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Phase II

Nexus Assessment for the Drin River Basin

NEXUS

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	MEANING
CORINE	Coordination of Information on the Environment (EU programme on land cover)
DCG	Drin Core Group
EEA	European Environment Agency
FAO	Food and Agricultural Organizsation
GWP	Global Water Partnership
IEA	International Energy Agency
LULUCF	Land Use, Land Use Change and Forestry
MAFWM	Ministry of Agriculture Forestry and Water Management
MARD	Ministry of Agriculture and Rural Development
MED	Ministry of Economic Development
MTE	Ministry of Tourism and Environment
MTI	Ministry of Trade and Industry
RES	Renewable Energy Sources
SAP	Strategic Action Programme
SDG	Sustainable Development Goal
TBNA	Transboundary Basin Nexus Assessment
TDA	Transboundary Diagnostic Analysis
UNECE	United Nations Economic Commission for Europe

1 INTRODUCTION

1.1 BACKGROUND AND SCOPE OF THE ASSESSMENT

This report has been developed within the framework of the Project "Promoting the Sustainable Management of Natural Resources in Southeastern Europe, through the use of Nexus approach" (SEE Nexus Project), funded by the Austrian Development Agency (ADA) and implemented by the Global Water Partnership Mediterranean (GWP-Med) in partnership with the United Nations Economic Commission for Europe (UNECE).

The Project's overall aim is to introduce the "water, energy, food and ecosystems Nexus" approach and tmio catalyse action for its adoption and implementation in the region of South-East Europe (SEE). The Nexus approach looks into the interlinkages and trade-offs among the sectors of water, land, energy and environment aiming to identify solutions that will foster not only water and environment security, but also energy and food security.

Under Component 2 of the Project, Nexus Dialogue Processes were implemented in three focus areas: the transboundary basins of the Drin and Drina rivers, and in Albania. Each of these Dialogue Processes was structured around a participatory consultation process involving a broad range of stakeholders, and the development of analytical Nexus Assessments, as per the methodology developed within the framework of the UNECE Water Convention. Additional activities under the Project in each of the focus areas include:

stakeholders and staff of institutions;

- workshops on the gender dimensions of sustainable development and the Nexus sectors in particular;
- the preparation of 6 Project Documents in total, for selected Nexus interventions, also exploring financing options; and
- the development of policy recommendations in the form of "Nexus Roadmaps", capturing the findings of the Dialogue Processes and the Assessments.

For the Project's activities on the Drin Basin, the set of stakeholders' processes used was that under the GEF-funded UNDP/GWP-Med "Drin Project", within the framework of the Drin Coordinated Action (Drin CORDA) process for the implementation of the MoU for the sustainable management of the Drin Basin. Activities in the Basin were steered by the Drin Core Group (DCG), the body mandated to coordinate actions for the implementation of the MoU for the Management of the Drin Basin. It comprises duly nominated representatives of the competent Ministries on Water and/or Environment of the Drin Riparians.

This report focuses on two areas where stronger cross-sectoral cooperation at the level of policy could improve water management in the Basin ("Hydropower and Floods" and "Biomass and Forestry") and enhance transboundary cooperation. Crucially, the Drin Riparians are strongly committed to transboundary cooperation and, through the Nexus Assessment process, have built capacity to address intersectoral issues in these areas.

Much of the information used for the analysis was collected through the GEF-funded Project "Enabling Transboundary Cooperation and Integrated Water Resources Management in the Extended Drin River Basin" (Drin GEF Project), which also provided the institutional platform for the stakeholder consultations. Among the different outputs, this Project, implemented by UNDP and managed by GWP-Med in cooperation with the UNECE, produced a Transboundary Diagnostic Analysis (TDA) and a Strategic Action Programme (SAP) for the Basin.

While the TDA for the Drin Basin aims to identify and assess transboundary basin management issues (including those related to the management of the environment, water, and other natural resources), assess the environmental impacts and socio-economic consequences, and identify the immediate and underlying causes of these issues, the SAP lays out objectives and actions to address the causes and drivers of these issues. The SAP, a key instrument to coordinate action in the Drin Basin, was endorsed in April 2020, and the Riparians committed to establishing a joint body for the Basin.

The overall Nexus Assessment process of the Drin River Basin – carried out using the Transboundary Basin Nexus Assessment Methodology that was developed under the Water Convention[1] – was supported both by the SEE Project and the Drin GEF Project. The Nexus Thematic Report[2] includes the identification and qualitative assessment of key inter sectoral Nexus-related issues in the Basin, while the Nexus Assessment Report builds on it and provides a more in-depth analysis of Nexus dynamics.

The Nexus analysis informed the TDA-SAP process. In fact, the Nexus analysis and recommendations provide beneficial guidance for the implementation of the SAP by analysing the interlinkages between

1 http://www.unece.org/index.php?id=498493.
2 Available at: https://www.gwp.org/globalassets/global/gwp-med-files/list-of-programmes/see-nexus/drin-phase-i-nexus-assessment/report-nexus-phase-i-assessment.pdf.

sectoral developments and the Basin's resources and their evolution in the future, thereby increasing awareness of intersectoral dynamics that are (or can be) triggered by strategic decisions taken "out of the Basin area", notably in the field of energy and agriculture, and improving the capacity of policymakers to account for them in the management of the Drin Basin.

As the SAP includes actions that should be implemented across the water, energy, agriculture and forestry and environment sectors, this Nexus Assessment Report aims to provide Riparians with information that is useful for their implementation, especially when the following two areas are explicitly mentioned:

- Hydropower production, renewable energy, and the energy sector in general, e.g.:

  2/1/1.5/Action 2 *Development of a basin-level climate-related vulnerability assessment for key sectors (energy, agriculture, forestry, industry, urban areas, etc.);*

  2/2/2.3/Action 1 *Establishment of a dialogue between the hydropower companies, other relevant authorities and the DCG/Drin Commission with regard to operation procedures of the dams to improve flow regulation and minimise negative effects; and*

  7/1/Action 2 *Evaluation of scenarios for the operation of dams to support sustainable basin management, contribute in the reduction of flood risks and maximise energy production).*

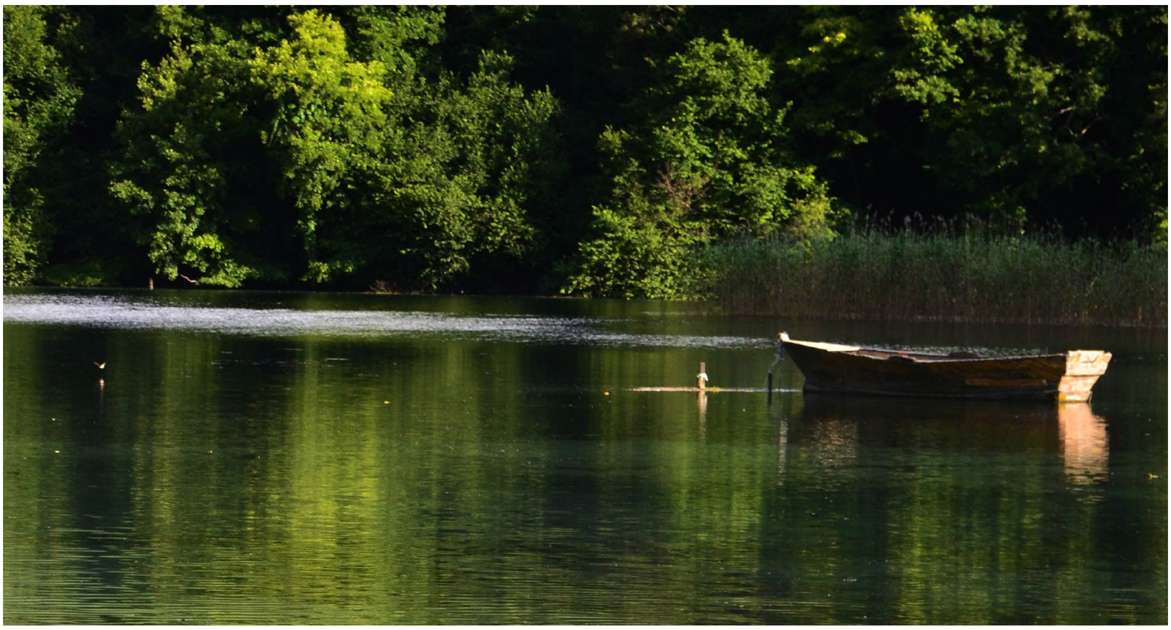
- *Forestry, biomass, erosion, and land use in general:*

  2/1/1.6/Action 3 Identification of market-based solutions and measures to reduce illegal forest exploitation

  2 /2/2.6 Implementation of a Nexus multi-sectoral dialogue supported through the establishment of a related dialogue platform functioning as advisory body for the DCG, involving energy, water, agroforestry and environment sectors; and

  2/3/Action 13 Implementation of erosion control measures (e.g. reforestation, nature-based solutions, sustainable tillage and irrigation systems) in priority areas.

The overall SEE Project, with the findings and recommendations from its Assessments, is intended to support the economies of the SEE in ensuring cross-sectoral policy coherence (at the national and Basin levels) also in the relation to those regional strategies that are expected to catalyse new investments in the water, energy, food, and environment sectors: notably the Green Agenda for the Western Balkans and the Strategy for South-East Europe 2030. The development and implementation of these strategies is supported by the Regional Cooperation Council (RCC), which includes a Regional Working Group on Environment (RWG-Env). To this end, the RWG-Env served as the Steering Committee of the overall Project, while the Drin Core Group (DCG) -– whose primary role involves the coordination of actions in the Drin Basin for the implementation of the Drin MoU – served as the Basin-level Steering Mechanism of the Nexus activities that focused on Drin.



1.2 THE DRIN RIVER BASIN

The "extended" Drin River Basin[3] is located in the region of the Western Balkans and is shared by Albania, North Macedonia[4], Kosovo*[5], and – for a small area – Greece[6]. The Basin is named after the Drin River formed at Kukës in Albania by the confluence of the Black Drin (flowing northwards from its origins in North Macedonia) and the White Drin (flowing south-west from its origins in Kosovo*). From Kukës, the Drin runs west towards the Adriatic Sea, and before reaching the sea, it splits in two: the smallest branch discharges directly into the sea (at Lezhë in Albania) whereas the main flow is diverted northwards, joins the Buna/Bojana River that is the outflow of the Skadar/Shkodër Lake (which is fed, in turn, by the Morača River of Montenegro), and soon after discharges into the sea as well. The Buna/Bojana delta is located about 20 km north of the Drin outflow.

The Basin has three major international lakes. Apart from the Skadar/Shkodër Lake (shared by Albania and Montenegro) located in the lower part of the Basin, the other two are located in the upper Basin and are shared by North Macedonia and Albania: Lake Prespa (more precisely this is divided into two lakes, Prespa and Small Prespa, linked by a channel) and Lake Ohrid. It is in the Prespa-Ohrid region that the Black Drin originates.

The area of the Basin is largely mountainous. Overall, the Basin has a mean elevation of 971 m above sea level. Mountain peaks reach over 2,500 m in the north of Albania and in Kosovo*, and 2,000 m around Lake Ohrid (in North Macedonia). The Skadar/Shkodër Lake Basin is a natural depression, and the Buna/Bojana delta region is also flat (with mean altitudes of 770 and 909 m respectively)[7].

Lake Ohrid is the deepest lake in South-East Europe and the biggest in terms of water volume (55,500 million m^3), while the Skadar/Shkodër is the largest when it comes to surface area (varying between 353 km^2 in dry periods and 500 km^2 in wet periods) and it is relatively shallow.[8] The Black Drin sub-basin drains a large part of the (eastern) mountainous region of Albania, while the White Drin drains the transboundary region between Kosovo* and Albania.

Due to the karstic nature of the region, the system of rivers, tributaries, and lakes is connected underground. In particular, the White Drin is hydraulically connected with the karstic aquifers of Beli Drin/Drin Bardhe.[9] Underground karstic cavities connect Lake Prespa to Lake Ohrid (with water flowing from the former to the latter).[10]

The Basin contains seven sub-basins, the biggest four being the White Drin, Black Drin, Drin, and Skadar/Shkodër (almost equivalent in size: 4,200 to 4,6700 km^2) and the smallest three Lake Ohrid, Lake Prespa, and Buna/Bojana (between 450 and 1,000 km^2). Each of them is shared between two countries, with the Black Drin – shared by Albania, Kosovo*, and North Macedonia – being the only exception.

The biggest part of the Drin Basin area is found in Albania (38%) and the smallest in Greece (2%), while Kosovo*, Montenegro, and North Macedonia share the remaining 60% in similar shares. Kosovo* and Montenegro are, however, the Riparians with the highest share of their area within the Basin. The majority of the Basin population – over 1 million in total – is from Albania and in Kosovo*. The size of settlements in the Basin is generally very small (about 90% of all settlements in Kosovo*, North Macedonia and Montenegro amount to less than 2,000 people). The three countries are experiencing migration from rural areas and small settlements to urban areas, and abroad.

Due to the structural changes that their economy has been undergoing since the breakup of Yugoslavia in the '90s (from centrally planned to market-based), the Riparians as well as the other countries in South-East Europe can be referred to as "transition economies". Such transition has been influencing not only the economic sphere but also institutions and society, with important implications in the governance of natural resources.

Today, the broad services sector is the largest contributor to the economy of all Riparians, followed by industry and agriculture, which contributes to 10 to 20% of the Gross Value Added.[11]

3 For a detailed description of the extended Drin River Basin (i.e. comprising the system of all water and groundwater bodies) refer to the Thematic Report on hydrology and hydrogeology for the Drin River Basin (2018). In writing this report, the word "extended" has been frequently omitted.

4 The name of the country was Former Yugoslavian Republic Of Macedonia (FYROM) until January 2019 when the Parliament approved the name change.

5 This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

6 The analysis of the Nexus focuses on the four main Riparians (without Greece).

7 GWP-Med, 'Situation Analysis. Management of the "extended" Drin Basin' (2014).

8 Ibid.
9 UNECE, 'Second assessment of transboundary rivers, lakes, and groundwaters' (2011).
10 GWP-Med, 'Situation Analysis. Management of the "ex- tended" Drin Basin' (2014).
11 GWP-Med, 'Thematic Report on Socio-Economics of the Extended Drin River Basin' (2017).

1.3 TRANSBOUNDARY COOPERATION IN THE DRIN RIVER BASIN

The choice of the Drin as one of the focus areas of the Nexus Project was motivated by the fact that the Riparians are committed to strengthening cooperation on the management of their shared environment.

Action for sustainable development in the Drin River Basin was largely uncoordinated until the development of the Shared Vision for the Sustainable Management of the Drin Basin and the signing of a related Memorandum of Understanding (MoU, Tirana, 25 November 2011) by Ministers from the Water and Environment Ministries of the Drin Riparians.[12] The main objective of the Drin MoU is achieving the Shared Vision: "Promote joint action for the coordinated integrated management of the shared water resources in the Drin Basin, as a means to safeguard and restore, to the extent possible, the ecosystems and the services they provide, and to promote sustainable development across the Drin Basin." The Drin Coordinated Action for the implementation of the Drin MoU (Drin CORDA) was put in place after the MoU was signed.

The management issues affecting sustainable development, as identified by the Drin Riparians through the Drin MoU, are listed below (Article 3 of the Drin MoU):

- improving access to comprehensive data and sufficient information in order to fully understand the current state of the environment, the water resources and the hydrological system (including surface, underground and coastal waters), as well as the ecosystems of the Drin Basin;
- establishing conditions for the sustainable use of water and other natural resources;
- developing cooperation and measures to minimise flooding, especially in the lower parts of the Drin Basin;
- improving management and appropriate solid waste disposal;
- reducing nutrient pollution deriving from untreated or poorly treated wastewater discharges and unsustainable agricultural practices;
- reducing pollution due to hazardous substances, such as heavy metals and pesticides; and
- minimising the effects of hydromorphological interventions that alter the nature of the hydrological system and of the ecosystems it sustains, leading ultimately to their deterioration.

12 This was the outcome of the Drin Dialogue coordinated by the Drin Riparians, with the support of GWP-Med and the UNECE.

1.4 THE TDA NEXUS THEMATIC REPORT: KEY AREAS OF CROSS-SECTORAL COOPERATION

The Nexus Thematic Report of the Drin, part of the Drin TDA, can be considered the informational basis of this Assessment report as it provides a broad overview of the socio-economic situation and of natural resource management from the different perspectives of water, energy, agriculture, and environment (both in terms of physical characterisation of resource availability and use by key economic activities, and governance of resources at various levels, from regional and transboundary to local).

On that basis, the Nexus Thematic Report to the TDA points at the existence of important interlinkages across sectors. These are trade-offs, impacts, and possible synergies that should be brought to the attention of policymakers to increase awareness of intersectoral dynamics that are (or can be) triggered by strategic decisions taken "outside of the Basin area", notably in the field of energy and agriculture.

The report focuses on three topics that are deemed of high priority for the Drin River Basin, based on a review of the literature on natural resource management and related policy documents related to the Basin, and later confirmed by the Drin Stakeholder Conference and by the Drin Core Group: (i) Hydropower and flooding; (ii) Biomass and forest management; and (iii) Agriculture and irrigation.

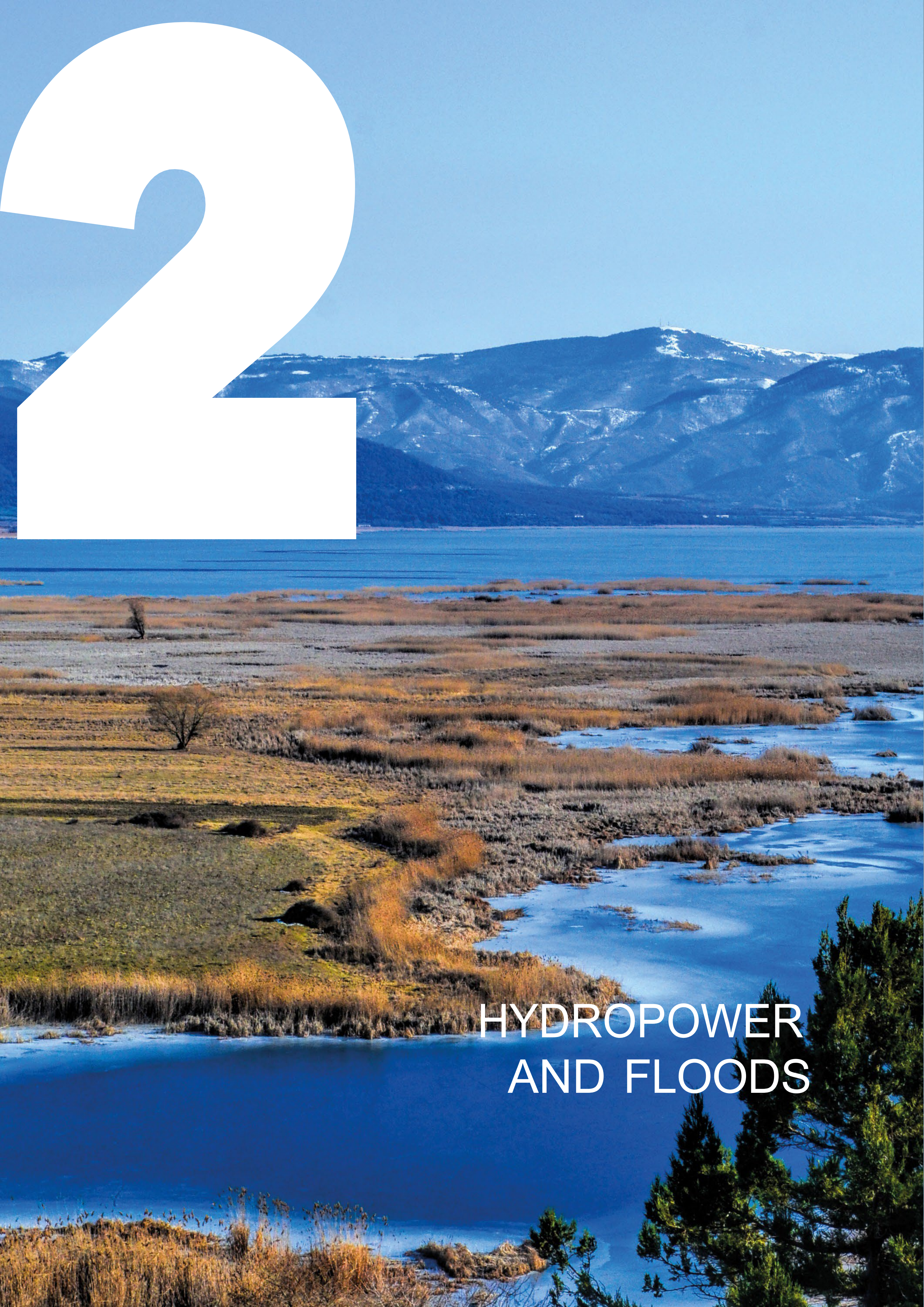
The following paragraphs report the key conclusions from the Nexus Thematic report.

The role of hydropower operators in flood management in the extended Drin is crucial because some areas of the Basin are extremely vulnerable to floods and the storage capacity of hydropower dams is significant. Chapter 6 of the Nexus Thematic Report discusses the critical role of hydropower operators in the management and prevention of floods, and the importance of their coordination between them (i.e. within and across countries) as well as between them and the concerned governmental actors. Even without new developments, hydropower operations could be better coordinated at Basin level, with clear benefits for the countries in terms of flood management and in line with a logic of regional development of the energy sector. By improving data and information exchange, increased cooperation would also enhance operators' capacity to adjust to changing hydrological conditions. Therefore, the chapter presents the results of a preliminary analysis of the costs and benefits associated with a flood-smart operation of dams on the Albanian side and, on this basis, sets forth the objectives and main features of the Basin-level modelling exercise that was undertaken in 2019-2020 and forms the basis of Chapter 2 of this report. Revised climate and extreme weather scenarios indicate that resilience related to hydropower and floods needs to be increased, meriting the governance arrangements to be revisited to evaluate their adequacy and possible adjustment. Notably, from a Nexus perspective, the chapter also highlights the fact that the damage from floods is deeply linked to the value associated with the environmental assets. Flooding can disrupt the incomes of farmers but also of those who rely on forest-related livelihoods.

Forests and biomass illustrate the aspects related to the Drin Basin's environmental assets in detail (Chapter 7 of the Nexus Thematic Report). In fact, with a substantial part of the land area covered by forests, and the multitude of forest-related uses, activities, and ecosystem services that often sustain the rural economy, these are a key asset for the Basin's population. Notably, the reliance on biomass for heating is a characteristic of all Riparians. However, while biomass is by definition a renewable resource, the current reality in the Basin is unsustainable biomass use, and forest degradation is widespread. But the impact of biomass use for heating goes well beyond forest degradation, and one of its most painful (and costly) consequences is very high levels of air pollution in households (indoors) and in settlements (outdoors). The inefficient use of biomass for energy has proven to be an intractable problem from a governance perspective. The effectiveness of policy responses in this area is limited by poor regulation, lax enforcement and social resistance against controlling access to forests. To step up efficiency and provide viable alternatives to uncontrolled biomass exploitation, the relevant institutions (in forestry, energy, natural resource management and land planning) need to be strengthened and should work together to deliver a more impactful response to the problem. In fact, among the many services that forests provide, they prevent soil erosion and play an important role as a buffer zone during flooding episodes, which can be considered crucial in the Drin Basin. This is a topic that is not fully understood and mapped at Basin level and that should be further investigated.

Agricultural development (Chapter 8 of the Nexus Thematic Report) is crucial as agriculture is a key livelihood for the Basin's largely rural population. Structurally speaking, the agricultural sector is quite similar in the Riparians, and despite the presence of common strategic objectives of sustainability, rural development, and recovery of regional trade of agricultural products, its development remains slow. When it comes to future vulnerability of irrigation to water shortages, there is an evident mismatch between the perception of farmers that water is abundant, and the situation of drought vulnerability as understood by academia and international organisations. Uncontrolled conversion of agricultural lands has been driven by remittances from citizens working abroad, and poor development planning has been unable to address the problem. From a Drin Basin perspective, it can be noted that poorly planned changes in agricultural production may result in increased rivalries and trade-offs between economic development, environmental impact, and transboundary cooperation. Vice versa, regional cooperation frameworks could be a platform for the promotion of local products, traditional agriculture, higher value-added production, and sustainable agro-tourism as well as for exchange of experience. Improved food safety, food standards and plant health are essential prerequisites to improve the export to outside markets and to stimulate the creation of a regional agricultural market. In this light, regional investments in phytosanitary laboratories and facilities could be convenient. This could simultaneously drive the much-needed aggregation of small agricultural producers into more coordinated and more sustainable agricultural value chains, while abating the key barriers to exporting to international food markets.

Later consultations with stakeholders indicated that only the first two topics needed further elaboration and quantification (the first one being already accurately addressed in the TDA). It is for this reason that the present document focuses exclusively on these two.



2

HYDROPOWER AND FLOODS

2.1 THE CONTEXT OF THE ENERGY SYSTEM

As summarised in the Nexus Thematic Report, the Drin Basin presents high risk for floods. The inundations of the Shkodra district in Albania in January and December 2010, and the flash floods in the coastal areas of Ohrid in January-February 2015 are the most severe events registered of late. The frequency and intensity of the floods is also increasing over time, likely due to both climatic changes and flow regulation practices. [13]The Basin is naturally prone to flooding, and the construction of infrastructure along the main stem of the Drin River (hydro-morphological changes) and flow regulation practices (operation of reservoirs) aggravate the risk.

The floods in the lowlands (Buna/Bojana) cannot be determined exclusively by the flow of the Drin, as they depend also on the outflow of Lake Shkodër into the Buna/Bojana, which is often very significant, and on two smaller rivers discharging without flood control into the lowlands. In fact, the Drin River shows marked variations in its flow throughout the year and between the years, with water levels that can be exceptionally high in the months of highest rainfall, from December to February. If the water level in Drin is high and that in Buna/Bojana is low, Drin water might flow into Lake Shkodër and significantly increase its level. Among other factors, the intensity of this phenomenon depends on the quantity of water released by the Vau-i-Dejës dam, which in turn depends on supply-demand dynamics in the electricity sector.

As previously mentioned, the 2011 MoU for the sustainable management of the Drin Basin has a specific objective to "promote joint action for the coordinated integrated management of the shared water resources in the Drin Basin"[14], and the signing of the SAP in 2020 indicated the commitment to establish a joint body for the Drin. This indicates how the Drin Riparians are working towards increased cooperation. However, as also discussed in this chapter, the challenges and opportunities related to such cooperation will depend, among other factors, on how hydropower infrastructure is operated and developed – which depends, in turn, on the hydrology of the Basin on the one hand and on the structure of the energy system of the Riparians on the other.

It is important to consider the role of the Drin hydropower cascade in the overall power system of the Riparians. The total installed electricity generation capacity in the four Riparians' basin is about 6,461 MW. This multi-country power system is currently dominated by hydropower, which

13 Global Water Partnership Mediterranean GWP-Med, 'Transboundary Diagnostic Analysis Thematic Report on the Resource Nexus (Phase I of the Water-Food-Energy-Ecosystems Nexus Assessment of the Drin Basin)' (Athens, 2020), https://unece.org/DAM/env/water/nexus/Drin_TDA_-_Nexus_Thematic_Report_Final.pdf.

14 Peter Whalley and Dimitris Faloutsos, 'Drin Basin - Transboundary Diagnostic Analysis (TDA)' (Greece: Global Water Partnership Mediterranean (GWP-Med), 2020), https://www.gwp.org/globalassets/global/gwp-med-files/list-of-programmes/gef-drin-project/drin-docs/tda_final.pdf.

accounts for over 50% of the installed capacity. Then comes thermal power with 43%, while wind (the only noticeable non-hydro renewable energy) constitutes just 3% of the capacity, as shown in **Figures 1 and 2**. In this picture, the Drin Basin cascade contributes 2,015 MW of hydro capacity, which is about half of the total hydropower capacity installed (and one third of the total capacity installed). This outlines the importance of the Drin River Basin for the Riparians, in terms of energy production and security.

Gaining a better understanding of the role of the Drin Basin for each Riparian requires taking a closer look at the power sector in Albania and North Macedonia – the countries that host the large hydropower infrastructure of the Basin.

The power infrastructure in Albania is largely

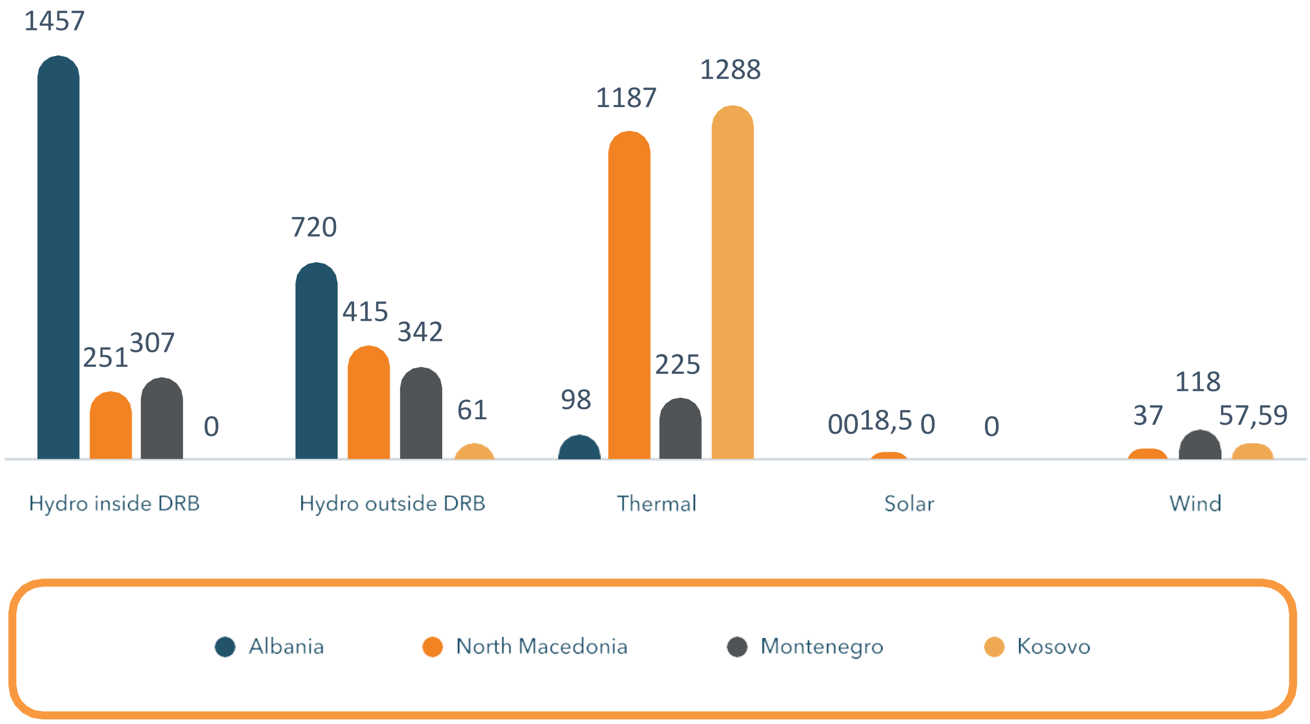


Figure 1. Total installed capacity in the Drin Basin countries by technology.

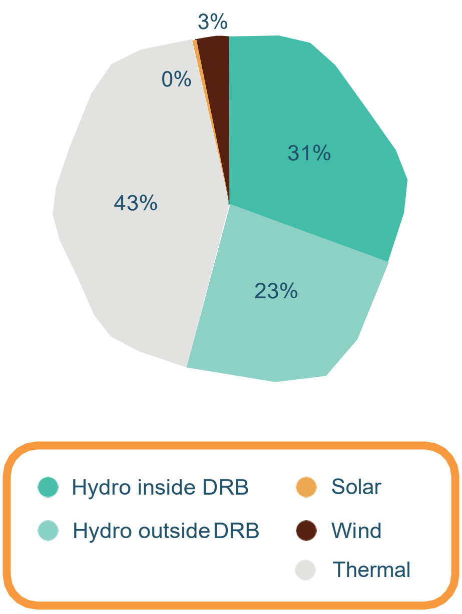


Figure 2. Total installed capacity by share (%) of different electricity generation technologies in the Drin countries.

managed by the State-owned company Albanian Power Corporation (KESH). KESH is the biggest electricity producer in Albania, with a total installed capacity of 1,448 MW (64%).[15] The total installed capacity in Albania in 2019 was about 2,275 MW. This includes 1,350 MW of hydropower and 98 MW of thermal power, as shown in Table 1. The remaining 827 MW (36%) comes from other (private/concession) production companies, and it consists mainly of small and medium hydropower plants – of which about 107 MW lies within the boundaries of the Drin Basin.[16]

Table 1. Total installed electricity generation capacity in Albania.

Power plant	Installed capacity (MW)	Share of total capacity (%)
Fierza HPP	500	22%
Koman HPP	600	26%
Vau-i-Dejës HPP	250	11%
KESH-Hydro	1,350	59%
Vlore TPP	98	4%
KESH-total	1,448	64%
Others (private producers)	827	36%

The power infrastructure in North Macedonia is comparatively more diversified. The total installed capacity in North Macedonia is 1,909 MW of which about 1,187 MW (62%) comes from thermal power plants. Hydro constitutes about 667 MW (35%) and non-hydro renewables make the remaining 56 MW (3%).[17] The thermal power plants consist mainly of coal power plants and combined heat and power natural gas-fired plants as shown in Table 2. Similar to Albania, the State-owned company Power Plants of North Macedonia (ESM) is the largest power producer in the country and makes about 70% of the total installed capacity.[18]

Table 2. Total installed electricity generation capacity in North Macedonia by technology.

Power plants		Installed capacity (MW)	Share of total capacity (%)
Thermal	Bitola (Lignite)	699	37%
	Negotino (HF)	198	10%
Combined Heat and Power (CHP)	TE-TO	230	12%
	Kogel	30	2%
	Energitica	30	2%
Total Thermal		1187	62%
Hydro	Globocica HPP – Inside DRB	42	2%
	Spilje HPP – Inside DRB	84	4%
	Vrben (small) – Inside DRB	13	1%
	Vrutok and Raven – (60% of total inside DRB)	112	6%
	Large hydro outside DRB	310	16%
	Run-of-river – Existing outside DRB	105	6%
Total Hydro		667	35%
Non-hydro RE	Solar	18.5	1%
	Wind	37	2%
Total non-hydro RE		55.5	3%
Total installed capacity		1909	100%

15 Albanian Power Corporation KESH, 'KESH Activity Report 2013-2016' (Tirana, 2016), http://www.kesh.al/wp-content/uploads/2020/05/KESH-Activity-Report-2016.pdf.

16 Energy Regulatory Authority, 'The Situation of the Power Sector and ERE Activity during 2019 - Annual Report' (Tirana, 2020), https://ere.gov.al/doc/ERE_annual_report_2019_26102020.pdf; Energy Regulatory Authority, 'The Situation of the Power Sector and ERE Activity during 2018 - Annual Report' (Tirana, 2019), https://www.ere.gov.al/doc/Annual_Report_2018.pdf; Ioannis Thermos, Albania and North Macedonia: The Evolution of the Electricity System under the Scope of Climate Change, 2019, http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-264262.

17 CEE Bankwatch, 'The Energy Sector in North Macedonia', The Energy Sector in North Macedonia (blog), https://bankwatch.org/beyond-coal/the-energy-sector-in-macedonia; Ministry of Economy of North Macedonia, 'Strategy for Energy Development of the Republic of North Macedonia up to 2040 - Final Draft for Public Consultations' (Skopje, October 2019), https://economy.gov.mk/Upload/Documents/Energy%20Development%20Strategy_FINAL%20DRAFT%20-%20For%20public%20consultations_ENG_29.10.2019(3).pdf; Whalley and Faloutsos, 'Drin Basin – Transboundary Diagnostic Analysis (TDA)'.

18 Ministry of Economy of North Macedonia, 'Strategy for Energy Development of the Republic of North Macedonia until 2040 – Final Draft for Public Consultations'.

Montenegro and Kosovo* have a smaller power infrastructure base, with 992 MW and 1,407 MW installed capacity, respectively. The three main power plants in Montenegro are: Pljevlja thermal power plant (225 MW), Piva hydropower plant (342 MW) and Perućica hydropower plant (307 MW). The latter lies within the boundaries of the Drin Basin. It should be noted that Montenegro has the largest wind capacity among the four Riparians with its Možura (46 MW) and Kornova (72 MW) wind farms.[19] Finally, in Kosovo*, coal power plants Kosovo* A (610 MW) and B (678 MW) constitute over 90% of the installed capacity. The remaining capacity consists of Kitka Wind Farm (32.4 MW), small wind power plants connected to the distribution system (25 MW), and small hydropower plants with a total capacity of 61 MW.[20]

The power sector in the Drin countries faces a number of challenges. First of all, the availability of hydropower is both an opportunity and a potential problem, as high reliance on this technology makes the system more vulnerable to climate change, making electricity supply directly dependent on water availability. This vulnerability has a cost. For example, in a dry year like 2019, the resulting electricity imports in Albania reached about 2,406 GWh, equivalent to 30% of total consumption.[21] In the same year, the imports in North Macedonia made up about 30% of the total electricity consumption.[22] Another challenge is related to the high transmission and distribution losses. Despite improvements in recent years, the losses stood at 22% in 2019 in Albania, which means one-fifth of the generated and imported electricity is being lost along the way.[23] The situation is comparatively better in North Macedonia where losses are at 12%.[24]

The two countries' long-term energy strategies aim to address these challenges in different ways.

- The National Energy Strategy for Albania 2018-2030 is consistent with national efforts to sustain economic development, and meet commitments to the Energy Community, EU integration and other international agreements, while increasing the security of the energy supply, minimising environmental impact, and ensuring affordable costs for Albanian citizens and the economy. The Strategy aims specifically to increase energy efficiency and the share of renewables in the primary energy mix.[25] The electrical supply comes mostly from renewable sources (hydro), but improving resilience to climatic changes and the security of supply requires the diversification of the electricity supply mix. The country is endowed with significant solar potential and the highest number of direct irradiation hours in Europe.
- The Montenegrin 2030 Energy Policy has several goals, spanning from diversification of the supply mix to increase of energy efficiency, increased penetration of renewables, energy supply infrastructure investments, and reduced dependency on imports.[26]
- The Energy Development Strategy for the Republic of North Macedonia until 2040 sets out objectives for the development of the energy sector inspired by those set out by the European Commission in its Clean Planet for All strategic vision.[27] Based on analytical evidence and least-cost principles, the strategic vision aims to maintain the current dependence on imports, improving energy efficiency, and increasing the penetration of renewables, while maintaining lignite power plants and minimising the costs of the overall system.

19 Energy Regulatory Agency Montenegro, 'Energy Sector Status Report Montenegro in 2018' (Podgorica, 2019), http://regagen.co.me/cms/public/image/uploads/20200211_IZVJESTAJ_O_STANJU_ENERGETSKO_SEKTORA_CRNE_GORE_ZA_2018._GOD..pdf.

20 Ministry of Economic Development - Kosovo*, 'Energy Strategy Implementation Program 2018-2020' (Prishtina, 2018), https://konsultimet.rks-gov.net/Storage/Consultations/10-01-49-14052018/DRAFT%20ENERGY%20STRATEGY%20IMPLEMENTATION%20PROGRAM%202018-2020_14.5.2018.doc; Energy Regulatory Office Kosovo*, 'Statement of Security of Supply for Kosovo* (Electricity, Natural Gas and Oil)' (Pristina, 2019), http://ero-ks.org/2019/Publikimet/Deklarate_mbi_Sigurine_e_Furnizimit_ne_Kosove(energji_elektrike_gaz_natyror_nafte)ZRRE_31_07_2019_eng.pdf.

21 Energy Regulatory Authority, 'The Situation of the Power Sector and ERE Activity during 2019 - Annual Report'.

22 Ministry of Economy of North Macedonia, 'Strategy for En ergy Development of the Republic of North Macedonia up to 2040 – Final Draft for Public Consultations'.

23 Energy Regulatory Authority, 'The Situation of the Power Sector and ERE Activity during 2019 - Annual Report'.

24 Ministry of Economy of North Macedonia, 'Strategy for Energy Development of the Republic of North Macedonia up to 2040 - Final Draft for Public Consultations', https://economy.gov.mk/Upload/Documents/Adopted%20Energy%20Development%20Strategy_EN.pdf

25 International Energy Agency, 'National Energy Policy 2013' (2014), https://www.iea.org/policies/5534-national-energy-policy-2013.

26 Ministry of Economy of Montenegro, 'Energy Policy of Montenegro until 2030' (Podgorica, 2011), https://wapi.gov.me/download/f0a01d7a-478d-4e57-93c8-afeb-0375b591?version=1.0.

27 Ministry of Economy of North Macedonia, 'Strategy for Energy Development of the Republic of North Macedonia until 2040 – Final Draft for Public Consultations'.

- The Energy Strategy Implementation Program of Kosovo* 2018-2020 has a strong focus on the security of supply, and its objectives are the construction of new thermal capacity (including power supply, co-generation and district heating), investments in gas infrastructure, and integration into the regional market.[28] At the same time, it aims to comply with obligations in terms of energy efficiency, renewable energy sources, and environmental protection.

Given the common denominator of security of supply and increased penetration of renewables, hydropower generation is expected to play an important role in the energy supply for all Riparians. However, this role must be considered jointly with that of the other supply options, especially non-hydro renewables (which are by nature variable, and in order to be upscaled need to be coupled with stable sources, like hydropower). In fact, a diversified power system could increase the resilience of the countries' energy system to climate changes, contribute to the security of supply, and at the same time mitigate the impact of floods.

Zooming in on the hydropower infrastructure, the biggest dams in the Drin Basin are located in North Macedonia (Spilje and Mavrova) and Albania (Fierza being the largest, followed by Komani and Vau-i-Dejës – see Figure 3). A new hydropower project is under development in Skavica, Albania.[29]

The cooperation on flow regulation during emergencies within the countries works effectively as the dams are operated by two actors (KESH in Albania and ELEM in North Macedonia). However, the cooperation between the countries could be improved in two ways. Firstly, it could encompass more real-time communication in case of emergency (a flood forecasting system has already been installed in the Drin Basin, moving a step towards this direction). Secondly, the focus could move towards more preparedness, which means more coordination outside of emergency situations. In this study we focus on the second scenario.

Flow regulation and flood risk management in the Basin depend on the structure of the power sectors of both countries and their ability to meet the electricity demands. In fact, the rule of operation of the hydropower dams in the Drin Basin has been driven mostly by the objective of maximising

Figure 3. Map of large hydropower plants in the Drin River Basin.[30]

28 Ministry of Economic Development- Kosovo*, 'Energy Strategy Implementation Program 2018-2020'.

29 GWP-Med, 'Transboundary Diagnostic Analysis Thematic Report on the Resource Nexus (Phase I of the Water-Food-Energy-Ecosystems Nexus Assessment of the Drin Basin)'.

30 Prepared by GWP-Med.

electricity production: usually, hydropower reservoirs require water levels to be kept at a maximum design level to store as much energy as possible for daily hydropower generation. However, given the vulnerability to flooding, it is important to establish operation criteria that consider better flood containment needs, with the double objective of (significantly) reducing the costs of floods while maximising electricity generation (within reasonable limits). This could be achieved by improving the "multi-purpose" nature of the dams and by leveraging their "cascade" structure. In other words, to decrease the risk of flooding downstream, dams and reservoirs could be used to regulate river levels by temporarily storing extra water volumes and delaying their release downstream. In this sense, the construction of the Skavica hydropower project could represent an opportunity to increase the electricity supply while also improving the flood control capacity.

However, to clarify the existing and potential role of hydropower operators in flood management and prevention, the physical dynamics between hydropower operations and flood episodes in the Drin River Basin need to be better understood. A quantitative cost-benefit analysis of some of these dynamics could inform decisions related to new dam operating rules.

This chapter contributes to this endeavour by presenting an analysis of the role of hydropower in the Drin River Basin vis-à-vis other electricity supply options, and in the context of the wider energy strategies of the Riparians. As such, it illustrates how hydropower, non-hydro renewables and electricity trade may all contribute to increasing the renewable supply shares and security of supply, while simultaneously reducing emissions and increasing flood protection.

The analysis is carried out by means of a model, built to quantify the costs and benefits of shifting to a "flood-smart", cooperative hydropower operation regime along the two hydropower cascades in the Drin River Basin. The model includes a representation of the hydrological characteristics of the Basin, the electricity generation system of the Riparians (in- and outside the Basin), and the links between them. The model is used to address the following questions:

- What are the costs and benefits of improved ("flood-smart") hydropower cooperation, for operators and for society? And what is the impact of keeping larger flood buffers in the dams on electricity generation in each HPP, and in each country?
- How would climate change impact the energy system in the Drin Basin?
- What is the impact of the new HPP (Skavica) on electricity production and electricity imports?

The remaining sections of the chapter describe the literature background (including previous and related modelling efforts in the region), the methodology, the scenarios created to address the above questions, the modelling results, and the broader insights that can be drawn.

2.2 ENERGY-WATER MODELLING

2.2.1 MODELS and METHODOLOGY used

The model used for the analysis consists of two parts: an accounting model that represents the hydrological characteristics and balances in the Drin River Basin (Panta Rhei) and a long-term energy investment optimisation model that calculates the least-cost energy supply mix meeting electricity demands. For brevity, we will call this the "water-energy" model. The following subsections introduce the modelling tools used for the analysis and then dive into the structure of the Drin River Basin model.

Panta Rhei

Panta Rhei[31] is a hydrological model that simulates the rainfall-runoff process and water budget at any point of the Basin where the model is applied. It is a hydrological distributed conceptual model that allows the user to perform simulations with high and temporal resolutions. The Panta Rhei hydrological model comprises three main components that are responsible for transforming rainfall into runoff: (i) the formation of runoff, (ii) the concentration of runoff, and (iii) the routing of flow through the channel system. The runoff formation is based on a modification of the SCS method.[32] The runoff concentration process and routing the method chosen is the linear storage function. Finally, for

31 Panta Rhei was developed and is continuously maintained by the Leichtweiss Institute of Hydraulic Engineering and Water Resources (LWI), in collaboration with the Institute of Water Management (IfW), in the Technical University of Braunschweig. Copyrights to the software are owned by LWI and IfW. The model has been applied in Germany and internationally for different purposes: water balance studies, river flow forecasting, and design floods and flood control measures.

32 SCS curve number is a simple, widely used method for determining the approximate amount of runoff from a rainfall event.

the reservoir release process, the Puls method[33] is applied. The model divides the area of application into sub-basins and hydrotops. The sub-basins are small portions of divisions according to the river network and topography. The hydrotops or hydrological units are a homogeneous area concerning the rainfall-runoff process. The hydrotop contains unique land use and soil type.

OSeMOSYS – The Open Source Energy Modelling System

OSeMOSYS is an open-source systems optimisation tool for long-run integrated assessment and energy planning.[34] It uses linear optimisation to determine the least-cost energy system configuration for a specified time horizon (e.g. 20152050). It is driven by exogenously defined demands for energy services and/or commodities in general. These can be met through a range of technologies that draw on a set of resources, defined by their potentials and costs. Additionally, policy scenarios may impose certain technical constraints, economic scenarios, or environmental targets.

OSeMOSYS creates a simplified representation of real-life resource systems based on two key concepts: "technology" and "commodity". The definition of "technology" and "commodity" is flexible. A technology represents any process of conversion from one commodity to another. A commodity represents any type of material or energy input to or output of a technology. Given this flexible definition, in OSeMOSYS a technology can represent anything between a thermal power plant (conversion process from e.g. coal to electricity), a hydropower plant (conversion process from a water mass flow to electricity), or even a segment of a river (a physical process of transportation of water from one point to another).

Due to this flexibility of representation and its open-source nature, OSeMOSYS has been applied in numerous analyses looking into long-term optimisation of water, energy, land uses, and related investments, from a global scale to regional, national and local scales.[35]

Based on its capability to jointly represent climate, energy and water systems and quantify the pressures between them, OSeMOSYS was used in the transboundary Nexus Assessments of the Sava River Basin,[36] Syr Darya River Basin[37] and the Drina River Basin.[38] In the latter case, the model encompassed a representation of the entire electricity supply system of the Basin's riparian countries, including a representation of the hydropower and dam cascade along the Basin and the related water flows.[39] This type of representation (with further improvements) formed the basis for the model supporting the Nexus Assessment of the Drin River Basin and is described in the following subsection.

2.2.2 The WATER-ENERGY MODEL

The model aims to represent the least-cost ways for the electricity supply system of the Riparians to evolve and meet future demands, while at the same time assessing the impacts of the electricity system on water flows and flood protection. It represents the electricity supply systems of Albania, North Macedonia, Kosovo*, and Montenegro in their entirety, including infrastructure outside and inside the Drin River Basin, and including all the transmission links between the countries and with neighbouring countries. The study covers the period between 2020 and 2050 and represents the evolution of the electricity system each year.

The hydropower cascade in the Drin River Basin is represented with high detail, so that the impacts of investments in hydropower, and operation of the hydropower infrastructure, on floods in the Basin may be captured distinctly within the whole picture of the multi-country electricity system.

33 Also known as storage routing, the Puls method is based upon a finite difference approximation of the continuity equation, coupled with an empirical representation of the momentum equation (Chow, 1964; Henderson, 1966).

34 Mark Howells et al., 'OSeMOSYS: The Open Source Energy Modelling System', Energy Policy 39, no. 10 (October 2011): 5850–70, https://doi.org/10.1016/j.enpol.2011.06.033.

35 Eunice Pereira Ramos et al., 'The Climate, Land, Energy, and Water Systems (CLEWs) Framework: A Retrospective of Activities and Advances to 2019', Environmental Research Letters (December 2020), https://doi.org/10.1088/1748-9326/abd34f.

36 United Nations Economic Commission for Europe UNECE, 'Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus' (Geneva, Switzerland: United Nations Publications, 2015), http://www.unece.org/fileadmin/DAM/env/water/publications/WAT_Nexus/ece_mp.wat_46_eng.pdf.

37 Eunice Pereira Ramos et al., 'The Role of Energy Efficiency in the Management of Water Resources of the Syr Darya River Basin', Int. J. Environment and Sustainable 20, no. 1 (2021).

38 Youssef Almulla et al., 'The Role of Energy-Water Nexus to Motivate Transboundary Cooperation: An Indicative Analysis of the Drina River Basin', 2018, http://dx.doi.org/10.5278/ijsepm.2018.18.2; Emir Fejzic et al., 'Exploring Power Sector Decarbonization Pathways through Implementation of CLEWs in OSeMOSYS – Case Study for the Drina River Basin Riparians', Forthcoming; United Nations Economic Commission for Europe UNECE, 'Assessment of the Water-Food-Energy-Ecosystems Nexus and Benefits of Transboundary Cooperation in the Drina River Basin' (New York and Geneva, 2017), http://www.unece.org/fileadmin/DAM/env/water/publications/WAT_Nexus/ECE_MP.WAT_NONE_9/Drina-EN-for_Web_final.pdf.

39 Almulla et al. (n33)

This electricity system model is entirely constructed in OSeMOSYS, and the part related to the hydropower cascade takes inputs from a detailed hydrological model of the Drin River Basin developed in Panta Rhei.

The Drin River hydrological model is divided into 2,562 sub-basins and 17,398 hydrotops. Hydrometric data was collected within the period 1960-2013. The focus was placed on the period selected for calibration (1979-1989) and validation (2001-2010). For these periods, there is available discharge data for 41 stations. The quality and the quantity of data vary substantially from one station to another. In some cases, data is not consistent and has data gaps. Albania and Kosovo* have 15 stations with discharge data available. Only 5 stations in Montenegro and 6 stations in North Macedonia have available data.

The existing version of the model includes a large number of sub-catchments because the model was created for flow forecasting mainly. However, for this application of the water-energy modelling, a better calculation of the hydrological parameters with a simplified version of the hydrological model was needed. The new version of the model reduces the number of sub-catchments and focuses on fewer points of interest according to the flood and energy outputs. This change reduces the calculations and is focused on the data that are used for the energy model. The figure below illustrates the change implemented to the previous original versions of the model to create the new simplified structure that can be integrated into the energy model.

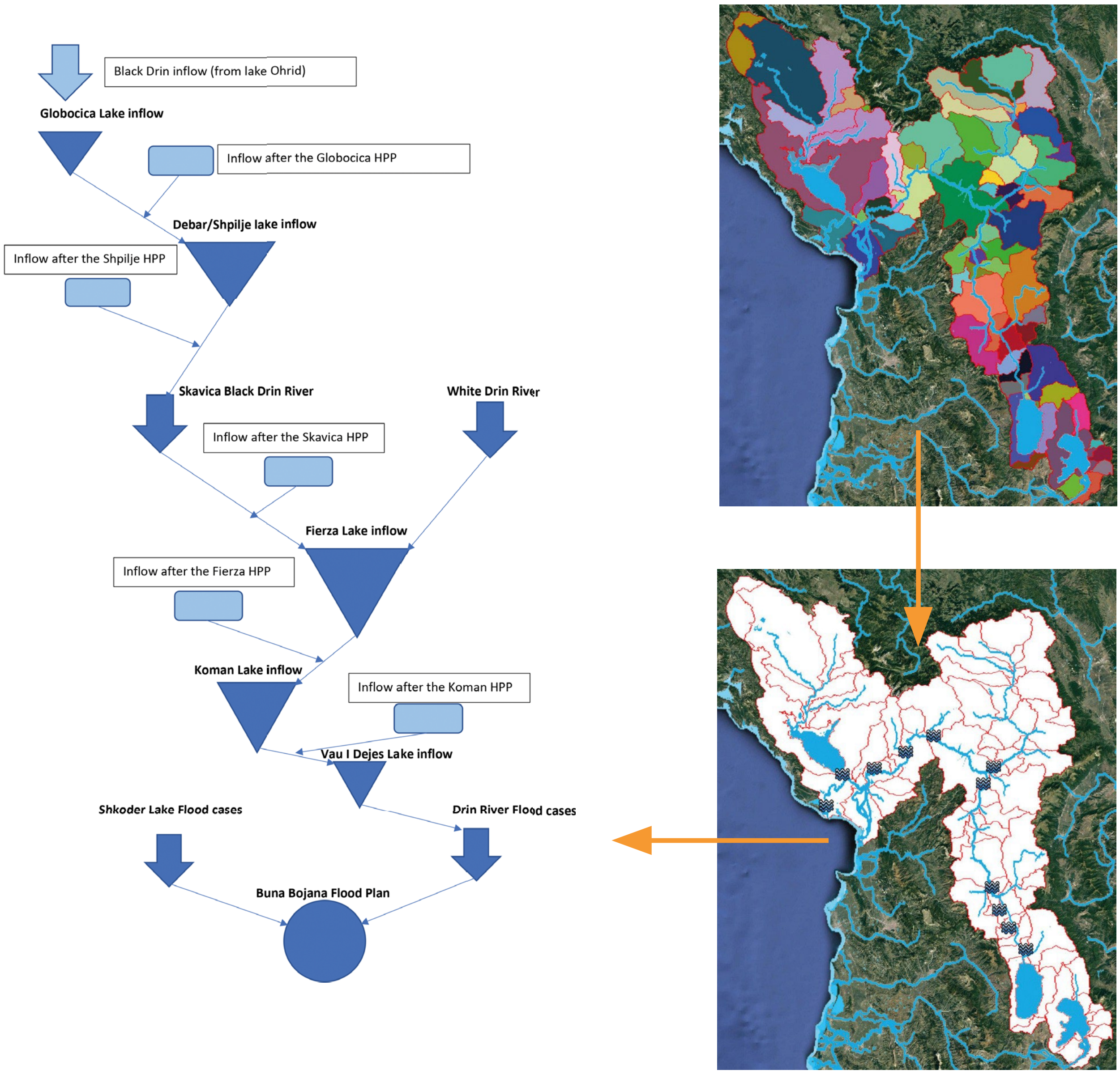


Figure 4. Original Model (first map), point of interest (second map), schematic diagram of the hydrological outputs and dams into the energy mode (third map).

The water flows upstream, and downstream all hydropower plants and dams resulting from Panta Rhei are fed to the part of the electricity system model representing the hydropower cascade in OSeMOSYS. Figure 5 shows the structure of the hydropower cascade model in OSeMOSYS.

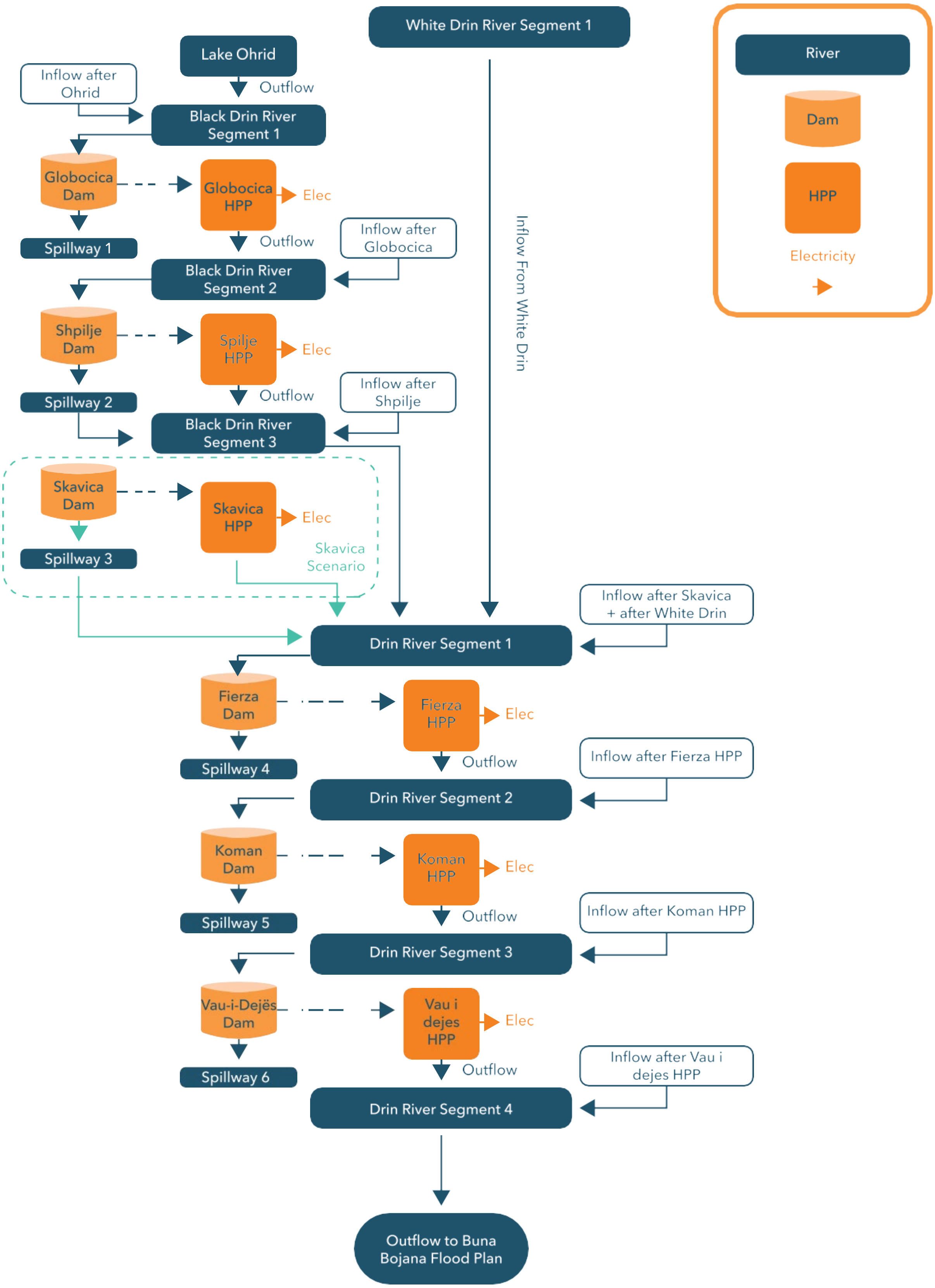


Figure 5.Structure of the hydropower cascade in the Drin River Basin, as represented in OSeMOSYS.

The model of the hydropower cascade in OSeMOSYS includes the White Drin, the Black Drin, and the Drin Rivers. All the power plants along the Black Drin and the Drin are represented nominally (starting from upstream): Globocica, Spilje, Fierza, Koman and Vau-i-Dejës. A representation of the potentially upcoming Skavica power plant is included, for one of the analysed scenarios (see following sections), in the position where the power plant is intended to be built, i.e. between Spilje and Fierza. Figure 6 shows a close-up of one part of the model, representing any of the hydropower plants and related dams and water inputs and outputs. This part is described in greater detail, as it represents thewhole modelling concept.

The river segments upstream and downstream of a power plant are represented in an aggregated way, as a generic box providing or receiving a certain water volume flow (calculated by Panta Rhei for each of the modelled scenarios). The river segment upstream feeds water to a dam. The water available in the dam can be fed to the hydropower plant when this needs to be generated (depending on user-defined electricity demands and load profiles), it can be stored in the case that the dam is not full, or it can be released through a spillway. The capacity of the dam and the spillway are user inputs, defined using data provided by the local stakeholders and utilities companies or publicly sourced. The dam can be discharged only down to the minimum storage level defined by the operators and can be filled only to the maximum level allowed by the buffer volume used for flood containment. The flow through the spillway is lower-limited so that it is at least equal to the minimum environmental flow dictated by law in each of the Riparians. When the hydropower plant generates electricity, it uses water from the dam, and then it releases it to the river segment downstream. In addition, water inflows from catchments are taken into account in the water balances before or after each hydropower plant.

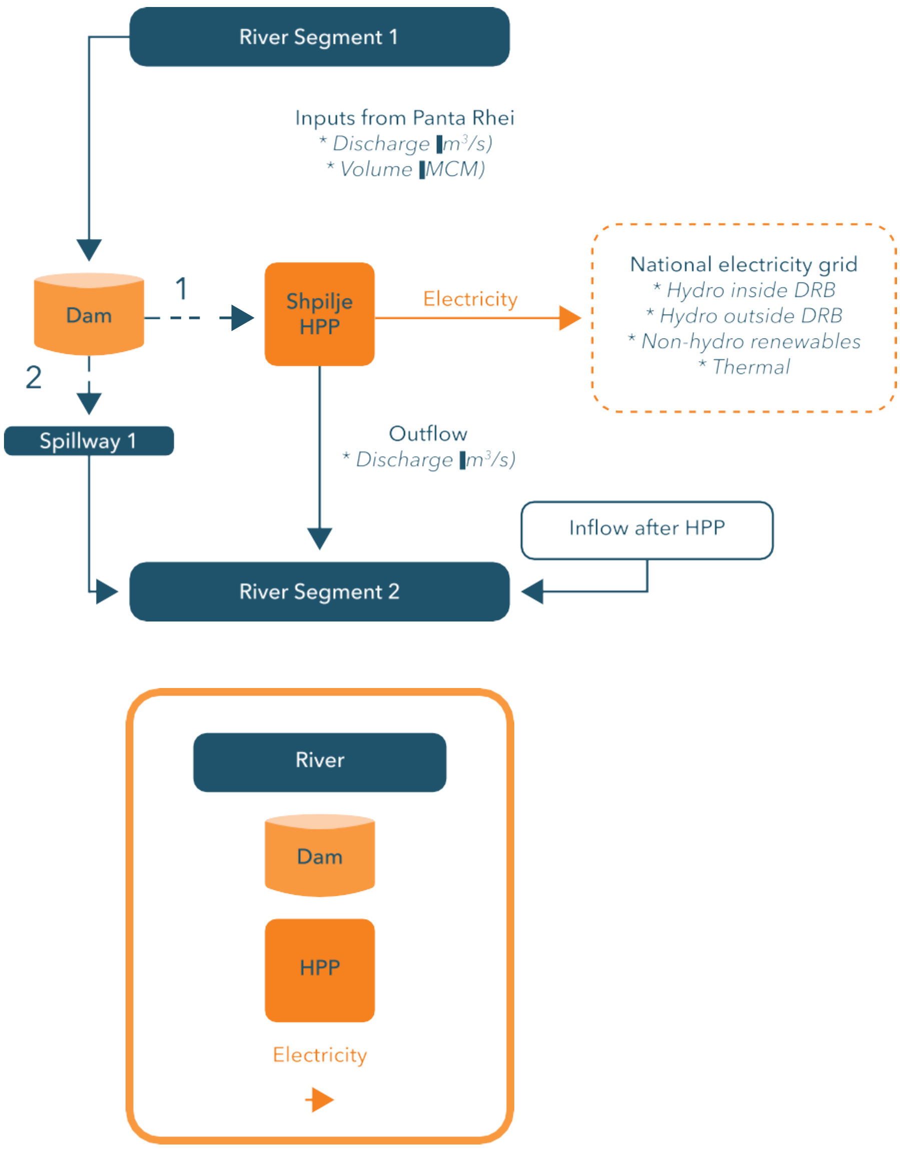


Figure 6. Detail of the hydropower cascade model.

2.2.3 KEY MODEL characteristics and input

The overall characteristics of the two tools used to build the water-energy model of the Drin River Basin, Panta Rhei and OSeMOSYS, are summarised in the following table:

Table 3. Key characteristics of the modelling tools used for the Assessment.

	Panta Rhei	OSeMOSYS
Type of model (integrated water-energy model)	Hydrological model	Long-term energy model
Institutions developing the model	GIZ Project "Climate Change Adaptation in Transboundary Flood Risk Management for the Western Balkans"	KTH (The Royal Institute of Technology, Sweden)
Licences, availability, openness	Licence	Open source, available for users without licence requirement
Links to models & resources (GitHub)		https://github.com/KTH-dESA/OSeMOSYS https://github.com/KTH-dESA/Drin
Model characteristics (optimisation + hydrology/ simulation)	Hydrological distributed conceptual model that performs simulations with high and temporal resolutions	Least-cost optimisation model: it determines the electricity generation mix and infrastructure investments, while minimising the total system cost
Geographical scope and resolution	Drin-Buna/Bojana catchment, 30 -metre Digital Elevation Model (DEM)	Albania, North Macedonia, Montenegro and Kosovo*, with special focus on the Drin Basin
Temporal scope and resolution	Flood Forecasting System, hourly resolution	Weekly time steps (52 time slices) from 2020-2050
Key assumptions and inputs	41 hydrological stations and 70 meteorological stations during calibration (1979-1989) and validation (2001-2010) periods	Capacity of all power plants (thermal and renewables), techno-economic aspects of power plants (e.g. costs, efficiencies, capacity factor, etc.), annual electricity demand, electricity trade interconnectors,and a simplified hydrological representation of the cascade
Key outputs	Water discharge in (m/sec) Water volume	Installed capacity (GW) Electricity generation (GWh) Costs (million USD)

The key numerical inputs of the two tools are as follows:

Hydrological model

The hydrological model aims to estimate the water resources for all points of interest. The first calculation was the monthly discharge distributions for three exploratory scenarios: average year, wet year, and dry year, based on the monthly water flow for the period 1980-1990 and the period 2000-2010. After testing the integration between hydrology and energy, the second version of the hydrological model was developed with high-resolution data (1 hour). This calculation was performed to gain a better understanding of the behaviour of the 5HPPs in normal and abnormal situations. The impact of climate change on the water balance was modelled assuming that there were no other changes to consumptive and non-consumptive water demands or other related climate change impacts concerning vegetation or soil degradation.

Energy model

The main model inputs include the change in the natural water flows along the hydro cascade (including seasonal changes and longer-term climatic changes), the characteristics and the operational rules of the reservoirs, the technical characteristics and operational limits of the electricity supply technologies, planned investments, technology phase-out plans and policy constraints. The temporal resolution in the model is weekly, which means that the average water discharge in each part of the river is represented on a weekly basis. Special focus is placed on the main hydropower plants in the Drin Basin with the characteristics shown in Table

4. The full list of power infrastructure capacities considered in each country is reported in the Annex and further technical details of the energy models can be found in the academic publication.[40]

Table 4. Characteristics of the large dams and hydropower plants along the Drin River.

	Plant	Reservoir Storage Volume (million m³)	Power Capacity (MW)	Started Operation (year)	Net Head (m)	Water Inflow to Turbines (m³/sec)	AVG Output Last 15 Years (GWh)	Spillway Capacity (m³/sec)
1	Globocica	55.3	42	1965	95.29	2 X 25	186	1,100
2	Spilje	506	84	1969	91.3	13 X 36	288	2,200
3	Skavica*	2,300	196	2025	about 140	2 X 87	NA	2,800
4	Fierza	2,350	500	1976	118	4 X 123,5	1,363	2,670
5	Koman	188	600	1985	96	4 X 180	1,804	3,400
6	Vau-i-Dejës	310	250	1970	52	5 X 113	929	6,700
Total Drin River Basin		5,709	1,672				4,570	18,870

Note: the Skavica hydropower plant(*) is introduced as a new capacity from 2025.

2.3 SCENARIOS

The integration of the hydrological and energy models enabled the exploration of five scenarios, as shown in Figure 7 . Each scenario aims to represent certain dynamics, as follows.

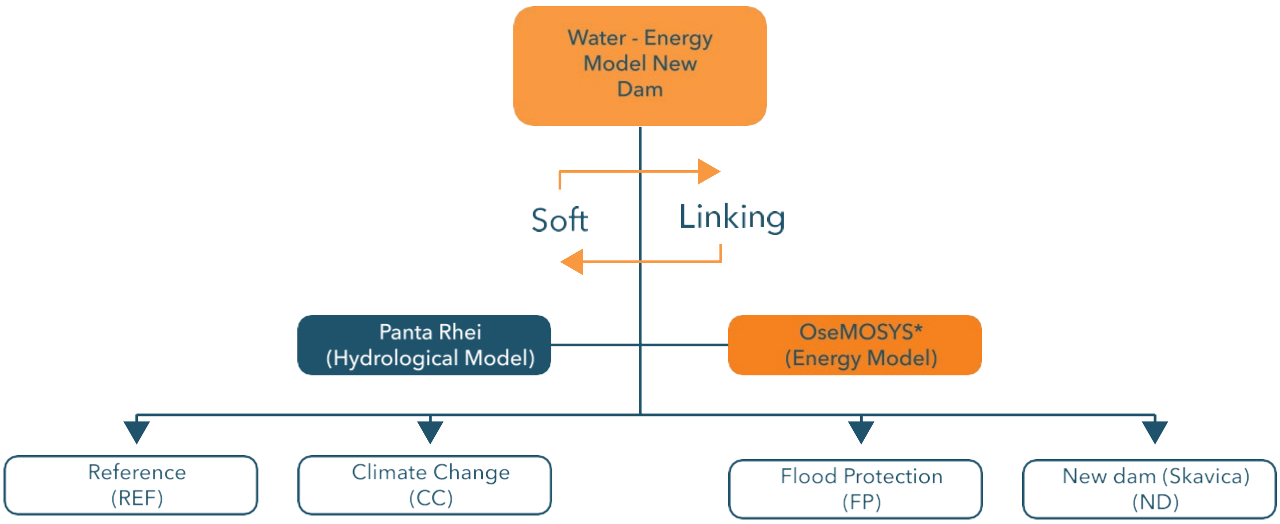


Figure 7.Modelling framework and scenarios analysed.

40 Youssef Almulla et al., 'Hydropower and floods, insights from the Integrated Water-Energy modelling of the Drin Basin.', Forthcoming.

2.3.1 REFERENCE (REF)

This scenario represents the current situation in the Drin Riparians (with the focus on the Drin Basin), on the basis that the HPPs' operation is determined for maximisation of production in each plant without considering the coordination between countries or the flood forecasting system that exists in the DRB. This scenario assumes that the hydrological conditions affecting surface water and groundwater availability are similar to conditions that have been observed in recent historical records (1980-1990 and 2000-2010). This scenario establishes a baseline approximating present conditions that are used to estimate the impact of changes expected in the future.

2.3.2 CLIMATE CHANGE (CC)

Climate change is expected to affect the region through changing temperatures, precipitations, and water availability. Although the total precipitation is expected to decrease, an increase of intensive rain episodes is also likely. Besides inland impacts of climate change, Albania is also facing an expected rise in sea level. The same trends are also anticipated for Kosovo* and the North Macedonian part of the catchment that influences the HPPs. This scenario assumes that hydrological conditions affecting surface water and groundwater availability reflect changes to the climate that are expected in the near future, in 2025 and 2050. Climate change projections are in line with the National Communications to the United Nations Framework Convention on Climate Change (UNFCCC).[41] The projections represent an average drop in precipitation of 3% and 6% respectively as shown in Table 5 and were based on data trends provided by the National Climate Change Reports. Further information can be found in the Annexes.

The water demands are assumed to be the same as the reference (current) demands, except in the irrigation sector, where consumptive water use requirements are assumed to change because of changes to rainfall and evaporation resulting from climate change. No other changes to consumptive and non-consumptive water demands are assumed. The simulation model is used to estimate the impact of changes to climate and demand assumptions on basin water balances in the Drin sub-catchments.

Table 5. Changes in precipitation and temperature under climate change projections.

	2025						2050					
	Precipitation (%)			Temperature (°C)			Precipitation (%)			Temperature (°C)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Annual	-2.6	-3.0	-3.4	0.8	0.9	1.1	-5.3	-6.1	-6.9	1.7	2.0	2.3
Winter	-1.3	-1.5	-1.8	0.7	0.8	0.9	-2.8	-2.2	-3.6	1.5	1.7	1.9
Spring	-0.9	-1.1	-1.2	0.7	0.8	0.9	-1.9	-2.2	-2.5	1.4	1.6	1.8
Summer	-8.7	-10.1	-11.5	1.2	1.3	1.5	-17.8	-20.5	-23.2	2.4	2.7	3.1
Autumn	-2.3	-2.6	-3.0	0.8	0.9	1.1	-4.7	-5.4	-6.1	1.7	2.9	2.2

41 United Nations Develoment Program UNDP, 'Third National Communication to the United Nations Framework Convention on Climate Change | UNDP in Albania', UNDP-Albania (November 2016), https://www.al.undp.org/content/albania/en/home/library/environment_energy/third-national-communication-to-the-united-nations-framework-con.html.

2.3.3 NEW DAM (Skavica) (ND)

A new HPP on the Drin is under development in Skavica, Albania. This will produce more energy and provide flood protection. In this scenario, we assume that the power plant is installed and starts operation in 2025, and we explore what the impact of the power plant will be on energy (power generation) and security of electricity supply. In this scenario, the Skavica dam was introduced in the cascade, which means that the water flow along the cascade was changed to fill the Skavica dam and then flow to the other HPPs in Albania as shown in this section of the cascade schematic.

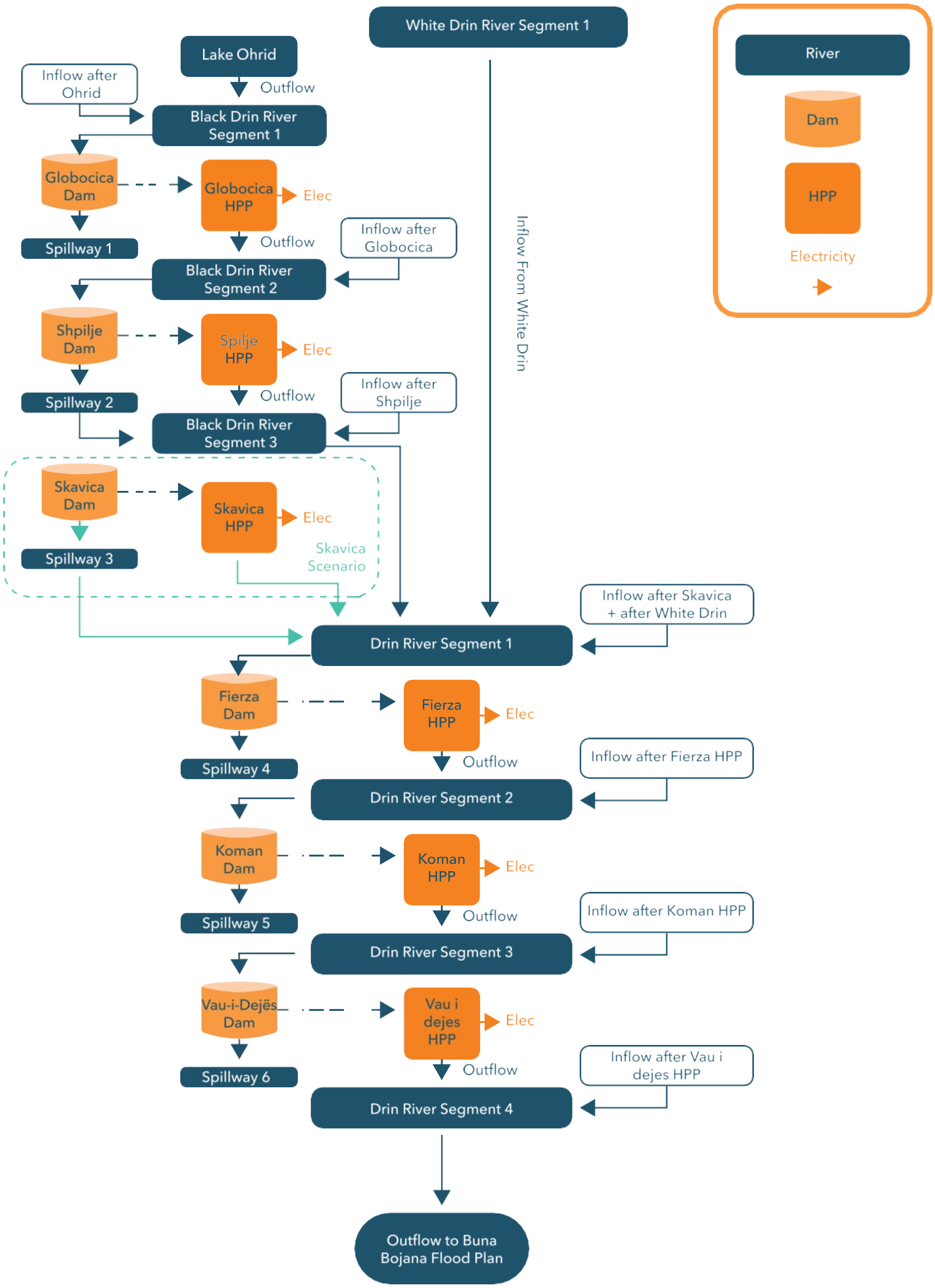


Figure 8. Sectional view of the cascade schematic showing the representation of Skavica Dam.

2.3.4 FLOOD PROTECTION (FP)

In this scenario, a new set of operational rules is suggested in order to improve the flood management in the Basin. Due to their storage capacity, Spilje HPP and Fierza HPP are the two dams that can influence the most flood control, therefore this scenario explores new operational rules for these two dams. The **buffer volume** in each dam is increased by 5%, 10%, 15% and 20% in the wet season (from October to May). This sensitivity analysis allows for the exploration of the impact of different buffer volumes on both **electricity generation** and **the flooded area downstream** in comparison with the reference scenario (REF). In other words, we try to quantify the trade-offs between the security of electricity supply and flood mitigation.

Increasing the buffer volume in Spilje by 5% would gain an additional storage volume of 7-9 MCM, while the 20% increase would add an additional buffer of about 26-34 MCM, as shown in Figure 9. This would mean lowering the water level in Spilje Dam by 2-4.3 m.

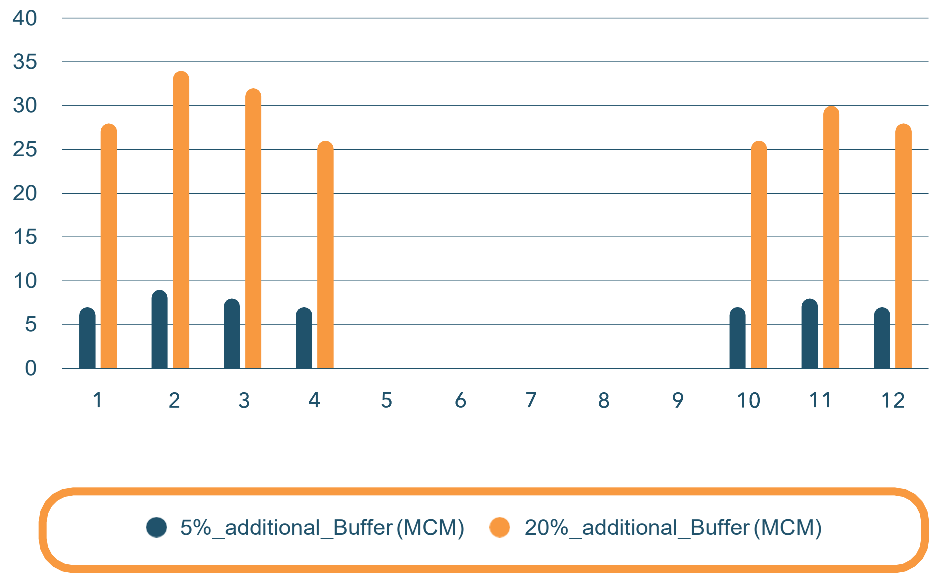


Figure 9. Additional buffer volume gained under 5% and 20% increase in Spilje Dam (Million Cubic Metres).

Due to its larger volume, the same changes in Fierza Dam would result in much larger buffers. Adding a 5% buffer would translate into 36-68 MCM of additional storage capacity, while adding a 20% buffer would create 144-270 MCM of additional storage capacity (Figure 10). Achieving this large volume would mean lowering the water level in Fierza Dam by 0.5-7.8 m, as shown in the Annex. It is worth mentioning that Skavica HPP is not considered in this scenario as it is still in the construction phase and there is no data publicly available for its operational rules.

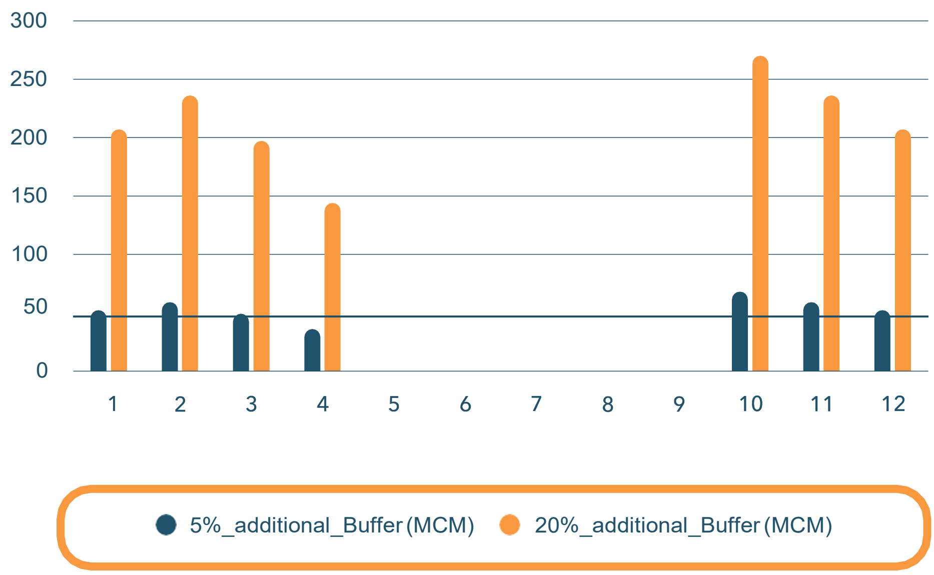


Figure 10. Additional buffer volume gained under 5% and 20% increase in Fierza dam.

2.4 RESULTS FROM THE INTEGRATED MODELLING

This section highlights key results from the scenario analysis. The outcomes of the scenario analysis are structured in such a way as to address the key research questions raised in this report. Results are discussed first from the energy system perspective and then from the flood control impact perspective. The focus is on the Drin Basin and its hydropower plants.

2.4.1 FLOOD-SMART OPERATIONS

The analysis below aims to answer the following questions: What are the costs and benefits of improved ("flood-smart") hydropower cooperation, for operators and for society? And what is the impact of keeping larger flood buffers in the dams on electricity generation in each HPP, and in each country?

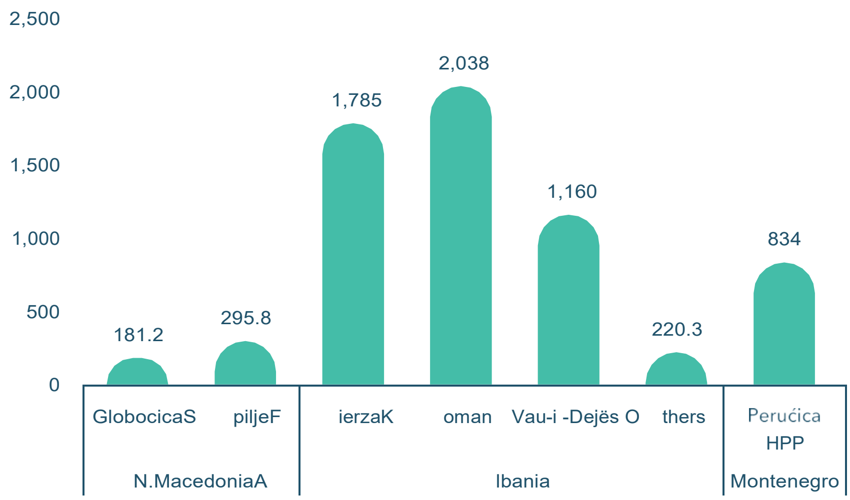


Figure 11. Average annual electricity generation (in GWh) from the hydropower plants in the Drin cascades under the reference scenario, between 2021 and 2024.

Before answering these questions, we examine the current status of the Basin. The electricity generated from the hydropower plants in the Drin Basin reaches about 6,514 GWh distributed between the countries, as shown in **Figure 11**.

The importance of the Drin Basin for the energy sector is obvious – especially in the Albanian part, where the hydropower generated in the Basin accounts for around 70% of the total electricity generation of the country. As shown in **Figure 12**, hydro in the Drin Basin contributes 5.4 TWh of a total of 7.9 TWh generated from all Albanian power

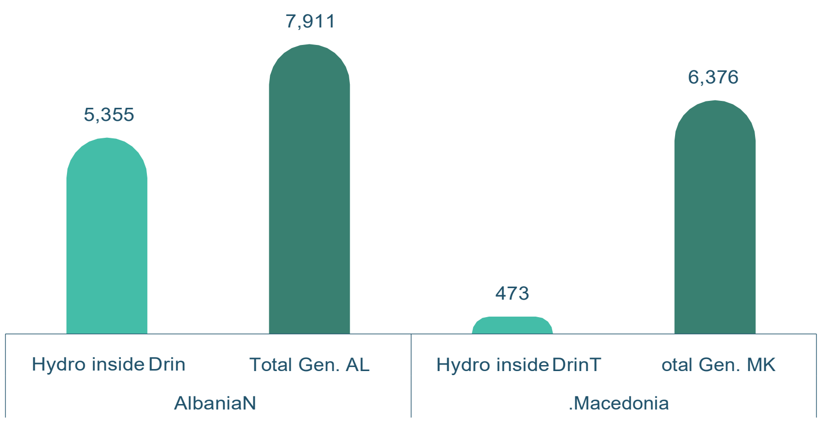


Figure 12. . Electricity generation from hydropower in the Drin Basin compared to the national electricity generation in Albania and North Macedonia under the reference scenario (in GWh).

plants. This value represents the mean for the years 2021-2024. Due to the lower capacity in the North Macedonian part, the generation from Drin Basin hydropower plants is 0.43 TWh out of the total generation of 6.4 TWh – or about 7% of the national generation .

Since the focus of the study is on the Drin cascade, we concentrate on the changes in electricity generation from the five large hydropower plants in the Basin, namely: Globocica, Spilje, Fierza, Koman, and Vau-i-Dejës. The Perućica HPP in Montenegro is not assessed as it does not affect the flow of the Drin River.

The "flood-smart" operations scenario explores the impact of increasing the buffer volume in selected dams on the electricity generation and more importantly on the flooded area downstream. Due to their storage capacity, Spilje HPP and Fierza HPP are the two dams that can essentially influence flood control, therefore this scenario explores new operational rules for these two dams. The new operational rules explored are those corresponding to increased buffer volumes in each dam of (i) 5%, (ii) 10%, (iii) 15% and (iv) 20% in the wet season (from October to May).

Results from the modelling analysis indicate that increasing the buffer volume in the wet season at the Spilje and Fierza hydropower plants bears minor impacts on electricity generation. As shown in Table 6, for 5% and 20% additional buffer volume levels, respectively, the average resulting reduction in generation ranges from 1.7–2.7% in Spilje and 0.3-1.9% in Fierza.

Table 6. Summary of the changes in terms of electricity generation at Spilje and Fierza hydropower plants.

	Spilje HPP		Fierza HPP	
Parameter	+5% Buffer (COOP05)	+20% Buffer (COOP20)	+5% Buffer (COOP05)	+20% Buffer (COOP20)
% change in generation	- 1.7 %	- 2.7 %	- 0.3 %	- 1.9 %
Mean annual change in generation (GWh)	- 5	- 8	- 5.4	- 34

In order to simulate hydrological scenarios and assess the effects on flooded areas downstream, resulting from increased buffer volume in the selected reservoirs, we coordinated with UNDP to use the 2D hydraulic model developed previously by the GIZ team for flood hazard and risk mapping along the Drin/Drim – Buna/Bojana in the Skadar/Shkodër area, in the framework of the "Climate Change Adaptation through Transboundary Flood Risk Management in the Western Balkans" Project. This model has been generated from Digital Terrain Models (DTMs) of the plain and cross-sections of the rivers, using HEC RAS software. This model has been calibrated using maximum water level records during recent flood events. The hydraulic model uses inflow hydrographs from all rivers and tributaries. Regarding the Drin River, the GIZ model provides hydrographs for 10- and 100-year return periods[42]: to simulate other return periods to those simulated by the GIZ Project (10 yrs, 100 yrs), a Gumbel adjustment[43] has been made on peak values for all inflow boundary conditions in order to estimate peak values for intermediate return periods (20 yrs, 50 yrs, and 200 yrs).

Two sets of scenarios were explored to assess the effects on flooded areas downstream resulting from increased buffer volume in the selected reservoirs. Results were compared between the present situation (BAU – current operational rules) and the maximum possible flood control in the reservoirs (increasing buffer volumes by 20%) in the scenarios of:

- floods with a 10-year return period, and
- floods with a 20-year return period.

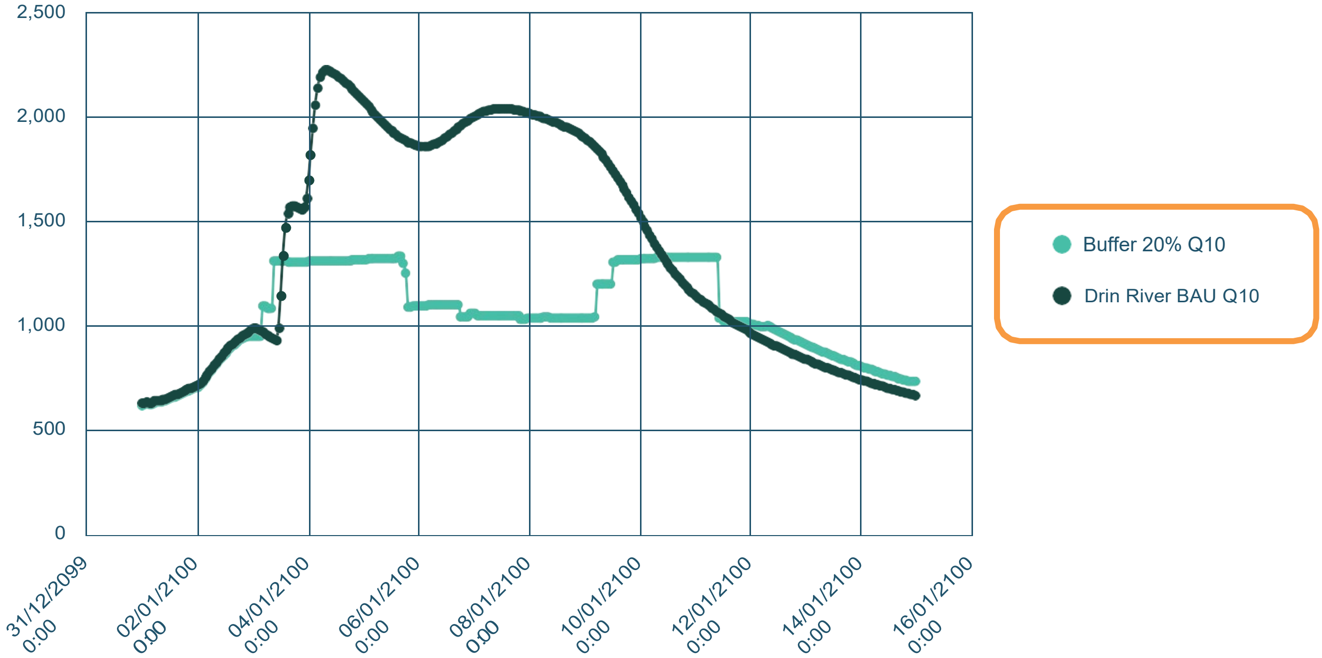
According to the modelling results, the benefits in terms of reducing the flooded area downstream from flood-smart operations of the HPPs are evident primarily in the cases of small to average flood events (10-year return period) while small improvements in flood risk are indicated in the case of bigger flood events (20-year return period – see Figure 13). This can be explained by considering that the bigger the flood is, the bigger peak value of the flow, given that the buffer volume is the same. Beyond a certain point, the impact of the dam on the peak flow becomes increasingly smaller.

It is important to note that due to lack of data on the operational rules of Skavica, the calculations do not include the Skavica Dam. Once operational, this dam is expected to further reduce the flood risk. This is an important aspect to consider in any future work.

42 The Return Period is a term used to represent the probability (in %) that an event such as flood will occur in any year. For example: a return period of a flood of 100 years will be expressed as its probability of occurring being 1/100, or 1% in any year regardless of when the last similar event occurred.

43 A statistical distribution method.

Flood control hydrograph 10-year return period



Flood control hydrograph 20-year return period

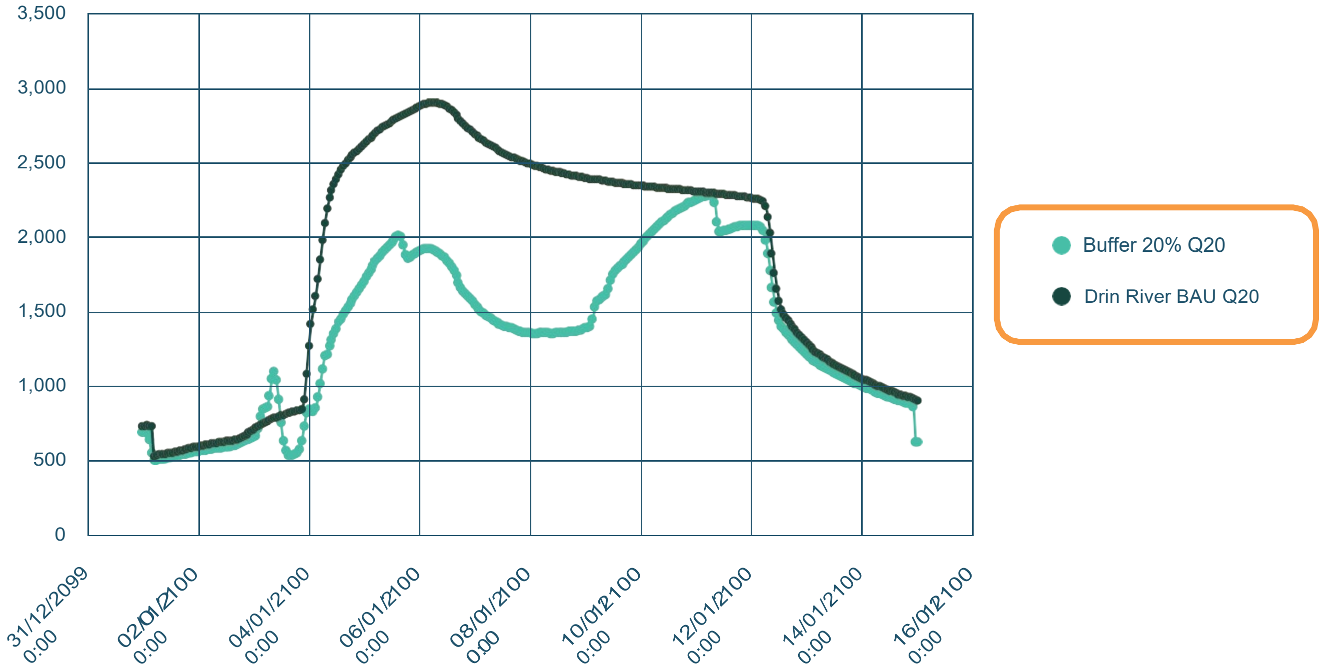


Figure 13. Flood hydrograph impacted from new operational dam rules. For 10-year return period (left) and 20-year return period (right).

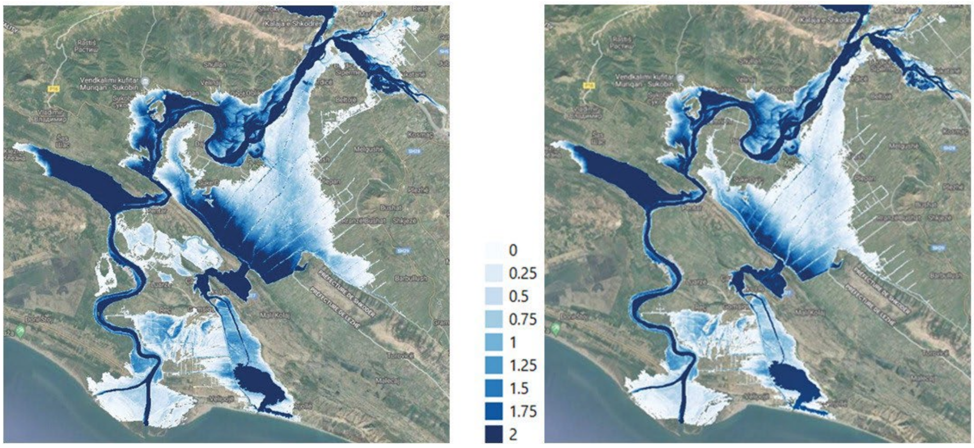


Figure 14. Flooded area and water depth for 10-year return period with present operational rules (left) and new operational rules (right).

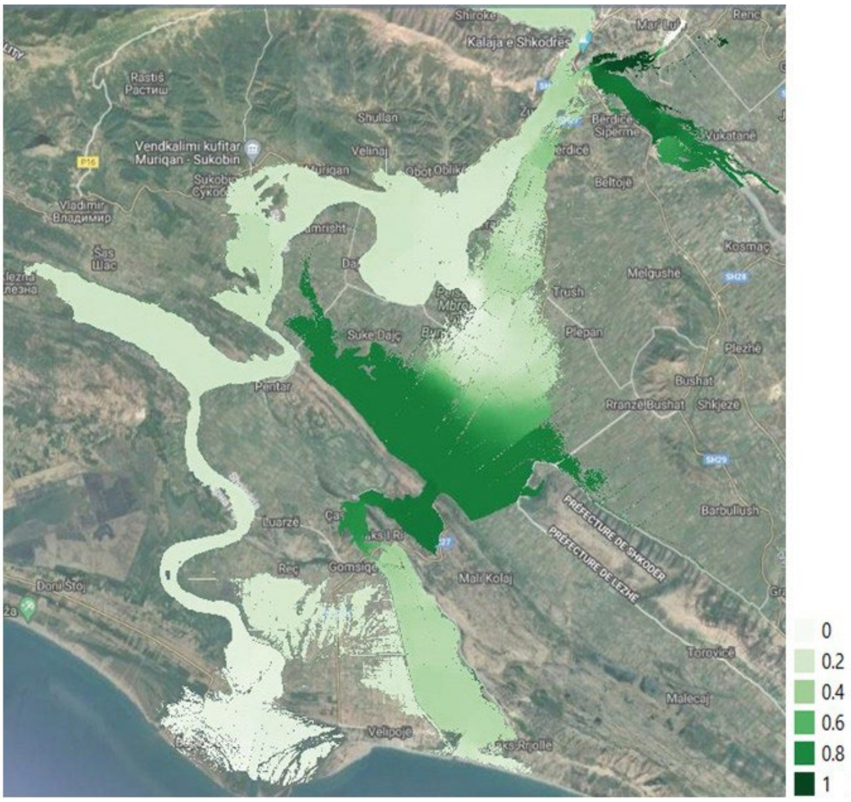


Figure 15. Difference of the water depth between scenarios (present and new operational dam rules).

Following the above analysis, the results from the hydraulic model were then used to estimate how the flood damages downstream (in Albania and Montenegro) would be affected under the aforementioned scenarios of "flood-smart" operational rules.

The estimation was implemented using the related application that had been developed by DHI Hungary Ltd for the purposes of the pilot project "Flood Insurance in the areas of Skadar/Shkodër Lake-Buna/Bojana River, and Struga in Ohrid Lake" in the context of the GEF/UNDP "Drin Project".[44]

This GIS-based application calculates the damage from the input spatial data and the descriptive background data. In terms of spatial data, the examined asset type (e.g. building, agricultural area) is symbolised by a polygon, which can be covered by the flood map provided as the other input. Depending on the depth of water covering the given polygon, the software calculates how much damage occurs in the examined element based on the loss curve.

44 Available at: http://drincorda.iwlearn.org/demonstrating-solutions/flood-insurance.

Following the hydraulic analysis above, estimated flood damages were compared between the present situation (BAU – current operational rules) and the maximum possible flood control in the reservoirs (increasing buffer volumes by 20%), in the scenarios of 10- and 20-year return periods (BAU-10yrp / HP-10yrp and BAU-10yrp / HP-20yrp respectively). The results of the simulations were aggregated separately for the flooded areas in Montenegro and Albania, respectively.

The maps in Figure 16 demonstrate absolute values in euros for the estimated damages or losses for the BAU-10yrp and the HP-10yrp scenarios as well as the difference in %. The graphs in Figure 17 display the estimated monetary values for both countries and sets of scenarios.

The results from the tool indicate that in terms of economic (and human) losses, in the case of the HP-10yrp scenario damages are significantly reduced compared to the BAU-10yrp scenario. In the case of the HP-20yrp scenario, the damages in Albania could be significantly reduced, while the economic losses in the Montenegrin areas could remain essentially unchanged. However, in terms of the protection of human lives, the HP-20yrp scenario's losses in Montenegro changed favourably.

All in all, the results from the modelling analyses under the "flood-smart" scenario explored in this Assessment provide the very interesting insight that **changing the operational rules of the Spilje and Fierza HPPs to allow for a 20% increase in buffer volume could significantly reduce the flood-related damages downstream for small to average flood events, with a negligible reduction in the power generated from these plants.**

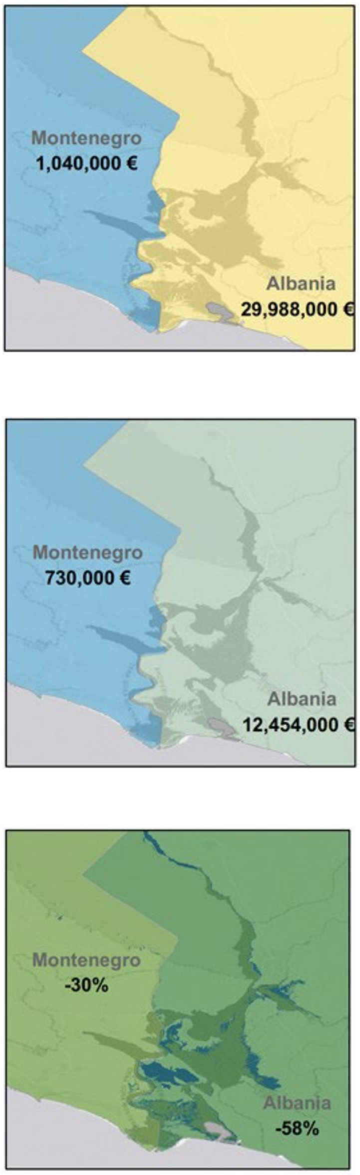
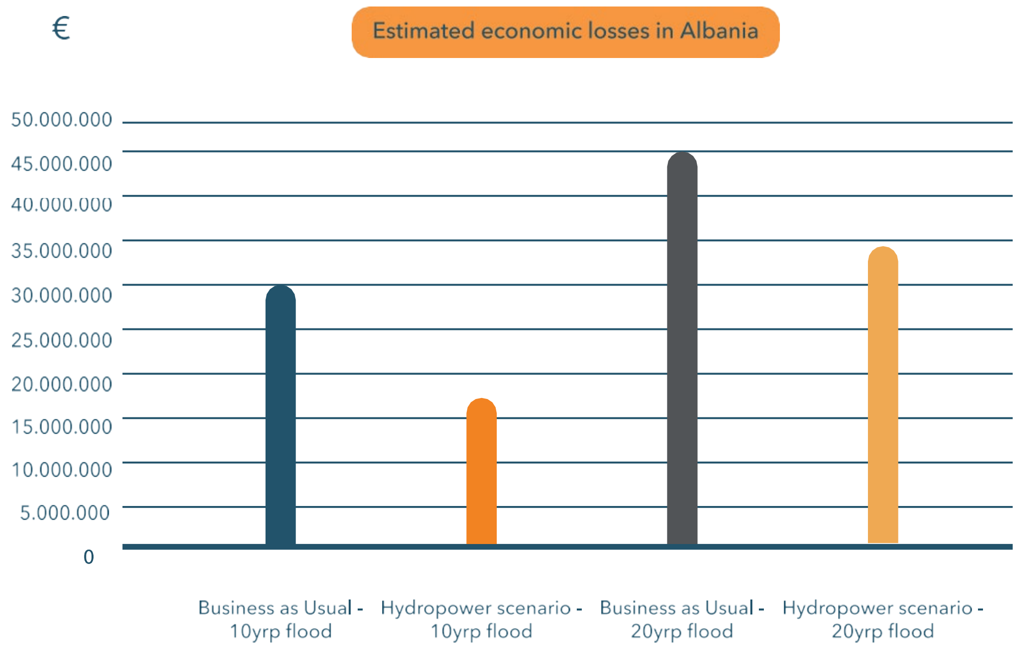


Figure 16. Flood damage losses under two scenarios, the reference scenario and the new dam rules with a 10-year return period (HP-10yrp scenario).



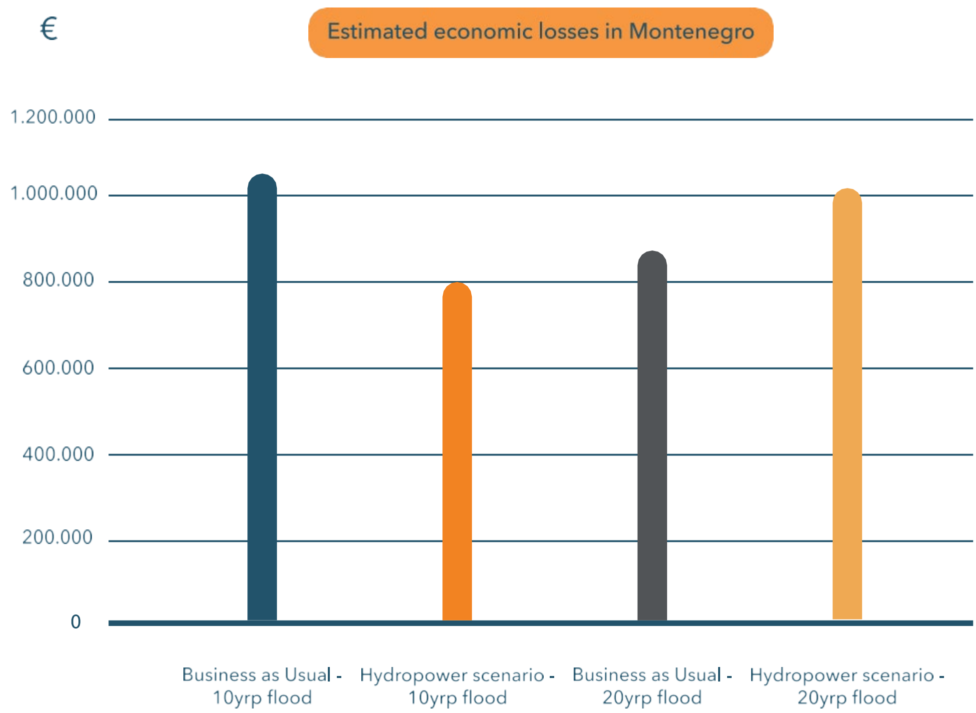


Figure 17. Flood damage losses (euros) in Albania and Montenegro (BAU represent present dam rules in a 10- and 20-year flood return period and HP new dam rules in a 10- and 20- year flood return period).

2.4.2 CLIMATE CHANGE scenario

The analysis below aims at answering the question: How would climate change impact the energy system in the Drin Basin?

The key assumption in this scenario was the change in precipitation due to climate change. This change in precipitation was then translated into a change in river discharge, which was used in OSeMOSYS to alter water availability for electricity generation in the coming years (**Figure 18**). The discharge was assumed to decrease by 3% by 2025 and 6% by 2050, in all the river segments.

The results of the scenario show that the impact of the assumed average change in precipitation patterns on electricity generation in the North Macedonian hydropower plants is about 10% by 2030 and 14% by 2050. More specifically, the generation from Globocica HPP in 2030 drops from

180 GWh in the reference scenario to 163 GWh in the CC scenario. This continues in 2050, when the generation drops to the level of 154 GWh. Similarly, Spilje HPP witnesses a drop from 293 GWh in the reference scenario to 264 GWh by 2030, reaching 253 GWh by 2050. It must be noted that these are average changes in electricity generation from average (linear) changes in precipitation patterns.

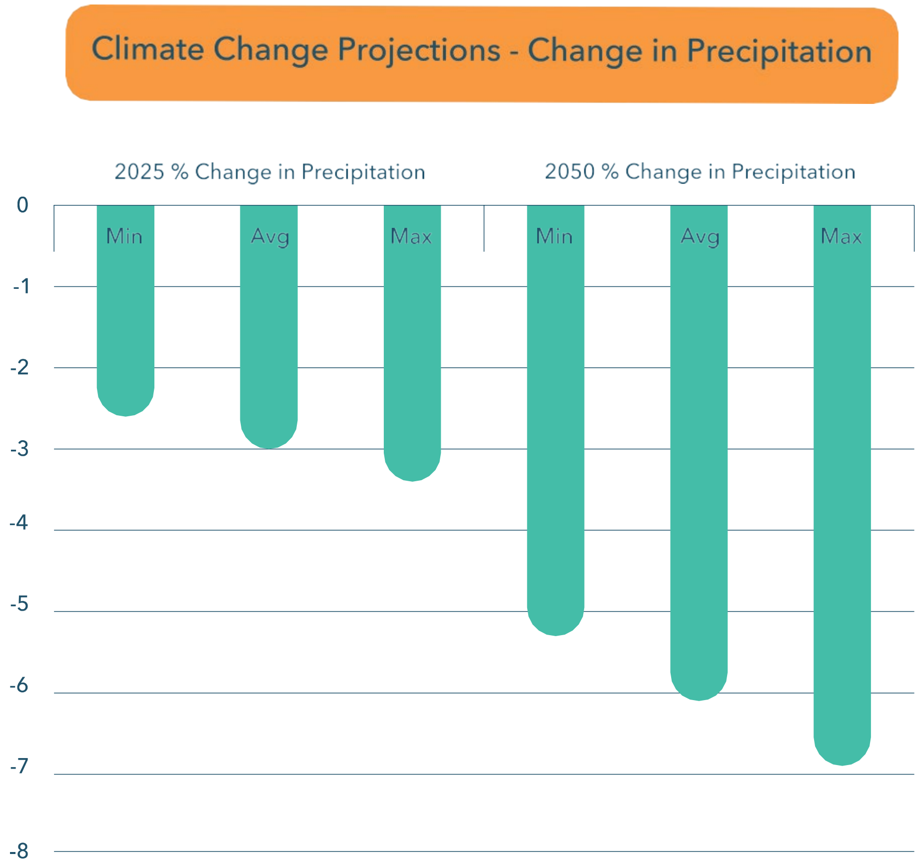


Figure 18. The average change in precipitation under the climate change projections.

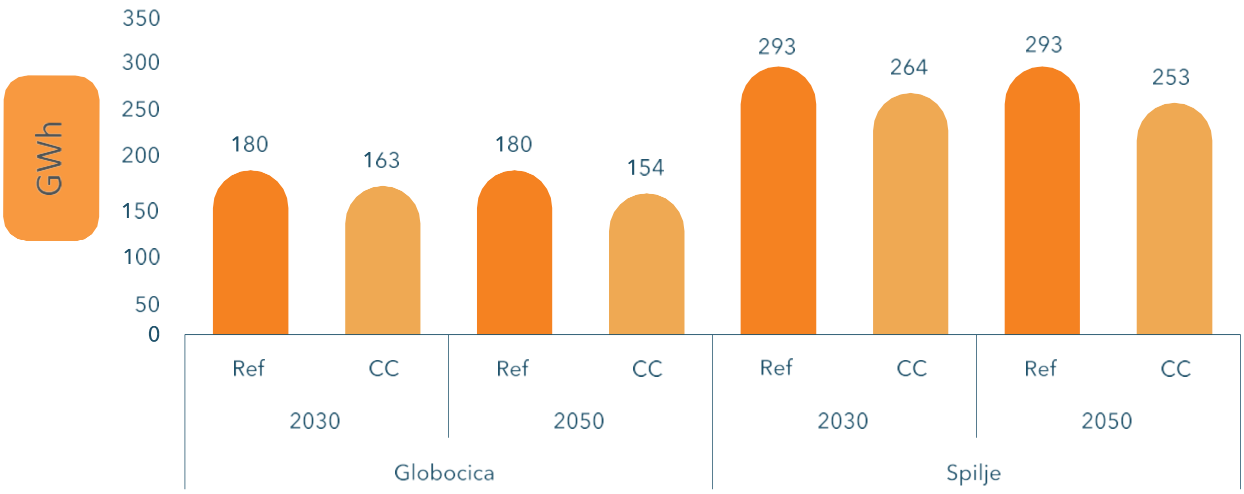


Figure 19. Change in the electricity generation in the North Macedonian hydropower plants.

In this study, we do not examine fluctuations in precipitation. More elaboration on this can be found in Section 4.

In other words, according to the assumptions of the study, climate change leads to a mean annual drop in electricity generation in the North Macedonian part of about 52 GWh in the period 2021-2050, as summarised in Table 7. This decline is compensated by increasing electricity imports in 2030 by 46 GWh (1%), and in the longer term, solar has a higher contribution in the mix, increasing by 65.5 GWh (2.3%) in 2050.

Moving to the Albanian cascade, climate change results in a similar trend, as shown in Figure 20. The losses vary from one hydropower plant to another, ranging from 6-8% by 2030 and 7-10% by 2050.

Table 7. Reduction in electricity generation in the North Macedonian hydropower plants due to climate change.

Reduction in (GWh)	Annual mean (2021-2035)	Annual mean (2021-2050)
Globocica	17	20
Spilje	27	32
Total ESM	44	52

The average annual drop in electricity generation from the Albania cascade in the Drin Basin is about 342-377 GWh as shown in Table 8. This is in line with the Climate Risk Management Plan released by KESH in 2018, which indicated that the mean annual generation in Albania would decline by 220-440 GWh due to climate change.[45]

Table 8. Reduction in electricity generation in the Albanian hydropower plants due to climate change.

Reduction in (GWh)	2021-2035	2021-2050
Fierza	93	108
Koman	154	167
Vau-i-Dejës	95	102
Total KESH	342	377

We explore how the electricity supply system of the Riparians would react to a reduction of hydropower production due to climate change if it were to operate according to cost-minimisation criteria. To compensate for the drop in electricity generation, the results show that in the short term, Albania relies on increasing its electricity imports, which increase by 365 GWh (15%) in 2030, compared to the reference scenario. In the longer run, the investments in solar and wind become more noticeable. The generation from wind plays an important role in mitigating climate change impact on hydro. Generation from wind increases by 42%, supplying an additional 430 GWh of electricity to the Albanian grid by 2050. It is worth mentioning that all the planned solar and wind projects in all countries were taken into consideration as shown in the Annex. Additionally, the model was given the flexibility to increase solar and wind installations gradually from 2030 onward. Since the model is an optimisation model, it decides to invest in a new capacity only when it is the least-cost option.

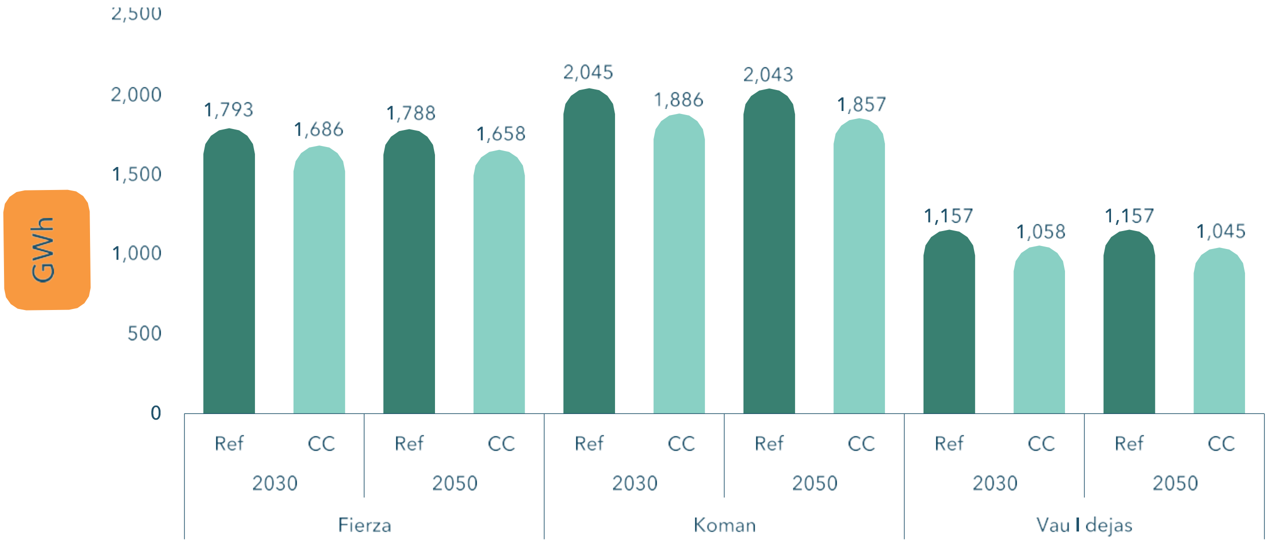


Figure 20. Change in the electricity generation in the Albanian hydropower plants in the BAU and CC scenarios.

45 Albanian Power Corporation KESH, 'Climate Risk Management Plan' (2018), http://www.kesh.al/wp-content/uploads/2020/05/CLIMATE-RISK-MANAGE- MENT-PLAN-2018-1.pdf.

2.4.3 The **ENERGY IMPACT** of a new dam (Skavica)

The analysis below aims to answer the following question: What is the impact of the new HPP (Skavica) on electricity production and electricity imports?

This scenario explores the impact of the Skavica dam on electricity generation in the Basin, in the case that the whole system follows a least-cost optimisation. In other words, the scenario places the new dam within the broader context of the entire electricity systems of the countries and allows competition for electricity generation with other technological options. The results show that with the introduction of the Skavica dam (2,300 MCM) and HPP (196 MW), the new hydropower plant starts adding about 550 GWh of electricity to the Albanian grid from 2025 onward. This improves energy dependency by reducing electricity imports by more than 9 TWh or 16% between 2025 and 2042.

On the other hand, the Skavica Project adds another hydropower plant to the Albanian electricity system, which is already highly dependent on hydropower and therefore vulnerable to changes in climate.

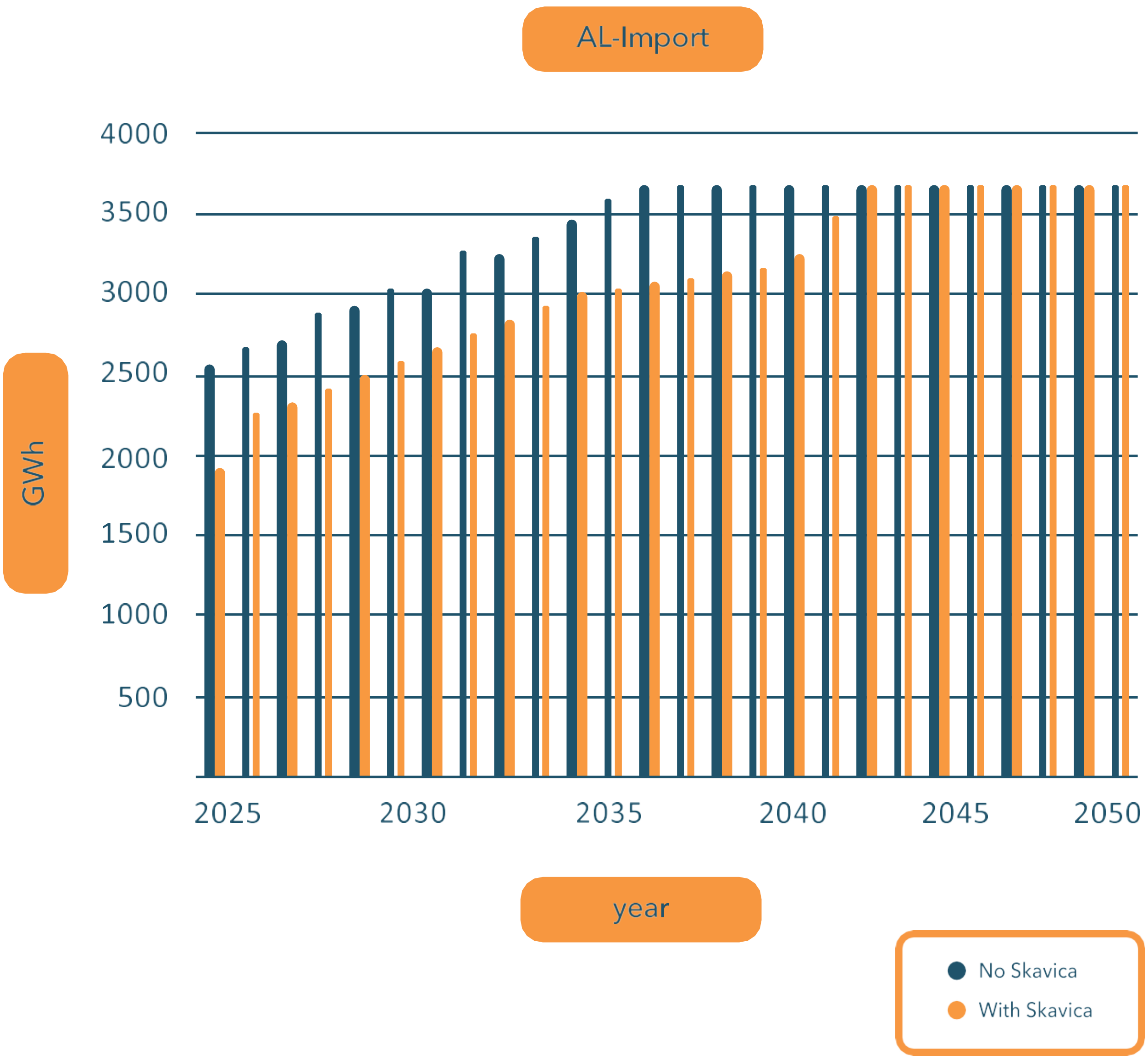
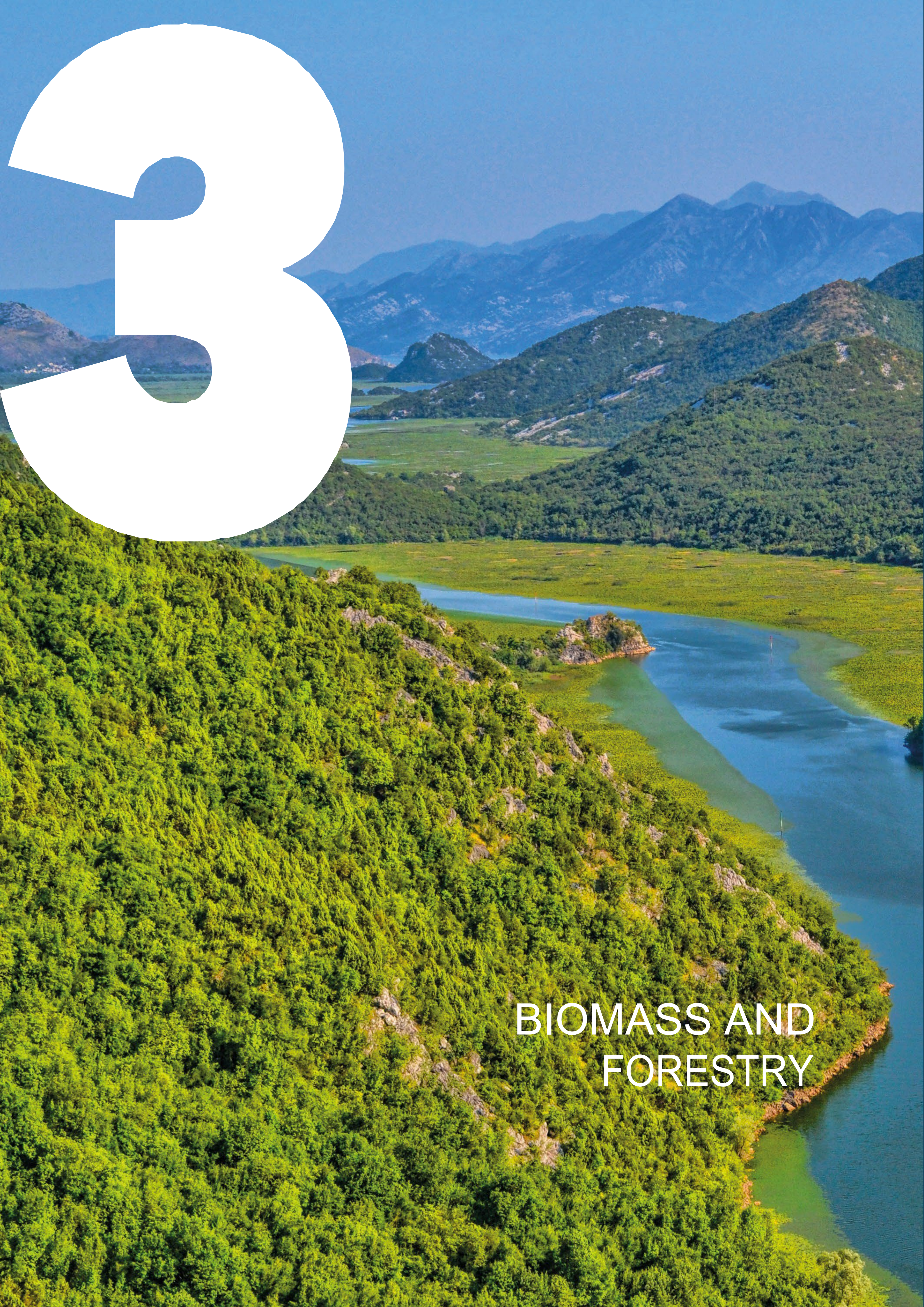


Figure 21. Change in annual electricity imports in Albania.



3

BIOMASS AND FORESTRY

This chapter is based on the Report "Strengthening the value chain of energy biomass in the Drin River Basin for a more sustainable management of forests, and related Nexus implications" prepared by CNVP for the UNECE.[46]

The first aim of the chapter is to provide a picture of various interdependencies across water, ecosystems, energy, food and other areas (e.g. climate change and biodiversity) in terms of uses, needs, economic and social benefits, potential synergies, conflicts and trade-offs of biomass. The second aim is to identify possible policy responses to the identified issues in order to strengthen the value chain of energy biomass and ensure a more sustainable management of forests in the Drin River Basin.

The chapter maps and quantifies – to the extent possible given the available data – key intersectoral linkages, shedding light on how action by the key economic sectors of energy and forestry can contribute to the objectives of the SAP.

46 Report available at: https://gwp.org/globalassets/global/gwp-med-files/news-and-activities/sub-srin/drin-nexus-assessment---biomass-forestry-report.pdf.

3.1 METHODOLOGY

The following main steps are included to address the required tasks within the set goals:

1. Collection of documents and data

Most of the data are obtained from direct sources, such as national institutions or international organisations. The list of policies, institutions, and legislations that are relevant to bioenergy and forestry in the Drin Riparians are reviewed. Relevant statistics on forestry and biomass for each Riparian (and sub-national regions belonging to the Drin Basin) were collected.

2. Mapping of interlinkages

A map of interlinkages (cross-sectoral impacts, trade-offs, synergies) related to the use of biomass across the water-food-energy ecosystems Nexus and associated interlinkages to quantifiable key indicators is elaborated based on the concept of biomass, its source, and products. Interlinkages are made with key indicators to policies/legislations from the countries. Quantified key indicators are provided at the national or Basin level as appropriate, clearly explaining assumptions and methodologies used and indicating major data gaps.

3. Review and analysis of data

The collected data are reviewed and analysed accordingly through charts and graphs.

4. Preparation of solutions and benefits package

A package of solutions is prepared using the 5Is framework (Institutions, Information, Instruments, Infrastructure [and investments], International cooperation), specifying the means of implementation. The goal is to achieve sustainable production and consumption of biomass in the region, and to maximise the impact that a modern value chain of biomass would have on the economy within the Basin.

The benefits associated with the package of solutions were determined and categorised into four groups: economic, environmental, social, and regional.

5. Consultation

Several consultation meetings were held with relevant stakeholders in the framework of the Project's activities. During such consultations the data collected, approach and expected results are shared with the relevant stakeholders. The feedback provided by the stakeholders is integrated in the report.

3.2 CONCEPTS AND DEFINITIONS

The relationships within the biomass sector are manifold in relation to Basin management. There are several critical issues that relate to the origin of the biomass, the source from which the biomass is obtained, and the products and use of biomass. The critical issues shown in Figure 22 below have been identified in relation to the biomass value chain.

The word biomass is frequently used and in many ways. The formal meaning of biomass is: "the mass of living organisms, including plants, animals, and microorganisms and it includes both the above- and below-ground tissues of plants."[47] This definition is used in ecology and biology.

However, there is another use of the term biomass. Often biomass is referred to as a product. In this case, the definition of biomass is: "plant or animal material used for energy production (electricity or heat), or in various industrial processes as raw substance for a range of products."[48] This encompasses all woody and non-woody biomass harvested, which includes fuelwood, as a product for any further use, especially energy. In general, this meaning of the word biomass is used within this report. At times, the term 'biomass product' is used, but in practice just the word biomass is used. There are also further usages of the term biomass, giving it a specific meaning and relevance. It is important to distinguish between these terms and to clarify what is meant when the term biomass is used. Other uses are wood biomass, which, in the case of following the ecological definition, would include all biomass that has a wood structure. However, when wood biomass is interpreted from the product side, it becomes confusing. Is it including timber and construction wood, or is it including fuelwood or only other biomass, such as chipped woody biomass? One way to define wood biomass is as: any timber-derived product (softwood or hardwood) capable of being converted to energy through direct combustion or gasification; to solid fuel through pelletising; or to liquid fuel through myriad processes. This report follows this definition, although it is understood that there is also a very limited use of wood biomass for other purposes than energy, such as gardening or landscaping. It is important to note that this definition includes fuelwood and processed wood biomass. It may also include residues from the wood industry. In this report, it includes fuelwood in general and processed biomass. When it includes other aspects such as residues, this is made explicit.

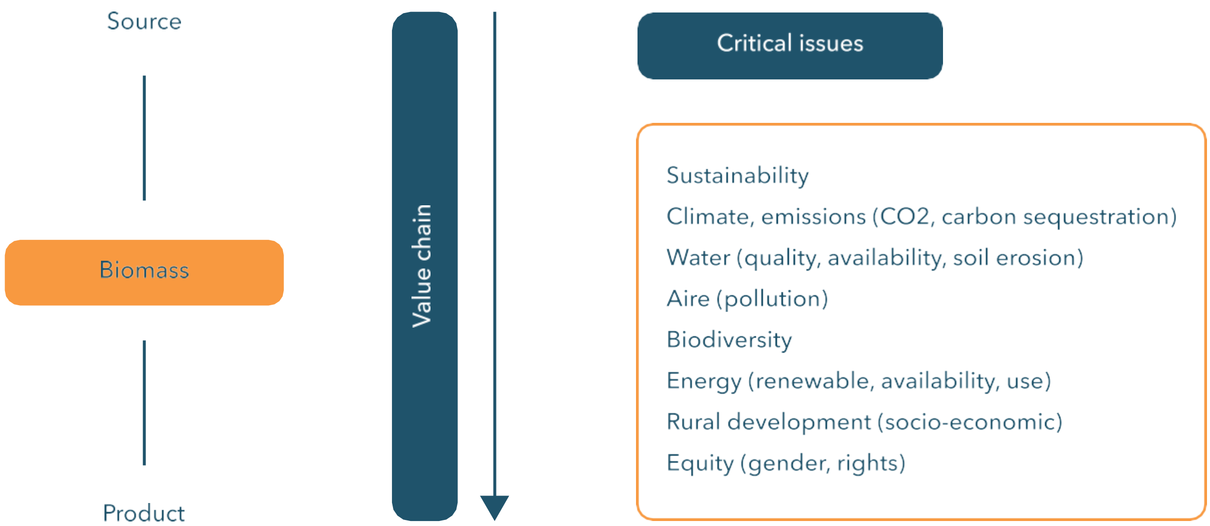


Figure 22. Concept and critical issues.

47 R.A. Houghton, 'Encyclopaedia of Ecology' (2008).
48 Ur-Rehman, S; Mushtaq, Z; Zahoor, T; Jamil, A; Murtaza, MA, 'Xylitol: a review on bioproduction, application, health benefits, and related safety issues', Critical Reviews in Food Science and Nutrition (2015).

3.3 GOVERNANCE, POLICIES AND STRATEGIES

The natural resources in the Drin Basin offer a prime opportunity to invest in the development of biomass. The use of biomass-based renewable energy provides benefits in terms of cleaner and more efficient energy, and would allow for rural development through the development of a more modern biomass value chain. It would enable more processing, creating more job opportunities and providing higher economic value. Although there might be export opportunities, the internal market with its strong focus on (biomass) fuelwood for energy will be the main offset. These benefits, however, only have a positive offset when the biomass comes from sustainably managed resources, and when the role and functioning of those natural resources to provide for ecosystem services is not compromised. The costs of diminished ecosystem services can outweigh the benefits of biomass from energy, as increased forest and land degradation leads to associated costs, for instance, regarding erosion, floods and sedimentation. Examples of such costs include those related to damaged infrastructure, higher flood risks, reduced hydropower production, and damaged agricultural land or irrigation channels.

Proper policy guidelines, a conducive environment, and a clear legal and institutional framework are required. Currently, Riparians promote the switch to efficient and cleaner biomass products, but this is not incentivised. However, North Macedonia has started providing subsidies to citizens to procure pellet stoves to switch to cleaner energy sources.[49]

Sustainable forestry and biomass development is not a high priority in the countries' development plans. Montenegro is an exception, prioritising its national forestry strategy and policy. The government has taken concrete political steps to address unsustainable forest exploitation.

To support further development of the biomass sector governance, a conducive environment is needed in several areas. These areas are in the fields corresponding to the key critical issues, and related to natural resources, especially forestry, energy, water and climate. Along with these socio-economic aspects are rural development goals. Annex 4 provides a long list of policy and strategy documents. The following sections cover the main ones.

49 Balkan Green Energy News, 'Skopje subsidising procurement of pellet stoves' (2018), https://balkangreenenergynews.com/skopje-subsidizing-procurement-pellet-stoves/.

3.3.1 FORESTRY

Sustainable management of natural resources is a prerequisite in order to develop the biomass sector. This is reflected in many policies and strategic documents, of which the policy and strategy for forestry are instrumental. The main strategy measures are as follows:

- In Albania's most recent forest law (2020), sustainable management is regulated and safeguarding ecosystem services is protected. Albania's Forest Strategy calls for the promotion of industrial wood, including biomass to produce pellets. To achieve this, it stipulates the need to create the possibility to harvest biomass from forests through thinning from young forest stands and protection forests.[50]
- North Macedonia's national forest strategy aims to promote sustainable forest management principles and develop a system of criteria and indicators for their implementation in real forests.[51]
- The Montenegrin forestry policy indicates the need for research, especially on the role of forests in mitigating climate changes, the adjustment of forests to climate changes, and the functioning of forest ecosystems, protection of biodiversity, use of timber and biomass, and the relationship between forests and water, competitiveness, and rural development.[52] Additionally, this policy stipulates the following measures: a coppice management system for biomass to be further developed; promotion of timber products as construction material and a source of energy; pilot project for biomass-based heating; and the promotion of construction of biomass heating plants.
- Kosovo* wants to take measures to increase biomass availability, considering other biomass users (agriculture and forest-based sectors) and mobilising new biomass sources. It has identified several issues:
  - a. No data is available on the level of degradation of agricultural and forest lands.
  - b. No data is available on the surface of unused arable land.
  - c. No measures are yet proposed for the

50 Forest Policy of Albania (2018), Ministry of Tourism and Environment.

51 Strategy for Sustainable Development of Forestry in The Republic of Macedonia (2006), Ministry of Agriculture Forestry and Water Economy.

52 National Forest Policy of Montenegro (2008), Ministry of Agriculture Forestry and Water Economy.

encouragement of use of non-arable land, degraded land, etc. for purposes of energy culture cultivation.

d. No use of primary materials is planned (such as animal fertiliser) for energy uses.

e. The encouragement of production and use of biogas is leveraged through state policies – the feed-in tariff for biogas.

f. In relation to the planning of measures for the improvement of techniques for forest management, the Forestry Development Strategy 2010-2020 foresees a project for forest management advancement.[53]

3.3.2 ENERGY

Biomass for energy is a renewable energy source. Policies, strategies and legislation increasingly promote the use of renewable energy and create a framework to support this:

- The National Energy Strategy of Albania calls for a maximal use of biomass, at low financial costs and limited costs for the environment. An approach for how to support this use of biomass has not yet been consolidated.
- In North Macedonia, the basic legal elements for renewable energy and the promotion of renewable energy are provided in the Law on Energy (Official Gazette of the Republic of Macedonia No. 63/2006, 36/2007, 106/2008).
- North Macedonia's Renewable Energy Strategy only plans for a future increase of waste biomass for combined heat and power generation. This, however, has not been consolidated and there are no specific goals and measures for other biomass utilisation or development.[54]
- Through its National Forest Strategy, Montenegro aims to increase demand for biomass by introducing the heating of public buildings with wood chips and cogeneration. It also aims to invest in sustainable forest management of private and State forests.[55]
- In its National Renewable Energy Strategy, Montenegro promoted the use of energy-efficient technology such as biomass boilers. It seeks to achieve this through interest-free credit lines for the installation of heating systems on modern biomass fuels (pellets, briquettes) for households.[56]
- Kosovo* – through its Policy and Strategy Paper for Development of the Forestry Sector – aims to develop efficient production and utilisation of wood biomass for heating purposes.[57]
- In line with this, Kosovo* will support the development of the wood biomass market, taking into account the forms of its use such as pellets and briquettes. It also seeks to construct a new co-generation plant based on biomass (16.5 MWt/1.5 MWe).[58]
- Wood biomass for energy is the main source in the Basin, but other resources could provide interesting opportunities. The majority of biomass is obtained directly from natural resources. Additional industrial residue from wood processing is used for biomass energy. Other biomass from municipal waste or other residues from industrial production processes could significantly contribute to the total energy generation from biomass.[59] Clear policies, strategies and practices are lacking in the Basin region.

53 National Renewable Energy Action Plan 2011 – 2020 (2013), Ministry of Economic Development, Government of The Republic of Kosovo*.
54 Strategy for Utilisation of Renewable Energy Sources in the Republic of Macedonia (2010), Ministry of Economy.

55 National Forestry Strategy, with Forest and Forestry Development plan 2014 – 2023 (2014), Ministry of Agriculture and Rural Development, Montenegro.
56 National Renewable Energy Strategy to 2020 (2009), Government of Montenegro.
57 Policy and Strategy Paper for Development of Forestry 2010 – 2020 (2009), Ministry of Agriculture, Forestry and Rural Development, Government of The Republic of Kosovo*.
58 Energy Strategy Implementation Programme 2018-2020 (2018), Ministry of Economic Development, Government of The Republic of Kosovo*.
59 Strategy for Energy Development in the Republic of Macedonia until 2030 (2010), Ministry of Economy, Government of the Republic of North Macedonia.

3.4 FOREST AND BIOMASS SITUATION IN THE BASIN

Forest and shrubs/open areas provide the vast majority of land cover in the Basin, each accounting for about one-third of the Basin area: 667,000 ha forest and 723,000 ha shrubs and open spaces.

This data is based on CORINE Land Cover.[60] The disadvantage of CORINE is that it does not always correspond to the classification used by governments in the different countries. For example, shrubs or wastelands are defined differently. When using the data for further analysis, CORINE also poses problems. In the analysis, details of forests are provided for degraded forests or for levels of illegal logging. Such details are not provided when using the CORINE data, hence these data will not correspond to the data of the Riparians. Use is therefore made of official data from the different countries for this report .

Unfortunately, there is no data available at river basin level. Although regional data is sometimes available at national level, they cannot be used at river basin level. For Basin levels, geographical boundaries are used, instead of administrative units. To obtain figures at Basin level the official Riparian institutional data is used to calculate the relative share based on the relative area size of the Basin at national level. This provides a **rough estimate** as it does not account for regional differences, therefore rounded figures are used. This corresponds with data from the specific national institutions for the Riparians and corresponding areas. Using the relative share for the Basin provides a higher forest cover of the Basin. This is mainly due to the difference in defining shrub areas between the CORINE data and national statistics.

Besides the forest area, there is a considerable area of trees and woodlots outside the forests. These include, for example, hedgerows, solitary trees and small woodlots located in rural areas and along agriculture lands. The total area for the Basin with trees outside forest is 550,000 ha (see Annex 1, Table 3).

These forest and forested areas provide an important source for wood products. The main categories are timber, construction wood, fuelwood and woody biomass (see Table 9). The most important product is fuelwood. Within the Basin, over 80% of all wood harvest is destined to become fuelwood. Processed biomass for energy is only produced and used on a limited scale, and processed biomass is barely produced in the Drin River Basin.

Table 9. Annual Harvest of Wood Products

Annual Harvest of Wood Products							
Drin Basin	Annual harvest timber (m^3/ yr) in Basin	Annual harvest timber (% of total)	Annual harvest fuelwood (m^3/yr) in Basin	Annual harvest fuelwood (% of total) in basin	Annual harvest processed biomass[61] (m^3/yr) in Basin	Annual harvest processed biomass (% of total)	Total annual harvest (m^3/yr) in Basin
Albania	20,000	2.5%	670,000	82.7%	120,000	14.8%	810,000
Kosovo*	90,000	7.1%	950,000	74.8%	230,000	18.1%	1,270,000
Montenegro	40,000	13.8%	250,000	86.2%	0	0.0%	290,000
North Macedonia	40,000	12.1%	290,000	87.9%	0	0.0%	330,000
Total	190,000	7.0%	**2,160,000**	80.0%	**350,000**	13.0%	**2,700,000**

Sources:
FAO database and FAO WISDOM: http://www.fao.org/faostat/en/#data/FO
MAFRD (2013) Kosovo* National Forestry Inventory 2012, Government of the Republic of Kosovo*, Pristina
WISDOM Montenegro, FAO, and http://www.fao.org/faostat/en/#data/FO
WISDOM North Macedonia, FAO, Rome 2018. and FAO forest products database

60 Available at: https://land.copernicus.eu/pan-european/corine-land-cover.

61 Processed biomass is defined here as woody biomass obtained for further processing, in general, a chopped material for energy.

Besides woody biomass, biomass from agriculture is also obtained. However, only a very limited share of the agricultural biomass is used for energy production (see Table 10). Biomass from agriculture, so-called “agro-residues”, are leftovers from the main agriculture production.

Table 10. Biomass from Agriculture

Biomass from Agriculture				
Drin Basin	Biomass from agriculture (tonnes/yr)	Share of total biomass from agriculture used for energy (%)	Biomass from agriculture used for energy (tonnes/yr)	Biomass from agriculture in Basin (tonnes/yr)
Albania	262,000	2.0%	5,240	70,000
Kosovo*	207,354	1.5%	3,100	90,000
Montenegro	8,154	0.0%	0	3,000
North Macedonia	72,636	4.0%	2,905	10,000
Total	550,144	1.9%	11,245	173,000

Source: World Bank (2017) Biomass-Based Heating in the Western Balkans, A Roadmap for Sustainable Development

3.5 KEY INTERLINKAGES BETWEEN WATER-ENERGY AND BIOMASS ALONG THE BASIN

3.5.1 FOREST and LAND

All biomass in the Basin originates from a land resource. To understand the biomass sector and further develop its value chain, it is crucial to know how much land is available and ascertain the growth capacity. In the Drin Basin, 21% of the land is arable land, 33% is forests and 36% is shrubland. The most important source for biomass is forests, with 870,000 ha within the Basin. From the forests in the Drin River Basin 2.7 million m^3/year wood biomass is harvested annually, of which 80% is fuelwood and 12% processed biomass (see Table 9). Additionally, about 0.17 million tonnes/year biomass is harvested from agricultural land.

It is important to review whether this harvest is sustainable. The total stock[62] of wood in the forests in the Basin is 82 million m^3 with an annual growth of 2.1 million m^3/year (see Annex 1, Tables 8 and 9). There are also trees and woodlots outside forests contributing to biomass. These comprise an area of 490,000 ha with an annual growth of about 0.1 million m^3/year (see Annex 1, Tables 10 and 11). This gives a total annual wood biomass growth of 2.2 million m^3/year within the Drin Basin.

Based on these figures, there is a negative balance of 0.5 million m^3/year of wood biomass harvest. This would mean that there is overexploitation of the resource. However, this figure needs to be taken with some consideration, as the annual growth figures are based on wood stem up to 7 cm diameter, not considering branches and smaller dimensions, while these are used often as fuelwood and for processed biomass. On the other hand, illegal logging is not considered, and there is also a loss of wood biomass due to forest fires and diseases.

Taking this into account, there is concern of unsustainable harvest leading to a diminishing ability of forest and land resources to provide ecosystem services, including the sustained provision of biomass and other forest products in

62 Total stock is defined as standing volume wood biomass in forests of stem volume up to 7 cm diameter.

the long term. The share of 11% degraded forest area in the Drin Basin is an indication of unsustainable management of forests.

Table 11. Degraded Forest Area.

Drin Basin	Relative forest area in the Basin (ha) Degraded forest in Basin (ha)		Share of degraded forest in Basin (%)
Albania	280,000	60,000	21%
Kosovo*	200,000	20,000	12%
Montenegro	260,000	10,000	4%
North Macedonia	130,000	6,000	4%
Total	870,000	96,000	11%

Sources:
Albania: INSTAT (2019) Statistical Yearbook 2019, Institute of Statistics, Government of the Republic of Albania, http://www.instat.gov.al/en/themes/agriculture-and-fishery/forests/publication/2020/forest-statistics-2019/
Kosovo*: MAFRD (2013) Kosovo* National Inventory 2012, Government of the Republic of Kosovo*, Pristina
Montenegro: FAO (2020) Country Report Montenegro, Global Forest Resources Assessment 2020, Rome, http://www.fao.org/3/cb0029en/cb0029en.pdf
North Macedonia: State Statistical Office (2020) Forestry 2020, agriculture statistics review, Government of the Republic of North Macedonia, https://www.stat.gov.mk/PrikaziPoslednaPublikacija_en.aspx?id=34

3.5.2 ENERGY-BIOMASS CONNECTION

The biomass obtained in the Drin Basin is mainly used for energy. Of the total harvest of 2.7 million m³/year in the Basin, 80% is used as fuelwood and an additional 13% is processed biomass. The harvest of biomass corresponds with the use of biomass in the Basin. The fuelwood harvest of 2.16 million m³/year compares with a 2.14 million m³/year use of fuelwood in the Basin. The vast majority of all fuelwood is produced for the internal markets. Only very limited amounts of fuelwood are exported (about 1% of the total annual fuelwood harvest), as indicated in Table 18 of Annex 1. The share of exported processed biomass is larger, but processed biomass constitutes only a limited part of the total annual harvest (see Table 3: Annual Harvest Wood Products).

Export is currently not a driver for forest exploitation. However, it is estimated that the demand for processed biomass for energy production will further increase in the future, both internally and within the European Union. This demand may lead to an increased demand for wood harvest. Biomass is the most important energy source for renewable energy in the region; 72% of all renewables comes from biomass, while renewable energy makes up about one-fourth of all energy used. In Albania and Montenegro, the share of hydropower of the total energy consumption is relatively large, making the share of biomass proportionally less in terms of total renewable energy, compared to Kosovo* and North Macedonia. Data used here refers to the total energy consumption in the countries; if only electricity were considered, the share of hydropower would be much higher. Biomass (fuelwood) is especially used for heating spaces, making it important for fulfilling the energy demand in the Riparians.

Table 12. Households using Fuelwood or Biomass for Heating or Cooking.

Drin Basin	Households using fuelwood or biomass for heating or cooking (#)	Share of total households in the country (%)	Average use of fuelwood by households for heating or cooking (m³/yr)
Albania	480,155	66.5%	6.4
Kosovo*	271,187	74.6%	7.6
Montenegro	131,004	68.1%	5.5
North Macedonia	349,839	62.6%	6.2
Total	1,232,185	68.0%	6.4

Sources:
Albania: INSTAT (2018) Statistical Yearbook 2018, Institute of Statistics, Government of the Republic of Albania, www.instat.gov.al/en/themes/censuses/census-of-population-and-housing/#tab2
Kosovo*: MAFRD (2013) Kosovo* National Forestry Inventory 2012, Government of the Republic of Kosovo*, Pristina
Montenegro: FAO (2020) WISDOM database: http://www.fao.org/faostat/en/#data/FO visited 2020-09-12
North Macedonia: FAO (2020) WISDOM database: http://www.fao.org/faostat/en/#data/FO visited 2020-09-12

The consumption of firewood in households is widespread in the region. Even with greater availability and increased use of other renewable energy sources, fuelwood remains and will remain a major source, at least for heating, in the near future.

The reason for fuelwood use is mainly driven by limited availability and affordability of alternative fuels, and habits and traditions of using fuelwood. Often people are not able to switch to alternative renewable energy sources, even if these are more efficient, due to the high upfront investment costs needed to make the switch. The investment costs in a new modern energy system are restrictive and intensify the use of fuelwood.

Other renewable biomass products are pellets and wood chips. Wood pellets, in particular, are becoming increasingly common. The use of processed biomass results in higher efficiency, as it gives a higher caloric burning value compared to fuelwood. Initial advancements can be observed at different stages of the biomass energy value chain. There is an increasing consumption of pellets in households and a growing import of efficient pellet stoves. The use of pellets and improved stoves are mainly due to import. There are a few initiatives – often with external Project support – to produce local pellets and stoves. Local pellet production takes place in Montenegro and Albania[63] as well as in Kosovo* and there is a wood stove producer in North Macedonia[64]. When developing pellet production, a mechanism has to be put in place to prevent it from causing outsize pressure for logging. Another development is the valorisation of various sources of biomass, e.g. some pellet production from vineyard debris. However, in general, the production of pellets in the Riparians remains very low and limited to small private businesses.

There is only a limited amount of export of biomass from the Basin. Some export takes place across borders within the Basin as local informal trade. Export production is, however, gradually increasing, not only driven by exports to the EU, but also as a result of growing demands in the region, most notably in Serbia and Bosnia and Herzegovina. The price of fuelwood has increased dramatically.

Between 2015 and 2018, the price of firewood in the region grew threefold (from €20 to €60 per stacked cubic metre).[65]

3.5.3 WATER RESOURCES and SOIL

The availability of water, its quality and water management are one of the major ecosystem services within the Basin. The water relations are directly dependent on the management of natural resources and the use of the resources for products, such as biomass. All Riparians depend on each other to effectively address the safeguarding of water management.

63 Wood biomass value chain analysis in four regions of Albania (2017), CNVP, Tirana.

64 Wood biomass production: Opportunities for sustainable biomass production from small scale forestry in Kosovo* and its region, Strengthening Sustainable Private and Decentralised Forestry Project Kosovo* & regional, Prishtina (2014), CNVP.

65 FAO, Forest Products Annual Market Review 2017-2018 (2019).

Soil degradation and erosion is a common problem in the region. The mountainous circumstances and steep slopes within the Drin Basin with high precipitation patterns make the Basin very sensitive to erosion. In North Macedonia yearly soil losses – at country level – are 17.1 million m^3, and over 2 million m^3 in Montenegro. In Albania, the yearly rate of soil loss is estimated at 10.9–15.1 t/ha.[66] Sustainable land use and sustainable natural resource management is required to ensure that a proper vegetation cover exists to control erosion and assure soil conservation. Different studies are available providing recommendations and insights on the extent of soil erosion, water run-off and sedimentation in relation to vegetation cover. Sustainably managed forests provide the best soil protection cover on slopes.

Table 13. Growing Stock.

Drin Basin	Relative forest area in the Basin (ha)	Growing stock (standing volume m^3)	Growing stock (standing volume m^3) in Basin
Albania	280,000	54,925,000	15,000,000
Kosovo*	200,000	40,508,000	17,000,000
Montenegro	260,000	122,000,000	39,000,000
North Macedonia	130,000	87,779,890	11,000,000
Total	870,000	305,212,890	82,000,000

Source: see Annex 1, Table 14
Albania: INSTAT (2018) Statistical Yearbook 2018, Institute of Statistics, Government of the Republic of Albania, http://www.instat.gov.al/media/4966/statistical-yearbook-2018-dt-21112018-i-fundit.pdf
Kosovo*: MAFRD (2013) Kosovo* National Forestry Inventory 2012, Government of the Republic of Kosovo*, Pristina
Montenegro: Dees, Mathias et. Al (2013) National Forest Inventory of Montenegro, Ministry of Agriculture, Forestry and Rural Development, WISDOM FAO
North Macedonia: FAO (2020) WISDOM database: http://www.fao.org/faostat/en/#data/FO visited 2020-09-12

The dilemma of increased use of biomass is an increased demand for biomass harvest in forests, which may lead to uncontrolled and unsustainable harvesting. If this is done unsustainably, it will reduce the amount of carbon stored and reduce the capacity of forests for carbon sequestration (CO2 storage) due to forest degradation.

66 Binaj, Veizi, Beqiraj, Qjoka, Kasa, 'Economic Losses from Soil Degradation in Agricultural Areas in Albania', Agric. Econ. – Czech, 60, 2014 (6): 287–293 (2014).

It is important to note that wood biomass used for energy directly releases the carbon through emissions, while wood used for lasting purposes (building and construction) stores carbon during the lifespan of the product. From a climate change perspective, the preference is therefore using wood products in a sustainable use (meaning products having a long-lasting life), above the use of wood biomass for products with a short lifespan, such as biomass for paper or energy. The carbon stored in the wood products is released immediately when it is used for energy production.

The overall mapping of interlinkages is presented in the graph below.

The conclusions of the analysis on sustainable biomass and forestry in the Drin Basin are presented in the following chapter.

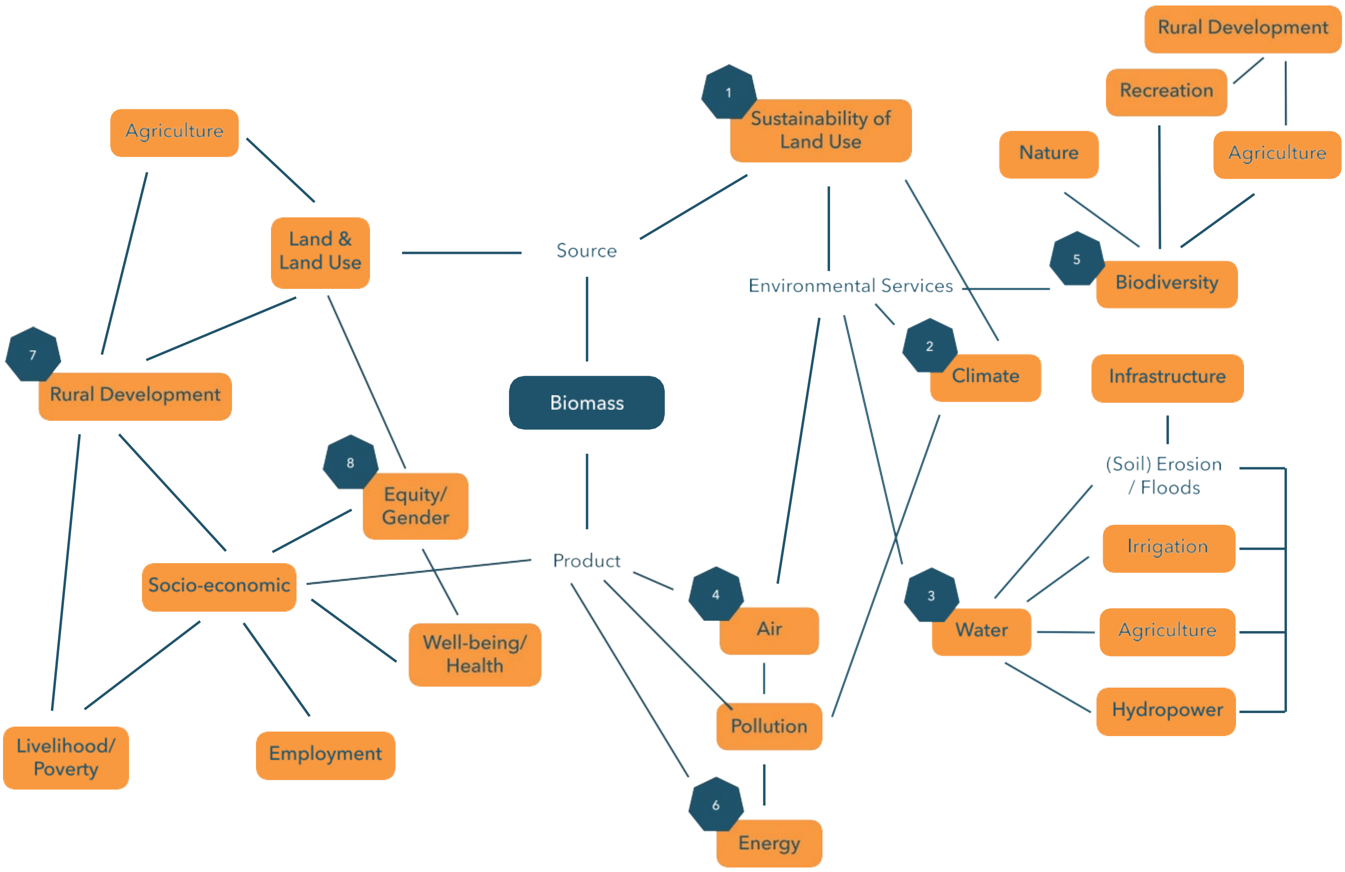


Figure 23. Map of Interlinkages.

4

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations from the Nexus analyses of the topics "Hydropower and Floods" and "Biomass and Forestry" are slightly different in nature, reflecting the different analytical approaches applied.

Drawing from the scenario analysis and backed by the water-energy integrated modelling exercise, this Assessment contains important quantitative *insights* for policymakers concerned with decisions on energy and water infrastructure in the Drin, in view of climate change. It is recommended that these insights are considered in the process of decision-making. Further analytical work is also recommended.

On "Biomass and Forestry", the available statistics did not allow for a fully quantitative analysis. However, it was possible to develop recommendations using the qualitative information available as well. The resulting *recommendations* are formulated based on the 5Is framework proposed by the UNECE [67](Institutions, Information, Instruments, Infrastructure and International cooperation). Where relevant, they make explicit reference to specific objectives of the SAP.

67 See: Methodology for assessing the water-food-energy-ecosystems nexus in transboundary basins and experiences from its application: synthesis | UNECE.

4.1 HYDROPOWER AND FLOODS

The Drin River Basin is naturally prone to floods and with climate change these are becoming more frequent. This study explored the role of hydropower operations and new hydropower construction in the Drin Basin, and their role in mitigating the risk of floods. This could be called 'flood-smart management of the hydropower plants in the Basin'. A number of conclusions can be drawn from this analysis, as follows.

First, the impact of climate change on hydropower generation in the Drin Basin may result in a non-negligible (6-14% annually) decline in generation in the coming two decades. The losses (in absolute terms) in the Albanian cascade are larger than in the other Riparians, and could reach on average up to 370 GWh per year. Taking a least-cost perspective to electricity supply planning, non-hydro renewables can play an important role in mitigating the impact of climate change on the security of the electricity supply, especially in the long term. Solar would have a higher share in the North Macedonian part, supplying up to 65 GWh of electricity by 2050, while wind would have a larger share in the Albanian side, which would supply about 430 GWh (40%) of the Albanian demand. In the short term, until the solar and wind investments take place, both countries would rely on increased imports.

Second, the investment in the new Skavica Hydropower Plant will improve flood mitigation and will also increase energy independence. The additional 200 MW capacity will add about 500 GWh of hydropower to the Albanian grid and will reduce imports by 9,000 GWh between 2025 and 2042. Furthermore, Skavica will add 2,300 MCM of storage capacity, which is needed to mitigate flood risk. However, its construction will not contribute to the country's diversification of electrical production, and Albania will remain highly exposed to climate change impact.

Third, changing the operational rules of the dams to accommodate floods would have a minor impact on the security of the electricity supply. The losses in terms of electricity generation from the studied hydropower plants (Spilje and Fierza) will be in the range of 1-3% annually. From an electricity-system-wide perspective, this supports the conclusions by the project 'Climate Change Adaptation in Transboundary Flood Risk Management in Western Balkans', which asserts that the losses in terms of electricity generation would be relatively limited. On the other hand, such changes have the potential to spare an additional 7-34 MCM of volume to be used for flood control. The changes in operational rules would result in better flood control, which would imply considerably higher savings in terms of flood damages – especially for small to medium flood events.

The insights derived from this analysis should motivate the dialogue between the water and energy sectors in the Riparians to translate this into tangible actions. A starting point could be to rethink the existing operational rules of the hydropower plants, which were set out three decades ago, to achieve flood-smart management by increasing the buffer volumes in the dams. An integrated water-energy management plan could be a tool enabling each dam operator to plan, not only in the shorter term, but also in the long term, both the production and flood control services. It could help identify the potential changes in the cost of operation and opportunities to increase market shares of electricity supply while providing flood protection and contributing to the countries' policy goals.

Climate change has a long-term impact by nature, which highlights the need for long-term planning and investment. The analysis shows that solar and wind have the potential to play an important role in the electricity mix of the Riparians and compensate for any decline imposed by climate change. However, the officially announced investments are not enough to reflect this high potential. At the same time, the electricity imports will continue to be a key element in the region's electricity system.

Future work could focus on addressing a number of limitations in this study. For example, the climate change impact can be detailed to have more realistic future projections with annual flow variation instead of the current linear projection. Additionally, sensitivity analyses could be carried out to explore the impact of different operational rules. More importantly, the impact of Skavica on the flooded area and the operation of the other hydropower plants in the Albanian cascade can be further detailed once actual operational data from Skavica is obtained.

4.2 FORESTRY AND BIOMASS

Institutions

- Sustainable management and use of natural resources is a prerequisite for the sustainable harvesting of biomass. There is a direct relationship between natural resources, especially forests, and the provision of multiple ecosystem services, such as sufficient water and water quality. Institutions responsible for natural resources, for example the Ministries of the Environment and/or Forestry, should ensure a proper regulatory and legislative framework for the implementation and monitoring of sustainable use of natural resources (linked to SAP Goal 2, Sub-Objective 2.4).
- River Basin Management planning and implementation must be embedded in government structures at national and regional level, at natural resource management level and in (rural) economic development, including international cooperation with counterparts within the Basin.
- To address sustainable forest (and natural) resource management, a River Basin approach is necessary for water and ecosystem management, including forests. This is required, as the effects of unsustainable forest use or over-exploitation have a direct impact on water quality and water availability and may lead to floods, erosion and related damages and costs throughout the Basin (SAP Goal 2, Sub-Objectives 2.3, 2.4 and 2.5).
- Standards must be established for sustainable use of forest resources and wood pellets. For example, this could include forest certification schemes (FSC or PEFC), chain of custody and product standards such as European Union standards on solid fuels including wood pellets (NEN-EN-ISO 17225-2), which determine fuel quality classes and specifications of graded wood pellets for non-industrial and industrial use. North Macedonia has extensive experience in forest certification and chain of custody for PEFC.

Information / Capacity-building

- Training on designing and implementing sustainable forest management practices to ensure sustainable use of biomass and mitigation of potential harm to soil and water resources. Focus should be given to all stakeholders involved, with specific attention paid to forest managers, but also farmers (men and women).
- Input should be provided by forestry experts to studies foreseen by the Drin Basin SAP on erosion hotspots, biodiversity trends, ecosystem services and in drafting respective management-related recommendations (SAP Goal 2, Sub-Objectives 1.3 and 1.5).
- Study on Payment for Ecosystem Services (PES) opportunities within River Basin approaches including schemes and practices. The case of Ulza Watershed in Albania could be used as an example.
- Awareness-raising campaigns on the benefits and applications of efficient and sustainable use of wood biomass (SAP Goal 2, Objective 4).

Instruments

- Create incentives for forest owners/managers for forest planting, especially in areas vulnerable to erosion particularly in the transboundary basin downstream in order to avoid damage by floods and transport of sediment.
- Launch pro-poor initiatives in the Basin area to support households in obtaining timely seasoned firewood and avoid using fresh firewood for heating.
- Provide incentives for wood industries to produce economically beneficial wood products with longer lifespans that also contribute to climate mitigation. Support the wood processing industry in developing construction wood such as cross-laminated timber or furniture. Sustainable use of forests, and especially of wood products, should not only focus on biomass, but address the total range of products as well as the entire forestry and wood industry sectors. Priority should be given to longer-lasting products with higher value, which are more economically beneficial and contribute to climate mitigation, such as timber and construction wood, which keep carbon sequestrated for a long period of time against biomass products that are often of a lower economic value and release carbon directly to the atmosphere. This action aligns with Chapter 15 on Energy of the EU acquis, in which renewable energy, including biomass, is supported.
- Efforts should be made to make suitable systems available for rural areas, including sufficient service and maintenance support as well as availability of processed biomass products locally and at an affordable price.
- Establish Payment for Ecosystem Services (PES) within River Basin approaches to ensure sustainable natural resource management. For example, downstream water users could pay for improved forest management or reforestation upstream.

Infrastructure and investments

- With support through the Instrument for Pre-accession Assistance (IPA III) becoming shortly available for 2021-2027 from the EU, priorities and operational rules at national level could be established in the Drin Riparians to support sustainable use of natural resources and biomass (in line with Chapter 11 of the EU acquis on agriculture and rural development) that requires adequate administrative capacity of agricultural administrations, in particular for the formulation, analysis, implementation, support payment and control of agricultural policy.
- In practical terms, measures could be designed to support (a) forest restoration and Sustainable Forest Management (SFM) practices (b) sustainable wood harvest practices for small forest holders, (c) SFM practices to expand production of processed biomass products (pellets, woodchips, briquettes) for local consumers, and related heating and/or combined heat and power systems, and (d) investments by consumers for a switch from firewood to processed biomass products.
- Identify options for establishing cooperation with development and commercial banks for the provision of micro-credit options/soft loans for households, businesses and public organisations to shift into alternative heating fuels (e.g. pellets, briquettes) as market-based measures to reduce illegal forest exploitation listed in the Drin Basin SAP (Goal 2, Sub-Objective 1.6).
- Value chain development for biomass should include a gender perspective to address the specific needs and opportunities of women and disadvantaged groups, in order to benefit from the biomass value chain but also to participate in it. This is in line with the EU acquis on agriculture and rural development (Chapter 11), in which at agricultural market level, setting up of market mechanisms, including marketing standards, price reporting, quota management, producer organisations and public intervention, is required.
- Small and Medium-Sized Enterprise establishment support mechanisms are recommended within the biomass value chain to promote further development and use of these renewable energy sources. Support is required for processing, product development (pellets, briquettes, wood chips), trade and transport as well as for the energy and heating systems and/or combined heat power systems.
- Support for biomass production should not compete with agricultural crops, nor endanger the preservation of forests with high biodiversity value.

International cooperation

- Coordinating at regional level the renewable energy transition and biomass markets, as well as wood and agro-products markets in general.

- Sustainable forest (natural) resource management should be properly integrated into national policies, as well as in regional cooperation and communication in the Drin River Basin countries.
- Clear interlinkages exist between the different spheres (natural resources, water, energy, food). Their link to climate change needs to be translated, defined and agreed among relevant sectors/stakeholders at regional, national and local levels to generate concrete actions that cultivate an environment for safeguarding the ecosystem services through the implementation of sustainable forest (natural) resource management.

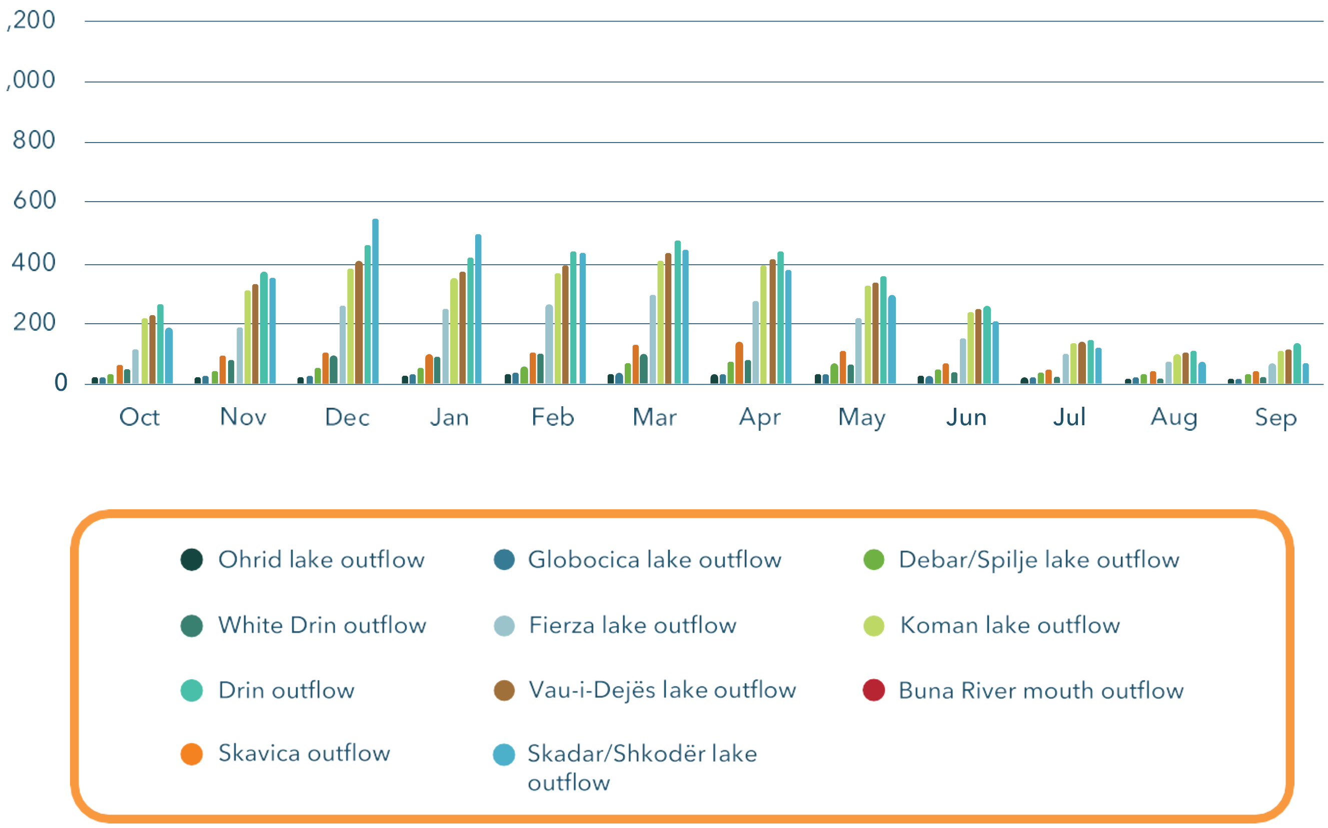

5
ANNEXES

HYDROLOGICAL DATA

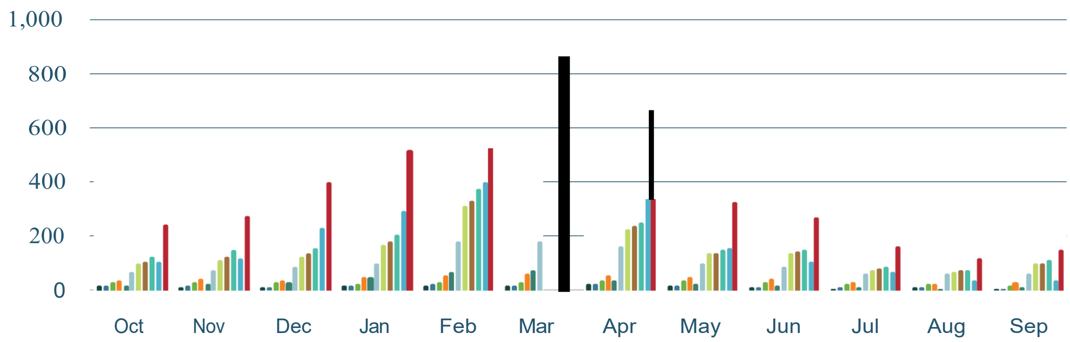
For all the points of interest the monthly distributions are calculated for the three scenarios:

An average year, wet year, and dry year: monthly water flow for the period (1980-1990) and the period (2000-2010).

Monthly Flow

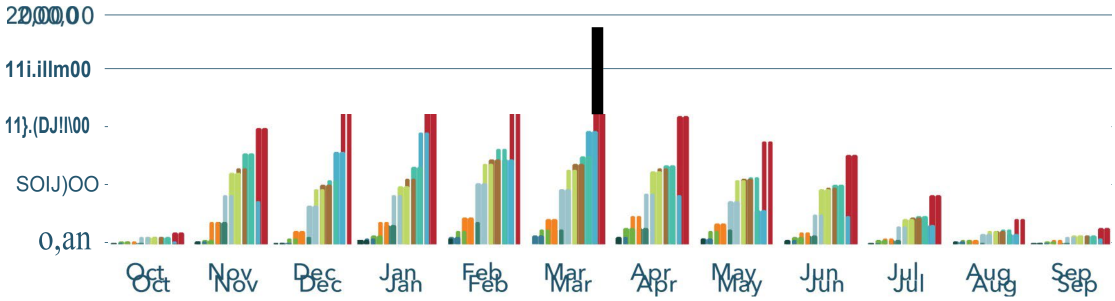


Dry year



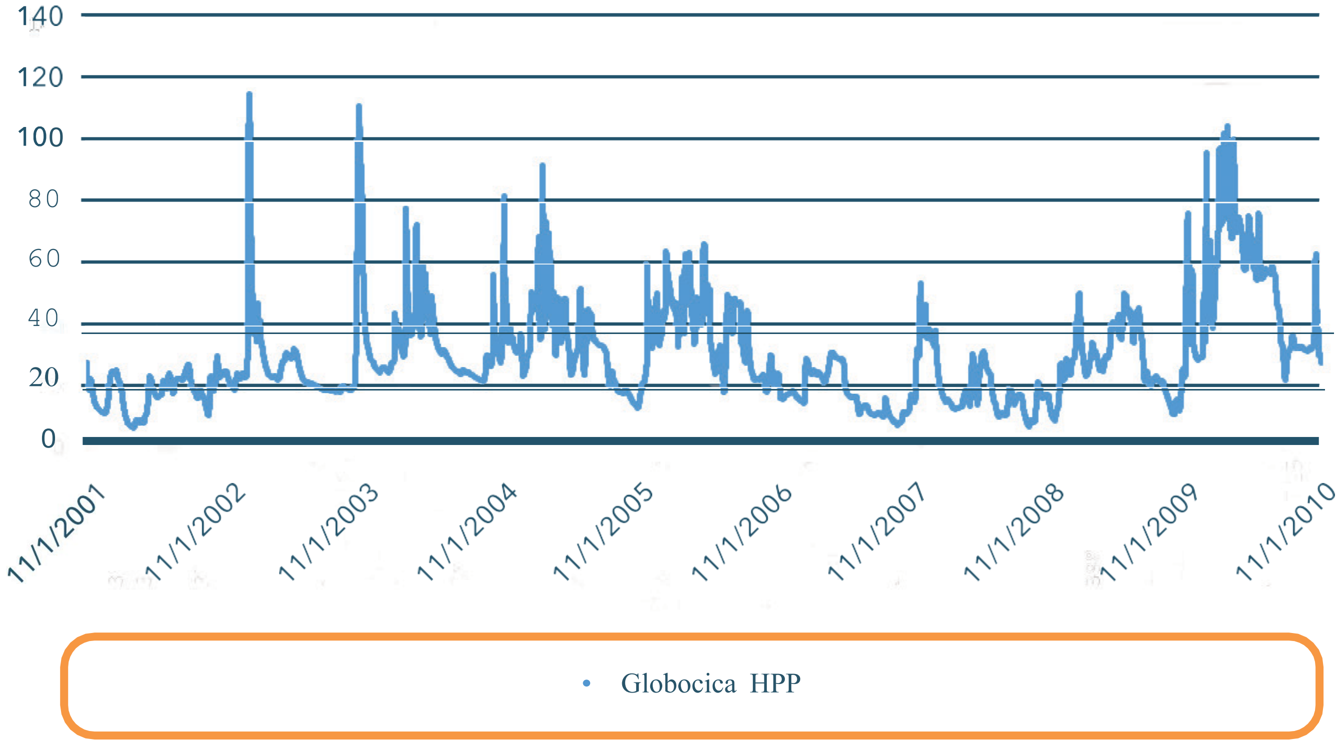
Ohrid lake outflow
Globocica lake outflow
Debar/Spilje lake outflow
White Drin outflow
Fierza lake outflow
Koman lake outflow
Drin outflow
Vau-i-Dejes lake outflow
Buna River mouth outflow
Skavica outflow
Skadar/Shkoder lake outflow

Wet year

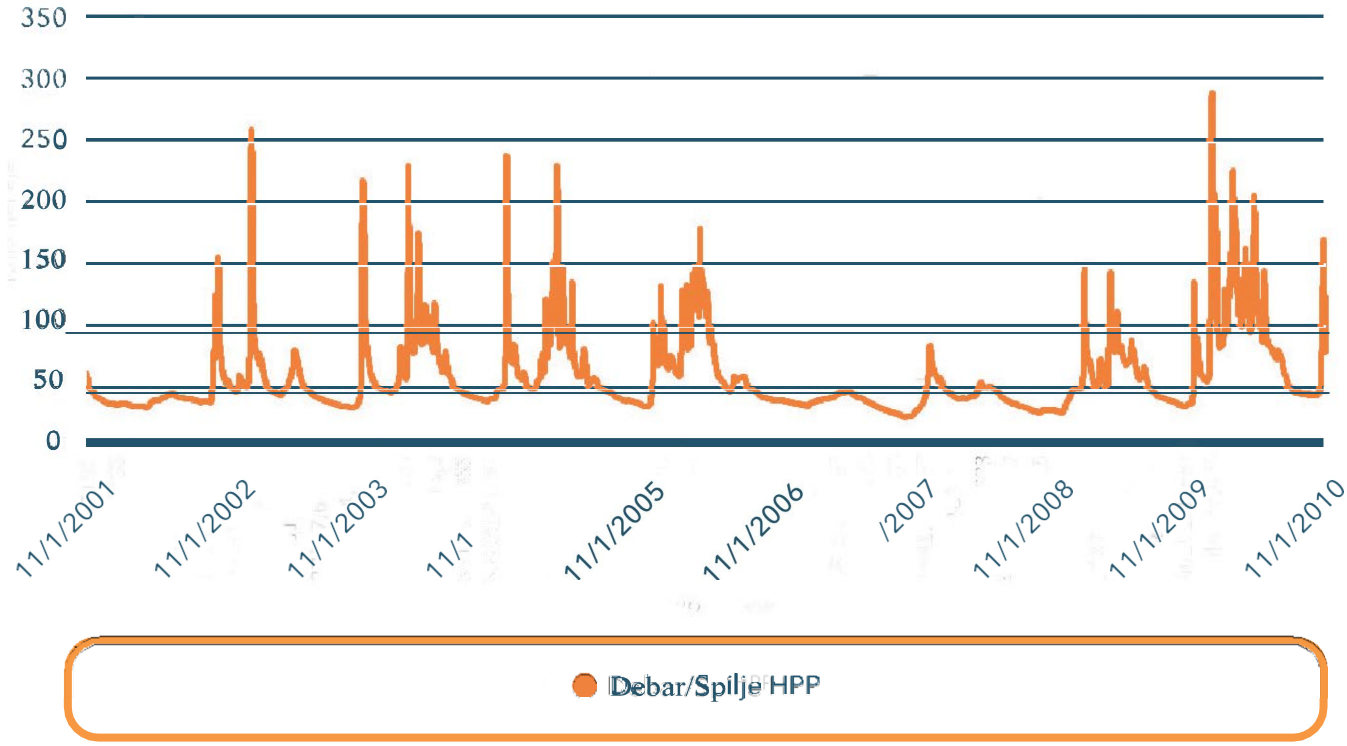


Ohrid lake outflow
Globocica lake outflow
Debar/Spilje lake outflow
White Drin outflow
Fierza lake outflow
Koman lake outflow
Drin outflow
Vau-i-Dejes lake outflow
Buna River mouth outflow
Skavica outflow
Skadar/Shkoder lake outflow

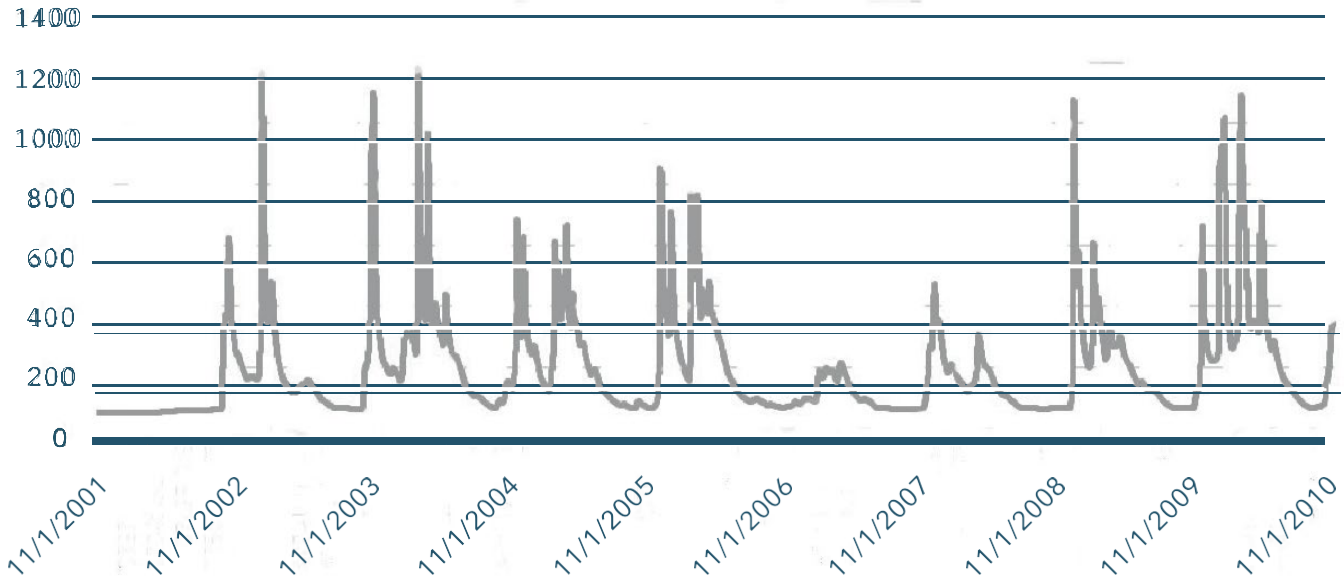
Hourly discharge calculations



Hourly discharge calculations

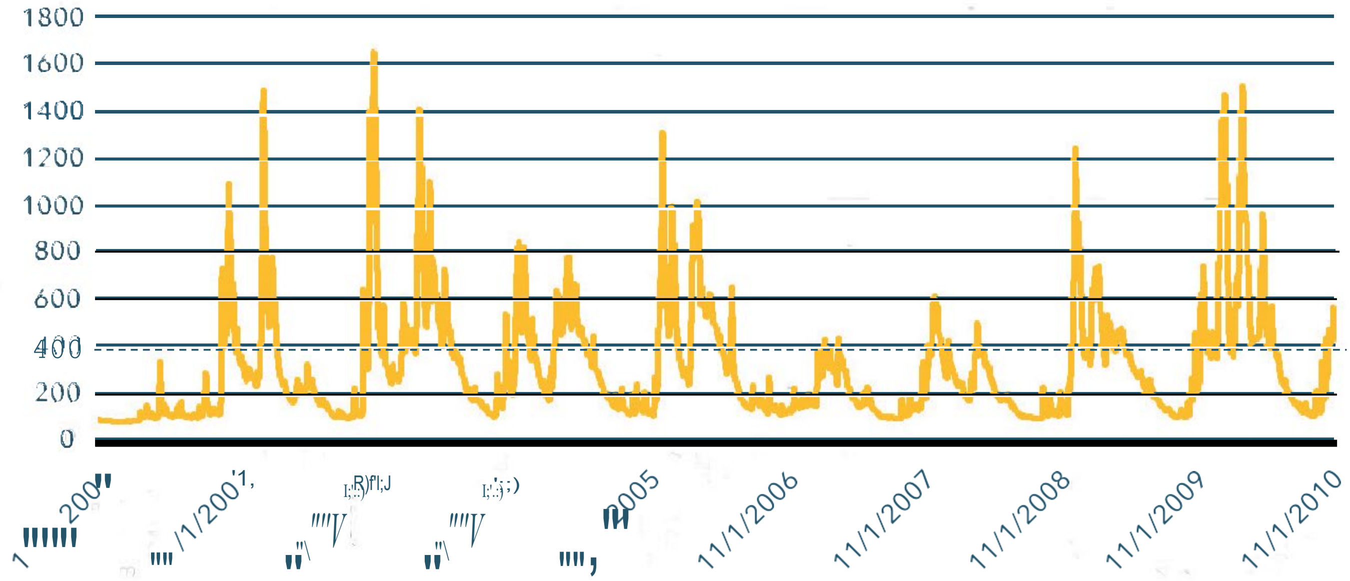


Hourly discharge calculations



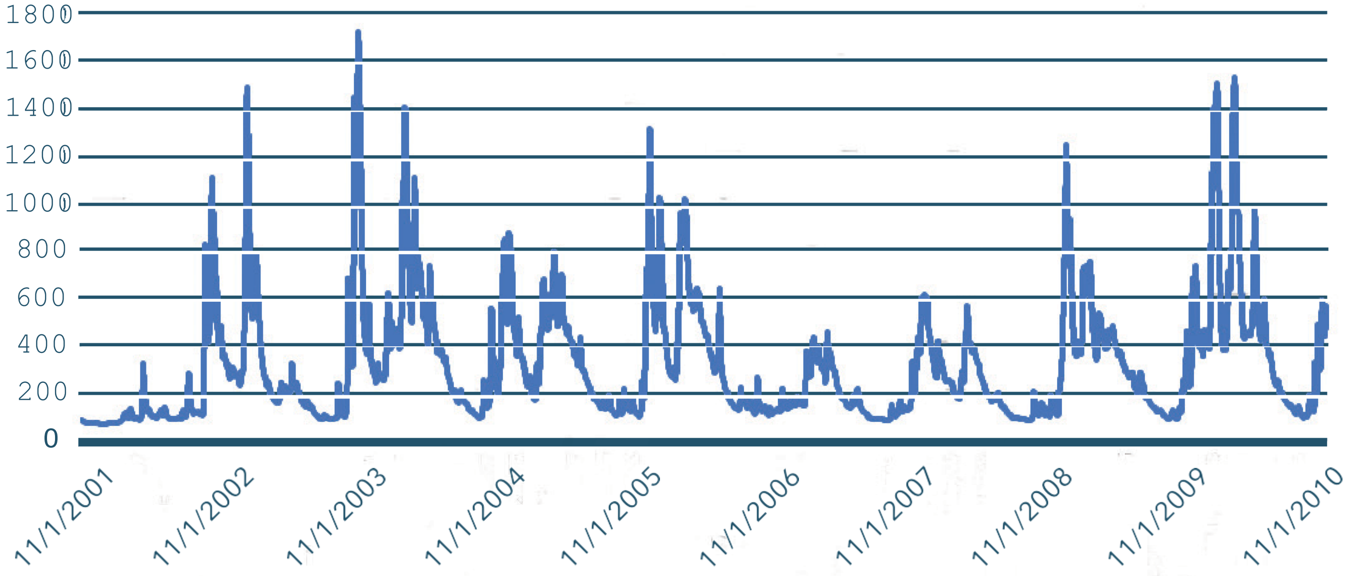
Fierza HPP

Hourly discharge calculations



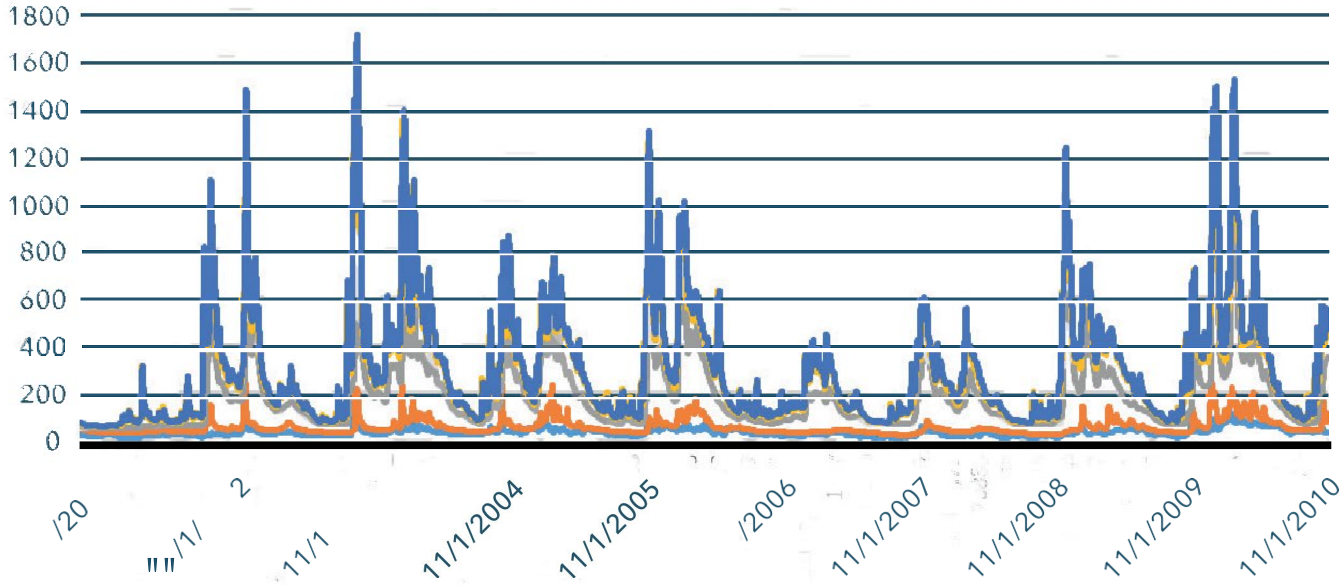
Koman HPP

Hourly discharge calculations



e Vau-i-Dejes HPP

Hourly discharge calculations



Globocica HPP Debar/Spilje HPP Fierza HPP

Koman HPP Vau-i-Dejës HPP

Sample model outputs for the year 2025, showing the water flow in m³/sec.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Ohrid lake outflow	20.3	23.7	24.0	24.4	28.8	33.0	32.4	32.3	25.5	20.1	17.7	16.3
Globocica lake-side flow	1.4	3.0	3.0	5.1	4.4	4.9	2.5	1.9	1.3z	1.2	0.9	1.0
Globocica lake outflow	21.6	26.7	27.0	29.5	33.2	37.9	34.8	34.2	26.8	21.3	18.5	17.3
Debar/Spilje lakeside flow	12.2	17.1	17.3	220.6	20.4	29.5	39.7	31.7	17.0	13.5	11.3	12.4
Debar/Spilje lake outflow	33.9	43.8	44.3	50.1	53.6	67.4	74.6	65.9	43.8	34.8	29.8	29.7
Skavica side flow	28.8	46.7	47.2	51.6	44.9	60.4	61.4	40.9	17.7	8.6	6.6	11.8
Skavica outflow	62.7	90.5	91.5	101.6	98.5	127.8	135.9	106.8	61.5	43.4	36.5	41.5
White Drin outflow	48.0	75.2	75.8	93.2	90.0	99.9	76.9	61.4	33.5	19.7	15.4	20.7
Fierza lakeside flow	2.8	17.5	16.9	59.9	54.3	61.6	54.8	44.8	38.2	24.3	13.8	4.3
Fierza lake outflow	113.5	183.3	184.1	254.7	242.8	289.3	267.6	213.1	133.3	87.4	65.7	66.4
Koman lakeside flow	94.8	118.2	119.6	121.3	98.8	110.8	117.1	105.9	74.2	31.0	22.2	40.6
Koman lake outflow	208.3	301.5	303.8	376.0	341.6	400.1	384.7	319.0	207.5	118.3	87.9	107.1
Vau-i-Dejës lakeside flow	19.9	18.1	18.1	26.0	23.3	22.9	17.7	12.7	9.9	5.7	3.8	6.7
Vau-i-Dejës lake outflow	223.2	319.5	321.9	402.0	364.9	423.1	402.3	331.8	217.3	124.1	91.7	113.8
Drin outflow	256.1	361.9	364.7	449.0	408.6	463.3	427.5	350.1	229.5	129.3	97.4	130.7
Skadar/Shkodër lake outflow	180.9	338.1	338.4	534.1	487.0	434.7	369.7	287.9	181.3	107.2	65.5	65.8
Buna River mouth outflow	431.6	683.7	685.7	1013.9	925.2	924.5	816.2	657.4	427.3	247.6	168.9	198.1

Sample model outputs for the year 2050, showing the water flow in m^3/sec.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Ohrid lake outflow	19.32	22.64	23.18	23.44	27.75	32.28	31.64	31.63	21.16	16.64	14.64	15.51
Globocica lakeside flow	1.32	2.83	2.81	4.95	4.23	4.77	2.41	1.85	1.07	1.03	0.71	0.99
Globocica lake outflow	20.64	25.47	25.99	28.39	31.99	37.05	34.05	33.48	22.22	17.68	15.35	16.50
Debar/Spilje lakeside flow	11.68	16.34	16.61	19.85	19.72	28.83	38.87	30.98	14.09	11.17	9.37	11.8
Debar/Spilje lake outflow	32.32	41.82	42.59	48.25	51.71	65.87	72.92	64.46	36.31	28.84	24.72	28.31
Skavica side flow	27.53	44.57	45.49	49.96	43.30	59.08	60.01	40.01	14.71	7.12	5.51	11.24
Skavica outflow	59.85	86.3	88.08	98.21	95.01	124.96	132.93	104.47	51.03	35.96	30.23	39.55
White Drin outflow	45.79	71.75	72.77	90.04	86.72	97.72	75.15	60.05	27.79	16.31	12.79	19.77
Fierza lake-side flow	2.64	16.72	15.26	58.00	52.34	60.22	53.58	43.81	31.68	20.16	11.44	4.08
Fierza lake outflow	108.28	174.86	176.11	246.25	234.08	282.90	261.66	208.34	110.50	72.43	54.45	63.40
Koman lake-side flow	90.49	112.76	115.49	117.69	95.36	108.34	114.47	103.58	61.51	25.67	18.42	38.75
Koman lake outflow	198.77	287.62	291.59	363.94	329.43	391.24	376.13	311.92	172.01	98.11	72.87	102.15
Vau-i-Dejës lakeside flow	14.17	17.22	17.31	25.16	22.53	22.44	17.27	12.47	8.17	4.76	3.17	6.39
Vau-i-Dejës lake outflow	212.94	304.85	308.90	389.10	351.97	413.67	393.40	324.38	180.18	102.87	76.04	108.54
Drin outflow	244.39	345.31	350.18	434.59	394.11	453.00	418.01	342.36	190.27	107.24	80.75	124.69
Skadar/ Shkodër lake outflow	172.63	322.62	322.09	516.96	471.86	425.08	361.51	281.48	150.34	88.89	55.14	62.82
Buna River mouth outflow	411.79	652.36	654.22	981.24	894.81	903.93	798.03	642.77	354.28	205.27	139.98	189.00

ENERGY DATA

The demand for each Economy is based on national projections[68] which in most cases are up to 2030-2035. For the remaining period until 2050, extrapolation is made based on the average annual growth rate of electricity demand for each Economy from the South East Europe Electricity Roadmap (SEERMAP) for Albania,[69] North Macedonia,[70] Montenegro[71] and Kosovo*.[72]

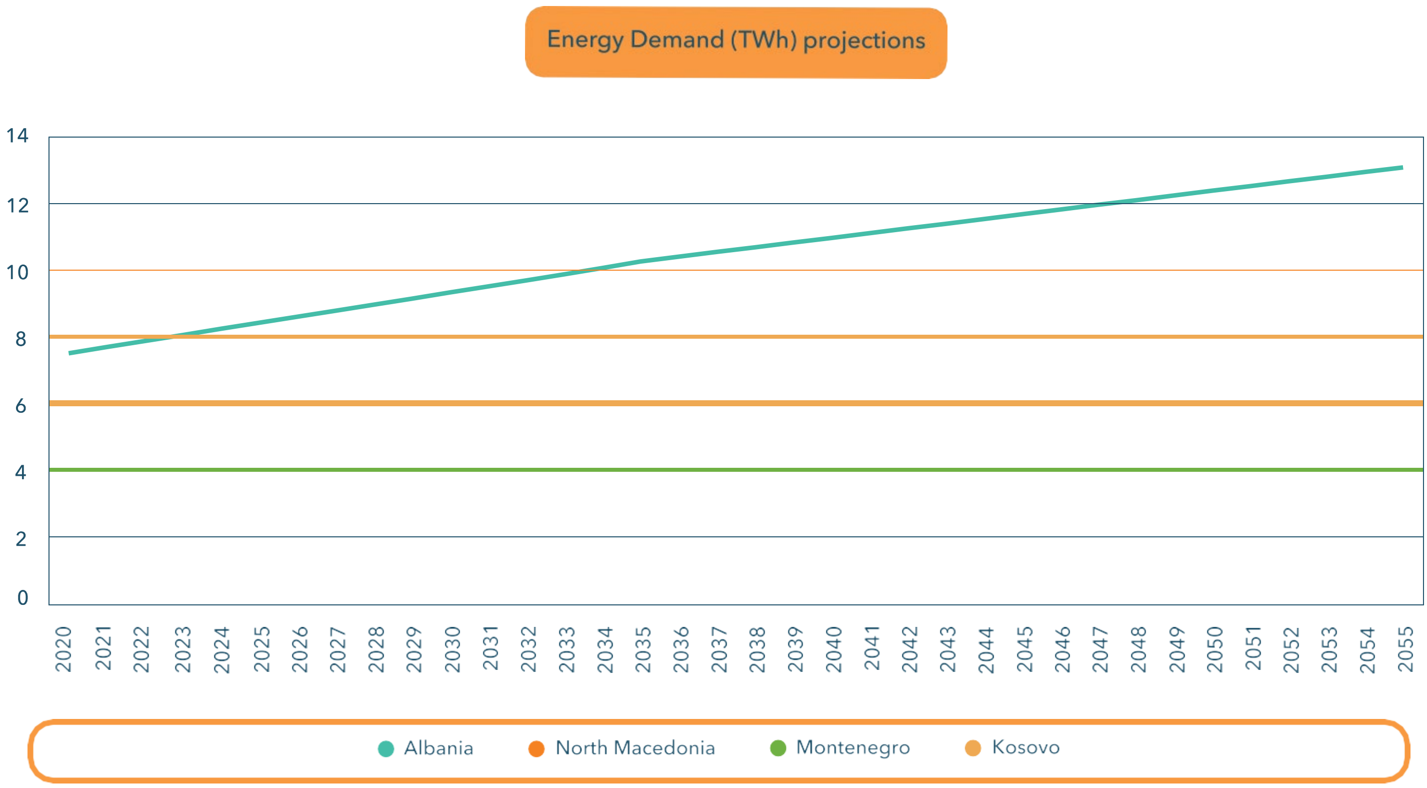


Figure 24. Final electricity demand (TWh) projections for the Drin countries from 2020-2050.

68 Energy Regulatory Authority, 'State of the Energy Sector and ERE activity during the year 2018 – Annual Report' (2019), https://www.ere.gov.al/doc/Raporti_vjetor_ERE_2018_perfundimtar.pdf; Government of Montenegro, 'Draft Decision on the Energy Balance of Montenegro for 2020' (2019), https://www.gov.me/en/documents/e82c924c-7591-4178-9733-08854e05cfd3; Energy Regulatory Office Kosovo*, 'Statement of Security of Supply for Kosovo* (Electricity, Natural Gas and Oil)'.

69 Regional Centre for Energy Policy Research REKK, 'South East Europe Electricity Roadmap (SEERMAP) - Country report: Albania 2017',https://rekk.hu/downloads/projects/SEERMAP_CR_ALBANIA_A4_ONLINE.pdf.

70 Regional Centre for Energy Policy Research REKK, 'South East Europe Electricity Roadmap (SEERMAP) - Country report: Former Yugoslavian Republic of Macedonia 2017', https://rekk.hu/downloads/projects/SEERMAP_CR_MACEDONIA_A4_ONLINE.pdf.

71 Regional Centre for Energy Policy Research REKK, 'South East Europe Electricity Roadmap (SEERMAP) - Country report: Montenegro 2017', https://rekk.hu/downloads/projects/SEERMAP_CR_MONTENEGRO_A4_ONLINE.pdf.

72 Regional Centre for Energy Policy Research REKK, 'South East Europe Electricity Roadmap (SEERMAP) - Country report: Kosovo* 2017', https://rekk.hu/downloads/projects/SEERMAP_CR_KOSOVO_A4_ONLINE.pdf.

Table 14. List of existing and planned thermal power plants modelled for each Economy.

Economy	Power Plant	Capacity (MW)	Assumptions
Albania	Vlore (CC gas)	98	Assumed to continue for the entire modelling period, with low capacity factor of 30%
Albania	GPP Korça shpk	500	The Project was not granted environmental permission,nor officially cancelled, but it is difficult to get through without this permission (removed from the model)
North Macedonia	Bitola	699	Operational Coal PP
North Macedonia	REK Oslomej	125	Not operating since 2015, not considered in the model
North Macedonia	Negotino (heavy fuel oil PP)	198	Assumed operational until 2025
North Macedonia	TE-TO	230	Operational CHP, phased out by 2040
North Macedonia	Kogel	30	Operational CHP, phased out by 2040
North Macedonia	Energitica	30	Operational CHP, phased out by 2041
North Macedonia	Bitola (revitalisation)	650	New: allowed after 2025
North Macedonia	Oslomej (revitalisation)	109	New: 2023
North Macedonia	New Lignite PP	300	New: 2035
North Macedonia	New CHP	450	New: 2025
North Macedonia	Exist CHP (revitalisation)	260	New: 2021
North Macedonia	New Cas CHP	40	New: 2023
North Macedonia	New Cas CHP	30	New: 2023
North Macedonia	New Cas CHP	30	New: 2023
North Macedonia	New NGCC by 2033	230	New: 2033
North Macedonia	A new NG-fired power plant in the southwestern city of Bitola	800	Not added yet to the model as there is no clear date; the Project cost is estimated at €400 million
North Macedonia	Shut down the coal-fired REK Bitola, with installed capacity of 675 MW, to convert it to gas from a planned pipeline	675 (699)	Not yet added to the model as there is no clear date
North Macedonia	Negotino Project is related to the plan to switch the 210 MW thermal power plant TEC Negotino from fuel oil to natural gas	210 (198)	Not yet added to the model as there is no clear date
Montenegro	Pljevlja TPP	225	According to EPCG, Pljevlja TPP will continue for at least five years, so it is considered in the model for the entire modelling period
Kosovo*	Kosova A: 610 MW	610	The new capacity is 915 MW for both units; Kosova A will phase out by 2030 and Kosovo B by 2040
Kosovo*	Kosova B: 678 MW	678	
Kosovo*	New (Kosova e Re)	500	Under construction, expected by 2023

Table 15. List of renewable energy projects in Albania

Economy	Technology	Plant	Operator	Capacity (MW)	Started Operation	Location
Albania	Hydro Dam	Skavica	KESH	196	2025	Inside Drin River Basin
Albania	Hydro Dam (Francis)	Moglice	Statkraft	184 (2 x 92 MW)	2019 (shifted to 2021)	Outside Drin River Basin
Albania	Hydro Dam (Francis)	Kalivac	Ayen Enerji & Fusha	111	2020 (shifted to 2022)	Outside Drin River Basin
Albania	Hydro Dam	Shala		83.5	2021 (shifted to 2023)	Inside Drin River Basin
Albania	Hydro	Pocem (stopped)				
Albania	Solar PV	Karavasta	Voltalia	140	Assumed by 2025	Outside Drin River Basin
Albania	Solar PV	Floating PV	Statkraft	2	Assumed by 2025	Outside Drin River Basin
Albania	Solar PV	Fier Solar		2.5	Assumed by 2025	Outside Drin River Basin
Albania	Solar PV	Solar power plant at Vau-i-Dejës	KESH	5.1	Assumed by 2025	Inside Drin River Basin
Albania	Solar PV	Floating solar PV at Vau-i-Dejës	KESH	12.9	Assumed by 2028	Inside Drin River Basin
Albania	Solar PV	Durres (Spitalle Solar Park)	French company Voltalia	100	Assumed by 2028	Outside Drin River Basin
Albania	Solar PV	Blue 1 and Blue 2	by Blessed Investment and Matrix Konstruksion, registered in Albania	100	Assumed by 2030	Outside Drin River Basin
Albania	Solar PV	Additional capacity		Annual increase of 10%allowed from 2026 onwards	2026 onwards	Outside Drin River Basin
Albania	Wind Onshore	Three Projects have been authorised for construction with a total capacity of 9 MW which qualify for FiT support (MIE, 2019)		9	Assumed by 2025	Outside Drin River Basin
Albania	Wind Onshore	At the end of 2020, a 150 (130) MW wind tender was launched (MIE 2019)		150	Assumed by 2027	Outside Drin River Basin
Albania	Wind Onshore	WPP in Tepelena region	Alb-Building	12	Building permit issued (assumed by 2023)	Outside Drin River Basin
Albania	Wind Onshore	Additional capacity		Annual increase of 10% allowed from 2030 onward.	2030 onwards	Outside Drin River Basin

Table 16. List of renewable energy Projects in North Macedonia.

Economy	Technology	Power plant option	Operator	Installed capacity (MW)	Start year (potential)	Inside/outside Drin River Basin
N. Macedonia	Large hydro	Tenovo-Kozjak Project		Project increasing supply of existing Kozjak, Malka & Sv. Petka HPP	2030	Outside Drin River Basin
N. Macedonia	Large hydro	Globocica II		20	2035	Inside Drin River Basin
N. Macedonia	Large hydro	Veles		96	2030	Outside Drin River Basin
N. Macedonia	Large hydro	Cebren (or Chebren)		458	2029	Outside Drin River Basin
N. Macedonia	Large hydro	Gradec		75.34	2030	Outside Drin River Basin
N. Macedonia	Large hydro	Galiste		77.9	2035	Outside Drin River Basin
N. Macedonia	Small hydro	Vardar Valley SHPPs 1		45	2025	Outside Drin River Basin
N. Macedonia	Small hydro	Vardar Valley SHPPs 2		153	2030	Outside Drin River Basin
N. Macedonia	Small hydro	Small hydro		Max. 135-160	2019	Outside Drin River Basin
N. Macedonia	Biogas	Biogas with FiT		18	2020	Outside Drin River Basin
N. Macedonia	Biogas	Biogas without FiT		10	2025	Outside Drin River Basin
N. Macedonia	Biomass	PP or CHP on biomass		12.5-15	2020	Outside Drin River Basin
N. Macedonia	Wind Onshore	Bogdanci Phase I	ELEM	36.8	2014	Outside Drin River Basin
N. Macedonia	Wind Onshore	Bogdanci Phase II	ELEM	13.8	Proposed	Outside Drin River Basin
N. Macedonia	Wind Onshore	Miravci Phase I	ELEM	14	Prelimi-nary De-sign	Outside Drin River Basin
N. Macedonia	Wind Onshore	Miravci Phase II	ELEM	36	Prelimi-nary De-sign	Outside Drin River Basin
N. Macedonia	Wind Onshore	Bogoslovec	Thor Impex D.O.O.E.L	33	Building permit issued	Outside Drin River Basin
N. Macedonia	Wind	Wind with FiT		64	2021	Outside Drin River Basin
N. Macedonia	Wind	Wind with FiP		50	2022	Outside Drin River Basin
N. Macedonia	Wind	Wind without FiP or FiT	German company wpd	100-500	2025	Outside Drin River Basin
N. Macedonia	PV	Oslomej PV		100	Assume 50 MW in 2025	Outside Drin River Basin
N. Macedonia	PV	PV with FiP		200	2020	Outside Drin River Basin

Table 16. List of renewable energy Projects in North Macedonia.

Economy	Technology	Power plant option	Operator	Installed capacity (MW)	Start year (potential)	Inside/outside Drin River Basin
N. Macedonia	PV	PV without FiP		400-800	2020	Outside Drin River Basin
N. Macedonia	PV	PV rooftop		250-400	2019	Outside Drin River Basin
N. Macedonia	PV	Voishanci PV		1.48	2020 (opr)	Outside Drin River Basin

Table 17. List of renewable energy Projects in Montenegro.

Economy	Technology	Plant	River	Capacity (MW)	Started Operation	Location
Montenegro	Dam (Francis)	HPP Andrijevo	Morača	127.4 (2 x 63.7 MW)	No date. Assumed by 2035	Inside Drin River Basin
Montenegro	Dam (gravitational) Francis	HPP Raslovići	Morača	37 (2 x 18.5 MW)	No date. Assumed by 2035	Inside Drin River Basin
Montenegro	Dam (gravitational) Francis	HPP Milunovići	Morača	37 (2 x 18.5 MW)	No date. Assumed by 2035	Inside Drin River Basin
Montenegro	Dam (gravitational) Francis	HPP Zlatica	Morača	37 (2 x 18.5 MW)	No date. Assumed by 2035	Inside Drin River Basin
Montenegro	Arch Dam	HPP Komarnica	Komarnica	168	2029 (EPCG)	Outside Drin River Basin
Montenegro	Dam	HPP Kruševo V1		82 MW	No date. Assumed by 2035	Outside Drin River Basin
Montenegro	Dam	HPP Kruševo V2		90-100 MW	No date. Assumed by 2038	Outside Drin River Basin
Montenegro	Dam	HPP Perućica – Unit 8		58.5 MW	2025	Outside Drin River Basin
Montenegro	Wind	WPP Gvozd	N/A	54.6	2023	Inside Drin River Basin
Montenegro	Solar PV	Solar PV plant – Briska Gora	N/A	Phase 1: 50 MW by 2022, phase 2: increases to 250 by 2024. (Some plans mention it will increase to 262 MW)	2022 (50 MW)/2024 (200 MW)	Outside Drin River Basin

Table 18. List of renewable energy Projects in Kosovo*

Economy	Technology	Plant	Units	Capacity (MW)	Expected year of commissioning	Location
Kosovo*	Wind	WPP Zatric I, II	-	64.8	-	Inside Drin River Basin
Kosovo*	Wind	WPP Bajgora, consists of 3 wind farms (Selac I, II, III)	27 turbines x 3.83 MW	105	2021	Outside Drin River Basin
Kosovo*	Wind	WPP Koznice	-	34.5	2022	Outside Drin River Basin
Kosovo*	Wind	Budakova		46	2026	Outside Drin River Basin
Kosovo*	Wind	WPP Cicav-ica	17 turbines x 3 MW	51	-	Outside Drin River Basin
Kosovo*	Wind	Wind farms PE Kameni-ca-1 and 2	2 x 34.8	69.6	2024	Outside Drin River Basin
Kosovo*	Solar	PS Kameni-ca-3	30	30	2024	Outside Drin River Basin
Kosovo*	Hydro dam	HPP Lepenc I		10	2020	Outside Drin River Basin

Table 19. Changes in the operational rules and the water level (masl) in Spilje dam.

Month	hist_level (m)	Level (m) +5% buffer	Level (m) +20% buffer	Diff in m (+5%)	Diff in m (+20%)
1	569	566.3	564.7	2.7	4.3
2	566	564	562.2	2	3.8
3	567	564.7	563	2.3	4
4	570	567.1	565.7	2.9	4.3
5	576	576	576	0	0
6	578	578	578	0	0
7	576	576	576	0	0
8	575	575	575	0	0
9	572	572	572	0	0
10	570	567.1	565.7	2.9	4.3
11	568	565.5	563.9	2.5	4.1
12	569	566.3	564.7	2.7	4.3

Table 20. Changes in the operational rules and water level (masl) in Fierza dam.

Month	hist_leve l (m)	5%_leve l (m)	20%_level (m)	Diff in m (5% level)	Diff in m (20% level)
1	279	278.5	275	0.5	4.2
2	276	274.9	270	1.1	5.8
3	280	279.7	276	0.3	3.8
4	285	285.3	283	-0.3	1.7
5	290	290	290	0	0
6	296	296	296	0	0
7	293	293	293	0	0
8	286	286	286	0	0
9	275	275	275	0	0
10	272	270.1	264	1.9	7.8
11	276	274.9	270	1.1	5.8
12	279	278.5	275	0.5	4.2

CLIMATE CHANGE MODELLING

There are three main types of climate change scenarios used in climate change impact studies: synthetic scenarios, analogue scenarios and scenarios based on outputs from Global Circulation Models (GCMs).

1. **Synthetic scenarios:** certain climatic variables are changed arbitrarily. For example, adjusting baseline temperature using a random amount such as +1 °C. Some climate change studies have introduced a seasonal and spatial variation of this random amount.
2. **Analogue scenarios:** are built based on recorded climate regimes which can represent the future in a given area. There are two types: temporal and spatial. The temporal type uses past data as a possible future climate (paleoclimatic and historical). The spatial type uses the present climate of one area and extrapolates to others as future possible climate. The main disadvantage of using the temporal analogues is that the climate changes might not have been created by greenhouse gas (criteria 1). The spatial analogue is not likely to fulfil criteria 2.
3. **General Circulation Models (GCM):** are a numerical model that reproduces physical processes in the atmosphere, ocean, land surface, etc. This is the most cutting-edge tool to study the impacts of the increase in greenhouse gases.

CLIMATE CHANGE SCENARIOS in the Drin Basin

In the case of Drin, there is a group of variables available that spatially cover the whole Basin for two periods: 1/11/1979 to 1/11/1989 and 1/11/2001 to 1/11/2010. Variables such as daily air temperature and precipitation, snow cover, sunshine duration, global radiation, relative humidity and wind are available. Some countries might have more data available, but this was not used because of the lack of data in other countries. The possible baseline period is discontinuous and far from a 30-year typical baseline. If these two periods are selected as a baseline and then used as a benchmark, two periods that are not continuous are merged. A positive issue is that data was used to calibrate and validate the hydrological model Panta Rhei. Besides, no climate model outputs or stochastic weather generators are available.

Two sets of climate scenario data are available and composed of average GCM results by Economy. The data covers North Macedonia, Kosovo* and Albania. In the case of Albania, we can observe an average output for the country of the GCMs divided into minimum, maximum and average increment (-/+) of precipitation and temperature, and summarised in annual and seasonal formats. Time horizons are 2025 and 2050. The climate scenarios by Economy are not related to the same supposed greenhouse concentration levels. Another approach is that the imputed data does not consider the spatial variability of temperature and precipitation. Both variables have strong altitude gradients by season. However, they can be used for a sensitivity impact assessment.

For a rough preliminary climate change study, we can choose a baseline of 1979-1989, 2001-2010; however, it is discontinuous. The baseline will be repeated until the time horizon. For a more rigorous study in the future, the baseline should be completed making use of global data sets until completing a 30-year continuous period. The representativeness of the 30 years should be studied. In the case that climate change scenarios for the Drin Basin are completed, Panta Rhei will be run for the multiannual periods, from 2010 till the time horizon and the baseline.

Climate change scenarios for Albania and Kosovo* indicate overall decreases in precipitation and increases in air temperature. Despite the total precipitation being expected to decrease, an increase of intensive rain episodes is also likely. Besides inland impacts of climate change, Albania is also facing an expected rise in sea level.

In North Macedonia, projected changes of average, maximum and minimum daily air temperature (°C) and precipitation (%) for the north-western part of Macedonia are indicated under prevailing mountain continental climate impacts. Values are presented separately for different seasons and are based on projections of results from four GCMs (CSIRO/Mk2, HadCM3, ECHAM4/OPYC3, NCAR-PCM) scaled to six emission scenarios (SRES A1T, A1FI, A1B, A2, B1, and B2).

The **“Phase II Nexus Assessment for the Drin River Basin”** was prepared within the framework of the project “Promoting the Sustainable Management of Natural Resources in Southeastern Europe, through the use of the Nexus approach” financed by the Austrian Development Agency (ADA), the operational unit of Austrian Development Cooperation, and implemented by Global Water Partnership-Mediterranean (GWP-Med) in partnership with the United Nations Economic Commission for Europe (UNECE).

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