically into “flood risk prevention”, “flood protection”, and “flood preparedness”.

The EUFD defines officially[2]:

- “Flood risk prevention: preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices;
- Flood protection: taking measures, both structural and non-structural*, to reduce the likelihood of floods and/or the impact of floods in a specific location;
- Preparedness: informing the population about flood risks and how to react;

[2] http://ec.europa.eu/environment/water/flood_risk/flood_risk.htm

- Emergency response: developing emergency response plans in the case of a flood;
- Recovery and lessons learned: returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population".

* *Structural measures* include firstly the construction of dikes, dams and polders but also specific restoration activities, while *non-structural measures* mainly refer to the improvement of forecast, to warnings systems and flood risk mapping. However, this can also mean the preservation of the remaining active retention areas.

Nature-based Solutions (NbS)

NbS as an umbrella concept emerged over the past 15 years and is defined "as actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits" (IUCN, COHEN-SHACHAM 2016).

Fig. 3: Nature-based Solutions are an overarching concept for ecosystem-based approaches to address societal challenges. Compare the text explanations, also for the icons of societal challenges (COHEN-SHACHAM 2016).

Based on Figure 3, NbS to specific societal challenges can be subdivided according to various approaches and summarised as follows:

1. Ecosystem restoration approaches (e.g. ecological restoration, ecological engineering and forest landscape restoration)
2. Issue-specific ecosystem-related approaches (e.g. ecosystem-based adaptation, ecosystem-based mitigation, and ecosystem-based disaster risk reduction)
3. Infrastructure-related approaches (e.g. natural infrastructure and green infrastructure approaches)
4. Ecosystem-based management approaches (e.g. integrated coastal zone management and integrated water resources management)
5. Ecosystem protection approaches (e.g. area-based conservation approaches including protected area management).

The concept of NbS is strongly interlinked with the Ecosystem Services approach, as stated in the Millenium Ecosystem Assessment 2005[3]: “The Millennium Ecosystem Assessment (MEA) assessed the consequences of ecosystem change for human well-being. From 2001 to 2005, the MEA involved the work of more than 1.360 experts worldwide. Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world’s ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably.”

Further, the Ramsar Convention on Wetlands (1971) summarises the ecosystem services of wetlands recently in 10 factsheets[4] (cost evaluations included):

1. Flood control
2. Groundwater replenishment
3. Shoreline stabilisation and storm protection
4. Sediment & nutrient retention and export
5. Water purification
6. Reservoirs of biodiversity
7. Wetland products
8. Cultural values
9. Recreation & tourism
10. Climate change mitigation & adaptation

This list clearly implies the importance of floodplains and coastal wetlands regarding flood risk prevention and climate change adaptation.

NbS are in fact much less costly, as they make use of natural ecosystem services that flood managers can gain from the natural environment and from well-functioning ecosystems, such as the retention of water in forests, soils and floodplains. Most structural measures re-

[3] https://www.millenniumassessment.org/en/index.html

[4] https://www.ramsar.org/document/wetland-ecosystem-services-factsheet-1-flood-control

quire engineering works that are rather expensive in both their investment and maintenance. The highest costs of NbS are the opportunity costs (REGUERO 2018).

To maximise the benefits of ecosystem services, modern flood management gives priority to measures with less engineering and more consideration of biodiversity and ecosystems:

1. Use of the natural riverine ecosystem: based on mapping and protecting of the remaining natural ecosystems and wetlands;
2. Managing or restoring the riverine ecosystem: improving and restoring the remaining ecosystems, which is a valid solution for all densely settled countries; the "less engineering" and the "working with nature" principles can be also applied when planning a floodplain reconnection (alternative to technical flood polders);
3. Creation of new ecosystems: only where no alternative exists (e.g. within towns and agglomerations).

In more detail, NbS as an ecosystem-based approach can contain or be combined with:

- Ecological Restoration (e.g. floodplain restoration)
- Ecological Engineering (e.g. planting of species, for salt marsh restoration or for waste water treatment)
- Forest Landscape Restoration (not only restoration of forested ecosystems but also connectivity between protected areas, protecting water and soil resources and reinforcing cultural values of forested landscapes)
- Green Infrastructure (restoring) and Natural Infrastructure (enhancing): e.g. in form of urban green structures (see e.g. Kabisch 2017a and b) but also by developing landscape (riparian) corridors as natural infrastructure; both terms are used interchangeably, often only as "green infrastructure" for both, see the already existing EU initiative and strategy[5]
- Ecosystem-based Management (e.g. various measures supporting natural processes)
- Ecosystem-based Adaptation (land uses adapted to ecosystem (services) e.g. climate change – for examples e.g. Doswald 2012)
- Ecosystem-based Mitigation (e.g. reducing the impact of flood protection measures by ensuring continued ecosystem functionality such as by reducing engineering works at riverine habitats)
- Ecosystem-based Disaster Risk Reduction: in particular forests, floodplains and wetlands can serve as a natural buffer against floods and provide numerous ecosystem services (water collection, purification, storage and flood discharge conveyance) and can therefore partially substitute so called grey infrastructure (e.g. dams, dikes, torrential control works, canals, coastal protection)
- Climate Change Adaptation Service (complementing ecosystem services concepts towards adaptation to climate change)

---

[5] http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

- Area-based Conservation (e.g. protection of river reaches and wetlands)

Tab. 2: Summary of the NbS approaches and respective examples (COHEN-SHACHAM 2016).

Category of NbS approaches	Examples
Ecosystem restoration approaches	Ecological restoration Ecological engineering Forest landscape restoration
Issue-specific ecosystem-related approaches	Ecosystem-based adaptation Ecosystem-based mitigation Climate adaptation services Ecosystem-based disaster risk reduction
Infrastructure-related approaches	Natural infrastructure Green infrastructure
Ecosystem-based management approaches	Integrated coastal zone management Integrated water resources management
Ecosystem protection approaches	Area-based conservation approaches including protected area management

The societal challenges, as indicated in Figure 3 and addressed by the NbS concept, are the following (based on COHEN-SHACHAM 2016):

- **NbS for disaster risk reduction** (see the symbols of house and flood wave in Figure 3): The regulatory role of ecosystem services can be very cost-effective in reducing risks. Disaster risk reduction (e.g. by the Eco-DRR (disaster risk reduction) approach) is an important way to significantly reduce the likelihood of a natural hazard event turning into a disaster (including through reducing the exposure to hazards and the vulnerability of people and property, wise management of land and environment, and improving the preparedness for adverse events). In past years there has been increasing recognition of this approach within global policy frameworks, namely the Convention on Biological Diversity (2014), the Sendai Framework for Disaster Risk Reduction (2015) and the Ramsar Convention on Wetlands (2015). Adressing this “challenge” and related NbS entail strong relations to all other challenges.
- **NbS for climate change** (see the symbol earth in Figure 3): They provide mitigation of and adaptation to climate change. NbS in form of ecosystem-based mitigation can make a powerful contribution against climate change by preventing the degradation and loss of natural ecosystems (in form of deforestation and forest degradation) through better conservation and land management actions, and this can be a powerful measure to mitigate greenhouse gas emissions. Further, natural and modified ecosystems can also deliver highly effective contributions through their function as a ‘natural carbon sink’ by absorbing and sequestring CO_2 emissions. Finally, in addition to providing these direct mitigation benefits, ecosystems can also help to better adapt and become more resilient to the adverse effects of climate change, including extreme weather events and climate-related disasters, through ecosystem-based adaptation and ecosystem-based disaster risk reduction.

To complete the picture, the other challenges are:

- NbS for water security (see the symbol hands on water drops)
- NbS for food security (see the symbol hands on grains)
- NbS for human health (see the symbol with people).

Application, functionality and efficiency of NbS to flood risk prevention

As referenced to scale- and catchment-based approaches as well as applied to different flood types (e.g. at upper catchments, middle and lower rivers courses, estuaries or riparian areas, versus flash flooding, coastal flooding, compare WWF US 2016), the following list and Table 3 will present some examples for NbS which are serving to reduce, retain and divert flood flows, to improve drainage and enhance resistance to damage as well as to adapt to floods:

- Upper river basin restoration
- Soil conservation (e.g. afforestation, agriculture)
- Wetland restoration (and protection)
- Detention basins and retention ponds
- Swales and infiltration devices
- Rainwater harvesting
- Green roofs/walls and blue roofs temporarily storing rain water
- Removal of flood discharge barriers
- Natural drainage path restoration, bypasses
- Restoration of riparian vegetation
- Restoration of coastal areas

To "reduce" flood flows the permeability and capacity of soils and surfaces must be increased (e.g. by a reducing the sealing effects in settlements but also in smaller catchments), but in most cases the reduction is directly based on the "retention" effect (e.g. by water storage in forests and soils). But the main issue of retention is focusing on the flood discharges, the buffering and storing of certain discharge volumes in floodplains or flood detention basins/polders. The diversion of flood flows from the main river channel can reduce the flood discharges in a particular river section, e.g. by bypass solutions, and can then protect agglomerations.

Tab. 3: Examples of NbS related to river reaches/catchment and the project region

Reach and prevailing hazard	Protection of ecosystems	Management	Issue-specific NbS	Restoration	Infrastructure
Headwaters (erosion)	Protection of mountain forests and creeks	Continuous forest cover	Observation and research on climate change (e.g. vegetation, hydrological development)	Afforestation	Torrential control and anti-erosion structures (e.g. avalanche, rock and mudflow barriers)
Upper catchment (flash floods, land slides)	Forested protected areas, understanding and protection of karst systems	Sediment/debris management, keep distance to mountain rivers (e.g. geomorphologcial space demand of rivers)	Adaptation of specific land use, e.g. agroforestry and terrace agriculture	Afforestation, restoration of the sediment continuum	Flood detention, reservoirs, better management of dams in flood case
Middle catchment (riparian floods, flash floods, land slides)	Protection of free-flowing river reaches and remaining floodplains	Reduce sealing, apply traditional farming in flood prone areas, allow flooding where possible (buffers), spatial planning (prevent further constructions in floodplains)	Foster ecosystem services and benefits, apply concept of space for rivers	River and floodplain restoration, removal of old/aging structures and barriers	Bypasses for flood conveyance, retention polders
Lower catchment (riparian floods)	Protection of river corridors and ecological stepping stones	Traditional farming in flood prone areas, keep flood conveyance	Enhancing carbon storage potential in wetlands	Floodplain restoration, create continuum of flood pathways	Bypasses for flood conveyance, retention polders
Estuaries, deltas (riparian and coastal floods)	Nature protection, protaction of natural coast structures	Management of natural coast structures (lagoons, salt marshes), sediment continuum, dune stabilisation	Creation of synergies of many coastal ecosystem services and coastal protection	Estuary and delta restoration, dismantling of dykes and further concrete construction measures	Bypasses for flood conveyance, retention polders

The functionality of nature-based solutions should be connected with and complementary to conventional structural or non-structural flood risk management (e.g. SAYERS 2013). Core elements could be the improved overall water retention in entire catchments (afforestation, reduction of land sealing, improved infiltration), but in particular all concepts serving to protect settlements and infrastructure, to keep river and floodplain corridors in sufficient spatial extension in between riparian settlements and to reconnect natural retention areas with the river. The behaviour of flood peaks can be very diverse (e.g. in the volume of discharge within one flood peak and its flow speed), leading to different type of flood events and different protection scenarios. Overlapping flood waves from different (sub-)catchments can increase the downstream discharge. NbS along rivers, e.g. in form of flood detention basins along headwaters, can even effectively cut the flood peak (therefore comprehensive forecasting and managing of flood waves are essential). Along middle and lowland rivers, extented floodplains with forests can significantly reduce the discharge volume and flow speed, giving much more time for flood preparedness or evacuations. The flood damage in rather natural floodplain areas covered by adapted forests and wet grasslands is much less severe than e.g. in agriculturally used flood polders or even areas disconnected by flood dikes.

NbS in the river corridor must be used in relation to long river stretches (accumulating effects, position within the flood continuum) and to conventional flood defences at settlements and infrastructure, managing and controling the flood discharge levels at critical points.

All these effects must be considered when assessing and calculating the impact and benefit of NbS for flood mitigation in comparison to other structural solutions: In many cases and at longer time frames, NbS can have a high cost-effectiveness and even greater efficiency (Reguero 2018): grey infrastructure (e.g. dams, dikes, torrential control works) may sometimes even worsen the situation in case of the wrong steering of dams prior and during floods or, as a worst case, in case of a dam and flood dike failure that will suddenly cause a flooding of large areas. With a view to their co-benefits (e.g. ecosystem services), NbS can reach high importance, not only by meeting environmental requirements such as the “good ecological status” under the EUWFD, preserving biodiversity under the EUHD and EU biodiversity strategy, or nutrient reduction, but also for multipurpose projects (a key word often used to justify grey infrastructure, in particular dams and reservoirs), serving for carbon sequestration, water storage (ground water infiltration), water balance in case of droughts (climate change adaptation), recreation and local nature products (fish, game meat, timber).

The core parameter assessing NbS for flood mitigation must be the reduction of a flood in its discharge volume or the reduction of a hazardous flood peak level for a particular place (usually a flood-prone land/settlement or industry site in the vicinity or a public infrastructure, such as a bridge). The effectiveness of water retention in floodplains or in technical polders is strongly dependant on the flood character: Not only the peak height is decisive but in particular its overall volume and duration. Usually flood defences are constructed according to specific design standards, mainly to protect against a 100 year flood event. But in case of untypically long flood waves or when tributaries superimpose flood waves, the effect may decrease. In case of steered technical polders the best moment to open the inlets is crucial and often not sufficiently applied by all stakeholders involved in their use. The effectiveness of flood risk reduction can be proven by hydraulic modelling and field monitoring (examples for large rivers: HABERSACK 2015 for Austrian rivers or BRUNDIC 2001 for the Sava: compare the case of the Upper Posavina flood system in chapter 1.3). Of course the motivation to construct a steered flood polder or to remove flood dikes to restore inundation of a floodplain depends on the project size and location within the river continuum (also on the availability of land, etc.). It may be that a mixture of different measures can be more efficient (smaller steered polders in the upper and middle catchment can locally cut flood peaks, but for middle and lower courses the cumulative effects of several large retention areas may be more effective). In any case, thorough studies and modelling research are essential to find the best solution.

Regarding the chosen purpose and application of NbS there must be a clear hierarchy. First, priority should be given to still existing natural retention areas. A case needs to be made by the potential gained benefits for biodiversity. Secondly, restoring natural habitats for NbS is the next best option. Thirdly, the management and maintenance of structural measures under the umbrella of NbS is necessary. The alternative option would be to deteriorate existing retention areas by structural measures (e.g. cutting off larger portions of existing floodplain and building polders or detention basins). All NbS should have biodiversity benefits by definition for river type-specific habitats and species.

Lo (2016) highlights in a publication of the Secretariat of the CBD the multiple benefits of NbS and ecosystem-based disaster risk reduction, based on a worldwide analysis. The “United Nations World Water Development Report 2018: Nature-based Solutions for Water” (UN 2018), launched 19 March 2018 during the 8th World Water Forum, even strongly supports NbS implementation, in particular in relation to the UN Sustainable Development Goal no. 6 on ensured availability and sustainable management of water and sanitation. It “concludes that NBS have high potential to meet contemporary and future water resources management challenges, as reflected in the 2030 Agenda for Sustainable Development, the SDGs and their targets.“ This UN study even praises at world-wide scale the transboundary water resources management in the Sava basin and the multiple benefits of its wetlands: “The Sava River Basin in Southeastern Europe is one such example, where the implementation of NBS is also generating several co-benefits through ecosystem services, from flood mitigation and the protection of biodiversity to economic growth related to ecotourism and improved navigation.”

The EEA study on “Flood risks and environmental vulnerability — Exploring the synergies between floodplain restoration, water policies and thematic policies” (EEA 2016b) aims to support the implementation of the EUFD, in particular with regard to environmental impacts, and how these can be linked to climate change adaptation and disaster risk reduction. In this context at EU level, the approach of Natural Water Retention Measures (NWRM)[6] was introduced with the aim to combine measures for both EUWFD and EUFD: “Natural Water Retention Measures are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes.” (EU 2014). Another term related to EUFD and WFDFD are “no regret measures” as part of the "Catalogue of good practices of ’no regret’ and ‘win-win’ measures regarding flood risk management in view of climate change"[7], aiming to prioritize measures with a high efficiency (cost-benefit) but also fulfilling a maximum of related benefits in form of ecosystem services for flood risk prevention and climate change adaptation.

Several platforms exist which collect “best practise examples”, such as for the EU Natural Water Retention Measures http://nwrm.eu/list-of-all-case-studies for ESS, natural capital and ESS https://oppla.eu/case-studies or for the EU RESTORE project https://restorerivers.eu/wiki/index.php?title=Main_Page. It is clear that such cases cannot be easily transferred to each region or purpose, but can serve as references and inspiration.

1.2 The study area: Western Balkan

The study area covers the Western Balkan area including the Dinaric mountain ridges, which build the boundary between the Danube river basin and the Mediterranean coastal basins.

---

6 http://ec.europa.eu/environment/water/adaptation/ecosystemstorage.htm and http://nwrm.eu/

7 https://www.google.at/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjiwZ6NrPHbAhWihaYKHQoVCTUQFggrMAA&url=https%3A%2F%2Fcircabc.europa.eu%2Fwebdav%2FCircaBC%2Fenv%2Fwfd% 2FLibrary%2Ffloods_programme_1%2Fb_wg_f_on_floods%2Fmeeting_272842010%2FWGF%25207-8-ENV-Good%2520practice%2520measures%2520draft%25201.doc&usg=AOvVaw37TjMQeBL6wD9QgLLaIrbx

The northern Danube basin part of this region is characterised by extended mountain formations and ridges of up to 2.500 m a.s.l. and hilly foothills followed by the huge lowlands of the Sava, Drava, Tisa and Danube rivers (Pannonian Plain). Only the Velika Morava lowland in Serbia spreads more towards the south. The small part of the mountainous Adriatic coastal catchments in the north-western Balkan (Croatia, Bosnia & Herzegovina and Montenegro) are deeply incised and their rivers reach only short lengths, with exception of the Neretva, whereas the southern coast in Albania features several larger rivers with deltas building up a coastal plain.

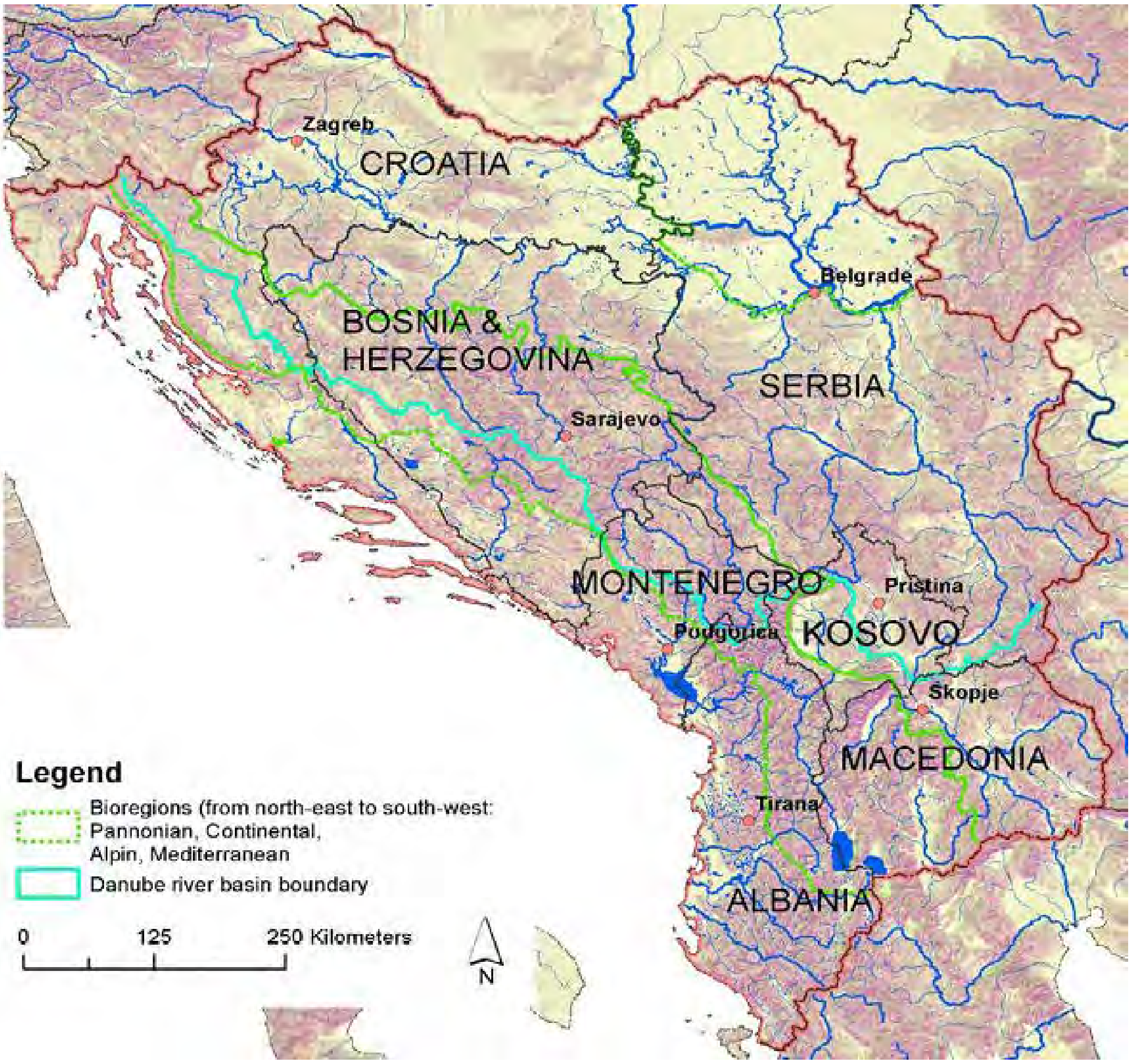


Fig. 4: The study area: The mountainous area of the western Balkan region and many large rivers cause intense water and sediment discharges into the Danube basin in the north and into the Adriatic Sea in the south. The mountain ridges (Alpine bioregion) split the Continental from the Mediterranean bioregion. Many useful data for the study were taken from the Copernicus platform (EC 2017) for the study's elevation model.

The whole catchment boundaries and in particular the Mediterranean basins are strongly influenced by the Karst and its many underground water systems. The study area is subdivided into two major bioregions, the Continental region (in the far north, i.e. the Pannonian plain) and the Mediterranean region. The dividing mountain ridges (Alpin bioregion) reaching between 1.500 and up to 2.500 m a.s.l are the origin of high precipitation rates and resulting sediment discharges (compare figure 4).

The geology is quite heterogeneous and reaches from various metamorphic and orogenetic material to large sediment-based rock formation and substrates. Open rock and karst undergrounds are followed by huge and deep sediment-based slopes and plains. As a result, a dense drainage network has established, both in southern and northern directions.

The Vegetation changes along the north-south gradient from continental tall deciduous forests (originally vast soft- and hardwood floodplain forests in the lowlands; in more humid climates those areas belong to the most productive ecosystem areas across Europe) and extensive beech and oak forests on the hills, over alpine coniferous forests and postglacial relict stands at the highest peaks towards the sub-Mediterranean species-rich deciduous forests and Mediterranean shrub zones along a small coastal strip. Again, lowlands (Lake Skadar) and estuaries of large rivers are home to floodplain forests and coastal wetlands. Lake Skadar is the largest Karst-floodplain lake in Europe, while Lake Prespa and Lake Ohrid are famous for their unique fish fauna, which results in many Adriatic catchments becoming hotspots for endemic and endangered species.

1.3 Regional example for the efficiency of existing NbS for flood risk prevention

The upper Posavina flood management system in Croatia along the Sava and Kupa rivers (compare no. 8 in the map of Figure 12) can best serve to demonstrate NbS as a functioning measure for flood risk reduction. Today, it is the most prominent case of a near-natural, active and controlled water retention solution. Lonjsko Polje Nature Park in HR, located between the towns of Sisak and Jasenovac, is a renowned wetland and Ramsar site and one of the core areas of the Posavina flood system.

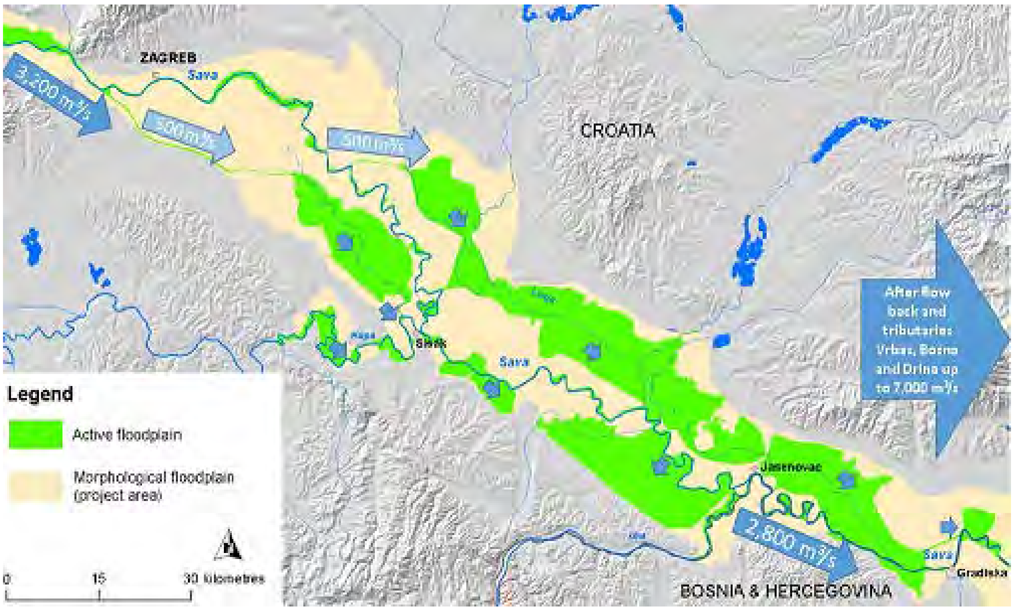


Fig. 5: Discharge reduction (in m³/s related to a flood with 100 years recurrence interval, arrows in flow direction) of the Sava main channel by the retention effect of the Upper Posavina flood management system. The green area reprensents the active floodplain and the beige one the morphological floodplain (maximum potentially flooded area). This area considerably reduces the downstream flood discharges (based on BRUNDIC 2001). The Sava flood of 2014 happened and origined downstream from here, comp. Figure 9.

Extending over 50.000 ha, it consists of vast wet grasslands, floodplain swamps and forests, and retains the original lowland character of the Posavina. The area is still connected to the Sava river and has a retention capacity of about 500 million m^3. It is a unique European example of near-natural flood retention along a large river. The wider area, in conjunction with other near-natural floodplain areas (summing up to about 1.5 Billion m^3 retention volume), is able to protect large settlements (Zagreb, Sisak, Jasenovac and Gradiska) and many villages along 200 km of the river (see figure 5). Overland flow on the floodplain reduces the speed of the flood wave by several days, thus significantly lowering the peak flow volumes (-1,000 m^3/s or up to -1 m lowering of the water level) and allowing for more preparatory time at downstream river reaches. However, the big floods of 2014 on the lower Sava originated from its Balkan tributaries further downstream of this area, where seven major dike breeches damaged huge areas: In those downstream reaches nearly 80 % of the floodplain had been cut off previously from the river, making it very different from the Upper Posavina flood management system, where only 40 % had been cut off (compare Figure 9 and Figure 39 respectively).

2 Major floods - natural and anthropogenic causes

2.1 Documentation of natural hazards and events

The key factors leading to particular natural hazards regarding floods are the high precipitation (amongst Europe's highest precipitation records) in the mountain ridges, causing, due to the mountainous topography, strong erosive forces in the headwaters and long-lasting floodings in the lowlands.

Figure 6 shows in light green the main flood-prone areas along all major rivers, including small mountainous basins and in particular the karst poljes in the Western Dinaric Arc, the coastal floodplains in Albania and the huge lowland floodplains at the major rivers in the north of the study area.

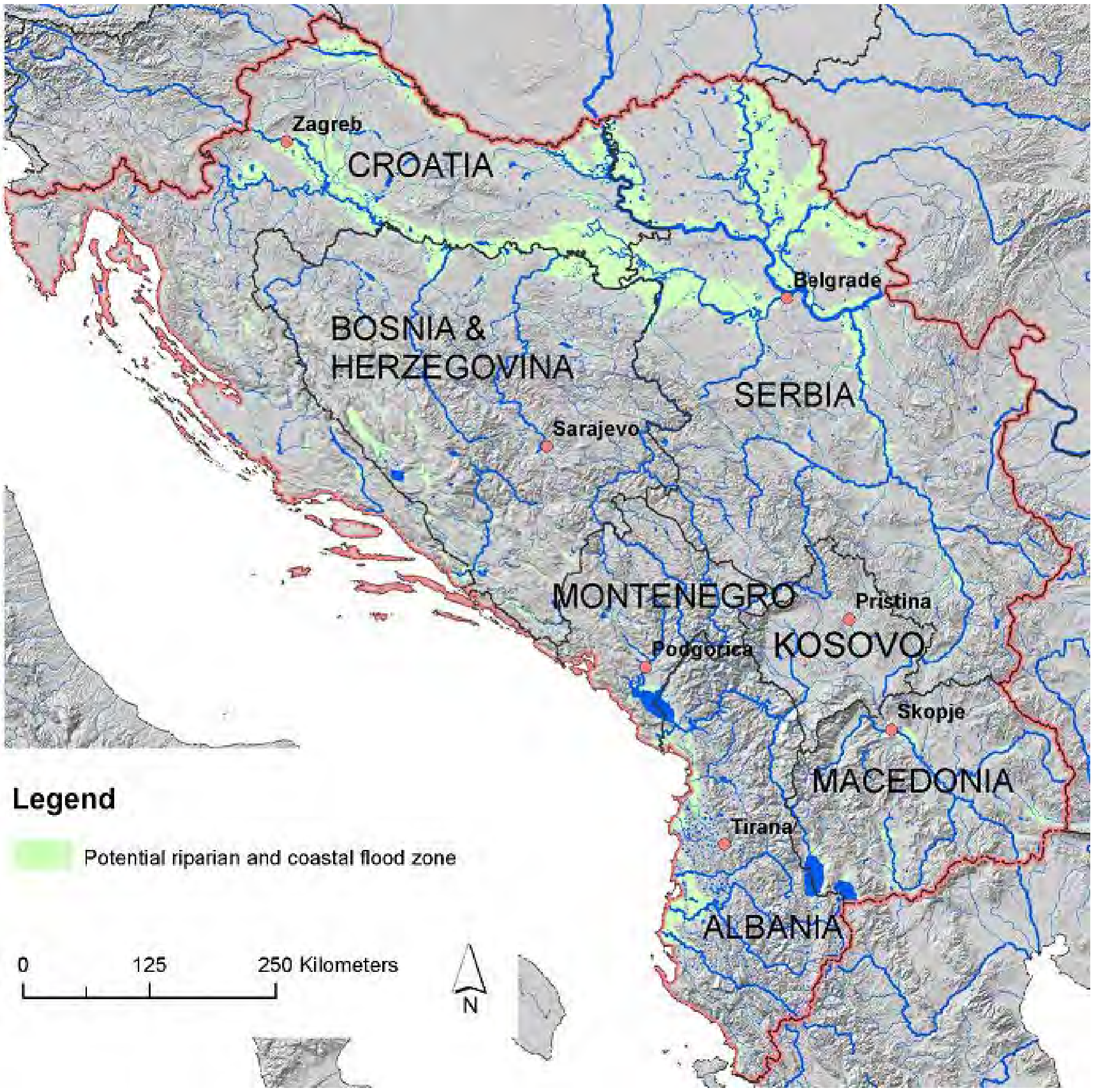


Fig. 6: Potentially flooded areas (light green) along major rivers based on the EU Riparian Zone dataset (European Commission 2017) significantly improved by other data sources and own investigations, e.g. on karst polje flooding (SCHWARZ 2014).

This data was specifically compiled for this study and summarizes the data of flood extent of the riparian zones with high probability (EUROPEAN COMMISSION 2017), limits of the morphological floodplains of Drava, Sava and Danube (SCHWARZ 2017) as well as the flooded karst polje and coastal wetland areas (SCHWARZ 2014). A review using other sources, in particular national flood risk maps, further improved the map layer in Figure 6. The overall study area covers all Western Balkan countries (264.198 km²), from which about 13 % (35.056 km²) are potentially prone to floods (except the waterbodies (rivers, lakes, reservoirs) which sum up to 2.980 km², thus roughly 12 % of the entire area is prone to floods).

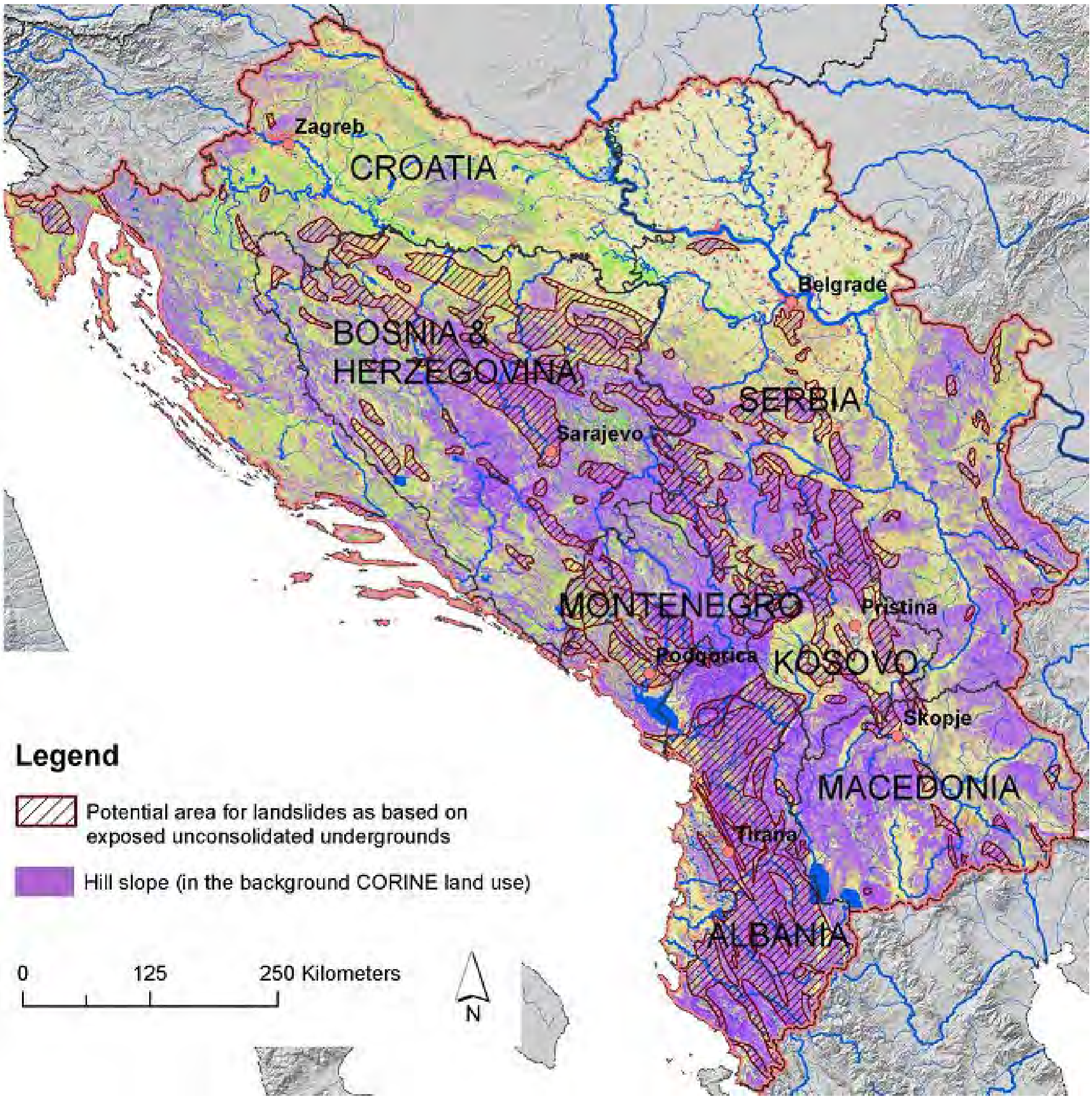


Fig. 7: Potential areas with high risk for landslides: This is an overlay of hill slope (purple colours), sensitive geological underground (fine and coarse loose and unconsolidated material) visualised as hatched polygons and landuse data (CORINE), serving as a base layer in the background (for a detailed pan-European map compare WILDE 2018). Areas with hatched polygons and darkest purple represent the most endangered areas.

Flash floods and in particular torrential floods are common and constitute in several Balkan countries the most destructive and frequent natural hazards (PETROVIC 2014). A typical phenomenon observed are increased pluvial flood events which may occur everywhere, thus also in lowlands. Examples from across the region indicate more intensive precipitation events in distinctive smaller areas or regions, causing inundations by overloaded underground reservoirs and exceeded discharge capacities in respective infrastructures, such as sewage canal networks.

Beside the larger lowlands in the valleys of Danube, Drava, Sava, Tisa and Morava in the north and the coastal plain in Albania, about 80 % of the land surface is at least hilly and some 30 % of the area is mountainous. Therefore landslides associated to those flash flood events happen frequently, not only in the mountain areas but also depending on the underground (geology, soil and the intensity of current land use, e.g. forestry and agriculture) in the more densely settled hill region. Torrential flood events often affect only relatively small areas of some 20 – 500 ha and may affect in one incident some 100 houses.

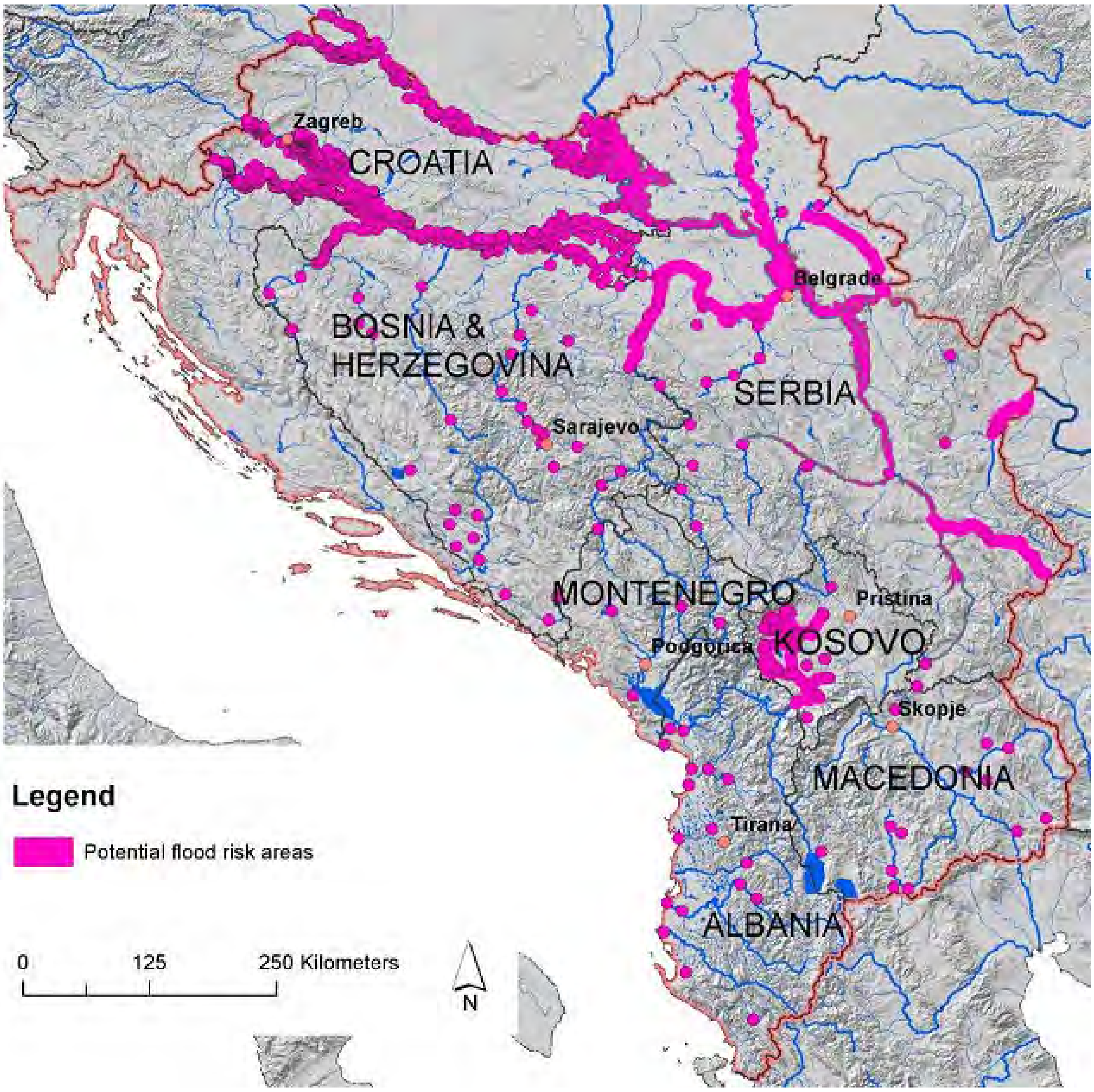


Fig. 8: Flood risk areas based on officially mapped potential flood risk areas according to EU Floods Directive, and major flood events and landslides in the Balkan region during past decades.

Landslides in the study area (compare DRAGICEVIC 2011, UNDP BA 2016, JOVANOVSKI 2013, JAUPAJ 2017 or WILDE 2018 for the pan-European level) occur mainly in hilly landscapes with sediments and at regolithic unconsolidated geological conditions depending on the slope and landcover. In those undergrounds with fine to coarse material the water may even stabilize to a certain degree the soil surface, but in case of water surplus those areas are highly vulnerable to surface or deeper soil mass movements. In Styria, Austria, for instance, a detailed landslide mapping and risk zonation combines the analysis of past landslides and mass movements with a precise elevation model (detecting also many past mass movements), the hill slope, geology, soil and land cover (PROSKE 2016). Therefore, the rocky mountain ridges and many karstic regions are not at particular high risk causing/creating landslides considering the sparsely distributed settlements in those areas.

Following the evaluation of mapping potential landslides for this study, an area of 12 % of land that is prone to floods increases by overlaying (area combined of slope and unconsolidated undergrounds) to some 25 % of the overall area. Regarding landuse and population, nearly 60 % of human activities in the area belong to those flood- and landslide-prone areas.

Figure 8 shows the most important and severe flood and landslide events of the past decades in the Balkan region. The picture is still incomplete: Sources are the official national Potential Flood Risk Zones (reaches/areas) according to the EU Floods Directive and other references, such as Desinventar.org[8], but nearly the entire region is affected, as can be expected from Figures 7 and 8. The 2014 floods in the lower Sava Basin alone caused damages in BA and RS (partially in HR) at a scale of at least 3.5 Billion €.

Exemplarily for Serbia, Petrovic et al. (2014) explored torrential flood events over the past 100 years and registered 848 major flood events with 133 fatalities and major local damages. These flood events are temporarily distributed over the summer half year, but occur mainly between late spring and early summer (May to end of June), when the highest precipitation values are recorded. Their regional distribution is clearly focusing on the mountainous areas, while the large alluvial lowlands are affected by floods from the large rivers in the northern part of the country, including several hotspots in the southern Morava basin (with intensive soil erosion due to forest exploitation), but also the central provinces of Serbia are regularly affected. The long-term evaluation of frequency and severity (number of casualties) indicate a clear increase of events: from about 6 events per year in the period 1931 - 1960 to 13 events per year in the period 1961 - 1990 and finally to 20 events during 1991 - 2013, as the end of the observation period. The severity (loss of life) seems to be decreasing from about 50 people (1931 – 1960) over 36 people (1961-1990) to 24 people in the 22 years period of 1991 - 2013.

Dragicevic et al. (2011) developed an integral vulnerability map of natural hazards for Serbia, including, beside floods and land slides, also seismic hazards, excessive erosion areas, areas with highest risk for droughts and wild fires, and covering thus the entire and representative range of natural hazards in the Western Balkan region.

The following table lists a selection of major or worst flood events since 2010, based on various national and international sources.

---

[8] https://www.desinventar.org/

Tab. 4: Examples of flood events since 2010

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

2.2 Anthropogenic factors that increase the flood risk

Flooding as a natural process can be influenced by various alterations, such as the reduction of floodplains, river straightening, the storage of water behind dams and general changes in land use, like deforestation or sealing of surfaces. The following chapter tries to characterise and summarise the most important anthropogenic impacts increasing the flood risk.

Loss of natural floodplains and flood dikes

Until today, by far the most important component in flood risk and management is the loss of floodplains due to land melioration and river regulation. This loss reaches in Western European countries 80-90 % (EEA 2016b), but also in SEE these losses are estimated at some 75 % in total (see SCHWARZ 2016), though with local differences (compare figure 9). Stumberger estimates the overall loss of coastal wetlands within the study area at some 78 % (STUMBERGER 2010).

Recent comparisons for the major wetlands (Lake Skadar with the Drin and Bojana Buna rivers, Neretva river delta and Livanjsko polje) indicate further losses between 4-10 % in the period from 2005 to 2017 (SCHWARZ, statement at the 3rd Adriatic Flyway conference, Fruška Gora, Serbia 2018). As a consequence of the reduced space for inundations (missing floodplains where river water overtops the banks), flood waves are moving faster along the regulated river reaches and the local flood peaks increase. On the Rhine or Danube the regulation of rivers and floodplains has led to an acceleration of flood waves to half of the time they need for e.g. 100 km (15 hours before regulation to some 8 h after regulation). When accelerated flood waves overlap each other at confluences, the downstream flood peak and volume can significantly increase (no retardation of flood wave and no time for preparedness and evacuations).

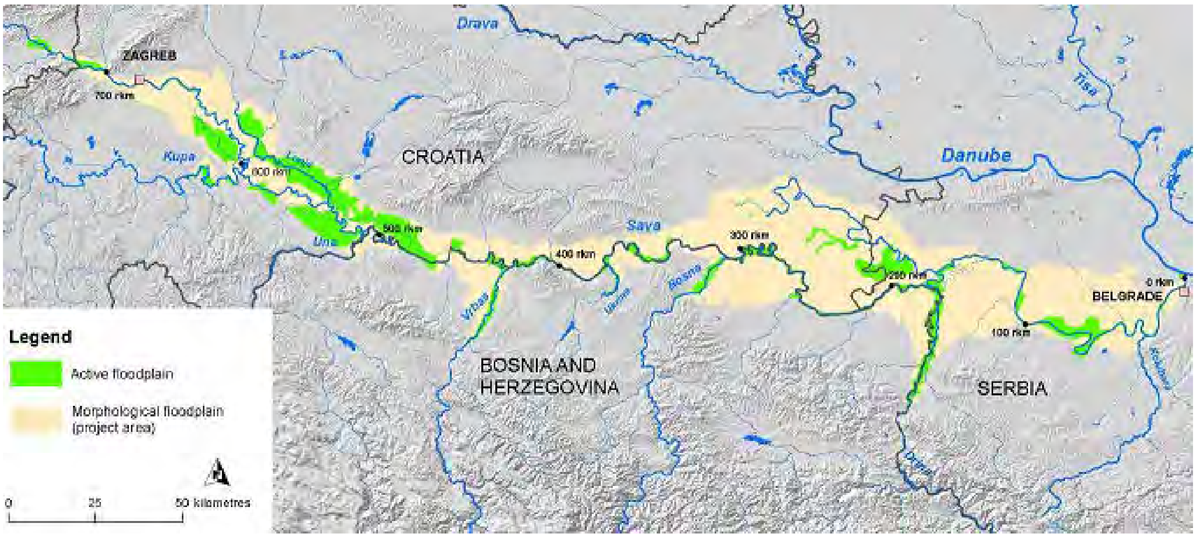


Fig. 9: The losses of floodplains (the morphological floodplain is indicated in beige colour as maximum potentially flooded area) along the lower Sava are, similar to many other rivers, considerable and reach up to 60-80 % on average, leading to greatly reduced retention capacities and increased risks of dangerous dam breeches, such as during the 2014 flood (compare Figure 39 at page 104). However, the large remaining near-natural lowland areas in Croatia represented by the upper Posavina flood system (indicated in the map as active floodplain in green south-east of Zagreb) still serve as a very effective near-natural flood retention area.

In most Balkan countries the flood defence systems (dikes, drainage canals, pumping stations) were built in the 1960-1970s, but in many areas flood defences were not erected at all. Recent land use changes, such as the enlargement of settlements and commercial areas, but in particular changes of agriculture uses, make more and better flood defences necessary. Earlier built drainage systems and pumping stations are not sufficiently dimensioned anymore to carry large floods away from flood-prone areas.

Directly linked to the changing and intensifying land use, it is the spatial planning which is the key to prevent further losses. In Austria, the average active land use change in favour of housing areas and infrastructure was estimated for 2014-2016 at 14.7 ha per day (Austrian Federal Environmental Agency[9]) in Germany, which is four times larger in size (2012-2015) at 66 ha per day[10]. The target value for a "sustainable" land use strategy in Austria, however, is 2.5 ha per day. Unfortunately, significant portions of these land conversions happen in former floodplain areas, which means that after building the houses and infrastructure, this potentially available flood retention space is lost forever, and financial costs are extremely high when these settlements are later on suffer damages caused by floods.

9 http://www.umweltbundesamt.at/umweltsituation/raumordnung/rp_flaecheninanspruchnahme/ (in German only - the records indicate the land use increases in ha/year since 2001)

10 https://www.umweltbundesamt.de/daten/flaeche-boden-land-oekosysteme/flaeche

River regulation

Figure 10 presents the overall hydromorphological assessment of the region (based on SCHWARZ 2012, prepared in 2008 - 2010), indicating the most altered river reaches, but also highlighting many intact rivers. In some countries like AL or BA, the construction of hydropower dams and infrastructure (e.g. highways in river valleys) has already worsened the situation over the past 10 years. However, this is a still ongoing process (an updated map will be published in 2018 by the NGO Riverwatch). Each new road built in mountainous river valleys must be protected against lateral erosion of rivers, and often rivers must be completely regulated.

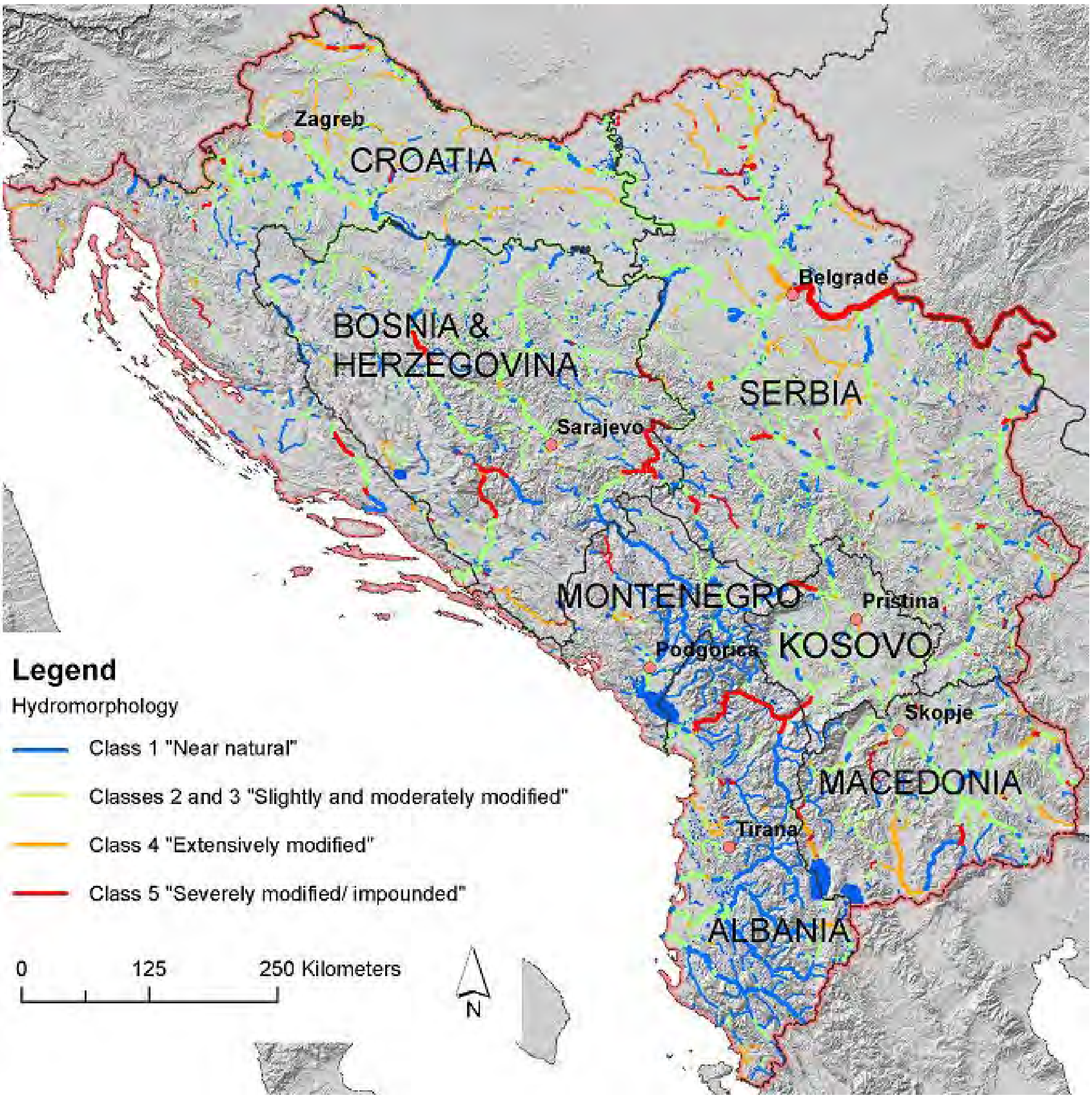


Fig. 10: The hydromorphological baseline assessment of Balkan rivers indicate the still high amount of intact rivers (in blue) in AL and ME. They are currently under pressure from hydropower development, while there is a large number of light green rivers (for the two hymo classes “slightly and moderately altered”). Mainly, reaches in the lowlands are extensively altered (orange) or even impounded (red) with exceptions of mountain reaches of Drina, Neretva and Drin, which are partly used for hydropower generation.

Regulated rivers with controlled, deepened cross-sections can basically carry more water than natural river beds. However, in case of major floods and overtopping of banks (also in case they have no additional flood defences), the rapidly flowing flood waters develop strong destructive forces. At increased flow velocity the flood water can be conveyed faster through critical sections, but the downstream neighbours then often suffer from increasing and even quickly rising flood water levels. Natural river beds and its floodplains have irregular structures that disturb and reduce the quick flow, thus lowering the flood height and downstream impacts.

Climate change

Any temperature increase and changing precipitation patterns directly influence the quantity of water possibly producing floods.

A temperature increase does not necessarily come alongwith decreasing precipitation but the long-term climatic trend implies a significantly decreasing precipitation and therefore a decreasing base flow discharged into rivers.

But besides longer and hotter dry summer seasons, climate change will increase the variability and number of extreme events, such as droughts and floods. In case of floods this effect is based on the fact that warmer air masses can carry higher amounts of moisture, and higher sea water temperatures in the Mediterranean Sea can boost this effect. If these cyclone systems, even local super cells, are slowly moving or hindered by the mountains, a hazard of local flash floods increases.

Effects of climate change are visible and strong in the Balkan countries (e.g. ALFIERI et al. 2016), even if several scenarios do not see a sudden reduction of water resources along the northern main mountain ridges. In particular, in coastal and south-eastern parts, increases of temperatures and decreases of runoffs are evident.

On the one side temperature and heat waves raise significantly, on the other side heavy rainfall increase the danger of flash floods (as happened in late November 2017 in Greece, where unusual warm air of 23 degrees over the sea collected a lot of moisture and caused flash floods in the north of Athens with over 20 fatalities and much destroyed infrastructure (which was partly built in dried-out river and creek courses).

The pressure of droughts and increasing evapotranspiration or significantly less water in many rivers over the summer season and the demanding agricultural production and water needs lead to a desire to build more big reservoirs to retain flood waters, and to store water for the dry season.

According to EEA (e.g. EEA 2016a and 2017b) and national climate change strategies, the main effects of climate change in this part of Europe are:

- Stagnation of the overall precipitation trend, but also an unfavourable distribution of the intra-annual precipitation, which is essential for the creation and provision of water resources (longer dry periods);
- Taking this into account, the potential impact of climate change will be a reduction of flows, which will result in lower water levels in watercourses and springs, and in reduced underground water resources and lowered water levels in natural and artificial lakes.

- Increased intensity of short-term and strong precipitation in the future as well as a higher number of floods, landslides, and of overall soil erosion.
- Higher water temperature in lakes, reservoirs and impoundments will lower the water quality that can have an impact on the bio-availability of contaminants (via oxygen binding and consumption) in the water environment.
- Water temperature changes will also alter the aquatic biodiversity.

A UNEP report on climate change in the Western Balkan (UNEP 2012) gives an overview on the general figures regarding exposure and vulnerability as well as on the adaptation capacities. The general trend is also reflected in this study, confirming higher average temperatures and lower precipitation.

Other land use changes

The origin of floods in the catchments is based on the drainage network. Landscapes were changed by human intervention over decades, centuries and even longer periods. Usually deforestation is a major cause of accelerated and increased flood peaks. In the study region this is valid for larger areas in Albania[11] and some smaller regions across all countries (in particular MK and RS). Also land cultivation is contributing to the increase of floods and the risk of erosion and landslides, in particular in the hill-dominated northern middle river catchment sections (e.g. more corn production, less pastures). The increasing use of fertilisers and expensive agro-industrial techniques leads to a growing damage potential for crops, since productivity in agriculture increased significantly. Agriculture needs both more water (expanding irrigation systems) and is prone to flooding with a high damage potential.

Improper exploitation and non-sustainable management of forests and agricultural land as well as uncontrolled urbanization worsen the (economic) impacts by natural hazards, such as torrential floods. In recent years, such floods have occurred more frequently and have become more destructive[12]; former discharges with a recurrence interval of 100 years are now events recurring already every 50 years or even more often. Various contributing factors are identified, including the transformation of the region from rural to urban land uses, diminishing forest vegetation, non-sustainable agricultural practices, etc. Further, it is of great importance to manage any land use in those areas where floods are “generated”. E.g. after the disastrous and biggest flood in 100 years of Elbe river in Germany in 2002 (e.g. flooding the city of Dresden), the federal province of Saxonia developed a spatial planning tool called “flood generation areas”. This instrument documents all impacts within this sensitive area and obliges municipalities to substitute lost floodplain areas or to compensate the loss of any retention volume. The second disastrous flood of Elbe river in 2013 was already mitigated due to this measure put in place since 2002.

Another important factor in SEE is the dramatically reduced investment in the water sector over the last decades, contributing to a deterioration of the countries’ water infrastructure.

[11] Between 1990-2000 an average loss of forest cover of about 2,000 ha/year is recorded https://rainforests.mongabay.com/deforestation/archive/Albania.htm. Between 2001 and 2012 the loss of in total 2,530 ha/year is not compensated by the annual gain of 613 ha, but the trend is going towards a reduction of losses https://www.globalforestwatch.org/country/ALB?widget=treeLoss

[12] For reference: two disastrous torrential floods have occurred in the country over a one-year period – August 3, 2015 in Polog and August 6, 2016 in Skopje.

Aging and disaggregating infrastructure and too little investments into their maintenance puts many flood control structures at risk of losing their functionality and reliability.

Hydropower and dams

Water retention dams can store a specific volume of water but, in case of improper usage or catastrophic events, they can soon reach their limits and rather endanger downstream river sections, where people believe to be protected by those facilities.

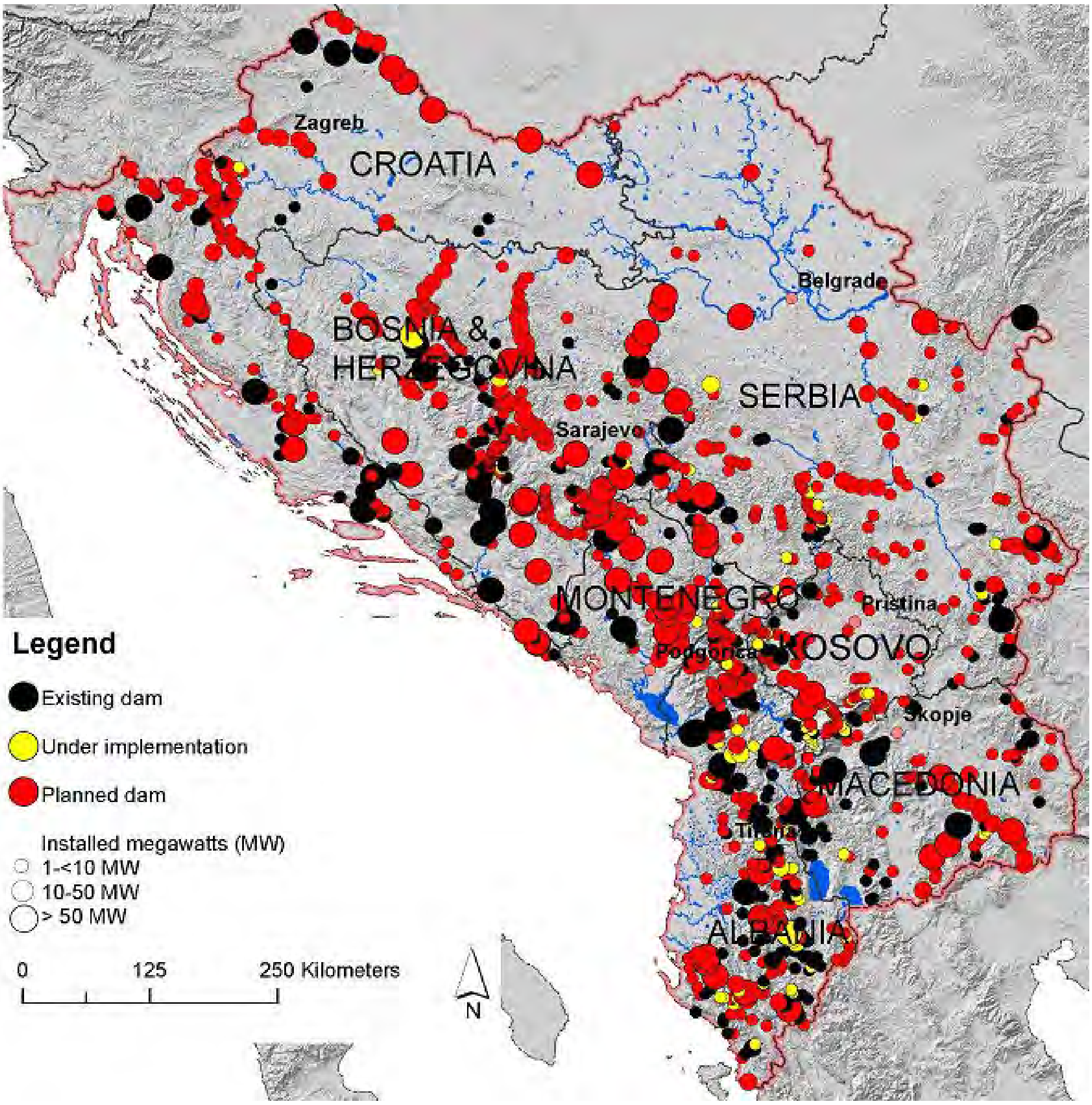


Fig. 11: Hydropower dams in the study area (black: existing, yellow: under construction, red: planned) (Schwarz 2012, data updated in 2017). Dams, reservoirs and flood detention basins form an important part of the “grey infrastructure”. However, dams are built only for a specific retention volume and the steering of dams must match the flood retention needs at a given event.

Two examples from Austria can be mentioned: The "2000 years flood event" at the Kamp river in 2002 where the water level downstream of the Ottenstein dam raised in a very short period, or the 2013 flood event at the Drava river in Slovenia and Croatia, where downstream the last Austrian dam at Lavamünd near the border to Slovenia the discharge increased within hours to a 100 years event. Two tragedies of dam failures occurred in France in 1959 with a real dam burst (Fréjus, Barrage de Malpasset) with at least 420 casualties and in Italy in 1963 (Vajont dam, Longarone), where a huge mountain slope slided into a just constructed reservoir, overtopped the dam and triggered a flood wave of 10 m downstream that was killing 2.000 people. Even today, when high standards are set and met in all countries to regularly control the stability of dams, extreme events can still endanger dams, such as in 2005 on Vltava river (Prague flood) in Czech Republic, when all big upstream reservoirs had already exhausted their capacity and flood protection became very difficult. The construction of new dams always goes hand in hand with river regulation/canalisation, which may also increase flood risk for the entire lower courses in case of disastrous floods. The figure 11 indicates the distribution of existing and planned hydropower plants.

In summary, across the entire region the land use development (agriculture, urbanization, transport infrastructure, etc.) consuming and depleting more and more space in river valleys and on the slopes of foothills is drastically increasing the damage potential in flood- and landslide-prone areas. Taking into account that nearly all settlements and agglomerations are located in valleys and plains, flooding becomes particularly more likely in former floodplain areas, that became excluded by dikes from natural inundation. Through the regulation of various rivers and a loss of available riverine retention areas, any flood wave peaks and discharge speed is increasing. Even worse, climate change is bringing higher temperatures and more instability of air moisture that may cause at least more flash flood events, but also more riparian flood damages downstream. A simple raising or constructing of new dikes and reservoirs cannot solve these increased flood hazards, it can even increase the danger in case of catastrophic floods and can induce failures of safety structures, behind which people "feel" safe since a long time. Therefore, it is necessary to provide additional and up-to-date flood protection measures, such as in particular NbS and systematic and wise spatial planning in river valleys that allows better and effective mitigation of future major floods.

2.3 Natural water retention areas

The overview of potential inundation and water retention areas in chapter 2.1 provided the framework to identify in the next step those still existing and potential natural retention areas that have high capability to store flood waters as well as other benefits, notably a high biodiversity value. These natural water retention areas should serve as priority sites for NbS and restoration activity in any region. The entire study region is still rich in natural water retention areas not only in the northern and coastal lowlands, but also in the Dinaric karst areas and in some upland plains along smaller tributaries in BA, RS, KV and MK. Beside the overview map (Figure 12), all significant areas will be shortly presented below for each country (compare the numbers in the map).

The map of Figure 12 is based on the potentially floodable area, as specified in chapter 2.1, having a total surface of about 31.076 km² or 12 % of the study region. Parameters to define *ecologically important areas* are

- the general land use (Corine data),
- the network of protected areas and
- the general hydromorphological condition (excluding all river impoundments and artificial storage lakes).

As regards the protection of river corridors in general, still many important river valleys, such as the lower BA Sava tributaries, are not protected today. In EU countries, many rivers, floodplains and wetlands became Natura 2000 sites, as in case of Croatia the entire Drava, Sava and Danube rivers. E.g. the active floodplains along the entire Danube with over 2.800 km length are protected at least on half of its course, including several national parks, Ramsar sites and Natura 2000 sites.

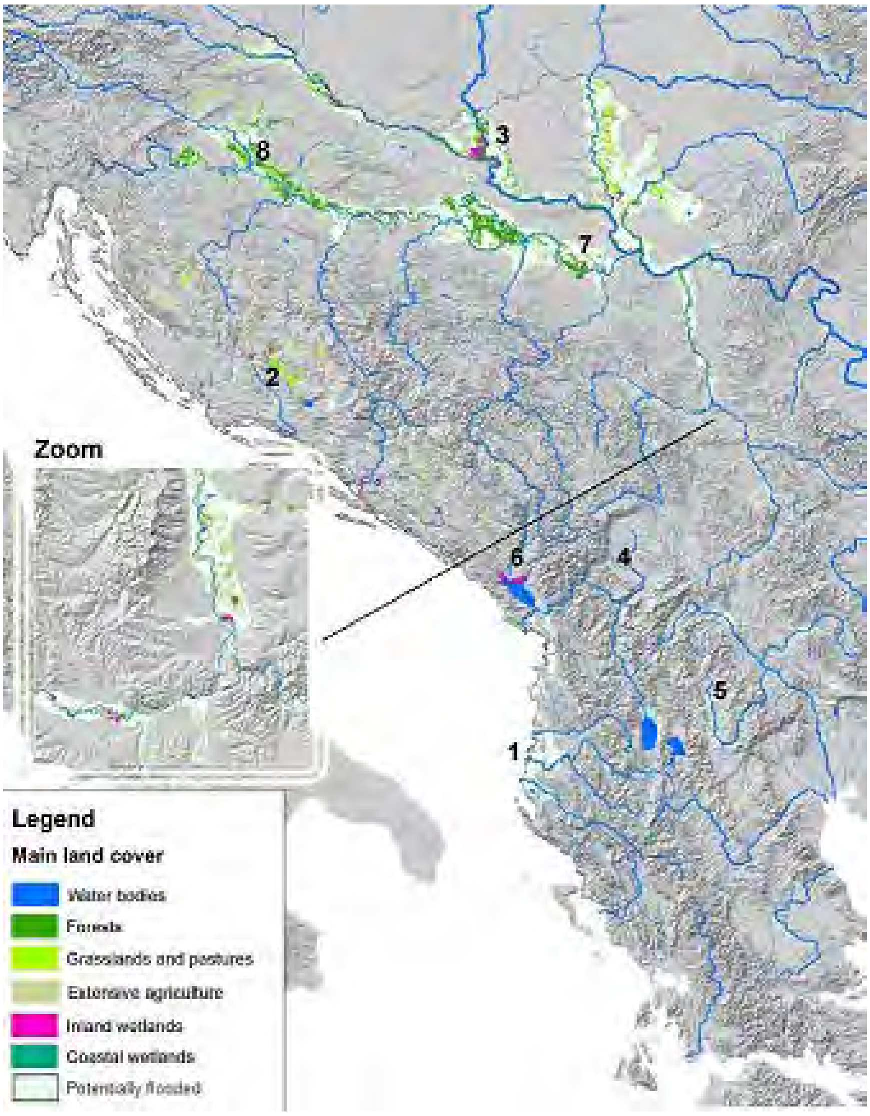


Fig. 12: Examples for existing important natural water retention sites. The small zoom map indicates a full detail. Numbers refer to the examples in the text below.

- This involves the following categories of protected areas: Ramsar sites, biosphere reserves, World Heritage sites, national parks, Natura 2000 sites, strict conservation and Emerald sites, as well as other protected areas (e.g. protected landscapes). Some longer river sections and their floodplains are part of protected areas and offer excellent opportunities to reconnect floodplains or to manage retention areas ecologically. However, many other river valleys are still not protected (even if the EU accession process will accelerate the nomination of Emerald areas and other sites for the Natura 2000 network). The most recent information about protected areas in the Balkan region can be obtained from IUCN (2018).
- For assessing the land use, the EU Corine vector data (EC 2017) give a rough estimate where to find forests and grasslands (wetlands and waterbodies) and where an area is used by agriculture or any kind of settlements or infrastructure, which excludes them from becoming a potential NbS area.
- Further excluded from the analysis are those areas along river stretches that are affected by impoundments. E.g. the Djerdjap "Iron Gate" reach of the Danube lays in forested hills and mountains and is even classified as national park (firstly on its banks, mainly steep slope and forest habitats) but lost its ecological functionality as a free-flowing river. Of course impoundments can store some flood water, but this function does not match with the qualities of "natural water retention areas".

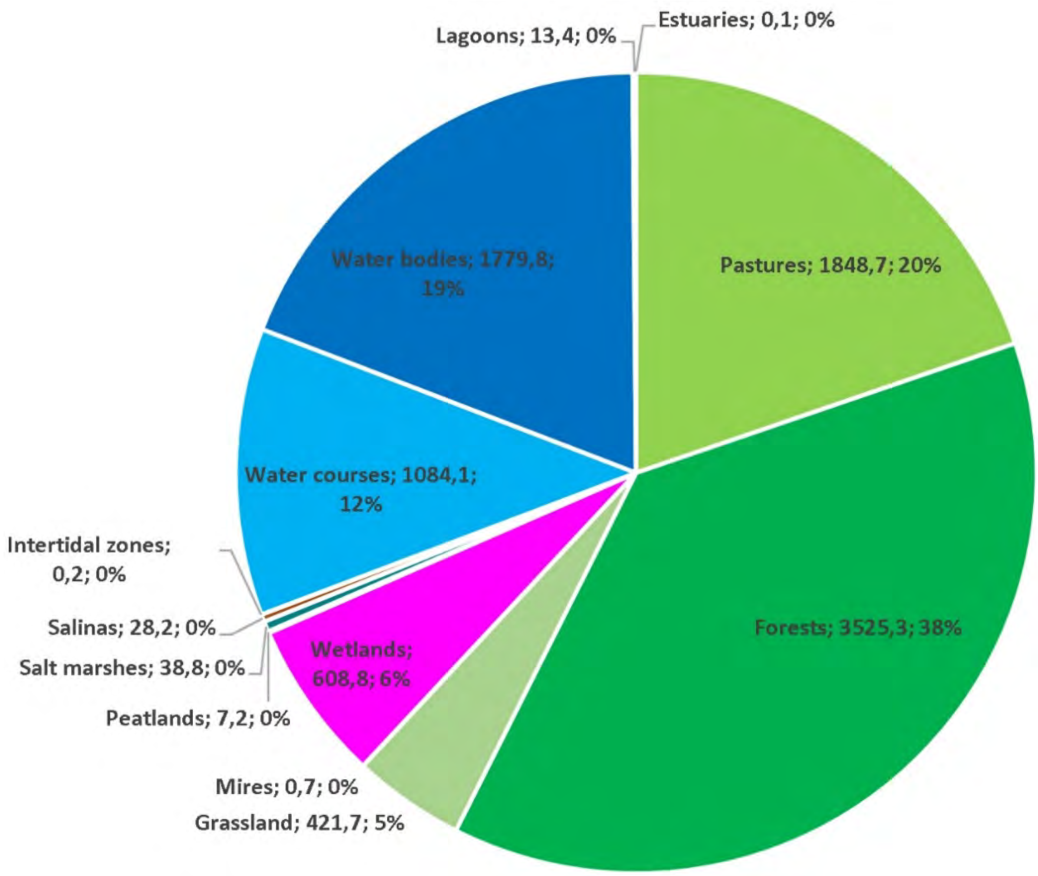


Fig. 13: Shares of different ecologically valuable land cover types within the potentially flooded area in the Balkan study region.

In fact, in most cases dams strongly alter the hydromorphological regime of rivers up- and downstream and, if well managed, can diminish regular and small floods. But during major floods the timely lowering of water levels of multi-purpose reservoirs is a precondition to really retain a flood, otherwise they cannot stop a flood wave but rather risk to suddenly raising downstream water levels, with a very high damage potential (e.g. the AT Drava flood in 2013 with serious downstream consequences in SI and HR).

Regarding the main land types, only 5 % within the potential flooded area are settlements and infrastructure, but 54 % are arable land or less intensively used agricultural land. Main land covers of the natural and extensively used landscapes are: 10 % forests (often soft- and hardwoods), 8 % rivers and lakes, 7 % extensive farmland, 6 % grasslands (5 % pastures), 5 % transitional woodlands, 4 % inland wetlands and 1 % coastal wetlands and water bodies.

For this overall land use, Figure 13 indicates the distribution of ecologically valuable land cover types in potential inundation areas. Alltogether this area, excluding permanent water bodies, extensive agriculture and transitional woodland shrub, covers about 6.452 km² or roughly 21 % of the identified total potentially floodable area in the Balkan study region. This seems to be much more in comparison to West European countries, where estimates expect about 10 % for this ecologically valuable land type in floodplains (EEA 2016b).

The various Balkan countries own the following most significant existing and potentially floodable areas:

Albania is characterised in the north-western part by an Alpine mountain environment, changing south into deep mountainous river valleys and coastal plains with originally large deltas, lagoons and lowlands along almost the entire coast.

These specific conditions lead to highly dynamic braided river reaches when leaving the mountains and entering the plain, followed by extensive river deltas (Figure 14). Until today a large number of these rivers and estuaries have kept a high potential for natural water retention areas, but more and more landscape is lost to settlements and land reclamation. At the same time, hydropower dams interrupt the sediment continuum which leads to coastal erosion.

Fig. 14: (Site no. 1 in the map of Figure 12 on page 40): One of the most natural river deltas in the Adriatic Sea is the Seman delta, actively contributing to the stabilisation of the coastline and the protection against coastal flooding by storm surges: The delta is shaped by river sediments deriving from land and by waves and lateral drifts of the sea. Belts of sand walls, lagoons, soft- and hardwood patches mix with gravel sand and mud bars and associated halophytic pioneer vegetation, all stabilising the young land. The lower end of the delta is the ”frontline” between sea and land. If sediment is retained behind upstream dams, erosion and delta regression take place (Google Earth 2018), and the coast in the delta region looses stability.

Bosnia & Herzegovina: Due to its orography, only the Sava lowlands at its northern border and several large Karst poljes (Figure 15-17) are potentially floodable areas.

Fig. 15: Overview map of the main karst poljes in southern BA. Most of the poljes are regularly flooded. The biggest is Livanjsko polje northeast of Cetina river (connected by underground) and near the Croatian city of Split (Schwarz 2014); see also area no. 2 in Figure 12 on page 40.

Fig. 16: Flood-adapted land use in form of extensive grasslands. However, pressure to intensify the use comes from land reclamation and from the settled margins. Livanjsko polje is also a Ramsar site.

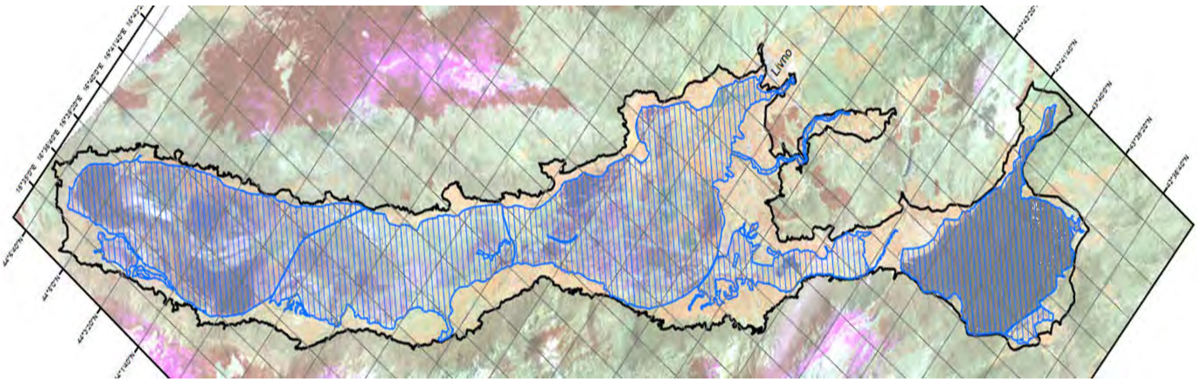


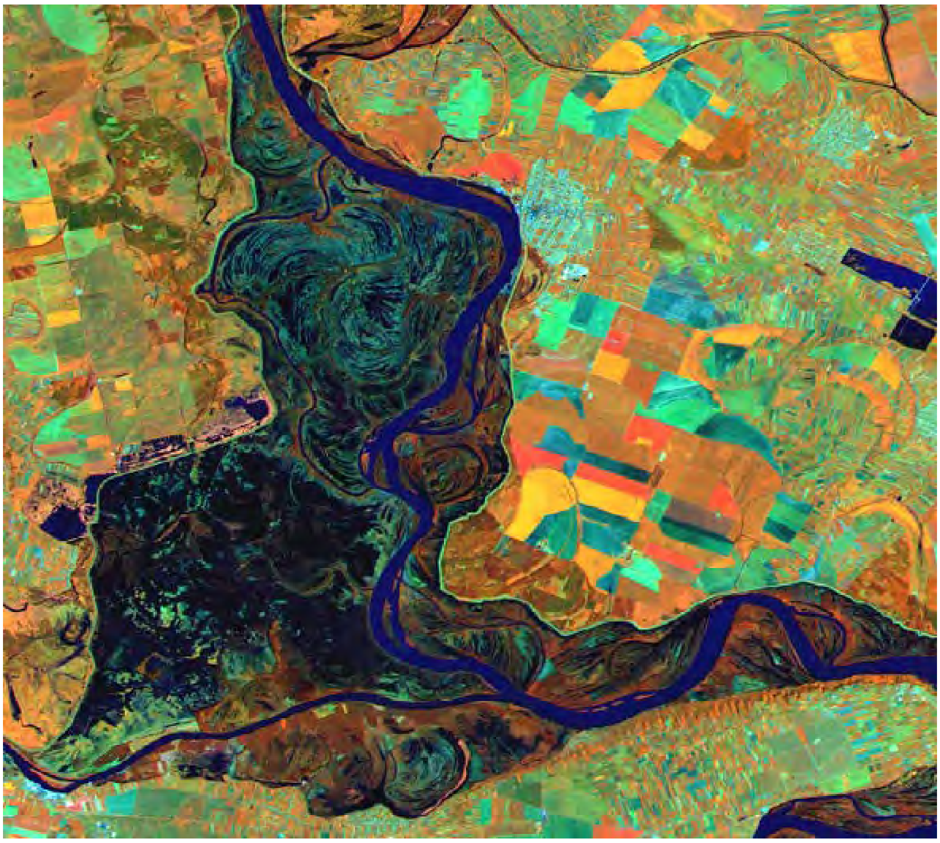
Fig. 17: Map overview of Livanjsko polje and regular extent of its inundations (blue hatched area). When the water rises 2 m above the ground, the retention capacity reaches up to 120 Million m³. On the right side there is Buško blato hydropower lake in a former polje area. There are several new hydropower projects across the karst region (upper horizon) in planning stage (Schwarz 2014).

Numerous larger rivers such as Una, Vrbas, Bosna and Drina are crossing the country from south to north, bringing significant flood risk and, depending on the settlement structure in side valleys, also triggering a high risk of flash floods or smaller landslides in the hill areas. Natural riparian retention areas can be found along some lower tributaries, along the Sava and in a very few side valleys along smaller tributaries such as Sana, Usora or Spreca. BA is rich in karst poljes (calcareous depressions without surface outflow) that are most regularly flooded in winter and spring, often for several weeks, fed by strong karst springs and storing the water temporarily, before it runs and seeps away into the underground to the next, lower laying polje or into short but water-rich rivers, which can suddenly appear and disappear in karst rock formations. Most of the drainage is oriented towards the Adriatic coast, and the water is used for drinking and as irrigation water in the dry Mediterranean coastal regions.

Croatia: In Croatia two large Danube tributaries are flowing from west to east across the northern part of the country, the Drava and the Sava. Both rivers, but in particular the Sava, still host various large floodplain areas (hardwood and grasslands). The famous Lonjsko Polje Nature Park with the Upper Posavina flood control system (no. 8 in map of Figure 12) is one of the most prominent flood control and retention systems in Europe (see chapter 1.3). The entire lower Sava corridor is able to retain more than 3 billion m³ of flood water, which means it relieves the main channels for some 1.500 m³/s in total over several weeks.

But also the last remaining large natural floodplain area along the entire upper reach of the Croatian Danube, the Kopački rit (see area no. 3 in Figure 12), has a remarkable retention function for the whole Serbian Danube reach with the cities of Novi Sad and Belgrade. With a floodable area of approximately 20.000 ha and a water depths of up to 5 m, it can store up to one billion m³, thus effectively buffering the flood wave downstream the Danube (Figure 18 and 19).

In the case of the upper Danube floods 2002 and 2013 (leading to disastrous events in DE and AT), the water levels on the entire Hungarian Danube and in Budapest reached dangerous levels and caused significant damages. However, downstream the Kopački Rit, with its high water retention function, no damages were recorded, as it took a long time for the flood wave to reach the Serbian part of the Danube at Novi Sad and Belgrade. The 2006 flood on the Danube, which caused a lot of inundations and damages in Belgrade, was triggered by the Tisa, which is strongly regulated in its lower and middle course with nearly 80 % cut-off floodplains. This demonstrates the beneficial function and importance of the specific location of each retention area: The Kopački Rit is very effective in retaining Alpine, upper Danube floods, but for floods further downstream triggered by the Tisa and Sava, there is no such big natural retention area left in the vicinity of the city of Belgrade.



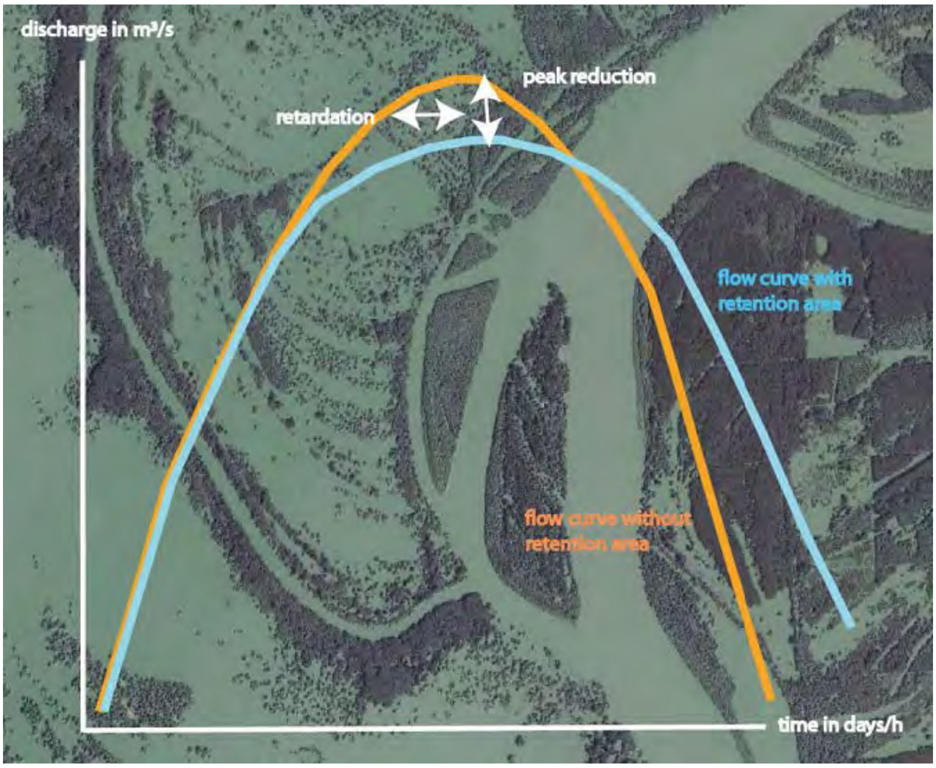


Fig. 18,19: Kopački Rit during flood (dark flooded area). Effects of peak flow reduction and retardation of the Danube flood wave (source Landsat (USGS 2007, Google Earth 2018). When a flood wave arrives, the water entering slowly the huge floodplain lowers the peak discharge volume downstream and retards the flood wave propagation speed. After the flood the water is released slowly back to the main channel.

Kosovo: The Beli Drin (or Drini i Bardhe) is the biggest river in the south-western part of the country (no. 4 in Figure 12) and still host several larger floodplain areas. Beside excessive gravel exploitation from the river bed and the active floodplain along its middle course in the Kosovo, the upper course still has some stretches subject to only extensive uses. However settlements, infrastructure and small weirs sprawl increasingly over floodplain areas, increasing the potential flood risk. Further large floodplains can still be found in the northern (Pristina) plain.

Macedonia: Vardar river divides the country in a south-western and north-eastern part with different hydrological and geomorphological conditions The plain of Crna river in the south-western area (no. 5 in Figure 12 is a good example for formerly extensively used wet grasslands which are today mainly used for intensive agriculture. Further important floodplains exist on the upper Vardar.

Montenegro: Skadar lake (Figure 20) can be called "the largest floodplain lake of Europe", as its extent varies regularly between 300 km² and 500 km² (for comparison: Lake Constance in Germany with a similar prominent through-flow by the river Rhine has 536 km² in average, but varies only between about 500 and 600 km²). The main reason for the great variation in extent are huge underwater karst springs fed by water deriving from the surrounding mountains, but also the river's interconnection with Drin river, joining on Albanian side the lake's outflow, called Bojana river, just downstream, and causing backwater level increases of the lake during floods of the Drin/Bojana. The lake's inundation zone of several km width at the shore (Figure 21) is still traditionally and sustainably used for fishery, reed cutting, wet meadows and forestry (soft- and hardwood trees).

Fig. 20: Transboundary Skadar Lake between Montenegro and Albania: Natural water retention at one of its largest extension can be observed along the upper Montenegrinean shore at the Moraca river delta.

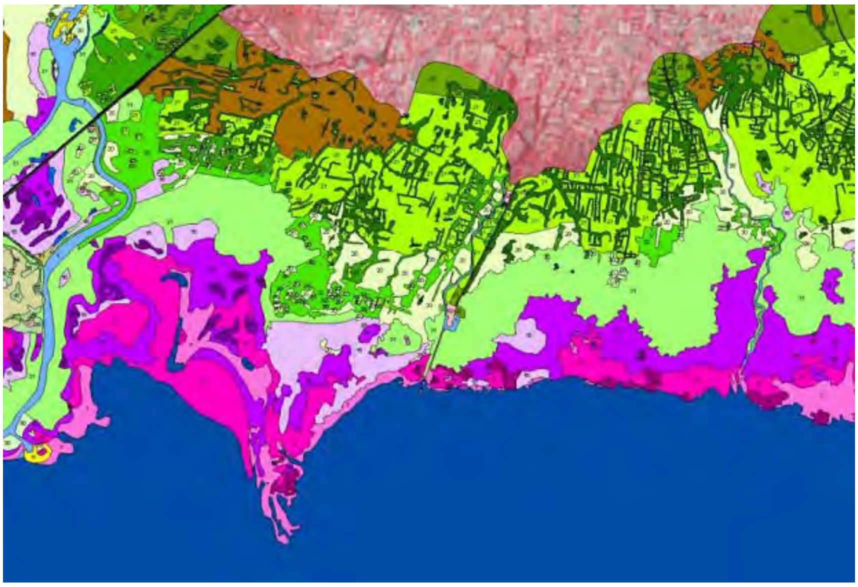


Fig. 21: Lake Skadar shore zonation (at left the mouth of Moraca river), starting with floating water plants, extensive reed beds and muddy pioneer vegetation (pink colours), followed by extensive softwoods (light green), wet grasslands (olive green) and hardwood hedgerows (dark green), and finally ending in agricultural and settled areas (brown) (SCHWARZ 2010a).

Serbia: The northern extensive lowlands and floodplains are strongly influenced by the three big Danube tributaries, the Drava, Tisa and Sava, originally building one of the largest floodplain complexes in Europe. Further, the Velika Morava river system entering the Danube from the south characterises the central and southern plains and valleys in Serbia.

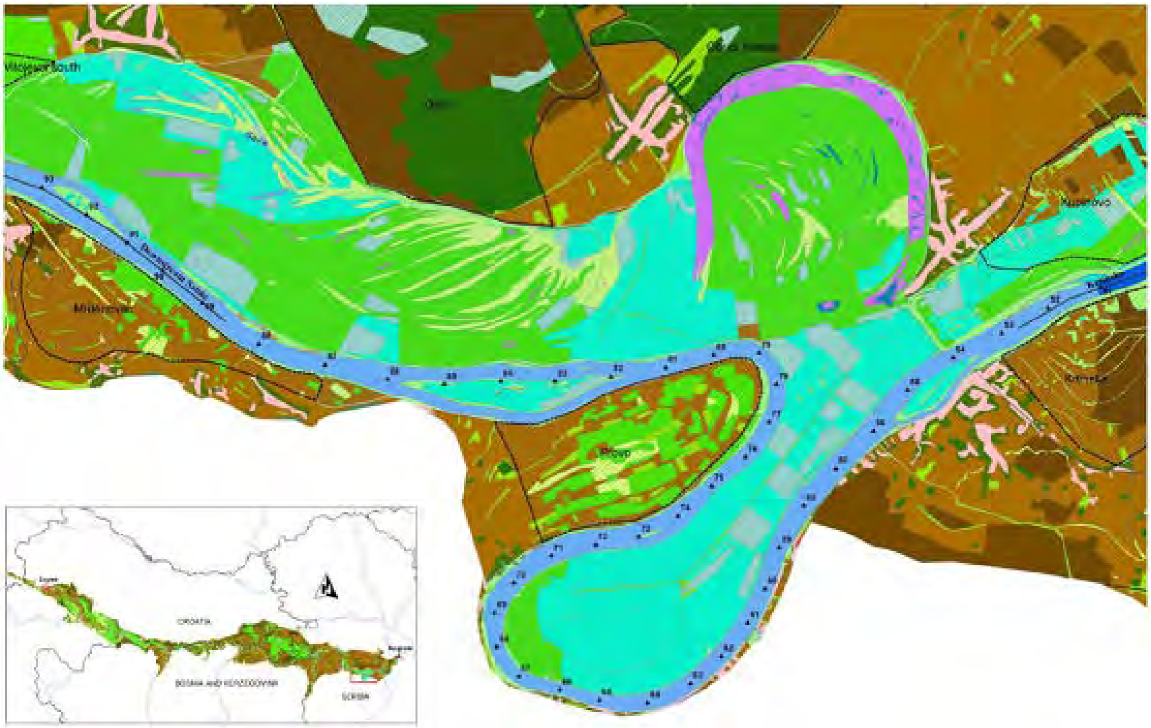


Fig. 22: Obedska Bara (pink oxbow, no. 7 in Figure 12 page 40) at the lower Sava river, is one of the most prominent of the few remaining flood retention areas in Serbia (for legend compare Figure 38 page 103), (SCHWARZ 2017).

As an example of NbS in Serbia, the Obedska Bara Ramsar site (Figure 22) should be mentioned, an extended large Sava oxbow with associated wetlands, soft and hardwoods, that is regularly flooded (with a capacity of some 300 Million m³) as a remnant of the former large inundation areas along the lower Sava.

Finally, Table 5 highlights the most important natural retention areas (Figure 23) based on their categories (river floodplain, lake floodplain, karst polje floodplain, coastal floodplain) and provides an estimation of the retention capacity, which was calculated by size and type-specific maximum flood level; e.g. the flood levels can reach 2-5 m above ground depending on area category, river size and local exposition (height above mean surface water level). When summing up the average total capacity, more than 12 Billion m³ of flood water can be stored in these sites. This should be set into relation to huge nature-based solutions, primarily to the Upper Posavina flood system and further adjeacent retention areas along Sava, which are able to store in total up to 3 Billion m³ or to the more artificially constructed flood polder system along the Hungarina Tisza (Vásárhelyi Plan, compare footnote 32), with up to 5 Billion m³.

Tab. 5: Major wetlands and natural retention areas with category and estimated retention capacity

Country, water body and name	**Category**	**Retention capacity in m³**
AL Lake Skadar shore	Coastal floodplain	100-200 Mill
AL Bojana-Buna delta	Coastal floodplain	10-50 Mill
AL Devoll delta	Coastal floodplain	50-100 Mill
AL Erzen delta	Coastal floodplain	50-100 Mill
AL Lower Mati	Coastal floodplain	50-100 Mill
AL Lower Vjosa Pocem-Mifol	Coastal floodplain	50-100 Mill
AL Bojana-Buna delta	Coastal floodplain	50-100 Mill
AL Devoll delta	Coastal floodplain	50-100 Mill
AL Erzen delta	Coastal floodplain	10-50 Mill
AL Mati delta	Coastal floodplain	50-100 Mill
AL Shengjin and Lezha lagoon	Coastal floodplain	50-100 Mill
AL Shkumbin delta and Karavasta lagoon	Coastal floodplain	50-100 Mill
AL Vjosa delta	Coastal floodplain	100-200 Mill
AL Lake Skadar shore	Lake floodplain	50-100 Mill
AL Lower Mati	River floodplain	10-50 Mill
AL Lower Vjosa Pocem-Mifol	River floodplain	50-100 Mill
AL Middle Devoll	River floodplain	10-50 Mill
AL Middle Shkumbin near Elbansan	River floodplain	50-100 Mill
AL Middle Vjose Pocem - Memalja	River floodplain	10-50 Mill
BA Dabarsko polje	Karst polje floodplain	50-100 Mill
BA Duvanjsko polje	Karst polje floodplain	50-100 Mill
BA Eastern Posusje	Karst polje floodplain	10-50 Mill
BA Gatacko polje	Karst polje floodplain	10-50 Mill
BA Glamocko polje	Karst polje floodplain	50-100 Mill
BA Hutovo blato	Karst polje floodplain	50-100 Mill
BA Livanjsko polje	Karst polje floodplain	200-500 Mill
BA Mostarsko blato	Karst polje floodplain	10-50 Mill

Country, water body and name	Category	Retention capacity in m³
BA Nevesinjsko polje central part	Karst polje floodplain	10-50 Mill
BA Podrasniecko polje Cadavica	Karst polje floodplain	10-50 Mill
BA Bardaca, lower Vrbas and Sava	River floodplain	100-200 Mill
BA Lower Bosna Odzac-Samac	River floodplain	100-200 Mill
BA Lower Drina	River floodplain	100-200 Mill
BA Spreca Gracanica	River floodplain	10-50 Mill
BA Spreca Lukavac and Zivnica	River floodplain	10-50 Mill
HR Krbavsko polje	Karst polje floodplain	50-100 Mill
HR Bezdan	River floodplain	50-100 Mill
HR Cesma Casma	River floodplain	10-50 Mill
HR Karasica Malinovac	River floodplain	10-50 Mill
HR Kupa east of Banska Selnica	River floodplain	100-200 Mill
HR Lower Drava	River floodplain	200-500 Mill
HR Lower Kupa	River floodplain	50-100 Mill
HR Lower Neretva	River floodplain	10-50 Mill
HR Middle Drava	River floodplain	100-200 Mill
HR Mura-Drava confluence	River floodplain	10-50 Mill
HR Sava Davor - Orljava confluence	River floodplain	50-100 Mill
HR Sava East of Slavonski Brod	River floodplain	100-200 Mill
HR Sava Lonjsko polje	River floodplain	500-1000 Mill
HR Sava Mokro polje	River floodplain	200-500 Mill
HR Sava Odranjsko polje	River floodplain	200-500 Mill
HR Sava Spacva forest	River floodplain	50-100 Mill
HR Sava Sunjsko polje	River floodplain	200-500 Mill
HR Upper Mura	River floodplain	10-50 Mill
HR Upper Sava	River floodplain	50-100 Mill
HR Western Morava Pozega	River floodplain	10-50 Mill
HR Wider Kopacki Rit area	River floodplain	500-1000 Mill
KV Prishtina field Plemetin	River floodplain	10-50 Mill
KV Drini i Bardhe Zllakuqan	River floodplain	10-50 Mill
ME Skadarsko Jezero	Lake floodplain	200-500 Mill
ME Middle Zeta river	River floodplain	10-50 Mill
ME Plavsco jezero	River floodplain	10-50 Mill
MK Kumanovska reka Shupli Kamen	River floodplain	10-50 Mill
MK Middle Bregalnica Grdovtsi	River floodplain	10-50 Mill
MK Strumica Bansko	River floodplain	10-50 Mill
MK Upper Pelagonia	River floodplain	50-100 Mill
MK Upper Vardar Polog	River floodplain	50-100 Mill
RS Apatin-Bogoljevo	River floodplain	100-200 Mill
RS Danube BackaPalanka - Novi Sad	River floodplain	100-200 Mill
RS Danube Novi Sad -Tisa confluence	River floodplain	200-500 Mill
RS Danube Tikvara	River floodplain	50-100 Mill
RS Lower Tamis Pancevo - Glogonj	River floodplain	100-200 Mill
RS Lower Tisa Zrenjanin	River floodplain	100-200 Mill

Country, water body and name	Category	Retention capacity in m³
RS Lower Velika Morava Pozarevac	River floodplain	100-200 Mill
RS Rasina Sogolj	River floodplain	10-50 Mill
RS Sava Bosut forest	River floodplain	100-200 Mill
RS Sava wider Obedska bara area	River floodplain	200-500 Mill
RS Sava Zasavica	River floodplain	10-50 Mill
RS Southern Morava Batusinac	River floodplain	10-50 Mill

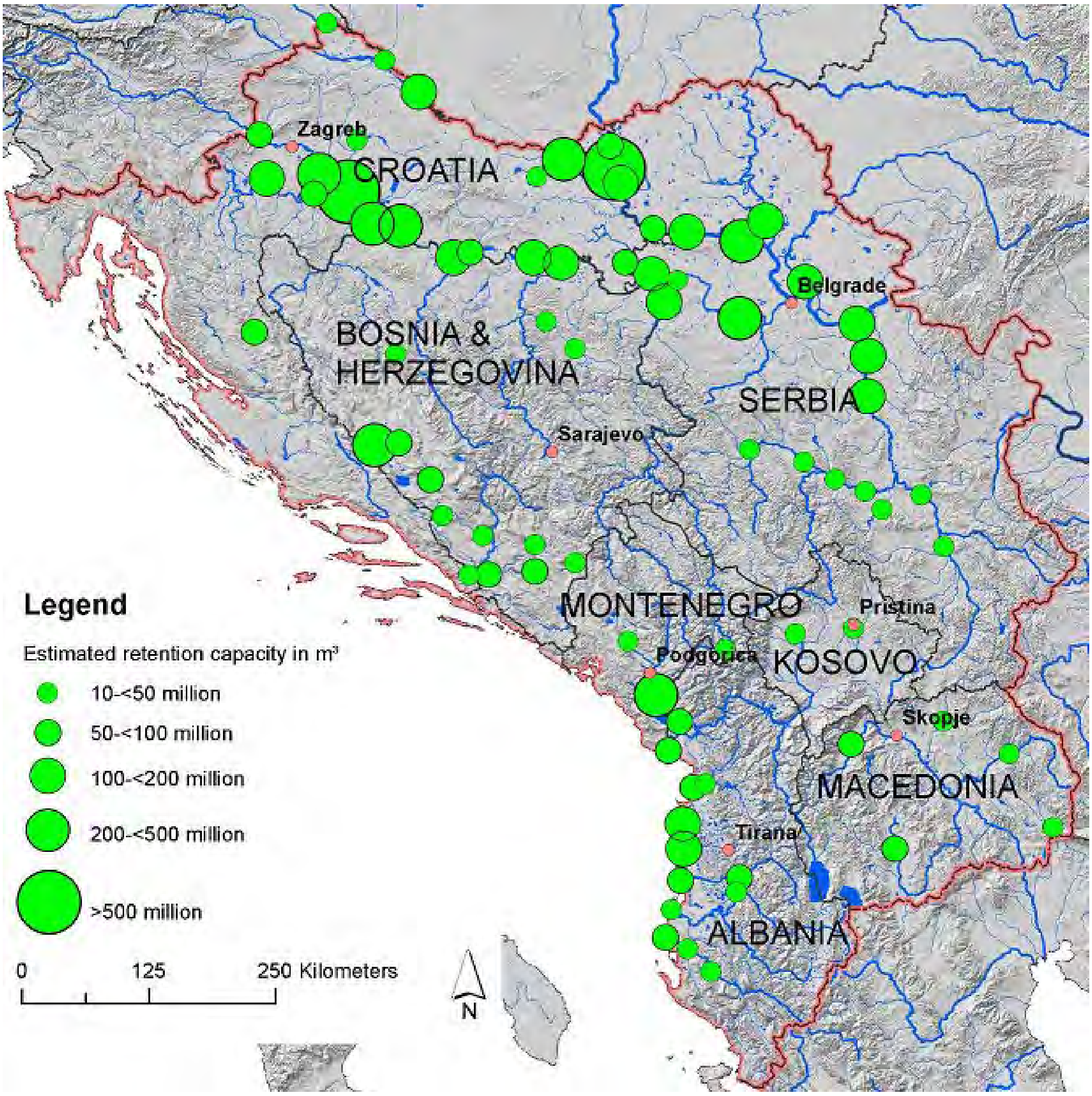


Fig. 23: Location of the exisiting major wetlands and natural retention areas listed in Table 5.

2.4 Conventional flood prevention measures and their effectiveness

Up to 2.000 km of flood dikes were erected since the early 20th century in the study area (Figure 24), but many dikes were reinforced and extended in the period 1960 - 1980. Based on detailed studies for the Drava, Sava and Danube, at least 75 % of potential floodplains were cut off by dikes, but at significant regional differences. While for the Danube and Tisa the loss is much higher on several reaches than on the Sava and Drava. Also on Albanian river deltas there are only few floodplain losses, while so far only few dikes have been built at karst poljes.

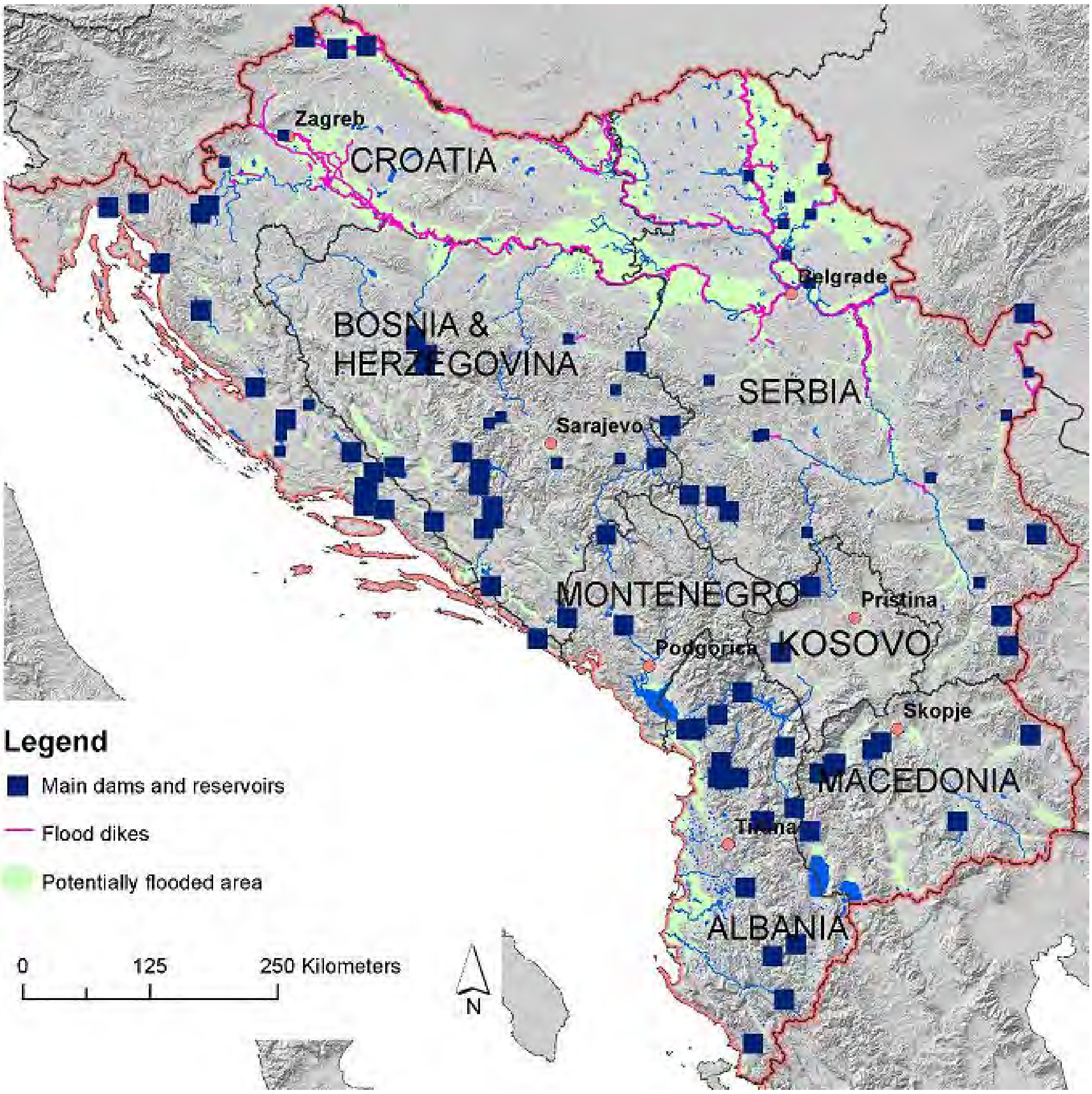


Fig. 24: Flood defence dikes (pink) and main dams/reservoirs (dark blue squares), which mainly operate for hydropower production but are also capable to retain at least small to medium floods. As usual, dams can be found mainly in the headwaters, while flood dikes extend along the lowland courses of rivers.

Several large reservoirs serving mostly for hydropower production exist since the mid 1960ies (e.g. on Drina, Drin or Vrbas) and can store and retain at least small to medium floods. However, the steering (lowering) of water levels in those reservoirs must be better managed in the future. Further, continued sedimentation of the reservoirs reduced their available capacities. Many of the existing flood dikes need to be renovated and reinforced, keeping in mind the raising flood levels due to climate change (in some regions there is an increase of a 100-year flood towards a 50-year event). Dikes were basically constructed to protect areas from a 100-year flood event (plus a small freeboard), but their function and effectiveness depends on their regular maintenance and coordinated management together with pumping stations and drainage canals.

The ongoing planned and proposed flood defense projects of Balkan countries (EUROPEAN COMMISSION 2015) focus mainly on the renovation of failed dike sections and on the reinforcement of critical sections. However, the increase of dike lines alone cannot reduce the flood risk, in particular when thinking of the upstream/downstream effects of accelerated and increased flood waves. Therefore, any structural measure must be planned as being part of entire reaches or even catchments, and must respect all transboundary effects. By consequence, NbS should be planned transboundary, with all adjacent neighbour countries having to invest in flood risk prevention (solidarity principle). Dike maintenance and the construction of expensive high and fortified dikes very close to the rivers and aiming to protect only agricultural areas, must be compared to variants with less expensive dikes far away from rivers. Any new dike construction should take into account the need for larger retention areas as NbS with low-intensity use. Land availability is crucial, but NbS can be more cost-effective than dikes close to the rivers (also accounting for cumulative effects and for the retardation of flood waves for downstream neighbours). Therefore, solutions that increase retention areas have a great potential to reduce long-term costs for compensation of land owners and costs for conservation and dike maintenance.

In particular after the Lower Sava and Balkan flood in 2014, BA and RS started huge investments with international aid to renovate and reinforce flood dikes. Several international projects collect wishes and proposals of countries to increase the structural flood defences (European Commission 2015).

In Croatia regular action plans include many renovation works along the Sava and Drava dikes. BA already reinforced and expanded the completion of river dikes at the Semberia lowland near the Sava-Drina confluence. Several World Bank and IPA projects are under implementation for flood protection on Drina, Bosna and Vrbas. The Sava Commission (ISRBC) coordinates many flood projects, but which are focusing on non-structural measures such as forecasting and the implementation of the EUFD (integrated planning).

In AL, MK and ME planning and construction activities for flood dikes and river regulations increase, which can also be seen as a reaction to the increasing number of flood events and economic values at risk in flood-prone areas (land development into floodplains and along rivers).

2.5 National activities and projects on nature-based flood risk management

Measures and projects with nature-based approaches can be found in several Balkan countries. However, only a few projects were originally dedicated to such approaches and provide not only the maintenance and extension of flood retention areas, but also afforestation or the reduction of soil sealing. In fact, a much broader group of projects could be interpreted as nature-based approaches. Most of the completed projects are so far more or less of conceptual nature and only a few smaller flood projects were already implemented. The focus in the following overview of past and ongoing projects was clearly set on water retention and flood mitigation within the river corridors. The provided links indicate for several cases real achievements but show also limitation of projects.

Selected Projects in Albania:

- Building the Resilience of the Kune-Vaini Lagoon through Ecosystem-based Adaption (EBA), 2016 to 2020, GEF and UNDP[13]: Aim of the project is to improve the capacities of public administrations and local communities to adapt to climate change. Among awareness raising and other measures, ecosystem-based approaches including the lagoon functions for coastal protection will be implemented.
- Lake Skadar-Shkoder Integrated Ecosystem Management Project, 2008-2012, GEF and World Bank[14]: For the first time a transboundary management for the sustainable usage of the lake was prepared. The importance of the lake for water retention was underlined.
- Identification and Implementation of Adaptation Response Measures in the Drini-Mati River Deltas, 2008-2012, GEF and World Bank[15]: Similar to the first project mentioned for Albania, many activities include capacity building and awareness raising, but also smaller pilot projects regarding coastal protection are accomplished.
- Elbasan Reforestation Project, 2016 to 2026, Ministry of Environment, Forestry and Water Administration and World Bank: This project includes several reforestation projects, e.g. for the degraded area along the Shushica river and the arrangement of the Shkumbin riverbed in the erosion zone.
- Towards the implementation of Nature-based Solutions in Albania: The role of ecosystem services in disaster risk reduction and climate change adaptation, IUCN (2017a).

Selected Projects in Bosnia & Herzegovina:

- UNDP Vrbas Project (UNDP/GEF, 2015-2020, 5 Million €)[16]: This constitutes a technology transfer for climate-resilient flood management in the Vrbas River Basin; supporting state, entity and local governments (14 municipalities) and public institutions. This project will enable a strategic management of flood risks via the legislative and policy frameworks, with appropriate sectoral policies and plans that incorporate climate change considerations. Among all relevant non-structural measures, also recommendations for “agro-forestation” are foreseen, which may be relevant for NbS. (UNDP 2015 and 2017).

---

[13] http://addis.unep.org/projectdatabases/01222

[14] https://iwlearn.net/iw-projects/2133

[15] http://www.al.undp.org/content/albania/en/home/operations/projects/environment_and_energy/identification-and-implementation-of-adaptation-response-measure.html

[16] http://www.ba.undp.org/content/bosnia_and_herzegovina/en/home/presscenter/articles/2018/01/24/unapre-enjem-sistema-reagovanja-na-poplave-do-smanjenja-teta-.html

- Drina GEF, development of RBMP and flood risk management[17] and further projects e.g. of REC (Regional Environmental Center for Central and Eastern Europe) and US EPA (United States Environmental Protection Agency), including a so-called river integrity analysis with at least NbS aspects are currently accomplished.

Selected Projects in Croatia:

Several projects already include the implementation of NbS for flood mitigation:

- Within the EU Structural Funds (Operative Programme "Competitiveness and Cohesion 2014-2020) the "Improvement of the non-structural flood risk management measures in Croatia" (2017-2022, up to 40 Million €) includes a big package for the improvement of flood forecasts, modelling and flood risk mapping, further a sub-item on "Improvement to the system of integrated water management and flood risk management, including identification of natural water retention measures." is under implementation by the Croation Water management (Hrvatske Vode).
- Flood Protection Project "Karlovac-Sisak" (2014-2022, 120 Million €): The Project will provide the necessary flood protection for the city of Karlovac and other settlements along the Kupa River from Karlovac to Sisak, which are frequently and severely flooded. The Project aims to enhance the capacity and operation of the natural retention area Kupčina by constructing facilities at the junction "Brodarci" upstream of Karlovac, which will increase the amount of water that can be diverted from Kupa River via the existing diversion channel "Kupa-Kupa" into the retention area Kupčina. In addition, the Project aims to improve flood protection by the reconstruction of dikes and the construction of other facilities which will provide more "room for the river" (e.g. channel Korana-Kupa).
- Flood Protection Project "Krapina" (2014-2019, 13.6 Million €): Aim of the Project is to improve flood protection in a number of settlements within the Krapina River Basin, where significant flood risks had been identified. The project will include the implementation of integral measures in 9 settlements. They will consist of main channel regulation (capacity increase) within settlements, coupled with green infrastructure measures downstream the settlements, thereby reducing the flood risk within settlements and ensuring no increased flood risk downstream and providing environmental benefits at the green infrastructure sites. In addition, the project will include construction of two retention areas (Slani Potok and Reka) on tributaries and one retention site on the main course of Toplicina River for the purpose of protecting Stubicke Toplice, as well as the construction of a flood protection dike at Pojatno (which was found as the best option after considering the technical and economic feasibility of potential green infrastructure measures).
- Flood Protection Project "Ogulin" (2014-2019, 14.6 Million €): Aim of the project is flood protection for the city of Ogulin. The main project feature is the construction of the retention area "Ogulin" on River Dobra, which will retain flood waters and reduce flood peaks within the city of Ogulin. Additional measures for cleaning the Dobra River channel and the "Dulin Ponor" sink will further enhance flood protection of the

[17] http://www.wb-drinaproject.com/index.php/en/?iccaldate=2015-07-1

city, while providing more room for the river in line with the green infrastructure concept.

- Development of Transboundary Forest Retention Project for Integrated Flood Risk, Environmental and Forestry Management (FORRET[18]; 2017-2019, 1.5 Million € - under revision): The development of a transboundary retention forests in the transboundary area of Spacva/Bosut/Morovic together with Serbia would reduce peak flood flows of the Lower Sava River by diverting water into the natural retention area north of the Sava River, while improving environmental and forestry management in the retention area. In addition, a joint monitoring system to measure the Sava River flows upstream and downstream of the Croatian-Serbian border will be established. The expected results of the project are joint studies on alternative options for integrated flood risk, environmental and forestry management in the transboundary area, including a feasibility study for the project that would implement the best alternative, and a joint monitoring system.
- DravaLife (EU Life Project, 2015-2018, 7 Million €): River restoration on six sites along the Drava including measures to improve the flood conveyance by river restoration and channel widening near Repas/Koprivnica.
- EU Structural Funds/Natura 2000 funding to prepare a guidance book for the implementation of environment-friendly project implementation of water management projects (incl. flood defences) from 2018; set of measures incl. monitoring and implementation.

Selected Projects in Kosovo:

- ECRAN[19] 2015: Expert Training on Risk and Vulnerability Assessment and Adaptation Planning – Urban Planning and Development: The training aimed to improve the understanding of climate change adaptation measures in the water management sector and the preparation of national strategies and action plans.
- CRESSIDA solutions in Kosovo (Building Local Community Resilience for the Sustainable Development of Watersheds in South Eastern Europe): Building Local Community Resilience for Sustainable Development in International Watersheds 2015 (REC[20], EPA US): This project refers to the flood management of the communities of Sapniq and Bellaja on Rimnik river and set relations to the river basin management.
- Disaster Risk Reduction Initiative , with some hints on NbS (UNDP Kosovo, 2014): The project focus on communication and awareness raising regarding disaster risk reduction, in particular for floods.

Selected Projects in Montenegro:

- ECRAN 2015: Expert Training on Risk and Vulnerability Assessment and Adaptation Planning – Urban Planning and Development: See above explanation for Kosovo.

---

[18] http://www.voda.hr/hr/novosti/medunarodna-suradnja-hrvatske-srbije-na-projektu-forret

[19] http://www.ecranetwork.org/

[20] http://www.rec.org/project-detail.php?id=30

- Lake Skadar-Shkoder Integrated Ecosystem Management Project Lake Skadar[21]: See above explanation for Albania.

Selected Projects in Macedonia:

- UNDP 2016: Vardar valley, several projects (2012-2016): Besides many projects dealing with the reconstruction of structural flood defences after several significant flood events in the period between 2012 and 2016, the “Vardar planning region” set the framework to wider sustainable flood risk planning including NbS.
- UNDP: Strumica[22] and Prespa Lake lowlands (since 2010 e.g. “Restoring the Health of the Strumica River Basin”): While in the Strumica basin the focus is put on the reduction of flood risk and droughts and on the decrease of pollution, at the Prespa lake shore the focus is put on the improvement of water purification through wetland restoration with positive side effects regarding flood control, sustainable land use and erosion control (afforestation).
- ECRAN 2015: Expert Training on Risk and Vulnerability Assessment and Adaptation Planning – Urban Planning and Development See above explanation for Kosovo.

Selected Projects in Serbia:

- The UNDP study on flood management in the Kolubara river basin (2015-2018[23]) aims to reduce future flood risks. The study indicates a variety of measures required to reduce flood risks and to prevent potential infrastructural damages. It also aims to develop an integrated protection system for various threatened areas at the Kolubara basin. The study is a step forward to more efficient flood protection planning in this basin, and aims at more focused efforts for flood prevention measures. This is part of a wider project dedicated to ‘’Increased Resilience to Respond to Emergency Situations’’, financed by the Government of Japan and implemented by United Nations Development Programme in partnership with the Serbian Public Investment Management Office.
- Development of Transboundary Forest Retention Project for Integrated Flood Risk, Environmental and Forestry Management FORRET; Compare above proposed project together with HR and pilot area in chapter 4.3 to prepare a feasibility study for reconnecting a large floodplain area south of Bosut forest with the Sava.
- Tisza River Modelling on the common interest section of Hungary and Serbia and developing of measuring equipment: This project resulted in the harmonisation of river modelling on both sides of the border, which has contributed positively to flood prevention measures, making them more effective. Further, upgraded equipment and the wealth of new information, such as predicted water height and assessment of the risk of a breach of dikes, have helped decision-makers to plan water management activities.

---

21 http://documents.worldbank.org/curated/en/846961468101064060/Albania-Lake-Skadar-Shkoder-Integrated-Ecosystem-Management-Project

22 http://www.mk.undp.org/content/the_former_yugoslav_republic_of_macedonia/en/home/operations/projects/environment_and_energy/restoring-the-health-of-the-strumica-river-basin.html

23 http://studijakolubara.srbijavode.rs/izvestaji_o_rezultatima_studije/

- Measurement, Monitoring, Management and Risk Assessment of Inland Excess Water in South-East Hungary and North Serbia (Using remotely sensed data and spatial data infrastructure): The project investigated the formation of the different types of inland excess water and monitored conditions of seepage of groundwater using acoustic sensors to monitor the well system. Further, the project devised and tested a novel methodology for mapping field inundations based on remotely collected data and developed an Internet-based monitoring system, which can support the management of inland excess water.
- Environment-friendly Water Management in Plain Areas: This cross-border project aimed to improve water management cooperation and monitoring in AP Vojvodina and Csongrad County in Hungary. The activities conducted as part of this project have ultimately played a great role in preserving the biodiversity and improving the water quality of the River Jegricka and the Kurca Stream.The project partners successfully improved the watercourse of these two bodies of water in the cross-border region by dredging and removing sludge and excess vegetation from the riverbed. They also developed a joint monitoring and analysis system in order to help prevent flooding in the cross-border region. The joint work has brought direct benefit to farmers and the local populations, as precise and timely information about potential flood risks is now available to them and the authorities.
- IUCN workshop and study on NbS “Towards the implementation of Nature-based Solutions in Serbia” (IUCN 2017b): Examples for NbS in Serbia.
- Various smaller projects, in particular in the Vojvodina and Backa regions between 2005-2015 mainly in floodplain areas, which include vegetation management, clearance of side channels and re-establishment of the lateral connectivity with the Danube, initiated by the Institute for Nature Conservation of Vojvodina Province in Novi Sad.
- Feasibility studies in preparation (Nature Conservation of Vojvodina Province): An area within the nature park Gornje Podunavlje is proposed for further flood retention measures.

Selected international Projects:

- The German Cooperation project “Climate Change Adaptation in Western Balkans (CCAWB, from 2012-2018, 3.5 Million €) started in 2012 as a cooperation project between the relevant Ministries in Albania, Kosovo, Macedonia, Montenegro, and Serbia with the GIZ. The overarching project objective is the adaptation to predicted impacts from climate change. Specifically, the project aims at reducing the risks of floods and droughts. In particular, support is provided in the following areas: flood risk management (establishment of a regional flood early warning system for the Drin River basin and communal flood risk management), development of drought management plans for water companies, supporting processes to draft national climate change adaptation strategies and plans, enhancement of regional cooperation in water resources management, integration of climate change adaptation in urban planning and development in the cities of Belgrade, Podgorica and Skopje.
- GEF/World Bank: Drina basin project in BA, RS, ME - The “West Balkans Drina River Basin Management (WBDRBM)”: This project aims to improve mechanisms

and build capacity of the project countries to plan and manage the transboundary Drina River Basin, incorporating climate change adaptation[24].

- The Drin River Basin Initiative (AL, KV, MK, ME, GR), also a new GEF project[25], works on establishing a transboundary water management and flood planning. But so far no continuous funding is secured.
- In 2015, the EU Western Balkan Investment Framework (WBIF, European Commission 2015) prepared an extensive assessment of flood policy implementation and assessment of projects (planned projects and country wish lists). The inventory includes numerous structural projects but only a few links to NbS).

[24] https://www.thegef.org/project/west-balkans-drina-river-basin-management-project

[25] https://www.gwp.org/en/GWP-Mediterranean/WE-ACT/Programmes-per-theme/Transboundary-Water-Resources-Management/gef-drin-project/

3 Review and analysis of policies, practise and stakeholders of nature-based solutions

Based on a review and interviews with various stakeholders for each country, the national implementation of policies related to flood risk management and the role of NbS as well as climate change adaptation strategies were evaluated, and barriers for implementation for NbS and NWRM identified. Relevant projects are listed below.

Stakeholders were identified for each country in the following sectors:

- Ministries for water management, environment, spatial and physical planning, agriculture, forestry, energy, rural development and departments concerned with the (pre) implementation of the EUWFD and EUFD
- Representatives of international organisations like UNDP, GEF, World Bank, ICPDR e.t.c.
- Agencies and directorates for civil emergency management
- National institutes for hydrometeorology and universities
- National disaster risk organisation
- Nature protection administration and practitioners
- International NGOs
- National NGOs
- International and national experts
- Municipalities

Various international projects in the area (EU, World Bank/GEF, UNDP, State development agencies, International River Commissions) are additionally considered. Based on the interviews, barriers for implementation for NbS and NWRM, and ways how to find solutions were explored at the end of each chapter.

Tab. 6: Responsible sectors and stakeholders for the implementation of potential NbS

Country	Water sector	Environmental sector	Disaster risk sector
AL	Ministry of Agriculture, Rural Development and Water Management; Water councils	Ministry of Environment; National Agency of Protected Areas; National Coastal Agency	Ministry of Interior Affairs
BA	Two entites, Republika Srpska and Federation of Bosnia and Herzegovina: Federation of Bosnia and Herzegovina, Ministry of Agriculture, Water-Management and Forestry, Sector for Waters Republika Srpska, Ministry of Agriculture, Forestry and Water Management	Republika Srpska, Ministry of Physical Planning, Civil Engineering and Ecology Federation of Bosnia and Herzegovina, Ministry of Environment and Tourism	Ministry of Interior/Security
HR	Ministry of Environment and Energy HV (Hrvatske Vode) (Croatian Water Management)	Ministry of Environment and Energy	Ministry of Interior

Country	Water sector	Environmental sector	Disaster risk sector
KV	Ministry of Environmental and Spatial Planning	Ministry of Environmental and Spatial Planning	Ministry of Internal Affairs
ME	Ministry of Agriculture and Rural Development	Ministry of Sustainable Development and Tourism	Ministry of Interior; National Protection and Rescue Directorate
MK	Ministry of Environment and Physical Planning ; Ministry of Agriculture, Forestry and Water Economy	Ministry of Environment and Physical Planning	Ministry of Interior; Protection and Rescue Directorate
RS	Ministry of Agriculture, Forestry and Water Management	Ministry of Agriculture and Environmental Protection- Directorate for Waters	Ministry of Interior

3.1 Implementation of the EU Floods Directive

A thorough evaluation of the implementation of the EU Floods Directive (2007/60/EC) and compatible related national policies in the Western Balkan countries, carried out by European Union after the catastrophic floods in 2014 (EUROPEAN COMMISSION 2015), assessed the status of organisational and legal implementation of the EU Floods Directive as follows: RS and BA are both at about 70-75 %, (with RS having much stronger organisational level due to its centralised bodies, compared to BA with its two large entities), AL reached similar values (73 %) but its organisational conditions, overlaps in responsibilities and legal implementation still to be improved. In ME, at least WFD is in implementation but the adoption of FD is still pending and its implementation percentage reaches only 52 %. MK and KV follow with only some 15 %.

As a member state, Croatia completely adopts European legislation, but for the implementation and data completion it still needs additional time. The climate change adaptation strategy is already at an advanced stage.

First, it should be pointed out that the EUFD is strongly related to the implementation of the EUWFD, and their cycles of application of management plans, and programme of measures need to be synchronised. Therefore, from the year 2021 on both directives and management plans should be working smoothly together. The ICPDR and Sava Commission strongly support this integration.

The EU IPA Floods Project

Started in 2015, the “Programme for Prevention, Preparedness and Response to Floods in the Western Balkans and Turkey (“The Programme” or “IPA FLOODS“) – funded by the European Commission, DG ECHO (European Civil Protection and Humanitarian Aid Operations) through the Instrument for Pre-Accession Assistance (IPA) – is intended to increase beneficiaries’ capacity to ensure proper flood risk management at national, regional and EU levels.”[26] Until end of 2018 in total 6 Million € are available to:

- Increase beneficiaries’ capability to develop effective national civil protection systems
- Support beneficiaries in becoming better prepared to cope with the challenges posed by approximation to/implementation of the EUFD.
- Collaborate in a coherent manner in dealing with floods at regional/European level (prevention, preparedness and response)
- Implement capacity building for flood preparedness and response through establishment of multinational civil protection modules for flood response.

Most of the project is focusing on non-structural measures, such as the establishment of forecast and warning systems as well as the implementation of the EUFD, by supporting countries to prepare flood risk assessments and related management plans.

Albania

The legal and institutional framework for Flood Risk Management was updated considerably over the last years and will apply and implement EUWFD and EUFD to a large extent until 2020. The National Water Council with its technical secretariat has a central function in all issues related to water. It elaborates National Sector Programmes including those on floods.

Flood event records and data about losses are collected at the “DesInventar” platform. Since 2012 single flood prone areas, such as in particular the lower Drini and Buna rivers near Shkoder, were mapped systematically. Only for the Shkoder Region, a GIZ project developed a first flood risk management plan within Albania (GIZ 2015).

Bosnia & Herzegovina

BA consists of two entities and one district, forming the main administrative units: The Federation of Bosnia and Herzegovina, Republika Srpska and Brcko District. The Ministry of Foreign Trade and Economic Relations has the overall coordination at a state level and for international cooperation regarding water related issues, but the legislation on water management is organised at the entity level, following different approaches. Today, the Federation and the Republika Srpska apply new laws being mainly coherent with the EUWFD and EUFD. Also the development of respective FRMPs and RBMPs became better coordinated between the two entities, with support and in coordination with the Sava Commission, but also within connecting activities such as the IPA Flood Project. The civil protection sector was also adapted in all entities to ensure better coordination and international cooperation.

[26] http://ipafloods.ipacivilprotection.eu/

Regarding preliminary flood risk assessments according to EUFD, both entities already started work in 2014 and 2015, thus partly before the major flood of 2014 and only for parts of the country. These assessments are currently under revision and near completion, and the preparation of flood risk maps and planning shall be achieved until 2019.

Croatia

Croatia is the only EU member state within the project area and fulfils all legal requirements for the completion and implementation of flood risk and river basin management plans according to both directives within the envisaged deadlines. Croatian Waters / Hrvatske Vode (HV) is the management body under the Ministry of Agriculture dealing with all water issues, notably EUWFD and EUFD implementation.

According to the National Flood Risk Management Plan besides Croatian Waters, the following institutions are involved in flood management:

- Ministry of Agriculture
- National Meteorological and Hydrological Service
- National Protection and Rescue Directorate
- Units of local and regional self-government
- Other competent state administration bodies
- Companies certified by HV for works in implementation of preventive, regular and emergency flood defence measures

All flood risk assessments and the FRMP are publically available at http://korp.voda.hr/. Croatian Waters collected extensive data of historical flood events as a basis for the EUFD and analysed over 260 flood events in more detail (flood risk mapping[27]). Nearly 3,000 areas with potential significant flood risk were delineated. For the update cycle of 2018 the inventories will be reviewed by better considering the exposure (human activities) and the flood origins (fluvial, pluvial, groundwater, sea water, artificial water bearing infrastructure).

The FRMP as a planning document comprises general measures without specific site locations. In its national Flood Risk Management Plan, Croatia states:

"Croatia's draft Flood Risk Management Plan (FRMP) reflects the orientation towards emphasising the natural water retention areas and flood retention areas for the flood prevention and flood protection. As a prevention measure, the FRMP provides for the continuation of ongoing activities on formal introduction of a special level of protection and maintenance of natural water retention and wetland areas and boundaries of the public water domain in the process of physical planning. As a protection measure, the FRMP encourages selection of technical solutions that will ensure:

- Retention of water in the watershed as long as possible and allowing room for watercourses to slow down the runoff;
- Preservation, restoration and enlargement of areas that can retain flood waters, such as natural water retention areas, wetlands and floodplains;

27 http://voda.giscloud.com/map/321490/karta-opasnosti-od-poplava-po-vjerojatnosti-poplavljivanja

- Prevention of pollution of water and soil by harmful substances during flood events in areas reserved for flood water retention by land use restrictions and administrative measures;
- Continue creating lowland retentions in the areas of former floodplains for the purpose of flood flow reductions and flood protection of downstream areas;
- Usage of the existing lowland retention areas for meadows and grazing areas or for restoration of alluvial forests;
- Identification and preparation of protection and management programmes for floodplains and retention areas that could be used as natural water retention areas.

In the prioritisation of the flood protection measures, the natural water retention and flood retention measures (i.e. Green Infrastructure measures) are emphasised over the structural flood protection measures where their application is technically and economically feasible. Concerning the financing of the flood protection measures in Croatia the EU structural funds should be used."

Kosovo

The Ministry of Environment and Spatial Planning and the Inter-ministerial Council for Waters are responsible for all issues regarding water. The EUWFD is to become more or less legally adopted and implemented, however the EUFD is so far not implemented, but there is a law under adaptation towards the requirements of the EUFD by the Water Department within this Ministry. The new regulation had to be approved in 2018. Important for international relations is the "Memorandum of Understanding for the Management of the Extended Transboundary Drin Basin", signed in Tirana, November 2011 by the Ministers of Water and Environmental Management of Albania, the former Yugoslav Republic of Macedonia, Greece, Kosovo and Montenegro.

Only a few pilot projects on preliminary flood risk assessment were accomplished so far (Water project for flood risk in the location of Skenderaj and projects on Drini Bardhe and Morava Bince catchments). A database on historical floods has been developed based on the DesInventar approach. No flood risk and flood hazard maps are available so far.

Macedonia (FYROM)

As an EU candidate country The former Yugoslav Republic of Macedonia (FYROM) is undergoing a continuous process of harmonization of its national legislation, and its full adoption is envisaged towards 2020. Thus, In the field of flood protection, the national legislation is in line with the EUFD which provides a framework for assessment of the risk of flooding in river basins, mapping of flood risks in all regions (50 % of the country covered so far) with a serious risk of flooding and drawn up flood risk management plans.

The impact of natural hazards such as torrential floods intensifies due to improper exploitation and management of forests and agricultural land as well as due to uncontrolled urbanization. Former flood discharges with 100 years recurrence intervals are now events of a recurrence interval of 50 years or even less. Various contributing factors are identified, including transformation of the region from rural to urban landuses, deforestation, unsustainable agricultural practices, etc.

Another important factor is the dramatically reduced investment and maintenance in the water sector over the last decades, contributing to a deterioration of the country's water infrastructure. Aging infrastructure and inadequate investments in maintenance of public infrastructure put many flood control structures at risk of losing their functionality. In the best case the removal or at least the shortening/lowering of existing old flood dikes can be combind with the restoration and enlargement of retention areas. It will be important for FYROM to develop base line scenarios and flood design standards to properly react to future flood events.

Montenegro

Both directives (EUFD and EUWFD) are legally transposed into national law, but their implementation is slow. For the EUFD it has not even started yet. Similar to the other countries, the national Water Directorate is the competent authority and responsible to develop the plans which will be adopted by the Parliament and implemented by the Ministry of Agriculture and Rural Development. Flood management during emergencies is under the responsibility of the Ministry of Interior. The legal framework is under transposition and not fully revised yet, but the water act was updated in 2015 and is now fully compliant with EU law.

In the North, Montenegro belongs to the Danube catchment and aims to become member of the Sava and Danube Commissions.

There are still no country-wide flood risk assessments and plans, but at least the development plans of the largest towns and municipalities include a flood map based on the maximum water level. Flood events are recorded since 2001 and next step must be preliminary flood risk assessments. Pilot maps exist for the Lim river. Its FRMP is envisaged for 2021 together with the RBMP.

Serbia

The Serbian Water Law of 2010 (to be revised in 2018) complies with EU legislation. RBM and FRM plans will be fully aligned with WFD and FD requirements until 2021.

Implementation of the EU Flood Directive started on international level (draft of 1st FRMP for the Danube) and national level. The 1st Preliminary Flood Risk Assessment was completed in 2012, but included only riparian floods, without assessment of climate change impacts. 99 Areas of potentially significant flood risk will be defined (27 are already mapped) and the preparation of flood hazard and flood risk maps is in progress. Related objectives and measures are set in the Water Management Strategy.

FRMP: All APSFRs shall be mapped through the IPA 2014-2020 programme. The 2nd Preliminary flood risk assessment in 2018 will include all relevant types of floods and climate change assessment, also taking into account the 2014 flood.

The 1st draft FRM plan for the territory of the Republic of Serbia was finished in 2017, and its finalisation is foreseen for 2020. A FRMP in line with EUFD will be ready in 2021.

EUFD implementation at regional level (international bodies - Sava and Danube Commissions)

The ICPDR developed the first FRMP for the roof level (Danube River Basin District) already in 2015 and supports and guides its member countries in the EUFD implementation. Further, the ICPDR commissioned several studies on climate change and adaptation strategies. ICPDR prepared and accomplished successfully a workshop on climate change adaptation in Belgrade (March 2018[28]).

The Sava Commission (ISRBC) develops a huge hydrological database and GIS data on flood risk management and strongly aims at developing an overall Sava FRMP, based on the so-called "Protocol of Floods" and a paper on the "Development of the FRMP". In an updated version, this will include explicitly nature-based solutions as complementary measures (ISRBC 2014, WORLDBANK GROUP 2015).

The European Commission commissioned 2015 an extensive gap analysis and needs assessment in the context of implementing the Floods Directive within the Western Balkan region (after the flood in 2014), with extensive project and investment estimations per countries (mainly potential structural projectes proposed by countries).

The most extensive European project or even programme is the IPA floods project, covering all Western Balkan countries (IPA 2016). It aims at supporting all countries in the adoption and implementation of the Floods Directive.

Current bottlenecks and management needs for implementation

Across all countries in the region, various barriers and implementation problems exist, depending on the political situation, structure, funding source and stage of EU accession:

- Implementation of EU policies: The most relevant EUFD is yet not fully adopted in any of the countries. While it is adopted in Croatia, it is partly transferred into national law in BA and RS, and it is partly implemented in AL. Practical implementation will follow (in particular with the Potential Flood Risk mapping), so that until 2020 all countries will have at least preliminary flood risk maps. Other key policies, such as WFD, are in similar stages of implementation.

- Governance: The structure and organisation of implementation of the EU Directives varies between the countries. For example RS is basing it on a strong central competence and hierarchical organisation, while BA splits it up in the two entities with their ministries and public institutions (at least with a basic cooperation). Other countries like AL still have to define consistent responsibilities and ensure good organisation. Another governance issue is narrowly focused policies within sectors, thus incapacitating the authorities to look at problems in an integrative way.

- Gaps of data: Missing data, starting with hydrometeorological and discharge records, but in particular flood risk data, are still a serious problem in many countries and one of the core interests of international support. In several countries data are not collected systematically (in a centralised, digital way) and data for several time series hardly exist. The continuous delineation of flood-prone areas is in some countries just at the beginning (pilot projects exist everywhere).

- Lack of knowledge and capacities: Another crucial reason for weak implementation of NbS is the lack of competence (training, responsibility) and capacities (equipment, staff), both on the side of authorities but also in the education and research sectors.

[28] http://publications.jrc.ec.europa.eu/repository/handle/JRC111817

- Funding, incl. compensation for farmers: Several financial tools for non-EU and accession countries exist, however the funding of flood management (investment, operation and maintenance) is difficult for national budgets. Also compensation payments for flood damages are strongly limited and insurance systems are still underdeveloped.
- Land availability: In most of the countries land availability is a crucial factor for the feasibility of flood management projects. Nevertheless, land prices are still rather moderate and the case of the Hungarian flood polder plan on the Tisza shows that over some decades large projects with significant areas for flood management can be realised.

Based on this short country review of barriers, constraints and problems, the following list of management needs can be concluded in order to apply and upscale NbS to flood prevention:

Knowledge and competencies

- Trainings and capacity building regarding NbS-approaches (mapping and assessment of the flood risks)
- Improved implementation due to better education and training (engineers, ecologists, field workers)
- Improved methodology for flood risk assessment adapted to the region
- Share knowledge how to reduce hydromorphological pressures and impacts on flood defence structures
- Increase involvement of trained experts (universities, competent institutions, consultants)

Data preparation

- Systematic mapping of flood-prone areas
- Assessment of flood retention capacities along still unregulated rivers
- Improvement of the ecological and hydromorphological assessment and monitoring (EUWFD and EUFD)

Planning and cross-sector cooperation

- Continuous (entire river reaches or catchments) flood management planning and combination of structural measures with NbS; problematic environmental impact of many structural projects versus combined NbS
- Priority for measures that address EUWFD and EUFD including hydromorphological pressures (achieve synergies wherever possible)
- Regular cross-sectoral cooperation of the water sector with e.g. spatial planning, energy, fisheries, nature conservation, transport
- Obligatory mitigation measures for reduced flood safety due to hydropower projects (master planning)
- Improvement of emergency plans and crisis management

Funding

- Coordinated and secured budget and funding from national to local levels
- Extension of staff and capacities (water administration)
- Provision of additional resources (for field visits, studies, analyses)
- New funding opportunities for flood management where the application of NbS is made conditional

Policies

- Improvement of cooperation between entities in BA, but also between local and national authorities and civil protection units, and development of further harmonized methodologies on flood risk management
- Good synchronisation for Flood Risk Management Plans between local, national, transboundary and multilateral levels (Sava Commission)
- Strengthening of the institutional framework resulting in a clear structure and responsibility
- Ensurance of cooperation betweeen the water management/flood risk management and the environmental sector
- Existing and planned CCA strategies make use of both structural measures and NbS; new dams and dikes are planned in a way not to impact nearby river reaches.
- Full implementation of the legal framework and administrative capacities

3.2 Climate change adaptation strategies and NbS

Regarding the political framework and implementation of NbS, the CBD, UNFCCC, EUWFD & EUFD provide a favourable context for NbS, as well as related work of ICSRB and ICPDR, resulting in a need to accordingly "greening" national flood protection strategies. Core elements can be found in national and international CCA strategies.

Most of the Balkan countries are member of the "United Nations Framework Convention on Climate Change" (UNFCCC) and ratified at least the Kyoto Protocol (1997), the larger ones also the Paris Climate Agreement (2015).

In each country, at least national climate change reports have been developed since 2010, followed up in most countries at least by low carbon adaptation strategies but in many countries also by the development of full CCA strategies. Croatia, which participates as an EU country also on the EU CCA Strategy, prepared so far the most advanced strategy, with nearly 180 pages of various thematic content and rather detailed action plans, which are currently under public consultation.

In most of the strategies, the immediate activities to face the increasing risk are laying in the improvement of knowledge and awareness, and therefore in preparedness of disaster risks across entire societies, to improve the early warning systems and related emergency organisation in case of disasters, also by sufficient funding. In particular, in the small countries, an effective institutional and regulatory framework does not always exist, and effective approaches and responses to disasters are not available.

In general, all countries address the regulation of river floods mostly by structural measures and by the construction of dams which serve during droughts as reservoirs, e.g. for irrigation. As a response to climate change, spatial plans should be revised and adapted, or in many countries, they have to be systematically developed for the first time. CCA strategies should foster the integration of adaptation in various sectors. E.g. the water sector already reacts with the Flood Risk Directive of 2007 to both address flood management and climate change adaptation.

Albania launched its national adaptation plan for climate change (NAP) in 2016. For biodiversity, a project on environmental services is mentioned, which aims to build up payment for ecosystem services schemes to halt further land and forest degradation and to ensure a more traditional use of the country's natural resources. Further, adaptation measures are proposed and recommended under the project "Identification and Implementation of Adaptation Response Measures in the Drini – Mati River Deltas", which must be further extended and adapted to the entire Albanian coast.

In Bosnia-Herzegovina (UNDP 2013), the strategy focuses on water resources and agriculture, and on the reduction of emissions (therefore the hydropower sector is promoted by the strategy, not fully considering the environmental impacts, which is the case for most of the country strategies).

Croatia developed an extensive CCA strategy over the past years. Regarding NbS, there are in addition to the already stated links to the EUFD relevant chapters of the national FRMP, the commitments to better implement environmental protection (environmental impact assessments and strategic environmental impact assessments for structural measures) to reduce anthropogenic pressure on the rivers. Key points relevant for NbS explicitly mentioned are "Flood adaptation measures" and the development of "Green infrastructure" (river restoration and provision of natural lowland areas for controlled flooding and retention). On the other hand, there are clear statements in favour of structural measures, including the construction and upgrading of existing accumulation and retention systems and multifunctional hydraulic facilities. Also foreseen is the construction of protective dikes. Finally, the long-term modelling of climate change effects forms an integral part of the strategy. Croatia is the only country further working on disaster risk assessments and the modelling and prediction of potential future damages caused by climate change.

For Montenegro, an extensive report on climate change was published in 2015 by the Ministry of Sustainable Development and Tourism. In ME, KV and MK, the ECRAN project initiated the preparation of relevant strategies (ECRAN 2015).

In Macedonia sectorial strategies were developed, in particular for agriculture.

In Serbia the draft Law on Climate Change is intended to ensure a continuous and transparent monitoring of the climate change situation, fulfilling international obligations, including national reporting, and covering all relevant sectors. There is also an ongoing project on the development of a national cross-sectoral Climate Strategy and Action Plan[29].

The Sava Commission (ISRBC) fosters a process towards a CCA strategy for the entire Sava basin (e.g. workshop in October 2017). To support the transboundary planning of CCA strategies and measures, the ISRBC aims at preparing a basin-wide strategy analys-

[29] http://www.serbiaclimatestrategy.eu/

ing first the climate change in the Sava region and the expected impacts on all sectors as well as disaster risk reduction and nature conservation. It will include advanced contents in the fields of guiding principles on climate change adaptation, adaptation objectives and targets as well as all (transboundary) measures. It will enable full public information and participation.

Very first basic guiding principles on climate change adaptation can be summarised as follows:

To avoid new, unacceptable natural hazard risks and maladaptation, **nature-based adaptation solutions have priority**, the creation of win-win solutions with other strategies and implementation actions (e.g. EUWFD) aim for no-regret measures. Such measures can be justified under all plausible future climate change scenarios. Plans and actions required by the EUWFD and the EUFD are building the basis for adaptation and ecosystem-based measures should be explicitly mentioned in such a strategy.

In the recommendations of the Water & Climate Adaptation Plan for the Sava River Basin (Worldbank Group 2015) the countries stated: “The Flood Guidance Note, as well as the stakeholders, emphasizes the need to give more space to rivers especially by using the natural wetlands and floodplains both for flood control and biodiversity conservation, but also by deepening and/or widening the river channels. Introducing the flood hazard maps into the spatial plans and prohibited or controlled development in flood plains is also of primary importance.”

On international level, several recent publications (EEA 2017a, Lo 2016) address climate change adaptation and disaster risk reduction. Regarding the implementation of NbS in Europe, Strosser et al. (2015) published numerous case studies for the European Commission.

Other important EU directives of relevance for NbS for flood mitigation are the Habitats Directive (EUHD) and the Renewable Energy Directive (EURED). IUCN will soon publish a detailed report on the state of nature conservation in the Balkan countries, highlighting the implementation of the EUHD and the great importance of habitats including wetlands in the Balkan region. The EURED will lead to significant hydroelectric exploitation in the region which will heavily alter the hydromorphological conditions of affected river systems.

4 Potential NbS sites, priority areas and pilot project proposals

Based on the findings of chapter 2 including the delineation of potential floodplains and areas prone to landslides and the identification of current or potential ecologically valuable retention areas) and on the review of current projects and relevant policies in chapter 3, the identification of potential NbS project areas will finally lead to a prioritized list and proposals for pilot projects.

4.1 Determination of potential NbS sites and criteria for identification of priority sites

First, all the data collected in the previous steps, namely the flood and landslide prone areas, the inventory of still existing flood retention areas and wetlands as well as the numerous flood related projects, were analysed. The list of potential NbS and initiatives is heterogeneous and can range from the preservation of still existing flood retention areas to adaptive measures in the built environment (water infiltration and storage in cities, which is not part of the study).

One core criteria for the prioritisation of areas must be the function and amount of retention of water in relation to the vulnerability of landuse in the downstream area. The water can be stored in permeable soils, underground (incl. karst), in (coastal) permanent wetlands or, as the most important way, as temporal flow through the active floodplain along the rivers.

Due to very limited hydrological data on retention capacities in relation to continuous discharge data (for calculation of the retention effect), such an assessment can be done only very roughly. In many cases the precise size of a project can vary significantly (e.g. the size and effect of afforestation, potential versus feasible restoration area extent or the number of infiltration devices or effect of reduction of sealing). On the other, side cost-benefit calculations are important but must also take cumulative and spatio-temporal effects into account (one bigger flood detention basin (dam construction and maintenance) can be less cost effective than several flood retention areas downstream, e.g. by reconnection of still exisiting floodplain areas if land is available and usage adapted to floods.

For this study the delineation of potential areas is based mainly on the available land in the floodplains and, where possible, on the location of settlements and on the damage potential in the vicinity. Only potential major NbS projects with a focus on water retention areas were considered. The ranking is done according to three priority classes (or better “significance classes”), with a) very high b) high and c) low priority. Further, NbS such as upper catchment river basin restoration, soil conservation measures, coastal restoration etc. are only considered if reliable project information was available.

Criteria to assess and prioritise proposed NbS are:

1. Magnitude of expected impact (e.g. retention capacity, lowering of water levels)
2. Cost effectiveness (construction costs of the NbS versus potential flood damage and additional other ESS)
3. Feasibility, namely land ownership
4. Opportunities incl. local support (e.g. workshop results to this project, pilot sites)
5. Biodiversity benefits

6. Other benefits (ESS), such as nutrient retention, cooling effects, carbon storage, recreation potential, etc. are not covered but would complete a comprehensive ESS assessment.

To facilitate the assessment for each parameter, three values, 1, 2, 3 are possible, whereas “1” means the highest score, “2” a medium score and “3” a low score. Finally the arithmetic mean is set, also if one of the parameters in missing.

Methodology of assessment:

In Tables 7 – 14 further below, the following criteria are assessed:

Ad 1) Estimation of retention capacity[30] (no precise data or prediction of reduction of water levels or discharges possible): Based on the river size (Danube, major tributaries and large Mediterranean catchment rivers, all other rivers), area size and maximum flood depth A): >15 Million m³, B): 5-15 Million m³ and C): < 5 Million m³.

Ad 2) The **Cost-Effectiveness** can be estimated by comparing potential damages in a flood case with the reduction of the downstream risk by implementing the NbS measure. To allow the inclusion of previously elaborated potential restoration projects (Schwarz 2010b, 2013 and 2016), the costs for a flood dike re-construction in case of a measure can give a first rough estimation. In the best, very rare cases old flood dikes can be removed without constructing new ones, but in most cases it will be necessary to erect a new dike with shorter or the same length than before (all those cases are assessed with A). If the length of the new dike is longer (100-120 %), the assessment is B) and if it is longer than 120 % it is C).

The detailled estimation can be based on the continuous resampled 50x50 m raster on impervious areas (sealed areas) and Corine data (EC 2017) within an appropriate distance to the NbS (10-30 km, and depending on tributaries entering the main river), which was applied only exemplarily.

Finally, the assessment can only give a general indication if the cost/benefit ratio is a) positive, b) even or c) negative.

General flood damage values and flood depth damage functions can be obtained from an EU guide[31] from 2017 trying to harmonize, standardize and determine average values across Europe and even globally. Flood damage and related values are very complex and heterogeneous, and can vary from country to country and from sector to sector (residential, industrial, agriculture, and infrastructure). The damage functions regarding the flooding depth “simply” try to predict the losses for e.g. 0.5, 1, 2, 3, 4, 5 or 6 m of flooding depth. The average maximum damage in Europe is calculated e.g. for residential buildings as zero, for 0.5 m flooding = 0.25 or 25 % loss of values, for 1 m = 0.4 (or 40 % loss), for 2 m = 0.6, for 5 m = 0.95 and finally for 6 m flood level = 1 (or 100 %). Due to lack of data on flood level and values, only overall and average damage values can be obtained and used in compari-

---

[30] The detailled retention capacity can only be calculated with 2d hydraulic models. For approximation, the retention area size and the maximum average flood depth are used to calculate the capacity in m³. The real capacity is depending on discharge and flow velocity as well as on roughness (land use) of retention areas. Finally the overall discharge volume over time in flood case and the filling behaviour influence the effectiveness of retention areas and the lowering of water levels or retardation of the flood wave progagation speed.

[31] https://ec.europa.eu/jrc/en/publication/global-flood-depth-damage-functions-methodology-and-database-guidelines

son to construction costs for NbS. Within the above mentioned EU study detailed country figures, including all Western Balkan countries, for 2010 allow to determine the overall mean value for maximum damage at 229 €/m² (per ha 2,3 Million €) for settlements (including commercial and industrial areas) and, based on data for the countries of the study area, for agriculture on average as nearly 803 €/ha. The used resampled 50x50 m settlement point raster (EC 2017) allows in combination with the Corine landuse classes of residential and urban areas the spatial assignment to potential NbS.

Costs to provide additional retention space (in m³) could be calculated based on the experiences of the Hungarian Vasarhely Plan polders[32] constructed within the past 10 years (in total some 5 Billion m³ new retention capacity along middle Tisza). To get for example one retention polder of 250 Million m³ the costs are about 65 Million €, or in other words for 1 m³ the price is 0,25 € (other polders reach 0,50 €/ m³ depending on land owner agreements and needed construction works), keeping in mind that this kind of polders might be even more expensive (inlet/outlet constructions) than the slicing of old and repositioning/construction of new dikes. In the Hungarian case, the expected water level reductions downstream are calculated with 30 to 40 cm for a 100 years event. With other words, those retention areas with comparable size could easily protect a small town where damages exceed the construction costs over several decades.

To give an example, if a potential NbS has the capacity to reduce flood peaks significantly (e.g. for some 30-40 cm by an increase of retention capacity of 20 Million m³, additional 1.000 ha will be flooded for 2 m) and will be implemented upstream of a settlement, the costs would be approximately 5 Million € (according to Hungarian costs and experiences). If the value of potential damages exceeds this value in a certain period, the cost/benefit ratio will be positive. In the case of a settlement and agricultural areas downstream, maybe 5 ha settlements (area of buildings and infrastructure only) and 500 ha agricultural areas can be flood-free after the NbS is implemented, the reduced average damage potential would be 11.5 Million € for settlements and 401,500 € reduction for agriculture, therefore potential maximum damage of 12 Million € could be saved for the maximum potential damage (e.g. a hundred year event, to be calculated by hydraulic models). This calculation is of theoretical nature (often the NbS should be implemented in combination with local structural measures, e.g to control erosion in rivers within settlements), but the general trend and spatial relevance and dependency of NbS must be considered.

Ad 3) Feasibility must consider in particular land availability and therefore land ownership. In the Hungarian case mostly agricultural areas, but also former grass- and wetlands, were included in the planning. Here only the general landowner ship pattern derived from one land use, and sometimes digital kadastrial system and maps (e.g. for HR) can be included, such as a) mostly public (e.g. forestry), b) mixture of public and private, c) mostly private land, often with various land owners. To allow the inclusion of previous proposals a rough estimation of ownership based on the land use (large, small or mixed plots) can be applied, like >70 % would fall into large plots (e.g. forest units) is A), 30-70 % (mixture of large and

[32] The so-called “Vasarhelyi plan” in Hungary along middle Tisza was developed after the disastrous floods in 2003. These are large-scale technical examples (and therefore only partial good examples for NbS), so far in total 6 polders with capacities between 20-900 million m³ were built which cost between 15 and 55 Million € each (EU funding was 25-50%): http://www.vizugy.hu/index.php?module=content&programelemid=113 Future floods will show the efficiency, but the increase of roughly 5 billion m³ is significant. However once the polder is flooded (compensation of the partly still intensively used agricultural lands will be expensive), more water cannot flow through it or only to a limited amount.

small plots) fall into B) and < 30 % fall into C) (mostly small scattered plots indicate mostly private ownership and therefore require complex land purchase).

Ad 4) Opportunities and local support are important for each project, therefore the proposed pilot areas should be ranked higher than others. Where local communities or public bodies already plan and initiate projects, or where already flood risk measure planning is ongoing (also including structural measures), this should be considered as a favourable condition. Only value 1 (A) for already initiated projects and 2 (B) for the pilot projects were given.

Ad 5) Regarding **biodiversity benefits** information about the habitats/land structure, the hydromorphological conditions and the presence of protected areas raise the scoring. Also nutrient reduction and carbon sequestration as well as groundwater infiltration, to state only a few other ecosystem services and benefits are covered by areas that are more natural. To include data from previously elaborated projects, the parameters of land structure (near-natural vegetation) is set in relation to agricultural usage. If the intensive agricultural usage is < 30 % the assessment is A), if 30-70 % it is B) and if > 70 % it is C). In terms of hydromorphology assessment values of 1 (near-natural) and 2 (slightly altered) were included as A), 3 (moderate) as B) and the values of 4 and 5 (extensively and severely altered) as C). Finally the coverage of protected areas allow a basic estimation about the ecological values of a certain area and the possibility of the ecological management of a potential restoration area. A coverage of > 70 % would lead to A), 30-70 % to class B) and <30 % to C).

Prioritisation score

The overall river restoration prioritisation score (A, B or C or in numerical values 1, 2 or 3) assigned to each area is the arithmetic mean of the scores for each parameter (compare country tables in the next chapter):

1 - 1.4 = 1 – very high potential/priority

1.5 - 2.4 = 2 – high potential/priority

2.5 - 3 = 3 – moderate potential/low priority

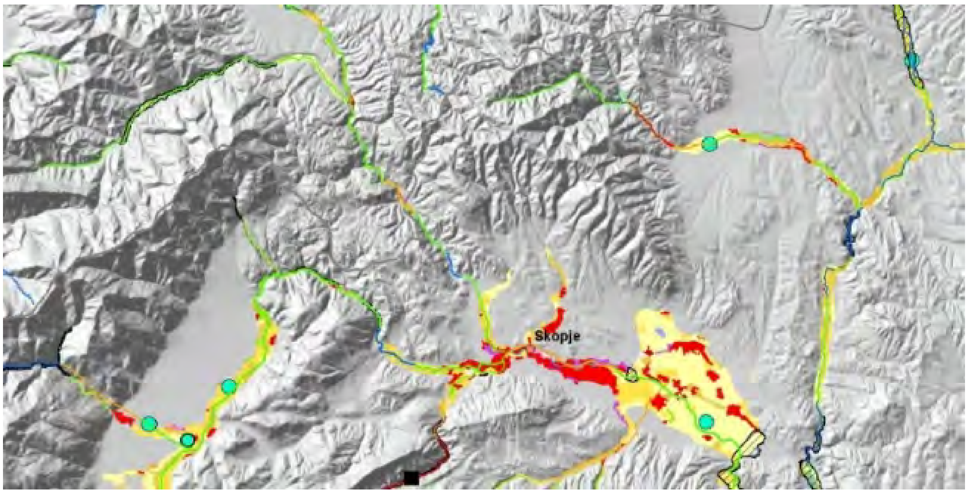


Fig. 25: Example for the used data layers to define potential NbS: Based on the seamless available data on flood prone zones, landuse (Corine), hydromorphological base assessment (rivers in four colours from blue “near-natural” to red “entirely modified and dam/reservoir information) and protected areas (hedged areas) at potential NbS sites (green dots) can be proposed.

4.2 Potential NbS projects and priority sites in each country

Potential NbS projects were collected and prioritised. In the first step, existing proposals for the potential reconnection and restoration of retention areas as well as proposed areas for afforestation/agricultural areas/coastal restoration or other NbS were investigated and combined in a map (Figure 26). Pilot projects as described in the next chapter 4.3 will derive not only from the "priority 1" areas list, but depend mostly on the regional initiative and feasibility of specific projects (those pilots where determined together with the workshop participants of each country in December 2017). Therefore, the prioritisation can serve only as a mid- and long-term planning instrument to focus at the beginning to those projects.

In total 264 potential NbS are proposed with a total area size of 399.322 ha and a potential retention capacity of up to 6 billion m³. Out of these projects, 24 (9 %) are ranked in the highest priority class, 151 (65 %) in priority class 2 and the remaining 69 projects (26 %) in priority class 3.

Tab. 7: All potential NbS projects with priority ranking (detailed parameter description in chapter 4.1).

Country	No of NBS	Total size in ha	Retention capacity in m³	Priority 1	Priority 2	Priority 3
AL	14	35,000 ha	150 million	5	7	2
BA	28	41,000 ha	750 million	1	15	13
HR	86	173,270 ha	2.8 billion	13	81	29
KV	7	9,000 ha	50 million	1	5	1
ME	4	3,000 ha	30 million	0	1	3
MK	17	20,400 ha	250 million	1	9	7
RS	66	161,900 ha	2.3 billion	3	53	14
Total	**264**	**399,322 ha**	**~6 billion m³**	**24**	**171**	**69**

In particular the cumulated effectiveness of several flood retention areas, but also their position in the river continuum (e.g. just upstream of settlements or of pairs of towns along transboundary rivers) should be evaluated to further sharpen the prioritisation. But also the combination of measures in different river sections (upper/middle/lower courses) can lead to successful implementation of NbS and is not considered so far.

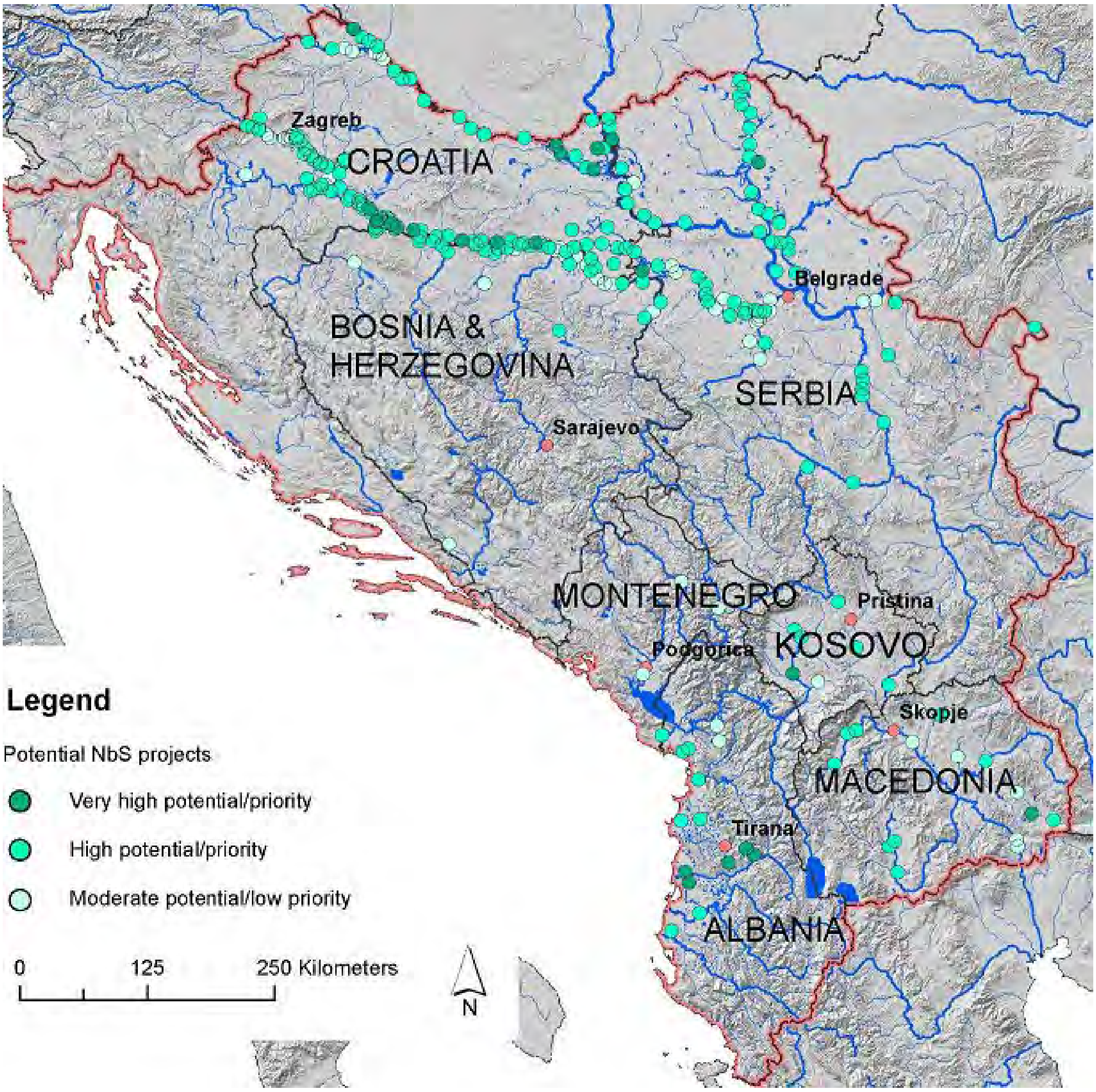


Fig. 26: Identified potential areas for reconnection of retention areas as well as sites for afforestation and other NbS (projects are categorised and assessed in the three priority/significance classes).

Albania

Albania hosts several potential sites for NbS in a wide range from afforestation in the mountains, over floodplain and retention areas along the middle and lower courses of rivers to several potential sites along the coast.

Tab. 8: Potential NbS projects in Albania

CountryNo, Name and river	1 Retention capacity	2 Cost effectiveness	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
AL01-05 Shkumbin, IUCN (wide range of potential measures)	2	-	1	1 (IUCN pilot proposal)	-	1
AL06-07 Drin-Buna	1 (diversion of about 1500 m³/s flood discharge	-	-	2 (pilot proposal)	-	2
AL08 Vjosa delta	1	-	-	2 (pilot proposal)	-	2
AL09 Devoll	2	-	-	-	2	2
AL10 Mati	2	-	-	-	2	2
AL11 Erzen	2	-	-	-	2	2
AL12 Ishem	2	-	-	-	2	2
AL13 Lezhe afforest., Drin	3	-	-	-	2	3
AL14 Puke afforest., Drin	3				2	3

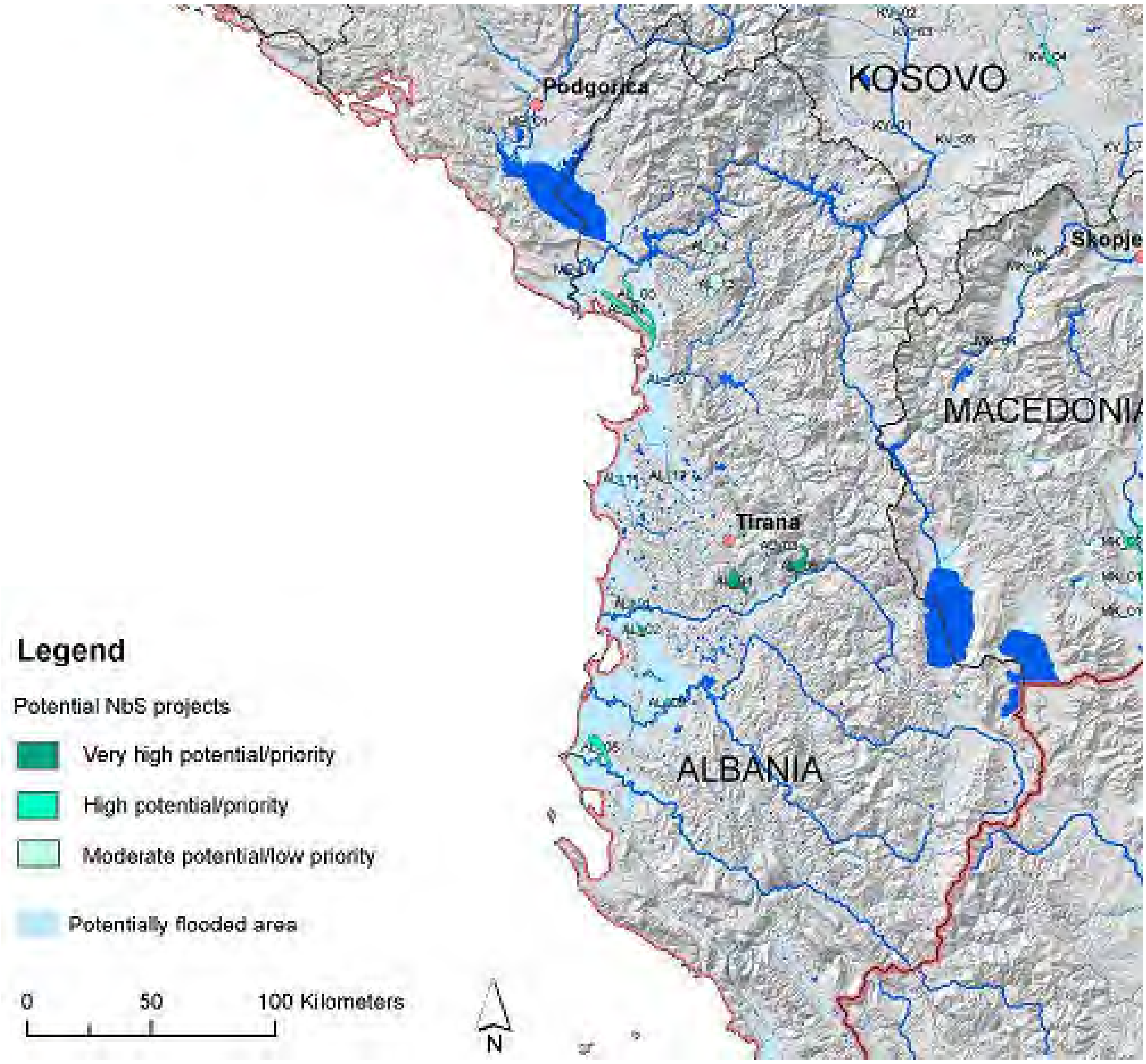


Fig. 27: Proposals for NbS-sites in Albania.

Bosnia and Herzegovina

Various potential sites for NbS are concentrated along the lowland reaches of the Sava and the lower Sava tributaries Una, Vrbas, Bosna and Drina. Some additional areas can be found along the middle courses of tribuatries and in some karst poljes.

Tab. 9: Potential NbS projects in Bosnia and Herzegovina.

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
BA01 Lower Bosna / Bosanski Samac, Bosna/Sava	1	3	3	2 (pilot proposal)	2	2
BA02 Modran	2	2	3	-	2	2
BA03 Novi Grad, Sava	1	3	2	-	2	2
BA04 Samac, Sava	2	3	3	-	2	3
BA05 Vucilovac south, Sava	1	3	3	-	2	2
BA06 Crnjelovo, Sava	1	1	3	-	2	2
BA07 Glavinac, Sava	3	2	3	-	2	3
BA08 Orahova, Sava	2	1	2	-	2	2
BA09 Gradiska, Sava	2	3	2	-	2	2
BA10 Greda, Sava	1	3	3	-	2	2
BA11 Skele, Sava	3	2	2	-	3	3
BA12 Gornji Svilaj, Sava	1	1	2	-	1	1
BA13 Gradina Donja west, Sava	3	3	2	-	2	3
BA14 Bardaca, Sava, Vrbas	1	3	2	-	2	2
BA15 Sijekovac fish ponds, Sava	2	3	2	-	2	2
BA16 Lijesce, Sava	2	3	2	-	3	3
BA17 Donji Svilaj, Sava	3	2	2	-	2	2
BA18 Tolisa	2	3	3	-	2	3
BA19 Vidovice, Sava	2	3	3	-	2	3
BA20 Vucilovac east, Sava	1	2	3	-	2	2

CountryNo, Name and river	1 Re-tention capa-city	2 Cost effec-tive-ness (only for dike relo-cation)	3 Feasabili-ty (land ow-ner)	4 Opportunities, local support	5 Biodiversi-ty benefits	Nbs prio-rity
BA21 Prud, Sa-va and Bosna	2	3	3	-	2	3
BA22 Gradina Donja east, Sa-va	2	2	2	-	2	2
BA23 Lower Una, Una	3	3	2	-	2	3
BA24 Crnaja, Vrbas	3	2	2	-	2	2
BA25 Cardaci-ne. Drina	3	2	3	-	2	3
BA26 Dragotinja	3	-	-	-	-	3
BA27 Spreca	2	-	-	-	-	2
BA28 Grabovnik, Thi-alnija	3	-	-	-	2	3
BA29 Ukrina	3	-	-	-	-	3

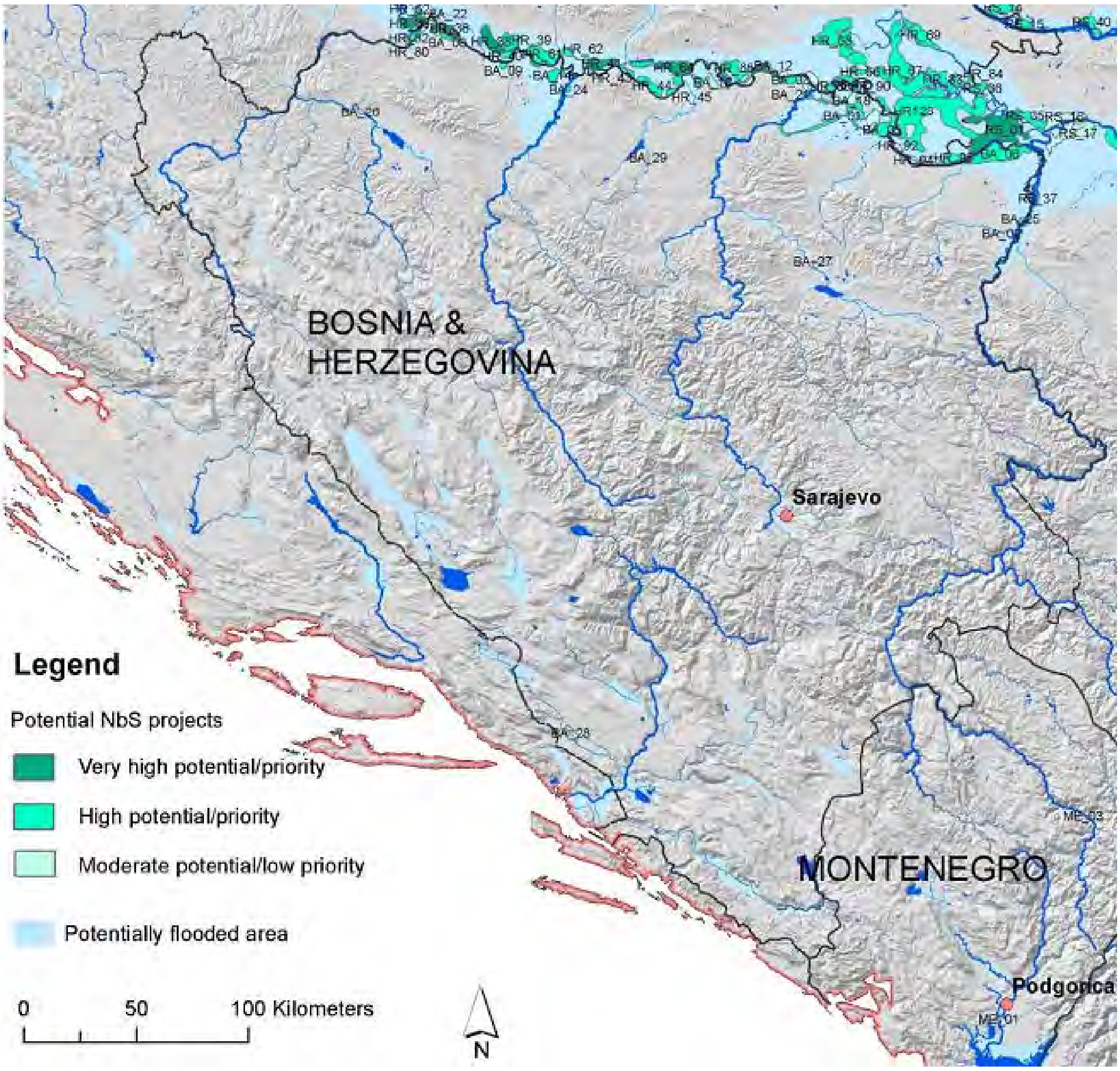


Fig. 28: Proposals for NbS-sites in Bosnia & Herzegovina.

Croatia

The Croation NbS proposals are concentrated along the Drava and Sava rivers and origin mostly from related previous studies for the Mura-Drava-Danube transboundary Biosphere reserve and the Sava White Book (Schwarz 2013 and 2016). The data is extended to fit for the concise prioritisations.

Tab. 10: Potential NbS projects in Croatia

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR01 Odra and Poljana Cicka	2	2	-	2 (pilot proposal)	1	2
HR02 Bregana	2	2	-	2 (pilot proposal)	1	2
HR03 Domasinec, Mura	2	1	-	-	1	1
HR04 Kotariba, Mura	2	2	-	-	2	2
HR05 Ujtelep, Mura	3	2	-	-	2	2
HR06 Mura near Drava confluence, Mura	2	1	-	-	2	2
HR07 Svibovec Podravski, Drava	2	1	-	-	2	2
HR08 Totovec, Drava	2	3	-	-	2	2
HR09 Prelog, Drava	3	3	-	-	2	3
HR10 Sesvet e Ludbreske, Drava	3	3	-	-	2	3
HR11 Upstream Legrad, Drava	3	3	-	-	2	3
HR12 Downstream Legrad, Drava	3	3	-	-	2	3
HR13 Cingi-Lingi Botovo, Drava	3	3	-	-	2	3
HR14 Drava near Gotalovo, Drava	2	2	-	-	1	2
HR15 Repas bridge, Drava	3	3	-	-	1	2
HR16 Drava near Belavar and Novo Virje, Drava	2	2	-	-	1	2
HR17 Podravske Sesvete, Drava	2	2	-	-	2	2
HR18 Drava near Detkovac, Drava	2	1	-	-	2	2
HR19 Vaska, Drava	2	3	-	-	2	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR20 Sopje, Drava	2	3	-	-	1	2
HR21 Donlji Miholac, Drava	2	3	-	-	2	2
HR22 Dravske Sume west, Drava	2	1	-	-	1	1
HR23 Valpovo, Drava	2	1	-	-	1	1
HR24 Dravske Sume east, Drava	1	3	-	-	2	2
HR25 Bilje west, Drava	2	3	-	-	2	2
HR26 Bilje east, Drava	2	1	-	-	1	1
HR27 Draz, Danube	2	3	-	-	2	2
HR28 Tikves, Danube	1	3	-	-	1	2
HR29 Lug, Danube	1	1	-	-	2	1
HR30 Trebez, Sava	2	1	1	-	1	1
HR31 Puska, Sava	3	3	2	-	1	2
HR32 Ustica, Sava	3	1	3	-	2	2
HR33 Kosutarica, Sava	3	1	2	-	1	2
HR34 Drenov Bok, Sava	2	1	1	-	2	1
HR35 Visnjica, Sava	1	1	2	-	1	1
HR36 Mlaka west, Sava	1	1	2	-	1	1
HR37 Mlaka east, Sava	2	1	1	-	1	1
HR38 Gredani, Sava	1	2	2	-	1	1
HR39 Pivare, Sava	1	3	2	-	1	2
HR40 Stara Gradiska, Sava	2	1	2	-	2	2
HR41 Radinje, Sava	1	2	1	-	1	1
HR42 Pricac, Sava	3	1	2	-	1	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR43 Slavonski Kobas west, Sava	3	3	3	-	2	2
HR44 Slavonski Kobas east, Sava	2	3	2	-	2	2
HR45 Zbjeg, Sava	3	3	2	-	2	2
HR46 Kaniza, Sava	2	3	2	-	1	2
HR47 Slavonski Brod south, Sava	3	1	2	-	2	2
HR48 Gornja Bebrina, Sava	3	1	3	-	2	2
HR49 Donja Bebrina, Sava	3	1	3	-	2	2
HR50 Svilaj, Sava	3	2	3	-	2	3
HR51 Ruca, Sava	3	3	3	-	1	2
HR52 Jasenovac west, Sava	2	3	2	-	1	2
HR53 Jasenovac north, Sava	2	3	1	-	1	2
HR54 Drnek, Sava	3	2	3	-	1	2
HR55 Lonjsko polje extension west, Sava	2	2	3	-	2	2
HR56 Lonjsko polje extension east, Sava	2	2	2	-	2	2
HR57 Veliko Svinjicko, Sava	1	3	1	-	1	2
HR58 Selisce Sunjsko, Sava	2	3	2	-	1	2
HR59 Lonjsko polje extension south, Sava	2	3	2	-	1	2
HR60 Jasenovac east, Sava	2	1	3	-	2	2
HR61 Mackovac, Sava	1	3	2	-	2	2
HR62 Bodovaljci forest, Sava	2	3	2	-	2	2
HR63 Stupnicki Kuti fish ponds, Sava	1	3	2	-	2	2
HR64 Slavonski Brod west, Sava	1	3	1	-	1	1
HR65 Trnjanski Kut, Sava	1	3	2	-	1	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR66 Stitar, Sava	1	3	2	-	2	2
HR67 Bosut-Spacva north, Sava	1	3	2	-	1	2
HR68 Gradiste forests, Sava	1	3	1	-	2	2
HR69 Vrapcana, Sava	2	3	1	-	2	2
HR70 Sisak, Kupa	3	1	3	-	2	2
HR71 Staro Pracno, Kupa	2	1	2	-	2	2
HR72 Petrinja east, Kupa	2	2	2	-	2	2
HR73 Petrinja west, Kupa	3	1	2	-	2	2
HR74 Letovanic oxbow, Kupa	2	3	2	-	2	2
HR75 Obedisce east Cesma	3	3	1	-	2	2
HR76 Obedisce south, Cesma	3	2	2	-	3	3
HR77 Vezisce, Cesma	3	2	2	-	3	3
HR78 Okoli, Cesma	3	2	3	-	3	3
HR79 Obedisce west, Cesma	3	3	1	-	2	2
HR80 Hrvatska Dubica, Una	2	1	3	-	2	2
HR81 Tanac south-west, Una	3	3	3	-	1	2
HR82 Cuklina, Una	2	1	2	-	2	2
HR83 Spacva northern forest west, Bosut	2	3	1	-	1	2
HR84 Spacva northern forest east, Bosut	3	3	1	-	1	2
HR85 Karlovac, Kupa	2	-	-	-	3	3
HR86 Krapina	2	-	-	-	-	2
HR87 Prnjavor, Sava	2	3	3	-	2	3
HR88 Sikirevici, Sava	2	3	3	-	2	3

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR89 Slavonski Samac, Sava	2	2	3	-	2	2
HR90 Babina Greda, Sava	2	1	3	-	2	2
HR91 Bosnjaci, Sava	2	2	2	-	2	2
HR92 Rajevo Selo, Sava	3	2	3	-	3	3
HR93 Gunja, Sava	3	3	2	-	2	3
HR94 Durici, Sava	2	3	3	-	3	3
HR95 Jamena, Sava	1	3	3	-	2	2
HR96 Savrscak, Sava	3	1	3	-	2	2
HR97 Strmec, Sava	2	3	-	-	2	2
HR98 Zapresic, Sava	3	1	3	-	3	3
HR99 Zagreb Jankomir, Sava	3	2	2	-	3	3
HR100 Zagreb Blato, Sava	3	3	2	-	3	3
HR101 Zagreb, Sava Savica	3	3	3	-	2	3
HR102 Micevec, Sava	3	3	3	-	3	3
HR103 Novaki Scitarjevski, Sava	3	3	2	-	2	3
HR104 Zagreb upstream water works, Sava	3	3	2	-	3	3
HR105 Ivanja Reka, Sava	3	3	2	-	2	3
HR106 Hruscica, Sava	3	3	-	-	1	2
HR107 Scitarjevo, Sava	2	3	2	-	1	2
HR108 Novaki Nartski, Sava	3	3	2	-	2	3
HR109 Strmec Bukesvski, Sava	3	3	1	-	1	2
HR110 Valesevec, Sava	3	1	3	-	2	2
HR111 Oborovo, Sava	3	3	3	-	2	3

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
HR112 Lijeva Luka, Sava	3	1	3	-	2	2
HR113 Lijevo Zeljezno, Sava	2	1	3	-	2	2
HR114 Palanjek, Sava	3	3	3	-	3	3
HR115 Galdovo, Sava	3	3	3	-	2	3
HR116 Topolovac, Sava	3	2	-	-	2	2
HR117 Cigoc, Sava	3	2	2	-	2	2
HR118 Bistrac, Sava	3	3	2	-	2	3
HR119 Kratecko, Sava	3	3	3	-	2	3
HR120 Suvoj, Sava	3	3	2	-	1	2
HR121 Ivanjski Bok, Sava	2	3	-	-	2	2
HR122 Crkveni Bok, Sava	2	3	2	-	1	2
HR123 Bosut-Spacva south, Sava	1	3	2	-	1	2

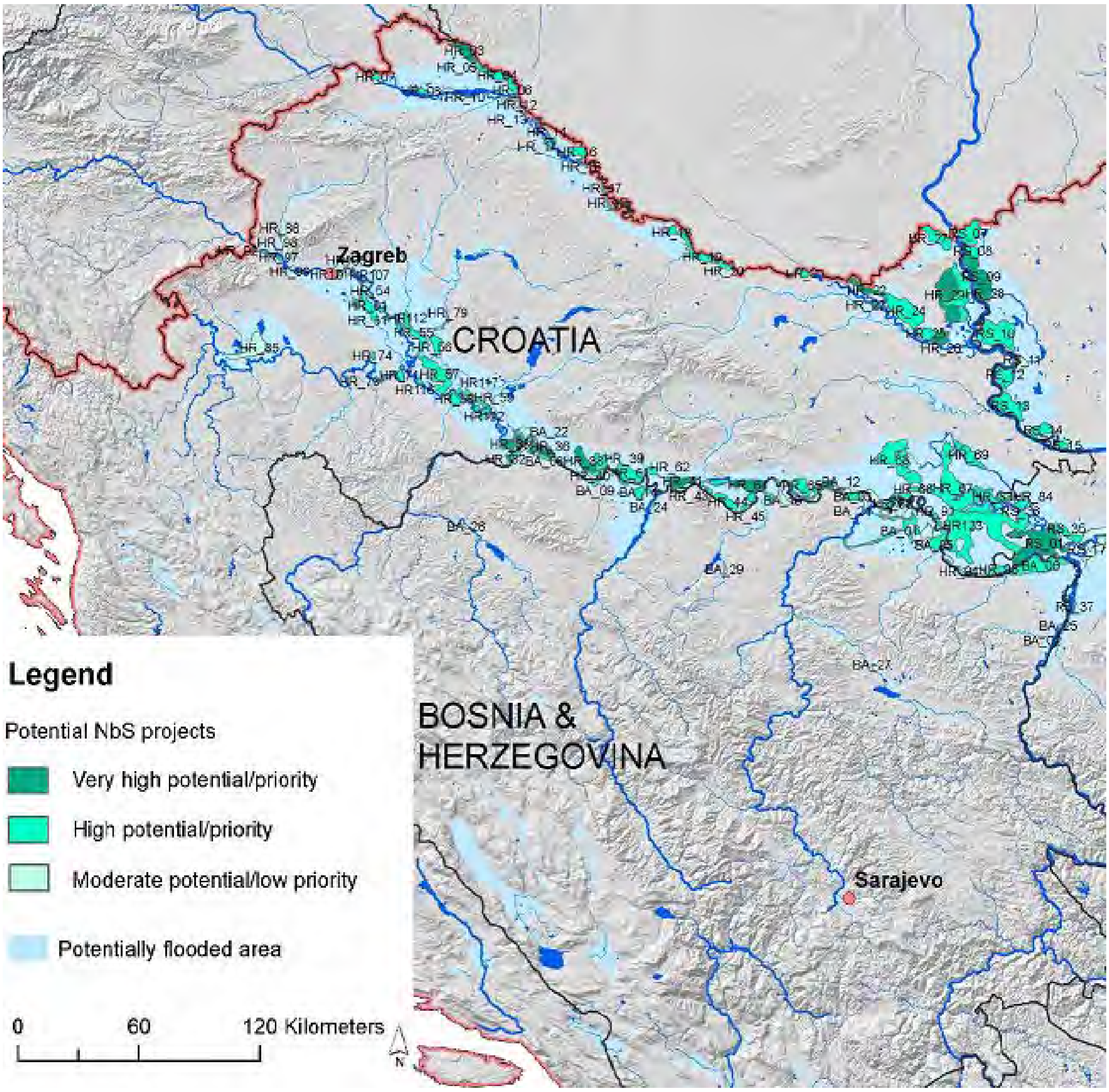


Fig. 29: Proposals for NbS-sites in Croatia.

Kosovo

For the Kosovo only a few potential sites for NbS are proposed along the two biggest river systems, the Drini i Bardhe and the Morava Bince. But also the Pristina field is subject of another proposal.

Tab. 11: Potential NbS projects in Kosovo

CountryNo, Name and river	1 Retention capacity	2 Cost effectiveness	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
KV01 Drin I Bardhe 1	1	-	-	-	1	1
KV02 Drin I Bardhe 2	2	-	-	-	2	2
KV03 Klina	2	-	-	-	-	2
KV04 Skullan	2	-	-	-	-	2
KV05 Sopijes	3	-	-	-	-	3
KV06 Sitnica	2	-	-	-	2	2
KV07 Morava Binze	2	-	-	-	2	2

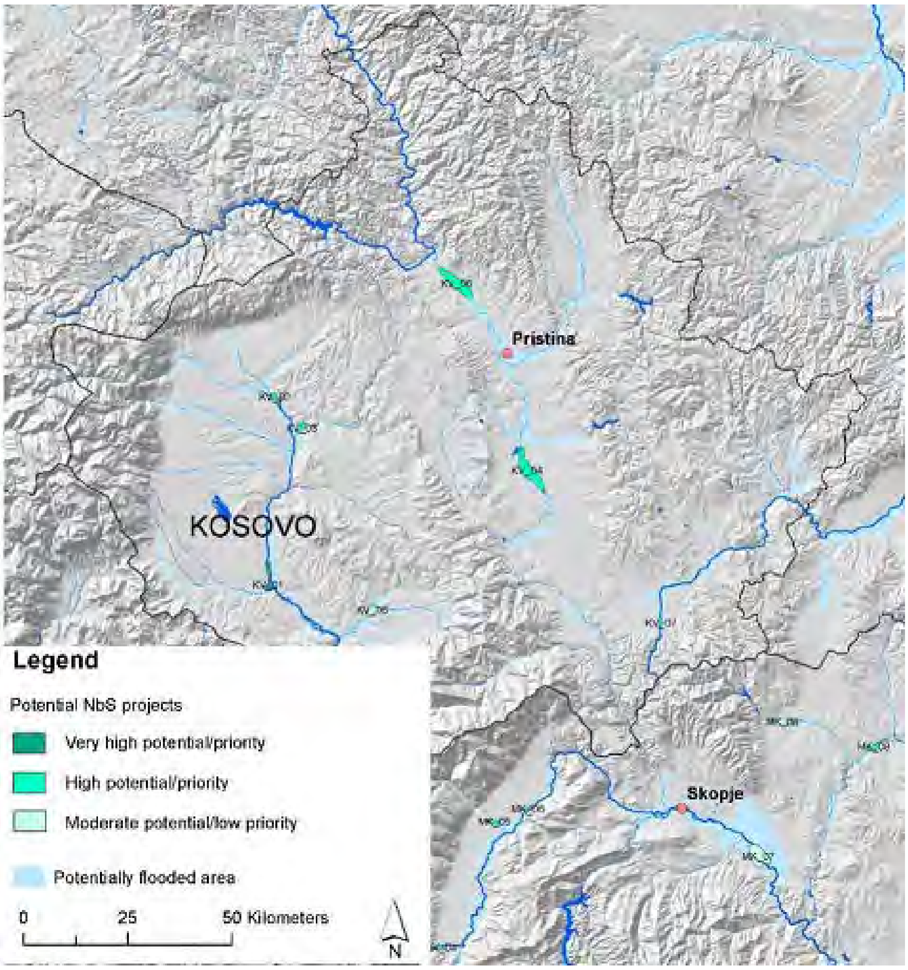


Fig. 30: Proposals for NbS-sites in Kosovo.

Montenegro

Since Montenegro is poor in lowlands, only a few NbS are feasible.

Tab. 12: Potential NbS projects in Montenegro

CountryNo, Name and river	1 Retention capacity	2 Cost effectiveness	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
ME01 Moraca	3	-	-	-	2	3
ME02 Lim	3	-	-	-	2	3
ME03 Tara	3	-	-	-	2	3
ME04 Bojana	3	-	-	-	1	2

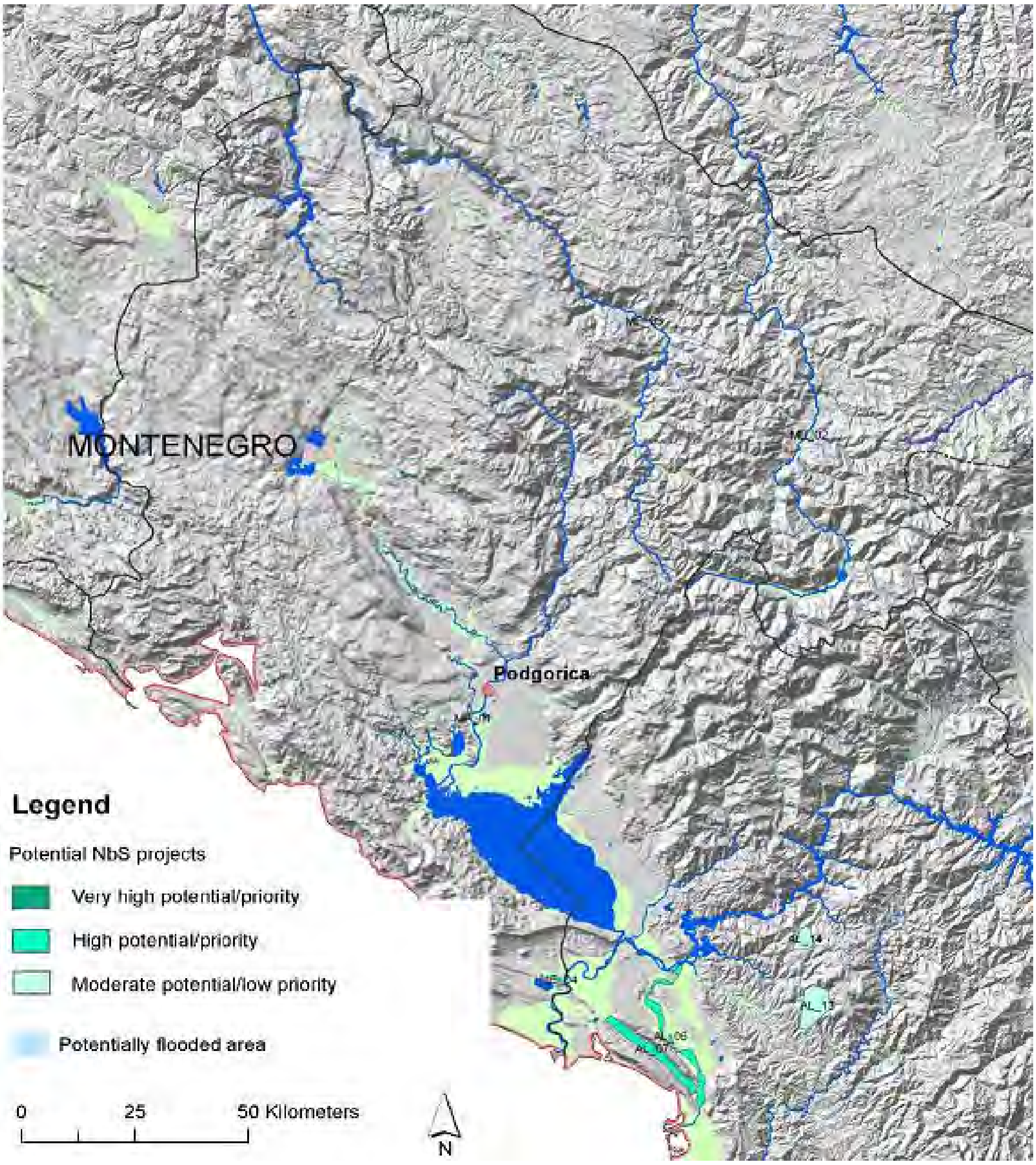


Fig. 31: Proposals for NbS-sites in Montenegro.

Macedonia

The Macedonian NbS-sites are distributed to the Polog, Pelagonia and Driniaca plains in the north- and southwest and east respectively, and along the main river Vardar and a few tributaries. Catchment-based proposals as for afforestation are not of such significance as in Albania.

Tab. 13: Potential NbS projects in Macedonia

CountryNo, Name and river	1 Re-tention capa-city	2 Cost effective-ness	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiver-sity be-nefits	Nbs priority
MK01-3 Pelago-nia, Crna	1	2	3	2 (pilot proposal)	1	2
MK04-6 Polog, Vardar	2	-	-	-	2	2
MK07 Downstream Skopje, Vardar	2	-	-	-	3	3
MK08 Pcinja	2	-	-	-	-	2
MK09 Lipkovs-ka	3	-	-	-	-	3
MK10 Kriva	3	-	-	-	-	3
MK11 Sveti Ni-kole	3	-	-	-	-	3
MK12 Bregalni-ca	2	-	-	-	2	2
MK13-14 Lower Vardar	2	3	3	-	2	3
MK15 Strumica 1	2	-	-	-	-	2
MK16 Strumica 2	2	1	-	-	1	1
MK17 Strumica 3	3	-	-	-	3	3

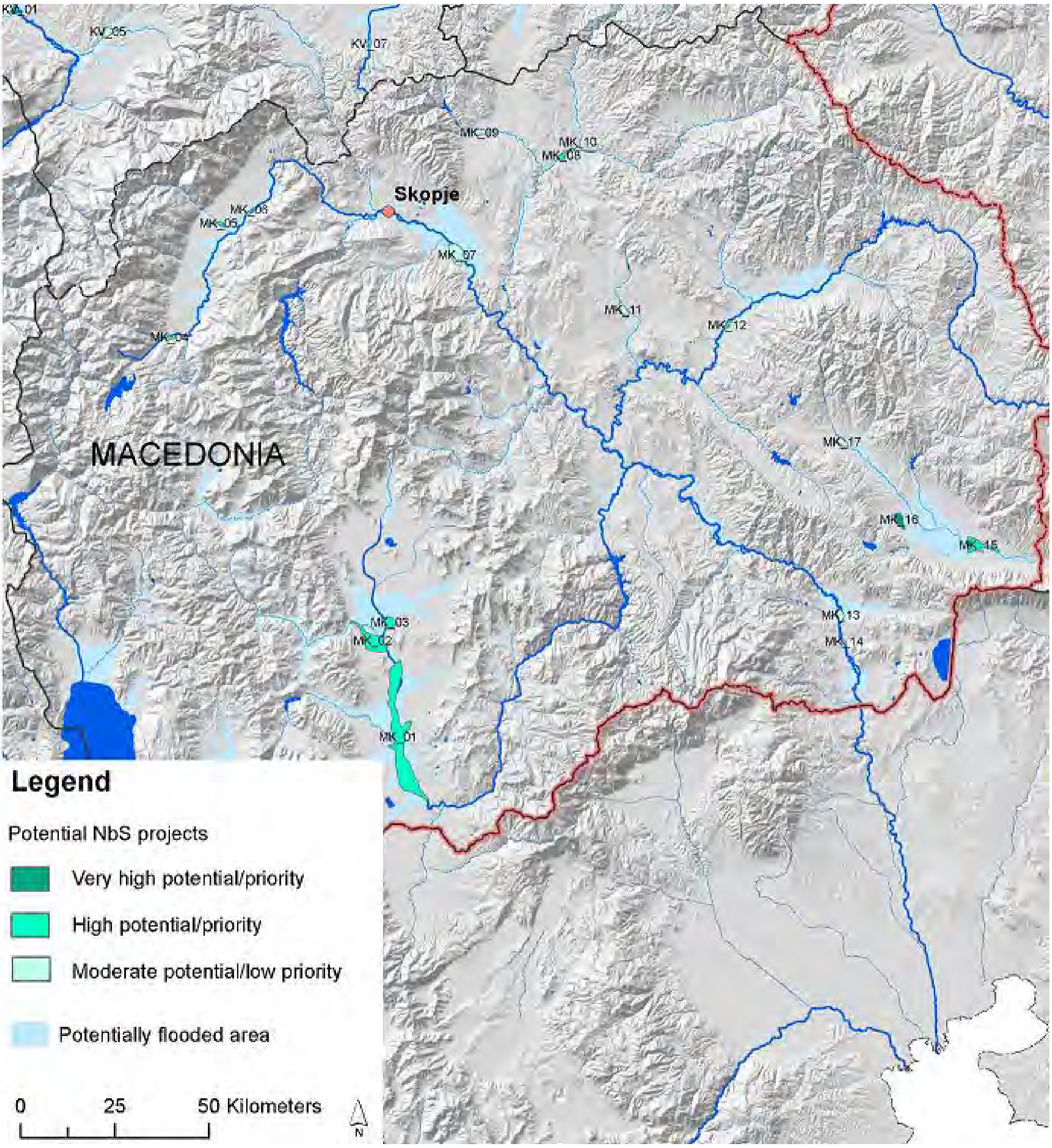


Fig. 32: Proposals for NbS-sites in Macedonia.

Serbia

Serbia is the most significant river and lowland spot in SEE (confluences of Sava and Tisa into the Danube) and therefore many sites for NbS fall into the northern region of the country. Further some NbS are proposed for the Velika Morava valley, catchment based NbS should be considered also for the hill region south of Belgrade which is densly populated and intensively used for agriculture.

Tab. 14: Potential NbS projects in Serbia

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
RS01 Bosut forrest Bosut-Spacva south and Sremska Raca, Sava	1	2	2	1 (pilot proposal, ongoing projects)	1	1
RS02 Belo polje, Kolubara	3	2	3	-	3	3
RS03 Obrenovac south, Kolubara	2	3	3	-	2	3
RS04 Kolubara 1	2	-	3	2 (ongoing project, UNDP)	3	3
RS04 Kolubara 2	2	-	3	2	2	2
RS06 Kolubara 3	2	-	3	2	3	3
RS07 Gornje Podunavlje north, Danube	2	2	2	1 (ongoing projects)	1	2
RS08 Bezdan, Danube	2	1	2	-	3	2
RS09 Gornje Podunavlje central	1	2	2	1 (ongoing projects)	1	1
RS10 Gornje Podunavlje south	1	2	2	1 (ongoing projects)	2	2
RS11 Bogojevo, Danube	2	3	2	-	3	3
RS12 Vajska, Danube	2	1	2	-	3	2
RS13 Plavna, Danube	1	2	2	-	3	2
RS14 Tikvara, Danube	2	3	2	-	2	2
RS15 Karadordevo, Danube	3	1	2	-	3	2
RS16 Martinci, Sava	2	2	3	-	3	3
RS17 Zasavica, Sava	2	3	3	-	2	3
RS18 Sremska Mitrovica, Sava	2	1	3	-	2	2
RS19 Vitojevci south, Sava	3	2	2	-	2	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
RS20 Krtinska, Sava	2	2	2	-	3	2
RS21 Kupinovo, Sava	2	1	2	-	1	2
RS22 Progar, Sava	2	1	2	-	2	2
RS23 Zabrezje, Sava	3	1	2	-	3	2
RS24 Obrenovac, Sava	3	3	2	-	2	3
RS25 Boljevci, Sava	1	1	2	-	3	2
RS26 Surcin, Sava	1	3	2	-	3	2
RS27 Hrtkovci, Sava	3	1	2	-	3	2
RS28 Platicevo, Sava	2	3	2	-	2	2
RS29 Ogar, Sava	3	3	2	-	2	3
RS30 Obrez forests, Sava	3	3	2	-	1	2
RS31 Provo, Sava	2	1	2	-	2	2
RS32 Downstream Umka, Sava	3	3	2	-	2	3
RS33 Coal power plant Obrenovac, Sava	3	3	1	-	3	3
RS34 Mrdenovac, Sava	2	3	3	-	2	3
RS35 Visnjicevo, Sava and Bosut	2	3	2	-	2	2
RS36 Batrovci, Bosut	2	3	2	-	2	2
RS37 Badovinci, Drina	3	1	3	-	2	2
RS38 Röszge, Tisa	2	-	2	-	2	2
RS39 Slano Kopovo, Tisa	2	-	1	-	2	1
RS40 Celarevo, Danube	2	-	-	-	2	2
RS41 Lok, Danube	2	-	-	-	2	2
RS42 Centa, Tamis	2	-	-	-	2	2
RS43 Zrenjanin, Tisa	2	-	-	-	2	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
RS44 Mosorin, Tisa	1	-	-	-	2	2
RS45 Curug, Tisa	1	-	-	-	2	2
RS46 Upstream Belgrad, Danube	1	-	-	-	3	2
RS47 Gaj, Danube	2	-	-	-	3	3
RS48 Klicevac, Danube	2	-	-	-	3	3
RS49 Zatonje, Danube	2	-	-	-	2	2
RS50 Kladovo, Danube	2	-	-	-	2	2
RS51 Martonos, Tisa	2	-	-	-	2	2
RS52 Kanjiza, Tisa	2	-	-	-	2	2
RS53 Senta, Tisa	2	-	-	-	2	2
RS54 Coka, Tisa	1	-	-	-	2	2
RS55 Padej, Tisa	2	-	-	-	2	2
RS56 Mol, Tisa	2	-	-	-	2	2
RS57 Novo Becej, Tisa	1	-	-	-	2	2
RS58 Sakule, Tamis	2	-	-	-	2	2
RS59 Baranda, Tamis	2	-	-	-	2	2
RS60 Ovca, Tamis	1	-	-	-	2	2
RS61 Velika Morava 1	2	-	-	-	2	2
RS62 Velika Morava 2	2	-	-	-	2	2
RS63 Velika Morava 3	2	-	-	-	2	2
RS64 Velika Morava 4	1	-	-	-	2	2
RS65 Velika Morava 4	1	-	-	-	2	2
RS66 Mlava	2	-	-	-	2	2
RS67 Juzna Morava	2	-	-	-	2	2
RS68 Ibar	2	-	-	-	-	2
RS69 Carska bara, Stari Begej	3	-	-	-	1	2

CountryNo, Name and river	1 Retention capacity	2 Cost effective-ness (only for dike relocation)	3 Feasability (land owner)	4 Opportunities, local support	5 Biodiversity benefits	Nbs priority
RS70 Downstream Tisa mouth, Danube	2	-	-	-	2	2

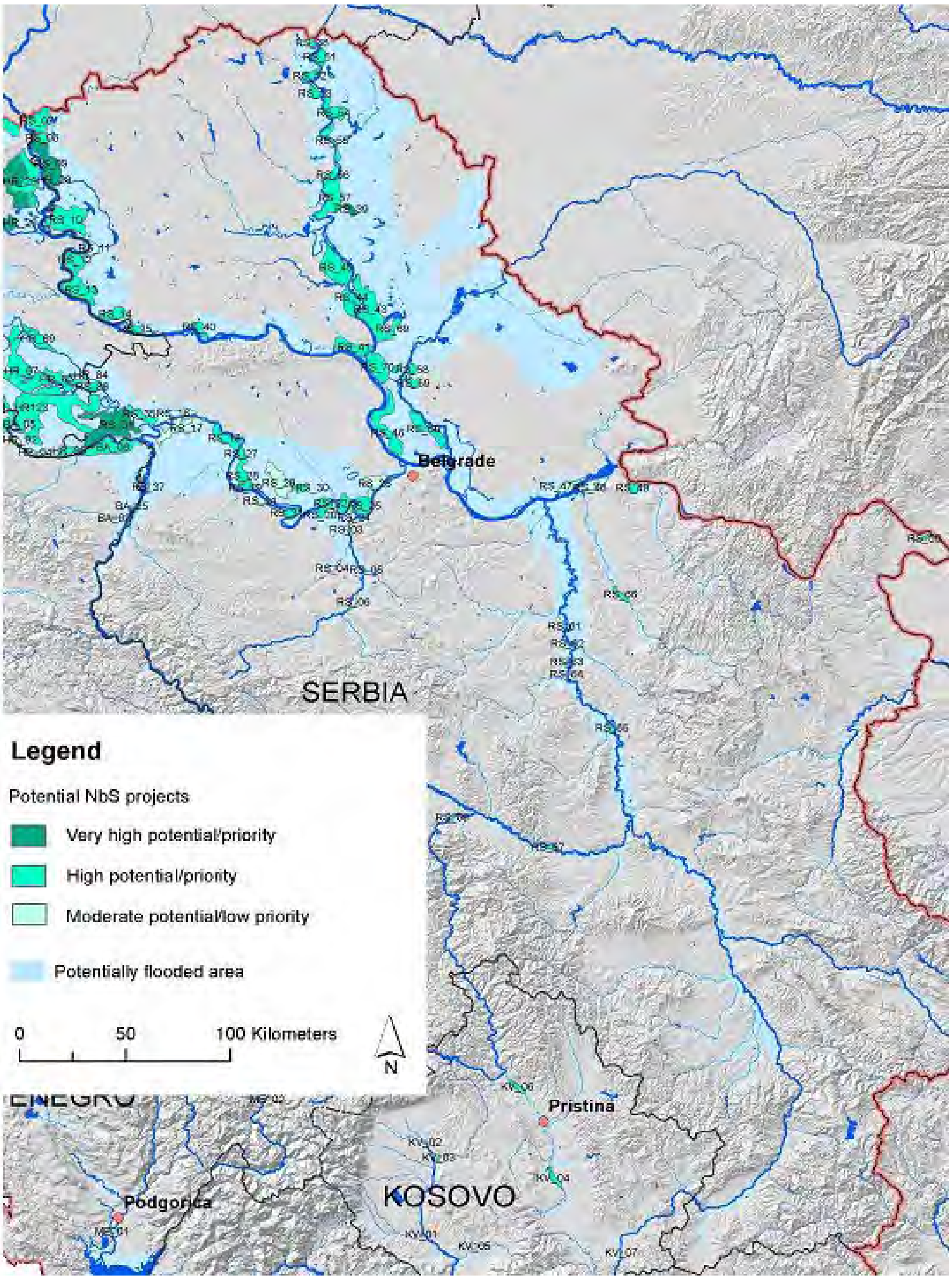


Fig. 33: Proposals for NbS-sites in Serbia.

4.3 Potential pilot projects

The following identified pilot areas constitute potential individual projects and measures presented in detail, based on their selection by workshop participants. These pilot projects will strongly depend on a regional initiative, available funding and concrete implementation opportunities and therefore must not always meet the general approach of prioritisation. So far pilot projects focus on the improvement/restoration of flood retention areas and on land use (afforestation, agriculture), but could be extended e.g. to settlements and other uses.

AL: Proposals for coastal zones of Drin-Buna, Vjosa and for the Shkumbin basin

BA: Floodplain reconnection along the Sava

HR: Odra or Bregana river and floodplain restoration, transboundary area to Serbia on the Sava (Bosut forest retention)

MK: Proposal for Pelagonia

RS: Transboundary area to Croatia on the Sava (Bosut forest retention)

AL Pilot 1: "Master planning for coastal zone "flood and sediment management", the case of Buna and Vjosa"

Geographical description and historical development

Albania is basically rich in water originating from the Balkan mountain ridges in the North and East but with a clear distinction in water availability during the winter and water scarcity during the summer. The Albanian coast is entirely built up of river sediments originating from the numerous large rivers leaving the mountains, namely the Drin/Buna system in the north-west and the Vjosa in the south-east.

Originally, the coastal plain in Albania was covered by extensive wetlands, coastal lagoons and large floodplains with dynamically shifting rivers. Even today, significant remnants of these wetlands and free flowing rivers and their estuaries exist, making the Albanian coast one of the ecologically most valuable shallow coastlines of this type in Europe. Several rivers still show the entire spectrum of high mountain headwaters, straight and deeply incised mountain valleys, even narrow canyons, turning into large braided river sections when leaving the mountains, down to even short meandering reaches before entering the coastal zone with its numerous deltas, estuaries and brackish lagoon water bodies. Most of the deltas are still actively contributing to the stabilisation of the coastline due to their high sediment load.

The two largest river systems, the Drin and the Vjosa, will be presented in more detail:

Drin/Buna: The transboundary catchment of Buna/Drin has 19.500 km² (including the Skadar lake catchment) and the flood discharges into the Adriatic Sea can reach 6.500 m³/s: This refers to the max. estimate when Lake Skadar reaches its historical level, such as in December 2010 with a recorded 4.000 m³/s outflow into the Buna river section (receiving both the Lake Skadar and the Drin river discharges) and at a potential coincidence to hit the max. discharge of the Drin (estimated with at least 4.000 m³/s). A flood water volume of 6.800 m³/s for Buna is after the Po river in Italy the second largest river discharge into the Adriatic Sea.

The largest hydropower dams of Albania can be found along Drin river, however its flood discharges can be controlled only partially, in particular in the Shkodra reach where the Lake Skadar outflow joins the Drin and forms Buna river. Sediment transport is considerably reduced due to its large dams. The close vicinity of the lake outflow and the Drin river entering into Buna river are subject of complex hydrological interactions, even more with the dam water releases and local sedimentation taking place at the confluence close to the city of Shkodra. Flood peaks occur from December to March (winter rain and snow melt, latter in particular from the mountainous middle Drin). Until 1850 the two rivers Drin and Buna with Skadar Lake were separated from each other and the Drin was flowing along the former, so-called Drinit river branch, which today is most of the year completely dry. The change of flow direction was initiated by the diversion of water for the mills in Shkodra and in the following decades by a natural breakthrough during major floods. As a consequence, the Skadar lake level may raise by 3 m during floods.

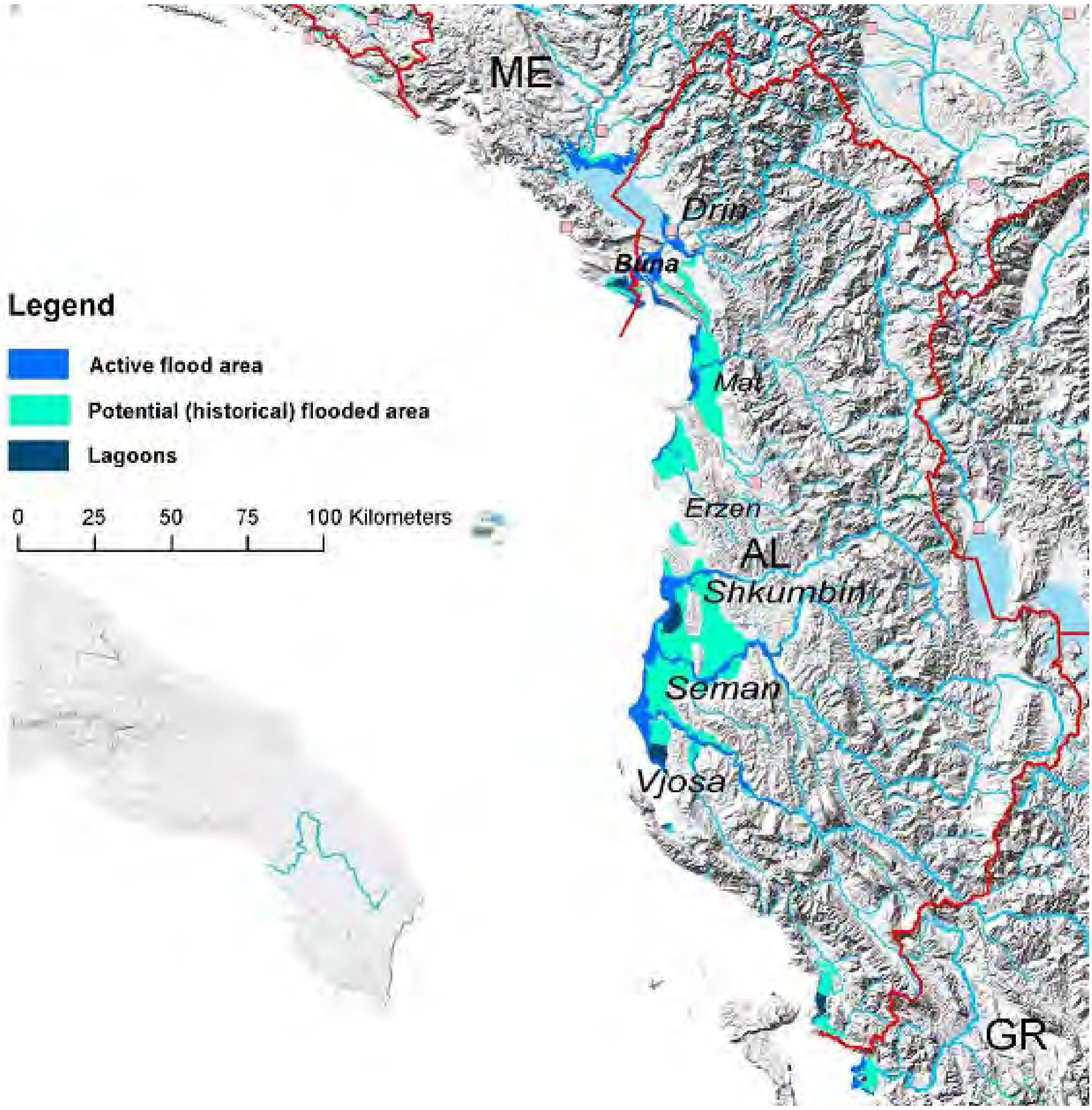


Fig. 34: The most important river systems in Albania (Drin in the north, Vjosa in the south) and the coastal plain with its extensive recent and former wetlands (SCHWARZ 2017).

Vjosa: The Vjosa/Aos (260 km long) has its source in north-western Greece and a total catchment of 6.710 km². Its extreme flood discharge can be up to 4.600 m³/s in its lower course (mean water is at some 200 m³/s). There are no dams in the catchments hindering the sediment transport, and the river flows mainly in its highly dynamic braided "active" channel – a rather unique situation for European rivers. But when leaving the mountains, floods along its lower course are frequent and causing damages to agriculture which spreads along the river. The hydrological regime is similar to the Drin and all Albanian rivers, with a clear peak in the winter half year and low water during the dry summer season.

Considerable changes of land use in the coastal zone lead to increasing flood damage due to intensified land uses, namely in agriculture but also by increasing scattered settlements and inefficient flood mitigation (old incomplete defence lines, poor flood management). More intensive uses along the river banks increased the damage potential. Along the coastline and the shore of the lagoons in particular, tourist business facilities increased significantly.

Another major issue is sediment retention in existing, very recently constructed and many planned dams in all Albanian river systems. This will be leading to a considerably reduced sediment discharge into coastal zones (Simione et al. 1997 estimate the sediment discharge only of Drini prior to dam construction 20 % higher than at the Po river, despite the fact that the Po has a five times larger catchment and a four times higher discharge). The same author estimates the whole sediment discharge into Adriatic Sea at 35 million m³ per year (or 65 million tons per year) with a high proportion of 16-23 % of bedload (gravel, coarse sand). However, even today about 60-70 % of this sediment load does not reach the sea due to its retention at dams (and other factors like, sediment exploitation in the lower courses) or due to changes of hydrological regimes for irrigation and hydropower.

Flood risk, coastal erosion and loss of biodiversity

Both target rivers regularly inundate large areas in their lower courses, which is a natural phenomenon of this coastal plain and deltaic landscape. Human settlements, and in particular agricultural uses, occupy more and more space of the coastal zone close to the rivers after construction of the first flood defences in the 1960ies.

Flood dikes, drainage/irrigation canals and ditches along the lower courses of the rivers were constructed in the 1960ies, however maintenance works and a risk to be eroded laterally by the rivers are causing many problems, including overtopping and breeches of dikes. Their design should be fit for a 100-years event, however hydrological data are missing or being only available since 1950 for some stations, therefore the determination of water levels and rating curves are urgently needed.

The flood event of the Buna in 2010 had a peak discharge of 3,600 m³/s. Only small floods can be conveyed by the Buna channel downstream from Shkodar (1,600-2,200 m³/s), any additional water floods agricultural land and settlements. The December 2010 flood reached at least 4.000 m³/s in the Buna, but was mainly caused by the highest ever recorded lake water level and was not driven by Drin, as is usually the case for January.

In the case of the 2010 flood event, the city of Shkodra was severely inundated after the hydropower dams released a lot of water during short time (from 800 to 2.400 m³/s). Suddenly the Lake Skadar outflow was blocked and the lake level started to raise by 6-7 cm per day. Even after the Drin turned back to considerably less discharges the flood situation persisted, as the lake outflow kept also the Drin upstream very high. It took another 10 days until the water level sank again. When imagining the extreme disaster of a timely coincidence of maximum water levels and discharges from the Lake and the Drin river, and taking into consideration the problematic discharge bottleneck (reduced cross section and capacity at confluence), such a potential historic event could flood the entire city of Shkodra and wide areas of the coastal zone downstream to Lethsa town at the coast.

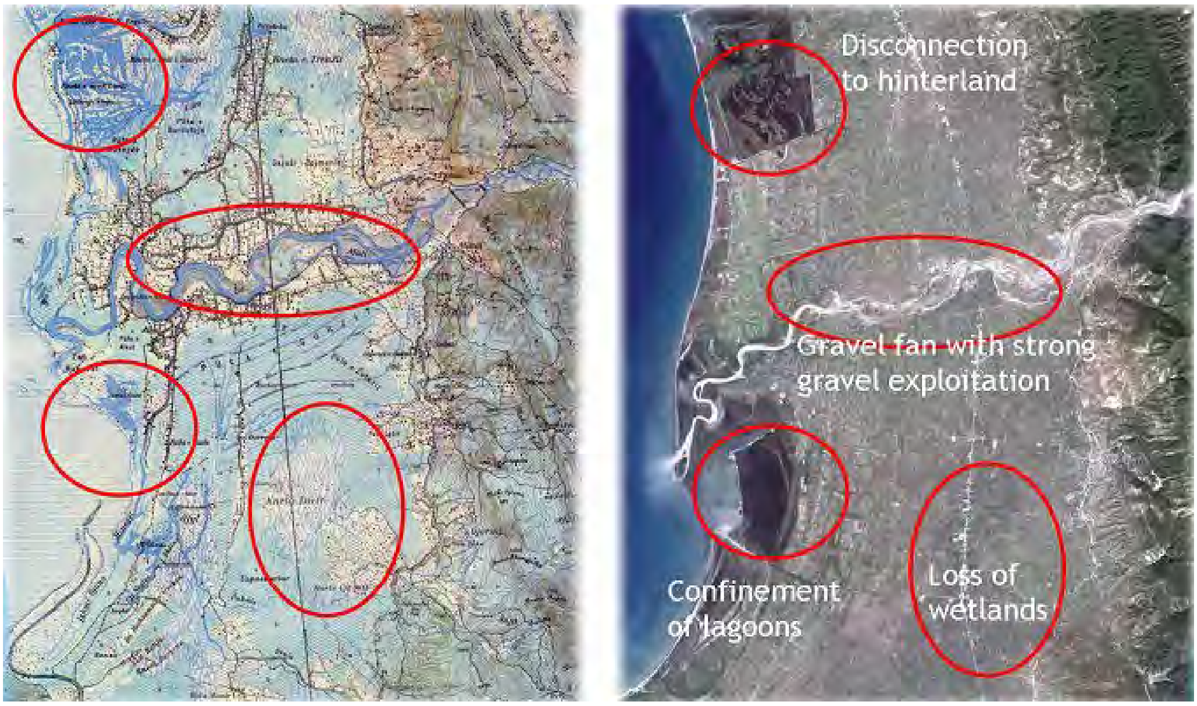


Fig. 35: Historical comparison and development of coastal plain in Albania (source left: Topographical map 1:75.000, 1918, Institute for Geography, University of Vienna; source right: Google Earth 2018).

Regarding coastal erosion and losses of biodiversity, it is obvious that land use intensification (reclamation, drainage/irrigation, but also the construction of big dams) plays an important role:

Erosion on the coastline at the Velipoja settlement including the Albanian part of the Bojana/Buna delta was estimated at up to 10 m per year during the last 50 years. Main reason is the reduced sediment supply from the Drin catchment that is retained behind its major dams. For comparison, in the case of the Drina catchment (territories in RS/BA/ME/KV) and its major dams, the bedload and suspended load reaching the mouth of the Sava river was reduced from 4,5 to 1,5 Million m³/a (bed load and suspended load). In comparison, the material originally reaching the Albanian coast, estimated at some 35 Million m³/a (SIMIONE et al. 1997), would be reduced to some 12 Million m³/a and causing serious coastal erosion and damage. Taking into account the raising sea levels of up to some decimetres in the next 100 years, the consequences would be even more disastrous and most probably arable land will be reduced due to salt intrusion or even flooding and erosion.

Proposed measures

As the coastal zone is in general the most densely settled area with most inhabitants living there it is important to find long-lasting solutions for flood mitigation and coastal protection.

Such “Master Plan” should tackle two major issues that should be considered in each catchment, i.e. the origins of floods and sediments:

- Assess the hydrologic and hydraulic discharge and the behaviour of floods, and calculate and model all relevant discharges of the lower river courses in the plain. Elaborate a sediment balance and detailed analysis of coastal erosion.
- Keep free all remaining space along rivers and conduct a mapping of the morphological floodplains (potentially flooded areas, also in line with the Floods Directive): This helps to determine all flood-prone areas and to delineate all inundation zones. First action must therefore be to stop any intensification of land uses close to the river banks, and to maintain a maximum space for rivers for future generations. Only this can guarantee the important function of Albanian rivers as a resource for drinking water and agriculture, as well as for the supply of sediments to stabilise the coastline.
- Develop concepts how to manage floods, in particular major floods, where the natural retention areas are lost (by settlements or critical infrastructure, not just for agriculture only) and take into consideration where former river channels can be used to divert and split flood discharges on their way to the coast. Those former channels have to be identified, and bypass solutions in addition to other retention areas could protect settlements and critical infrastructure.
- Critically review and revise the development of dams, in particular of large dams being constructed or planned along all AL rivers, in terms of sediment balance (all profit from electric power generation must be set into relation to the long-term costs for coastal protection as a public interest).
- In order to better protect the city of Shkodra, reactivate in the Drin/Buna system the former Drinit channel to divert up to 1,000 m^3/s of flood water discharge: Drinit starts where Drin enters the plain and enters near Lethsa in the south into the Adriatic Sea. But also the second major “pathway” of floods at Bishti Juges towards Lethsa must be reactivated (for some 500 m^3/s) and the existing floodplains of Buna river, mainly grasslands, must be protected and partially become extended.
- At the Vjosa, reduce the intensive and poorly protected agriculture close to the river banks and in the active floodplain; analyse solutions of additional bypasses with extensively managed retention areas to north and south of the main branch.
- Use, wherever possible, former channels and depressions as potential bypasses. The construction could be expensive but their cost-benefit analysis will prove a long-term flood risk reduction. These flood channels should be managed as extensive grasslands with grazing possibilities for local farmers.
- Apply the proposed bypass and floodplain management options as a solution for the entire coast, keeping maximum space for floods and allowing maximum sediment input to coastal waters.
- Keep in mind that lagoons as products of deltaic processes are sensitive against reduced sediment transport and raising sea water levels.

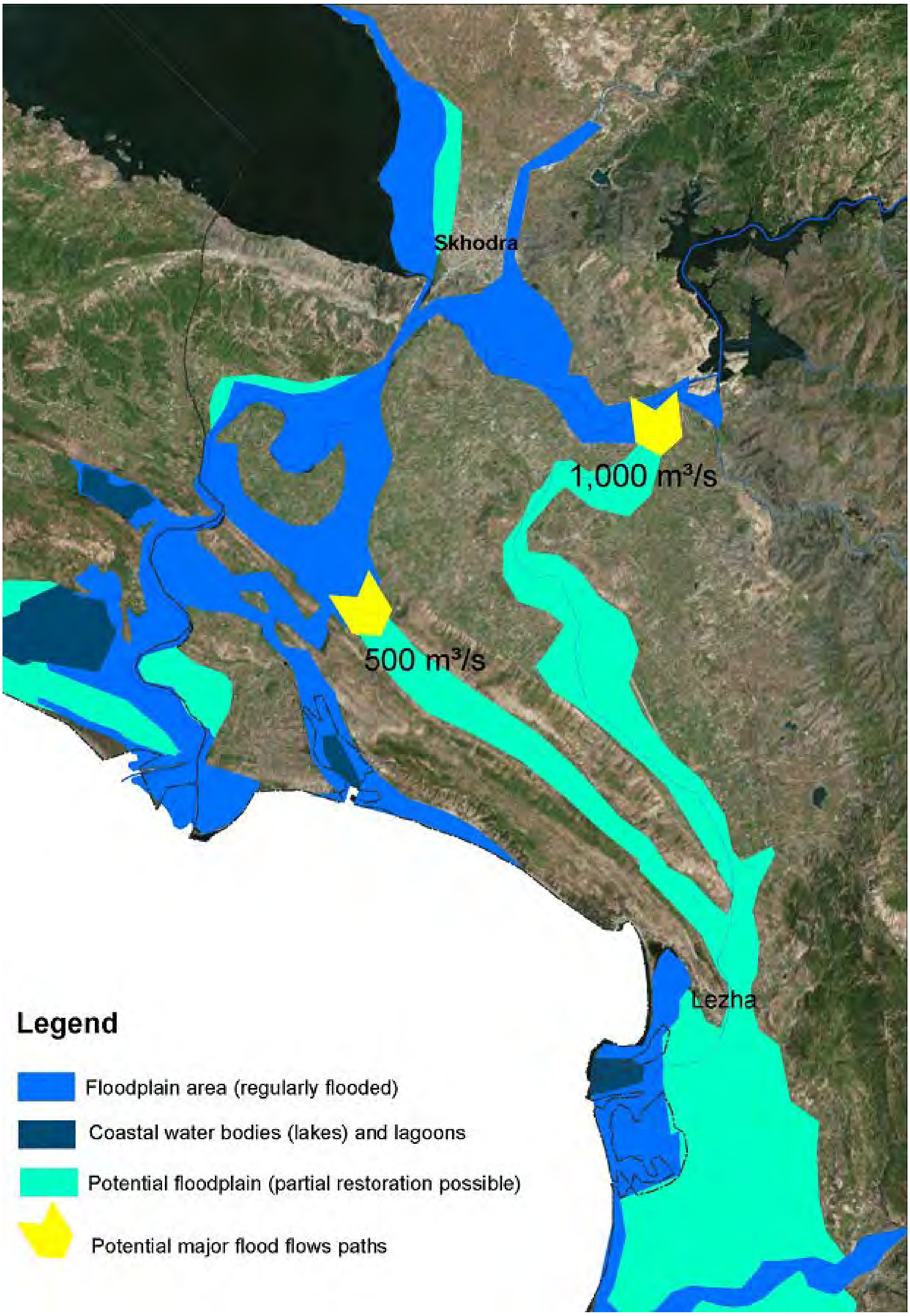


Fig. 36: Proposal for the Drin/Buna case, considering all potential flood pathways and options for floodplain restoration (background Google Earth 2018).

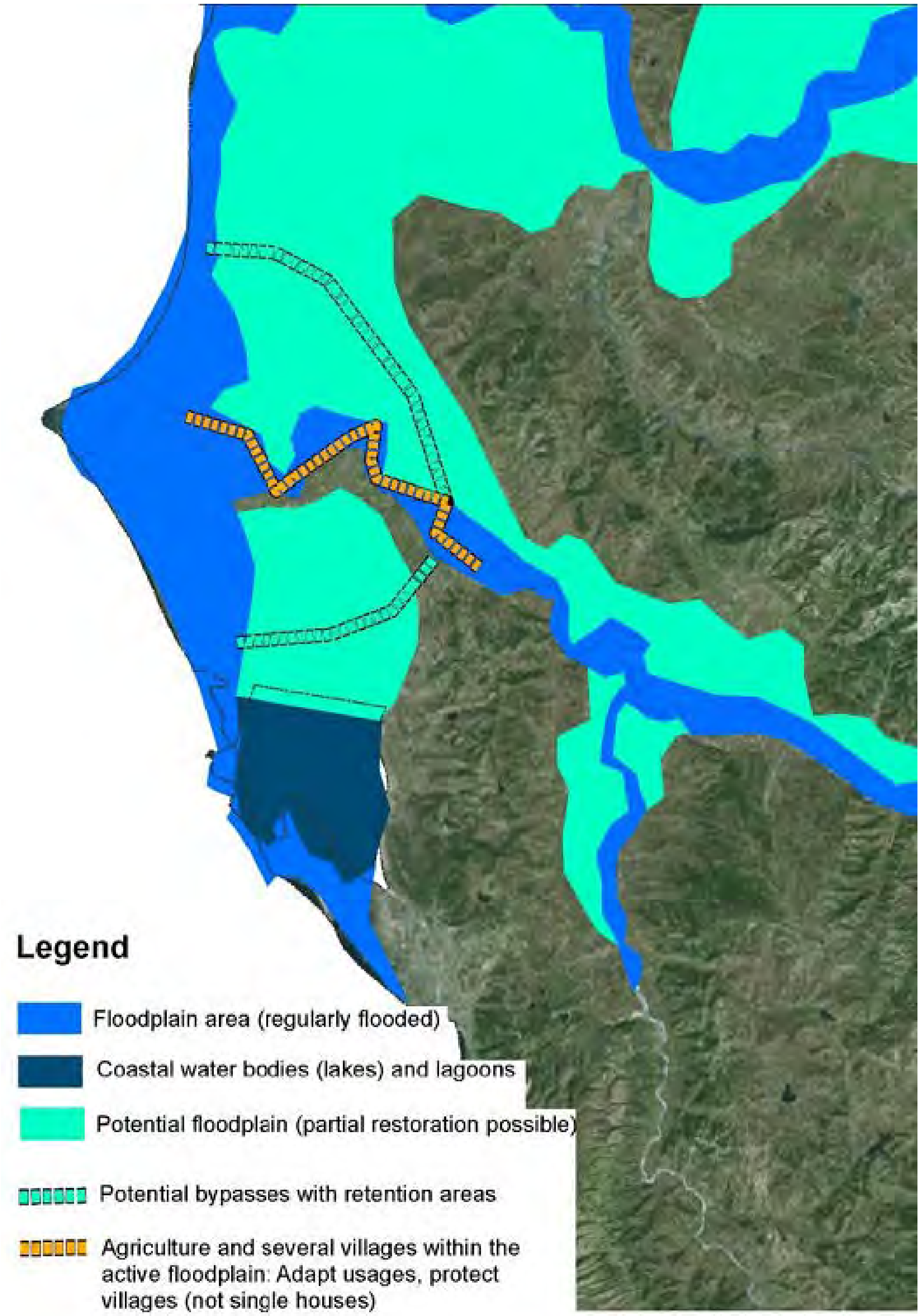


Fig. 37: Proposal for the lower course of Vjosa, combining land use extensification, local flood defence and possible bypass solutions with the restoration of retention areas/floodplains (background Google Earth 2018).

AL Pilot 2 (IUCN 2017a):

Description of the pilot site: River Shkumbin

Located in central Albania, Shkumbini River is 181 km long with a catchment area of 2,445 km². The river source is in the Valamara mountains, and flows into the Adriatic Sea northwest of Divjake. Along its course it receives tributaries of secondary importance like Rapuni, Gostima, and Zaranika. Chemical analyses taken from the Shkumbini showed high values for some parameters (iron, nitrites, ammonium), which was probably due to the mining areas upstream and to the metallurgical combine of Elbasani. As a consequence, the biodiversity in the estuary area is reported to be seriously affected. Since the drastic reduction of activities of the compound, no complete analyses were made available but it is believed that the quality of the water has largely improved.[33]

Floods regularly happen along Shkumbini River, but with increasing frequency and intensity. Flooding also occurs in the Divjake–Karavasta National Park from the Shkumbini and Semani rivers. Like Semani, the Shkumbini basin is experiencing high levels of land erosion, with no or inadequate measures to prevent erosion.

As a consequence, Shkumbini River was included as a key area for implementing green measures to “Protect/adapt agriculture against Sea-Level Rise” into the Adaptation Plan developed by the Ministry of Environment of Albania.[34] These measures include the restoration of agricultural areas and wetlands, and the maintenance and upgrading of flood embankments in the North and South of the Shkumbini river mouth.

The river is surrounded by three protected areas (Divjake–Karavasta National Park on the coast, Shebenik-Jabllanice National Park and Kuturman Nature Park at the inland), which represent a great potential for implementing nature-based solutions based on protected area management. NbS interventions in the Shkumbini River basin will include

- ecological restoration of degraded lands and riverbanks to prevent erosion and soil losses;
- green/grey infrastructure measures to reduce erosion and prevent soil loss and landslides;
- restoration of wetlands for flood prevention and water purification;
- restoration of agricultural areas, and development of agroforestry for food security;
- improved management of the Shebenik-Jabllanice National Park, Kuturman Nature Park and Divjake–Karavasta National Park for increased resilience of ecosystems and communities.

---

33 Lushaj, B., Hoxhaj, F., Ndini, M., Selenica, A., Pambuku, A., Dafa, I., Hasimi, A., Zaimi, K., Marku, M., Çomo, E., Vako, E.,Isufaj, S. and , Myrtaj. B. (2016). ‘General Overview of the Transboundary Waters of Rivers, Lakes, Groundwater and Trend of them, in Albania’. Online International Interdisciplinary Research Journal (6) 1: (Jan-Feb 2016 Issue) 418-446.

34 Ministry of Environment of Albania (2016). Third National Communication of the Republic of Albania to the United Nations Framework Convention on Climate Change (UNFCCC). Tirana, Albania: Republic of Albania, Ministry of Environment.

The necessary analyses will be undertaken by the responsible authorities, mapping conducted and baselines determined, capacity building adapted to local needs and policy engagement initiated, using tested methods and tools.

The exact interventions at the pilot sites will be detailed in consultation with the main stakeholders, through a participatory process, including consultations, meetings and workshops and involvement of various institutions and centres of excellence at national, sub-national, regional and local levels. The interventions, based on predicted climate and weather patterns and socio-economic forecasts, will take into consideration the risk of disasters, the highest benefits for the local communities and society as a whole, and good governance principles and sustainability of results over long-term. Capacity building and planning will take into consideration traditional knowledge and experience of the local populations.

The project will cooperate with the land management, coastal management, agriculture, water management, energy and nature conservation sectors; private companies (hydropower companies, for example), protected area management, and local communities will be strongly involved in the process from the onset in order to ensure the sustainability of results.

Committed main partner: Ministry of Tourism and Environment, Ministry of Agriculture, Rural Development and Water Administration

Proposed other partners:

- Ministry of Interior
- Directorate General of Civil Emergencies
- Directorate of Water Resources Policies and the River Basin Authority
- Ministry of Energy and Industry
- IUCN
- Technical secretariat of the National Water Council
- Municipal Authorities
- National Agency for Protected Areas
- Civil society (PPNEA (Protection and Preservation of Natural Environment in AL), INCA (Institute for Nature Conservation in AL, EcoAlbania)

Duration: 4 years

BA Pilot 3: Flood mitigation at the Bosna confluence with the Sava

Geographical description and historical development

At the Bosna confluence with the Sava river, the small town of Bosanska Samac is one of the most flood-prone areas along the entire lower Sava. The settlement originates from an early ferry and crossing point from Croatia to Bosnia, and is today a border town with a bridge and a small harbour at the Sava.

The Sava and Bosna floodplains overlap and during the past huge Sava floods also triggered flooding of the lower Bosna and, to a much smaller degree, the other way round (e.g.

during the 2014 Bosna flood the backflow reached Slavonski Brod in Croatia some 20 km upstream at the Sava).

The systematic construction of flood dikes started in the 1960ies (enlargement of already existing and building of many new dikes much closer to the main channel) and cut off wide areas of the Sava and partially the Bosna floodplains from the river (the loss in this part of the Save reaches up to 80-90 %). In general, the southern (Bosnian) banks of the Sava are higher and therefore floods spread across its northern floodplain. But at the confluence areas of its large southern tributaries (Una, Vrbas, Bosna, Drina), the floodplains reach also to the southern bank at a width of several km (compare Figure 9).

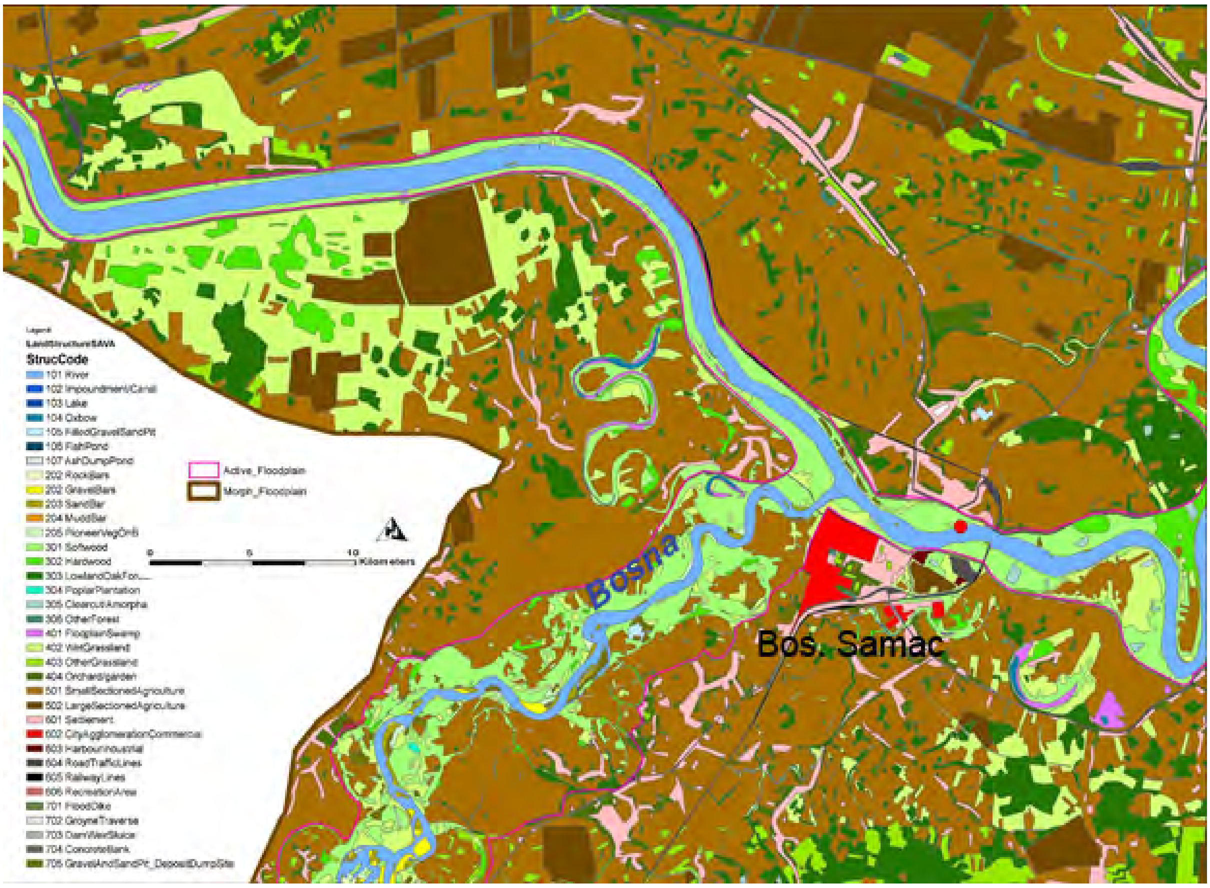


Fig. 38: Confluence of the Bosna with the Sava (current status): Brown colours indicate agricultural areas, green colours forests and grasslands) (Schwarz 2016)

Flood risk

After the construction of first flood dikes in former times, but in particular during the past Yugoslavian time, large river areas could be turned into agricultural land and a system of drainage ditches and canals and pumping stations kept them largely dry. Due to the floodplain loss of up to 90 % in the reaches nearby (in difference to the upper and lower Sava reaches) the flood conveyance space was significantly reduced, thus accelerating flood waves and raising flood peaks in this river reach. During the 2014 flood, the peaks of the upper Sava and of the Una and Vrbas tributaries did not coincide with the Bosna peak or were much lower. But at times when extraordinary high discharges of the Bosna (500 years event with over 4.000 m^3/s) reached the Sava, the main river raised upstream up to Slavonski Brod, and increased downstream to about 6.000 m/s (>500 years event!). This had caused several dike failures at the confluence reach but also downstream at the Sava. Water then entered the area behind the southern flood dikes (drainage canals and pumping stations were not able to prevent such flooding) and large agricultural areas and settlements were inundated.

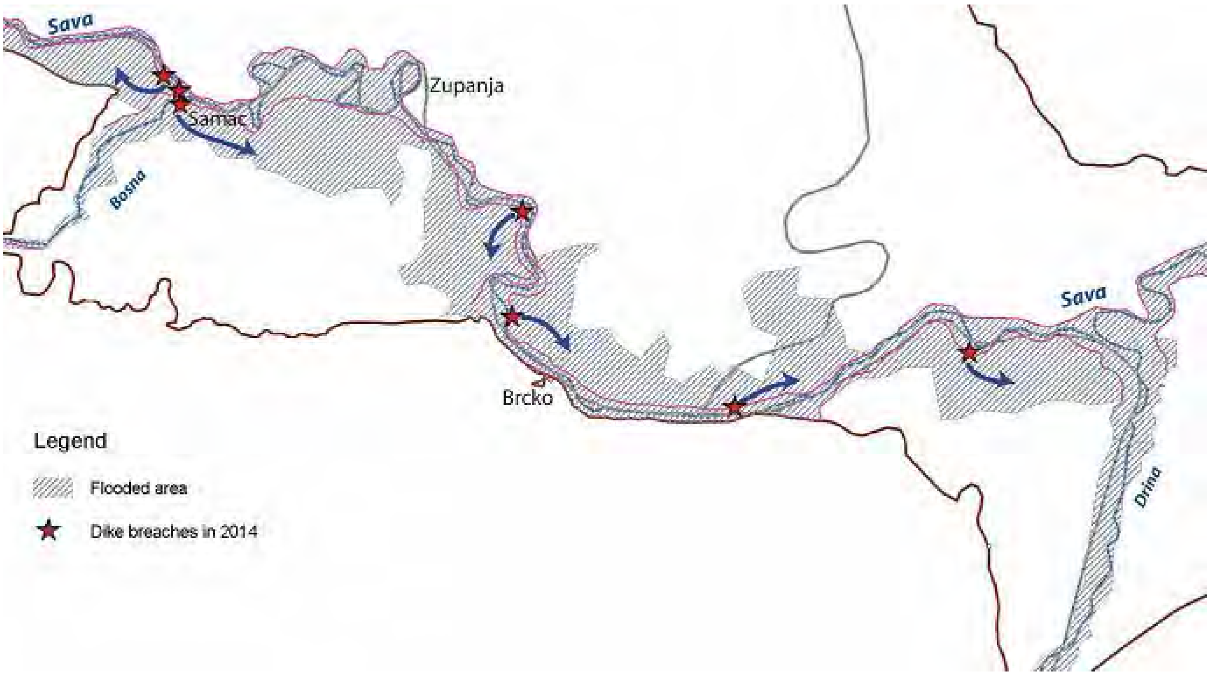


Fig. 39: The 2014 flood on the lower Sava starting at the Bosna confluence and related dikes (thin pink line) as well as the seven major dike breaches causing wide flooding behind the dikes (SCHWARZ 2016).

Proposed measures

The core problem of this particular Sava reach is the considerable loss of original floodplain (up to 90 %) which significantly reduced the flood conveyance capacity and led to the severe flooding in 2014. Therefore, the retention capacity within the region but also upstream on the Sava must be restored again. In the particular case of Samac town at the confluence area it is necessary to realise - beyond the local conventional flood defences - a kind of bypass solution, such as it practically exists at the upper Posavina flood system. Flood risk management in this part of the river can be solved only together with the neighbour countries. Therefore joint activities with Croatia in the upstream Sava course are essential.

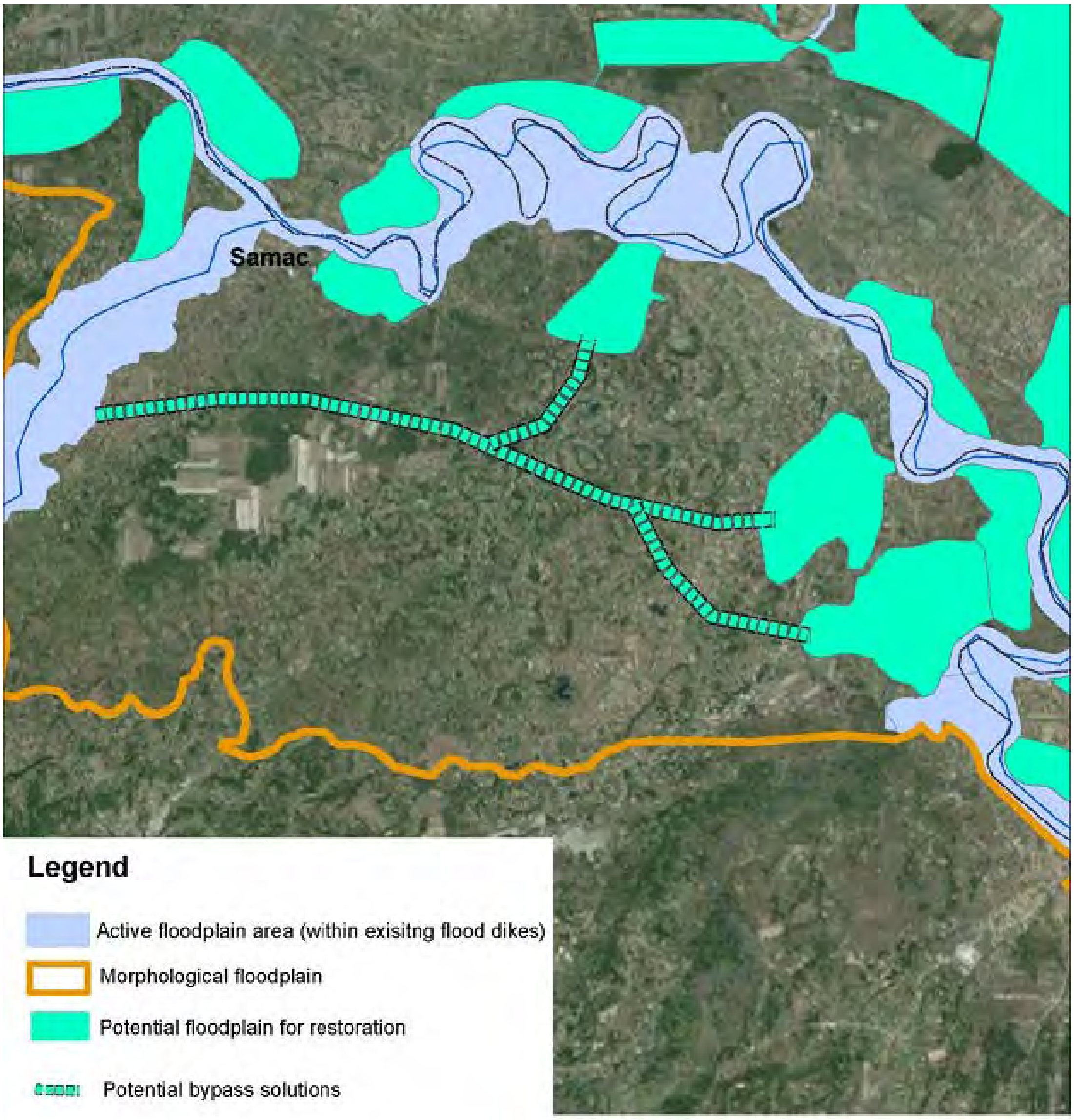


Fig. 40: Proposal for the Bosna confluence: Bypass in combination with floodplain restoration and increase of retention capacity (background Google Earth 2018)

Recommended measures at the BA side:

- Prevention of further losses at the still existing floodplains to maintain the maximum still available retention capacity. At existing flood dikes (in particular along the lower tributaries), renovation or new construction of dikes to manage a maximum of flood waters, while in areas of irreplaceable retention losses, the capacities have to be compensated, in neighbouring river reaches (compensations, resettlements, ring dykes).
- Restoration of floodplain areas (in both countries, also upstream on the Sava) to increase the retention capacity (compare the *Sava White Book 2017* , Schwarz 2016 for the upstream reach, e.g. large areas upstream of Slavonski Brod) but also just upstream on BA territory (see Figure 40).

- To protect Samac with its critical infrastructure (bridge, harbour), the construction of a bypass, making use of an existing drainage canal, could be a simple solution. Such a bypass with widenings could subsequently still be used as extensive grassland and convey up to 500 m³/s across the former floodplain back into Sava near Gorice. This would allow reducing the input of Bosna flood waters into the Sava not only to mitigate floods at Samac but also at the towns of Zupanja in HR and Orastje (BA). The latter was entirely flooded in 2014 due to a dike breach.

Tab 15: Summary table of the pilot at the Bosna-Sava confluence

Country and name	**BA, Bosna-Sava confluence and lowland**
1) Background and rationale for the project	High flood risk in the region should be reduced by increasing the loal flood retention capacity via floodplain restoration and a bypass solution
2) Criteria that determined the choice of this site (feasibility, cost-effectiveness, political support, high flooding risk, potential biodiversity benefits, funding possibilities, etc.)	Area was heavily flooded during the 2014 flood Potential damages (settlements and agricultural areas) are high Ongoing flood risk planning in the whole region (in BA and by the Sava Commission) International donors (e.g. World Bank/GEF, WBIF) are engaged and open to support flood risk projects Envisaged projects focus on the reinforcement of existing dikes and river regulations (and on a chain of dams on the lower Bosna): it is important to develop options having wider benefits (NbS) and to not conflict with objectives of WFD (good ecological status) and biodiversity (candidate sites for the future Natura2000 network)
3) Project goals and objectives, including mitigation of the existing flood risks and saving the expected biodiversity benefits (capitalising the available ecosystem services)	Maintaining the still existing floodplain areas, in particular along the lower Bosna (similar to all other Sava tributaries) Floodplain restoration to increase the retention capacity (in the area along Sava up to 90 % losses of original floodplains); this will lower the flood discharge peaks and overall flood water levels Prevent that the remaining floodplains will be cut off for more intensive uses, including that at the areas for the bypass system agricultural use will be reduced, and valuable wetland habitats maintained
4) Lead institution for project and partners	Within the framework of the Int. Sava Commission, the neighbouring countries should discuss those options and jointly develop a master plan for the wider transboundary area of the Middle Posavina National water management units in BA (entities) and HR
5) Stakeholders which need to be taken on board	From the beginning a broad range of stakeholders from BA and HR, as land will have to be purchased or compensated District and local governments, competent agencies for water and nature, land owners, all municipalities Interested NGO's
Activities	Involve the Int. Sava Commission and relevant technical experts Prepare a detailed project outline and road map
6) Resource needs (time, finance, other)	€ 50-100 Million 5 years
7) Risks and risk mitigation regarding the accomplishment of the project	Lack of continuous commitment by government and local stakeholders Competition with other infrastructure projects

HR Pilot 1: Reconnect the Odra River for biodiversity and people

Background and rationale for the project

The Odransko polje in north-western Croatia is protected by the Croatian Nature Protection Law as an important landscape and Natura 2000 site. One of the main drivers for development of important habitats in this area, and especially for moist grasslands and wetlands, was regular flooding which naturally occurs here. Odransko polje is a natural retention area, historically flooded by waters from the Odra river but also from the Kupa river. Today, during high water levels in the Sava river, excess water from the Sava is bypassed through the Sava-Odra flood canal and then discharged into Odransko polje as part of the Upper Posavina flood management system. The Sava-Odra bypass brought more water into Odransko polje, but it also cut the Odra River in two pieces, since it goes straight across it. The Sava-Odra bypass was built in the 1980s but has never been finished. Original plans included to reconnecting its two parts with the river. Connection was supposed to be built under Sava-Odra canal (Dyker-syphon) and water was supposed to be transferred by water pumps. These plans were never realized and led to a lack of flowing fresh water in parts of the Odra floodplain which is situated south from Sava-Odra channel, and to a change of its ecological characteristics.

Further, the current situation also causes flooding of settlements, which are situated north of the Sava-Odra canal. Water from the northern Odra catchment is today bypassed through a small bypass ditch, which goes in parallel with the dike and reconnects with the Odra only 15 km downstream. The bypass ditch has no capacity to convey all the water from the northern part of Odra during high floods. Reconnecting the Odra would be the best solution, as it would be a natural solution for flood protection and would also bring high-quality water to Odransko polje and the southern part of the disconnected Odra segment.

„Odransko polje“ is a Natura 2000 site hosting the following EU habitat types: 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea*, 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation, 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*), 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*, 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). Most of the key habitats in this Natura 2000 site are flood-dependent.

The Odransko field and its surrounding area have already lots of problems because groundwater level has lowered significantly (Sava riverbed incision). In addition, the “*Zagreb on Sava*” project has plans for reconstructing the Sava River, which include also reconstruction of the Sava-Odra canal (it would become deeper and wider and possibly reconnected with the Sava). This project could lead to a complete loss of flooding for Odransko polje and would thus have significant negative effects for other Natura 2000 sites (EU Birds Directive) and the Turopoljski lug (highly valuable natural wet oak forests).

Fig. 41: Current situation and plans for the project area along Odra (Odranjsko Polje) (background Google Earth 2018).

LEGEND

Red line – Sava-Odra channel

Blue line – The Odra River – two segments, which are cut in two pieces by Sava-Odra channel

Green dotted polygon – Odransko polje

Thin orange line – channel which takes water from northern part of the Odra River 15 km south-east

Purple line – plans for connecting Sava-Odra channel to the Sava River (Zagreb on Sava project)

Fig. 42: Detailed plans for the project area (background Google Earth 2018).

Criteria that determined the choice of this site (feasibility, cost-effectiveness, political support, high flooding risk, potential biodiversity benefits, funding possibilities, etc.)

The biodiversity of that area is highly endangered for several reasons, some of them being very important: Loss of populations of endangered species, flood levels and frequencies and decrease of groundwater levels that affect also agriculture in the Odransko field and in the nearby Turopolje forests. This site would be a good pilot area since local politicians support the restoration of the Odra River (head of local municipality – Orle, mayor of the nearest city Velika Gorica and mayor of Zagreb County).

Project goals and objectives, including outlining the expected flood risks management effects as well as the expected biodiversity benefits

Two segments of the Odra River, which are now disconnected, should be reconnected, bringing freshwater, to the southern segment of the Odra river. This would lead to reduced risk of flooding of settlements, which are situated in the northern part of the Sava-Odra channel and which are now flooded because of the insufficiently small bypass ditch.

Lead institutions for project and partners

Croatian Waters, Municipality Orle, Green Ring Public County Institution for Management of Protected Areas

Stakeholders which need to be taken on board

Croatian Waters (HV)

Activities

- Collecting existing data
- Gap analysis - which data are still needed
- Starting studies for collecting necessary data
- Developing project documentation

Resource needs (time, finance, other)

Not assessed yet

Risks and risk mitigation regarding the accomplishment of the project

Lack of motivation among all stakeholders; unclear financing; possible alteration of the water regime due to the *Zagreb on Sava* project.

HR pilot 2: Bregana

Green infrastructure for natural management of floods and protection of endemic fish species

Location: Bregana stream – part of Natura 2000: HR2001506 Sava upstream of Zagreb

Problem: Bregana is a torrent stream which causes lots of problems for flood defence during heavy rains and high level waters. Main problems are flooding, destruction of roads, high erosion level of stream banks and flood protection walls. Impacts are not only caused by heavy rains: Bregana is the first tributary of Sava River after the Croatian-Slovenian border, and there are 7 big hydropower plants with big impoundments situated in the upstream Sava part in Slovenia. This results in unexpected water discharge alterations, which combined with heavy rains and backwaters from the Sava, can fill up Bregana. On top, this torrent carries a lot of sediments, rocks, trees, wood material and similar which maximizes its erosion power. A good part of that material comes from surrounding slopes (also Žumberak mountains, via small tributary streams), which lost their vegetation cover over the last decades. Erosion also alters the stream bed which is an important habitat for an endemic fish species – Souffie (*Telestes souffia* Risso, 1827). This „devastating“ potential is used by Croatian Waters as arguments for more canalization and for more flood defence structures which again further degrade the Souffie habitat.

Bregana is the only location of the Souffie fish in Croatia, which was the key species for designating the Natura 2000 site - HR2001506 Sava upstream of Zagreb and thus requires strict protection measures.

Proposed solution by this project: The proposed project provides nature friendly solutions for flood defence, different to the solutions being implemented by Croatian Waters. This aims at a combination of green infrastructure and artificial infrastructure (though rather nature friendly). This includes, first, to plant trees (afforestation) on slopes where during heavy rains, most sediments are mobilised (land stabilization). Secondly, a planting of hedgerows will gradually slow down water runoff into the stream. In other small canyons where water and a lot of woody material and rocks enter Bregana stream, the building of debris flow barriers would decrease in the volume of material reaching Bregana and decrease its erosion potential. Material retained at the barriers will have to be removed occasionally to keep their function (water flow permeability). On two locations, biological waste-water treatment plants will be built for improving water quality. Further, rock blocks would be put into the stream bed for slowing down water discharge and also serve as a hideout for fish during fast flows). One artificial cascade has been identified as unsuitable for fish migration (cascade is too high) and is proposed to be removed.

MK Pilot: Pelagonia "Country of Storks"

Geographical description and historical development

The Pelagonia lowlands (local name meaning „stork land") are part of a large north- to south-directed geological depression (1.000 km²) in southwestern Macedonia along the Crna Reka river (app. 66 km long and 16 km wide at a sea level of in average 600 m a.s.l.). The mean discharge of the main waterbodies is about 25 m³/s, the flood in the period of snow melt in the surrounding mountains (1,600 to up to 2,500 m a.s.l.) can easily reach about 100 m³/s (maximum flood in February 2015 reached 223 m³/s), flooding large areas of the shallow bottom plain, not only east of Bitola along a 20 km long river reach, where formerly large wetlands existed, but also in the central and upper reaches.

Originally, in this lower part close to Bitola, the floods spread over the entire valley floor, building a huge permanent wetland with changing flood conditions and hosting a great variety of swampy plants and particular bird species. Beside all kind of major water plants, such as floating carpets of water lilies and reed patches, in particular the yellow floating heart (*Nymphoides peltata*) should be mentioned as an indicator for changing water levels. Among the numerous breeding bird species, such as the two European pelican species (*Pelecanus crispus* and *onocrotalus*), ibis, spoonbill, pygmy cormorant, ducks, herons, wading birds and raptors, also the large number of white storks should be highlighted. The surrounding flood-prone land (permanent swampy zone had a diameter of about 3 km) was used mostly as pasture for horses, water buffalos and geese. For the highly endangered Dalmatian pelican (*Pelecanus crispus)*, the Pelagonia wetlands were perhaps the most important areas across the entire Balkan (in 1956 about 1.500 individuals could be counted at one place). Before regulation Crna Reka itself was a meandering, very slow flowing small river (compare STUMBERGER 2002).

Since 1959, larger parts of the area were meliorated (in total 54.000 ha – alone 20.000 ha after 1975), 300 km of canals has been digged out), most of the river courses were straightened. Whereas in the upper and central parts, grasslands still covering wider areas (today mainly pasturing by sheep), the southern part with the former swamps has nearly disappeared and the area is today mostly used for corn and tobacco production.

However, since the melioration works were not systematically maintained over the past 30 years and a local comeback of ecologically more valuable areas can be observed, the chance to restore large areas exists. For instance, some 15 km upstream a remnant of about 1.000 ha of wet grasslands can be found, which can be considered as a reference area, however, Crna Reka is also regulated in this region.

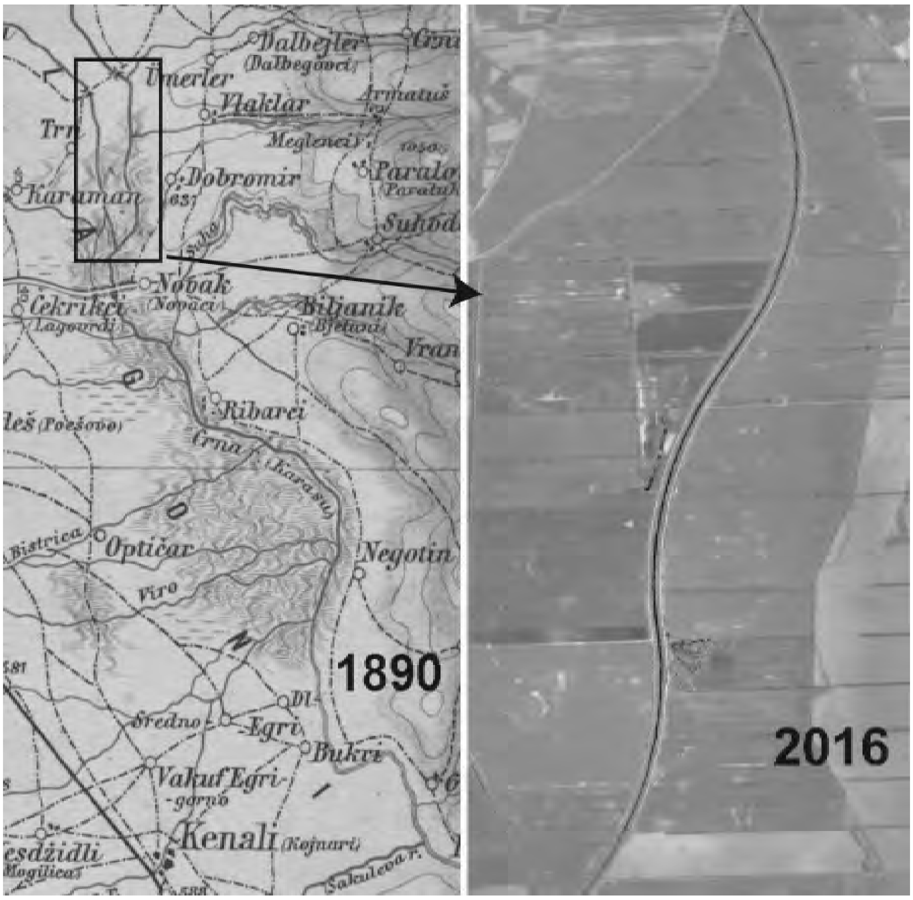


Fig. 43: The general development of the lower Crna Reka wetlands east of Bitola (unfortunately, historical maps are not available in sufficient resolution and geometric accuracy for overlay). Left image from „Austrian Generalkarte 1890, Institute for Geography, University of Vienna“, and right „Google Earth“.

Flood risk, loss of biodiversity

In the past, the area was frequently flooded and the uses were adapted to this wetland character (fishing, reed usage, pasturing). With the melioration of large areas, land use was significantly intensified and the wetlands got limited to very small areas. Settlements at the margins grew and the flood damage potential increased substantially (affected crops). To indicate the loss of wetlands and grasslands in this southern part of Pelagonia, the decline of white stork populations was significant: from up to 500 breeding pairs in 1958 just before the melioration to some 200-250 pairs after (also the significant loss of colony breeders towards single breeders is a clear indication of habitat losses and alterations). With the loss of about 5.000 ha of core wetlands, the pelicans became extinct (STUMBERGER 2002).

On the other side, the entire region is listed as prone to droughts as a result of climate change. The restoration could therefore impressively demonstrate the balancing functions of wetlands for flood and drought, and therefore show the perfect adaptation to climate change of this particular region.

Proposed measures

The main channel, which is entirely rectified, should be restored and sufficient area for its lateral development should be serving as retention space. Here, grazing should be allowed as a traditional but economically still relevant extensive form of farming and could thus buffer the limitation of land uses.

The earlier formulated national project "Rehabilitation and construction of the drainage system Pelagonija" envisaged for 2007-2010 with a size of 40 Million €, which has not started so far, would give the opportunity to include substantial restoration measures, such as

1. Restoration of the active floodplain at a considerable size (4.610 ha for the respective reach and another 5.000 ha upstream - not visualized yet): Both areas should be set in relation to the loss of over 50.000 ha of floodplains during 1959-80 and the recently flooded agricultural area of 34.000 ha (February 2015). A pilot project could start on smaller areas, maybe 1.000-2.000 ha.
2. Restoration of channels: All channels should be restored/initialised as meandering channels, keeping water and moisture much longer in the area (stabilising of the groundwater tables in the adjacent arable land). Ditches and drainage canals can be simply closed at their ends, valuable oxbow parts must be protected.
3. Complementary conventional measures to improve flood defence in settlements and critical infrastructure: This should be done adaptively based on detailed hydraulic modelling and assessment of the flood damage potential (i.e. analysing where flood dikes are absolutely necessary). The channel restoration and its increased flood conveyance capacities should be taken into account. The existing dams in the catchment and the restoration of upstream retention areas (central Pelagonia) will support overall flood mitigation. These dams should be used wisely, allowing sufficient water flow during the dry season but also regular flooding of the restored areas.
4. Land use: Within the restored floodplain, areas should be taken out of intensive use (i.e. serve for grasslands instead of crops), namely by re-establishing grazing. Outside the restoration area but depending on the flood risk (the establishment of entire flood dike systems is expensive and maybe not necessary), a buffer of less intensive agricultural areas with the option of compensation at flood cases should be developed. The grasslands would buffer the moisture during dry seasons much better than water-intensive crops.

By convincing local people and politicians to combine flood protection with restoration, bird (stork) protection and a preserved landscape heritage as a local identity, the project would be of multiple benefit for the whole region. Economically, the frequent losses in agriculture during floods must be considered when planning this project as well as its multiple benefits by restoring and strengthening ESS, including better adaptation for climate change-induced floods and droughts.

Lead institutions for the project and key partners

Ministry of Environment and Physical Planning; Ministry of Agriculture, Forestry and Water Economy; Water Management Organization – Branch Offices 'Bitolsko Pole' and 'Prilepsko Pole', municipalities in the Pelagonija region

Stakeholders which need to be taken on board

All of the above and the UN Development Programme (having conducted preliminary flood risk assessments and a feasibility study of flood mitigation options, which should be made available to any other complementary project)

Activities

1. Review of existing studies and relevant technical documents (e.g. UNDP flood risk assessment; technical reports for river bed regulation and clean-up actions)
2. Feasibility analysis of proposed NbS measures (from the environmental, economic, social and financial perspectives)
3. Preparation of a detailed technical documentation (basic designs in line with national regulations)
4. Permitting procedures (including resolving outstanding land property- issues)
5. Physical implementation of NbS measures

Resource needs (time, finance, other)

EUR 50.000 for additional feasibility assessments (adding NbS to existing UNDP-backed analyses)

EUR 50.000 for additional technical documentation

Costs for physical implementation (to be defined as part of the design process)

Risks and their mitigation and risks to be addressed in the further planning

Financing constraints

Likely opposition by potentially affected private interests (mainly farmers)

Lack of commitment by authorities (limited ability to understand long-term benefits of NbS application; lack of willingness to carry out expropriation processes)

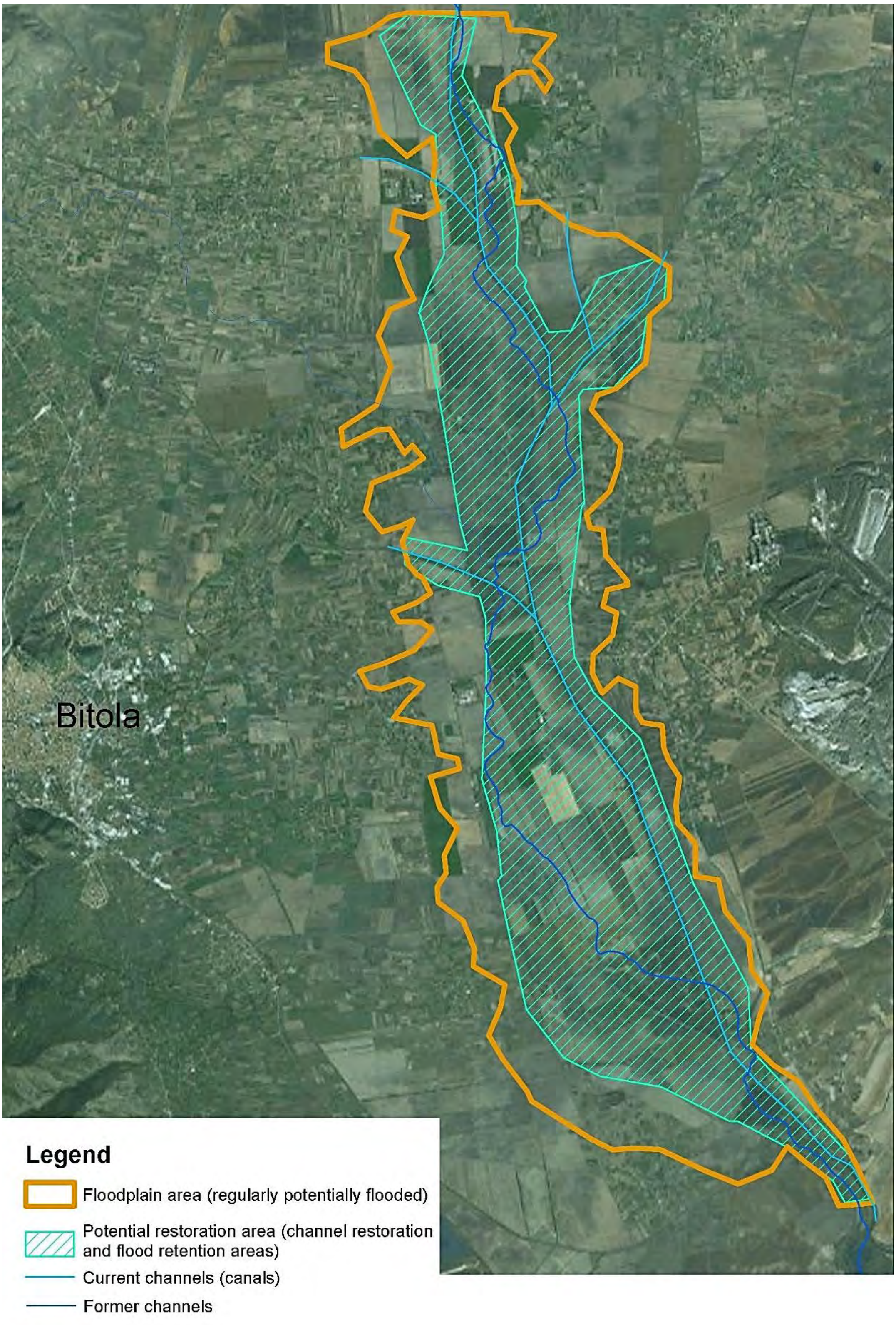


Fig. 44: The potential restoration area for the central southern part should at least cover the indicated hatched area (4.610 ha). This would allow a sustained restoration of the river and its wetlands. For a pilot project smaller areas with 1,000-2,000 ha should be selected (background Google Earth 2018).

RS Pilot: Restoration of the former floodplain between the rivers Sava and Bosut

Forested retention area as an instrument for integrative flood risk management and habitat conservation

Location: Municipalities Sremska Mitrovica and Šid, Srem District, Vojvodina Province, Republic of Serbia

Proposal by the Institute for Nature Conservation of Vojvodina Province (former department of the Institute for Nature Conservation of Serbia)

Overall project objective

Designation of a lowland forest matrix between the rivers Sava and Bosut for retention of exceptional floods and ecological flooding of wetland habitats

General description of the area

The proposal area is located in the former floodplain between the river Sava and its tributary Bosut, both covered by natural and semi-natural habitats. The dominant land cover is a lowland forest of outstanding ecological importance. The most common tree species are oak (*Quercus robur*) and ash (*Fraxinus angustifolia ssp. oxycarpa*). Grassland fragments are scattered in the forest, in form of wet meadows as parts of forest management units. Some plots of arable land are situated near settlements (Jamena, Morović, Višnjićevo, Sremska rača). The former floodplain area behind the dikes (embankments) is not naturally flooded but still kept its wetland character that is maintained by irregular water logging, resulting from high water levels of Sava River.

The project site is located at the lower course of Sava River, approximately 10 km upstream from the mouth of its largest tributary Drina. Different to the Drina, its left-sided tributary Bosut is coming from Croatia, through the lowland area of the Pannonian Basin, at a very moderate slope. The described forests and surrounding rural mosaic are situated within the Bosut River basin. The basin area is 2.943 km^2 with 132 km of river length. Except for springtime and periods of heavy rains, Bosut is functioning mainly as a stagnant waterbody (only flowing in its upstream reach). Large reaches of the river are regulated and its lower course water level can be managed by sluice gates on the river mouth.

Conservation importance

The outstanding conservation importance of the river area is given both by its habitat types and its wildlife species of national and international importance (e.g. *Bombina bombina*, *Triturus dobrogicus*, *Emys orbicularis*, *Ciconia nigra*, *Haliaeetus albicilla*, *Milvus migrans*, *Alcedo atthis*, *Dendrocopos medius*, *Ficedula albicollis*, *Lutra lutra* etc.). The listed species are linked to habitats that are depending on periodical inundation.

The existence of these specific habitats results in a high diversity of rare insects (*Ephemeroptera*, *Trichoptera*, *Odonata*, *Gerridae*, *Dytiscidae*, *Gyrinidae*, *Tabanidae*) and other groups of aquatic invertebrates along the river (*Oligochaeta*, *Bivalvia*, *Gastropoda*). The cover of muddy substrate, decreased by river regulation, is hosting certain species of mayflies (*Ephemeroptera*), caddisflies (*Trichoptera*) and midgeflies (*Chironomidae*). The rich floating and submerged vegetation provides habitat for dragonflies (*Odonata*), mosquitoes (*Culicidae*), water bugs, all indicating the functional diversity of the area. In accordance, the names of old ponds and other toponyms point out to its former importance for fish spawning, that still has a potential for restoration. The landscape and biodiversity characteristics meet the criteria of the Birds and Habitats Directives.

Conservation status

The project site is recognized as an area of national and international conservation importance. Status of IBA (Important Bird Area, as based on the BirdLife International nomenclature) (RS007) and IPA (Important Plant Area, as based on the British organisation PlantLife) confirms its qualification as future NATURA 2000 areas.

The site belongs to the larger forest matrix being part of the national ecological network. The bylaw on the national ecological network announced both rivers Sava and Bosut as international ecological corridors.

The proposed area encompasses four forest protected areas at national level. The loss of hydrological dynamics and consequential habitat alteration lately resulted in the decline of the conservation status of these protected areas. Legal steps have been undertaken for the PA revision and the ecological flooding is considered as the most effective tool for habitat revitalisation.

Key threats

Biodiversity

The potential NATURA 2000 habitat types identified along the Sava River have been deteriorated by the new delineation of waterbodies and dikes constructed during the early 20th century. 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 to lowland forest habitats, too.

Local development

The regional hydrologic and climate changes (GALIĆ 2009 and 2010) indicate increasing flood risk for the wider region. Forestry, as the main land use type, is particularly affected by unnatural forest dying due to severe droughts and groundwater depletion (BAUER 2013).

Management practices and key stakeholders

Lowland forestry, game management and traditional acorn-grazing (pig herding) are the most common land use activities, managed or governed (pig herding) by the public enterprise for forestry and game management - PE Vojvodinašume. Some of the specific biodiversity features of the former Sava/Bosut floodplains are linked to the traditional grazing of domestic animals. Sheep herding used to be practiced as an effective tool for dike maintenance, usually with local breeds.

Proposed solution - key field activities

- 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.

Project deliverables

The proposed integrated floodplain management provides:

- Reduced risk of catastrophic flooding of settlements and of complexes of arable land;
- Improved conservation status of the habitats and species of national and international importance;
- WFD objectives implemented via cross-border stakeholder participation as a pilot for the EU candidate country;
- Increase in water availability and quality, consequently higher biological productivity, more sustainable forestry and wildlife management;
- Increased capacities for traditional pasturing, as a practical tool for dike maintenance;
- Historical spawning and nursery grounds for many fish species restored;
- Improved ecosystem services for various beneficiaries.

Relevance to the objectives in national and European legislation and project documentation

- The project activities and results are in line with EU Water Framework Directive, EU Habitats Directive (92/43/EEC), Bern Convention, Law on Nature Protection of Serbia, national bylaws on protected areas, species, habitats and national ecological network.
- The proposal will be in compliance with the Sava River Basin Management Plan (SRBMP, endorsed by the ISRBC).
- In addition, the site was recognized for potential retention in the LIFE III Project[35], named Morovićko- Bosutske šume.

[35] LIFE III Extension Programme (LIFE06/TCY/INT/246.) Project Title: PROTECTION OF BIODIVERSITY OF THE SAVA RIVER BASIN FLOODPLAINS. Land Use WG Report. Available at: http://www.savariver.com/results%20download/Task%20C%20-%20Land%20use%20analyses.pdf

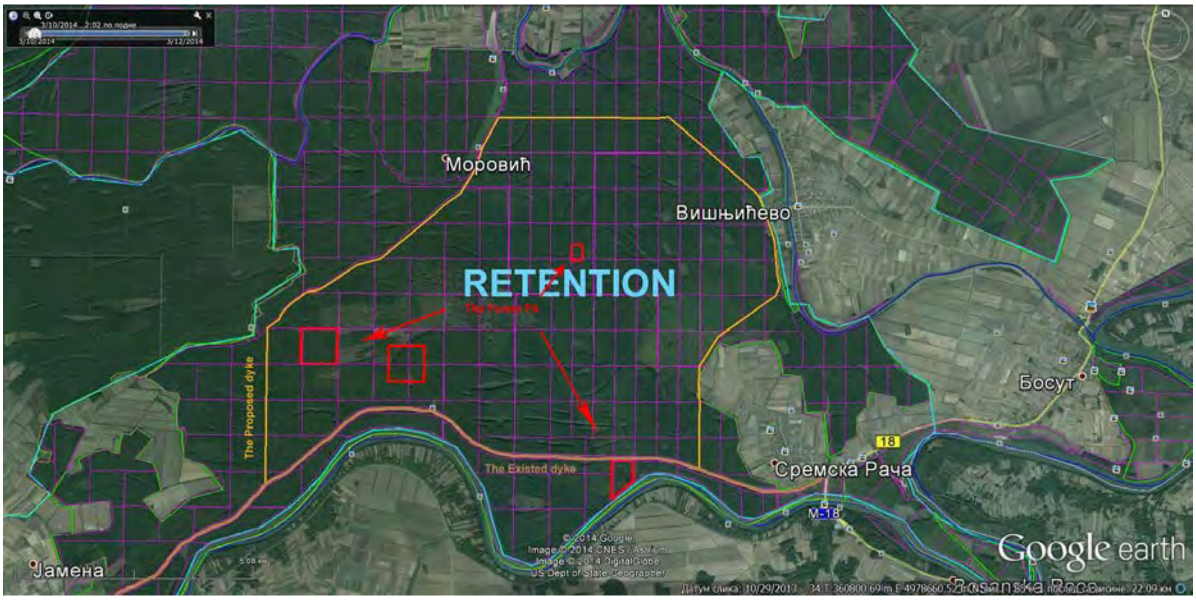


Fig. 45: Bosut forest, potential area for reconnection with the lower Sava (orange marked area north of the flood dike).

Rationale

In the frame of the regional hydrologic and climate changes, the economical, ecological and social needs can be satisfied through the concept of integrative river management. Both the current excessive flood risk and the impaired conservation status of the habitat types and species of European interest are strongly indicating the necessity to establish a more natural retention area for Sava flood waters. Establishing a forested retention area is compliant with the flood protection needs, both the current and traditional land use practices, as well as with nature protection guidelines (compare also GIZ 2018). The project deliverables includes improvement of ecosystem services, in particular: intensified water purification, increased water availability and biological productivity (forest biomass, fish spawning). Results provide a solid basis for achieving the requirements of the EUWFD.

Importance of the proposed retention was confirmed particularly during the catastrophic floods in May 2014, when large downstream towns have been endangered by extensive flooding and literally saved due to accidental water retention due to upstream breeches of embankments in Bosnia and Croatia.

Material for the dike constructions is available at the site. The height of the dike constructions endorsing the forest and the water level within the retention must be adjusted to the flood tolerance of tree species and wildlife.

Additional drainage on arable land close to the retention area can be avoided or minimized due to the loamy soils and appropriate distance from the arable land. The only section of the proposed dike foreseen along the edge of arable land can be easily drained due to the Bosut regulated (lower) water levels.

The enclosure of the retention area would have no negative impact on nearby forests in the Republic of Croatia. However, there are possibilities to further increase the retention area and flooding capacity through transboundary water management in cooperation with Croatia.

Additional inputs (will be provided in project realization):

- A historical comparison of water levels on Bosut and Sava;
- Water levels during floods in May 2014 in the forest area, the forest community response, and the situation at higher parts of forests that have then not been flooded;
- Risk of unwilling waterlogging on arable land due to the retention and mitigation measures (possible need of additional drainage);
- The potentials for coordinated cross-border flood risk management by means of connecting the proposed retention with the Bosut and its tributary Studva.

5 Conclusions

The Western Balkan region is one of the most vulnerable areas concerning the natural hazards from flooding and climate change in Europe. At the same time the Western Balkan rivers provide outstanding opportunities for nature-based solutions for flood-prevention. Apart from the necessary reconstruction of any destroyed infrastructure and upgrading of local flood defence systems close to settlements, additional complementary nature-based solutions can mitigate and reduce the impacts of future disastrous events. It has to be highlighted that the Balkan region still hosts several large-scale wetlands and natural flood retention areas which are serving as blueprints for NbS: They have to be maintained in their flood mitigation function and as hotspots for biodiversity in Europe.

This study

- introduced and explained the concept of NbS and discussed it regarding flood management in the study area;
- presented existing examples of NbS and remaining floodplain areas such as the Upper Posavina flood system in Croatia, and underlined the necessity to effectively maintain their function;
- collected data to assess the status of all flood- and landslide-prone areas;
- discussed the pressures on rivers and floodplains that are increasing the local flood risk, such as river regulation, urbanisation and intensive floodplain uses;
- tried for the first time to identify those areas with still existing retention functions and a high ecological value;
- reviewed national policies and collected stakeholder information across all sectors, from governements, national and international institutions, science and NGOs;
- delineated and prioritized potential areas for NbS and
- presented eight pilot projects in more detail.

Key messages based on the study results can be summarised as follows:

1. The study area still hosts various near-natural water retention areas, fulfilling all requirements for nature-based solutions for flood prevention, but which became drastically reduced in their size and capacity (75 % loss). On the other hand, over 20 % of flood-prone areas are covered by adapted wetlands, riparian forests or grasslands, which is approximately the double percentage than in Western Europe, where land use has extremely changed since about 1900. It is necessary to protect those areas and to keep their functionality for flood mitigation and biodiversity. It is therefore necessary to prevent further losses, as the pressure of more intensive landuse is high.
2. Most of the flood-prone area is used for agriculture (66 %), except for grasslands which are adapted to regular inundation. Settlements and infrastructure cover 5 %, which is less than expected (in comparison with Western Europe). Spatial planning must prevent further uncontrolled landuse and illegal housing especially in floodplains.
3. The review of national policies for the study and by stakeholders (such as at the BfN workshop at the International Academy for Nature Conservation Isle of Vilm in December 2017) implies a certain strategic attention to NbS for flood prevention (or

green infrastructure) e.g. in Croatia, but no systematic approach or consideration in national programmes of measures was observed so far. It is therefore necessary to strengthen the commitment for implementing NbS politically and in spatial planning to increase their multifunctional contribution and effectiveness for climate change mitigation.

4. The review of ongoing flood management projects in the Western Balkan region clearly shows the focus on conventional structural measures. Only few non-structural measures aim to improve warning systems and awareness but none on NbS. A lot of expensive projects are envisaged to construct flood defences and river regulations, without considering NbS. Therefore, taking into account many valid arguments, as presented in this study, NbS should no longer be ignored but become an integral part of every flood risk planning, providing synergies with other policies in the field of green infrastructure, water quality, biodiversity and climate change adaptation and mitigation. Expensive projects must first prove to respect all those policies, while NbS could ensure many political, social, economic and biodiversity co-benefits.
5. The list of 264 potential sites for NbS to flood prevention with a total retention capacity of roughly 6 Billion m^3 across the region (taking into account the loss of 75 % of floodplains and the remaining capacity of major wetlands and floodplains of about 12 Billion m^3) can serve as a long-term pool for potential future projects regarding flood mitigation and encourage all stakeholders to promote their implementation. The chosen prioritisation tries to highlight certain projects but only their individual analysis can lead to their practical implementation. In any way, governments and regional administrations should include these potential project areas into their spatial planning. Because once potential sites are used for other purposes, they are lost to be developed as site for NbS to flood prevention in the future.
6. Finally, the eight pilot projects point to the enlarged perspective of sustaining the multifunctional ESS in their support for flood management, and therefore much beyond their role as small additional projects to fulfil various environmental objectives (such as for EUWFD or EUHD), but as integral projects combining flood risk prevention, climate change adaptation and ecological improvements. This implies integrative (upper-lower neighbours) and transboundary (catchment approaches, cumulative effects of measures) activities.

6 References

ALFIERI, L., BISSELINK, B., DOTTORI F., NAUMANN G., ROO A., SALAMON P., WYSER K., FEYEN, L. (2016): Global projections of river flood risk in a warmer world: River flood risk in a warmer world. In: Earth's Future, December 2016.

BAUER A., BOBINAC M., ANDRAŠEV S., RONČEVIĆ S. (2013): Devitalization and sanitation fellings on permanent sample plots in the stands of pedunculate oak in Morović in the period 1994- 2011. Bulletin of the Faculty of Forestry 107: 07-26.

BRUNDIC, D., BARBALIC, V., OMERBEGOVIC, V., SCHNEIDER-JACOBY, M., TUSIC, Z. (2001): Alluvial Wetlands Preservation in Croatia – The Experience of the Central Sava Basin Flood Control System. In: NIJLAND, H.J. & CALS, M.J.R. : River Restoration in Europe, Pratical Approaches, Proceedings of the Conference on River Restoration 2000 - July 17, 2000, RIZA rapport nr.:2001.023: pp. 109 – 118.

COHEN-SHACHAM, E., WALTERS, G., JANZEN, C. AND MAGINNIS, S. (eds.) 2016. Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97pp.

DOSWALD, N., OSTI, M. (2012): Ecosystem-based approaches to adaptation and mitigation – good practice examples and lessons learned in Europe. BfN-Skripten 306. (https://www.bfn.de/fileadmin/MDB/documents/service/Skript_306.pdf).

DRAGICEVIC, S. et al. (2011): Natural hazard assessment for land-use planning in Serbia. In: Int. J. Environm. Res., 5 (2) pp. 371-380.

EC (European Commission) (2017): Copernicus, Europ‘s eyes on earth. Land monitoring service (2017): CORINE CLC land cover 2012, Digital Elevation model, water bodies, riparian zones, settlements. http://land.copernicus.eu/pan-european.

EC (European Commission) (2015): Flood Prevention and Management Gap analysis and needs assessment in the context of implementing the EU Floods Directive in the Western Balkan countries. WBIF pp. 87, Brussels.

EC (European Commission) (2014): EU policy document on Natural Water Retention Measures. By the drafting team of the WFD CIS Working Group Programme of Measures (WG PoM). Technical Report - 2014 – 082, pp 18, Brussels.

ECRAN (Environmental and Climate Regional Accession Network) (2015): Report on Expert Training on Risk and Vulnerability Assessment and Adaptation Planning – Urban Planning and Development. Pp. 52. Podgorica.

EEA (European Environmental Agency) (2017a): Climate change adaptation and disaster risk reduction in Europe. 172 pp. Brussels.

EEA (European Environmental Agency) (2017b): Trends in annual and summer precipitation across Europe between 1960 and 2015 https://www.eea.europa.eu/data-and-maps/indicators/european-precipitation-2/assessment.

EEA (European Environmental Agency) (2016a): What is the trend in mean river flow in different seasons across Europe https://www.eea.europa.eu/data-and-maps/indicators/river-flow-3/assessment.

EEA (European Environmental Agency) (2016b): Flood risk and environmental vulnerability. Exploring the synergies between floodplain restoration, water policies and thematic policies. PP. 78, Kopenhagen.

EEA (European Environmental Agency) (2011): Precipitation map. https://www.eea.europa.eu/themes/water/water-resources/figures-and-maps/precipitation/view

GALIĆ, Z., ORLOVIĆ, S., KLAŠNJA B. (2010): Microclimate Conditions – Possible Link of Understanding Vulnerability of Forest Ecosystems Under Climate Change. Institute of Forestry, Belgrade, Serbia. Plenary lectures. pp 213-220.

GALIĆ, Z. (2009): Expected Climate Change and Options for European Silviculture. Country report for SERBIA COST action FP0703 – ECHOES.

GIZ (German Cooperation) (2018): Advocating Ecosystem Services Assessment and Valuation (ESAV) in Bosut Forests area - integrating biodiversity and ecosystem services in natural resource uses and management. Implemented by Institute for Nature Conservation of Vojvodina Province (INCVP), Novi Sad, Serbia. Pp.78.

GIZ (German Cooperation) (2015): Flood risk management plan for Skoder region. In cooperation with Ministry of Environment, Ministry of Interior, Ministry of Agriculture, Rural Development and Water Administration. pp. 138. Tirana.

GOOGLE EARTH (2018): Satellite images worldwide. DigitalGlobe 2018. http://www.earth.google.com.

HABERSACK, H., SCHOBER, B., HAUER C. (2015): Floodplain evaluation matrix (FEM): An interdisciplinary method for evaluating river floodplains in the context of integrated flood risk management NAT HAZARDS. 2015; 75: S5-S32.

IPA FLOODS IMPLEMENTING CONSORTIUM (2016). Findings and Recommendations: Albania, Bosnia & Hercegovina, Croatia, Kosovo, Macedonia, Montenegro and Serbia. “Programme for Prevention, Preparedness and Response to Floods in the Western Balkans and Turkey” – IPA Floods.

ISRBC (2014): Preliminary Flood risk plan and (based on Flood protocol for the Sava basin). Zagreb, 36 pp.

IUCN (2018): State of Nature Conservation Systems in South-Eastern Europe. In print, pp. 150, Belgrade.

IUCN (2017a): Towards the implementation of Nature-based Solutions in Albania. The role of ecosystem services in disaster risk reduction and climate change adaptation. Will be published in 2018). pp. 74 Belgrade.

IUCN (2017b): Towards the implementation of Nature-based Solutions in Serbia. Draft study (Will be published in 2018). Belgrade.

JAUPAJ, O., LAMAJ, M., KULICI, H., JUSUFATI, M., PLAKU, E., GJETA, I. (2017) Landslide Inventory Map of Albania. In: MIKOS M., TIWARI B., YIN Y., SASSA K. (eds) Advancing Culture of Living with Landslides, pp 39-44, Cham.

JOVANOVSKI, M., MILEVSKI, M., MARKOSKI, B. (2013): Landslides in the Republic of Macedonia Triggered by Extreme Events in 2010. In: Geomorphological impacts of extreme weather, Case studies from central and eastern Europe. Edition: Springer Science+Business Media Dordrecht, Chapter 17, pp. 265- 278.

KABISCH, N., KORN, H., STADLER, J., BONN, A. (Eds.) (2017a): Nature-based Solutions to Climate Change Adaptation in Urban Areas - Linkages between Science, Policy and Practice. Springer International Publishing, ISBN 978-3-319-53750-4. (open access book: https://link.springer.com/book/10.1007/978-3-319-56091-5?wt_mc=Other.Other.8.CON951.OABEnvir_09&utm_medium=other&utm_source=other&utm_content=oabenvir_09&utm_campaign=8_nish01_oabenvir_09).

KABISCH, N., STADLER, J., DUFFIELD, S., KORN, H. & A. BONN (Eds.) (2017b): Proceedings of the European conference „Nature-based solutions to climate change in urban areas and their rural surroundings“. BfN-Skripten 456. 179 pp. (https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript456.pdf).

LO, V. (2016): Synthesis report on experiences with ecosystem-based approaches to climate change adaptation and disaster risk reduction. Technical Series No. 85. Secretariat of the Convention on Biological Diversity, Montreal, 106 pages.

MONTENEGRO, MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM (2015): The second national communication on climate change (under the UNFCCC). Podgorica, pp. 295.

PETROVIC, A., KOSTADINOV, S., DRAGICEVIC (2014): The Inventory and Characterization of Torrential Flood Phenomenon in Serbia. In. Pol. J. Environ. Stud. Vol. 23, No 3, pp. 823-830.

PROSKE, H. & BAUER, C. (2016): Indicative hazard maps for landslides in Styria; Austria. In: Acta Geoblacanica, Volume 2, Issue 2, pp. 93-102. http://geobalcanica.org/wp-content/uploads/AGB/2016/AGB.2016.10.pdf.

REGUERO, BG., BECK, MW., BRESCH, DN., CALIL, J., MELIANE, I. (2018): Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States. PLoS ONE 13(4): e0192132.
https://doi.org/10.1371/journal.pone.0192132.

SAYERS, P., L.I, Y. GALLOWAY, G., PENNING-ROWSELL, E., SHEN, F., WEN, K., CHEN, Y. AND LE QUESNE, T. (2013): Flood Risk Management: A Strategic Approach. pp. 202, Paris, UNESCO.

SCHWARZ, U. (2017): Habitat loss as a major threat for migratory bird conservaton along the Adriatic Flyway. In: ADRIATIC FLYWAY - BIRD CONSERVATION ON THE BALKANS. Proceedings of the Second Adriatic Flyway Conference in Durrës, Albania, 1 – 3 October 2014. Edited by: Peter Sackl, Stefan W. Ferger. Euronatur, Radolfzell, Pp. 74-80.

SCHWARZ, U. (2016): Sava White Book. The Sava River Corridor: Status, threats and restoration potential. Published by Euronatur and RiverWatch. Radolfzell, pp.204.

SCHWARZ, U. (2014): Flooding analysis of the karst poljes in Bosnia and Herzegovina. In: Dinaric Karst Poljes – Floods for Life. Proceedings of 1st Workshop on Karst Poljes as Wetlands of national and international importance, Livno 30.9.-2.10.2013. Edited by Sackl P., Durst R., Kotrosan D. and Stumberger B., EuroNatur, Radolfzell, p. 39-44.

SCHWARZ, U. (2013): Assessment of the Restoration Potential in the Transboundary Unesco Biosphere Reserve “Mura-Drava-Danube”. Comissioned by WWF Austria, 167 pp., Vienna.

SCHWARZ, U. (2012): Outstanding Balkan River landscapes – a basis for wise development decisions. For ECA Watch Austria/Euronature Germany/MAVA Switzerland, 150 pp and 101 pp. Separate Annex („River Catalogue“). Vienna.

SCHWARZ, U. (2010a): Habitat mapping of the Livanjsko Polje (BA), the Neretva Delta (HR, BA) and Lake Skadar-Shkoder (ME, AL) (a); Zonation Concept for Lake Skadar-Shkoder and the Bojana-Buna Delta (b); Rapid Assessment of the planned Hydropower Plants on the Drin River near Ashta (southeast of Shkodra) (c). In: Denac D., Schneider-Jacoby M. & Stumberger B. (eds.): Adriatic Flyway - closing the gap in bird conservation. Euronatur, Radolfzell. pp 79-88 (a), 89-102 (b), pp.135-142 (c).

SCHWARZ, U. (2010b): Assessment of the restoration potential along the Danube and main tributaries. For. WWF International Danube-Carpathian Programme, 58 pp. Vienna.

SIMIONE, U., PANDO, N., CIAVOLA, P. (1997): The coastline of Albania: morphology, evolution and coastal management issues. In: Bulletin de l'Institut océanographique, Monaco, n° spécial 18. CIESM Science Series n°3, pp. 151-168.

STROSSER, P., DELACÁMARA, G., HANUS, A., WILLIAMS, H. AND JARITT, N. (2015). A guide to support the selection, design and implementation of Natural Water Retention Measures in Europe - Capturing the multiple benefits of nature-based solutions. European Commission, pp. 98 Brussels.

STUMBERGER, B., SCHNEIDER-JOCOBY, M. (2010): International importance of three Adriatic Flyway priority sites: Livanjsko Polje, the Neretva Delta and Lake Skadar-Shkoder with the Bojana-Buna Delta. In: D. DENAC, M. SCHNEIDER-JACOBY, B. STUMBERGER (eds.): Adriatic Flyway – closing the gap in Bird Conservation, 53-58. EuroNatur, Radolfzell.

STUMBERGER, B., VELEVSKI, M. (2002): White Stork Ciconia ciconia survey in Pelagonia indicates a decrease in its breeding population and colony disintegration. In: ACROCEPHALUS 23 (112), pp. 67-74. Maribor

UN (2018): The United Nations World Water Development Report 2018: Natural-based Solutions for Water. Paris, pp. 154.

UNDP Kosovo (2014): Kosovo Disaster Risk Reduction Initiative (KDDRI). ProDoc. Pp.30.

UNDP Bosnia & Herzegovina (2016): Landslide Risk Management Study in Bosnia and Herzegovina. Sarajevo, pp. 82.

UNDP Bosnia & Herzegovina (2015): Vrbas project.

UNDP Bosnia & Herzegovina (2013): Climate change adaptation and low emmission development strategy for Bosnia and Herzegovina. Sarajevo, pp. 81.

UNDP Macedonia (2016): Vardar project.

UNDP Serbia (2015): Kolubara project.

UNEP (2012): Climate change in the west Balkans. ENVSEC, Vienna, pp.80.

USGS (2007): Landsat satellite images. Landsat-7 image courtesy of the U.S. Geological Survey.

WILDE, M., GÜNTHER, A., REICHENBACH, P., MALET, J.-P., HERVÁS, J., (2018). Pan-European landslide susceptibility mapping: ELSUS Version 2. Journal of Maps, 14(2): 97-104 and supplemental map.

WORLDBANK GROUP (2015): Water & Climate Change Adaptation Plan for the Sava River Basin. Water Partnership programme 100525 v1.

WWF US (2016): Natural and nature-based flood management: Agreen guide. Washington, DC, pp. 20.