Evaluating the InVEST® Seasonal Water Yield Model for Streamflow Simulation in the Brazilian Savanna

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Introduction

- The Brazilian Savanna (Cerrado) is the most biodiverse savanna worldwide, holding nearly 5% of global biodiversity hotspots.
- It provides key ecosystem services such as water regulation, carbon storage, and agricultural productivity.
- The region supplies about 40% of Brazil's freshwater, making it essential for national water security.
- Rapid agricultural expansion in the MATOPIBA frontier, combined with climate change, threatens the resilience of these water-related ecosystem services (WES).
- In such data-scarce tropical landscapes, accessible hydrological models are needed to evaluate trade-offs between land use, climate, and water security.

Objectives

Critically assess the InVEST® Seasonal Water Yield (SWY) model as a tool to simulate streamflow (quickflow + baseflow) in the Alto Parnaíba watershed, northeastern Cerrado. Specifically, the objectives are to:

- Evaluate the model's strengths and limitations in capturing WES under land-use and climate change.
- Comparison of modeled streamflow against long-term observed flows.

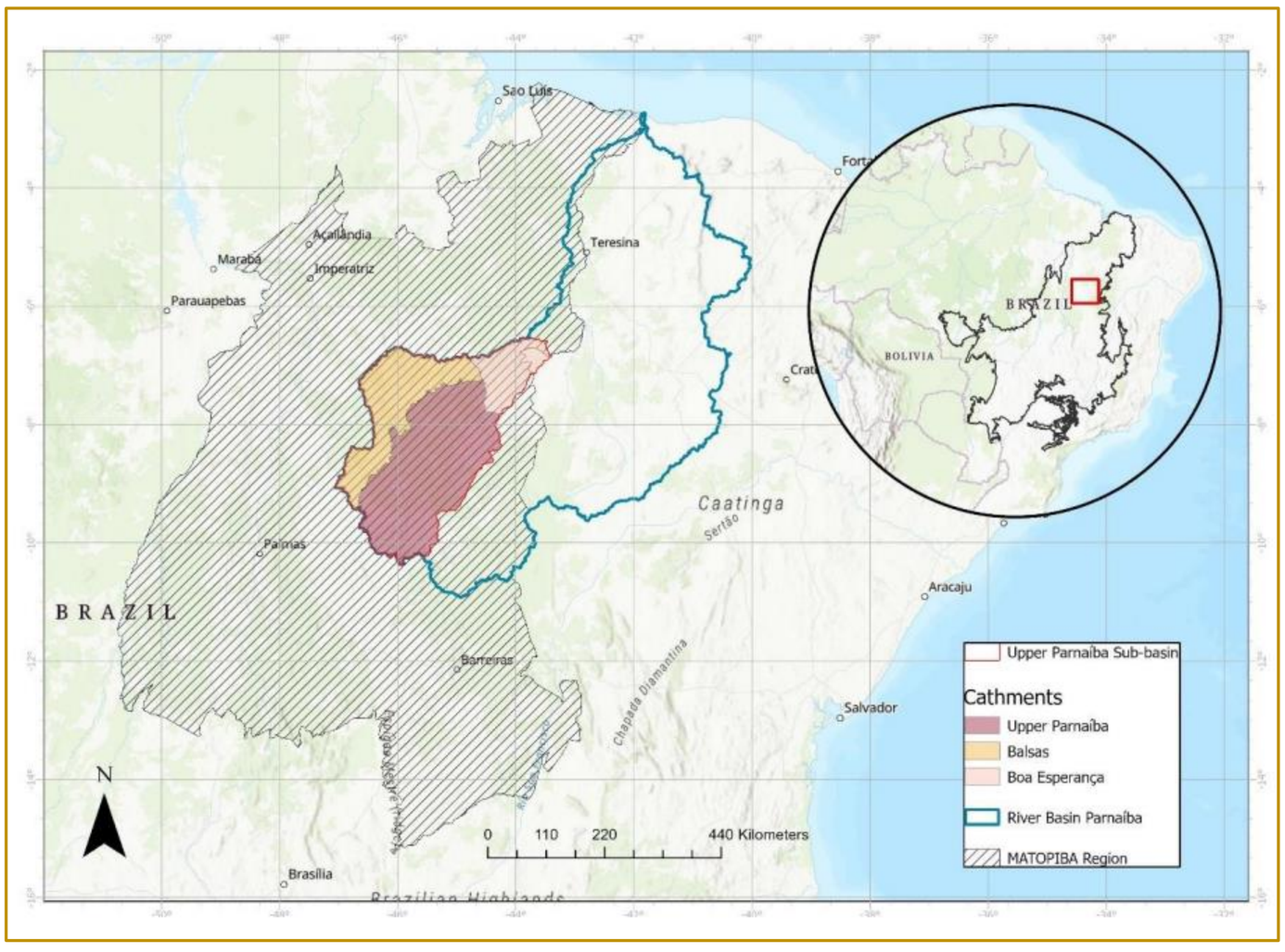

Figure 1: Study area of the Alto Parnaíba Sub-basin and its three sub-divisions, Boa Esperança and Balsas and Alto Parnaíba, located within the Cerrado biome and the MATOPIBA region, Brazil.

Methodology and Materials

- Model**:** InVEST® (Integrated Valuation of Ecosystem Services and Tradeoffs) – the Seasonal Water Yield (SWY) module estimates water yield from a balance between precipitation and actual evapotranspiration (P − AET).
- Purpose: Applied to evaluate water-related ecosystem services, with focus on dry-season baseflow regulation.
- Scenarios: Compared historical (2000) and present (2023) land use/cover.
- Calibration & validation: Used 2015 land-use scenario (climate 1985–2015) and compared modelled streamflow with observed discharge.
- Post-processing: Outputs analyzed with GIS tools.

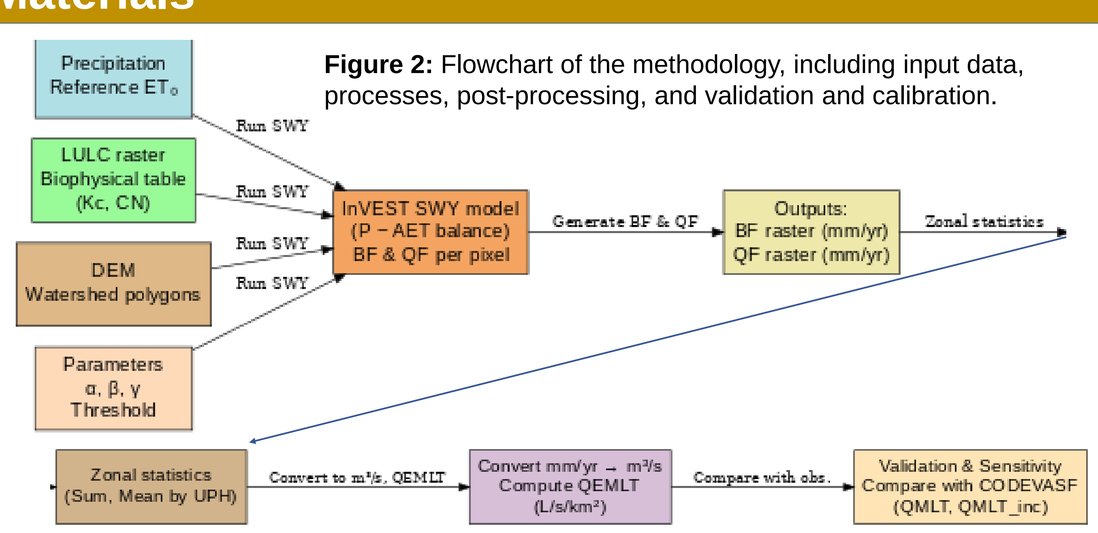

Figure 2: Flowchart of the methodology, including input data, processes, post-processing, and validation and calibration.

Results

- Between 2000 and 2023, the model estimated that dry-season baseflow increased by more than 100% in some agricultural catchments, even under declining rainfall and agriculture expansion
- The Balsas sub-basin showed the best fit. Alto Parnaíba sub-basin was strongly overestimated, The Boa Esperança sub-basin was underestimated likely due to the reservoir.

Sub-basin	Station	Q_obs (m³/s)	Q_model (m³/s)	Match
Alto Parnaíba	Pa04	0.03	3.3–6.4	Overestimated
Balsas	Pa01	4.14	4.1–5.2	Closest match
Boa Esperança	BE	14.58	0.6–1.0	Underestimated

Figure 3: Comparison table of observed (real) values and the range of modeled values (from different calibrations) for each sub-basin.

Discussion

- ✓ The model best reproduced observed streamflow in the Balsas sub-basin, an intensively farmed area.
- ✓ In the Alto Parnaíba sub-basin, flows were overestimated; in Boa Esperança, they were underestimated, likely due to the reservoir.
- ✓ Modeled baseflow doubled between 2000–2023 in agricultural catchments, linked to soybean expansion (lower crop coefficients → less evapotranspiration → more infiltration in the model).
- Strengths: Provides spatially explicit outputs, easily processed in GIS, requires relatively low data input, and is widely recommended in the literature for scenario comparison and analysis.
- Limitations: Not suitable for absolute streamflow or long-term resilience, sensitive to crop coefficients and connectivity parameters, does not represent groundwater recharge, root-zone water storage, or reduced atmospheric moisture recycling caused by deforestation.

Outlook

- ❖ SWY is a useful exploratory tool for scenario analysis of water-related ecosystem services and can support land-use planning and water governance in tropical savannas.
- ❖ Best applied in combination with local datasets and process-based hydrological models.

Acknowledgements and references

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