

Consulting Services for

**Support to Water Resources Management in the**

**Drina River Basin**

Project ID No. 1099991

**DRINA RIVER BASIN ROOF REPORT**

June 2017

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**Draft**

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| **ACRONYMS AND ABBREVIATIONS** | |
| --- | --- |
| AASWA | Agency of the Adriatic Sea Water Area |
| ASRWA | Agency of the Sava River Water Area, Sarajevo |
| BiH | Bosnia and Herzegovina |
| oC | Degrees Celsius |
| DIV | Diversion (Hydropower Type) |
| DNA | Designated National Authority |
| DRB | Drina River Basin |
| EBRD | European Bank for Reconstruction and Development |
| EEA | European Environmental Agency |
| EEC | European Economic Community |
| EF | Environmental Flow |
| EIA | Environmental Impact Assessment |
| EP | Elektroprivreda |
| EPA | Environmental Protection Agency |
| EPCG | Elektroprivreda Crna Gore (Montenegro) |
| EPR | Environmental Performance Review |
| EPS | Elektroprivreda Serbia |
| ERS | Elektroprivreda Republike Srpske |
| EU | European Union |
| EUR | Euro |
| FAO | Food and Agriculture Organisation |
| FASRB | Framework Agreement on Sava River Basin |
| FBiH | Federation of Bosnia and Herzegovina |
| FCDA | Federal Civil Defence Authority |
| FGO | Federal Geological Office |
| FHMO | Federal Hydro meteorological Office |
| FHMS | Federal Hydro meteorological Service |
| FIA | Federal Inspection Authority |
| FMAWMF | Federal Ministry of Agriculture, Water Management and Forestry |
| FMEMI | Federal Ministry of Energy Mining and Industry |
| FMET | Federal Ministry of Environment and Tourism |
| FMIA | Federal Ministry of Internal Affairs |
| FMTC | Federal Ministry of Transport and Communications |
| FOFDP | Federal Operational Flood Defence Plan |
| FRY | Federal Republic of Yugoslavia |
| FSO | Federal Statistical Office |
| GCOS | Global Climate Observing System |
| GDP | Gross Domestic Product |
| GEP | Guaranteed Environmental Flow method |
| GHG | Green House Gas |
| GIS | Geographical Information System |
| GW | Groundwater |
| GWB | Groundwater Body |
| GWh | Gigawatt hours |
| HDWG | Hydrology Domain Working Group |
| HEC-HMS | Hydrologic Engineering Centre – Hydrologic Modelling System |
| HEC-RAS | Hydrologic Engineering Centre – River Analysis System |
| HIS | Hydrological Information System |
| HME | Hydro-mechanical Equipment |
| HMSS | Hydro-Meteorological Service of Serbia |
| HMWB | Heavily Modified Water Body |
| HMZ | Hydro Meteorological Institute |
| HPP | Hydropower Plant |
| HS | Hydrological Station |
| IAWD | International Association of Waterworks in the Danube Catchment Area |
| IBRD | International Bank for Reconstruction and Development |
| ICPDR | International Commission for the Protection of the Danube River |
| IMO | International Meteorological Organization |
| INC | Initial National Communication |
| INDC | Intended Nationally Determined Contribution |
| IPCC | Intergovernmental Panel for Climate Change |
| IPF | Investment Prioritisation Framework |
| ISRBC | International Sava River Basin Commission |
| IWRM | Integrated Water Resources Management |
| JCI | Jaroslav Černi Institute |
| JV | Joint Venture |
| KM | Convertible Marks |
| km | kilometres |
| Km2 | Square kilometres |
| kV | Kilovolt |
| kW | Kilowatt |
| kWh | Kilowatt hour |
| l/c/d | Litres per capita per day |
| LEP | Law on Environmental Protection |
| LFFEP | Law on Fund and the financing of environmental protection RS |
| l/s | Litres per second |
| l/s/km2 | Litres per second per square kilometre |
| LW | Law on Waters |
| LWM | Law on Waste Management |
| LWP | Law on Water Protection |
| m | Metres |
| m³/s | Cubic metres per second |
| m³/year | Cubic metres per year |
| MAEP | Ministry of Agriculture and Environmental Protection - Serbia |
| MAFWM | Ministry of Agriculture, Forestry and Water Management (RS BiH) |
| MARD | Ministry of Agriculture and Rural Development - Montenegro |
| MAWRMF | Ministry of Agriculture, Water Resources Management and Forestry – RS BiH |
| MCH | Meteorological, Climatological and Hydrological database |
| MCT | Ministry of Communications and Transport |
| MET | Ministry of Environment and Tourism |
| Mg/l | Milligrams per litre |
| MH | Ministry of Health |
| MIA | Ministry of Internal Affairs |
| MIEM | Ministry of Industry Energy and Mining (RS) |
| mm | Millimetres |
| Mm3 | Millions of cubic metres |
| Mm³/yr | Million cubic metres per year |
| mm/a | Millimetres per year |
| MME | Ministry of Mining and Energy |
| MNE | Montenegro |
| MOFTER | Ministry of Free Trade and Economic Relations (BiH) |
| MoU | Memorandum of Understanding |
| MQ | Mean Monthly Flow |
| MS | Meteorological Station |
| MSPCEEP | Ministry of Spatial Planning, Civil Engineering and Environmental Protection (RS) |
| mV | Milli volts |
| MVA | Mega Volt Ampere (apparent power) |
| MW | Megawatt |
| NAMA | Nationally Appropriate Mitigation Actions |
| Nat. | Natural |
| NE | Not Endangered |
| NE | North East |
| NGO | Non-Government Organisation |
| NH3 | Ammonia |
| NO2 | Nitrous Oxide |
| NRW | Non-Revenue Water |
| O3 | Ozone |
| O&M | Operation and Maintenance |
| OECD | Organisation for Economic Cooperation and Development |
| OEL | Operation Elevation Level |
| OG | Official Gazette |
| Pas | Protected areas |
| PE | Public Enterprise |
| pH | a numeric scale used to specify the acidity or alkalinity of an aqueous solution |
| PHI | Public Health Institute |
| PHO | Public Health Office |
| PSHPP | Pumped Storage Hydropower Plant (reversible HPP) |
| PM | Particulate Matter (PM10 PM2.5) |
| POP | Persistent Organic Pollutants |
| PRTR | Pollutant Release and Transfer Register |
| PUC | Public Utility Company |
| Q | Discharge |
| RBMP | River Basin Management Plan |
| RCM | Regional Climate Model |
| RCP | Representative Concentration Pathways |
| REC | Regional Environmental Centre |
| RES | Renewable Energy Sources |
| RGSO | Republic Geologic Survey Office (RS) |
| RHMO | Republic Hydro Meteorological Office (RS) |
| RHMS | Hydro meteorological Service of Serbia (RS) |
| RIA | Republic Inspection Authority |
| RNP | Regional Nature Park |
| RP | Regional Park |
| RS | Republic Srpska |
| SAA | Stabilisation and Association Agreement |
| SEA | Strategic Environmental Assessment |
| SEEBAP | South East Europe Biodiversity Action Plan |
| SEI | Stockholm Environment Institute |
| SEPA | Serbian Environmental Protection Agency |
| SFRY | Socialist Federative Republic of Yugoslavia |
| SHPP | Small (mini) Hydropower Plant |
| SNC | Second National Communication |
| SNR | Special Nature Reserve |
| SO2 | Sulphur Dioxide |
| SOx | Sulphur Oxides |
| SRB | Sava River Basin |
| SRES | Special Report Emissions Scenarios |
| SRO | Science Research Organisation |
| TDA | Drina Rapid Transboundary Diagnostic Scan and Analysis |
| TNC | Third National Communication |
| TPP | Thermal Power Plant |
| TOR | Terms of Reference |
| UN | United Nations |
| UNDP | United Nations Development Program |
| UNECE | United Nations Economic Commission for Europe |
| UNEP | United Nations Environment Program |
| UNESCO | United Nations Educational Scientific and Cultural Organisation |
| UNESCO-IHE | UNESCO – Institute for Water Education |
| UNFCCC | United Nations Framework Convention for Climate Change |
| USA | United States of America |
| USD | United States Dollar |
| WAAC | Water Area Advisory Council |
| WAC | Water Area Council |
| WATCAP | Water and Climate Adaptation Plan |
| WB | World Bank |
| WBIF | Western Balkans Investment Framework |
| WD | Water Directorate |
| WEAP | Water Evaluation and Planning System by SEI |
| WFD | Water Framework Directive |
| WHO | World Health Organisation |
| WHYCOS | World Hydrological Cycle Observing System |
| WISKI | Water Information Systems KISTERS |
| WMO | World Meteorological Organisation |
| WMR | Water Management Region |
| WQI | Water Quality Index |
| WRMP | Water Resources Master Plan |
| WWTP | Wastewater Treatment Plan |
| % | Percentage |
| µg/l | Milligrams per litre |
| µS/cm | Micro Siemens per centimetre |
| µm | Micro metres |

# Introduction

## Background

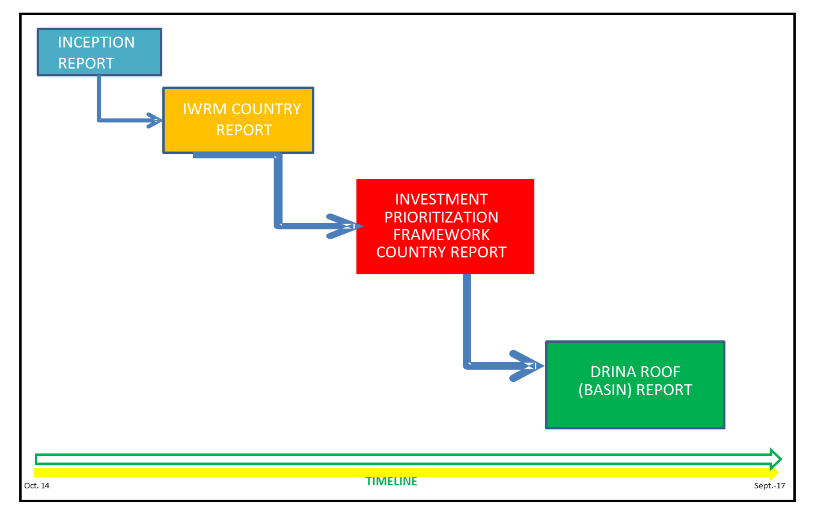
The project for "Support to the Water Resources Management in the Drina River Basin" extends within the three riparian states of BiH (FBiH and RS), Montenegro and Serbia. The World Bank awarded the project to the Joint Venture (JV) Consultant comprising COWI AS of Norway as lead together with JV partners Stucky Limited from Switzerland and Jaroslav Černi Institute (JCI) from Serbia. A World Bank contract (Contract No 8005176) to provide support to the Water Resources Management (WRM) of the Drina River Basin (DRB) was awarded in September 2014. The Lead Consultant is also supported by three Sub Consultants, the Consultant "Regional Environmental Center for Central and Eastern Europe" "REC" with headquarters based in Hungary, the Consultant "CEStra" based in Belgrade and the Faculty of Civil Engineering of the University of Belgrade (FCS-UBG).

The overarching objective of the project is to support more effective water resources management in DRB taking into consideration sustainable water use, flood mitigation and environmental management, while involving stakeholder consultations to ensure adequate public participation. This approach supports water management authorities in preparation of investment plans, strategic environmental assessment (SEA) and the river basin management plans.

The Project commenced in October 2014 with the Inception Phase (October – November 2014), however it was very evident at the onset that the project would need more time in order to answer the TOR requirements and to reach all relevant stakeholders in three riparian countries. The Project was therefore extended a total of 2 times until December 2017.

The Inception Report was prepared and presented at an Inception Workshop on 1st December 2014 that was held in Zagreb. The final version of the Inception Report was submitted in English in February 2015. Following minor amendments, the World Bank and the Steering Committee subsequently approved the Inception Report in March 2015 and a local language version was prepared and distributed in May 2015. Based on the request of the BiH stakeholders the inception report was additionaly modified with more accurate data for BiH in April 2017.

Following inception, all subsequent reports with the exception of the report in hand (Roof Report) were prepared individually for each riparian state. The summary of the main deliverables of the Support to Water Resources Management in the Drina River Basin project are given in the *Figure 1*.



**Figure 1:** Main Deliverables and Project Timeline

### Bosnia and Herzegovina

The Integrated Water Resources Management (IWRM) draft Country Report for BiH was submitted in English in September 2015 and December 2015 (in local language). Comments were received from stakeholders and further comments made at a stakeholder workshop held in Belgrade on 25/26 January 2016. After receipt of these comments and further discussions, the final version of the IWRM Country Report for BiH was submitted in June 2016.

The Investment Prioritisation Framework (IPF) Report for the BiH part of the DRB was submitted in draft format in English on November 2016 and presented to the stakeholders at the meeting held in Sarajevo in January 2017. The final version of IPF BiH report was delivered in June 2017 after additional requerements from stakeholders, received in March 2017.

### Montenegro

The Integrated Water Resources Management (IWRM) draft Country Report for Montenegro was submitted in English in August 2015 (October 2015 for local language version). Comments were received from stakeholders and further comments made at a stakeholder workshop held in Belgrade 25/26 Janaury 2016. After receipt of comments and further discussion the final version of the IWRM Country Report for Montengro was submitted in June 2016.

The draft IPF Report for the Montenegrin part of the DRB was submitted in English on November 2016 and was presented to stakeholders at the meeting in December 2016. After receipt of comments from stakeholders, the final version of the IPF report was submitted in June 2017

### Serbia

The Integrated Water Resources Management (IWRM) draft Country Report for Serbia was submitted in English in September 2015 (December 2015 for the local language version). Comments were received from stakeholders and further comments made at a stakeholder workshop held in Belgrade on 25/26 January 2016. After receipt of comments and further discussion the final version of the IWRM Country Report for Montengro was submitted in July 2016.

The draft IPF Report for the Serbian part of the DRB was submitted in English on November 2016 and presented to stakeholders in December 2016. After receipt of comments from stakeholders the final version of the IPF report was submitted in April 2017

### Other Reports

Besides the Country Specific IWRM and IPF reports mentioned above, other deliverables were also submitted.

This included the report on development of the water resources management (WRM) model for the DRB in the WEAP software (SEI, 2015), submitted as draft in English and local language in January 2017. After the trainings performed in January 2017 and additional one in June 2016, the comments from participants were integrated in the final WEAP report, delivered in June 2016 (in English and local language).

In addition, the Public Consultation Report in English and local language which will provide a summary of the main feedback to the planned WRM of the DRB after the final public consultation will be prepared. The public consultations are planned for beginning of July 2017 in all three countries and the reports will be presented in draft and final version until end of summer 2017.

Finally, an Annual (Interim) Report was prepared in English and local langauges to respond to the World Bank TOR requirements, which reported on operational and financial issues.

The presented Roof Report has the objective to provide the overall findings of the investigations, data collections and analyses for all riparian countries related to the Water Resources Management in the Drina River Basin. It is a high-level document summarizing the main results of the project in a concise and synthetic view for the whole Drina River Basin and not from country optiocs. It is based on the previous reports as mentioned above for all three countries (BiH, Montenegro and Serbia) and summaries the main outcomes.

This Roof Report emphasis the main issues and baselines retained in the study, harmonised at the DRB level in order to help for a sustainable water resources management.

# The Drina River Basin

## Natural setting

### Geographic, topography and geology characterisation

#### Geographic characterization

The Drina River is 346 km long and is the largest tributary of the Sava River Basin, which in turn is the largest tributary by volume of water of the Danube River Basin that drains into the Black Sea. The Drina River Basin (DRB) has a surface area of 19,680 km2 and spreads over territory within principally three riparian states: Bosnia Herzegovina (BiH), which is subdivided into two entities (Republika Srpska (RS) and Federation of Bosnia-Herzegovina (FBiH); the Republic of Montenegro and Serbia. In addition, Albania accounts for a very small part of the DRB (<1%) and is not included within the scope of this project. The division of territory within DRB and the geographical determination is shown in Figure 2.



**Figure 2**: Drina River Basin

The Drina originates between the slopes of the Maglić and Pivska planina mountains, between the villages of Šćepan Polje (in Montenegro) and Hum (Bosnia and Herzegovina). The Drina River rises at the joining of the Tara River and Piva River near the town of Šćepan Polje. The biggest and the most water-abundant tributary in BiH is the Lim River. Its tributaries are also Sutjeska River, Bistrica River, Ćehotina River, Prača River, Rzav River, Drinjača River and others. The DRB makes one fifth of the Sava River basin, and even one third of the Sava River water arrives through the Drina River. The most water abundant tributaries of the Drina River originate in Montenegro and the Piva River, Tara River and Lim River provide two thirds of the Drina River water. Average altitude of the DRB is 961.6 m a.s.l. and it ranges between 75.4 m a.s.l., at the confluence, and more than 2,500 m a.s.l. on the highest mountains in Montenegro (Prokletije Mountain 2,694 m a.s.l., Komovi 2,487 m a.s.l. and Durmitor Mountain 2,522 m a.s.l.)

#### Topography characterization

The lowest point in the DRB is at 82.3 m.a.s.l. at the confluence of Drina River and Sava River near the village of Crna Bara. The average altitude of the DRB is 961.6 m.a.s.l. and altitude is in the range from 75.4 m.a.s.l. at the mouth to more than 2500 m.a.s.l. on the highest mountains (e.g. Prokletije Mountain 2,694 m.a.s.l., Komovi Mountain 2,487 m.a.s.l. and Durmitor Mountain 2,522 m.a.s.l.).

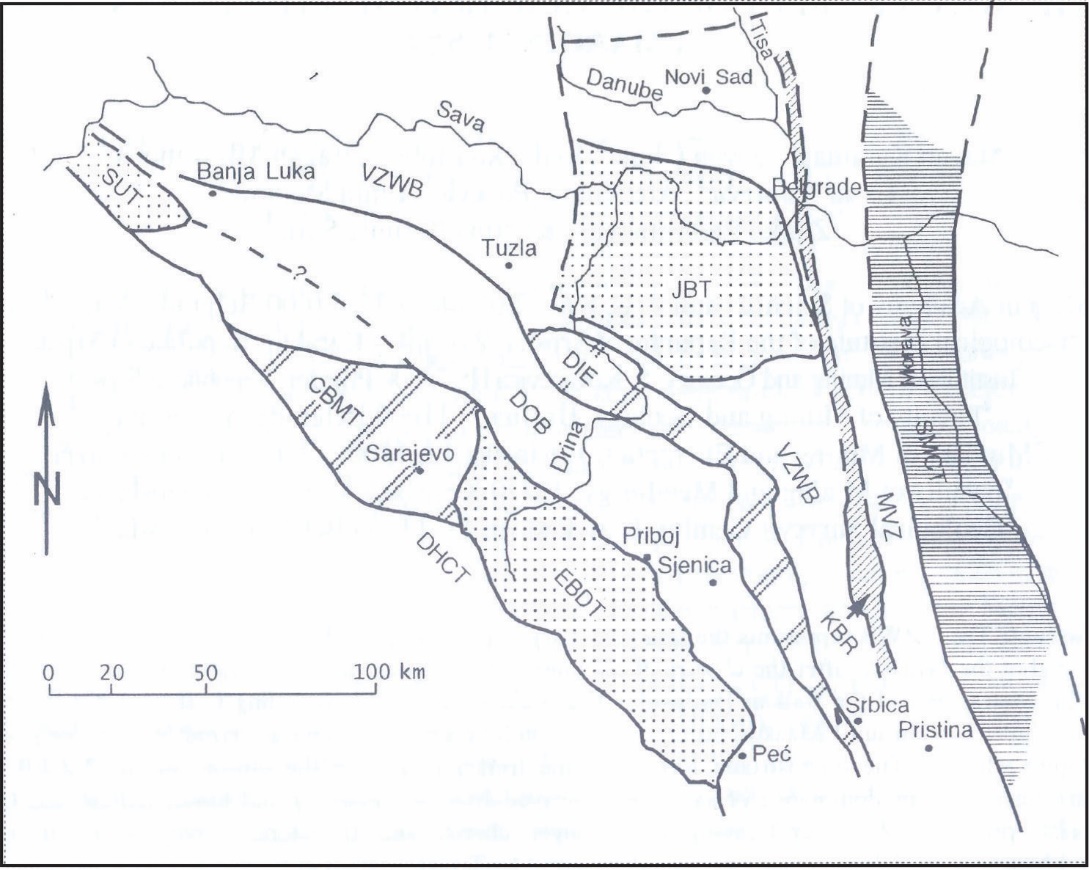
#### Geology characterization

Driva River with trubutaries (DRB) in Serbia, Bosnia and Montenegro flows over few geotectonic units (terranes, blocks; Karamata et al., 2000; Figure 3). In upper part (NW Serbia) Driva River flows into Sava River and passes through Jadar Block terrane (JBT). Then passes through Vardar Zone Western Belt (VZWB), known as "Zvornik suture" (Dimitrijević, 1995, 2001), which marks tectonic boundary between Drina-Ivanjica and Jadar-Kopaonik thrusts (Schmid et al., 2008). Toward south Driva River passes through Drina-Ivanjica Element (DIE), than Dinaridic Ophiolitic Belt (DOB) and East Bosnian-Durmitor Block Terrane (EBDT). In Montenegro, in area of Dalmatian-Hercegovinian Composite Terrane (DHCT) rivers Piva and Tara flows into Drina River.

In Serbia Drina River flows in Sava River strongly meandering. From Bosnian side is region of Semberija, from Serbian side is region of Mačva. Both regions around are very arable, covered by sediments of Neogene age (sands and pebbles, sandy clays and clayey marlstones of Lower Pliocene in age) and Quaternary sediments (sands and fine-grained pebbles). Towards south, the river is passing through clastic and carbonatic formations of Devonian-Caboniferous age (thick over 1000 m), also Middle Permian clastites, bituminous Upper Permian limestones, sediments of Lower and Middle Triassic (claystones, sandstones and limestones), andesites of Middle Triassic age, Upper Triassic limestones and small masses of Cenomanian limestones. Neogene sediments cut by Drina with tributaries are represented by marine and lacustrine facies. For DRB is also important eastern part of Boranja granodiorite intrusive with granodiorite-porphyrites and pegmatites, also extrusive rocks: dacito-andesites, quartz-latites and following pyroclastites. Further, Drina River in "Zvornik suture" (Vardar Zone Western Belt) cut rocks of Ophiolite melange of Jurassic age in which are incorporated folded blocks and fragments of sediments of Lower Creataceous age. From Zvornik town, it passes through Paleozoic rocks of Drina-Ivanjica Element, made of change of metamorphosed sandstones and siltstones partly intercalated with conglomerates, and through rocks of Triassic age.

Drina River with tributaries through Bosnia and Herzegovina cut the same geotectonic units (terranes, blocks) like in Serbia. In upper part first Jadar Block terrane, then slightly Vardar Zone Western Belt, i.e. "Zvornik suture". Afterwards, flows through Paleozoic and Triassic rocks of Drina-Ivanjica Element, sediments and magmatites of Dinaridic Ophiolitic Belt and younger Paleozoic rocks of East Bosnian-Durmitor Block Terrane.

DRB in territory of Montenegro includes two geotectonic units: East Bosnian-Durmitor Block Terrane () and Dalmatian-Hercegovinian Composite Terrane, both in general Dinaric oriented (northwest-southeast). On the north is bordered with Dinaridic Ophiolitic Belt, and on southwest is overthrusted over Dalmatian-Hercegovinian Zone. DRB includes areas of mountains Volujak, Pivske mts., Durmitor, Ljubišnja, Kovač, Sinjajevina, Lisa, Bjelasica, Komovi, Visitor, Mokra, Hajla and Žljeb. The East-Bosnian-Durmitor Block, which predominates in Montenegro, is built of clastic sediments of Paleozoic age, then clastic, carbonatic and siliceous sediments and volcanic rocks of Triassic age, also rocks of Jurassic, Cretaceous, Neogene and Quaternary age.



**Figure 3:**  The geotectonic position of central part of Balkan peninsula between Moesia plate and Adriatic Sea

Legend: DHCT - Dalmatian-Hercegovinian composite terrane; CBMT - Central Bosnian terrane; EBDT (=IBDB) - East Bosnian-Durmitor terrane; DOBT (=DOP) - Dinaridic Ophiolite Belt terrane; DIT (=DIE) - Drina-Ivanjica terrane; JBT(=JB) - Jadar Block terrane; VZCT - Vardar Zone composite terrane; SMCT - Serbian-Macedonian composite terrane. 1. Fault, observed and covered; 2. Thrust; 3. Tectonized boundary (simplified; Karamata et al., 2000).

### Climate and hydrology

Climate of the DRB is complex and influenced by general atmospheric circulation, its elongate shape along a meridian, local orography and proximity of the Adriatic Sea. The Southernmost part of the basin has a Mediterranean and a maritime temperate and humid climate according to the Köppen climate classification. Moderately cold and humid continental climate can be found at the altitudes above 1000 m. Mediterranean influence, although mild, can be found in the upper part of the basin, up to Foča. From that point downstream a temperate continental climate prevails with warm summers and moderately cold winters.

Generally, from south to north, along the altitude decline, accumulated annual precipitation also decreases, from about 2100 mm measured in Kolašin to 820 mm in Loznica. In the same direction annual mean temperature increases, from 4.6 °C in Žabljak to 11 °C in Loznica. Annual distribution of precipitation differs throughout the DRB. Northern parts receive the most rain in the late spring, mainly in May and June, while winter is dry with the lowest precipitation in February. Due to the influence of the Mediterranean climate in the southern parts, maximum rain falls in the late autumn and the minimum during the summer months. The warmest month is July and the coldest is January

Relative humidity in the DRB is rather uniform, and is at its lowest in the period June-August and the highest in the December-January period. Snow cover significantly impacts the Drina River water regime due to large amounts of water accumulated in it, with the highest flows recorded in spring time, in April and May.

Snow depth in some sections of the lower middle part of the DRB can be as high as 1.20 m (corresponding to a maximum of 200 mm of water) with frequent snow-drifts and in upper sections it can even exceed 5 m.

Fogs constitute a characteristic feature of the Drina River valley and can occur throughout the year, but are most frequent in spring and autumn. Complex local topography in the upper course of Drina River significantly affects and modifies wind direction and speed. Despite this, strong winds are quite rare and are generally of low intensity.

### The Drina River and its main tributaries

The Drina River is the largest tributary of the Sava River in terms of the total area of the basin, length of the watercourse and the volume of water. The Drina River originates in Montenegro at an altitude of 2,500 masl between the slopes of the Maglić and Pivska Planina mountains, between the villages of Šćepan Polje (in Montenegro) and Hum (BiH), draining a substantial karst plateau that receives the highest annual rainfall in Europe (about 3,000 mm/a), resulting also in the highest specific runoff in Europe (up to 50 l/s/km²).

The three source-rivers of Drina River in Montenegro are Tara (sub-basin area of 2,006 km²), Piva (1,784 km²) and Lim (5,968 km²). Tara river and Piva river merge at Šćepan Polje along the BiH/Montenegrin border with a combined mean annual discharge of 154 m³/s. whereas Lim river joins Drina river at the Višegrad reservoir with a mean annual discharge of 113 m³/s.

The Drina River reaches the confluence with the Sava River at an altitude of 78 masl on the Pannonian Plain (Semberija and Macva) after a length of 346 km and a height difference of 350 m (equivalent to an average 1% slope), the mean annual discharge of the Drina close to Bijeljina is about 400 m³/s, corresponding to a mean annual total volume of 12.6 billion m³ or about 14% of the Nile river flow volume in Cairo.

The major tributaries of the Drina River in Serbia are Lim River with Uvac River, Rzav River, Ljuboviđa River and Jadar River. The major tributaries of the Drina River in BiH are the Sutjeska River, Bistrica River, Ćehotina River, Prača River, Lim River, Rzav River, Žepa River, Rogačica River, Ljuboviđa River, Drinjača River and Janja River.

### Groundwater in the DRB

Carbonate rocks predominate in the DRB and are suitable for karst processes, which are a significant hydrogeological feature. The underlying geology is suited for karst processes, tectonic movements have created, and old karst plateau, which is, incised with deep canyons such as the Piva, Komarnica and Tara rivers. Karstification can range from a few meters to >2,000 metres. These karstic features are numerous and characterized by surface and underground forms including cracks, gorges, dry valleys, sinkholes, caves, potholes and ponors.

Hence, porosity is a defining feature in aquifers in the DRB. The following units occur in the basin:

* Karst-fissure aquifer, with good permeability,
* Karstic-fissure aquifer, with moderate permeability,
* Fissured aquifer,
* Intergranular aquifer with good permeability,
* Intergranular aquifer with moderate permeability,
* Aquitard with poor permeability

Groundwater sources provide the main water supply to rural communities from boreholes, dug wells and from springs. The current knowledge of the flow regime of the aquifers is inadequate and limited systematic long term monitoring has occurred, but more is needed to fully understand the groundwater regime.

Spring flow varies considerably due to climatic conditions with the largest flows generally observed in the late autumn and early winter and the minimum flows between August and September. The ratio between the maximum and minimum flows is difficult to quantify due to lack of data. The general trend of groundwater flow direction is along the Drina River valley from southwest to northeast.

### Biodiversity and Protected areas

**Biodiversity**

As mentioned above, the Drina River originates in the Dinaric Alps of BiH and Montenegro at an altitude of approximately 2,500 meters, draining a vast karst plateau which receives the highest annual rainfall in Europe (approaching 3,000 mm of annual precipitation), resulting in the highest specific runoff in Europe, reaching up to 50 l/s/km2. Therefore, the DRB has a very complex and high diversity of ecosystems, adapted or developed in accordance with its notoriously extreme high and low flows. Even though, integrity of these ecosystems is already partially damaged as DRB hosts eight medium to large hydropower generation dams in addition with a history of lack of sustainable water and waste managements, which are already affecting sections of rivers. However, some sections of the flows in DRB are still rather untouched ecosystems and, despite possible pollution problems, constitute a unique heritage to be preserved. In addition, the DRB still hosts many species and habitats of outstanding ecological value and unique importance for biodiversity on national, regional and European level.

Wetlands and alluvial forests are amongst of the most important habitats in DRB. Even though they are not covering large surfaces along the Drina River and its tributaries above the level of 140m a.s.l, they are still an important factor in habitat diversity and they are providing conditions and shelter for a large variety of species and habitats that would be otherwise absent from the region.

Downstream from the city of Zvornik, and especially from Loznica, all the way to the Drina confluence into Sava, wetlands are vast, old and more recent meanders dominate the landscape. These areas host some of the most important habitats on a continental level, they form freshwater supply, provide food and building materials, biodiversity. The wetlands help also in flood control, mitigate groundwater recharge, correcting the irregular discharge of dams, and the climate change. However, these precious ecosystems are insufficiently protected in the three countries of DRB.

DRB is a region rich in biodiversity and is a home to many endemic species, as well as many species that have become rare or endangered locally and on continental level. Considering the large surface it covers, as well as the diversity of expositions and altitudes, DRB has very diverse flora and fauna. The Drina basin holdsa high number of endemic species, many of them of European importance. The most famous endemic species in the DRB is the Serbian spruce (*Picea omorika*) but there are many others, including *Campanula secundiflora*, a Balkan stenoendemic species, whose populations are threatened by planned developments on the Lim River. The number of endemic and relict plants is exceptionally high in the southern part of the basin, in the karst massifs surrounding rivers Piva and Tara, where endemic plant diversity reaches almost a 100 per one UTM 10x10 square. In the whole Basin, the number of endemic plant species exceeds 130. As an example, here are some of the important endemic plant species: *Daphne malyana*, *Saxifraga rocheliana*, *Centaurea incompta, Dianthus kitaibelii, Cerastium lanatum, Centaurea derventana, Aquilegia grata, Aquilegia nikolicii, Amphoricarpus autariatus, Valeriana braun-blanquetii, Campanula balcanica, Adenophora liliifolia, Cirsium wettsteinii, Cicerbita pancicii, Melampyrum hoermanianum, Teucrium arduini, Iris bosniaca*. Endemic species are highly adapted to their home range and in a changing environment. Their adaptations can function as a sort of “insurance” for continuance of genetic diversity in the face of rapid changes. In average, losing one endemic plant species, between 10 and 30 specialized endemic animal species are gone with it. Thus, endemic species are a focus for the conservation of biodiversity.

Drina River offers a variety of different habitats and ecosystems and is inhabited by more than 50 fish species. They are approximately half of all freshwater fish species found in all the three countries of the DRB. Drina River represents one of key fish diversity locations within the Balkans. The upper parts of the basin are primarily inhabited by Salmonid fish, mostly Danube Salmon (*Hucho hucho*) and Brown trout (*Salmo labrax*). Bullhead (*Cottus gobio*) and Brook barbel (*Barbus caninus*) are also common in these regions. These species are mostly affected by small dams, overfishing, especially Brown trout, and from a moderate amount of nutrients coming from nearby fish farms. Fishes are among the most endangered vertebrates. Preserving the rich fish ecosystems of the Drina River would enable also the protection of a high proportion of the Balkan and European fish species and their genetic diversity. As an example, the Danube Salmon is one of the most endangered European fish species (IUCN Red list), endemic for Danube drainage, DRB being the most important population pool in the Balkans, totalling at 30% of Balkan distribution of the species. Its migration routes are interrupted with dams, and populations are showing a disrupted structure, whilst the population size has decreased significantly. Other important fish species present in the basin are the Greyling (*Thymalus thymalus*) and at only one locality (Gromiželj in BiH), the European mudminnow (*Umbra krameri*).

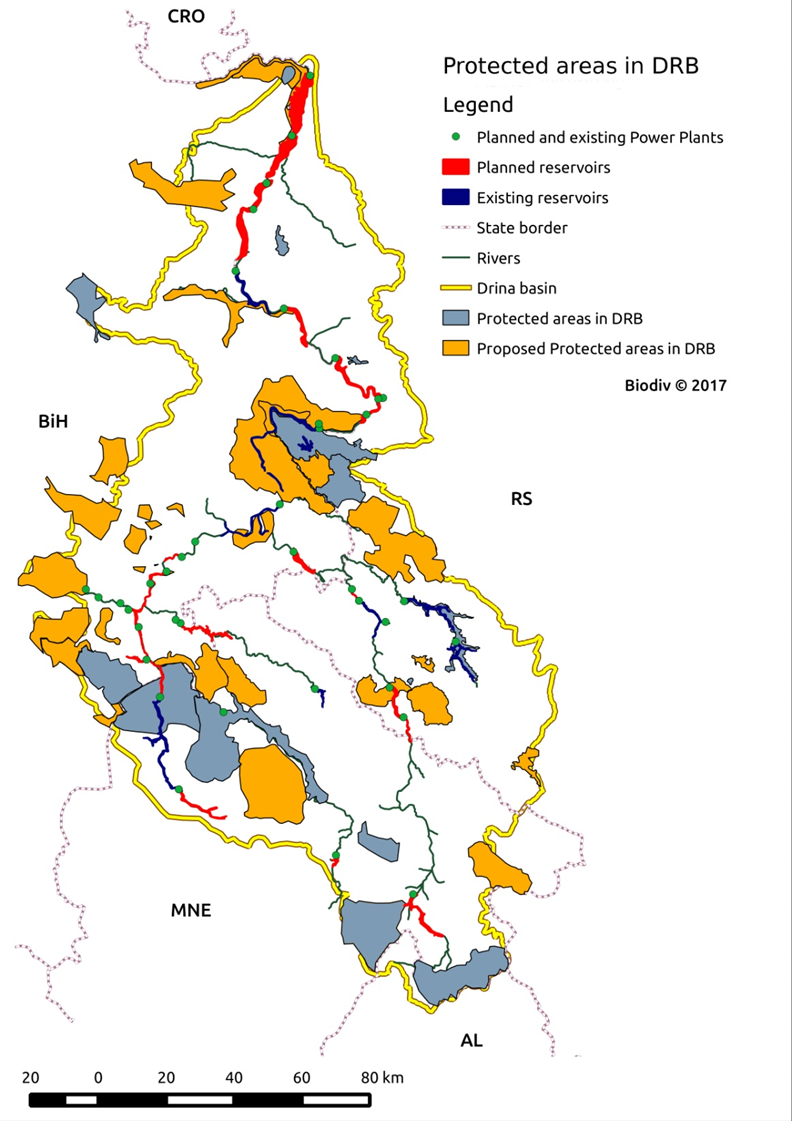
Regarding birds and mammals, the DRB shows exceptional richness. Indeed, there is a presence of over 230 species of birds and a large variety of mammal species. Otherwise, there are the rare elsewhere such as Brown bear (*Ursus arctos*), the Eurasian wolf (*Canis lupus),* the chamois (*Rupicapra rupicapra*), the wild cat (*Felis silvestris*), the Eurasian Lynx (*Lynx lynx*) and the European otter (*Lutra lutra*), as well as two endemic species, the Blind Mole (*Talpa caeca*) and the Balkan Snow Vole (*Dinaromys bogdanovi*). Bats are exceptionally diverse in the DRB with a probable number of species ranging between 30 to 32. The Drina River has been confirmed as a corridor for the migration of bats. Especially important species are *Barbastella barbastellus* and *Myotis bechsteinii*, because they represent indicators for the quality of forest habitats and both are very abundant in the forests of DRB. In addition, DRB holds some very rare species for the region, such as *Eptesicus nilssonii* and *Tadarida teniotis*.

**The future management of the DRB needs to ensure that the focus of measures is not only on the restoration of pollution that affects rivers but also it must preserve the few important areas that are still ecologically intact.** Nature protection in the basin is a challenging task as it is could oppose the planned investments and efficiency of its measures depends strongly on cross-border dialogues and regional cooperation.

**Protected areas**

A number of natural parks and protected areas covered the DRB and the landscape is dotted with unique glacial lakes and canyons. The DRB even host the Tara Canyon, a UNESCO World Heritage site.

However, only 5.44% of the DRB is protected (under 3% in BiH, 5.5 % in Serbia and 7.9 % in MNE), that is far under the Europen average. The DRB is then not sufficiently protected regarding the fact that it holds above average precious biodiversity and diversity of habitats. There are many of the planed protected areas (Pas), that could bring a better protection regarding terrestrial habitats but the benefit for the preservation of aquatic biodiversity is rarely considered in the future plans for protection. The existing and planned Pas are summarized in Table 1 and they are located in the Figure 4.



**Figure 4**: Existing and planned protected areas in the DRB in regards to proposed development scenarios

**Table 1:** Protected Areas of BiH, Montenegro and Serbia in the DRB

| **Name and type of Protected Area** | **Size (km2)** | **Date Formed** |
| --- | --- | --- |
| **BiH: Federation** |  |  |
| Plans for several small sites exist |  |  |
| **BiH: Republika Srpska** |  |  |
| **Sutjeska:** NP, IUCN: II | 160.52 | 1962 (2012) Planned extension |
| **Gromiželj:** SNR, IUCN: Ib Bijeljina municipality | 8.33 | 2011 |
| Sava-Drina: NP |  | not yet protected |
| **Perućica** (located within NP Sutjeska): SNR, IUCN: Ia | 14.34 | 1954 |
| **Tara canyon and Ljubišnja:**  NP |  | not yet protected |
| **Drina:** NP |  | not yet protected |
| **Drina:**  Biosphere reserves |  | not yet protected |
| around 25 other PAs (see map) |  | not yet protected |
| **Montenegro** |  |  |
| **Biogradska gora**: NP | 56.5 | 1952 |
| **Durmitor**: NP, UNESCO world heritage site, IBA | 390 | 1952 |
| **Prokletije**: NP | 166.3 | 2009 |
| **Komovi:**  RP, IUCN: VI | 195.04 | 2016 |
| **Piva**: RP, IUCN: VI | 320 | 2015 |
| **Serbia** |  |  |
| **Tara**: NP, Emerald site, IUCN: II | 191.7 | 1981 |
| **Šargan – Mokra Gora**: PP | 108.14 | 2005 |
| **Part of the area of the village of Tršić and Tronoša Monastery**: MNM |  | 1965 |
| **Trešnjica River Gorge**:  SNR Trešnjica River Gorge | 5.95 | 1995 |
| **Mileševka**: RNP | 4.57 | 1976 |
| **Uvac**: SNR  Canyon of the Uvac River | 74.53 | 2006 |
| **Slapovi sopotnice**: MoN Waterfalls of Sopotnica River |  | 2005 |
| Many other MoN (small objects) |  |  |

Legend: MNM: Memorial Nature Monument; MoN: Monument of Nature; NP: Nature Park; RNP: Regional Nature Park; RP: Regional Park; SNR: Special Nature Reserve.

## Socio economic characteristics

### Natural resources

Territory of the DRB is rich in natural resources, which are distributed among the region in a specific manner. Agricultural land dominates in the Lower Drina Region (Republic of Srpska and Serbia), while the forestland and forests can be found in the Upper Drina Region. In the area of Upper Drina, agricultural land is less common and mostly consisted of meadows and pastures. There are also mineral resources spread over the area of the DRB.

However, natural resources are insufficiently planned without a sustainable exploitation: insufficient exploration of mineral resources, inappropriate use from the standpoint of the welfare of the Republics and the local government units (water, minerals and forests), unsustainability of the use of agricultural land (reducing the amount and worthiness) and forests (more the cutting than increment).

The importance and role of agriculture and forestry stem from natural conditions for its development (agricultural land, forests), but also from the tradition and the fact that the majority of the population of DRB is directly and indirectly economically relied on agriculture and forestry (to a lesser extent).

The past period was characterized by insufficient investment in land development, so that significant agricultural areas exposed to floods, erosion, landslides and various forms of pollution. The current trend is that agricultural areas in the DRB are constantly decreasing. Besides, the process of land comminuting reached such a volume that the agricultural production on small plots becomes economically unjustified and uncompetitive.

Important natural resource is the gravel from the riverbed of the Drina River which extraction is an important economic activity and significant source of income for small private companies. It should be regulated by the state but the data on the quantities of excavated sediments are unavailable. **There is a strong lack of a cooperative management of the gravel extraction in the DRB, integrating the environmental and security components.**

Furthermore, the Drina River is very important resource for the development of tourism. For now, there are two main touristic manifestations in Middle Drina: “Drina Regatta” and “Drina-Praca New touristic paths”. The Drina Regatta is the oldest event of tourist - recreational character in the Drina River region, which is organized in memory of the ancient tradition of the Drina rafters. The regatta is the most visited event in Western Serbia and central summer event on water that attracts with a variety of amenities tens of thousands of visitors from Serbia and abroad. Rafting Drina is organized by Municipality of Ljubovija in the length of approximately 40 km from Ljubovija town to the village of Rogatica. In BiH the Tourist Board of the Bosnian-Podrinje Canton Gorazde and the municipality of Foca - Ustikolina organize Drina River rafting starting from Ustikolina to Gorazde town.

### Demography

The area of DRB includes parts or the entire territory of 56 local government units (municipalities and cities), in which, according to the last census lives a population of approximately 1,100,000 inhabitants. The administrative boundaries of municipalities and cities include a larger area (22,948 km2) than the DRB area (19,680 km2).

The total area of DRB is divided into three main administrative units, so that the participation of Serbia is 34%, Montenegro 30% and BiH 36%. However, from total population of the DRB in Montenegro live only 14% inhabitants, while in Serbia live 47% and in BiH live 39%. The area of DRB in Montenegro is located in mountainous terrain, which is characterized by low population density of 22 inhabitants/km2. The highest population density is in the Serbian part of DRB, approximately 63 inhabitants/km2. The population density in the RS BiH is 51 inhabitants/km2, while in the FBiH it is 59 inhabitants/km2, in the area covered by DRB.

In the period from 1948 to 1991, the population in the DRB increased steadily, but after this period, the number of inhabitants constantly declined until the last Census.

"Urbo-oriented" policy in the years after World War II, under the conditions of a command economy, increased the differences in quality of life between urban and rural settlements. The economic collapse of the countries in the 1990s intensified migration, particularly economic migration not only from villages to the cities, but also from towns and smaller cities to the capital cities. Most of these cities during the 60s and 70s of the last century, were the pillars of accelerated industrialization. When the industry extinguished, cities have turned into cities of pensioners.

Observing the level of the states in the DRB, highest average age of the population is characteristic for Serbia (41.9 years). For BiH it is 40.8 years, while the lowest is in Montenegro (39.2 years). In all three countries, average age of female population is greater than for male population. Population growth rates are negative in all three countries (Serbia -0.46, BiH -0.11 and Montenegro -0.49).

The main problems in DRB are unfavorable demographic structures and distribution of the population. DRB is facing complex demographic problems that manifest by constant reduction in the birth rate and negative population growth, by reducing the number of pupils in primary schools, by processes of de-population, the disappearance of villages, aging population, and emigration of fertile and working population abroad.

There is a possibility of a slight recovery of demographic resources, which depends on appropriate economic and social development. Population aging is especially characteristic of rural areas, while the primacy in the reproduction of the population takes place in urban areas.

### Cultural heritage and monuments

The DRB has been inhabited by early man for many millennia and evidence from charcoal burning can be seen in some of the caves that are interspersed along the Drina River valley. Cultural and historical capital of DRB is heterogeneous, including cultural goods created in a wide range, from prehistoric and ancient to medieval, Ottoman and modern times. They were created, because of its geographical position, by participation in four major civilization of Europe: Mediterranean, Central European, Byzantine and Oriental-Islamic.

Cultural heritage in BiH is very important compared to other countries in the basin primarily due to the period of conflict between 1992-1995 where a large number of sacral, secular and monumental sites, have been destroyed or damaged. Some of the institutions in the field of heritage lost their status, budgets, documents and experts.

There are 258 protected cultural heritage sites in the DRB (138 in Serbia, 258 in BiH and 38 in Montenegro). The most important are two UNESCO World Heritage Sites: The Mehmed Pasha Sokolovic Bridge in Visegrad in BiH and Djurdjevi stupovi - Monastery of the tracts of St. George in Berane in Montenegro.

Considering the municipalities where the HPPs and storages have been planned in the future development of the DRB, there are 46 cultural heritage sites in Serbia, 35 in BiH and 7 in Montenegro. For now, it is not known if some of them would be directly affected by the construction of the dams and reservoirs. Not only the officially protected cultural heritage could be affected but also a numerous religious objects, urban structures and other sites important for the local population and their cultural and religious feelings. It is also possible that project work may affect accidentally discovered buried or submerged cultural resources.

**Therefore, it is essential to make a social assessment study for each planned HPP and to propose mitigation measures to preserve the cultural heritage of the DRB and to bring benefice to the DRB population.**

## Proposed development scenarios

Based on the outcomes of the IWRM countries reports, on the strategic and investments plans and overall in collaboration with stakeholders of the three countries, different development scenarios have been proposed for each country.

For the selection of the optimal scenario, the VIKOR method of multi-criteria compromise ranking was used. VIKOR is the method that is used to solve optimization tasks with several heterogeneous and conflicting criteria. Finding a compromise solution included the following activities: study of the system and generation of scenarios, definition of criteria, evaluation of the proposed scenarios and analysis of the preferred stability.

The generation of scenarios was based on the main objective and purpose of the system, which is the same for all scenarios; only the values of some parameters were changing.

The evaluation of the proposed scenarios was made according to a matrix of criteria and indicators and their relative weights. This matrix is shown in Table 2.

**Table 2**: Matrix of the criteria and indicators and their relative weight

|  |  |  |  |
| --- | --- | --- | --- |
| **CRITERIA** | **WEIGHT OF CRITERIA** | **INDICATORS** | **WEIGHT OF INDICATORS** |
| **Levelized cost of electricity (LCOE) / Dynamic prime cost (DPC)** | 0.3 |  |  |
| **Dynamic generation cost of water storage capacity** | 0.2 |  |  |
| **Envirovmental impact** | 0.3 | Geography and soils | 0.02 |
| Climate | 0.03 |
| Air quality | 0.03 |
| Hidrology | 0.09 |
| Hydraulic | 0.09 |
| Surface water quality | 0.07 |
| Ground water quality | 0.07 |
| Terrestrail vegetation and habitats | 0.05 |
| Migration corridors | 0.05 |
| Terrastrial fauna | 0.05 |
| Aquatic ecosystems | 0.14 |
| Alluvial ecosystems | 0.12 |
| Conservation areas | 0.16 |
| Landscape | 0.03 |
| **Social-economic impact** | 0.2 | Population | 0.50 |
| Agriculture | 0.10 |
| Forestry | 0.10 |
| Fishing/Hunting | 0.05 |
| Infrastructure | 0.05 |
| Energy sources/Use | 0.04 |
| Health | 0.04 |
| Education | 0.03 |
| Ethnicity/Culture | 0.01 |
| Visual aspects | 0.04 |
| Cultural Heritage/Tourism | 0.04 |

Methods for technical and preferential definion of relative weights were applied for determining weights of the criteria and indicators. The evaluation of the proposed scenarios was done in accordance with the territorial affiliation, for Serbia, Montenegro and Bosnia and Herzegovina, and in accordance with a division into options CONSTRUCTION and OPERATION.

For the territory of Serbia, two scenarios were evaluated, VS2 and VS3 (reduced/optimized HPP maximization, resp. full maximization), in accordance with the options CONSTRUCTION and OPERATION. In the OPERATION option, the compromise solution for final decision is the scenario VS2, with an advantage of 100% compared to the scenario VS3. The result in the option CONSTRUCTION is same.

For the territory of Bosnia and Herzegovina three proposed scenarios were evaluated, VS2A, VS2B and VS3 (reduced/optimized HPP maximization (4 resp. 7 new HPPs), resp. full maximization). According to the option OPERATION, a compromise solution for the final decision is the set of scenarios VS2B and VS2A, where VS2A scenario has an advantage of 10.4% compared to VS2B. The Compromise and final decision for option CONSTRUCTION is VS2A with an advantage of 33.4% compared to the scenario VS2B.

For the territory of Montenegro, two scenarios were evaluated: VS2 and VS3 (reduced/optimized HPP maximization, resp. full maximization). For both option CONSTRUCTION OPERATION, the compromise solution for final decision is the VS2 scenario. The VS2 scenario shows an advantage of 100%, compared to the scenario VS3.

### Serbia

Within the Drina River catchment area located on Serbian territory, the following power plants are presently in operation: “Zvornik”, "Bajina Bašta" (HPP and PSHPP), "Bistrica", "Kokin Brod", "Uvac" and "Potpeć". The “Zvornik” HPP and "Bajina Bašta" HPP are located along the boundary line between Serbia and Republic of Srpska (BiH); they are managed by EPS. The total installed capacity of these existing HPPs is 675 MW (PSHPP capacity: 614 MW). The total annual energy production of HPPs and PSHPP is 4,152 GWh.

Projects for the construction of ten new hydropower schemes have already been developed. A multi-criteria analysis aiming at making the best selection among these projects was conducted with the stakeholders and it was concluded that a package of six projects would optimally satisfy the imposed criteria (Table 3). These six projects are:

* "Rogačica" HPP 113 MW Drina River Trans-boundary HPP
* "Tegare" HPP 121 MW Drina River Trans-boundary HPP
* "Dubravica" HPP 87 MW Drina River Trans-boundary HPP
* "Kozluk" HPP 88 MW Drina River Trans-boundary HPP
* "Brodarevo I" HPP 26 MW Lim River
* "Rekovići" SHPP 7.2 MW Lim River

Generally, pumped-storage HPPs (PSHPPs) are not effective in water-management and improvement of, water balance and low discharges. They are not energy sources, but sinks (typical round-trip efficiency of the PSHPP operation is approximately 80%). Their possible role in flood protection is very uncertain, as their pumping capacity is usually drastically lower than the incoming flood discharges. Improvement of low discharges using water from PSHPP's upper reservoir is financially prohibitive in comparison with usually dedicated reservoirs along rivers.

Therefore, it makes little sense to compare PSHPPs and HPPs using criteria adopted in the present study. Consequently, no PSHPP was analysed in this report. In particular, the "Bistrica" PSHPP was not included into development scenarios for Serbia. Since this PSHPP was included into various planning and strategic documents in power in Republic of Serbia, as well into the strategic documents developed by the Electric Power Industry of Serbia, the Consultant recommends the inclusion of this project into further projects that should follow the present one.

The large active volume of existing reservoirs provides conditions for a very flexible management of "Uvac" HPP, "Kokin Brod" HPP and "Bistrica" HPP. These HPPs can satisfy almost of all needs of the system, such as regular coverage of the consumption of energy and power, all forms of reserves in the system (including the “cold” reserve), power regulation etc. The smallest possibility of regulation is provided by the "Zvornik" reservoir, since it is already half-filled with sediment. This storage can also play only a limited role in flood control. The flexibility of load variation (i.e. the regulation capacity) of the "Bistrica" HPP is limited by its long diversion system. However, under present conditions it satisfies the actual needs.

The selected development scenario can satisfy the electricity production and consumption projections defined in the Energy Development Strategy of the Republic of Serbia with minimal environmental and optimal socio-economic impact. It is also estimated that this scenario is in line with other strategic documents of the Republic of Serbia.

Comparing the main characteristics of the proposed optimal scenarios for Republic of Serbia and BiH, it is important to note that four of the six selected HPPs ("Dubravica" HPP, "Tegare" HPP, "Rogačica" HPP and "Kozluk" HPP) are located along the border with Republic of Srpska (BiH).

**Table 3:** The main characteristics of HPPs proposed by optimal scenario in Serbia

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **HPP** | **"Rogačica"** | **"Tegare"** | **"Dubravica"** | **"Kozluk"** | **"Brodarevo I"** | **"Rekovići"** |
| River | Drina – Middle part | Drina – Middle part | Drina – Middle part | Drina – Lower Part | Lim | Lim |
| Chainage | km 173+250 | km 148+750 | km 118+700 | km 60+200 | km 101+887 |  |
| Qav (m3/s) | 330.2 | 333.5 | 340.4 | 369.9 | 74.4 | 87.63 |
| Dam type/height (m) | Concrete gravity/ 42 | Concrete gravity / 44.3 | Concrete gravity / 39 | Concrete gravity / 38 | Concrete gravity / 38.8 | Concrete gravity / 14.7 |
| Reservoir volume total/active (mil. m3) | Negligible | Negligible | Negligible | 49.8/15.0 | 3.99/1.02 | 0.5/0.5 |
| Plant type | non-diversion | non-diversion | non-diversion | non-diversion | non-diversion | non-diversion |
| Inst. capacity (MW) | 113 | 121 | 87.2 | 88.5 | 26.10 | 7.18 |
| Mean annual electricity generation (GWh) | 420 | 452 | 333 | 394.69 | 101 | 34.46 |
| Investment costs  (mil. EUR)\* | 217 | 253 | 281 | 290 | 75 | 20 |

*\* Note: Estimated based on methodology described in the corresponding IWRM Report.*

### Montenegro

On the territory of Montenegro currently there are several hydropower plants in operation, but only "Piva" HPP is located in the DRB. This HPP and its dam and reservoir present the largest structure that was built on the Piva River. With its generous useful volume, the "Piva" reservoir provides favorable conditions for important discharge regulation. The "Piva" HPP operates in the "peak-load" mode within the regional hydropower system. Its installed capacity is 342 MW and its annual energy production 800 GWh.

Within the Drina River catchment area the "Otilovići" Dam is in operation, its main purpose being water supply. The use of surplus water and environmental discharges for energy production in some future small HPP has been considered.

Projects for the construction of eight new hydropower schemes have already been developed. A multi-criteria analysis aiming at making the best selection among these projects was conducted with the stakeholders and it was concluded that a package of three projects would optimally satisfy the imposed criteria (Table 4). These three projects are:

* "Komarnica" SHPP 170 MW Piva/Komarnica River
* "Otilovići" SHPP 3.0 MW Ćehotina River
* "Kruševo" SHPP 120 MW Piva River

The selected development scenario can satisfy the electricity production and consumption projections defined in the Energy Development Strategy of Montenegro with minimal environmental and optimal socio-economic impact. It is also estimated that this scenario is in line with other strategic documents of Montenegro.

**Table 4:** The main characteristics of HPPs proposed by optimal scenario for Montenegro

|  |  |  |  |
| --- | --- | --- | --- |
| **HPP** | **"Komarnica"** | **"Otilovići"** | **"Kruševo"** |
| River | Piva/Komarnica | Ćehotina | Piva |
| Chainage | km 50+000 (Piva) |  |  |
| Qav (m3/s) | 21.6 | 4.15 | 75.8 |
| Dam type/height (m) |  | Arch concrete (existing) | rock-fill - concrete gravity / 68 |
| Reservoir volume total/active (mil. m3) | 176 | 59 | 25.4/18 |
| Plant type | non-diversion | Diversion (105m long) | non-diversion |
| Inst. capacity (MW) | 170 | 2.961 | 120 |
| Mean annual electricity generation (GWh) | 220.5 | 11.73 | 267.4 |
| Investment costs  (mil. EUR)\* | 322 | 4 | 166 |

*\*Note: Estimated based on methodology described in corresponding IWRM Report.*

### Bosnia and Herzegovina

On the territory of BiH, three hydropower plants are in operation: "Zvornik" HPP, "Bajina Bašta" HPP and "Višegrad" HPP. The first two are located along the boundary between Serbia and Republic of Srpska (BiH) and are managed by EPS. Only "Višegrad" HPP is completely located in Republic of Srpska (BiH) and is managed by ERS – the "Višegrad" HPP. Its installed capacity is 345 MW and its annual energy production is 1,010 GWh.

Projects for the construction of sixteen new hydropower schemes have already been developed. A multi-criteria analysis aiming at making the best selection among these projects was conducted with the stakeholders and it was concluded that a package of four projects would optimally satisfy the imposed criteria (Table 5). These four projects are:

* "Buk Bijela" ("low") SHPP 94 MW Drina River
* "Foča" ("low") HPP 44 MW Drina River
* "Ustikolina" HPP 60 MW Drina River
* "Mrsovo" HPP 37 MW Lim River Under construction

"Buk Bijela" HPP is the most important and attractive hydropower plant along the upper part of the Drina River course, with a long history. The "Buk Bijela" profile (12 km upstream of Foča) controls the basin area of approximately 4.000 km2 (20% of the total DRB area). "Buk Bijela" dam height was chosen so as to not disturb the natural flow regime at the "Šćepan Polje" profile under adverse conditions.

According to reasons cited in Chapter 2.3.1 and similarly to the "Bistrica" PSHPP, "Buk Bijela" PSHPP was initially not included into development scenarios. Since the "Buk Bijela" PSHPP was in the mean time included into the Spatial Plan in force in Republic of Srpska, as well into the strategic plans developed by the Electric Power Industry of Republic of Srpska, the Consultant recommends the inclusion of this project into further projects that should follow the present one.

When comparing the main characteristics of the proposed optimal scenarios for Republic of Serbia and BiH, it is important to note that four ("Dubravica" HPP, "Tegare" HPP, "Rogačica" HPP and “Kozluk” HPP) of the six HPPs included in the selected development scenario for the Republic of Serbia are located along its border with Republic of Srpska (BiH). None of these HPPs is included in the most favourable development scenario for BiH.

The Consultant believes that the most reasonable solution for construction of these HPPs would be a joint effort of Investors from both countries, as any "asymmetric" construction could lead to a number of problems. Present development scenarios, unfortunately, are not coordinated at this point.

**Table 5**: The main characteristics of HPPs proposed by the optimal scenario in BiH

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **HPP** | **"Buk Bijela" (" low”)** | **"Foča" ("low")** | **"Ustikolina"** | **'Mrsovo"** |
| River | Drina | Drina | Drina | Lim |
| Chainage | km 334+550 | km 324+678 | km 305+285 | km 17+850 |
| Qav (m3/s) | 162.37 | 178 | 204.70 | 112.5 |
| Dam type/height (m) | Concrete gravity / 36 | Concrete gravity / 21 | Concrete gravity / 19 | Concrete gravity / 28 |
| Reservoir volume total/active (mil. m3) | 15.7/11 | 6.7/4.6 | 8.23/2.51 | 8.9/7.7 |
| Plant type | non-diversion | non-diversion | non-diversion | non-diversion |
| Inst. capacity (MW) | 93.5 | 44.15 | 60.48 | 36.80 |
| Mean annual electricity generation (GWh) | 375.33 | 199.24 | 235.29 | 141 GWh |
| Investment costs  (mil. EUR) | 195.50\*\* | 119.09\*\* | 109.00\* | 94\* |

*\*Notes:*

*\* Estimated based on methodology described in the corresponding IWRM Report*

*\*\* Taken from existing technical documentation on request of EPRS*

# Water management

## Protection against water

### Flood control

Current flood hazard and risk assessment indicate that the Drina River Basin is endangered by:

* Flood waves that propagate along the river valleys of the Drina River and its tributaries;
* Urban flooding within the flood-protected (interior) zones originating from coinciding occurrence of heavy storms and high groundwater levels;
* Flooding of the interior areas due to insufficient drainage;
* Migration of the main Drina channel in the river valley due to lack of the river engineering works;
* A lack of riverbank stabilisation, especially in urban areas, where river training works should be exercised for safety reasons, as well as for urban planning purposes ;
* A torrential river flow and accompanying erosion processes, which eventually result in aggradation of a riverbed and consequent increase in water levels, reduced discharge capacities that increase the probability of main-channel overflow in minor tributaries at greater discharges;
* Uncontrolled dredging of sand and gravel that alters riverbed morphology and might also trigger flow destabilisation.

Flood prone areas in the upper DRB include urban areas along the main Drina course (towns of Foča, Ustikolina, Goražde, Donji Modran, Ravan and Mrđelići) and left tributaries (Sokolac, Rogatica, Pale-Prača, Hrenovci, Čajniče, Rudo and Miljevina), as well as traffic roads along the tributaries. The town of Prijepolje by the Lim River is also flood prone. In the middle DRB, flood prone areas include: Krupanj municipality by the Likodra River, Osečina municipality by the Jadar River, the town of Loznica by Štira and Jadar Rivers, the town of Bajina Bašta by the Drina River, the municipality of Ljubovija by Ljuboviđa and Drina Rivers, Mali Zvornik municipality by the Drina River, and towns of Bratunac and Srebrenica by Drina's left tributaries.

The largest flood prone areas are in lower DRB and include arable lands of Semberija on the left Drina bank and Mačva on the right bank. They are endangered both from external and internal flooding. The Sava and Drina Rivers are potential origin of external flooding, while the internal flooding is caused by high groundwater table. Frequent external flooding on the left Drina bank is due to the absence of flood protection infrastructure along this river bank and a low conveyance capacity of the Drina main channel (1100 m3/s) caused by shallow, braiding and meandering channel. Such a morphology results from great discharge variability, geological composition of river bed and banks, regimes of bed and suspended load and unscheduled dredging of sand and gravel from the main channel and/or banks. Landslides usually accompany the flooding during/after heavy rains in mountainous regions, sometimes causing damage to dwellings and infrastructure or triggering mud spills from old mine tailings and mines with eventual ecological consequences on farming lands.

The effects of three proposed development scenarios in the DRB (“Green Growth”, “Reduced/Optimised HPP Maximisation” and “Full HPP Maximisation”) on flood hazards and risks are discussed in view of estimated changes in flood flows along the Drina River under the impact of climate change.

The upper and middle DRB. No changes in flood risk are expected for the “Green Growth” scenario (no new reservoirs in the basin). Under the “Reduced/Optimised HPP Maximisation” scenario, construction of three or five concrete gravity dams (scenario option 1 or option 2) would introduce high risk of potential dam-break induced flows in towns downstream of the dams (Foča, Goražde and Ustikolina). Therefore, inundation and flood risk maps, and emergency plans must be a part of the design for every dam. Since the evacuation capacity of each dam exceeds estimated 1% flood at the representative site, the flood risk should be controlled by reconstructing existing revetments and embankments and/or construction of new ones. Reconstruction of the storm sewer systems should be considered to avoid flooding of urban and interior areas. The risk level downstream of each dam in the cascade would increase unless an integrated river basin management was applied, and particularly unless the consensus between the water and hydropower sectors was achieved. The same conclusions and recommendations hold for the “Full HPP Maximisation” scenario.

The lower DRB. Under the “Green Growth” scenario, the existing flood protection system along the lower Drina course is not fully adequate and can have its full protection effect against the 1% flood only under a series of preconditions. Structural preconditions include reconstruction of the existing system to meet design criteria, enlargement of the system in areas where it does not already exist, regular infrastructure maintenance, and systematic protection of banks from erosion. Non-structural preconditions include improved management practice related to management of all upstream reservoirs during high-water periods to reduce risk of downstream flooding, as well as establishment of the strict sediment management practices, especially in the lower Drina course.

Construction of the “Kozluk” concrete gravity dam in the “Reduced/Optimised HPP Maximisation” scenario would increase the risk of internal flooding on the left bank due to permanent rise of groundwater table caused by the reservoir operating levels. To reduce this risk, a complementary drainage and pumping stations system in the valley should be built. Additionally, preparation of inundation and flood risk maps is recommended for a selected number of embankment-breach scenarios. Since the total evacuation capacity of the “Kozluk” reservoir (8000 m3/s) highly exceeds 1% flood estimated both from the observed records and two climate change scenarios, the downstream risk level would increase unless an integrated river basin management is applied, and particularly unless the consensus between the water and hydropower sectors is achieved.

Under the “Full HPP Maximisation” scenario, risk of external flooding would be decreased, but the operational reservoir levels, which would be well above the ground level on one or both river banks would foster the risk of internal flooding due to permanent rise of groundwater table in Semberija and Mačva regions. To control/reduce such a risk, it is highly recommended that: 1) operational plans for the entire reservoir cascade during floods are synchronised, 2) the consensus between water and hydropower sectors on drawdown plans from reservoirs during floods is achieved, and 3) both Mačva and Semberija regions are divided into polders that would help localise the possible damage to the area close to the dike-breach.

It must also be taken into account that it is necessary to implement a more restrictive policy regarding land use planning. On no account should housing and the procedures for issuing construction permits be allowed when the plans show such buildings to be in flood prone areas.

### Drought

The high environmental value of the DRB could be endangered during drought periods. Primarily the small tributaries of the Drina River can be most affected during these drought events. Indeed, during extreme droughts, the main effects on environment could be:

* Endangered fish population (reduction of the population) by drying complete section of small tributaries, putting pressure on the food resources, increasing the water temperature, increasing the concentration of polluants and degrading the water quality,
* Endangered terrestrial fauna habitats by destruction due to increase of forest fires.

Thi situation happened during extreme droughts in 2012 and 2013 when many kilometres of salmonid streams were left without water.

However, the Drina River Basin is generally abundant with water and the droughts were rare in the historical period. However, the hydrologic simulations with the ensemble of climate projections under two climate change scnarios for 2011-2070 have shown that significant reduction in the river discharge during summer season can be expected in the future. Having in mind that the low flows occur in late summer and early autumn, such a result gives rise to a concern about the effects of the droughts in DRB in the future.

The results of the water balance simulations with the Drina water management model in WEAP[[1]](#footnote-1) for two climate change scenarios (based on the ensemble of hydrologic projections for 2011-2070) suggest that the coverage of the required environmental flows at head parts of the basin where no reservoirs exist would generally decrease in time with decreasing runoff under both climate scenarios. On the other hand, the flow requirements below the existing reservoirs and HPPs (Green Growth scenario) can be fully satisfied from the reservoirs at any time in future. The flow requirements below the planned reservoirs and HPPs under Reduced/Optimised Hydropower scenario can be fully satisfied everywhere except for the Lim River. Under the Full Hydropower Maximisation scenario, four planned facilities on the Lim River (Andrijevica, Lukin Vir, Brodarevo 1 and Brodarevo 2) can meet the environmental flow requirements by discharging water from the reservoirs with coverage of about 99%.

The analysis of the effects of specifying greater environmental flow requirements (suggested by stakeholders) on water balance has shown that, under the same hydrologic input, the higher flow requirements along the Drina main course can be fully satisfied (with 100% coverage). Increased flow requirements are not reflected upon hydroelectricity production or upon coverage of municipal, industrial and agricultural water supply.

In conclusion, the guaranteed release of the environmental flow for the development scenarios is a key issue to mitigate the impacts on the aquatic ecosystem during drought events. For small tributaries without planned reservoir, the presence in situ and observations of fishing guards are essential to restock the fish population into an appropriate river before the drying of the watercourse.

## Use of water

### Hydropower

In a general way, the management of HPPs depends on the actual reservoir capacity, the hydrological situation, the production tool availability (efficiency, outages, maintenance, etc.) and the situation in the power system of the country and the region.

The reservoirs are structures that can enable the largest and the most flexible human influence on the water regime of a basin. The relative size of a reservoir is the ratio of the reservoir useful storage volume (Vus) to the average annual inflow into the reservoir (Vavg), as shown in the formula below:



This ratio is usually named the regulation coefficient (β). Engineering experience indicates that large reservoirs (with seasonal regulation) are those with regulation coefficients above approximately 0.08, i.e. a reservoir useful storage volume higher than 8% of the average annual inflow into it.

The flow regulation status of the existing reservoirs is presented in the Table 6.

**Table 6:** The flow regulation status of the existing reservoirs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rank No** | **Reservoir** | **Country** | **Useful Volume Vus (Mm3)** | **Average Annual Inflow Qavg (m3/s)** | **Regulation Coefficient β=Vus/Vavg** |
| 1 | "Kokin Brod" HPP | Serbia | 209 | 13.9 | 0.477 |
| 2 | "Uvac "("Sjenica") HPP | Serbia | 160 | 11.5 | 0.441 |
| 3 | "Piva" HPP, | Montenegro | 790 | 74.4 | 0.337 |
| 4 | "Otilovići" SHPP | Montenegro | 13 | 4.68 | 0.088 |
| 5 | "Bajina Bašta" HPP | Serbia/BiH | 218 | 349 | 0.020 |
| 6 | "Višegrad" HPP | BiH | 101 | 342 | 0.009 |
| 7 | "Radoinja-Bistrica" HPP | Serbia | 4.1 | 14.4 | 0.009 |
| 8 | "Potpeć" HPP | Serbia | 19.8 | 77.6 | 0.008 |
| 9 | "Zvornik" HPP | Serbia/BiH | 21.3 | 369 | 0.002 |

Based on obtained reservoir flow regulation coefficients, the flow regulation status of the existing reservoirs is as follows:

* "Kokin Brod" HPP and "Uvac" HPP – weekly and seasonal regulation. The large active volumes of these reservoirs provide conditions for very flexible management, flood retention and mitigation and releases of environmental flow in all hydrological regimes. Even in extremely dry periods, they can satisfy almost of all needs of the energy system, such as regular coverage of the consumption of energy and power, all forms of reserves in the system, power regulation etc.
* "Piva" HPP reservoir – seasonal regulation. It can achieve positive retention of flood and can satisfy environmental flow requirements in all hydrological regimes. The regime of the entire Drina River is considerably influenced by the operation of the "Piva" storage and HPP. Until 2014, this plant operated within the electricity transmission system of Serbia and worked according to its rules. Since January 2014, "Piva" HPP operates in accordance with the demands and rules of the power system of Montenegro. Due to a lack of retention reservoir downstream ("demodulation basin"), during the peak-load operation of “Piva” HPP was occasionally released uncontrolled flow downstream, which caused large fluctuations of the water level.
* "Zvornik" HPP and "Potpeć" HPP reservoirs – daily regulation. The smallest possibility of regulation is provided by the "Zvornik" storage, since its reservoir is filled with sediment (almost 50% of the reservoir volume). This storage can also play only a limited role in floods and droughts control.
* "Bajina Bašta" HPP reservoir – daily and weekly regulation. It can achieve a positive retention on flood waves.
* “Bistrica” HPP and “Višegrad” HPP reservoirs – daily and weekly regulation.

"Potpeć" HPP, "Bajina Bašta" HPP and "Zvornik" HPP may participate in the regulation of the power system. They also participate in the seasonal water regulation of the "Piva", "Sjenica" and "Kokin Brod" reservoirs.

* Existing reservoir "Otilovići" provides seasonal regulation. In the present state, this reservoir is not equipped with an HPP; it can satisfy requirements for water supply of the "Pljevlja" TPP, wood industry and water supply to part of the population of the Pljevlja city. An environmental flow of 0.8 m3/s is being constantly released from the reservoir.

Most plants proposed as the optimal ones according to the recommended scenarios are non-diversion type run-of-river plants that have no impact on river water management. Based on their reservoir volume summarized in the Table 7, all proposed new HPPs, except the "Komarnica" HPP, do not have a capacity for significant flood retention.

**Table 7:** The flow regulation status of the new reservoirs proposed within selected optimal scenarios

|  |  |  |  |
| --- | --- | --- | --- |
| **Reservoir** | **Useful Volume**  **Vus (Mm3)** | **Average Annual Inflow Qavg (m3/s)** | **Regulation**  **Coefficient**  **β=Vus/Vavg** |
| **Serbia - new HPPs within the "Reduced/Optimised HPP Maximisation"Scenario** | | | |
| "Kozluk" HPP | 15 | 365.4 | 0.0013 |
| "Brodarevo I" HPP | 1.02 | 69.3 | 0.0005 |
| "Rekovići" SHPP | 0.5 | 91.9 | 0.0002 |
| "Rogačica" HPP | 0 | 388.3 | 0.0000 |
| "Tegare" HPP | 0 | 341.7 | 0.0000 |
| "Dubravica"” HPP | 0 | 347.7 | 0.0000 |
| **Montenegro – new HPPs within the "Reduced/Optimised HPP Maximisation" Scenario** | | | |
| "Komarnica" HPP | 160 | 20.1 | 0.2524 |
| "Otilovići" + SHPP | 13 | 4.68 | 0.0881 |
| "Kruševo" HPP | 18 | 71 | 0.0080 |
| **Bosnia and Herzegovina – new HPPs within the "Reduced HPP Maximisation" Scenario / Variant #1 as per Sava RBMP in BiH (app. 6 years)** | | | |
| "Buk Bijela" ("low") HPP | 11 | 158.4 | 0.0022 |
| "Mrsovo" HPP | 7.7 | 122.9 | 0.0020 |
| "Foča" ("low") HPP | 4.6 | 173.1 | 0.0008 |
| "Ustikolina" HPP | 2.51 | 202.9 | 0.0004 |

Based on the obtained reservoir flow regulation coefficients, the flow regulation status of the proposed new reservoirs is as follows:

* "Komarnica" HPP - seasonal water regulation.
* "Kruševo" HPP, "Buk Bijela" ("low") HPP and "Foča" ("low") HPP reservoirs can provide daily or weekly regulation, but they may also participate in the regulation of the water released from the "Piva" HPP reservoir. Their role may be significant in the mitigation of flood waves released from the "Piva" HPP reservoir and reduction of water elevation oscillations along to downstream river sections.
* Although the other new reservoirs do not have volumes sufficient for significant flow regulation and flood retention, they help in meeting requirements regarding environmental flow released even during dry periods.

In order to avoid negative effects caused by unfavourable operation of existing reservoirs (especially the "Piva" reservoir), in the future it will be necessary to pay attention to developing management strategies for all existing reservoirs. Also should as soon as possible be considered the erection of new structures along the upper part of the Drina River watercourse, between "Piva" and "Višegrad" reservoirs.

### Irrigation

In Montenegro irrigation demand is less important and the principal focus lies on quality products rather than on large productions, and this is reflected by the number of organic food producers which are increasing year on year. Through its access to EU pre-accession funds Montenegro can promote organic produciton, expand good farming practices and improve the market for organic and local products in eco touristic areas.

Agriculture water demand through irrigation is very important in the lower Drina basin covering Serbia and BiH. With the likely onset of climate change water demand for agricultural production will become more important throughout the DRB.

The principal agricultural areas are assigned to the sub-basins downstream of Kozluk in both BiH and Serbia Crop production is highly vulnerable to weather conditions and this situation is expected to worsen with climate change. In order to keep up production, irrigation demand in the basin will likely increase. For example the area of Semberija in BiH is planned for expansion.

For new and existing irrigation schemes, it is important to put efficient irrigation technologies to avoid overuse and limit cross-sectoral impact. Such technologies will provide improved resilience to droughts and will provide reduced competition with domestic use on groundwater

### Potable water

Groundwater is used as the main potable water source in the DRB, and the quality is good, but the actual monitoring is often sparse and irregular. In spite of a general abundance of water in the basin, some areas face severe shortages in water supply and availability during dry seasons where demand increases substantially during the summer months (although this concern is more relevant to the tourism at the coastal region, outside of the DRB).

Due to impacts of climate changes the occurance from heatwaves could be foreseen, where safe drinking water supply are under threat in the event of floods. Disaster management/early-warning systems for heatwaves and floods are necessary. There are also indirect effects of higher temperatures such as an increase in the number of water borne diseases (e.g. gastroenteritis) where children are particularly vulnerable and algal contamination of water.

It is assessed that also the potable water in the future will be of sufficient quantity. It is recommended to improve monitoring system in a systematic way to be able to control the quality also under more severe climate conditions.

### Industrial uses

The water supply for industry is not a significant issue for the WMR in the DRB. Industry use is the smallest among the other uses (domestic with the largest procentage and irrigation, as second one). Industrial production has significantly declined in last decades and demand is not substantial what is also assessment for the future. The same issue prevails on the quality aspects and there is need of corresponding wastewater treatment plants at the main centres of population and for industry in order to reduce the pollution loads in the rivers.

### Recreation

The DRB is a very important recreational resource and there are potential opportunities to expand this sector (especially tourism) throughout the rivers of the DRB. To achieve this, it is essential to promote and to agree on cooperation between the riparian states.

Socio-economic pressures from forest ownership and management, invasive species, hunting and fishing, land ownership disputes in protected areas, change of land use, water use and water management, wastewater, tourism and recreation, and illegal collection of medicinal herbs and fungi, are all contributing to the detriment of the protected areas.

Growth of tourism leads to the development of legal and illegal constructions, to the development of infrastructure, to an increase of waste left behind, and to increased water consumption. This development of tourism threatens the ecosystem balance, damages vulnerable zones and needs sustainable management with a limitation of the number of tourists and of the access to natural areas to protect the vulnerable habitats and species.

Recreation, tourism and fishing are in obvious conflict with other water uses, e.g. hydropower construction and operations, the diversion of waters resulting in dry riverbeds, pollution etc. The ISRBC has recently developed initiatives and specific guidelines for the promotion of eco-tourism at the level of the Sava basin.[[2]](#footnote-2) This document offers a cooperative perspective on the sector, aimed at promoting rural economy across the riparian borders, along the natural course of the river. The guidelines can be focused down to the Drina Basin level aimed at the protection of wildlife and biodiversity, promotion of local products - including agricultural products -and renewable energies.

### Aquifers

The general trend of groundwater flow direction in DRB is along the Drina valley from southwest to northeast. Although there is adequate groundwater protection legislation in place in all three countries; and the fundamental principles, objectives and measures from the EU Groundwater Directive have been included in the national legislation; often monitoring, enforcement and correct implementation is frequently lacking due to lack of staff and training. This issue can seriously undermine and threaten groundwater quality at source, which is important, as groundwater is the main source of domestic consumption in all counries. Aquifers are particularly at risk near the main settlements.

Therefore it was recommended that in the future establishment of a common groundwater monitoring program and harmonisation of criteria for explanation of source protection zones for the whole DRB should be implemented.

## Protection of water

### Sediment management

All DRB riparian states through the ISRBC have developed a Protocol on Sediment Management to the FASRB, which affirms the need for efficient cooperation among the riparians for promotion of sustainable sediment management (SSM) solutions. The above UNESCO/Sednet initiative provided a practical guidance on how to achieve an SSM plan (as in ISRBC publication "Towards Practical Guidance for Sustainable Sediment Management using the Sava River Basin as a Showcase").

Unfortunately, sediment analysis in the DRB is poorly monitored. Ideally, there should be well-established stations, which should take the following measurements:

* Suspended sediment concentrations (SSC) and suspended load, size graduation of suspended sediment and bed materials on a regular basis
* Bedload measurements on an occasional basis

Alas, in Montenegrin and the BiH part of the DRB systematic monitoring of sediment does not exist[[3]](#footnote-3). In the RS part of BiH a soil erosion map that can provide data on erosion processes has been prepared, but the monitoring sites are not within the DRB[[4]](#footnote-4) In Serbia three stations are located within the DRB at Mihalijevici, Radalj and Badovinci, which are being monitored by RHMZ for SSC and load transport rate. However, there are many gaps and uncertainties in the record due to outdated instruments and the scope of sediment monitoring is not sufficient.

Therefore, for the future the DRB should be better monitored and assessed for sediment by:

* increasing the number of sediment monitoring sites especially on the Drina and the main tributaries
* Increasing the montoring of bed load measurements
* Agreeing a standardised methodology for sampling and measurement of suspended load and bed load in the DRB
* Increasing and updating the amount of monitoring equipment especially for continuous monitoring and for peak flood events and
* Undertaking sediment quality measurements according to the EU WFD

Furthermore, the monitored sediment parameters in the DRB stations (existing and future stations) should be connected to a joint Sediment Database free to access for all riparians preferably through the ISRBC.

There should be better harmonisation of monitored sediment data through application of the same technical international standards.

The monitoring network should be made denser with the introduction of new stations and there should be improvements in modelling the data.

### Environmental flow

Environmental flow (EF) is considered as being the minimal water discharge necessary for maintaining the river health (water quality protection), as well as for the ecosystems (environmental protection) and recreation (social protection).

After several discussions with the stakeholders in 2016, it was decided that the aim of the study was not to set up a new methodology to estimate the EF in the DRB, but:

- to compare the EF values according to the regulations of the three riparian countries, as well as with regard to other international methodologies (USA method, Lanser and GEP methods used in Europe);

- to analyse the water balance with the EF values specified in the existing technical documents of the planned HPPs[[5]](#footnote-5) and, if no value was found, with the values proposed by the consultant as well as with the maximal values of the respective regulation;

- to propose harmonized values to be applied over the entire DRB.

As specified during the study, the respective methodologies proposed in the BiH, Montenegro and Serbia countries are based on hydrological data and allow to calculate the minimal environmental flow. They are summarised in the Table 8.

**Table 8:** Minimal EF hydrological methods of the riparian countries in the DRB



As recommended in the countries' regulations of FBiH and MNE, and recommended by the Consultant, in regions of high environmental value, dedicated a environmental study should be performed to adapt (and possibly increase) the magnitude of the minimal EF.

The results of the water balance computations with the Drina Basin water management model (using the WEAP software) show that the water balance is conserved when using the EF minimal values based on the three countries regulation and when using the EFvalues proposed in the technical documents of the planned HPP.

The Drina River crosses the FBiH, RS-BiH and Serbia territories; some tributaries as the Lim and Cehotina rivers also cross two or three countries in the DRB. The Consultant therefore recommends the three countries to agree on adopting a harmonized method of evaluation of the minimal EF based on hydrological data of the DRB.

The FBIH methodology (art. 11 of rulebook OG FBiH n°04/13) proposes a method to calculate the minimal EF resulting from a consultation of key stakeholders from HPPs, hydrology and environmental institutions. The method defines a seasonal variation of the minimal EF relevant for the corresponding needs of both users and aquatic ecosystems. In addition, the resulting minimal EF values are a good compromise covering the values estimated by the Serbia and RS-BiH methods (single constant value over the year).

The MNE method (art. 8 of the addendum of the rulebook OG n°2/16) depends on the monthly hydrological values. It leads to monthly minimal EF values. It can be observed that in some cases, the fluctuation of the monthly minimal EF value is not always in harmony with the needs of the aquatic ecosystems.

Therefore, the consultant recommends to adopt the FBiH method for calculating the minimal EF throughout the DRB. In river sections with natural spawning areas of high value fish species (like the Danube Salmon or the brown trout) or in protected areas or in sensitive alluvial ecosystems, a specific environmental study shall be performed.

### Water quality

**Classification**

The classification of water quality in the DRB is summarized in Table 9. The methodology used to determine the ecological and chemical status of water bodies in Serbia is formulated in the Act on Parameters of Ecological and Chemical Status and Quantitative Status of Surface Waters and Parameters of Chemical and Quantitative Status of Groundwaters (Official Gazette RS, No. 74/11). This Act establishes the parameters and their threshold values for the determination of the ecological and chemical status of rivers and lakes; parameters of ecological potential for artificial and significantly modified water bodies; and parameters of the chemical and quantitative status of groundwater. Ecological status of surface water is determined based on the three groups of quality indicators: biological, hydromorphological and physico-chemical. The ecological status of natural (unmodified) water bodies is classified as: excellent (I), good (II), moderate (III), poor (IV) and bad (class V). Chemical status indicates whether the water body is under the influence of pollution by priority, priority hazardous, and other pollutants. The chemical status of water bodies is assessed based on the monitoring results, as good status or failure to achieve good status.

The classification of water quality in BiH is comparable with the Serbian legislation. The classification of the water quality in RS-BiH is provided by the Decree on Water Classification and Categorization of Water Courses (RS OG No 42/01) and on the Law of water (RS OG No 50/06). However, the Decree did not define limit values for all biological and physical-chemical parameters as required on EU Directive and for some specific parameters, the prescribed limit values do not comply with these EU regulations. In FBiH, the classification is based on the Characterization of surface water and groundwater (FBiH OG No 1/14), which has been harmonized with the EU Directives. This decision provides the reference conditions and parameters to determine the status of surface water and groundwater.

In Montenegro, Decree on classification and categorization of waters (OG 2/07) categorises water into three classes according to the permissible limit values of certain groups of parameters, depending on the purpose of the water usage. In this sense, water may be used for drinking, used for beverages and food industry; fish and shell farms; bathing and swimming.

Obviously, **there is a need for harmonization of the classification for the three countries, in order to have a homogeneous picture of the surface water status at the basin level.**

**Table 9**: Comparison of water quality classification legislative in three countries

|  |  |  |
| --- | --- | --- |
| Serbia | BiH | Montenegro |
| Ecological status for surface water and Ecological potential for highly modified water bodies (HMWB) is classified based on physico-chemical and microbiological indicators  Classes I to V (Excellent to Poor)  Chemical status is categorized as good or not achieved good status, based on the content of priority, priority hazardous and other pollutants.  Overall status/potential is classified as the worse case of two. | FBiH:  Since 2014, classification harmonized with EU Directives  RS-BiH:  Five classes of water quality status (I to V) based on physico-chemical, microbiological and hydromorphological parameters. Not completely harmonized with the EU directives. | Classification according to permissible values of physico-chemical and biological indicators depending on the purpose of the water usage:   * Water that can be used for dinking and food production (Classes A, A1, A2 and A3) * Water for fish and shell production (Classes S, W and C) * Bathing water (Classes K1 and K2)   Water quality categorization:  Class I: A1, S, K1  Class II: A2, K2, C  Class III: A3 |

Following characterisation is determined according to each country classification.

**Baseline water quality characterisation**

Generally, the water quality in the DRB has been improving after the war (since 1995), mainly due to the reduction/closure of industrial facilities in the basin and the slow uptake of new industry and agriculture.

The characterisation study revealed that present water quality status, which includes ecological and chemical status of the Drina River and its tributaries, can be considered as moderate to good.

Drina River

At the upstream part of the Drina River (up to Gorazde) the ecological and chemical status is good, while the downstream part has higher nitrogen, phosphorous and organic loads. The ecological status from Gorazde to Visegrad and from Zvornik to the mouth is classified as moderate. However, its chemical status from Gorazde to Visegrad and from Zvornik to the mouth is classified as bad.

Tributaries

The tributaries in the DRB are mostly considered to have a good water quality status. There are few tributaries with moderate to bad water quality. They correspond to tributaries under direct influence of sewage outflows or industrial/mining dumpsites (e.g. Ćehotina River and its tributary Vezišnica River in Montenegro with pollution discharges from the thermal power plant, the coalmine and the Suplja stijena lead and zinc mine in Pljevlja; Kostajnička River and Korenita River in Serbia receiving filtrate from the tailing, etc.). Lim River has good status at the upper, while the lower part (downstream from Berane) has not reached the good status. Tara River has a good status along nearly 65% of its watercourse. However, the water quality is deteriorated by communal waste deposit site in the municipality of Kolašin and one site within the Municipality of Mojkovac. Piva River has a good status with the best quality of water in Montenegro. This is due to the very few settlements along this river.

Groundwater

Despite the lack of precise information, groundwater bodies are mainly considered as of good water quality and quantity status. The karstic aquifers with good permeability and substantial groundwater accumulation dominate the DRB and represent the most significant water-bearing rocks of the DRB, especially in the Montenegro. It should be emphasized that groundwater is the main source of potable water in the DRB. The most significant pressures on groundwater quality are evident in the area of Mačva and Semberia with intergranular aquifer porosity, due to agriculture activities and inadequate sanitation. The recharge of quaternary aquifers in this area is dominated by the surface infiltration and Drina riverbank infiltration, while the water supply exploitation represents the main discharge in the aquifer water balance.

**Identification of significant pressures**

The most significant adverse impacts on water quality are urban and industrial non-treated wastewater, municipal solid waste, wild landfills, industrial waste deposit sites near the riverbanks and agricultural activities.

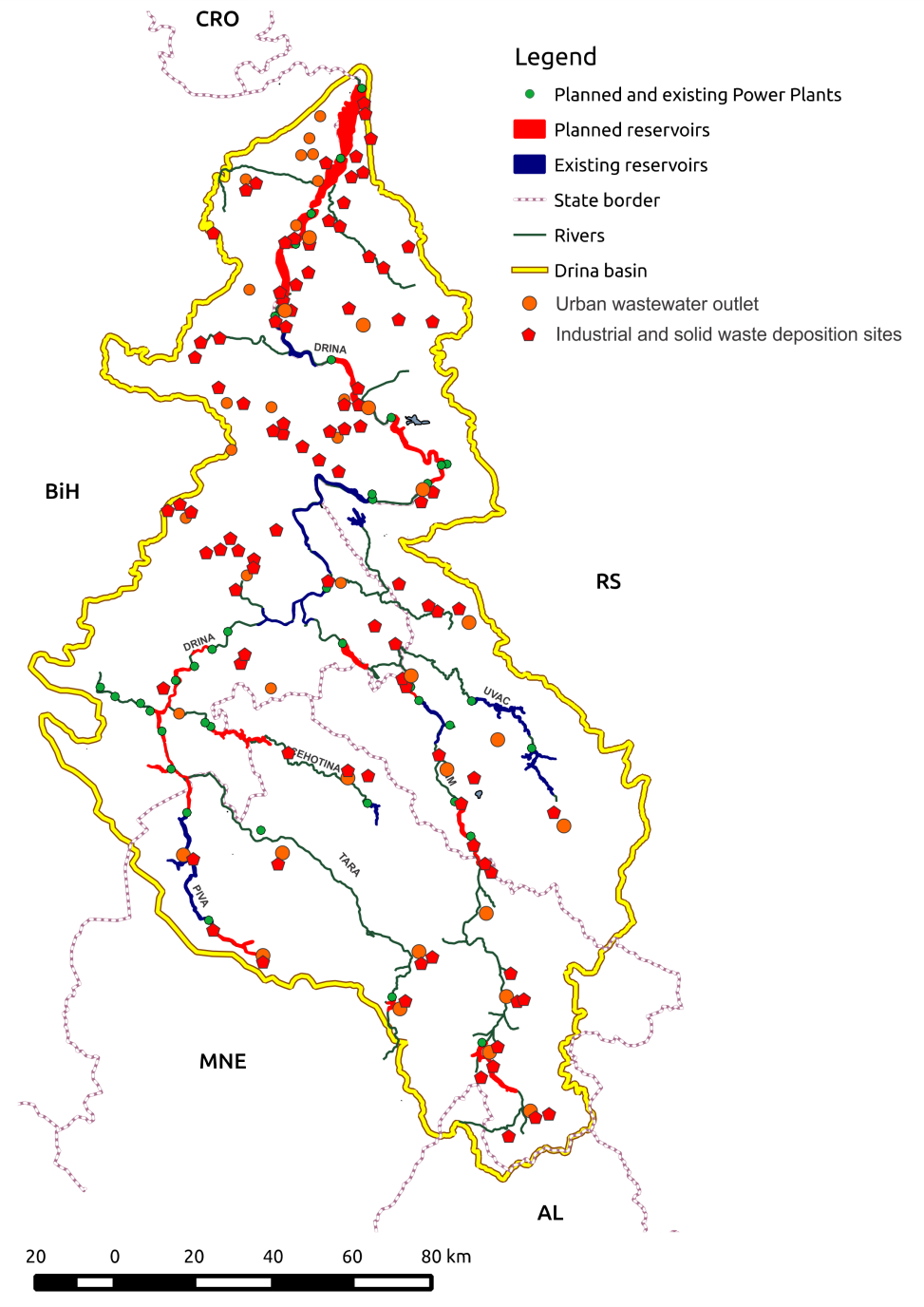
The main municipal hotspots in Montenegro are present in Pljevlja, Berane and Bijelo Polje. In FBIH, they are present in the municipalities of Gorazde, Pale-Prača, Ustikolina and Kladanj. In RS-BiH, all the municipal hotspots are located downstream of wastewater outfalls from main settlements on the tributaries and on the main Drina River. This includes settlements such as, Bijeljina, Zvornik, Višegrad and Foca. In Serbia, Loznica, Mali Zvornik, Krupanj, Ljubovija, Bajina Bašta, Prijepolje, Sjenica, Priboj, Nova Varoš and Čajetina.

At the DRB scale, slightly above 20% of population is covered with the sewage collection systems, with similar coverage ratio in all three countries. The rest is considered as diffusive load released directly into the streams or into the septic tanks. The collected wastewater is mainly released directly into the river without any treatment. In Monenegro part of the DRB, about 22% of population is connected to the sewage system, with municipal wastewater discharge load of 80,250 EP. Only Mojkovac and Zabljak have a WWTP facilities (5250 EP and 2150 EP, respectively). In BiH part of the DRB, the percentage of coverage is similar (22%) with total municipal wastewater discharge load of 137,000 EP. There is only one functional WWTP in Bijeljina (V. Obarska) with capacity of 40,000 EP. In the Serbian part of the DRB, there are no operational WWTPs and municipal wastewater load is estimated about 91,000 EP.

The most polluting centres of industrial activity are located at nine sites in the BiH part of the DRB, with the four largest potential industrial pollution sources being coal mining in Ugljevik, bauxite mining in Zvornik and lead and zinc mining in Srebrenica. Main industrial sites in the Serbian part are located at Loznica, Bogatić, Koceljeva, Ljubovija and Mali Zvornik, with the Loznica chemical industry and the mines at Ljubovija with the greatest cause for concern. In Montenegro DRB, there are no significant industrial facilities, except in the Pljevlja region, where the TPP and coal, zinc and lead mines pose a significant threat to human health and environment.

Solid waste disposal into landfills and general "fly tipping" in the catchment represent a persistent problem. There is no waste incineration or mechanical and biological waste treatment in the DRB. Landfill disposal is the only current option for solid waste management; hence, work to reclaim, remediate and sanitise them is urgently required.

The Figure 5 shows urban wastewater hotspots of the DRB and registered industrial and solid waste landfills including the “wild” landfills.



**Figure 5:** Urban, Industrial and solid waste hotspots at the DRB

Agricultural hotspots are a major source of distributed pollution of surface water and groundwater, originating from uncontrolled and excessive use of agrochemicals, improper use of pesticides and fertilizers, and others discharges such as farm slurry etc. The main agriculture hotspots are located in large pockets of farmland, particularly surrounding the cities of Gorazde, Bratunac Bijeljina in BiH, Loznica, Bogatić, Vladimirci and Koceljeva encompassing the Semberija area in the north part of the DRB.

**Main challenges to protect water quality**

All strategic documents in three countries indicate release of urban wastewater into streams and rivers as a significant pressure on water quality. It is certain that planned goals established in these documents regarding sanitation infrastructure and WWTP construction are quite optimistic. These investments require significant investments.E.g. in the MNE part of the DRB by 2029, it is planned realization of WWTP facilities in 9 municipalities with the extension of the existing sewage infrastructure by 227 km of primary of secondary mains. In the BiH part of the DRB, it is planned to construct seven new WWTP facilities by 2027. In the SRB part of the DRB it is planned that all conglomerations larger than 2,000 EP will provide adequate wastewater treatment by 2040.

Realization of planned sanitation and WWTPs will be challenging from additional reasons: existing sewage systems are mainly developed partially, from the central part of municipalities towards the periphery, causing the capacity problem; dominantly the combined sewer systems are present; limited sewage coverage; etc. However, its implementation will have significant positive effects on water quality management of proposed reservoirs. HPPs, as the most economically effective parts of integrated water management system in the basin, may represent a spin-off trigger for realization of wastewater related strategies. Similar conclusion can be derived regarding existing solid waste management development strategies.

The current waste management at the DRB rely heavily on landfill disposal, with extremely low operational standards and environmental considerations. This is best illustrated by the fact that there is only one existing regional solid waste center in the DRB (Bijeljina, BiH-RS), while nine more are planned according to existing strategies on waste management (Foca, Gorazde and Zvornik in BiH, Bijelo Polje, Berane, and one for municipalities Pljevlja and Zabljak in Montenegro, and Loznica, Uzice and Nova Varos in Serbia). Development of sanitary compliant landfills must be accompanied with gradual closure of the existing waste dumps and significant shift in public attitudes to waste.

As dams and water management schemes are constructed, the requirements of wastewater treatment investments will be additionally pronounced. Formation of reservoirs and transition from lotic towards the lentic conditions generally increases the sensitivity of water quality status on untreated wastewater load. Implementation of comprehensive wastewater infrastructure development plans is needed for the DRB, since pollution of water is mostly due to untreated municipal and industrial wastewaters caused by the lack of facilities for wastewater treatment.

**Mains expected impacts of scenarios development and investments**

In the case of relatively low reservoir volumes of the planned HPPs, the river flow regime downstream of the HPP is not expected to be influenced significantly. The most of considered reservoirs will represent aquatic ecosystems that will act and function as a transitional form between river and the lake systems, characterised by an average water retention times between 0,5 days (HPP Gorazde) and 4,8 days (HPP Drina III). Several would form the typical lentic conditions due to significant volume related to average flow rates (HPP Komarnica – 118 days, HPP Andrijevica – 32 days, HPP Vikoc – 146 days and HPP Sutjeska – 52 days retention time). Considering the current water quality at the designated locations, i.e. anthropogenic influence reflecting in this quality, reservoirs will generally not have a significant potential trophic level, except the HPP Vikoc reservoir on the Cehotina River, with the significant trophic potential.

In addition, reservoirs at the lower part of the basin (HPP Drina I-III and HPP Kozluk), due to relatively small averaged water depth, will have significant trophogenic portion of the volume and significant littoral zones with fine sediment and low water velocity. This will provide excellent conditions for production of macrophytes. Accompanied with stable water level and favourable water temperature, significant primary production can be expected in these reservoirs. In all other cases, there is a potential of minor adverse impact of proposed reservoirs on several water quality indicators.

As an example, one may expect that water temperature will be slightly increased during the warm season and slightly decreased during the coldest period. In addition, dissolved oxygen concentrations will certainly be slightly decreased in comparison with current conditions. On the other hand, one could expect certain beneficial effects regarding water quality at downstream stretch of the river (e.g. turbidity, heavy metal concentrations, etc.). Overall, it can be expected that planned reservoirs will represent a kind of water treatment reactors for downstream users. In addition, the reservoirs may have significant protection role in accidental contamination events.

**Main objectives of protection and recommendations**

The targets of the Water quality development comprise all relevant water related national strategies and other relevant development policies and strategies that can influence the water quality.

Main strategic objectives:

* Achievement and maintenance of good status of surface water and groundwater bodies in the context of overall environment and health protection:
* For water bodies with estimated good or high status, the objective is to provide conditions for its long-term maintenance through the pollution control.
* For other surface water and groundwater bodies with moderate to bad status, it is necessary to suspend the causes of pollution and to provide conditions for water quality revitalization.

Operational objectives:

* Reduction of contamination of surface water and groundwater (point pollution sources):
* Development of urban waste water sewage collection systems and WWTPs in accordance with strategic priorities;
* Reduction of pollution from industrial activities in accordance with the relevant legislation: Improvement of waste water treatment and application of best available technologies;
* Sanitation of solid waste landfills and industrial tailings/dump sites;
* Improvement of the solid waste management;
* Improvement of the fish farming process (as built of nutriment precipitators).
* Reduction of contamination of surface water and groundwater (distributed pollution sources):
* Reduction of individual domestic wastewater releases (distributed type of pollution); Development of sanitation infrastructure must be followed with WWTP developments, otherwise, effects on surface water quality are adverse.
* Reduction of pollution from agriculture activities: strengthening of the use of insecticides and pesticides.
* Establishment of information system and monitoring of water quality status indicators for surface water and quality and quantity status indicators for groundwater.
* Improvement of water management towards improvement and maintenance of good status of water bodies: reservoir management, HPP operation, promotion of groundwater recharge, etc.
* Identification and protection of protected areas:
* Establishment and Protection of water supply sources;
* Identification and protection of nutrient-sensitive areas;
* Identification and protection of economically significant aquatic species;
* Identification and protection of water bodies identified as bathing waters.

Main short term proposed priorities:

In order to prioritise the water quality targets and base on previous discussions with stakeholders, it is proposed to consider in a short term the following targets:

* Increase of population covered with the sewage system and construction of treatment facilities with prioritization from larger agglomerations towards the smaller ones.
* Removal of illegal municipal and industrial solid waste landfills near rivers and construction of regional sanitary landfills and sanitation of existing landfills.
* Increase of the solid waste collection system and of the education to sort-off wastes.
* Protection of groundwater (application of groundwater protection zones, regulation of groundwater extraction and implementation of measures for prevention of contamination).

### Flora and fauna management

**Main expected impacts of scenarios developments and investments**

The development of the Wastewater and solid waste managements of the retained scenarios will improve the water bodies’ status and the riparian areas. Therefore, these managements will contribute tothe improvement of the aquatic ecosystem for biodiversity.

Finally, the main pressures for biodiversity due to the proposed development scenarios concern the construction and the operation of new HPP and SHPP. The main maximal expected impacts of these HPP and SHPP investments, without appropriate mitigation measures, are summarized below.

**During construction phase:**

The negative effect of the dams development is the direct destruction of wildlife by cleaning of the terrain. Therefore, during development of individual dams, associated objects and infrastructure, it will be necessary to remove all vegetation on surfaces on which these objects will be situated.

Potential emission of pollutants during construction can have direct and indirect negative effects on organisms. Burning fossil fuels and usage of heavy machinery that uses large quantities of lubricants will have direct and indirect negative influences on biodiversity and especially plant communities found around the sites if they are used without caution and if the machines do not meet the pollution standards.

Noise levels on site during construction, as well as presence of humans and heavy machinery will increase significantly, limiting the use of the construction site by local fauna.

Hydro-technical works during construction will influence migration patterns and reproduction success of aquatic organisms in the construction site, with potential spread of influence on the zones proximate to the site. They will have diverse negative effect on the ecosystem of the river as well as habitats associated with it. Most prominent negative influences are changes in river profile, changes in water level and turbidity, emission of dust and vibrations, potential emission of liquid pollutants. These effects will have a negative influence on aquatic organisms, notably on migration and food base of fish, habitat requirements and availability for aquatic invertebrates, macrophyte and phyto and zooplankton.

Activities during construction will affect alluvial forests (forests of willow, alder and birch) within DRB. As construction activities affect flow regime and remove vegetation, the floristic structure will be changed in surrounding terrestrial ecosystems. This can lead to proliferation of invasive plant species that were recorded in the surrounding areas, considered very aggressive: *Amorpha fruticosa*, *Acer negundo*, *Aillanthus altissima*, Aster sp. *Reynoutria japonica* etc.

Destruction of plant communities will be followed by other negative effect such as reduction of food availability and of hides for fauna as well as erosion and reduction of nutrient value of the soil. Bigger and more mobile representatives of fauna will be able to evacuate the site and find more suitable feeding and breeding grounds, but this will come with an increased resource competition with the individuals already present on these sites. During construction, population of many of the species will decline on the site.

Due to all the stated negative influences, landscape characteristics will degrade and numbers of grand majority of species previously present in the area of the future reservoir will drop, some of which will disappear.

It should be noted that most of the “construction phase” adverse effects might be reduced or mitigated by application of adequate mitigation measures and best available technologies (see below following chapter).

**During operation phase:**

At the moment, there are eight medium to major reservoirs in DRB. Among them, there is only one fish ladder (at the Zvornik dam) with a temporary function.

Construction of reservoirs destroys habitats over the area they covers. In addition, the reservoirs divide the populations of many species. This division is at times incomplete, as the fish ladder can be constructed and integrated in the project, but even then, ecological division will remain, as the ecological conditions in free flowing rivers are completely different when compared to reservoirs (free aerated high-speed water stream to calm and slow stream). For the lower Drina, where the section of the river is characterized by calm water and rich population of Cyprinid fish, the impact of new dams is more mitigated than in the upper part of the DRB.

Construction of reservoirs on Drina River will drastically change the ecological characteristics of the basin, altering significantly ecological balance. Downstream from the reservoirs, rivers will flow as before, but with variable temperature, clarity and water level. Upstream of dams, it will change into an ecosystem similar to the small natural mountain lakes in the upper-stream and further downstream, as the turbidity and level of pollutants rise, the newly formed reservoirs will likely advance to typical mesotrophic lakes.

Therefore, most of the negative impacts can be summarized into following categories:

* Change of river ecosystems into lake ecosystems, whose influence is augmented through their role as a physical and ecological barrier.
* Loss of ecological balance: Fast change of temperature, turbidity and oxygen levels, downstream from reservoirs lead to ecological problem for the required conditions for the present fish population.
* Changes in microclimate that leads to change of groundwater levels: that could affect the plant communities, potentially at a larger scale.
* Loss of autochthonous plant communities and fauna, followed by invasion of alochtonous or previously absent species.

As already mentioned, the impacts of development scenarios can be mitigated with adapted measures as described in following sections. Even equipped with a fish ladder, the proposed new reservoirs will change the abundance and the population structure of certain species. This issue can be mitigated with complex fish restocking but the history of the dams already constructed on Drina River did not really demonstrate proper management of the fish populations, even though initial projects demanded it after construction. The risk that the same will happen with future projects is therefore high.

**Main objectives of protection and challenges**

The water management and developments of investments must integrate environmental managements with a set of specific protection measures:

- Aquatic ecosystem protection in particular fish ecosystem

The protection of aquatic ecosystem is perhaps the most important of the environmental parameters to consider. Indeed, construction of HPP could jeopardise the natural migration of fish species in the DRB if it is not limited and if it is not properly mitigated. The changes in water intakes and water abstractions management, in dam constructions and operation as well as in climate changes would modify hydraulic regimes (discharge, water level and stream velocity). This could deeply influence the functionality of the fish ecosystems in DRB, even though they would continue to exist in a near natural state in the sections of the river unaltered by reservoirs and hydro-peaking.

Based on the status described above, preservation of the functionality and resilience of the aquatic ecosystems is a key issue and to achieve it, the following objectives can be derived:

* Improvement of the existing water resource management (quantity of water).
* Avoiding reservoir construction and hydro-peaking in the areas known as spawning sites of Danube Salmon.
* Impose fish ladder for new dams where technically possible for every new reservoir.
* Establishment of the fish-stocking programme: Reservoirs represent ecological and physical barriers to the free movement of fish species, especially important during migration period, even with a functioning fish ladder.
* Establishment of a monitoring scheme of aquatic ecosystems, primarily the populations of the 4 targeted fish species: the Danube salmon (*Hucho hucho*), the Greyling (*Thymallus thymallus*), the Bullhead (*Cottus gobio*) and the Brown trout (*Salmo labrax*),
* Monitoring of the state of the remaining riparian vegetation.
* Impose and control of the environmental flow.
* Reduce in hydro-peaking during spawning period.
* Efficient regulation and management of gravel exploitation.
* Enforcement of the stricter fishing regulation during the period of drought.
* Reduce the pollution caused by the fish farming process

- Achievement and maintenance of the good status of surface and ground water bodies (quantity and quality)

See the above chapter 3.3.2.

- Guaranteed provision of a minimal environmental flow in all rivers and tributaries of the DRB

The provision of a minimal environmental flow (EF) is necessary to meet the aquatic ecosystem and the water quality objectives. In order to provide sustainable and sufficient minimal quantity of water, the targets for the provision of minimal quantity of water are:

* To impose a minimal EF for all surface and groundwater intakes structures (HPP, fish farms, industrial water intakes, groundwater extraction…) which is compatible with the sustainability of the ecosystem and other water uses.
* In high ecological regions (protected areas, spawning areas), definition of the EF value based on an environmental assessment study (see chapter 3.3.2).
* Harmonization of the minimal EF method of calculation between the riparian countries for transboundary Rivers (see chapter 3.3.2).

- Protection of wetland/alluvial riparian ecosystems

Unfortunately, there is very little data available about riparian ecosystems and no European classification of quality of the riparian ecosystems. Therefore, at this stage it is not possible to locate the riparian ecosystems of high, good and moderate quality. In order to secure the functioning and preservation of the alluvial and riparian habitats, the following targets should be met:

* A classification and monitoring scheme of the riparian and alluvial habitats in the DRB should be established
* Riparian vegetation along rivers should be protected and restored, especially along smaller tributaries in order to prevent soil erosion, filter pollution and prevent floods
* Concept of flood protection to be coordinated
* Mitigation of drought with water from HPP reservoirs
* Coordination of land use and in particular agriculture
* Protective forests should be managed in order to prevent clear cutting, especially near the streams or other water bodies.

- Extension of protected areas

In order to secure the functioning and preservation of the protected area network and the biodiversity it supports, the following targets should be met:

* Harmonisation of the national regulations and fostering of cooperation between the three countries in the DRB in order to successfully implement biodiversity protection programs,
* Reinforcement of the protection regime in protected areas in coherence with the requirements for nature protection and target species
* Strengthen regulation concerning riparian ecosystems in protected areas.

**Main recommendations to protect the biodiversity for the future developments**

As already mentioned, the environmental impacts due to the future developments can be significantly mitigated with adapted mitigation measures, as following:

Environmental recommendations during construction

* All sites of temporary storage of materials should be restored to their original state after the construction process has been terminated.
* As the biodiversity values of the sites proposed for construction are relatively unknown, a detailed field study of the biodiversity of the local sites should be conducted during minimum 1-year period to implement the environmental assessment study. If necessary, projects should be adapted based on the results, within the technical characteristics of the project.
* In case that the impact cannot be avoided, destroyed habitats or species should be, if technically possible, moved, relocated, recreated or ameliorated elsewhere to compensate for the loss caused by the project development. If it comes to species relocation or amelioration of the habitats outside of project zone, appropriate management should secure their long-term sustainability.
* During submission procedure to the enterprise, specificity of type of machines and antipollution measures should be imposed in the tender documents. As an example, only organic oil should be used for machines, sealed area for hydrocarbons, deposit area outside the river influence….
* Material managements should be optimized to use as possible the site materials and to minimize the transport of material (and therefore to minimize the air pollution).

Environmental recommendations for operation (including existing dams)

* For the existing dams, fish ladder has to be used whenever possible and flushing should be done in a low intensity increase and decrease of discharge to avoid erosion and fast changes in turbidity, water level and temperature.
* Fish ladder should be installed on all the proposed dams as a mean of connecting the populations on both sides of the reservoir. Even though fish ladder cannot overcome ecological barriers of a reservoir, it can help in preservation of migration routes and have a positive influence on spawning success.
* Based on the characteristics of the river flow and its fauna, a complex, site-specific fish stocking programs should be designed and applied to mitigate the negative effect of dams on the quantity and the structure of the fish population.
* An assessment environmental study should be realized to fix the environmental flow, indeed, the country regulation gives the methodology to calculate the minimal environmental flow based on hydrological data, but in any case, the minimal value should be improved to integrate the high environmental value of the downstream section of the impacted River.
* A controlled flushing program, for normal operation condition, should be established taking into account the sensitive period for the aquatic and riparian ecosystems to prevent rapid changes in turbidity, water and oxygen levels. This operation program should decrease stress and destruction on the organisms located downstream during flushing operation.
* A monitoring of the target species defined in the environmental assessment study should be done during the three first years of operation to control if the mitigation measures are sufficient for the impacted biodiversity and should concluded if some improvements of the dam and operation are needed.

## Monitoring

### Introduction

In the ToR are defined the following Consultant's tasks related to monitoring:

* To perform the identification of the existing monitoring networks,
* To present an overview of data availability and reliability of existing data and
* To propose improvement measures (network optimization and standardization).

These tasks were not modified in the Inception Report.

The Consultant has presented the corresponding analyses in IWRM and IPF Country-Reports in the following manner:

* In IWRM Country Reports are presented the list of existing (active) measurement stations (hydrological and meteorological) and general recommendations related to network improvement and
* In IPF Country Reports are presented specific recommendations, i.e. the list of stations proposed by the Consultant or stakeholders.

### Results presented in IWRM Country Reports

In Section 11.1. "Monitoring infrastructure" is presented the general information on monitoring, division of monitoring into types, classification of measurement stations, as well as the basic data on monitoring in the Drina River basin. In Section 11.2. "Organization of Monitoring" is given an overview of organizations in the Drina River Basin involved in monitoring, for the entire basin, as well as for individual countries. In Section 11.3. "Data Exchange" are presented the explanations related to data management and data exchange on various levels (global, regional and basin level). In Section 11.4. "Conclusions and Recommendations" are presented recommendations related to improvement of the measurement stations' network, improvement of the data management system and improvement of the data exchange practices.

Within the annexes are presented the data on existing hydrological and meteorological stations in the basin, as follows:

* For Serbia on 10 hydrological and 42 meteorological stations,
* For Montenegro on 12 hydrological and 45 meteorological stations,
* For Federation BiH (BiH) on 1 hydrological and 1 meteorological station and
* For Republic of Srpska (BiH) on 1 hydrological and 18 meteorological stations.

This overview was formulated upon information and data obtained from authorized institutions, primarily hydro-meteorological services, electric power companies and water management companies. It served as a good starting point for definition of proposals related to improvement of operation of existing and introduction of new hydrological and meteorological stations on the River Drina Basin territory.

### Results presented in IPF Country Reports

In IPF Country Reports were used data on the existing network of stations, the overview of which was presented in IWRM Country Reports; based on that were developed specific recommendations, i.e. the list of stations proposed by the Consultant.

The list of existing stations presented in IWRM Country Reports was updated and the total of 30 hydrological and 78 meteorological stations in the Drina River Basin were identified (in Serbia 10 HS and 44 MS, in Montenegro 12 HS and 18 MS and in BiH 8 HS and 16 MS).

In Section 4.4.1 "Current state of the network" is given an overview of the current monitoring network status. In Section 4.4.2 "Users' needs for system improvement" are identified individual users and their needs related to the improvement of the existing system. In Section 4.4.3 "Minimum set of measurement parameters" are given comments on the minimum set of parameters which should be measured on all existing and future stations. In Section 4.4.4 "Improvement of existing station network" are given specific recommendations regarding the improvement of the existing monitoring network. In Section 4.4.5 "Network expansion with new stations" are given proposed new hydrological and meteorological stations, based upon harmonized stakeholders' and Consultant's opinions. In Section 4.4.6 "Increase in number of subjects whose measurements are used" is presented the discussion about the prospects of inclusion into the monitoring network of certain subjects whose measurements have not been used so far, except for their own purposes. In Section 4.4.7 "Implementation of network improvement program" is given a comment regarding the possibilities of implementation of the monitoring network improvement program. In Section 4.4.8 "Conclusions" are presented conclusions and recommendations, some of which will also be given here.

### Proposed new monitoring stations

One of the most important results produced by the Consultant is the list of proposed new stations, developed in the following manner.

First was performed a detailed analysis of the existing monitoring network. In the next step was defined the methodology for network improvement and identification of new measurement stations, which can be used for assessment of stations' importance based upon several criteria that take into consideration various users' needs. This methodology was first tested using the existing stations and it was demonstrated that its results correspond to generally accepted perception regarding the importance of specific stations.

Following this was formulated a wider list of potential stations and they were ranked using the abovementioned methodology. During the formulation of this list were also taken into consideration the stations the introduction of which was proposed by stakeholders themselves (they are listed in various stakeholders' planning and other documents).

The best rated stations are presented in the IPF Country Reports as high-priority ones and for a certain number of meteorological stations are also listed alternative locations. The following numbers of new stations are proposed:

* On the territory of Serbia 6 hydrological and 6 meteorological stations,
* On the territory of Montenegro 19 hydrological and 13 meteorological stations and
* On the territory of BiH 14 hydrological and 15 meteorological stations.

### Conclusions

The existing network of hydrological and meteorological stations in the Drina River basin is not uniformly developed and the same lack of uniformity can be noticed related to data availability, not only historical, but current as well. The improvement of this network, by improvement of the existing stations, as well as by introduction of new ones, is necessary.

A certain part of the funds necessary for these purposes already exists in budgets of the most important monitoring subjects in the basin. The remaining funds could be provided within the framework of planned projects in the basin. In IPF Country Reports it is stated that it would be possible to use the funds envisaged within the GEF SCCF project for this purpose. Currently there is no available information on this project, but there is an information on the West Balkans Drina River Basin Management Project (WBDRBMP), which should be considered as well.

It is also suggested that certain stakeholders should procure the software which would allow for uniform data management and facilitate data exchange in the basin.

The improvement program presented in IPF Country Reports defines the priorities and directions for further development of monitoring in the Drina River Basin in a clear and unambiguous manner.

# Specific issues

## Coherence of development scenarios

A potential source of incosistency could be imagined in a gap between the strategic development plans of the countries and the scenarios resulting from the MCA analysis. As the stakeholders were all actively involved in the preparation of the scenarios for their own territory, such a risk is however quite limited. It is therefore assumed here that, for each country, the results of the analysis applied to its own scenarios are in line with its strategic plans.

Montenegro is fortunate to be able to develop their electricity production infrastructure largely independently from the other countries. Their retained scenario does not generate serious inconsistencies with other development plans in the same sector. Some precautions will however possibly have to be taken for coordinating with other countries (located downstream) during the operation phase, but they do not jeopardize the meaningfullness of the selected projects.

The development strategy of Serbia and Bosnia i Herzegovina presents on the other hand a strong discrepancy along the lower course of the Drina River. BiH do not plan to build any new hydropower plant on this stretch of river, whereas Serbia opted for the construction of four HPPs there (Rogačica, Tegare, Dubravića and Kozluk). Obviously the development intentions are not coordinated. At this stage, it is not critical, as it was not the aim of the DRB project to come to a perfectly balanced image over the entire Drina River Basin. At all stages of the project, the countries were treated separately and had to find their best development way for the hydroelectric sector.

At the next station on the way to conretizing the plans developed in the present project, discussions will have to be initiated between the two countries, in order to find practicable solutions for a harmonious regional development. The next two sections present the legal implications of such a situation and sketches ways to resolve the – for now only temporary and apparent – inconsistency.

## Transboundary issues

### Status, challenges and obstacles

For realization of transboundary projects involving the three countries in the Drina River Basin, i.e. Republic of Serbia, B&H (Republic of Srpska and Federation B&H) and Montenegro, there are several general factors. The most important could be considered their status in regard of international agreements and character of obligations of these countries derived from international agreements they are signatories to, then the possibilities and methods of their implementation, then the status and prospects of development of country-level regulation in the field of water resources management and other regulation related to environment, status of regulation in other fields of direct importance to water resources management (energy production, communal services, agriculture etc.), status of capacities of institutions authorized for application and enforcement of regulation etc.

The EU integration process, into which all three countries are included, i.e. the process of harmonization of country-level regulation with the EU acquis, is the key factor that impacts, among the others, also upon the current legal system status and tempo of their further transition. In Serbia, Montenegro and B&H (at the level of Republic of Srpska and Federation B&H) there is a relatively complete system of regulation in the field of water resources management and other fields of importance to water resources management. In the EU integration process, the final objective of which is the membership in the EU, three countries have attained different levels of activities and different levels of harmonization of their country-level regulation with the EU acquis. Montenegro has gone farthest in this process, while a certain lag on behalf of B&H is most often explained by circumstances related to the complex political system structure and government organization, i.e. peculiarities of internal affairs in this country.

All three countries are signatories to the most important international multilateral agreements in the field of water resources management. These agreements are: Helsinki Convention on Protection and Use of Transboundary Watercourses and International Lakes and Sofia Convention on Danube River Protection and Sustainable Use. All three countries participate in activities defined by the Framework Agreement on Sava River Basin. However, there are certain differences regarding the status in certain multilateral agreements in the field of water resources management. Montenegro is the only one of these three countries to be a signatory to the Convention on the Law of the Non-navigational Uses of International Watercourses, but it is not a signatory of the Protocol on Water and Health attached to the Helsinki Convention on Protection and Use of Transboundary Watercourses and International Lakes. Montenegro had defined its status regarding the Framework Agreement on Sava River Basin by conclusion of the Memorandum of Understanding. The cooperation among the countries in the region is defined by obligations derived from international agreements, while the elaboration of a certain part of activities in the field of water resources management was realized through the content of strategic and other documents adopted within the framework of institutions established by the corresponding international agreements to which these countries are signatories.

There is a high level of symmetry among the countries in the region in regard of other key international multilateral agreements related to environment, but there are also certain differences, that could, under certain circumstances, present a challenge in implementation of activities which include transboundary projects. Of general importance are international agreements that regulate the issues of direct importance to the status of water resources and water resources management in the basin, such as international agreements in the field of climate change, biodiversity protection, industry accidents, hazardous waste management and hazardous chemicals etc. B&H is the only one to ratify the Paris Climate Agreement. For realization of cooperation among the countries in the region, one should particularly consider the obligations derived from international agreements which regulate the application of environmental impact assessment in the transboundary context and strategic environmental impact assessment, as well as the provisions of the Aarhus Convention. All three countries are parties to the Espo Convention and Aarhus Convention, but B&H is not a signatory to the Protocol on Strategic Environmental Impact Assessment to the Espoo Convention. B&H and Montenegro are not parties to the Kiev PRTR protocol.

All three countries are members of the Energy Community of South East Europe, and the Energy Community Treaty defines, inter alia, the obligations related to harmonization of regulation with the EU acquis, including the environment, renewable energy sources, energy efficiency etc. Implementation of the Energy Community Treaty has indicated that there are certain difficulties and challenges.

One of the issues that also deserve attention is the fact that the three countries in the Drina River Basin do not have bilateral agreements which should regulate the issues related to water resources management. The process of conclusion of an agreement between B&H and Republic of Serbia has been initiated.

There are similarities and differences in regard of the method of resolution of the authority in regard of performance of tasks related to water resources management. It can be estimated that the capacities of authorized institutions, as well as the coordination among them, must be improved. Organization of tasks related to water resources management, or of importance to water resources management (for instance, in the part related to waste management) at the local level requires further improvement. Financing in the water resources management sector presents a particular challenge to system functioning in all three countries.

The subject of method of regulation of (potentially) open issues derived from (or which could be derived from) the conflict of methods of water use can be considered one of the general challenges to all three countries, with certain impact upon the modes of international cooperation among the countries in the basin. Implementation of the procedure of transboundary consultations regarding preparation and adoption of the projects that could have a transboundary impact, i.e. preparation and development of strategic documents requires, among others, the public participation. Difficulties in provision of public participation can have various causes, some of which having system-related nature and be related with the circumstances external to water resources management in the narrow sense of the word, while a part of them can also be related with the provision of conditions for consistent adherence to defined obligations of competent authorities. Without harmonization of strategic documents of importance to water resources management between countries in the region the realization of transboundary projects will not be possible.

The issue of compliance of strategic documents related to water resources management, spatial planning and construction, with strategic documents in other fields, requires a considerably more intensive coordination between authorized institutions and other stakeholders.

Organization of tasks related to prevention measures and reaction to emergencies related to water resources management requires a more intensive cooperation between authorized institutions.

A special challenge can be posed by the manner in which the use of Drina River hydropower potential will be arranged. Construction of new hydropower structures will require the regulation of relations among stakeholder countries. The method of exploitation of existing plants' potential should also be regulated by corresponding agreements.

### Solutions

In international law are developed the rules for management of transboundary watercourses and all three countries in the region are parties to the international agreements contained certain rules of importance to these issues. Several general principles are of particular importance. The principle of equitable and reasonable utilization and participation in use of international water resources is considered an universally accepted rule, which is also explicitly stipulate by provisions of relevant international agreements. Provided is the (inexhaustible) list of criteria upon which it can be defined what constitutes an “equitable and reasonable share”. Related to this is the principle of prohibition of causing damages by the activities performed on the territory of one country to property and persons on the territory of another country, as well as certain other principles. Beside that, to the use of transboundary water resources of the countries in the Drina River Basin can also be of importance the rules of international custom, as well as the legal practice of various international judicial and arbitration bodies.

Countries in the Drina River Basin must intensify the mutual cooperation. The obligation to cooperate has a wider foundation in international law and a more detailed elaboration in international water law, also including the international agreements to which the countries in the Drina River Basin are parties.

Countries located in Drina River Basin must harmonize their strategic plans and the methods of use of common water resources in a manner that acknowledges the interests of all countries in the region. All three countries are parties to international agreements that regulate the rules of application of environment impact assessment in the transboundary context and strategic environmental impact assessment.

Stakeholder countries must continue with their activities related to ratification (adoption) of international multilateral agreements to which they are not parties. It is necessary to intensify activities aimed at testing of the most suitable common forms and content necessary to initiate cooperation between the institutions, i.e. to conclude regional treaty on cooperation in the field of water resource management, or certain elements of importance to water resources management (in accordance with estimated level of relevance in relation to the fact that the countries in the basin are in the same time the parties to multilateral agreements, i.e. in accordance with their estimated individual and common interests).

In the view of the above mentioned it is necessary to initiate, i.e. intensify the activities aimed at conclusion of bilateral agreements on cooperation between the countries in the basin, there subject of regulation being the specific individual issued of interest to bilateral relations between the countries in the basin.

It is necessary to further intensify the process of harmonization of country-level regulation, preparation of corresponding sub-laws in accordance with the real conditions in economy and society, building of capacity of authorized institutions and provision of conditions for a more complete implementation of regulation. Also it is necessary a consistent adherence to international agreements in the field of environmental impact assessment in the transboundary context to which the countries in the region are the parties. B&H should ratify the Protocol on Strategic Environmental Impact Assessment to the Espoo Convention and two amendments to the Espo Conventions (Sofia and Cavtat). B&H and Serbia should consider the possibilities related to ratification (acceptance, accession) of the New York Convention on the Law on Non-navigational Use of International Watercourses.

In the part related to energy production, depending on the position regarding the method of regulation of international relations, it would be necessary to contractually regulate the subject of harmonization of activities directed at the construction of new and use of the existing hydropower structures. In that sense, of certain importance can be the other countries' experience in practice of resolution of the issues related to common exploitation of hydropower potential of certain watercourses, also including the subject of sharing of produced energy and other benefits coming from the common use of transboundary water resources.

## Information to stakeholders

Reactions to meetings, proposal for communication streamlining – 2 pages – TO BE ADDED AFTER PUBLIC MEETINGS

# Conclusions and recommendations

## Conclusions

This report represents a snapshot of the complex and integrated use, development and management of water resources, in order to meet the water needs of multiple users and harmonization of their needs in the future. This report together with the earlier IWRM and IPF country reports, can enable further improvement of the water resources management of the DRB in the three riparian countries for the foreseeable future.

The objectives of the development scenarios mentioned in this report are to protect, restore and enhance surface water bodies and groundwater in order to at least achieve their “good” status, thus upholding the principles of the WFD, and to thereby provide sufficient water for unhindered and sustainable development of society in general in a sustainable environment.

It is important to emphasise the need for construction of reservoirs in the basin and their incorporation into the planning. In order to implement the proposed solution in the future, it is necessary to reserve and allocate space on the current cadastral and spatial plans; this should also include potential reservoir sites that are not yet a priority in the basin. These areas should have some form of protected status akin to that of natural resources so that their development is assured against future pressures on space from other needs for construction and other anthropogenic activities.

Besides, there is a critical need to build wastewater treatment plants (WWTP) and to improve the solid wastes management to give Drina River a chance to improve its water quality status. Considering the substantial financial investments for achieving this, it needs to be undertaken in stages.

Regarding the construction of new HPPs in the DRB, the Section 2.3 lists the projects included in the most favourable development scenario, along with additional explanations, necessary for the proper understanding of the results obtained by MCA.

In the conclusions, the Consultant would also like to comment upon these results from a different point of view, which transcends the former Country Reports. It is important to note that four of all HPPs included in the selected development scenarios (“Dubravica” HPP, “Tegare” HPP, “Rogačica” HPP and “Kozluk” HPP) represent a hydropower potential that has to be shared between Republic of Serbia and Republic of Srpska (BiH). None of these HPPs is however included in the most favourable development scenario for BiH.

The Consultant believes that the most reasonable solution for construction of these HPPs would be the joint effort of Investors from both countries, as an “asymmetric” construction could lead to a number of problems. Present development scenarios, unfortunately, do not provide such a possibility.

The improvement to the monitoring network in the DRB requires a number of measures, including improvements to the existing stations, establishment of new ones (with an emphasis on locations that already hosted measurement stations in the past) and improvements to data exchange in the DRB. Considerable financial means are already available from the budgets of a number of institutions involved in measurements in the DRB, some means will be provided within the GEF SCCF projects, but the countries in the basin should make an additional effort and provide additional funds for completion of this activity.

## Recommendations

As it was already mentioned in the Section 2.3, the selected development scenarios include the HPPs construction of which can be considered reasonably feasible. However, there remains the problem of the hydropower potential that has to be shared between the Republic of Serbia and Republic of Srpska (BiH). It is therefore recommended that all involved parties should harmonize their interests regarding the construction of the HPPs that produce electricity based upon the shared potential.

It should also be noted that the technical documentation developed for certain HPPs is not at the level necessary for final decision making. For the HPPs along the Middle Drina, only Conceptual Design Reports have been developed, so the development of Preliminary Design Reports are highly recommended.

There have been many recommendations provided on the DRB through the preparation of the three IWRM and IPF country reports. The present roof report focuses on the main recommendations associated with the Basin development scenarios. A full listing of all the prioritised recommendations from the Project will be provided in the final version of the report. Based upon the above conclusions, the preliminary recommendations are the following:

In terms of flood attenuation, the Consultant recommends:

* That water management operations within the DRB should seriously consider weather forecasting techniques in their future planning
* That HPPs operations and flushing should be coordinated between the riparian countries to mitigate sediment negative impacts and flood peaks.

In terms of climate change adaptation measures, the Consultant recommends to:

* Undertake revision and improvement of the monitoring system across the basin to enable better detection of the impact of climate change
* Undertake a detailed vulnerability survey in relation to climate change across the Basin to obtain details of the vulnerable areas to climate changes
* Raise public awareness within the Basin’s stakeholders regarding potential impacts associated with climate change and undertake education and training programs in adaptation measures especially regarding water use and water saving measures.

Based upon the outcome of the MCA, the Consultant recommends prioritising investigations into the feasibility of undertaking selected development scenarios. This will require at least the following:

* Improvement of the legislation enforcement
* Undertaking a full public consultation process advocating the preferred schemes
* Undertaking a detailed feasibility, EIA and SIA of individual schemes advocated as part of selected scenario
* Selecting and imposing a set of environmental and social mitigation measures of each individual scheme to reduce at minimum the impacts during construction and operation phases.
* For the selected scenario, devise a year-by-year identification of the projects to be completed and clear demonstration of the differences between the recommended scenario and the baseline plans.

In terms of hydropower development, the Consultant recommends:

* To undertake a baseline capacity expansion plan to define the opportunities for displacement by new hydro investments.
* To prioritise investigations into the feasibility of undertaking selected development scenario.
* Further studies need to focus centrally on investment and financing decisions for the specific set of projects that has been identified for implementation. Economic and financial feasibility studies sufficient to solicit international financing should be the next stage of project preparation.
* It is important to familiarize Government and stakeholders with estimates of what might be gained from carbon finance and with the necessary studies to secure such financing.

In terms of future monitoring within the Basin, the Consultant recommends:

* The general objective of network development could be data exchange with hourly time step.

In terms of water management concerns, the Consultant recommends:

* There is a need to accelerate the implementation of existing sub-laws and standards and harmonize the existing secondary legislation, including guidelines and standards.
* Stakeholders need to maintain the effort to improve the solid wastes management with adequate sanitary landfills construction and increasing the part of recycling wastes
* Stakeholders need to make concerted efforts to carry on the construction of WWTPs in the DRB.

In terms of transboundary cooperation, the Consultant recommends:

* Transboundary cooperation among the riparian countries will be needed for the purpose of maintaining and further developing the water resources management (WRM) model for DRB, developed within this project using the WEAP software. Upon the project finalisation, the countries will have to exchange data and information needed for model application to enable its sensible use. Harmonisation of the model structure and input data is a necessity for BiH and Serbia. Although Montenegro could maintain the model independently from the other two countries, its contribution to the downstream model users is of the utmost significance. Separate model application and development by the riparian countries would not support an integrated approach to water management in the basin. It is therefore highly recommended that the countries develop a protocol for exchange of data and information related to WRM model of DRB. Cooperation on the exchange can take various forms. The simplest form would be that the model files are exchanged annually, and that rotation of countries in charge of harmonising the input data occurs every three years. Occasional meetings on the technical level, with participation of stakeholders’ staff actually maintaining the model, would also be beneficial.

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1. Detailed description of the Drina water management model, developed using the WEAP software, and the simulation results are the subject of the separate report. [↑](#footnote-ref-1)
2. <http://www.savacommission.org/dms/docs/dokumenti/documents_publications/publications/other_publications/transboundary_eco_tourism_guidelines.pdf> [↑](#footnote-ref-2)
3. In 1989/90 some measurement of suspended sediment concentration and bedload size was undertaken upstream of isegrad to define reference conditions. [↑](#footnote-ref-3)
4. Tošić R, Dragićević S, Kostadinov S, Dragović N 2011: Assessment of soil erosion potential by the USLE method: case study: Republic of Srpska – BiH. Fresenius Environ. Bull., 20(8), 1910–1917 [↑](#footnote-ref-4)
5. The tested values in the WEAP model have been updated on the basis of the stakeholders' comments through the development of the IWRM and IPF reports and based on the requests during the WEAP workshops. [↑](#footnote-ref-5)