G o N E X U S

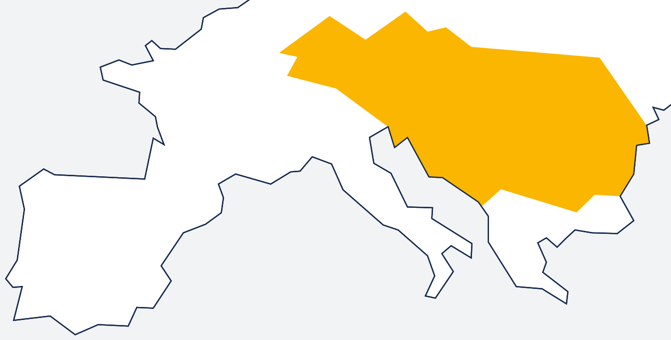
FACTSHEET

Danube River Basin

CENTRAL & SOUTHERNEAST EUROPE

BRIEF OVERVIEW

The Danube River is **the second largest river in Europe** covering an area of 817,000 km^2 and flows for 2,860 km. It is **the most transboundary river of the world,** and is home to a population of 80 million, spread over nine countries.



The Danube Basin encompasses various environmental regions. **The Upper Danube,** with a temperate and alpine climate, includes the Alps and mid-range mountains. **The Sava region** has a Mediterranean climate and covers the Dinarides. **The Tisza** is continental, covering the Pannonian Basin. Finally, **the Lower Danube**, also continental, spans the Carpathians and the Wallachian Plain.

It is primarily situated within the European Union, which means it is subject to various **directives aimed at protecting water resources and habitats.** However, a significant portion of the headwaters of its tributaries lies outside the EU, making water management in the Danube River Basin a challenging task.

There are significant **competing interests among the riparian countries** for the available water resources. To address this, the **International Commission for the Protection of the Danube River (ICPDR)** was established to strenghten international cooperation in the basin and to ensure an adequate supply of water in both quantity and quality.

Water resources in the Danube are already facing significant pressure. Currently, **about 10% of renewable water resources are withdrawn to meet human demands.** The majority of this water is used for manufacturing and cooling, followed by domestic use. However, irrigation is also a significant water consumer in some areas, and its share is expected to rise sharply throughout the 21st century.

The growing demand for irrigation water is not solely due to an increase in the irrigated area; instead, it mainly results from **elevated water scarcity caused by climate change.** Along with the shift towards non-fossil energy sources such as biofuels, hydropower, and thermonuclear energy, it may result in **increased water stress** for various sectors and the aquatic ecosystems within **the Water-Energy-Food-Ecosystems (WEFE) nexus.**

IDENTIFIED WEFE CHALLENGES & PROSPECTED SOLUTIONS

Water scarcity and increased flood risk due to climate change requiring changes in land management.

- Implementing land use management strategies and **establishing protected areas** to reduce runoff and manage flood volumes.

Water scarcity due to growing irrigation demand as a consequence of a warmer and drier climate.

- **Improving irrigation water use** by adopting improved irrigation techniques and **more efficient crops and cultivars** along with increasing local storage and reservoir releases.

Vulnerability of riverine and terrestrial ecosystems (biodiversity) due to water scarcity and land use changes from agriculture and energy development.

- **Adjusting the number and operation of reservoirs** to lessen the impact of hydroelectric power on aquatic environments; enforcing environmental flow regulations to **protect aquatic ecosystems.**

MODELLING TOOLS

The PCR-GLOBWB 2 model is central to water nexus modelling for the Danube River. Its simulations are linked to other specialised WEFE nexus models used in the GoNexus project. This connection allows for a detailed analysis of **how climate and socioeconomic changes impact the Danube River Basin.** These effects are evaluated using WEFE indicators from **the GoNexus Sustainability Assessment Framework (SAF).**

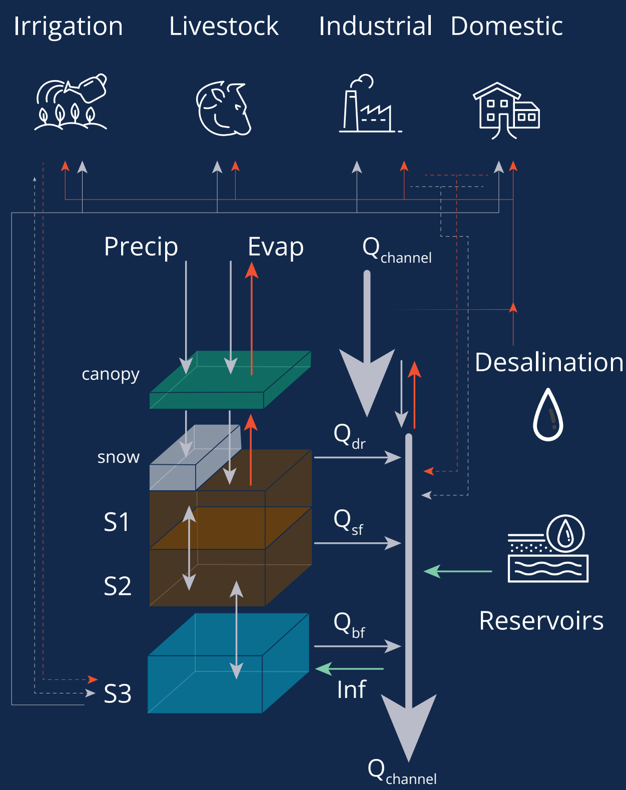


Figure1: Model structure of the large-scale water resources model PCR-GLOBWB 2. At the top, the different sectors withdrawing water to meet human demands within the WEFE nexus are depicted.

SCENARIOS

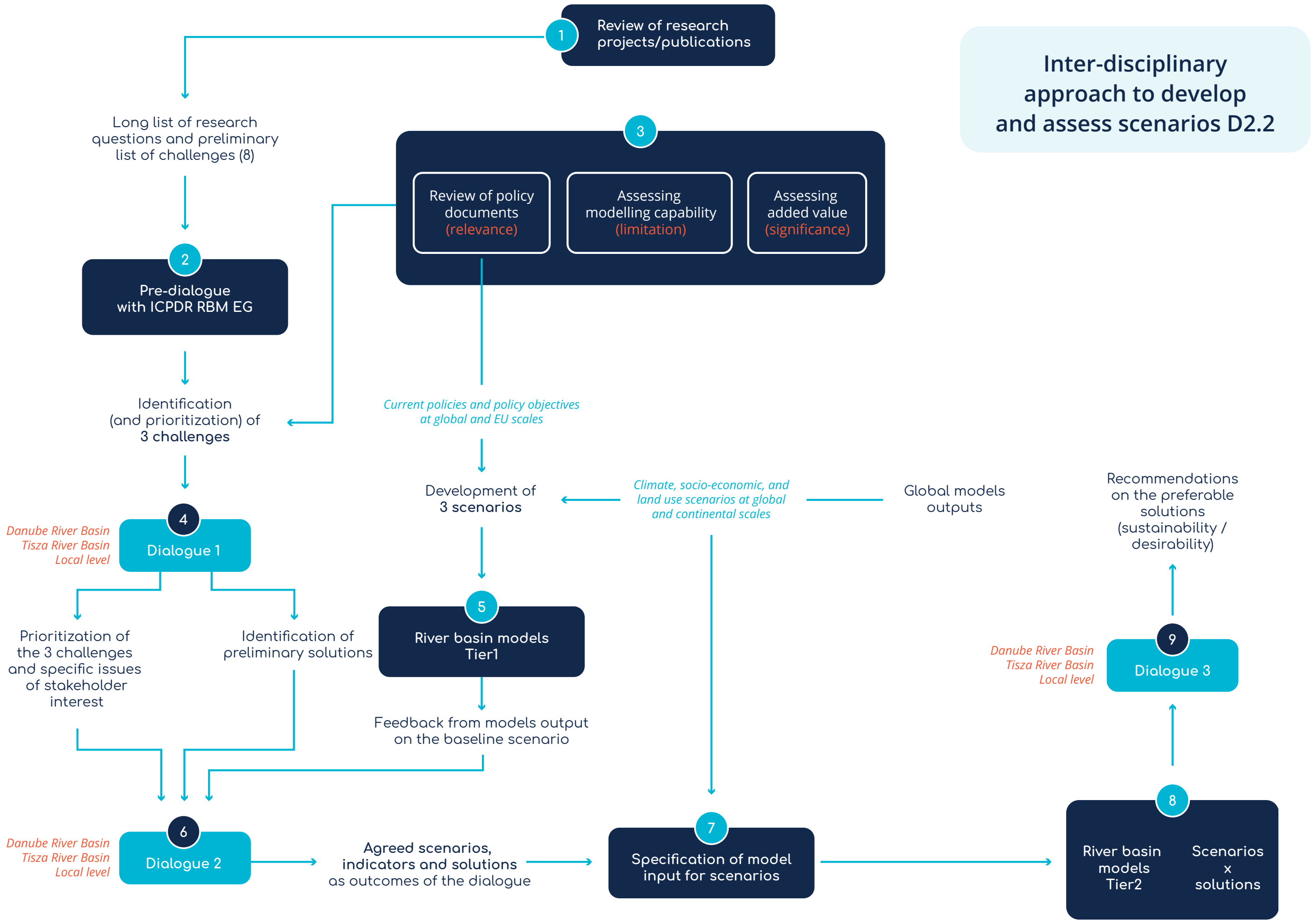
Taking global scenarios of predicted climate change and socio-economic developments for the 21st century as a starting point, **tailored local scenarios and solutions** were created in collaboration with stakeholders to address challenges in the Danube River Basin. These solutions are based on indicators and include the following initiatives:

Thirst in the bread basket?
This scenario examines **the rise in irrigated agriculture in the Danube** and its effects on various sectors within the WEFE nexus. Solutions aim to reduce water scarcity by lowering demand and increasing water availability to sustain higher agricultural production.

Dancing to a tune? The Blue Danube.
This scenario focuses on **protecting the Danube's aquatic ecosystems.** It incorporates environmental flow requirements and explores how groundwater use and hydropower generation impact other sectors within the WEFE nexus.

DIALOGUES

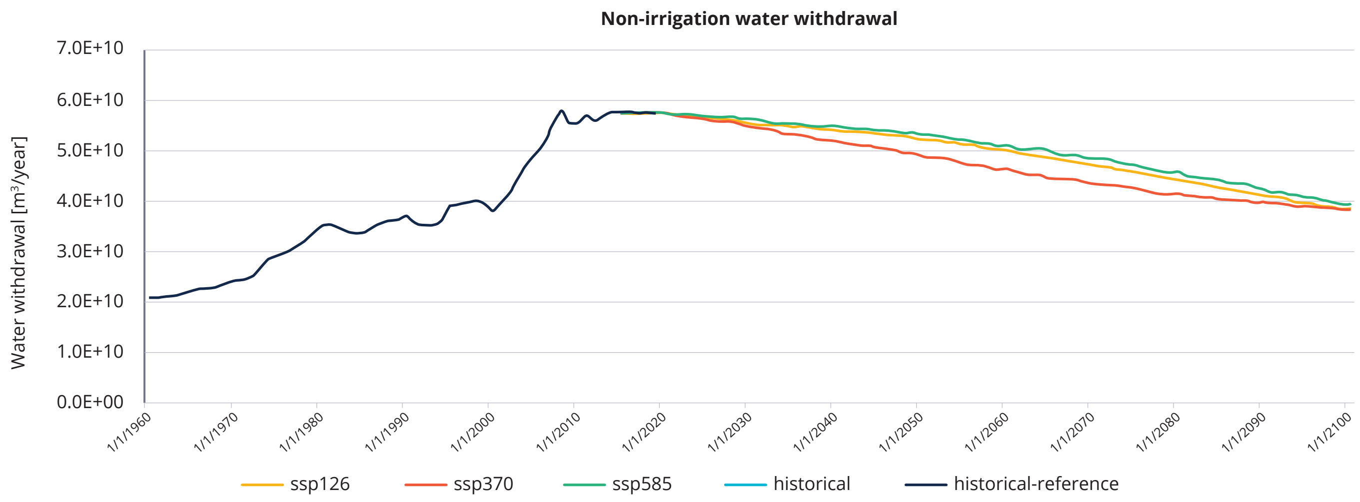
The GoNexus Dialogues are based on a **participatory approach**. They involve examining evidence from the models and collaborating with various stakeholders representing the WEFE nexus through basin workshops.

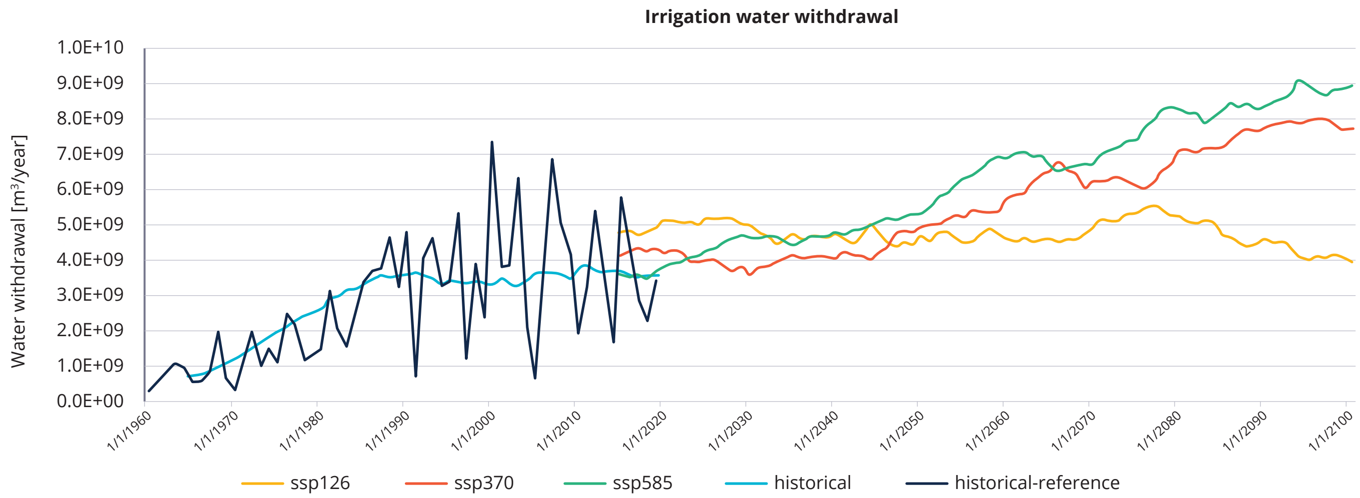


EVIDENCE

Throughout the historical period, there has been **a significant increase in total water demand** and corresponding withdrawals from available resources, both surface and groundwater. Overall, non-irrigation water demand is much greater than irrigation demand, with a sharp rise observed after 2005. However, non-irrigation water withdrawals have high return flows, whereas **most of the water withdrawn for irrigation is consumed.**

Additionally, non-irrigation water withdrawals are projected to decline significantly throughout the 21st century, returning to levels seen before 2000, which includes **withdrawals for cooling in the energy sector.** Irrigation water demand, on the other hand, is rapidly increasing after 2020. Although it remains smaller than non-irrigation demands and withdrawals, it is becoming substantial for agriculture within the Danube Basin. The most significant changes are anticipated after 2050, as suggested by projections using PCR-GLOBWB 2. This emphasises the heightened **risk of water scarcity,** which is a central concern across all three challenges.

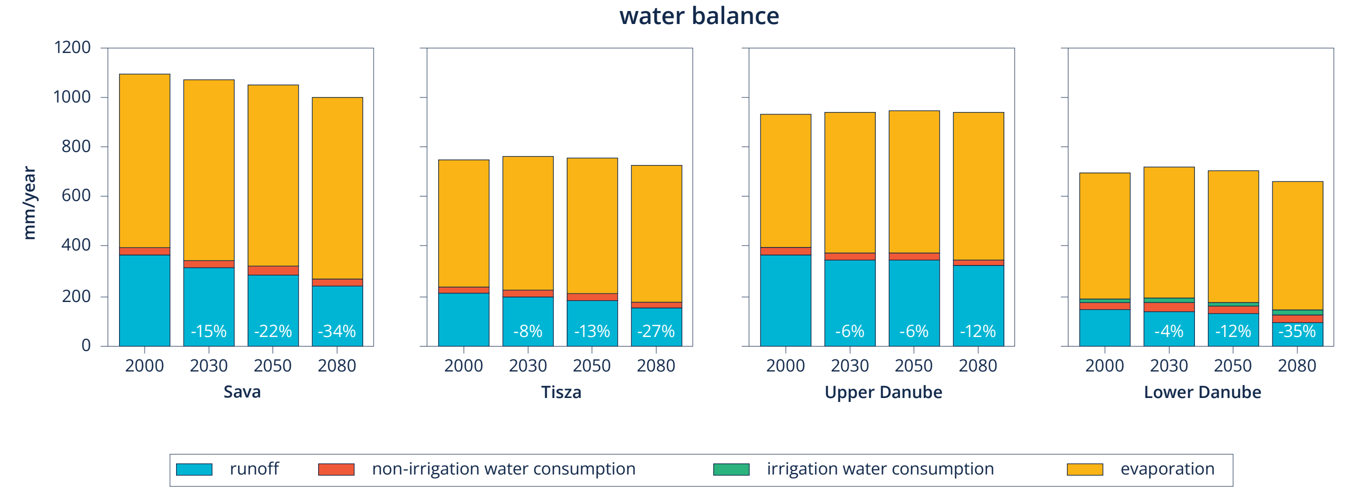




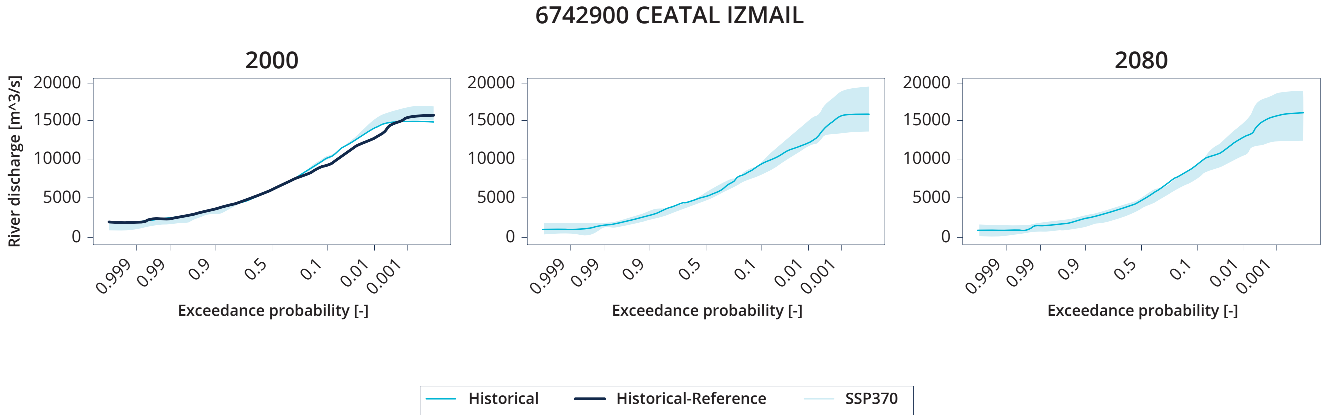
Projected non-irrigation water withdrawals and irrigation water withdrawals. The median values shown are derived from five separate General Circulation Models (GCMs) for the three combinations of climate change and socio-economic scenarios (RCP-SSP; in order of increasing climate change impacts, SSP1-RCP2.6, SSP3-RCP7.0 and SSP5-RCP8.5). The historical reference results relate to the reconstructed climate, while the historical results represent the GMC control simulation for the historical period. For clarity, a 10-year moving average is presented for irrigation water withdrawals to eliminate year-to-year variability, with the exception of the historical reference results.

For the four sub-basins of the Danube, a water balance has been established for four time periods: one historical and three in the 21st century. The total bars illustrate the total precipitation and its distribution among runoff, evaporation, and consumption. Across all basins and time periods, **water availability will decline in the Danube River Basin.**

Although water consumption is relatively low, water withdrawals account for approximately 10% of the total stream flow of the Danube. This includes a significant increase in irrigation, particularly in the Lower Danube. The Lower Danube heavily relies on the discharge from the Danube River to supply surface water for human use. This reliance poses a **direct threat to the environmental flow requirements** in this part of the basin and is expected to **increase stress on the river ecosystem** in the future.



The changing water availability and increased variability are illustrated by the **Flow Duration Curves** near the mouth of the Danube in the Lower Danube region. A partial decrease is observed in most flow levels, except for the most extreme high flows. As a result, low flows are expected to decrease, leading to overall reduced water availability, which poses **risks to water supply and navigation on the river.** At the same time, high flows are projected to increase in both expected average levels and variability. Therefore, while water is becoming scarcer overall, **the risk of high flows and flooding is also expected** to rise in the future.



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