The state of Balkan rivers 2025:

Hydromorphological assessment and 13-year trends

by Ulrich Schwarz, Fluvius Vienna

save the blue heart of europe

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Upper Neretva River and Ulog Dam on Neretva in Bosnia and Herzegovina. © Bruno D'Amicis

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1. SUMMARY

A decade of decline
The 2025 State of Balkan Rivers assessment confirms a troubling and steady erosion of the Balkan river network's ecological integrity. Since 2012, an increasing number of rivers have been physically altered, driven primarily by a surge in hydropower development, intensive river regulation for infrastructure and land reclamation, and the destructive impacts of excessive sediment extraction.

The 2025 assessment utilises high-resolution satellite imagery and updated dam inventories to evaluate the three critical pillars of river health: the channel, the banks, and the floodplain. Our analysis tracks the cumulative impact of:

- **Fragmentation**: Dams and barriers that break the natural river continuum.
- **Structural damage**: Artificial reinforcement of riverbanks and the straightening of natural meanders.
- **Habitat loss**: The degradation or total disconnection of vital floodplain ecosystems.

To accurately trace the development over time, we compared current findings with two previous benchmarks: the 2012 Hydromorphology and Dam Projects assessment (Schwarz 2012) and the 2018 Eco-Masterplan for Balkan Rivers (RiverWatch & EuroNatur) (**Figure Summary 1**). Because the 2012 study focused exclusively on larger rivers, our comparative analysis focuses on that specific subset of 35,530 river kilometres (rkm), finding:

- The **percentage of the most pristine rivers has dropped by 7% since 2012**. Conversely, the degraded classes increased, with moderately modified rivers rising by 5% and extremely and severely modified rivers each increasing by 1%.
- The **total length of reservoirs** (impoundments) for larger rivers grew from 2,224 rkm in 2012 to 2,626 rkm in 2025—an **18% increase** (402 rkm) that underscores the relentless pressure of hydropower expansion.

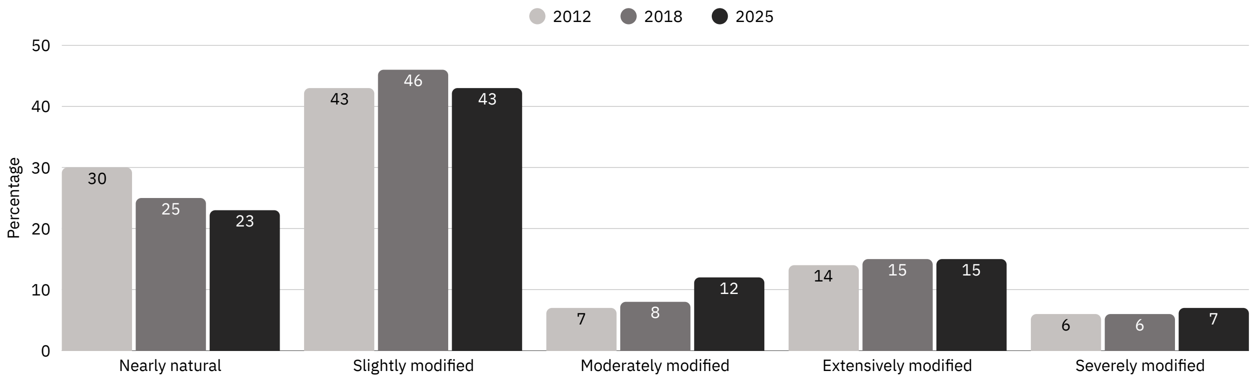


Figure Summary 1: Comparison of the percentage of HYMO classes for larger rivers 2012, 2018 and 2025.

National crises: Albania and Bosnia & Herzegovina
This 2025 analysis finds particularly severe degradation in countries heavily targeted by hydropower development. By calculating precise shifts in rkm, the data reveals a startling loss of integrity:

- **Albania**: Nearly natural river stretches plummeted from 68% in 2012 to just 40% in 2025—a massive 28% reduction. In absolute terms, the length of nearly natural rivers dropped from 3,812 rkm to 2,668 rkm in just seven years (2018–2025).
- **Bosnia & Herzegovina**: The share of pristine rivers fell from 1,170 rkm to 904 rkm, representing a 23% decrease in high-value ecological stretches (2012 - 2025).

The regional snapshot: Despite these persistent pressures, the Balkans remain unique in Europe. Across the 83,824 rkm evaluated, now including all small rivers as well:

The good news: Approximately 33% of Balkan rivers remain in a nearly natural state, with another 39% categorised as slightly modified (**Figure Summary 2**). This ensures the region remains a global ecological stronghold, far surpassing the river health status of Central and Southern Europe.

Photo: *Aoos River, Greece © Joshua D. Lim*

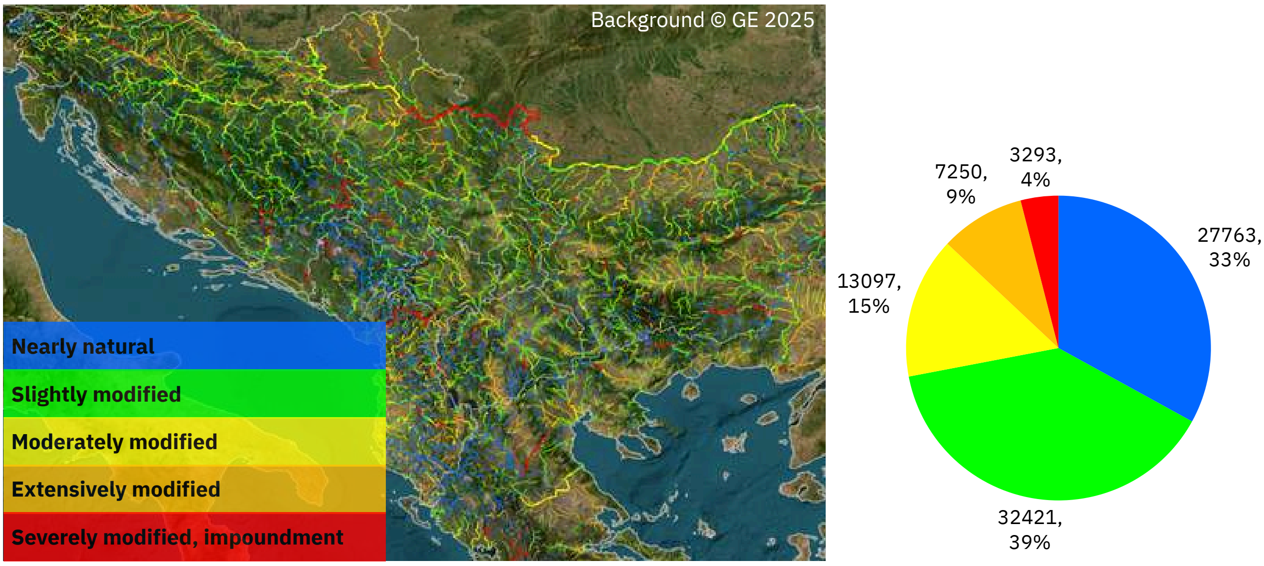


Figure Summary 2: Hydromorphological assessment and distribution in rkm for the entire Balkan area.

Signs of hope: Amidst the decline, significant river protections have been achieved. Most notably, the Vjosa in Albania was designated Europe's first Wild River National Park, successfully blocking nearly 40 planned dams. In Bosnia and Herzegovina, while high-value ecological stretches decreased by 23%, a landmark legal victory was achieved in 2022. Amendments to the Law on Electricity in the Federation of Bosnia and Herzegovina banned the approval of new small hydropower plants (under 10 MW), effectively halting approximately 116 planned projects. In total, some 200 km of large rivers and 700 km of small rivers have been preserved across the Balkans.

The bad news: Despite such achievements, the trend is moving rapidly in the wrong direction. The "Blue Heart of Europe" is being systematically compromised by short-sighted development. While hydropower remains a dominant threat, the transition from wild rivers to infrastructure corridors is the result of cumulative human impacts:

- **Hydropower & diversions**: Large-scale dams and small hydropower plants divert water, leaving long residual stretches dry and fragmenting the river continuum.
- **Extractive industries**: Excessive gravel and sand mining are depleting sediment reserves, causing riverbeds to incise and habitats to collapse.
- **Infrastructure & regulation**: Road construction along river valleys and aggressive flood-defense works have led to extensive channel straightening and floodplain disconnection.

2. INTRODUCTION

To understand the health of a river, we must look beyond water quality to its hydromorphology. Hydromorphology (HYMO) describes the physical characteristics of rivers, such as the channel, banks, and floodplain, and the processes that create them. It encompasses the flow of water and the movement of sediment. A "healthy" hydromorphological state means the river is free to move, flood, and reshape its landscape—processes that are essential for biodiversity and climate resilience.

Since the initial 2012 Balkan Hydromorphological Status and Dam Projects assessment conducted within the "Save the Blue Heart of Europe" framework, the Balkan Peninsula has remained the primary focus of European river conservation. However, the region's freshwater ecosystems are undergoing rapid transformation. While the Balkans still host the most significant network of wild rivers on the continent, these systems are increasingly threatened by a surge in infrastructure development.

This assessment examines the HYMO status of rivers across the Balkan Peninsula, with particular focus on the Western Balkans. The study area includes Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo, Albania, Bulgaria, North Macedonia, Türkiye and Greece.

A five-class integrity assessment system was used to categorise the physical state of the river network, ranging from pristine wilderness to heavily engineered channels:

Class 1 (blue): Near-Natural/Pristine. Rivers with undisturbed or mostly undisturbed flow regimes and natural floodplains. They function as they did centuries ago.

Class 2 (green): Slightly Modified. Some human interventions exist, but the river retains its fundamental natural character and connectivity.

Class 3 (yellow): Moderately Modified. Significant changes to the banks or flow, often due to smaller barriers or localised regulation.

Class 4 (orange): Heavily Modified. The river's natural processes are severely impaired by large dams, embankments, or extensive channelisation.

Class 5 (red): Severely Modified / Impounded. The river has been transformed into a series of stagnant reservoirs (impoundments) or concrete-lined canals.

To accurately track the trajectory of these ecosystems, this 2025 assessment compares current data against two critical benchmarks: the 2012 Baseline Study (Schwarz 2012) and the 2018 Balkan Eco-Masterplan (RiverWatch & EuroNatur). By integrating these datasets with current satellite imagery and the 2025 Balkan Hydropower Update, we can provide a high-resolution view of 13 years of change.

The primary objective of this report is to provide a comprehensive update on the physical integrity of the Balkan river network. Specifically, this study aims to:

- Identify and map the hydromorphological status of the entire drainage network across all five integrity catergories.
- Quantify the rate of hydromorphological change over the past 13 years to identify regional "hotspots" of degradation.
- Provide scientific evidence to support international conservation efforts.

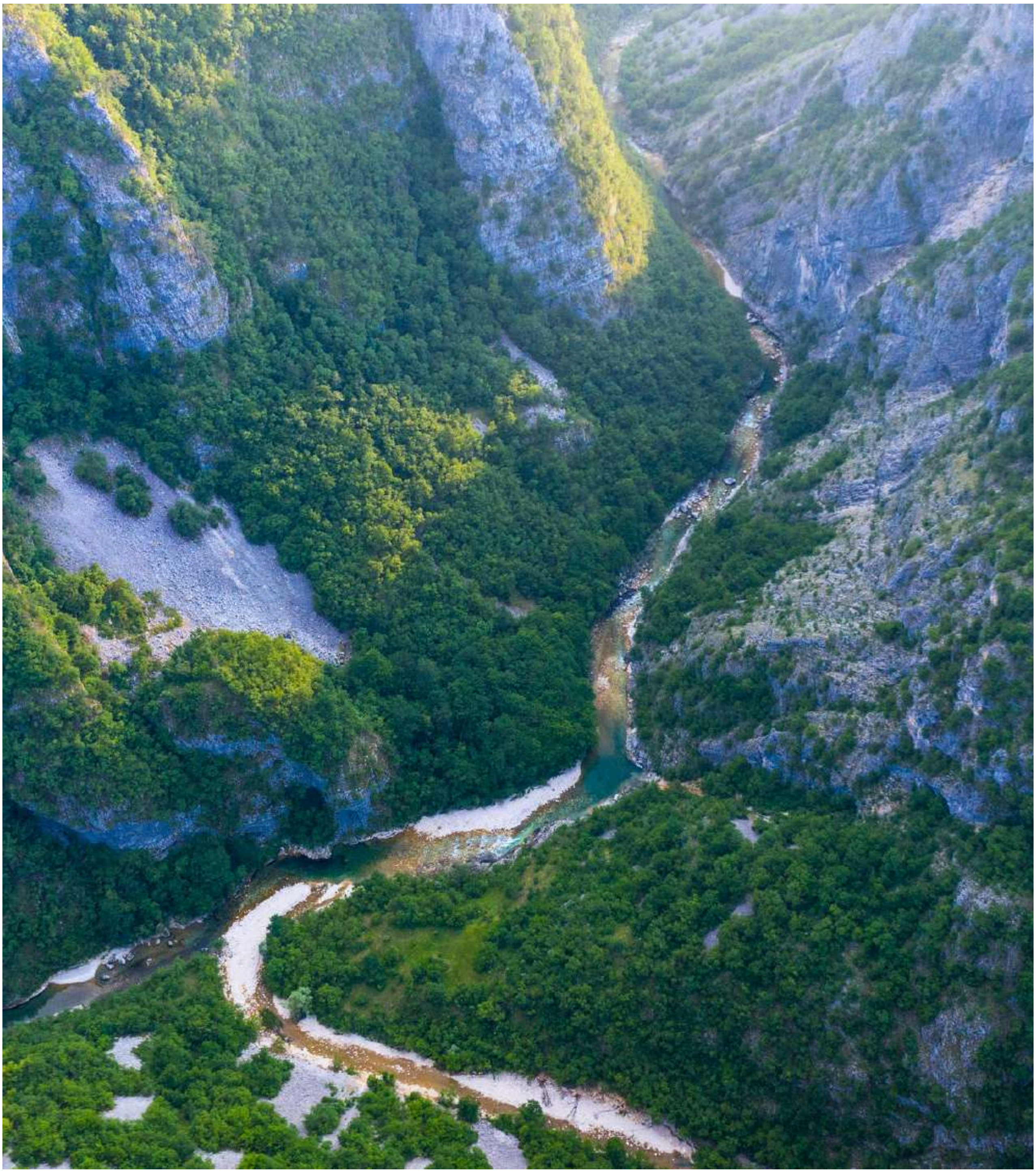


Photo: *Komarnica River in Montenegro is threatened by a hydropower project that will drown the river, the canyon and all the unique, endemic and protected species within them. © Bruno D'Amicis*

3. APPROACH

3.1 THE EVOLUTION OF HYDROMORPHOLOGICAL ASSESSMENTS

While the term "hydromorphology" (HYMO) gained formal recognition after the year 2000, the practice of surveying river structures and eco-morphology began decades earlier. These initial studies focused on the physical (abiotic) conditions of three primary zones: the river channel, the banks, and the floodplains (including riparian vegetation). The methodology has evolved through several key stages:

- **Early inventories** (1980s–1990s): Pioneering countries like the UK, France, Germany, Austria, and Italy developed the first national inventories. However, these reflected vastly different localised approaches, such as the River Habitat Survey in the UK and the SEQ Physique in France, making cross-border comparisons difficult.
- **Standardisation milestones** (2004–2010): The European Committee for Standardisation (CEN) established a unified framework to support the EU Water Framework Directive (WFD).
    - EN 14614:2004 set the first standard for assessing hydromorphological features.
    - EN 15843:2010 introduced a standardised scoring system.
- **The 5-Class System**: While some national systems (like Germany's) use seven classes, the CEN standard promoted a 5-class system to align with the WFD's ecological status classes. This framework enabled partial methodological comparability across countries for the first time.

Early standardised assessments (2004/2010) utilised a "pressure-based" approach. This method quantifies the extent to which a river has deviated from its reference condition—its natural, undisturbed state. The degree of alteration is measured through specific indicators, including:

- **Bank modification**: The proportion of reinforced or regulated banks compared to the natural state.
- **Planform integrity**: The loss of channel sinuosity (natural bends and meanders), the loss of braided and anabranching (multi-thread) channels as well as the width and depth variability of channels.
- **Floodplain connectivity**: The loss of active floodplains due to flood-defence works and embankments.

While newer "process-based" methods offer higher resolution, they require significantly more data; therefore, this report maintains the pressure-based approach to ensure compatibility with previous assessments while accounting for recent advancements in free-flowing river (Nature Restoration Law) and lateral connectivity metrics (**Annex A**).

3.2 CORE ASSESSMENT PARAMETERS

This 2025 assessment updated HYMO data for all river reaches, with particular focus on areas affected by hydropower dams and reservoirs constructed since 2017. The analysis covers visible changes in both upstream and downstream reaches, including water abstraction, new regulatory works (e.g., road construction), and sediment mining.[1]

The evaluation is based on three main compartments, channel, banks, and floodplain, and tracks five core indicators of alteration:

1. **River continuum**: Identification of dams and barriers that fragment the river.
2. **Channel regulation**: Monitoring of rectification, cut-off meanders, and river shortening.
3. **Bank integrity**: Identification of reinforced and artificial riverbanks.
4. **Floodplain health**: Loss or alteration of floodplain areas and their respective habitats.
5. **Morphological shift**: Reduction of dynamic, active channel zones with gravel and sand bars as well as river islands.

3.3 RIVER CLASSIFICATION AND TYPOLOGY

To ensure ecological accuracy, the assessment accounts for different river typologies across the Balkan landscape:

- **Narrow/gorge valleys** (upper reaches): Characterised by confined banks and steep slopes.
- **Anabranching courses** (middle/lower reaches): Found in broad valleys with partially confined banks.
- **Meandering lowland rivers**: Defined by unconfined banks and free lateral shifting.

Furthermore, river size was subdivided into four distinct "Size Categories". While originally based on Strahler river order, these were adapted to fit the unique geography of the Balkans, such as water-rich but short karst rivers:

- **Size category one:** The Danube. The largest drainage system in the region.
- **Size category two:** Major tributaries & Mediterranean rivers: Large systems such as the Drava, Sava, Tisa, Veliki Morava, Neretva, Bojana-Buna, Vjosa, Vardar, Maritsa and major Greek rivers.
- **Size category three**: Medium-sized rivers: Significant tributaries across all catchments.
- **Size category four**: Small rivers. Includes headwaters and karst streams (filtered to remove elevation-model artifacts).

1. For detailed parameters and visualization of HYMO assessments considered as background please refer to **Annex B**. The current assessment account only the overall integral value (mean value out of channel, bank and floodplain assessment) for each of the 25,000 assessment reaches.

3.4 DATA SOURCES AND PROCESSING

To ensure a high-resolution analysis of 13 years of change, this study synthesised multiple data layers covering both physical barriers and hydromorphological status:

- **The Barrier dataset**: Since 2012, data on river barriers have been continuously updated. In addition to extensive hydropower coverage (Schwarz 2025), the final dataset incorporates other significant barriers such as reservoirs, sluices, regulation weirs, and major ground sills.
- **Core HYMO layers**: The evaluation utilised existing data from the 2024 Balkan Hydropower Update and the 2018 Eco-Masterplan (slightly amended to align with CEN 2010 standards).
- **Remote sensing and external data**: We reviewed Euro Hydro datasets for river networks and Riparian Zone data provided by the EU Copernicus platform. The assessment of multitemporal Google Earth and Sentinel-2 imagery enables the precise localisation of all pressures and most HYMO assessment parameters.
- **National datasets**: Where available, official country data (e.g., Slovenia) and recent national risk assessments (e.g., Serbia's 2024 Water Framework Directive assessment) were considered.

For the final analysis, river stretches were intersected with national borders. To maintain consistency, borderline rivers on the margins of the project area (e.g., the Drava and the Danube) were merged into the respective adjacent Balkan countries (Croatia and Bulgaria). All distance measurements in this assessment have been rounded to the nearest rkm.

3.5 STATUS OF ASSESSMENTS IN BALKAN COUNTRIES

Hydromorphological data for the Balkan region remain highly heterogeneous. Under the Water Framework Directive and the Danube River Basin (ICPDR) cooperation, data for rivers larger than 4,000 km² have been provided since 2005. However, harmonised approaches have largely been limited to the Joint Danube Surveys (JDS 2–5).

- **National implementation**: EU member states (Slovenia, Croatia, Bulgaria, Greece) are required to provide HYMO risk assessments. However, systematic inventories across all HYMO classes and size categories are rare.
- **Baseline of this study**: The first attempt to map the main rivers of the entire Balkan region (~30,000 km) was completed in 2012 (Schwarz). The Balkan Eco-Masterplan (2018) expanded this scope to include small rivers and headwaters (~80,000 km).

This 2025 assessment evaluates a **total of 83,824 km**, including an extension into continental Greece (adding ~2,500 rkm), to provide the most comprehensive network analysis to date.

4. RESULTS

4.1 HYDROMORPHOLOGICAL ASSESSMENT FOR THE ENTIRE BALKAN PENINSULA

The 2025 assessment evaluated a total of 83,824 river kilometres (rkm) across the Balkan Peninsula. This comprehensive scope includes the continental portion of Greece and the European territory of Türkiye.

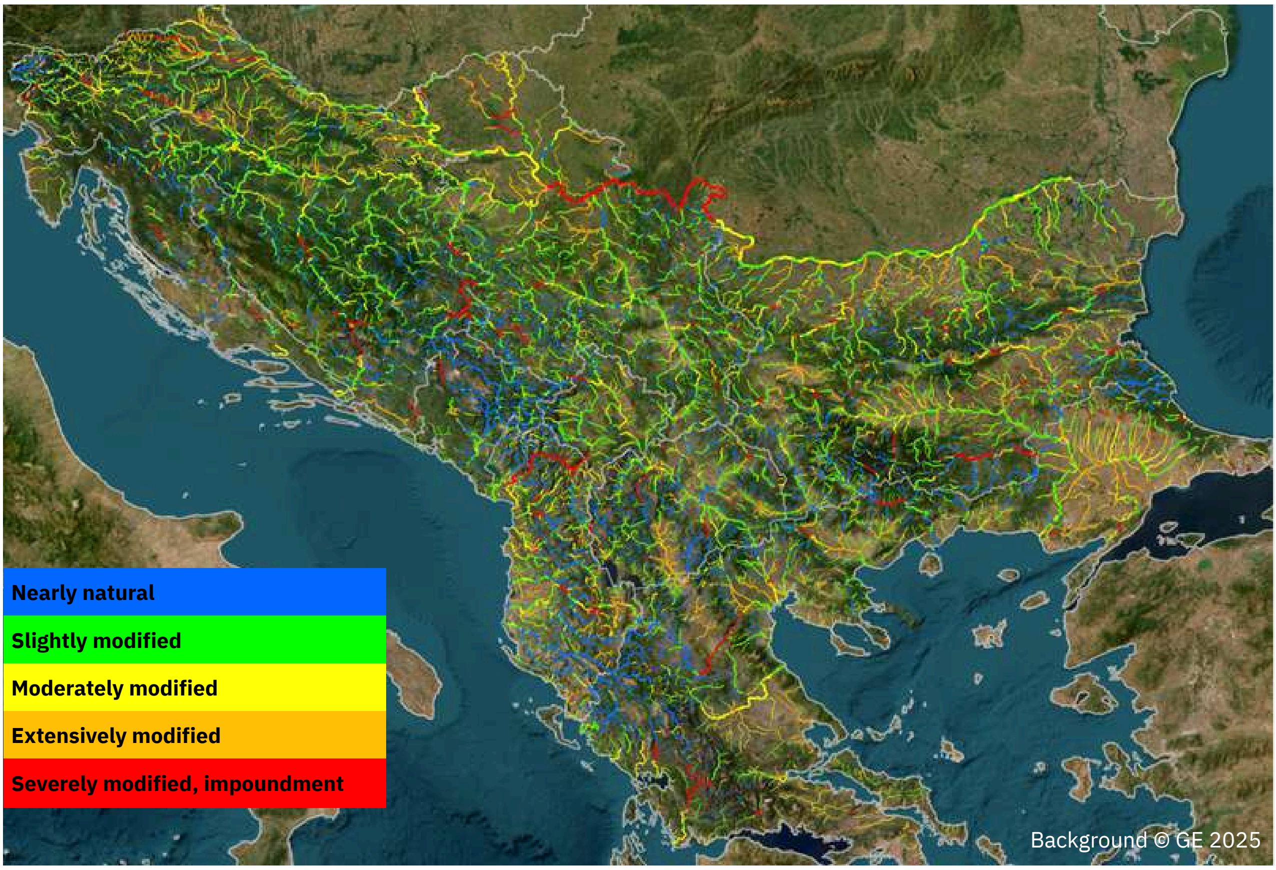
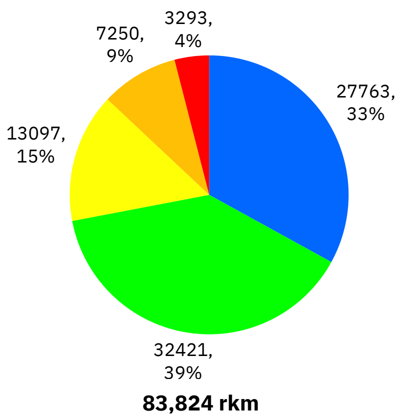
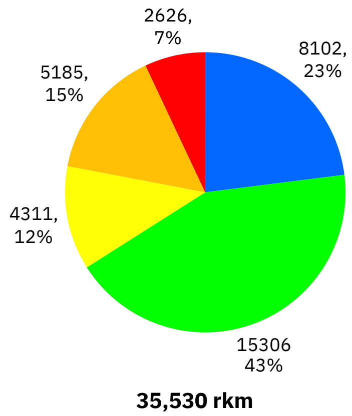


Figure 1: Hydromorphological assessment for the entire Balkan area. While blue and green colours indicate intact and slightly modified rivers, yellow, orange, and red indicate moderate to severe modifications, including impoundments (red). Background © GE 2025





Figures 2 & 3: Distribution in rkm for all rivers (left) and without the small rivers (right) indicates the difference as expected for large and small rivers (size category 4; the inclusion of small rivers and headwaters increases the percentage of rkm for the better classes).

To analyse the most significant ecological corridors, the study zoomed in on larger rivers, totalling 35,530 rkm. The distribution of these rivers across the five hydromorphological classes (**Figures 1 and 3**) reveals a unique ecological landscape:

- Nearly a quarter of the network (23%) remains in the near-natural class (class 1), while 43% falls into class 2. Combined, two-thirds of the larger river network retains high ecological integrity—a status that far surpasses any Western European region.
- Classes 3 and 4 cover 12% and 15% of the network, respectively.
- Class 5 represents the most extreme degradation, primarily in the form of stagnant reservoirs. These are most visible in large-scale infrastructure projects such as the Iron Gate dams on the Danube (Serbia) and the Drin River dam chain in Albania.

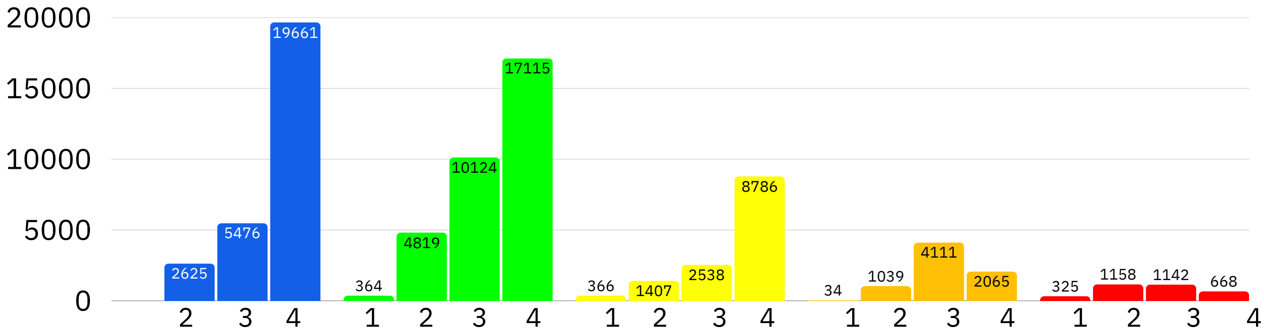
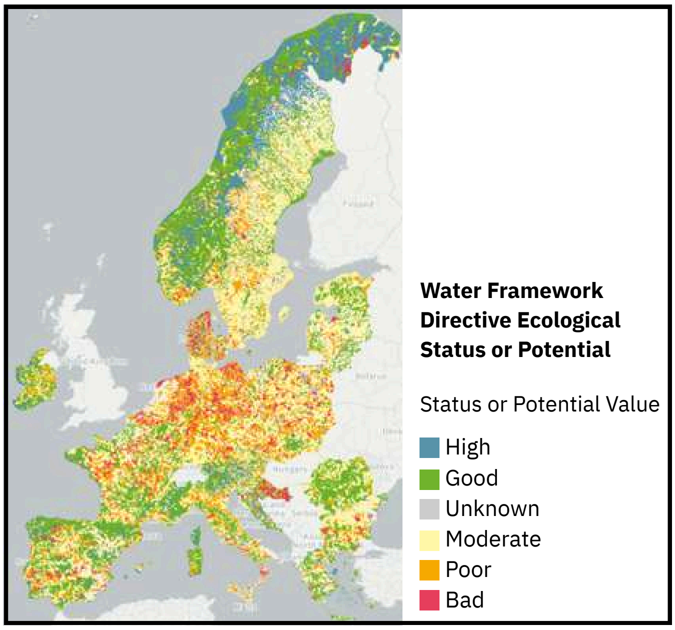


Figure 4: Distribution in rkm for the five HYMO classes within the size categories 1-4; 1=very large rivers, 2=large rivers, 3=medium-sized rivers, 4=small rivers (HYMO class 1 for the Danube (size category 1) cannot be found at all).



The data confirm that, while the Balkan rivers remain in favourable condition compared to the rest of Europe (**Figure 5**),[2] representing Europe's "Blue Heart," the footprint of severe modification is expanding, creating significant "dead zones" in what were once some of the continent's most dynamic river systems.

Figure 5: The most recent ecological status includes, reflects, and synthesises HYMO quality elements (hydrological regime, river continuity, and morphological conditions). Consequently, this map provides an impression and rough approximation of river health in Europe.

2. The most recent data from the Water Information System for Europe (WIS) indicate that no uniform, directly comparable data layer exists, as the quality elements for HYMO are divided into separate groups (hydrological regime, river continuity, and morphological conditions). Data are incomplete, hampered by missing country data.

4.2 COMPARISON WITH PREVIOUS ASSESSMENTS FOR THE ENTIRE BALKAN PENINSULA

For the comparison and development of the hydromorphological conditions two data sets have been evaluated, those from 2012 (Schwarz 2012) and 2018 (RiverWatch & EuroNatur 2018) (**Annex C**).

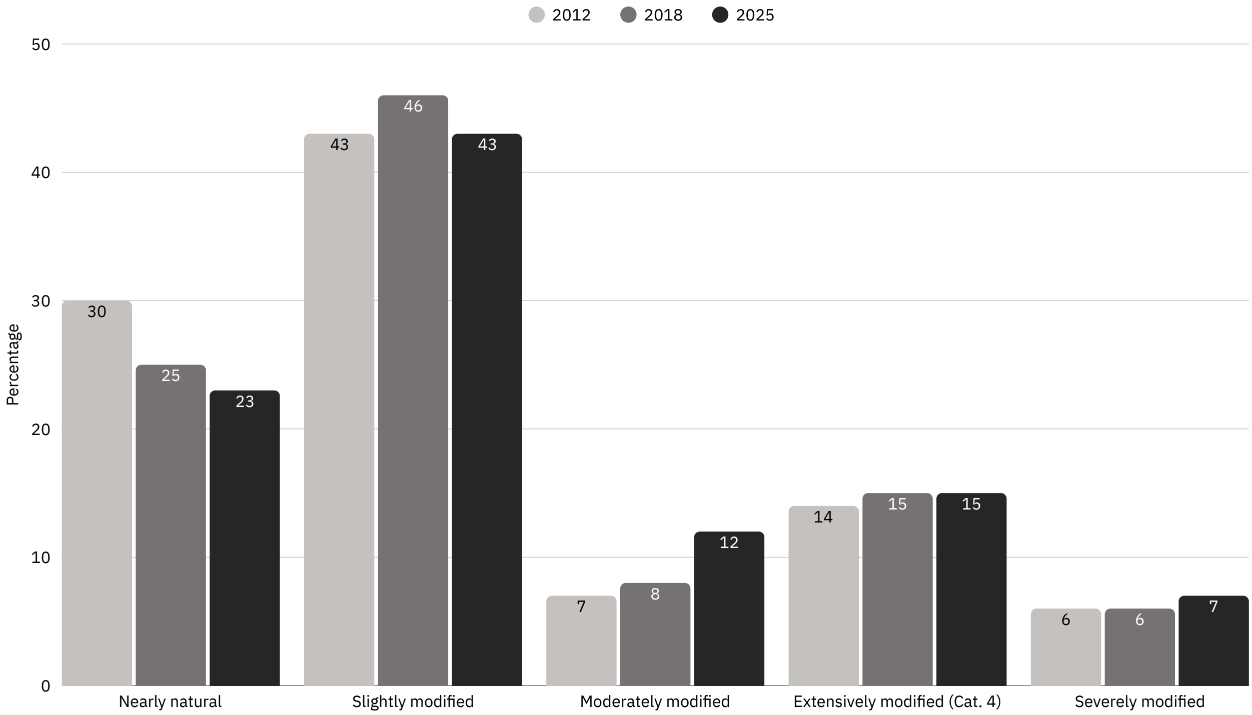


Figure 6: Comparison of the percentage of classes for larger rivers in 2012, 2018, and 2025.

The shifting distribution of classes (**Figure 6**) reveals a clear and concerning trajectory. There is a distinct decrease in class 1 (nearly natural) stretches as they are downgraded into classes 3, 4, and 5 due to human intervention. While class 2 (slightly modified) currently remains relatively stable in total percentage, it is also beginning to decline, as the influx of former class 1 rivers is offset by class 2 rivers being further modified into poorer ecological classes.

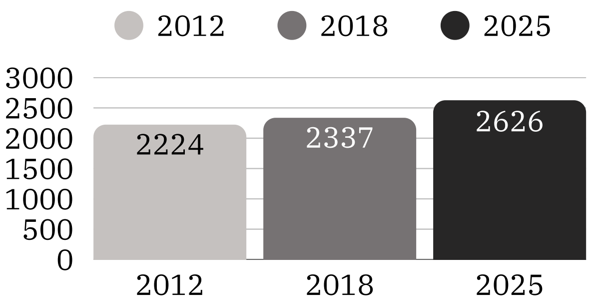


Figure 7: Development of impoundments for larger rivers in km.

The look on the total length of impoundments for the larger rivers in rkm clearly shows an increase for some 18% (**Figure 7**). However, the affected length by dams upstream and downstream is much larger (classes 4 and 3), in particular, as for small abstraction hydropower plants, impoundments are often very short in comparison to the affected residual river stretches.

4.3 HYDROMORPHOLOGICAL ASSESSMENT PER COUNTRY

4.3.1 SLOVENIA

The country's river catchments are subdivided from north to south into the Alpine-Danubian catchments of the Mura, Drava, and Sava, with their karst catchments in the south (Ljubljanica, Krka, Kolpa), and the Alpine-Mediterranean western catchments of the Soca. Slovenia also hosts several excellent river stretches and sub-basins, particularly in the west (the upper Soca basin) and in some karst rivers in the south.

The lower Mura exhibits high ecological value. However, the Sava and the lower Soca have long reaches that are heavily used for hydropower and are severely altered.

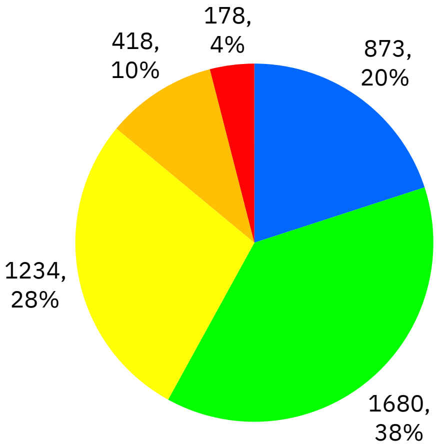
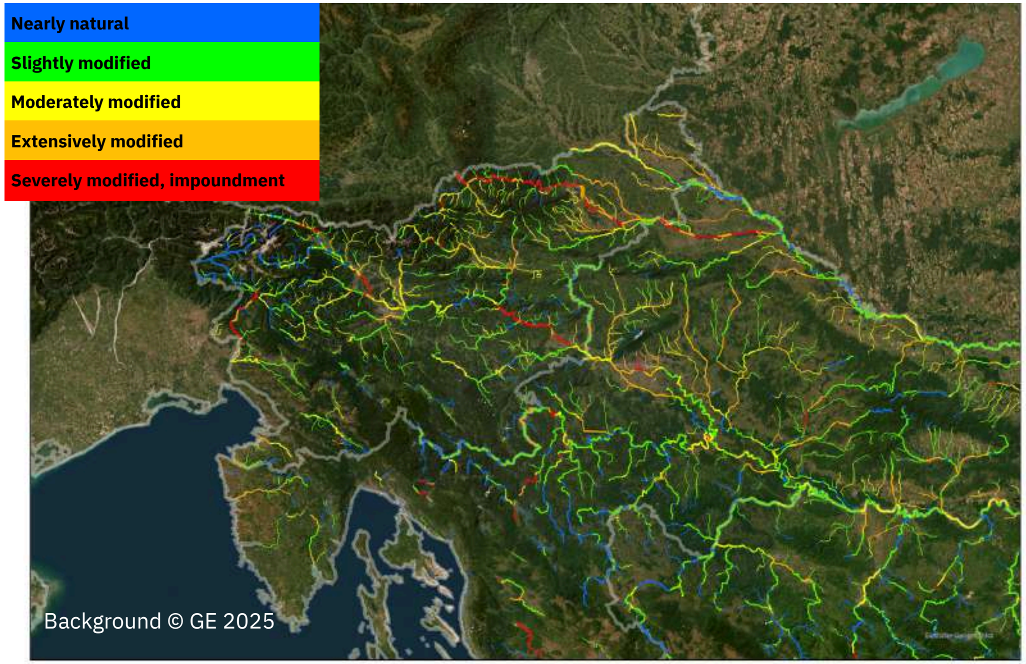


Figure 8: Slovenia HYMO percentages and rkm distribution.



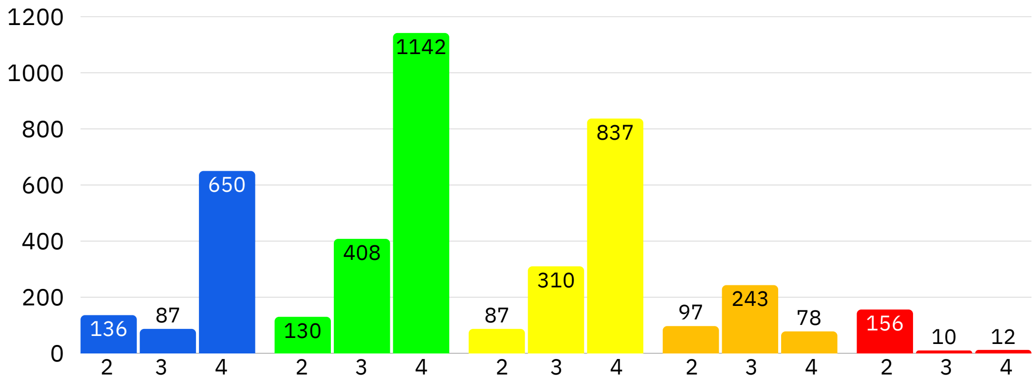
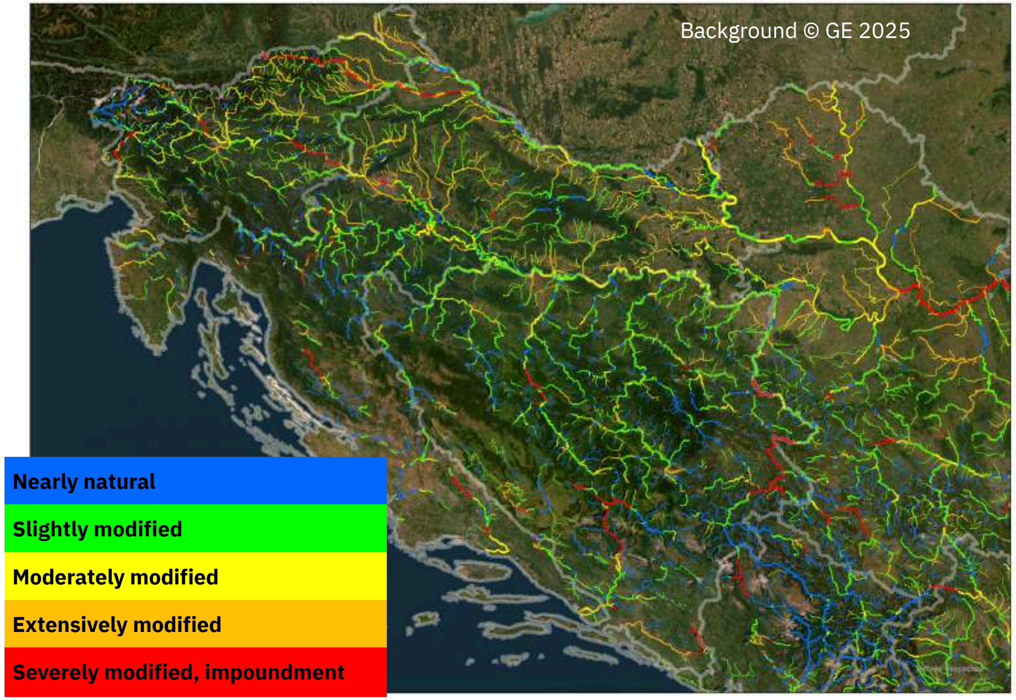


Figure 9: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube is not applicable).

4.3.2 CROATIA

Croatia encompasses a wide range of river types and sizes: the two large west–east river systems, the Mura–Drava and the Sava, even meet the Danube in broad plains, while the central and coastal regions are characterised by important karst river systems (e.g., the Korana, which includes the Plitvice Lakes). Only the upper reach of the Drava in Croatia and parts of the Lika karst system are fully utilised for hydropower production. By contrast, longer stretches of main rivers, such as the Mura, Drava, Sava, Kupa, and Una, remain free-flowing, with extensive adjacent floodplains.



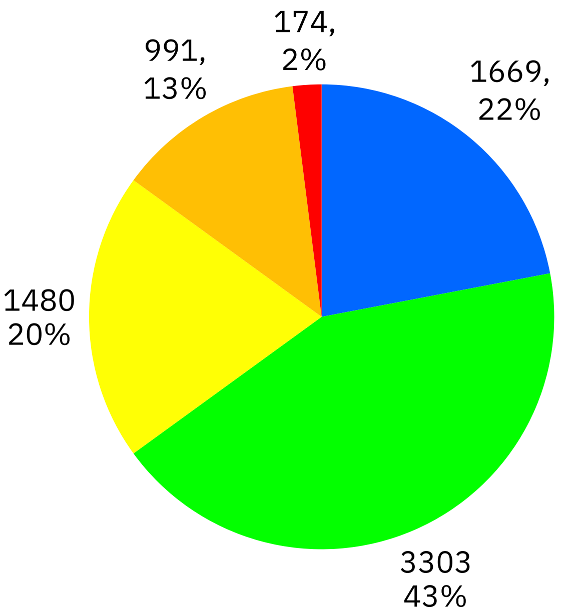


Figure 10: Croatia HYMO percentages and rkm distribution.

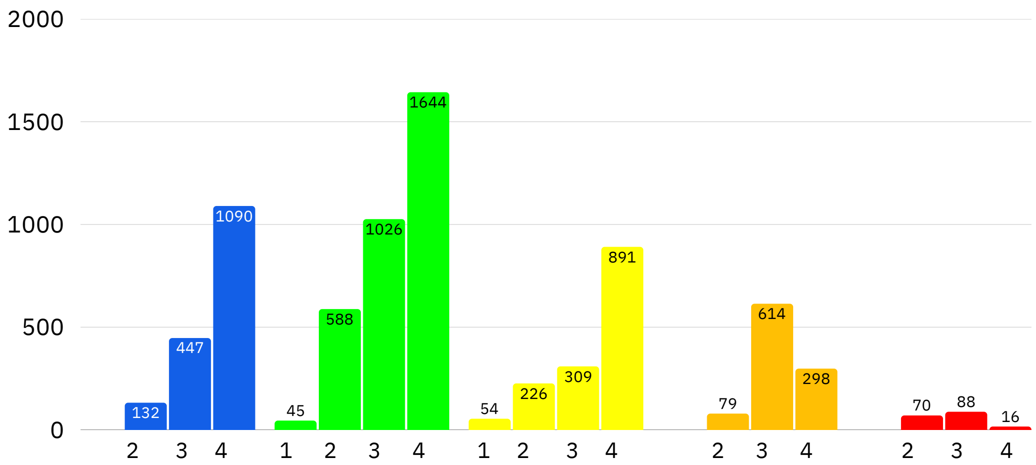
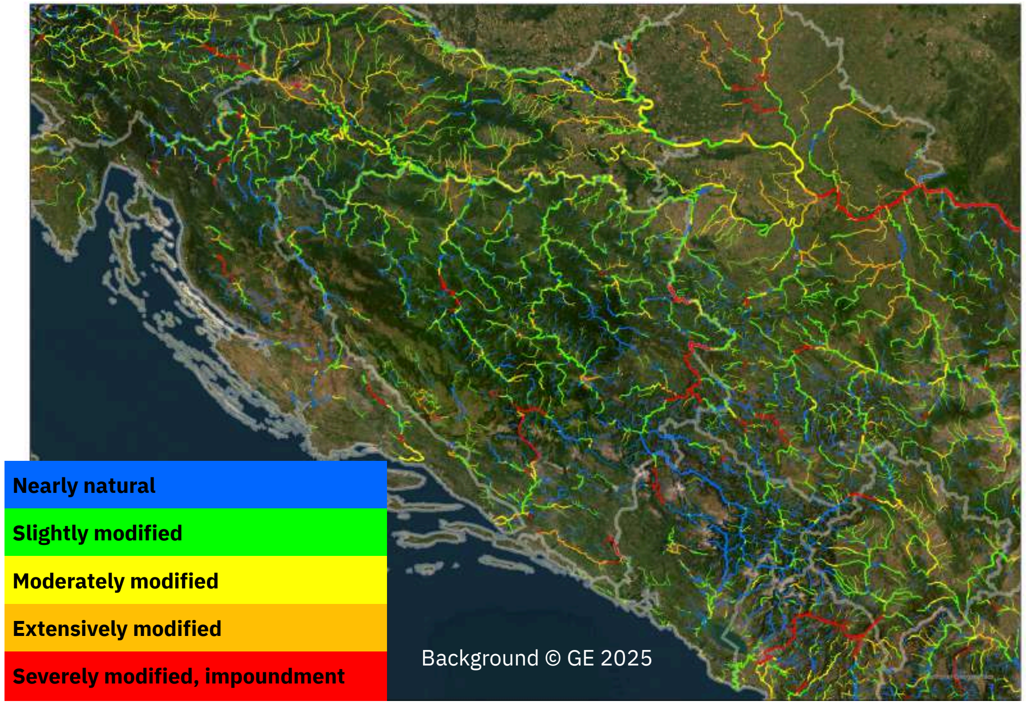


Figure 11: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4=small rivers (size category 1 for the Danube is not applicable).

4.3.3 BOSNIA AND HERZEGOVINA

The country is subdivided into the large Danubian catchment area of Sava tributaries (Una, Vrbas, Bosna, and Drina) and the Mediterranean catchment of Neretva in the south. Larger dams have been built on the Vrbas, Drina, and Neretva rivers, but many rivers fall into the second or even first class (i.e., many smaller rivers in the forested mountains). Hydropower development (e.g., Ulog on the upper Neretva), land reclamation (Bosna), excessive gravel extraction on the lower Drina and land reclamation (legal and illegal housing) on Una have deteriorated the hydromorphological status over the past decade while the stop of several hydropower projects and initiatives like on Una River, point towards a better protection.



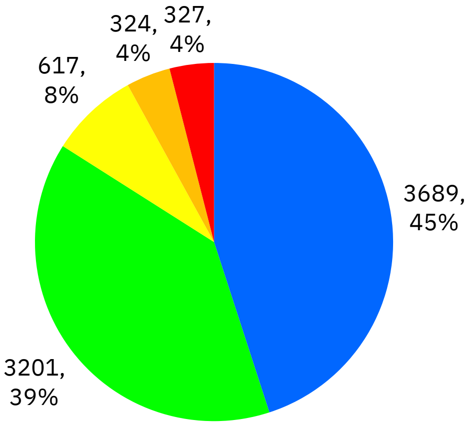


Figure 12: Bosnia and Herzegovina HYMO percentages and rkm distribution.

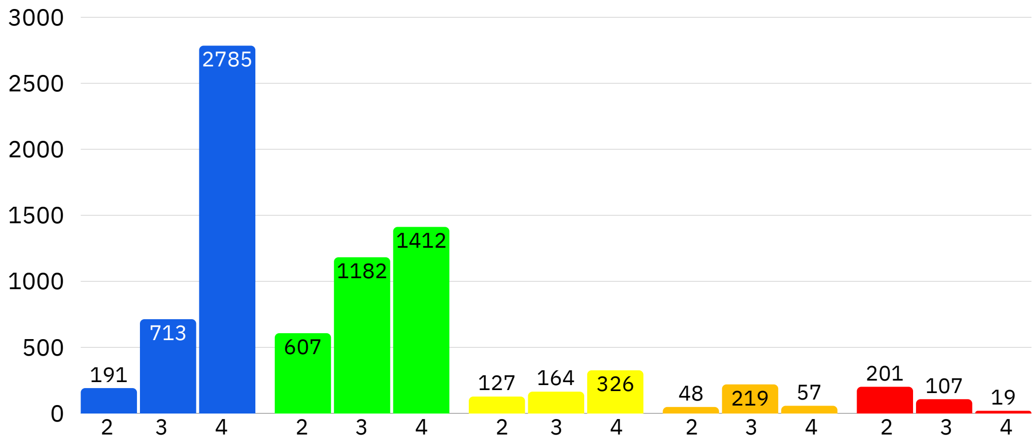


Figure 13: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4=small rivers (size category 1 for the Danube is not applicable).

In Bosnia and Herzegovina, the total length of the Nearly Natural HYMO class for larger rivers decreases from 1,170 river kilometres (rkm) to 904 rkm between 2012 and 2025, representing a loss of 266 rkm (23%). This decline is primarily driven by hydropower plants with capacities of up to 10 MW (**Figure 14**).

Considering further deterioration from river regulation and sediment exploitation, a total of 350 rkm of river length declined in intactness, representing 10% of the total assessed river length.

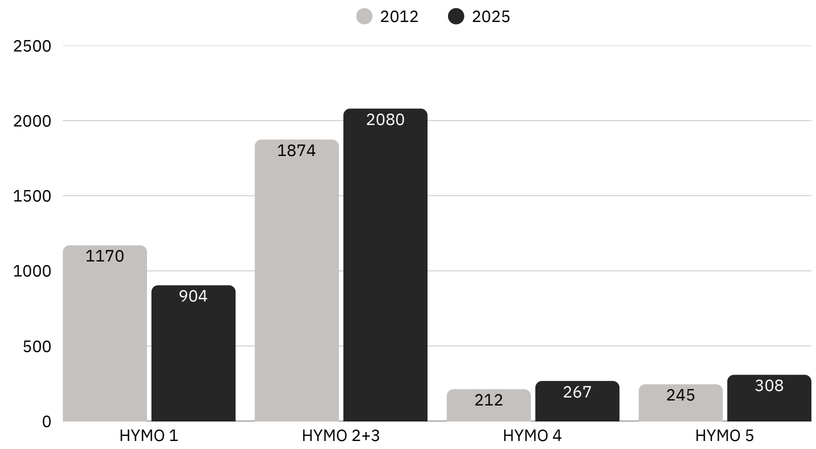


Figure 14: Comparison of large rivers for Bosnia and Herzegovina from 2012 to 2025. The assessment classes 2+3 were not distinguished in 2012. Due to slight differences in drainage networks (river vectors), the total length of assessed rivers was 3,501 rkm in 2012 and 3,559 rkm in 2025, respectively.

Top photo: *Despite years of resistance, the Ulog hydropower plant went into operation in 2025, causing significant environmental damage © Bahrudin Bandic.* **Bottom photo:** *The tragic result of Ulog HPP releasing oxygen-depleted water: A mass fish kill on the precious Neretva. © Hrabren Kapić, Organizacija Sportskih Ribolovaca "Konjic"*

4.3.4 SERBIA

The country can be subdivided into the great plains of the Danube, Tisa, Sava, and the lower Velika (Great) Morava, and the foothills and karst mountains of the Balkan Peninsula, with catchments including Drina, Ibar, Western and Southern Morava, and the eastern catchments of Nišava (Morava) and Timok (Danube).

While significant reaches of the large rivers—the Danube (including the Iron Gate hydropower plants), Drina with the Lim, and Ibar—are impounded by large dams, many rivers in the mountainous headwaters remain intact. Highway construction, initially in the narrow upper valley of the Southern Morava and now in the broad valley of the Western Morava, has led to notable deterioration and river regulation, and a large number of small hydropower plants impact numerous smaller rivers.

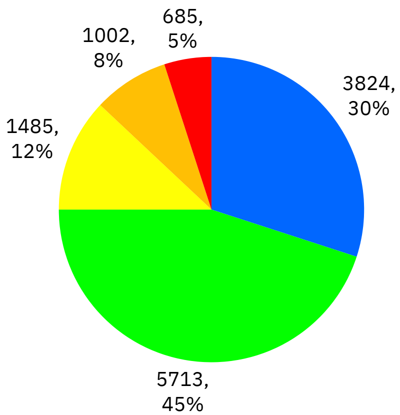
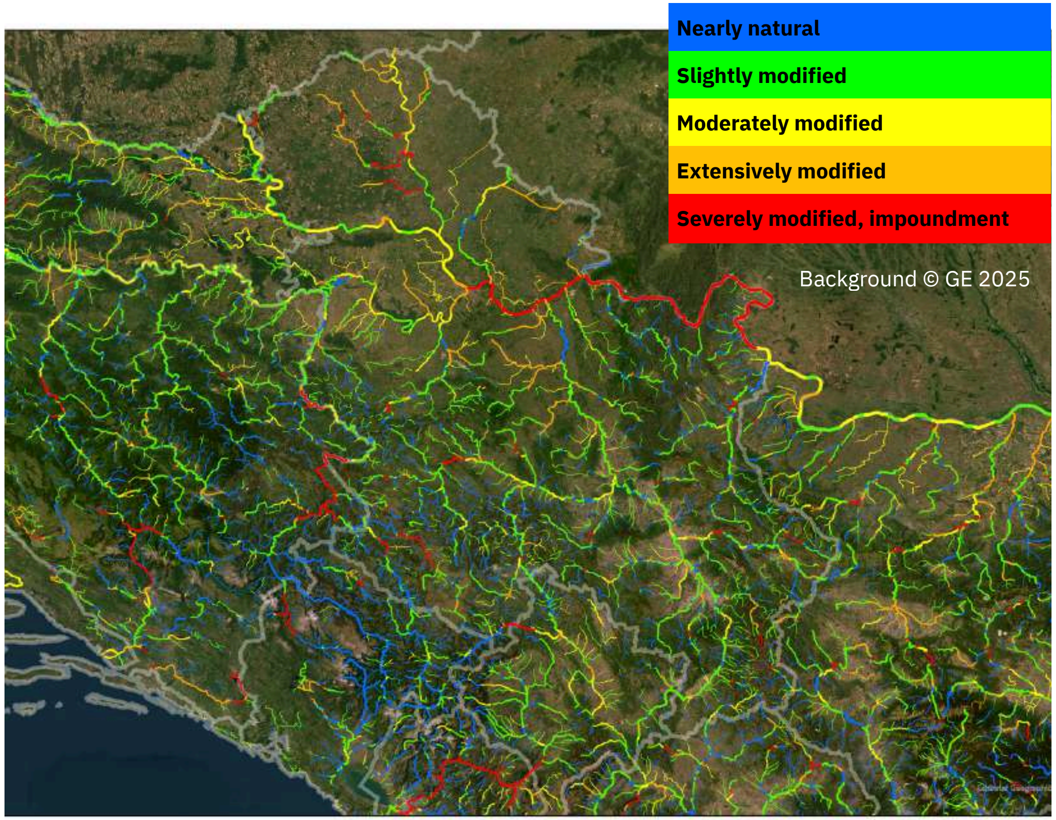


Figure 15: Serbia HYMO percentages and rkm distribution.



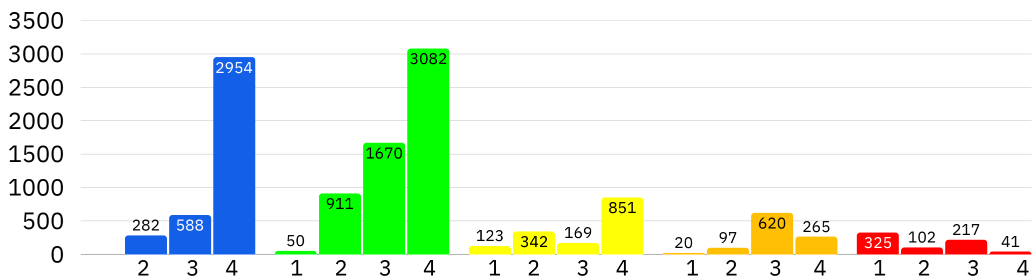
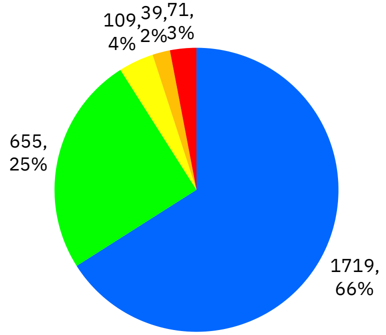


Figure 16: Distribution in rkm within the size categories 1-4, representing 1=very large rivers, 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube is not occurring for blue assessment).

4.3.5 MONTENEGRO

Montenegrin catchments are divided into the northern Danube catchment of the upper Drina (Tara, Piva, Lim) and Ibar, and the southern Moraca basin, with Lake Skadar and the Bojana Delta leading to the Mediterranean Sea. Highway construction has deteriorated some short reaches of the Moraca and Tara rivers. In general, Montenegrin rivers remain in favourable to excellent condition.



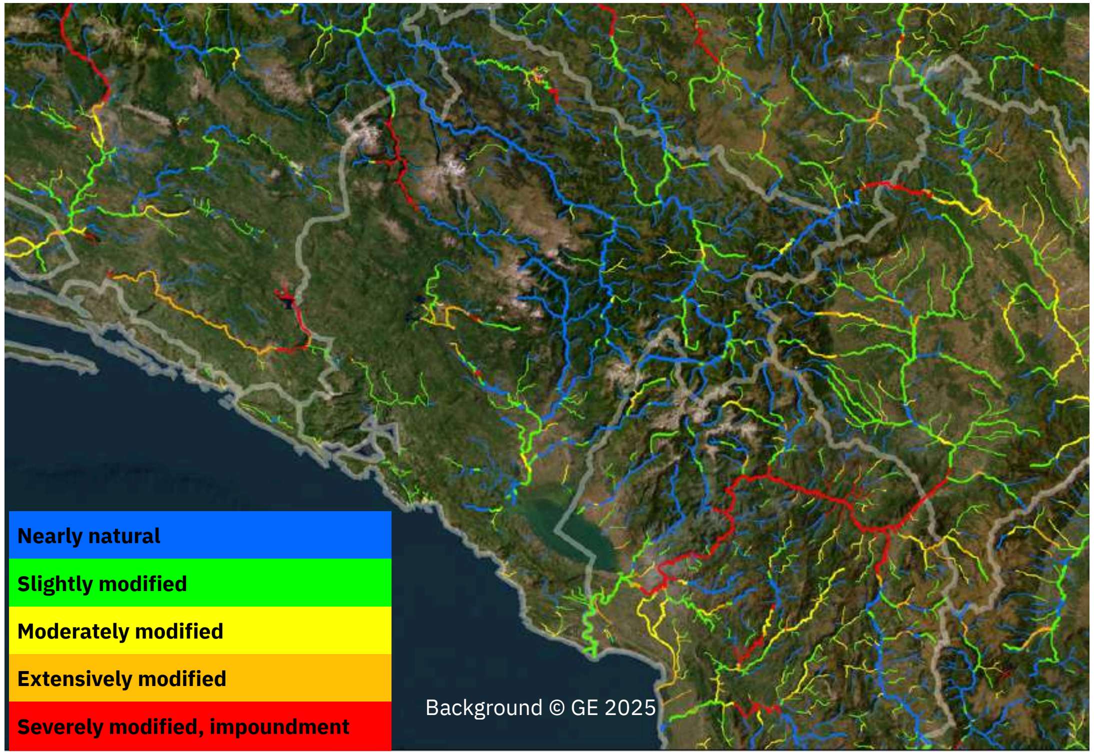


Figure 17: Montenegro HYMO percentages and rkm distribution.

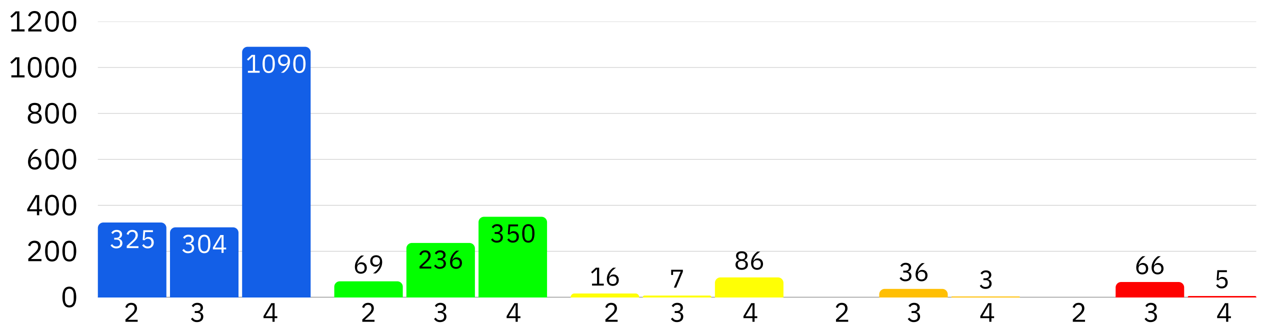


Figure 18: Distribution in rkm within the size categories 2-4, representing 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube is not applicable, and not all assessments are represented across all size categories).

4.3.6 KOSOVO

Rivers in Kosovo belong mainly to the Mediterranean Drin Basin (White Drin) and Vardar, while about 40% of the surface area is part of the Southern and Western Morava (Ibar). Aside from two large dams or backwaters on the Ibar and White Drin, most rivers remain in good HYMO conditions. Excessive gravel mining and the construction of small hydropower plants (sHPPs) have led to overall degradation.

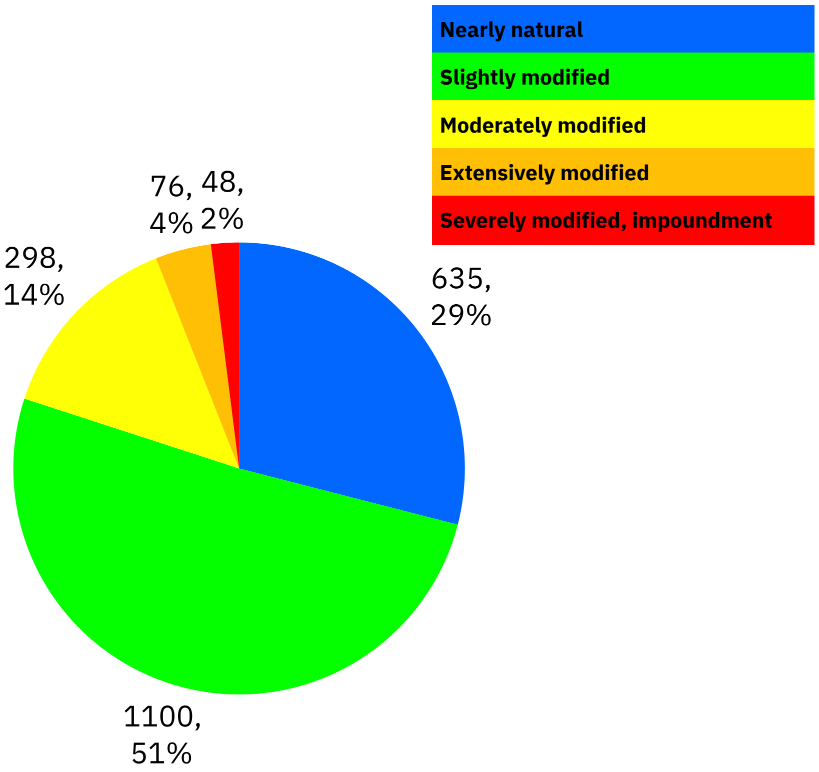
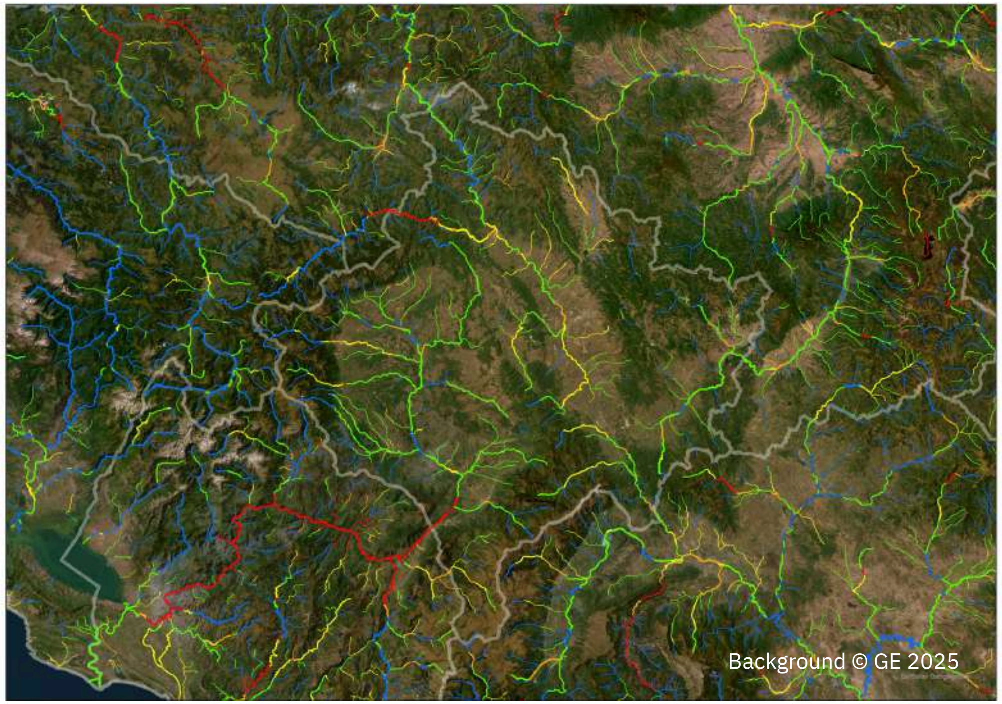


Figure 19: Kosovo HYMO percentages and rkm distribution.



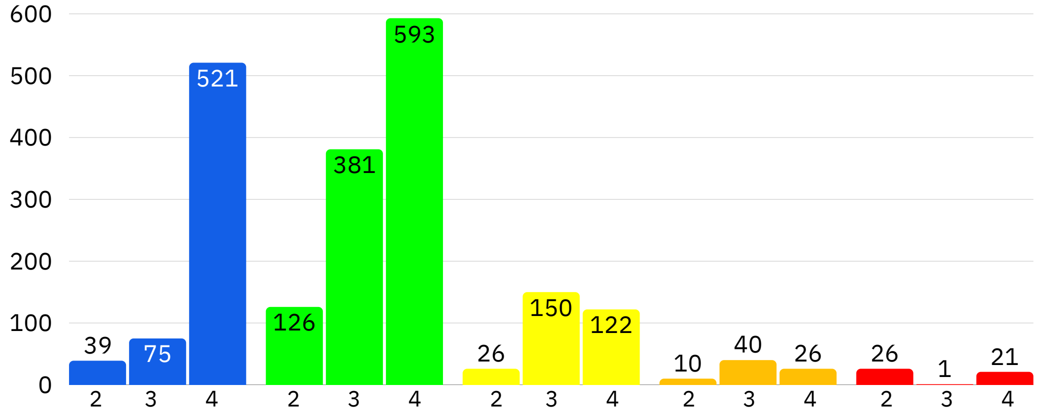


Figure 20: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium sized rivers, 4= small rivers (size category 1 for Danube is not applicable).

4.3.7 NORTH MACEDONIA

Aside from very small portions of tributaries entering the Danube basin and the Struma, the entire area lies in the Vardar catchment. Mountainous river stretches that remain in relatively high ecological condition are being strongly altered in some reaches, such as the large dams on Crna (Tikvesh Dam) and Treska (Kozjak Dam).

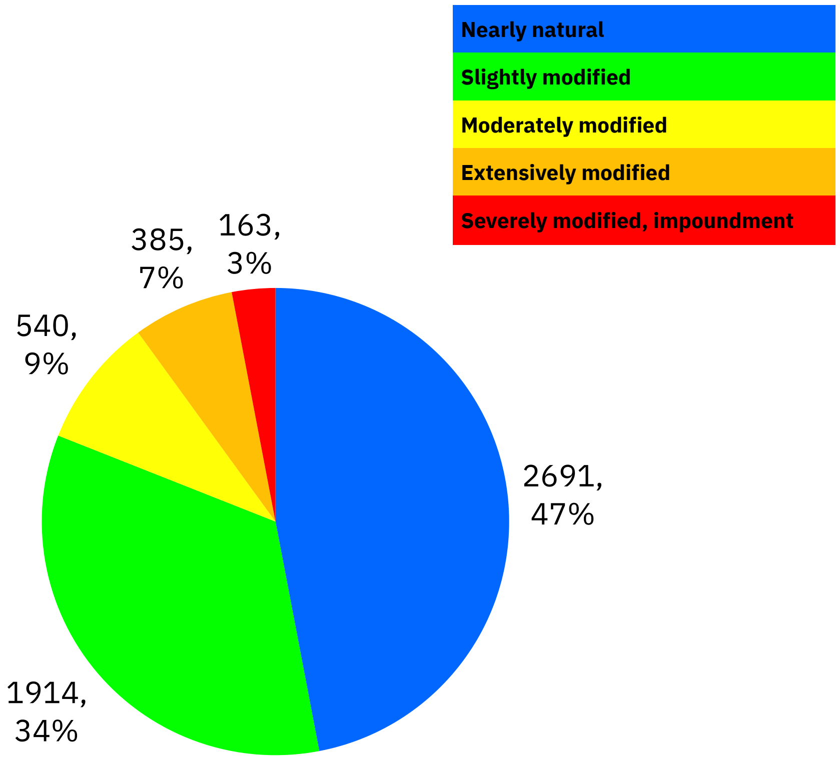
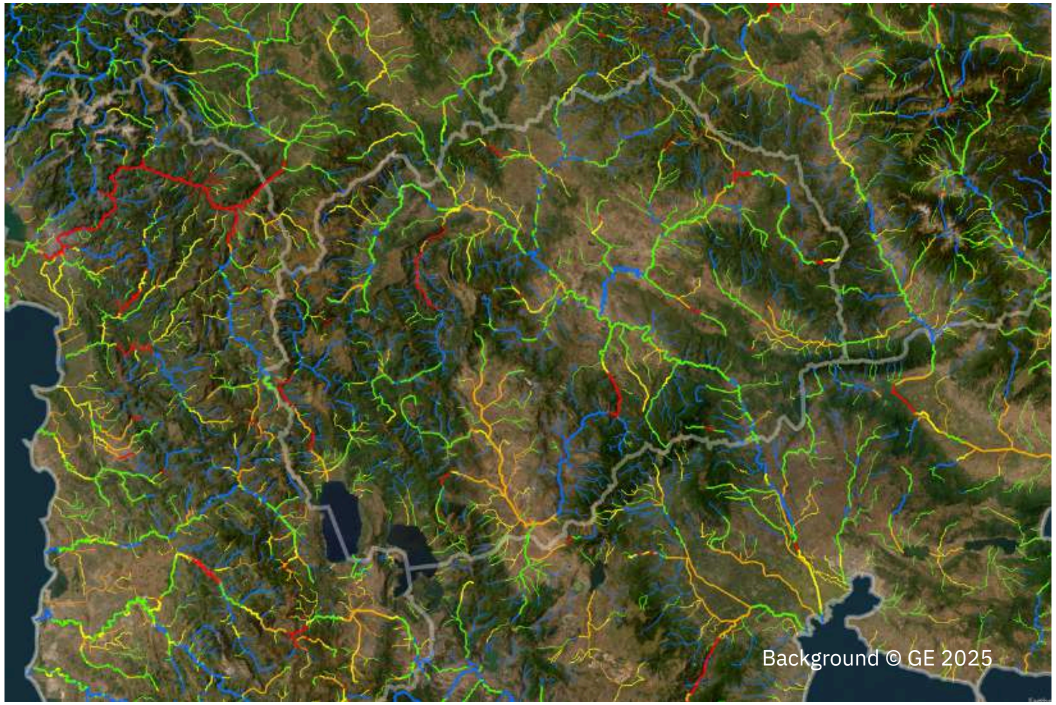


Figure 21: North Macedonia HYMO percentages and rkm distribution.



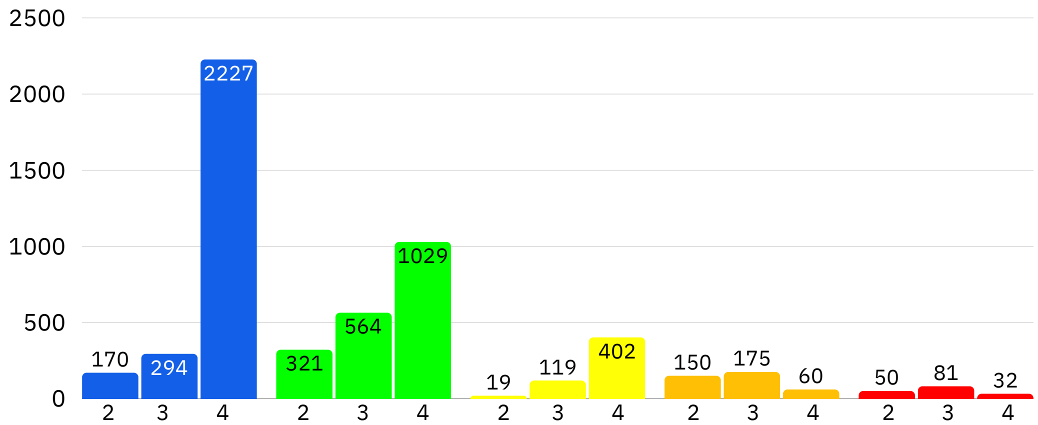


Figure 22: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4=small rivers (size category 1 for the Danube is not applicable).

4.3.8 ALBANIA

The entire country, except for a few square kilometres, feeds into the Mediterranean through several large rivers (Drin, Mati, Shkumbin, Seman, and Vjosa). Albania has lost many intact rivers to hydropower development over the past 10-15 years, while most intact rivers, such as the Vjosa and the Osum Canyon, remain.

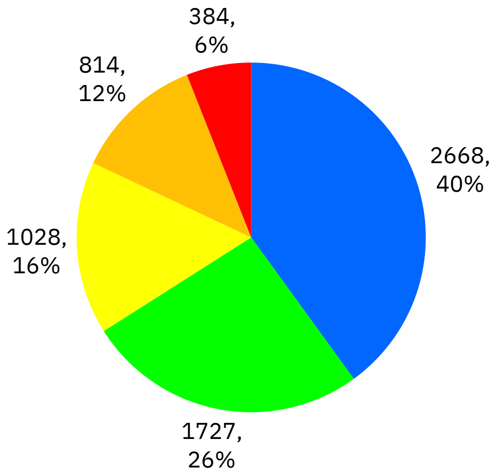
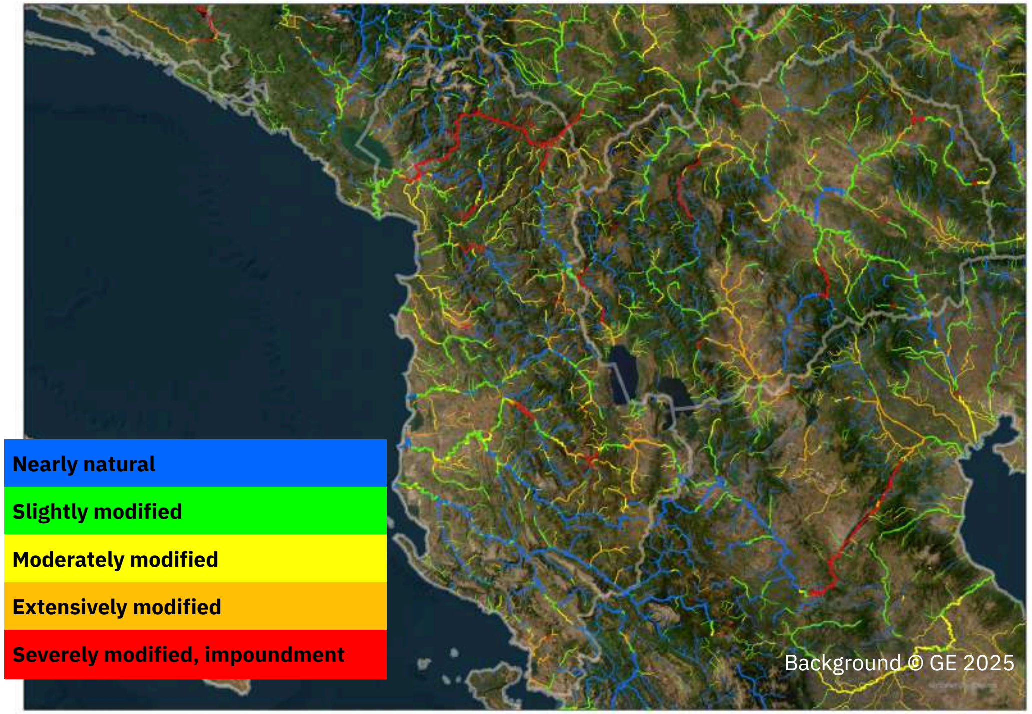


Figure 23: Albania HYMO percentages and rkm distribution.



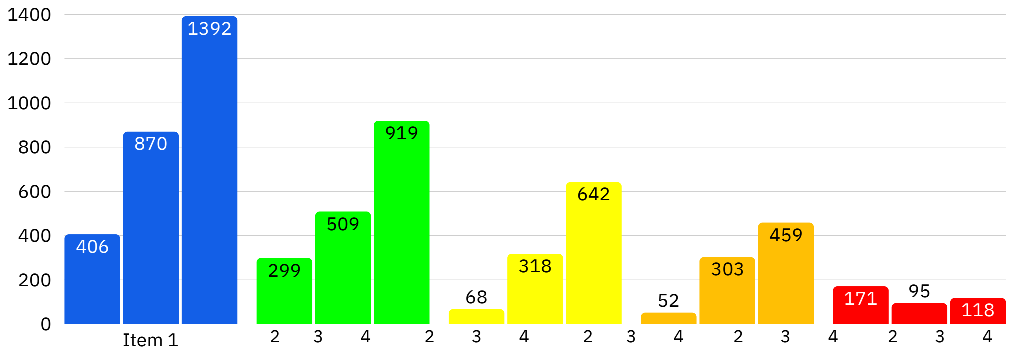
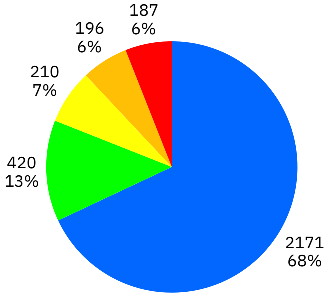
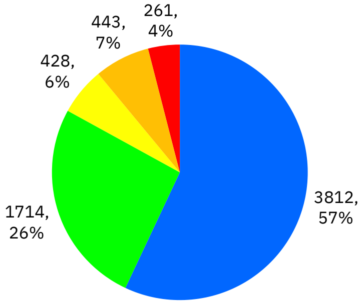


Figure 24: Distribution in rkm within the size categories 2-4, representing 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube is not applicable).

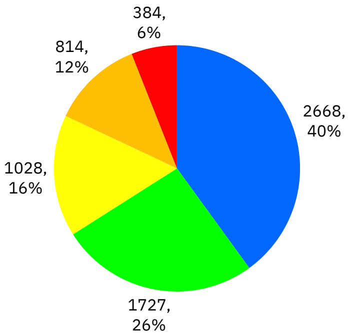
As a mapping example of the drastic deterioration of HYMO conditions on a large river, the middle Devoll (2018–2025) after the construction of the Banjë (built in 2016) and Moglice hydropower plants (upstream, operating since 2020) is symptomatic: not only do the impoundments appear in red on maps, but downstream stretches affected by residual water releases or altered discharge regimes have also become evident.



2012 (3164 rkm)

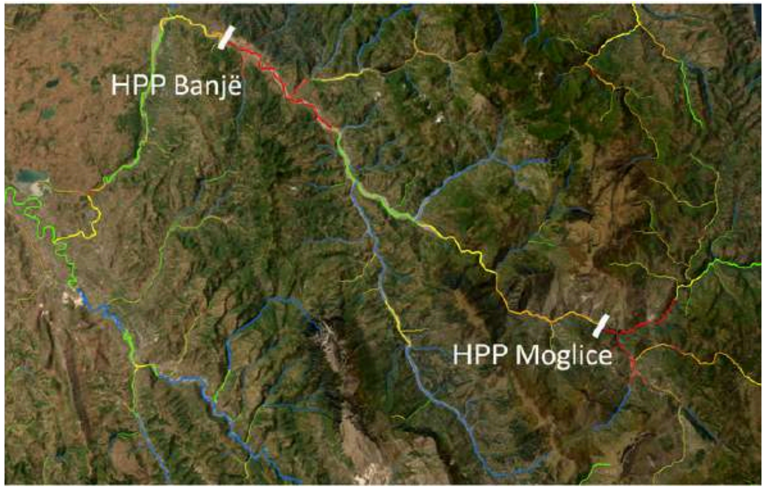


2018 (6608 rkm)



2025 (6621 rkm)

Figures 25 - 27: Development of status: Even though the total length of the assessed drainage network was doubled (3,000 to 6,000 rkm, which usually includes more pristine small rivers in headwaters), the percentages and share of classes 1-5 drastically shift from the best classes 1 & 2 towards the poor classes 3-5. The pristine class 1 declined from 2018 to 2025 by approximately 1,144 rkm.



Figures 28 & 29: TOP: Middle Devoll 2012 before the construction of the two main HPP dams of Banjë and Moglice in 2012 (only main rivers assessed). BOTTOM: In 2025, after the construction of the two main dams and several additional smaller HPPs on tributaries.

4.3.9 GREECE (CONTINENTAL PART ONLY)

Greece was covered for the entire mainland and the large island of Euboea, adding approximately 2,500 river kilometres compared with previous Balkan assessments. Although several large dams and irrigation schemes in the lowlands have altered many rivers, the headwaters in the mountains remain partly pristine; however, small hydropower development has increased in recent years.

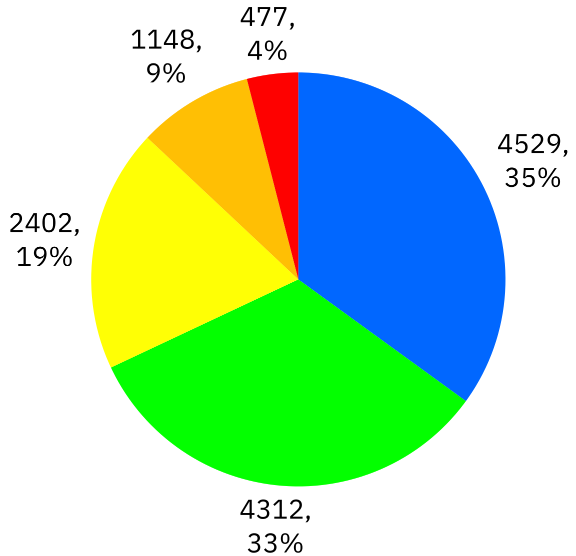
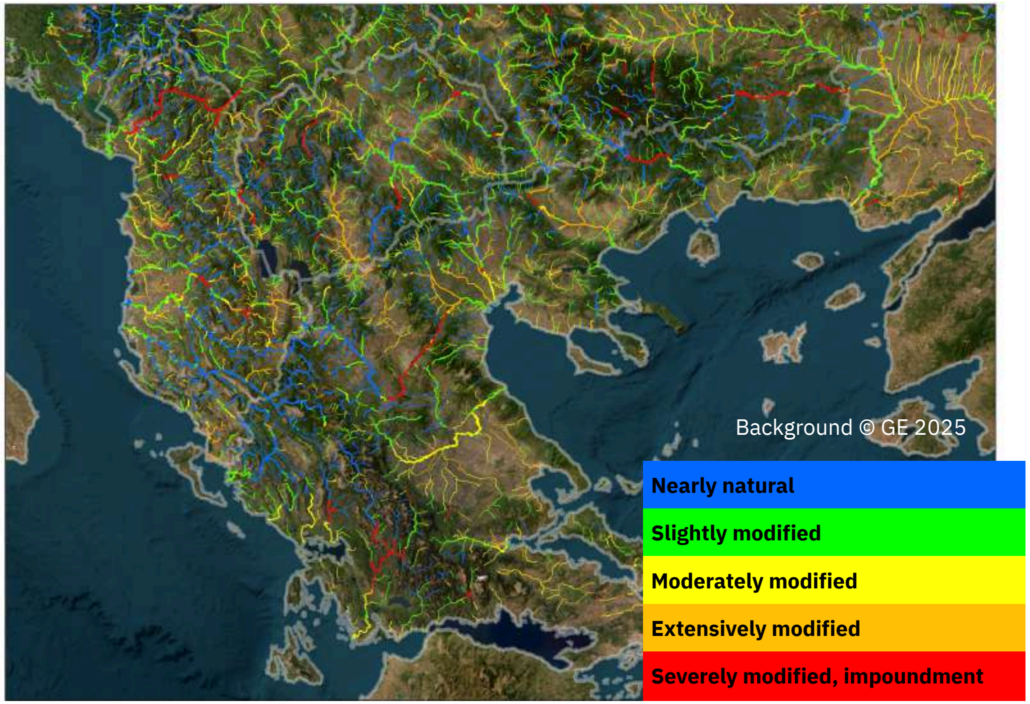


Figure 30: Greece HYMO percentages and rkm distribution.



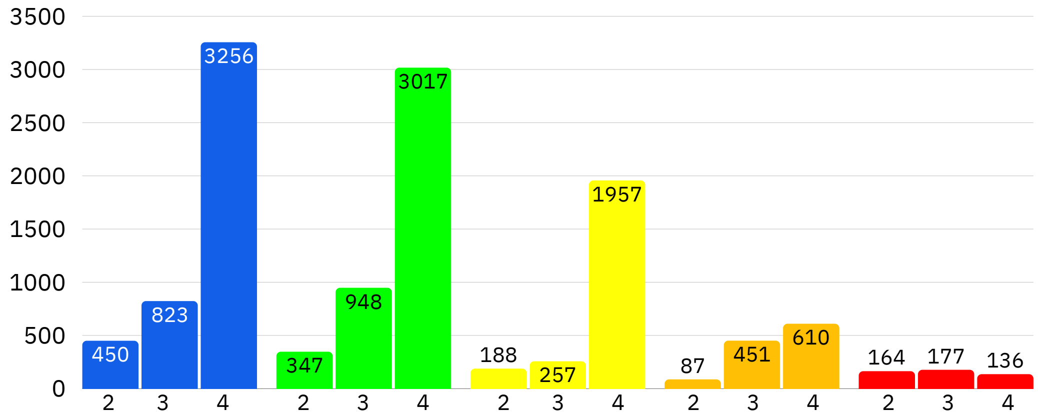


Figure 31: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4=small rivers (size category 1 for the Danube is not applicable).

4.3.10 BULGARIA

The country is subdivided into the large Danubian catchment with several major tributaries (Iskar, Osam, Yantra), the Black Sea coastal catchments, and the large Mediterranean region, including the Maritsa and Struma.

While hydropower development and large dams have focused so far on selected rivers and areas (e.g., the upper Iskar and Arda), the Danube and Maritsa are largely free-flowing. Some intact rivers are found in the Black Sea coastal catchments and in certain upper Arda tributaries.

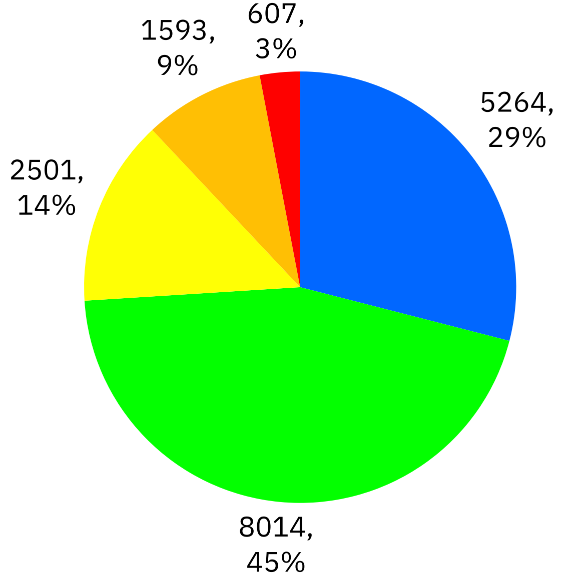


Figure 32: Bulgaria HYMO percentages and rkm distribution.

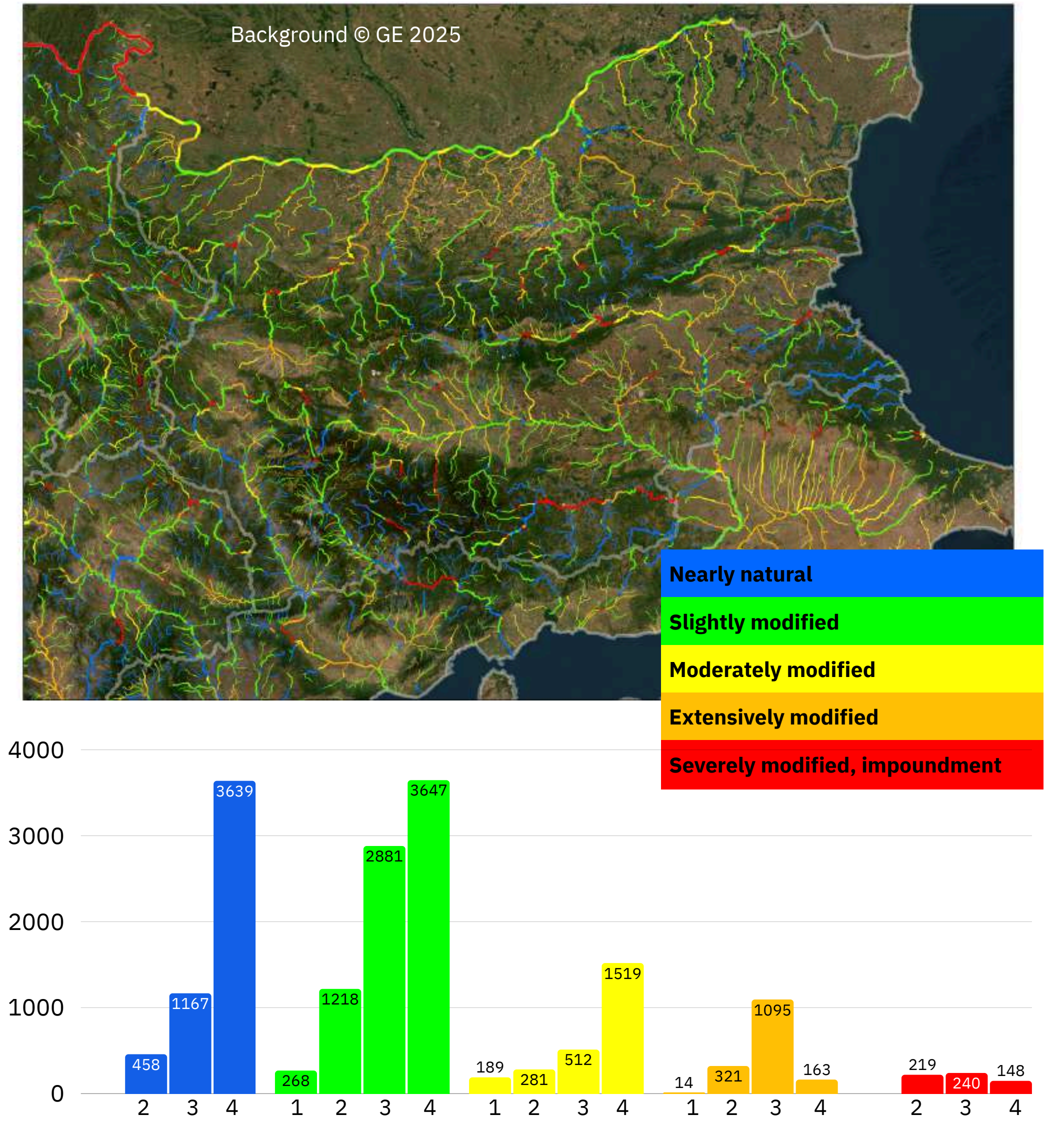


Figure 33: Distribution in rkm within the size categories 1-4, representing 1=very large rivers, 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube occurs only in green, yellow and orange classes).

4.3.11 TÜRKIYE (ONLY EUROPEAN PART)

While the lower Maritsa plain is largely used for agriculture and alters rivers to varying degrees, intact rivers are found only in the wooded, small Black Sea coastal catchment along the Bulgarian border.

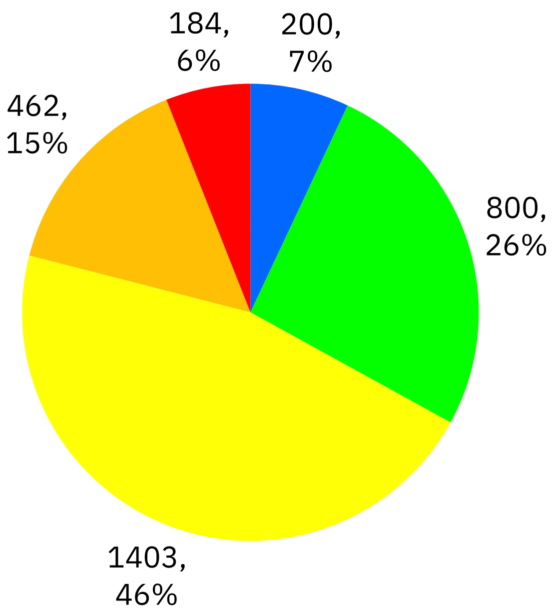
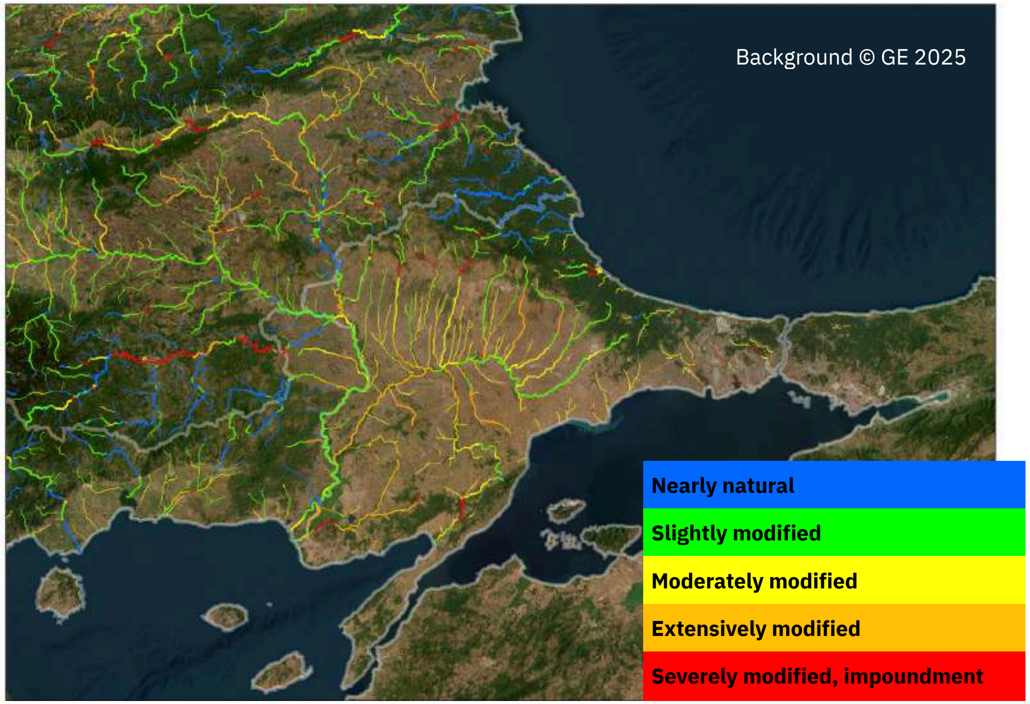


Figure 34: Türkiye HYMO percentages and rkm distribution.



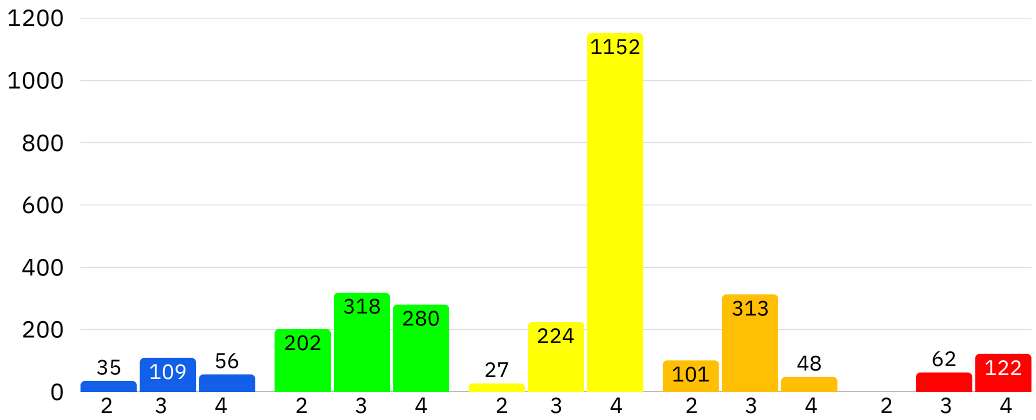


Figure 35: Distribution in rkm within the size categories 2-4; 2=large rivers, 3=medium-sized rivers, 4= small rivers (size category 1 for the Danube is not applicable).

4.4 EXAMPLES: BALKAN RIVERS UNDER PRESSURE OR PRESERVED

This section presents examples for ongoing pressures but also preserved Balkan rivers.

4.4.1 PRESSURES ON BALKAN RIVERS

The following pages present examples of stretches of rivers destroyed by the most evident hydromorphological pressures in the Balkan rivers.

Hydropower, dam construction


Figures 36 & 37: LEFT: Devoll River in Albania, 2014. RIGHT: HPP Banjë constructed in 2016. © GE 2025

Figure 38: HPP Brezice, Sava River, Slovenia, during construction works in 2017. © GE 2025

Hydropower, water abstraction

Figure 39: LEFT: Many tributaries in the eastern Drin catchment are impacted by hydropower water abstraction (nearly 100% of the water), Albania. UPPER RIGHT: Construction site on the Shkumbin tributary in Albania. The pipes carrying abstracted river water are often built into steep mountain slopes, leading to long-term erosion. LOWER RIGHT: Total water abstraction in June 2025 (HPP Lubonje (0.1-1 MW), upper Osum tributary, Albania. © GE 2025

Photos: Collection of destruction by hydropower. 1. Rrëshen River, AL © Amel Emric; 2. Cem River, AL © Amel Emric; 3. Rapuni River (AL) © Amel Emric; 4. Ugar River, BA, former Huchen spawning site. © U. Eichelmann; 5. Ulog Dam on the upper Neretva River, Bosnia and Herzegovina, © Bruno D´Amicis; 6. Jadar River, BA © Amel Emric; 7. Drinjaca River, BA © Amel Emric

Road construction

Figure 40: LEFT: Western Morava, highway construction with river regulation, RS. UPPER RIGHT: Southern Morava, RS. LOWER RIGHT: Tara, ME, highway construction. © GE 2025

Sediment exploitation

Figure 41: Gravel exploitation. LEFT: White Drin, Kosovo and RIGHT: Lower Drina, Serbia. © GE 2025

River regulation for flood projects and land reclamation

Figure 42: River regulation, flood/sediment: Before (in 2005) and after the construction of Edirne (TR), Mariza. © GE 2025

Figure 43: River Bosna near Sarajevo (BA): FROM LEFT 2015 - 2016 – 2019. © GE 2025

Figure 44: LEFT: Lilas Potamus, Euböa (GR) flood project 10 km. RIGHT: While solar energy may be a key energy form in the future and could replace hydropower, solar farms should not be built in active floodplains such as Botunja near Krivodol, Bulgaria. They should be placed on artificial surfaces, including existing built environments, rather than in flood-prone areas. © GE 2025

Irrigation for agriculture

Figure 45: LEFT: Axios GR (left and right-side water abstraction upstream of lower course and delta). © GE 2025. UPPER RIGHT: Shushica (temporal excavation after each flood, diversion of water to the top left corner). © GE 2025. LOWER RIGHT: Many small reservoirs not serving only for drinking water have been built and will be built, altering many catchments of all sizes AL. © GE 2025

Harbour/marina construction

Figure 46: ABOVE: Marina, harbour Vukovar, Danube, HR (steep bank destruction). BELOW: oil terminal, Danube, RS (destruction of floodplain forest). © GE 2025

4.4.2 PRESERVED BALKAN RIVERS

Although pressure on the ecosystem continues to increase, the most notable success among the Balkan rivers is the Vjosa in Albania. In 2023, it became the first European Wild River National Park, protecting 400 km of river. Other rivers have also been preserved over the past 13 years, including the Neretvica and Janjina in Bosnia and Herzegovina, the Rupska River in Serbia, and several tributaries of the Sarantaporos River in Greece. In Croatia, the source of the Una River will remain free-flowing because construction of a hydropower plant was halted in 2024.

Summarising the length of preserved rivers (mainly due to the prevention of hydropower plant construction, in some cases through the establishment of protected areas along rivers), a total of about 900 kilometres of rivers and streams across the Balkans have been preserved over the last 13 years.

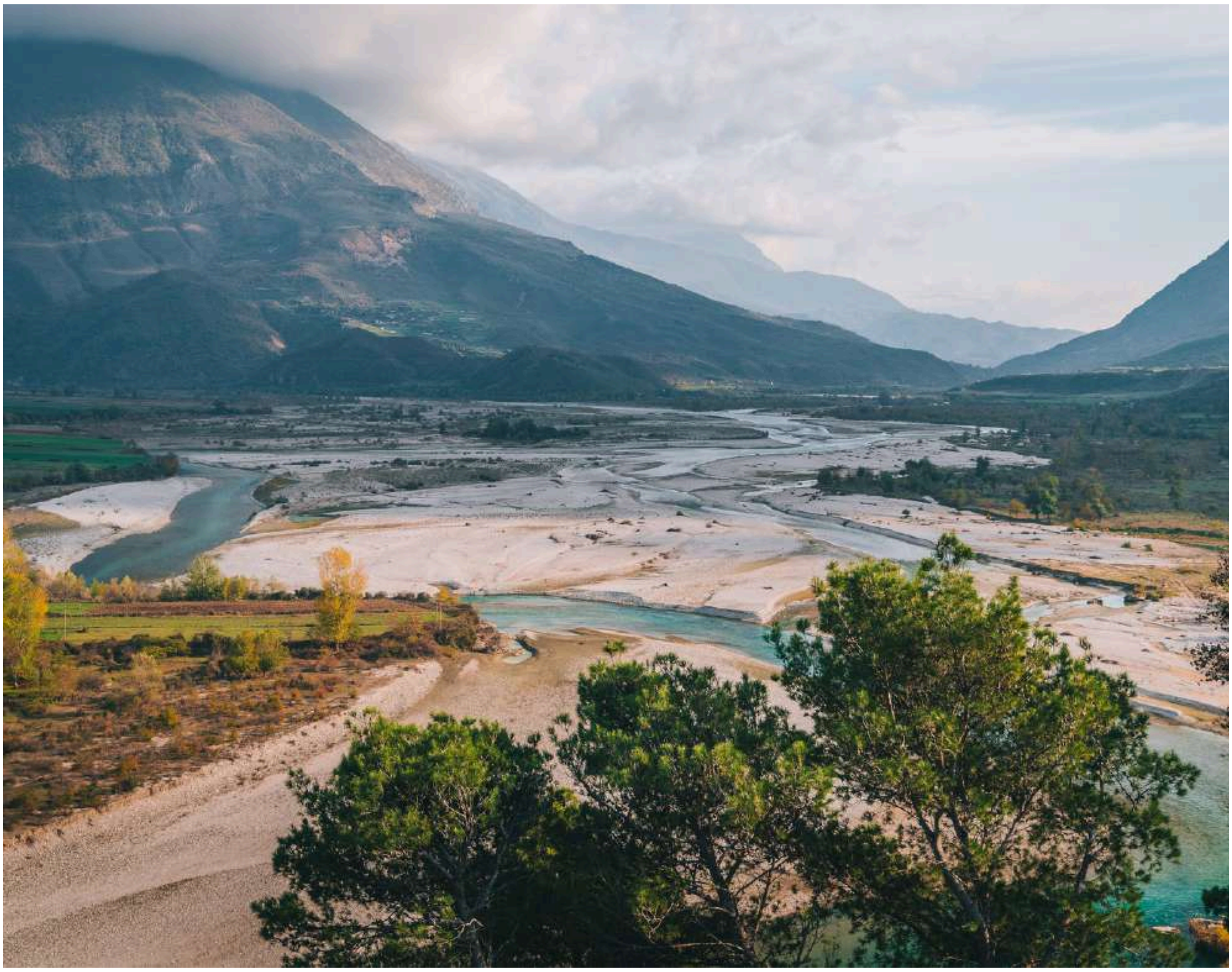


Photo: *Vjosa River declared as the first Wild River National Park in Europe in 2023, closing the chapter of plans to build at least five large hydropower plants on the middle and lower course, inundating the entire active channel and floodplain area in the image. © Nicolas Jehly*




Photos: TOP: Shushica (Vjosa basin): Stop of four hydropower plants. © Lukas Thuile Bistarelli. MIDDLE LEFT: Janjina (Drina/Sava/Danube basin): Remains free-flowing, and the breathtaking valley is untouched. © Bruno D´Amicis. MIDDLE RIGHT: Figure 87: Neretvica (Neretva basin), BA: Prevention of 15 planned hydropower plants. © Amel Emric. BOTTOM: Una (Sava/Danube basin): The Una Source remains free flowing. A protest stopped the construction of a small HPP in 2024. © Ray Demski

5. CONCLUSION

For the first time, a comprehensive and comparable hydromorphological assessment has been conducted for the entire Balkan region. This study highlights the extraordinary diversity of the region's aquatic ecosystems—from the high-altitude mountainous streams of Montenegro to the unique karst catchments of Bosnia and Herzegovina and the last large free-flowing systems like the Vjosa in Albania.

Based on the findings of this 13-year assessment, the following conclusions are established:

- **Clear downward trajectory**: While mapping approaches have evolved since 2012, the negative trend is undeniable. The region has seen a 7% loss in class 1 "Blue" rivers among larger systems, while total impoundment length has surged by 18% (402 rkm). The crisis is most acute in Albania, where the share of pristine rivers plummeted from 68% to 40%.
- **Systemic fragmentation**: Hydropower remains the primary driver of river degradation. Large barrages disrupt the river continuum, while abstraction for small hydropower plants creates long "residual" stretches where riverbeds are left essentially dry. These structures permanently alter downstream flood regimes and sediment transport, leading to severe channel incision.
- **Unsustainable extraction**: Excessive sediment extraction (predominantly gravel and sand) has moved beyond sustainable transport rates. This activity causes long-term, potentially irreversible damage to riverbed stability and aquatic habitats.
- **Secondary infrastructure pressures**: Beyond energy, the cumulative impact of road construction, land reclamation, and flood defence works is systematically disconnecting rivers from their natural floodplains.
- **Conservation successes**: Amidst the decline, the protection of approximately 200 km of large rivers and 700 km of smaller streams—most notably through the Vjosa Wild River National Park—proves that with political will, destructive development can be halted and high-value ecological corridors can be safeguarded.
- **Urgency for systematic monitoring**: There is a critical need to standardise and scale hydromorphological surveys across the entire peninsula. National governments must integrate these assessments into their legislative frameworks to meet international conservation standards and EU accession requirements.

6. REFERENCES

CEN (2021/2024): EN 14614:2021, Water quality - Guidance standard for assessing the hydromorphological features of rivers; EN 15843:2024, **Water quality - Guidance standard on determining the degree of modification of river morphology**.

CEN (2004/2010): EN 14614:2004, Water quality - Guidance standard for assessing the hydromorphological features of rivers; EN 15843:2010, **Water quality - Guidance standard on determining the degree of modification of river morphology**;

Danube4All EU project/BOKU (2025): **Restoration of the Danube River Basin for ecosystems and people from mountains to coast** (2025-2030).

Google Earth (2025): **Satellite images worldwide**. Maxar 2023. http://www.earth.google.com.

RiverWatch & EuroNatur, Chamberlain, L., Schwarz, U. (2018): **Eco-Masterplan for Balkan rivers** (EMPB). For: "Save the Blue Heart of Europe" campaign of RiverWatch and EuroNatur, PP. 53 pp. Vienna/Radolfzell.

Schwarz, U. (2025): **Hydropower Projects on the Balkan Rivers – Update 2024**. For RiverWatch & EuroNatur, Radolfzell-Vienna, 40 pp.

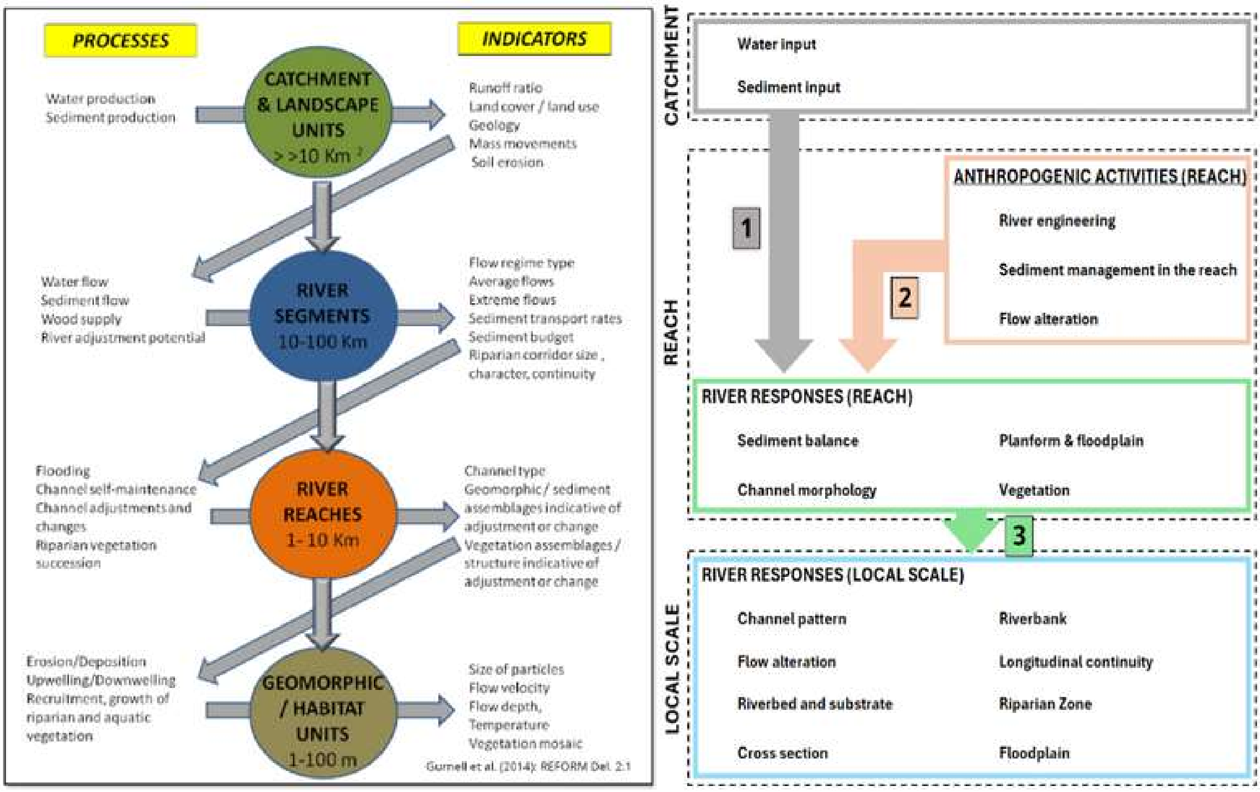
Schwarz, U. (2024): **Potential Wild River National Parks on Balkans. Assessment of free-flowing rivers on the Balkan Peninsula**. For RiverWatch & EuroNatur, Radolfzell-Vienna, 33 pp.

Schwarz, U., Holubova K., Cuban, R., Matok, P., Busovsky, J. (2015): **JDS 3 Hydromorphological survey**, pp. 40-71. In: ICPDR Joint Danube Survey 3. A comprehensive analysis of Danube water quality. Vienna, 369 pp.

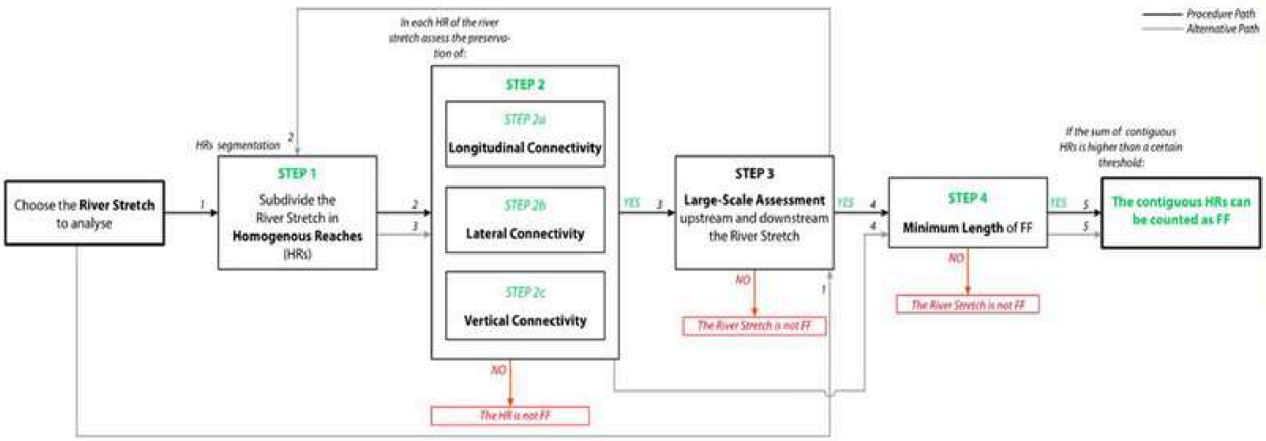
Schwarz, U. (2012): **Outstanding Balkan River landscapes – a basis for wise development decisions**. For ECA Watch Austria/EuroNatur Germany/MAVA Switzerland, 150 pp and 101 pp. Separate Annex („River Catalogue"). Vienna

ANNEX A

Processes and multiscale-based assessment for the river reach assessment (Danube4All EU project/BOKU 2025).



Extended assessment for lateral connectivity (as required under the Nature restoration Law 2024) (Danube4All EU project/BOKU 2025).



ANNEX B

Mapping example (color ribbon map) showing the individual assessments for the three components channel, left/right banks and left/right floodplains as well as an overall assessment (arithmetic mean of the three main components) (Schwarz et al. 2015).

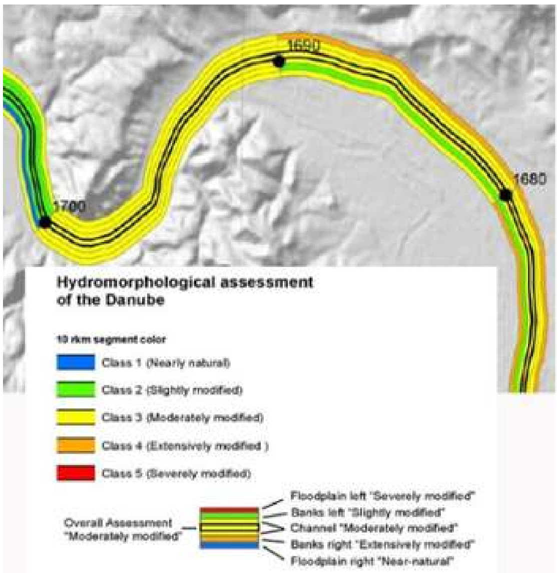


Table: Basic framework for the pressure-based assessment (CEN 2004/2010) and the translation into the five-class assessment as background for the Balkan assessment.

Parameter	**Descriptions**
Channel	
Planform (based on deviation from near to natural conditions for section types)	Class 1 = 0 % to 5 % of reach length with changed planform. Class 2 = > 5 % to 15 % of reach length with changed planform. Class 3 = > 15 % to 35 % of reach length with changed planform. Class 4 = > 35 % to 75 % of reach length with changed planform. Class 5 = > 75 % of reach length with changed planform.

Table continued

Parameter	Descriptions
Channel	
Substrates (Natural substrate mix or character altered), (based on deviation from near to natural conditions for section types) (this single parameter was only assessed in 1, 3 and 5)	1=Near-natural mix 3= Natural mix/character slightly to moderately altered 5=Natural mix/character greatly altered
Erosion/deposition character (based on deviation from near to natural conditions for section types) (this single parameter was only assessed in 1, 3 and 5)	1 = Erosion/deposition features reflect near-natural conditions. 3 = Erosion/deposition features reflect moderate departure from near-natural conditions (10 % to 50 % of the features expected are absent). 5 = Erosion/deposition features reflect great departure from near-natural conditions (≥ 50 % of the features expected are absent).
Impacts of artificial in-channel structures within the reach (impoundments, groynes, incl. flow character) (this single parameter was only assessed in 1, 3 and 5)	1 = Flow character not, or only slightly, affected by structures within the reach. 3 = Flow character moderately altered. 5 = Flow character extensively altered
Reach-based and local impacts of sluices and weirs on ability of biota (e.g. migratory fish) to travel through reach, and sediment to be transported naturally (this single parameter was only assessed in 1, 3 and 5)	1 = No structures, or if present they have no effect (or very minor effect) on migration or on sediment transport. 3 = Structures present, but having only minor or moderate effects on migratory biota and sediment transport. 5 = Structures that in general are barriers to all species and to sediment.

Table continued

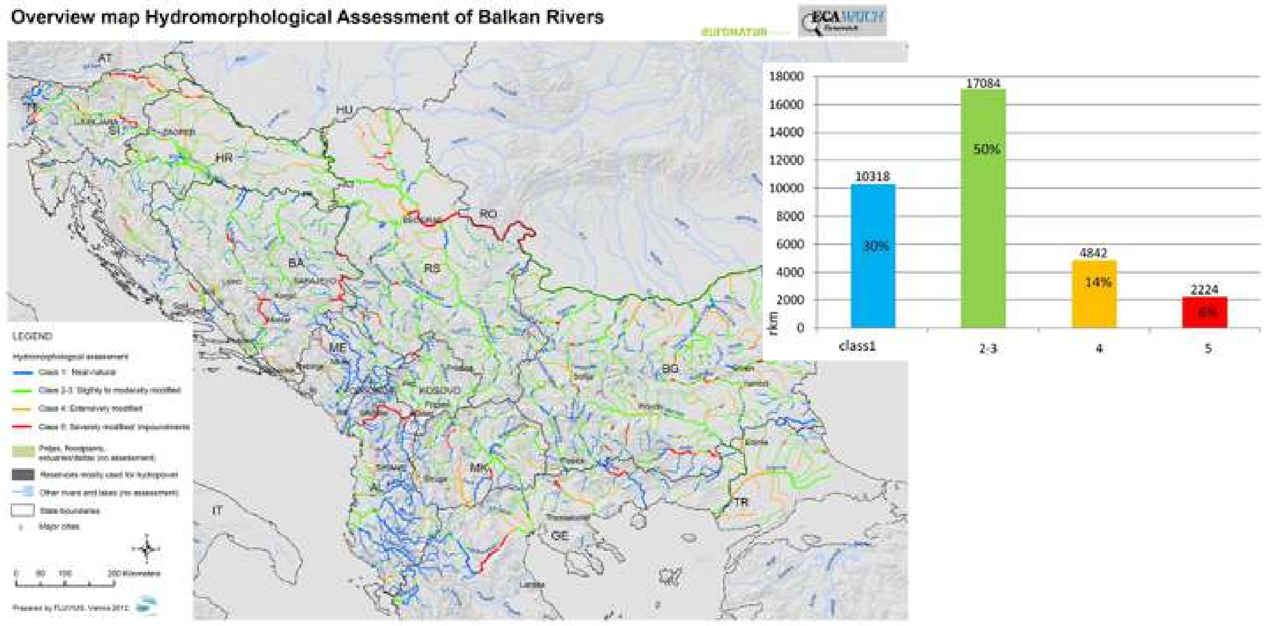
Parameter	Descriptions
Banks	
Extent of reach affected by artificial bank material (% of bank length)	Class 1 = Banks affected by 0 % to 5 % hard, artificial materials. Class 2 = Banks affected by > 5 % to 15 % hard, artificial materials. Class 3 = Banks affected by > 15 % to 35 % hard, artificial materials. Class 4 = Banks affected by > 35 % to 75 % hard artificial materials. Class 5 = Banks affected by > 75 % hard artificial materials.
Land cover in riparian zone (% of bank length)	Class 1 = 0 % to 5 % non-natural land cover in riparian zone. Class 2 = > 5 % to 15 % non-natural land cover in riparian zone. Class 3 = > 15 % to 35 % non-natural land cover in riparian zone. Class 4 = > 35 % to 75 % non-natural land cover in riparian zone. Class 5 = > 75 % non-natural land cover in riparian zone.
Floodplain	
Land cover beyond the riparian zone	Class 1 = 0 % to 5 % non-natural land cover beyond the riparian zone. Class 2 = > 5 % to 15 % non-natural land cover beyond the riparian zone. Class 3 = > 15 % to 35 % non-natural land cover beyond the rip..zone. Class 4 = > 35 % to 75 % non-natural land cover beyond the rip..zone. Class 5 = > 75 % non-natural land cover beyond the riparian zone.

Table continued

Parameter	Descriptions
Floodplain	
Degree of lateral connectivity of river and floodplain (Extent of floodplain not allowed to flood regularly due to engineering-based on hydromorphological surveys.) (based on deviation from near to natural conditions for section types)	Is over-bank flooding likely to occur (or likely to have occurred historically) naturally in the reach? Yes/No. If No – N/A. If Yes, score: 1 = 0 % to 5 % reach affected by flood dikes or other measures impeding flooding of floodplain 2 = > 5 % to 15 % as above. 3 = > 15 % to 35 % as above. 4 = > 35 % to 75 % as above. 5 = > 75 % as above.
Degree of lateral movement of river channel (% of length where lateral movement isartificially constraint)	Is the river likely to move laterally within its floodplain in the absence of any man-made constraints? Yes/No. If No – N/A. If Yes, score: 1 = 0 % to 5 % reach constrained. 2 = > 5 % to 15 % reach constrained. 3 = > 15 % to 35 % reach constrained. 4 = > 35 % to 75 % reach constrained. 5 = > 75 % reach constrained.

ANNEX C

Initial assessment 2012 (only main rivers 34,500 rkm).



First full assessment Balkan Eco-Masterplan (including small rivers 80,523 rkm), but only for larger rivers (excluding size category 4).