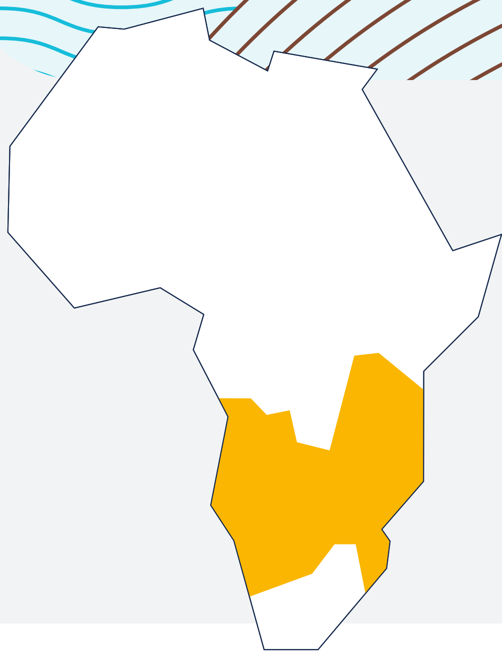
GoNEXUS

FACTSHEET

Zambezi River Basin
SOUTHERN AFRICA

BRIEF OVERVIEW

As **the fourth-largest river basin of Africa,** the Zambezi River Basin is shared by eight countries: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe. It is home to approximately **40 million people**, covers an area of 1,4 million km^2, and flows for 2,700 km through plains, gorges, and marshlands, with **an average annual discharge of 2,600 m^3/s** into a delta in Mozambique.



The climate of the Zambezi River Basin follows **a seasonal pattern,** characterised by a rainy season from November to April and a dry season from May to October. Rainfall is unevenly distributed throughout the basin, with significant variations from year to year. High evaporation rates result in considerable water loss. Discharge is low in the humid tropical regions and increases in the Southern latitudes.

The basin contains **numerous wetlands that offer a wide range of ecosystem services,** as well as large hydropower projects. Water resources in the basin are managed collaboratively under the **2004 Zambezi Watercourse Commission (ZAMCOM) agreement**. Sustainable management of these water resources is crucial to address challenges such as floods, droughts, and land pressure, especially given the expected intensification of these issues due to climate change.

IDENTIFIED WEFE CHALLENGES & PROSPECTED SOLUTIONS

The GoNexus Dialogues with stakeholders in the basin revealed a wide range of challenges. These issues highlight **the interconnectedness of key water users** and the need to model and analyse trade-offs to **achieve sustainable management of water resources.** While the Strategic Plan for the Zambezi Watercourse 2018-2040 developed by ZAMCOM outlines the overall direction for development, the Dialogues focused on identifying key challenges and potential solutions:

Flooding

- **Implement local flood protection measures,** designate land areas for river expansion during floods, and allocate free storage in reservoirs to retain floodwater during flood-prone seasons.

Water scarcity and droughts

- **Develop new storage infrastructure,** improve irrigation efficiency, increase the use of drop irrigation, and transition to less water-intensive yet still valuable crops.

Land use conflicts leading to soil depletion and erosion

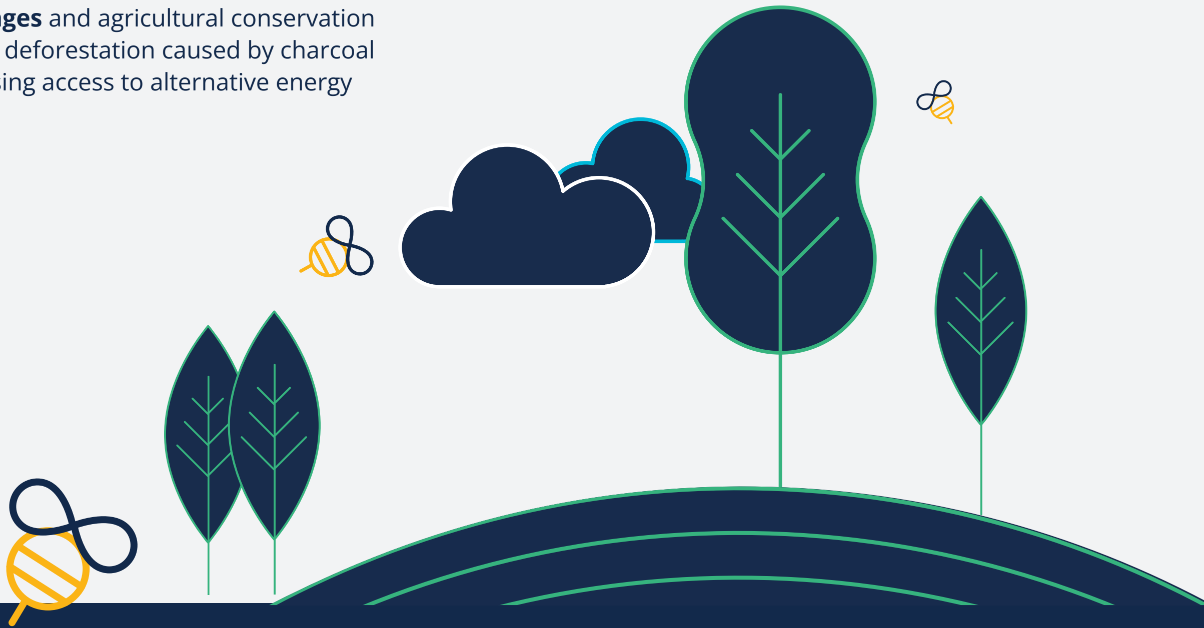
- **Adopt land use changes** and agricultural conservation practices, and reduce deforestation caused by charcoal production by increasing access to alternative energy sources.

Energy and water trade-offs

- **Provide incentives for solar energy investments** through enhanced regulatory and political frameworks, implement carbon pricing, re-operate reservoirs, and develop new hydropower reservoirs or floatovoltaics.

Ecosystems health

- **Establish mandatory environmental flow policies,** set and systematically implement environmental flow targets and create environmental corridors, reserves, and parks.



MODELLING TOOLS

Effective management of **the WEFE (Water-Energy-Food-Ecosystem) nexus** in the Zambezi River Basin requires careful consideration of the interconnected challenges and trade-offs. To address this, the GoNexus partners introduced **a modelling framework** that integrates two complementary approaches: an optimisation-based strategic model and a high-resolution, spatially distributed, physically explicit model.

The strategic model operates on a broader scale, focusing on key sectoral indicators to identify optimal management and development policies.

In contrast, **the high-resolution model** simulates the outcomes of these selected policies by increasing spatial and temporal detail and assessing a wider range of indicators, thereby expanding the scope of impact analysis for WEFE management strategies.

SCENARIOS

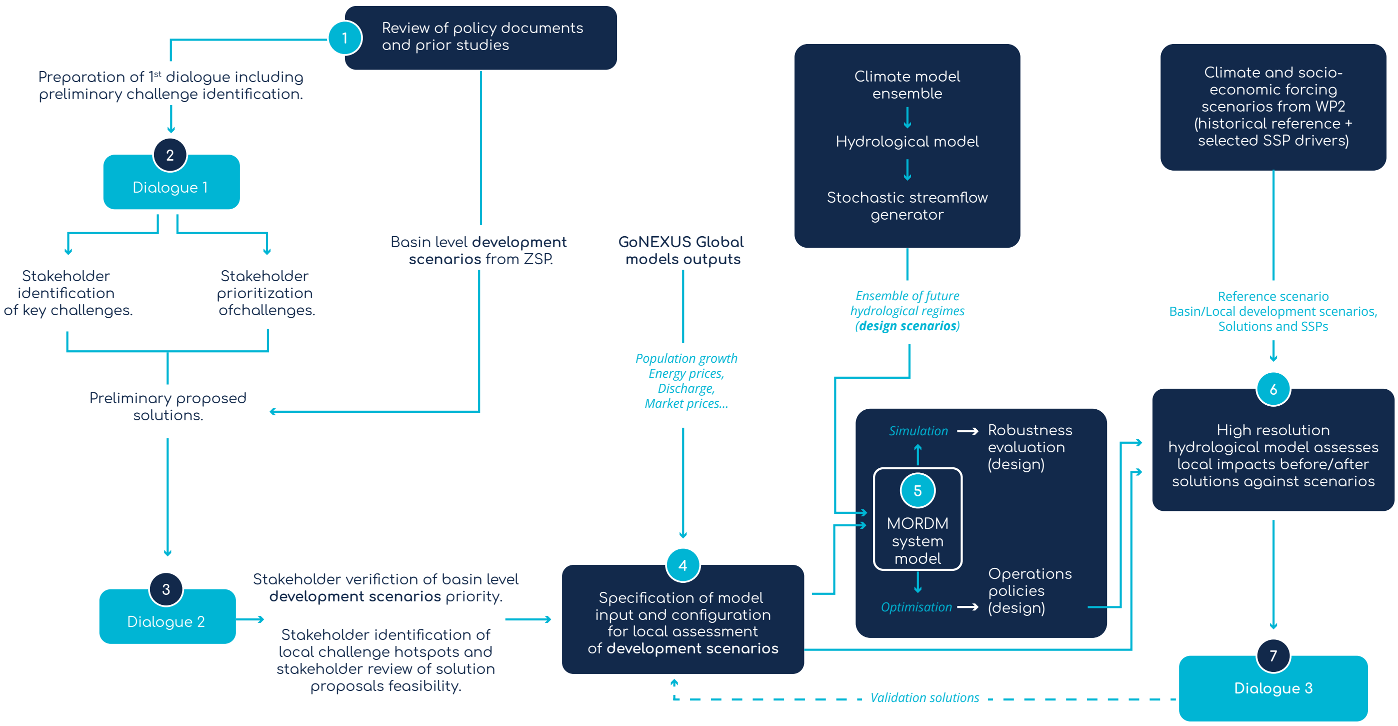
The GoNexus team produced initial results from their modelling framework, focusing on **the 'Energy Security' scenario** from the Strategic Plan for the Zambezi Watercourse 2018-2040. This scenario involves basin configurations where **the number of dams is increased.** The resulting policies were then used to conduct high-resolution simulations of flood and drought hazard changes, accounting for climate change and other factors from selected **Shared Socioeconomic Pathways (SSPs).** Further policies, based on discussions with stakeholders, will be optimised and followed by impact simulations. These results will help identify solutions to improve WEFE nexus management.

The starting point for developing these scenarios comes from the **seven ZAMCOM development scenarios** outlined in the Strategic Plan for the Zambezi Watercourse 2018-2040:

- *Energy security*
- *Food security*
- *Maximised economic benefits*
- *High environmental flows*
- *High delta and flood protection*
- *Moderate environment and delta/flood*
- *Ambitious environment and delta/ flood*

DIALOGUES

The GoNexus approach is notable not only for its innovative modelling techniques but also for its clear strategy for involving stakeholders. This strategy relies on ongoing Dialogues that **encourage participation in identifying challenges, setting goals,** and **understanding the scientific modelling** behind the project. These Dialogues involve reviewing documents and scientific data from external studies and global models. They also **engage various stakeholders** representing the WEFE nexus through interviews and workshops, as well as using different simulation and optimisation models for the basin. The outcomes from these Dialogues contribute to every phase of the WEFE nexus investigation, such as identifying challenge hotspots in the basin.



EVIDENCE

Preliminary simulations of various basin configurations revealed strong interdependencies among the key sectors in the GoNexus project. They also demonstrated that balanced water allocation policies can be achieved by **optimising reservoir operations**. These balanced policies indicate that it is possible to attain indicator values across key sectors without disadvantaging any particular sector, thereby alleviating **the negative impacts of competition for shared resources.**

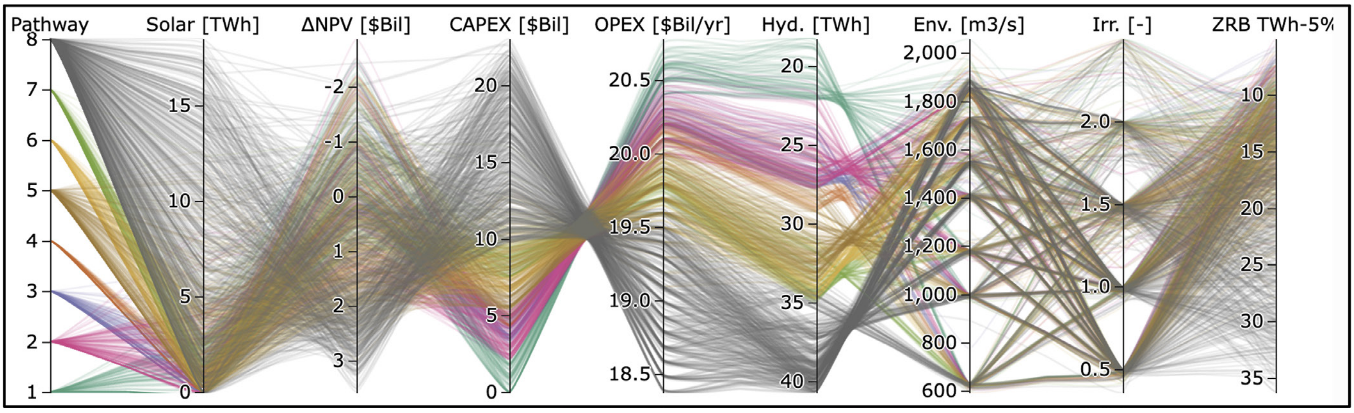


Figure 5 Pareto optimal alternatives of reservoir and irrigation management and floating solar capacity for the existing Zambezi Watercourse reservoir network and networks that include up to 1 (pathways 2, 3, and 4), 2 (pathways 5, 6, and 7) and 3 new reservoirs (pathway 8). The direction of preference is points downwards for the five WEFE objectives.

The implementation of compromise policies under selected SSP scenarios of one of the major challenges identified by stakeholders: flood hazards indicates **a trend toward lower flood magnitudes** for the most common flood events by mid-century, with this effect becoming more pronounced by the end of the century.

However, all simulations also revealed that the magnitude of the least **frequent flood events** is expected to rise due to the significant influence of climate change, regardless of the water management policies in place.

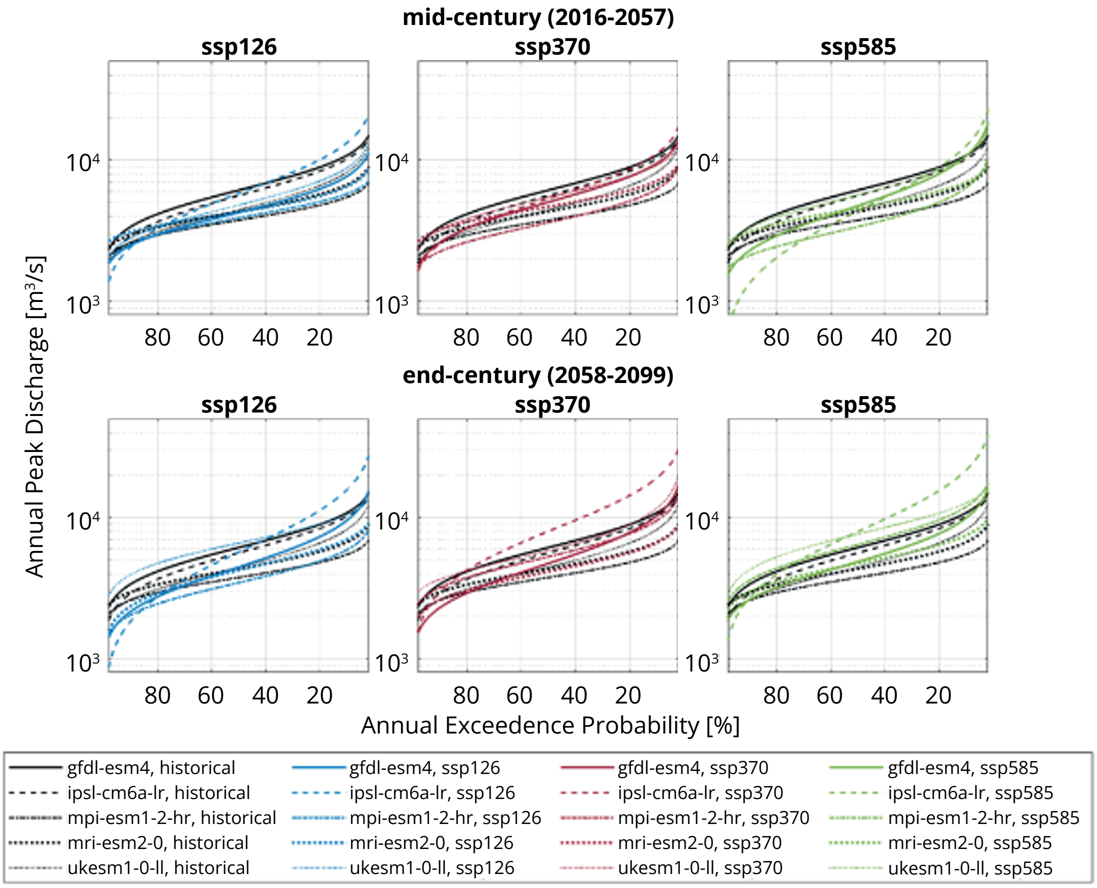


Figure 6 Mid- and end-century flood frequency distribution of the simulated future discharge (blue, green and red) of the five climate models and three climate scenarios, compared to the distribution of simulated historical dis-charge (black) of all climate scenarios at the outlet of the Luangwa sub-catchment.

For the second most pressing challenge identified by stakeholders—droughts—simulations showed a clear trend across all models and climate scenarios: **an increasing proportion of low water flows** compared to the reference period. This could impact several sectors, including hydropower and water availability for irrigation. There is a noticeable trend of **rising water stress in agriculture,** primarily due to increasing temperatures in future climate scenarios, despite little change in rainfall patterns. However, water stress varies significantly by location, with neighbouring areas experiencing opposite trends.

Figure 7 hange in frequency of low flow (dark green), medium flow (light green), high flows (yellow) and extreme flows (orange) from the historical reference period (1980 - 2014) to the mid-century (2015 -2057) and the end-century (2058 - 2099) period at the outlet of the upper Kafue sub-catchment.

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Funding

The GoNexus project is funded by the European Union Horizon Programme call H2020-LC-CLA-2018-2019-2020 - Grant Agreement Number 101003722.