# Model framework based on weighted WEFE indicators for climate- and socio-economic resilient water governance for the Upper Main catchment

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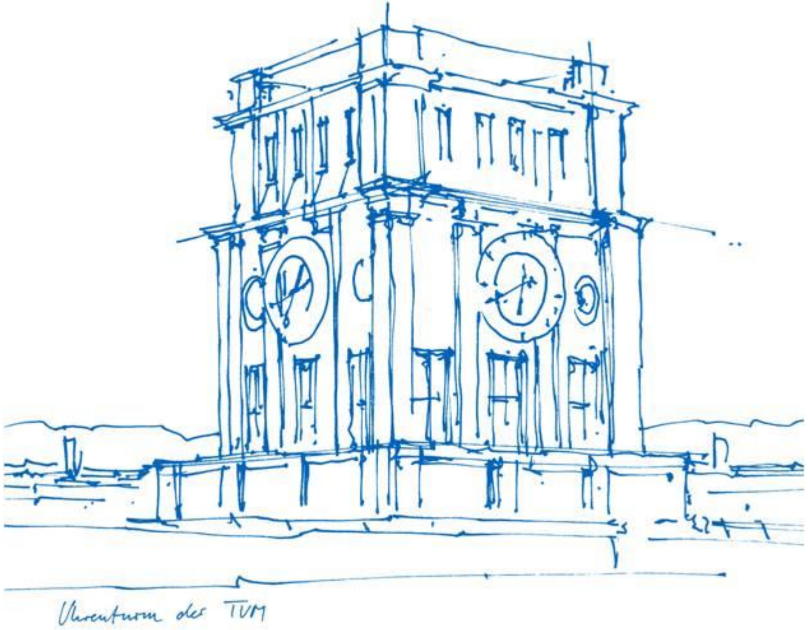
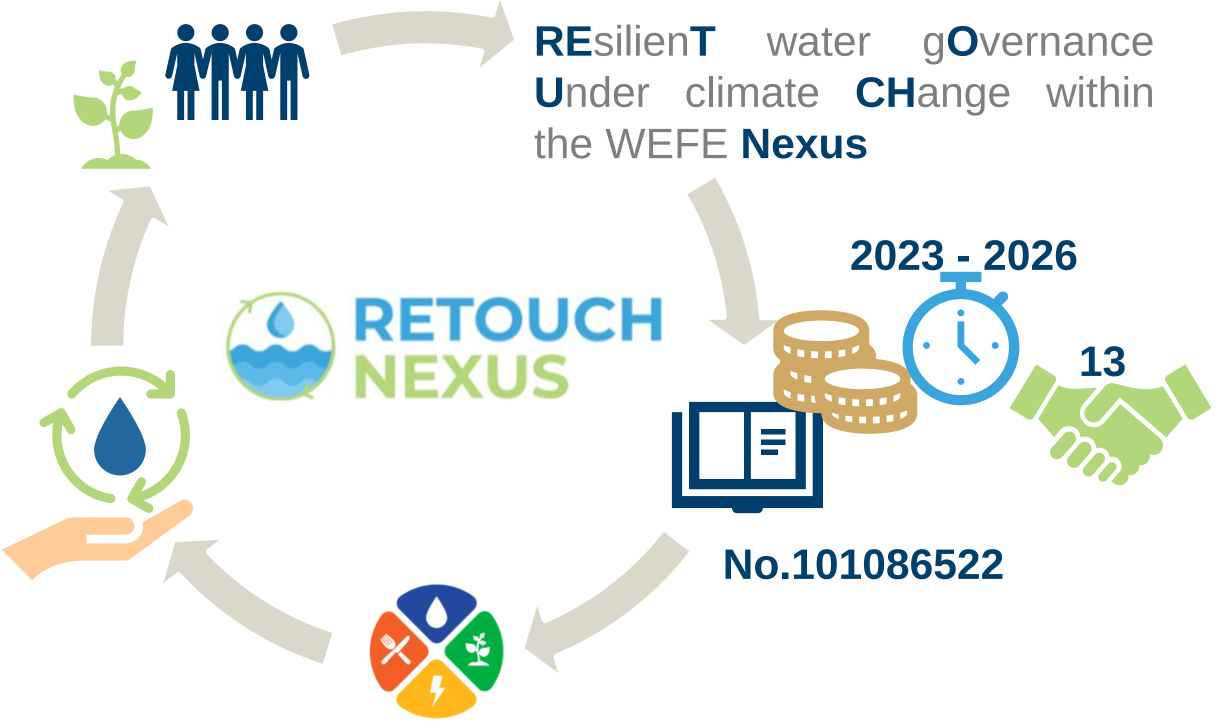


# Content

# 1 Introduction



# 1 Introduction

**RETOUCH NEXUS** aims to promote robust, integrated, sustainable, inclusive and upscalable water governance practices

→ evidence-based approach

→ 6 case studies in EU

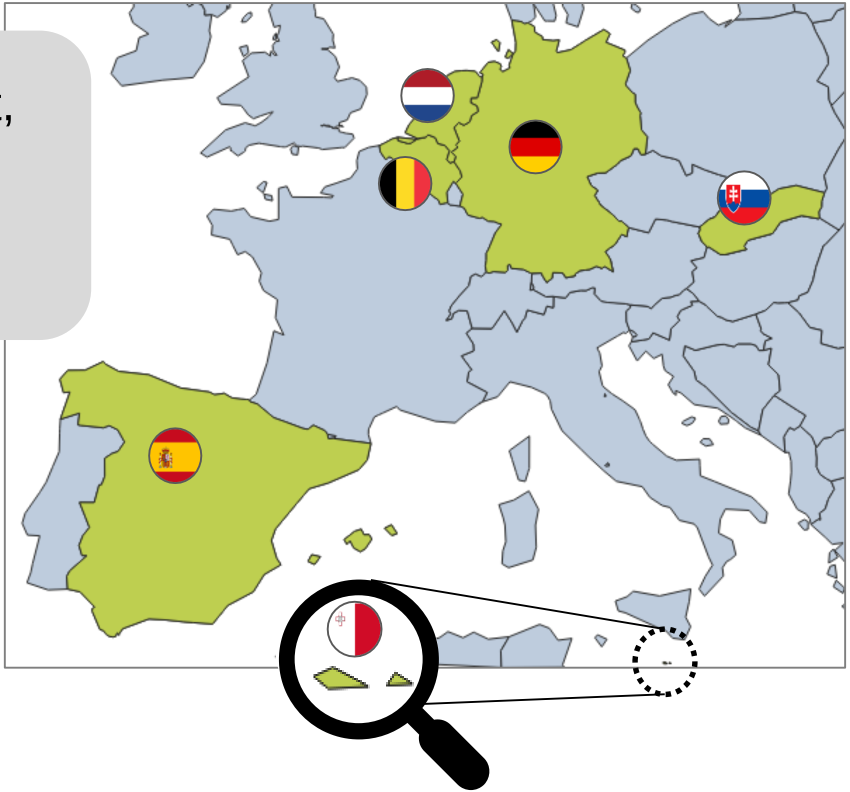


*Figure 1: Location of the case studies with the RETOUCH Nexus project.*

# 2 Research questions

1. **How to implement a weighted indicator based model framework for a sustainable climate- and socio-economic resilient water governance for the Upper Main Catchment using the SWAT+ and WEAP model?**
    1.1. **Which indicators based on WEFE und ESS can be derived using the SWAT+ and WEAP models?**
    1.2. **How do the stakeholders weight the indicators provided?**
    1.3. **What conditions prevail in the Upper Main catchment when the model framework is applied?**

2. **What are the results of using the weighted indicator based model framework in combination with climate change and socio-economic scenarios within the Upper Main catchment?**

3. **How can the weighted indicator based model framework contribute as a decision/planning framework to develop adaptation strategies to CC and SE scenarios within the Upper Main catchment?**

# 3.1 Study area – Location

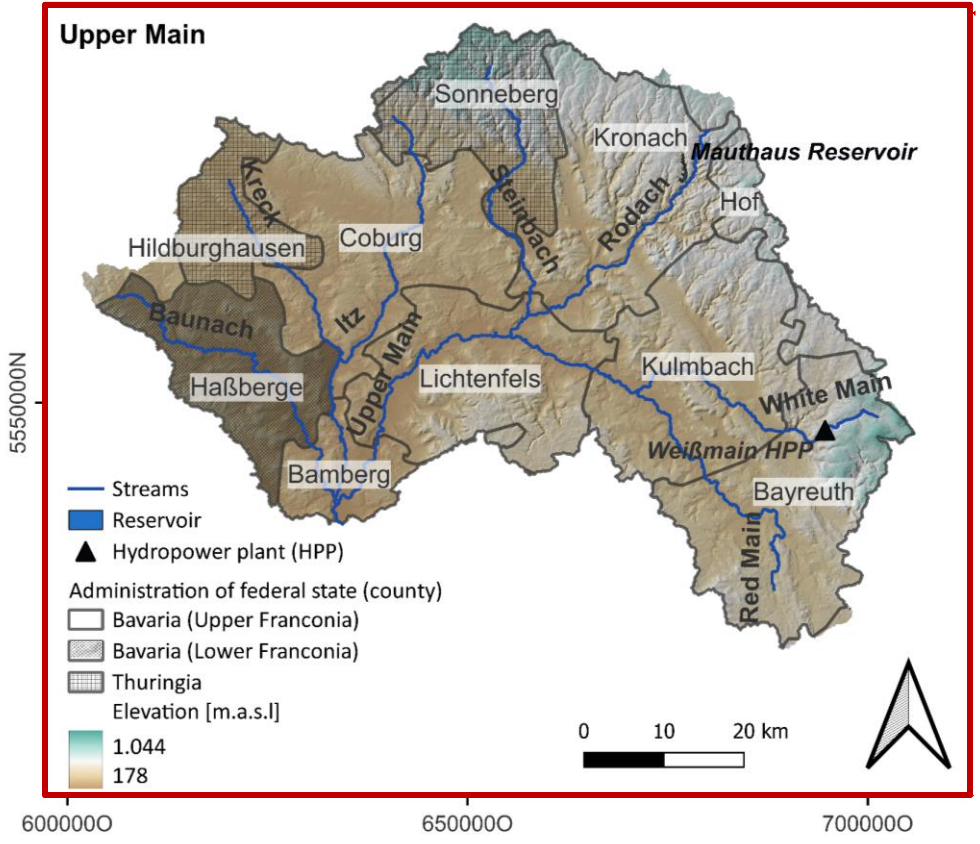
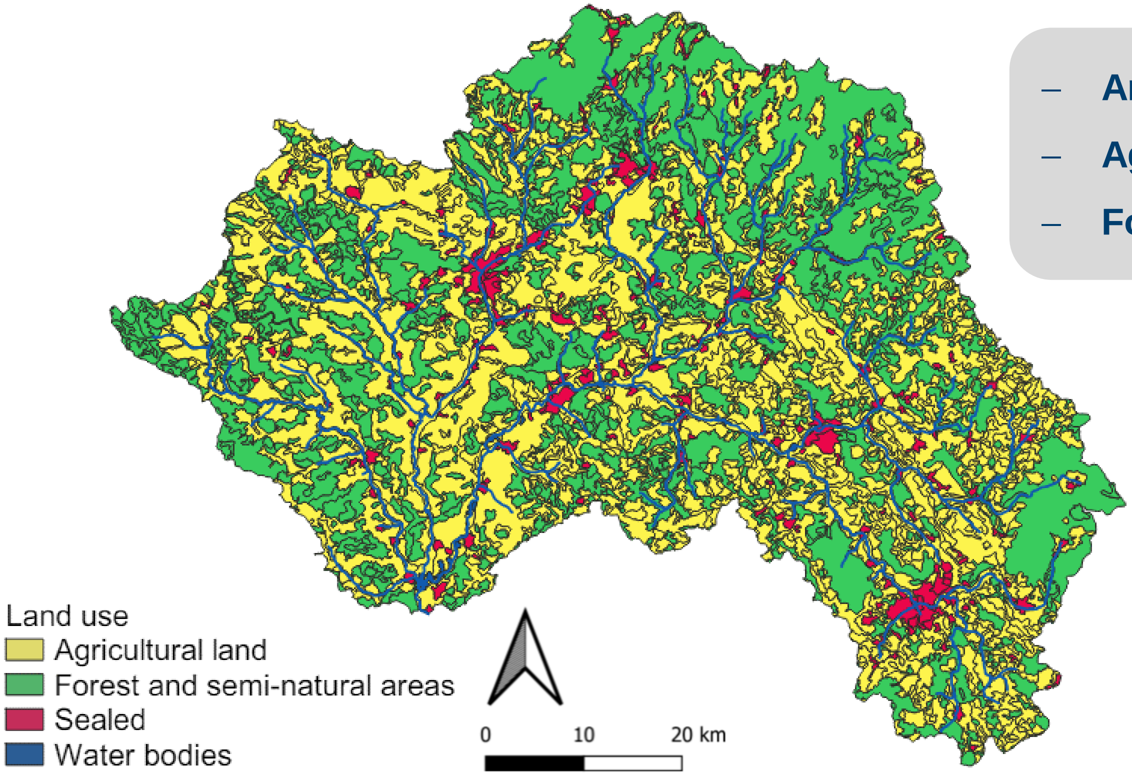



*Figure 2: Location of the Upper Main catchment.*

- **Catchment area:** 4.646 km$^2$
- **Elevation:**
  - east-west slope
  - [178, 1044] m.a.s.l.
  - ~ 75% located [178,500] m.a.s.l.
- **River network:**
  - Upper main has two springs:
    - White Main
    - Red Main
  - several tributaries
- **Mauthaus reservoir**
- **Weißmain Hydro Powerplant**

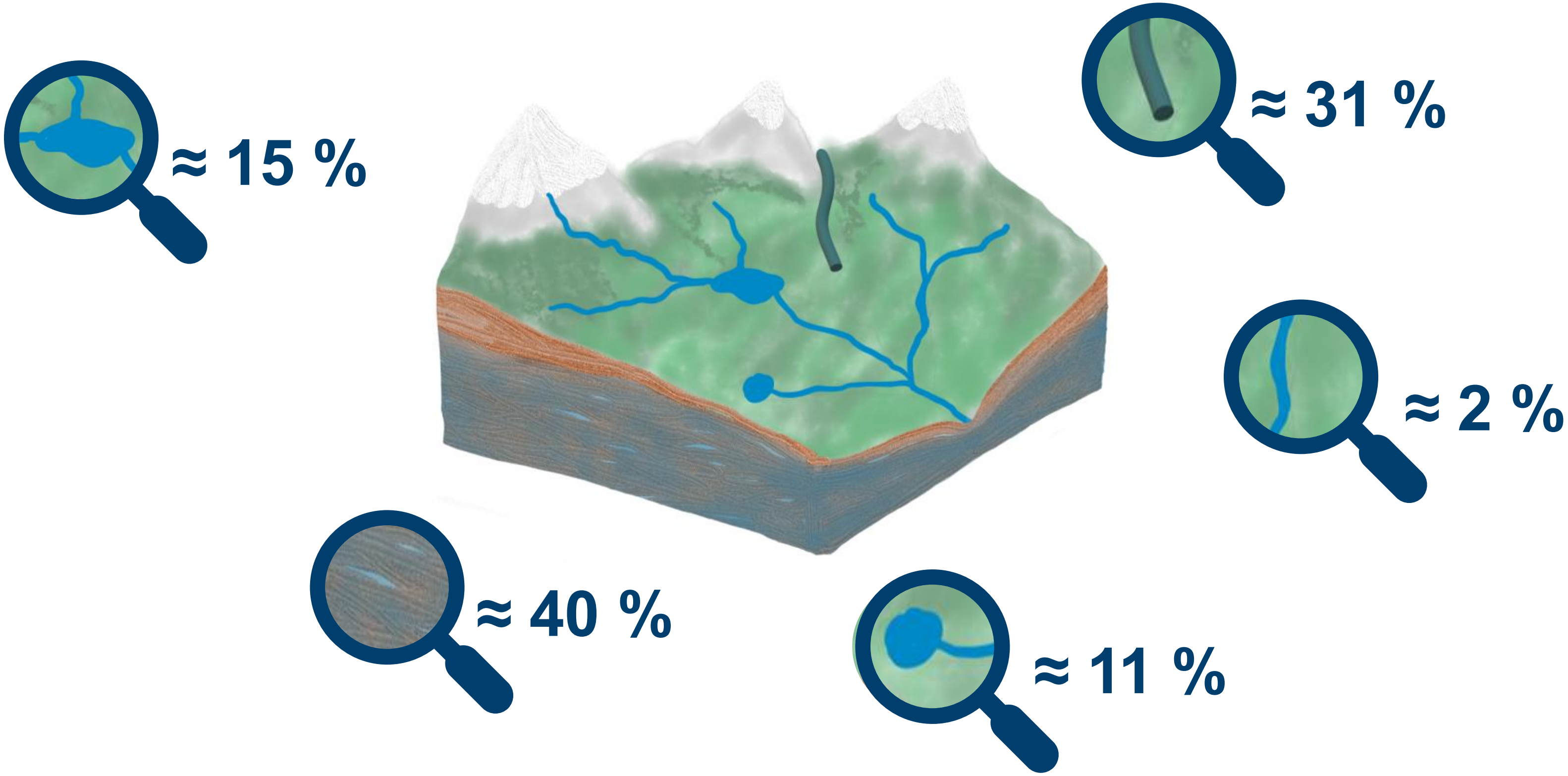
# 3.2 Study area – Land use




- **Artificial** areas: **+ 3.4 %**
- **Agricultural** areas: **- 6.5 %**
- **Forest** and **semi-natural** areas: **+ 2.9 %**

*Figure 3: Land use change from 2000 to 2018 (CORINE Land Cover).*

# 3.3 Study area – Water management



# 3.3 Study area – Flow regime

- **water bodies** are mainly fed by **rainwater**
- **summer season:**
  high ET → lower discharges
- **winter and early spring:**
  higher discharges

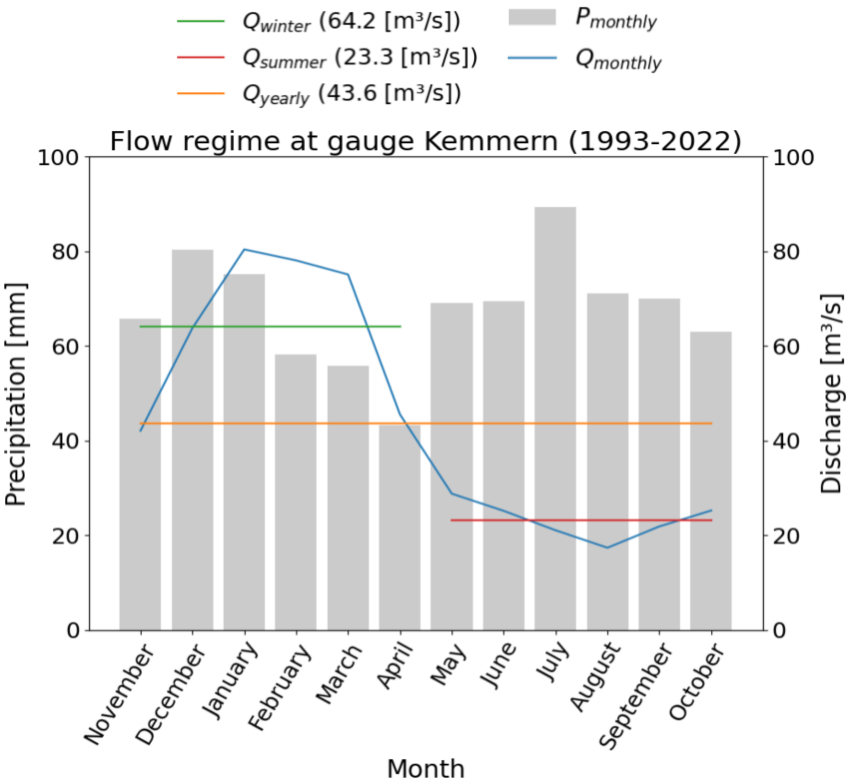
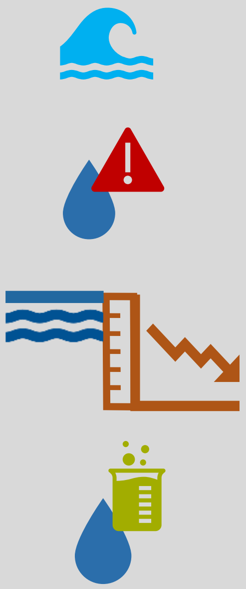
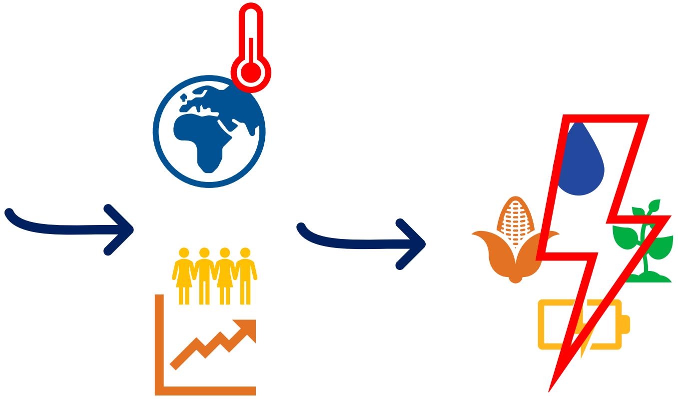


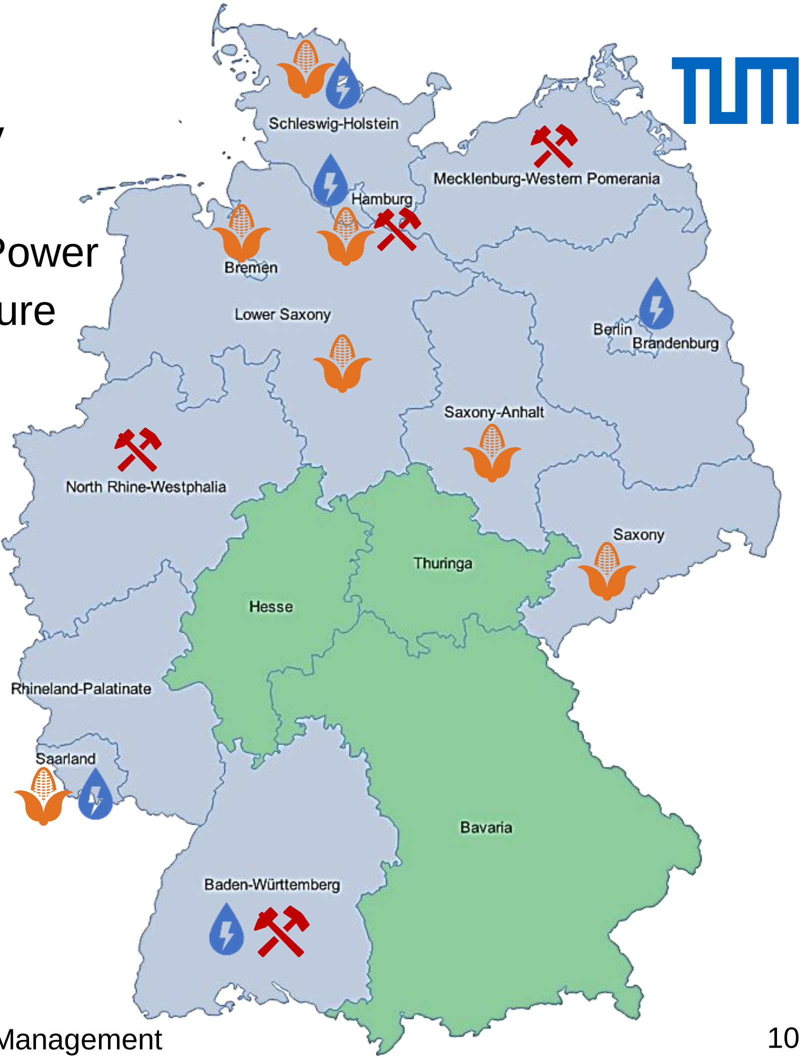

*Figure 4: Flow regime of the Upper Main catchment (gauge Kemmern) within the period from 1993 to 2022.*

# 4.1 Methods – Motivation

**Current**
challenges

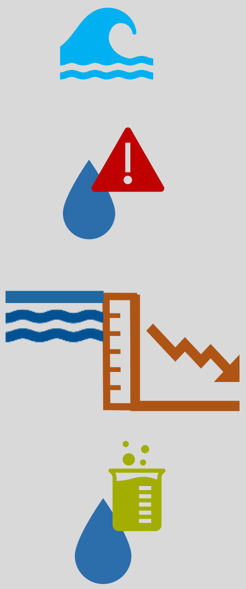


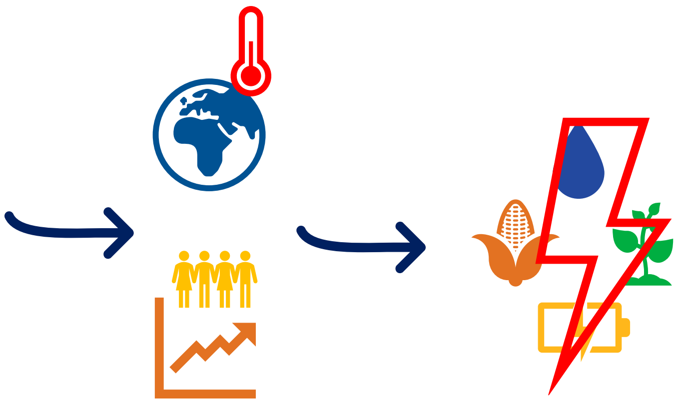


# 4.1 Methods – Motivation

**Current** challenges





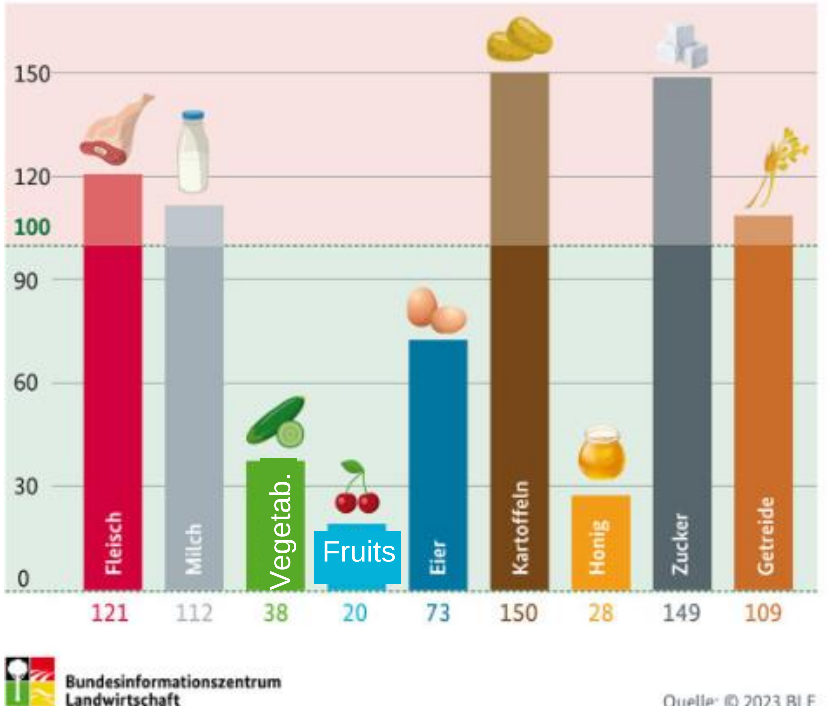
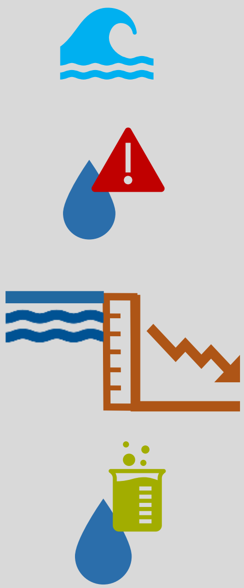
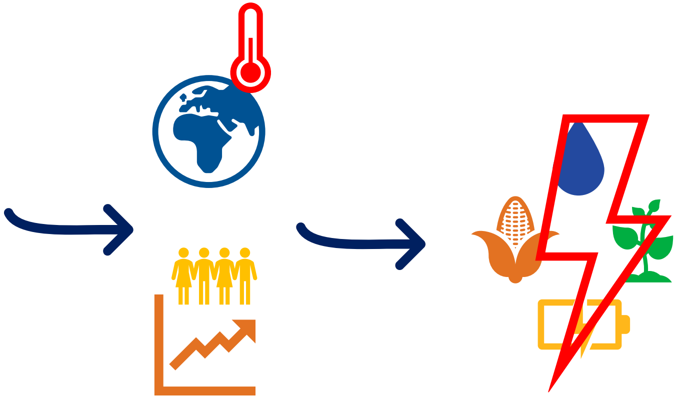



*Figure 5: Degree of self-sufficiency in Germany (BLE, 2023).*

# 4.1 Methods – Motivation

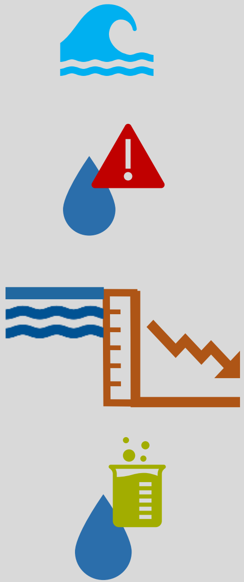
**Current** challenges

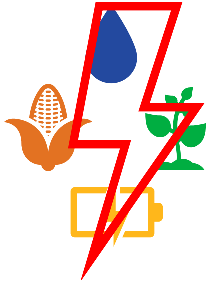




# 4.1 Methods – Motivation

**Current**
challenges





**Arising**
challenge

climate and
socio-economic

adaptation

# 4.2 Methods – Model framework

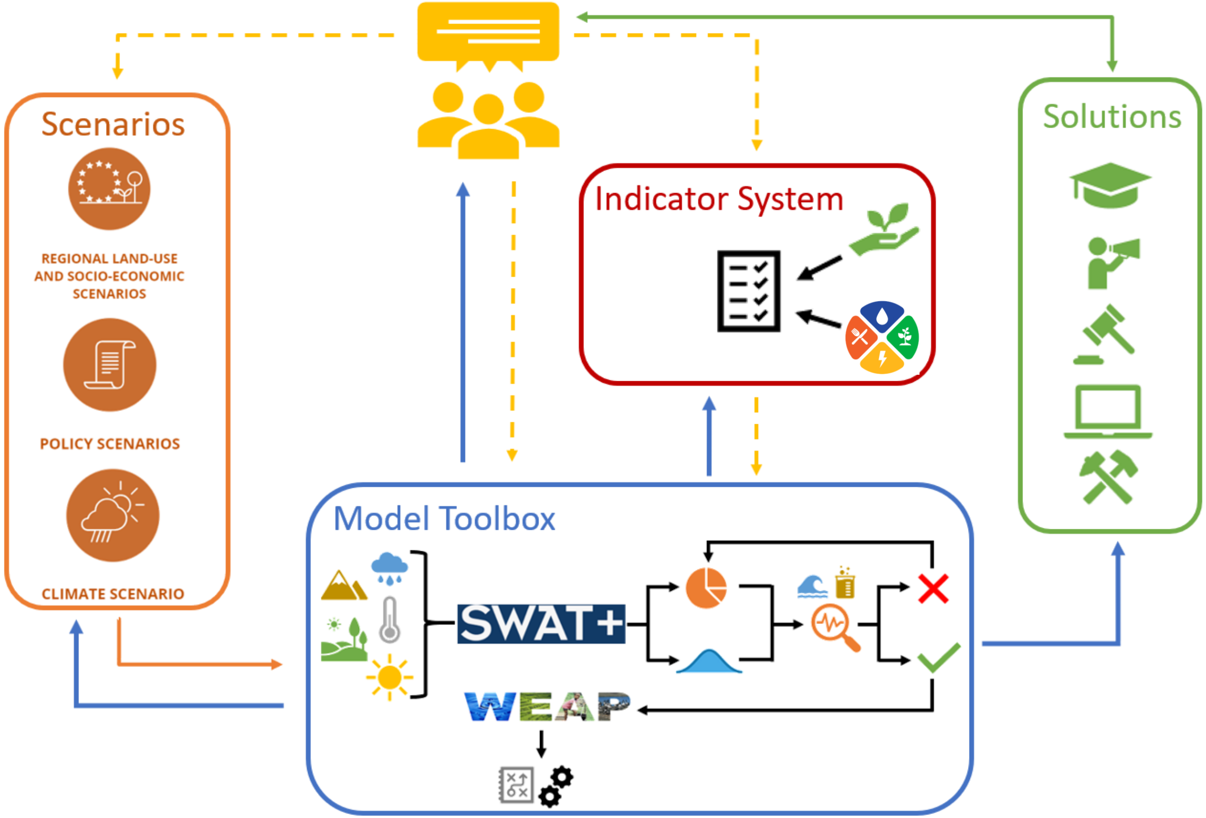
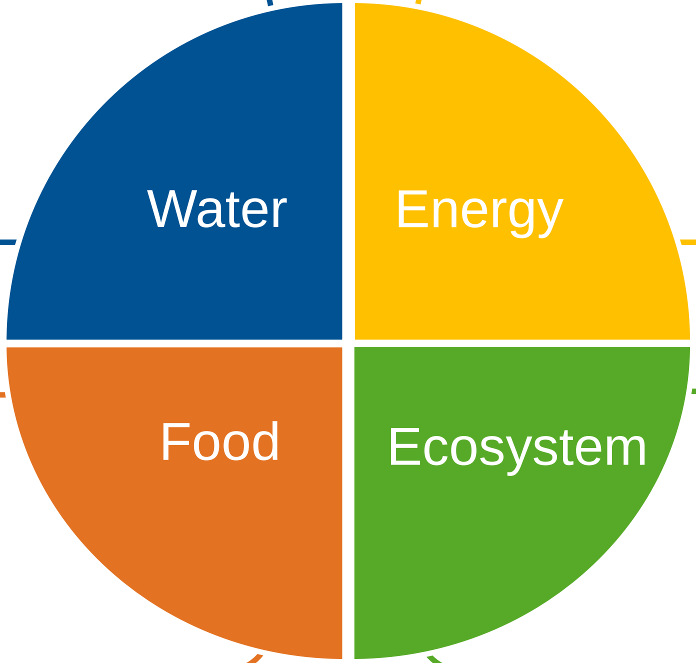



*Figure 6: Overview of model framework used for the Upper Main catchment.*

# 4.3 Methods – Indicators (WEFE)

- Water yield
- Blue water
- Green water

- Water yield
- Vegetation biomass (estimate biofuels)
- Soil erosion / deposition (reduce lifespan of HPP)



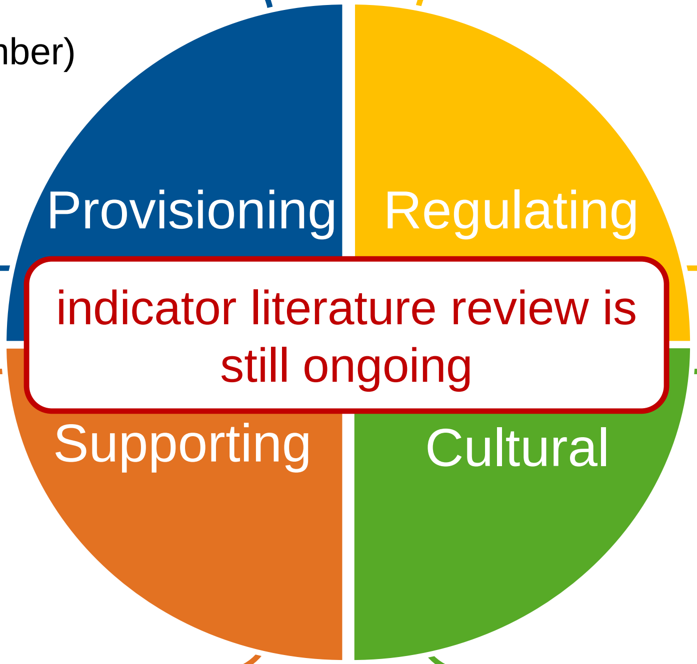

- Net rate
- Crop yield
- Sown area
- Crop land area
- NPP
- C-, N and $H_20$- flux

- carbon sequestration
- N
- P
- Dissolved Oxygen
- Temperature
- Q

# 4.3 Methods – Indicators (ESS)

- Productivity availability (e.g. water, bio fuels, timber)
- Food sovereignty
- Water availability
- Water quantity
- Water quality

- Erosion / sediment
- Deposition control
- Food control
- Drought control
- Soil nutrient cycling
- Pollination (water, soil)




Difficult
→ more literature review necessary

- Scared sites
- Knowledge of territory
- Traditional knowledge
- Ecotourism areas
- Maintenance of oral tradition

# 4.4 Methods – Model toolbox

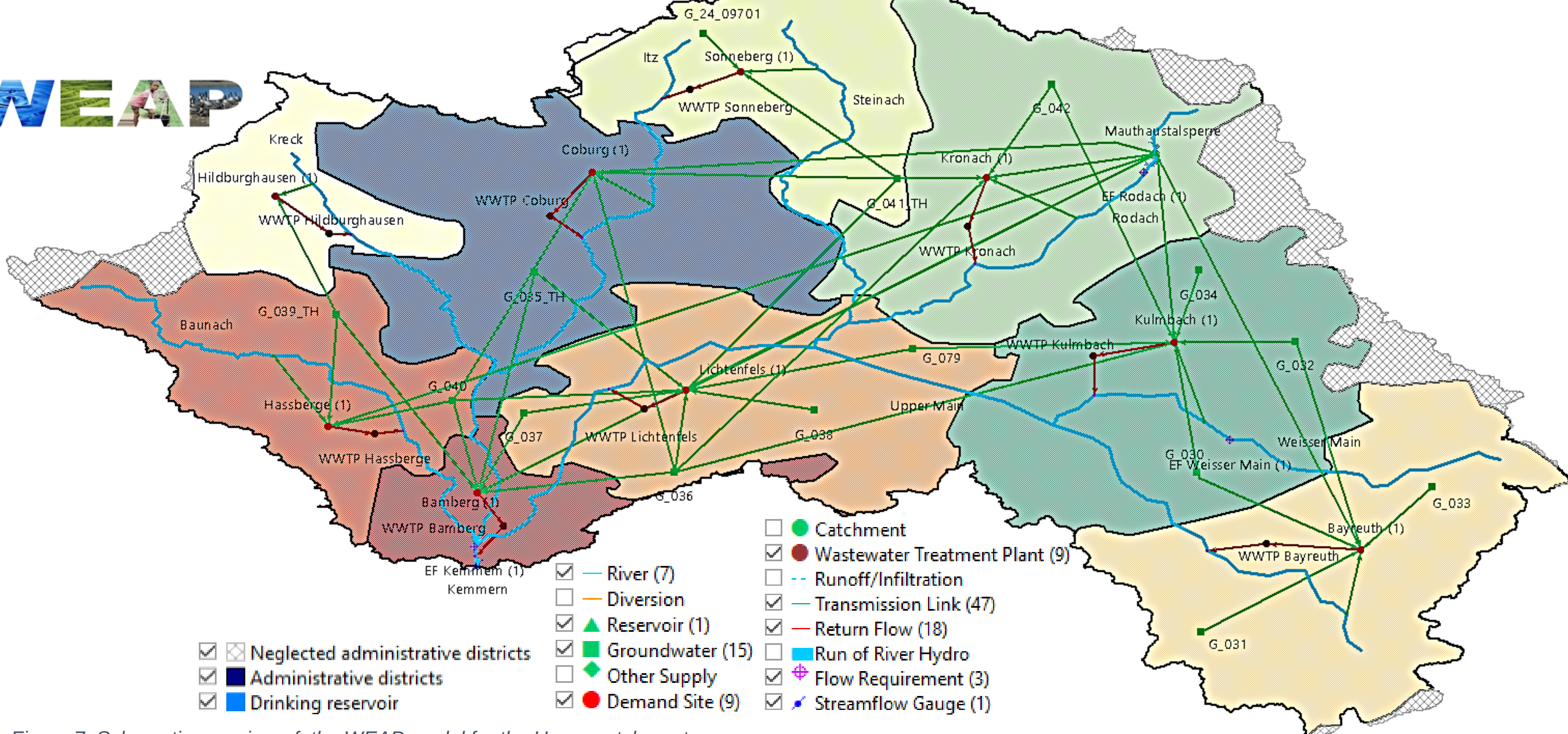



*Figure 7: Schematic overview of  the WEAP model for the Upper catchment.*

# 4.4 Methods – Model toolbox

**Why on district level?**

Water demand is available on district level

Measures are issued at district level

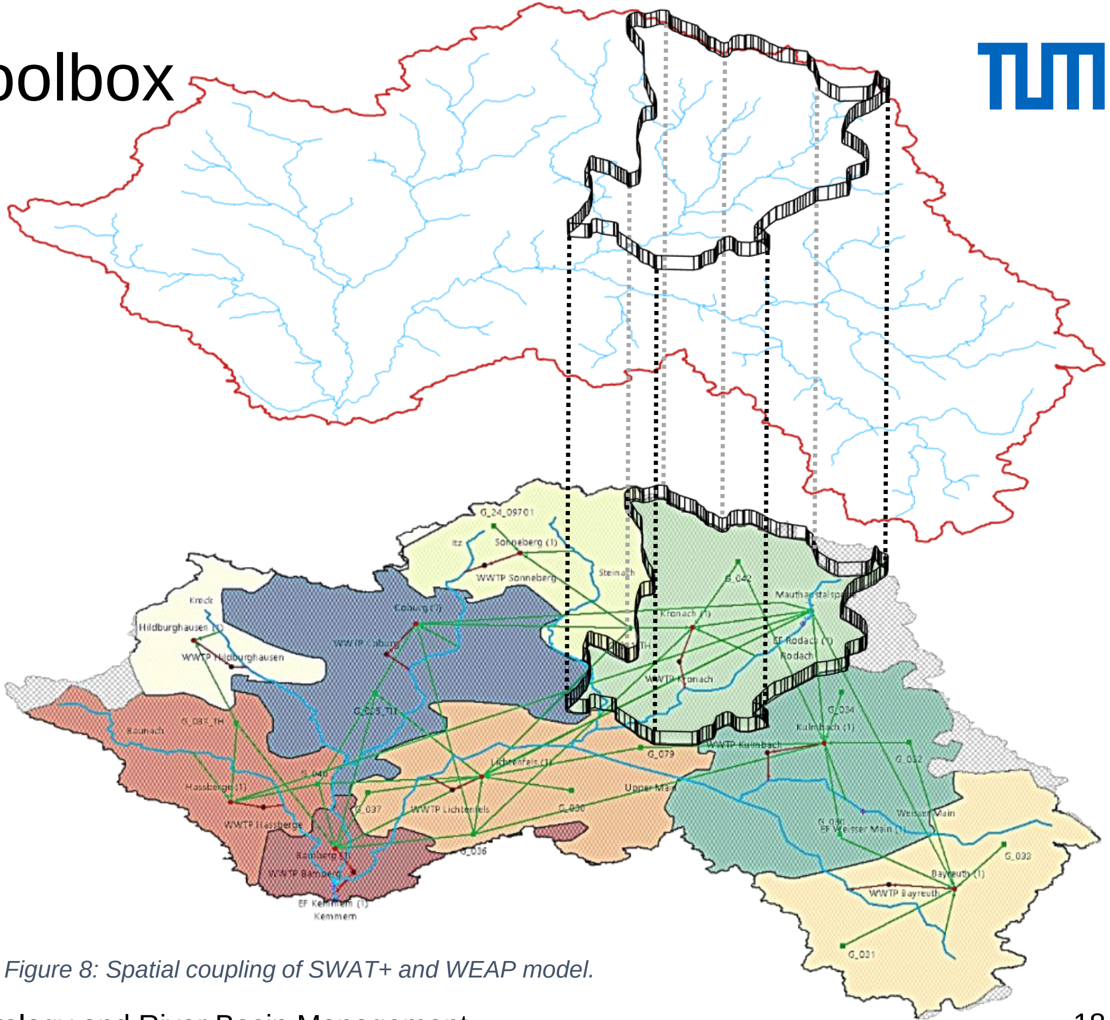
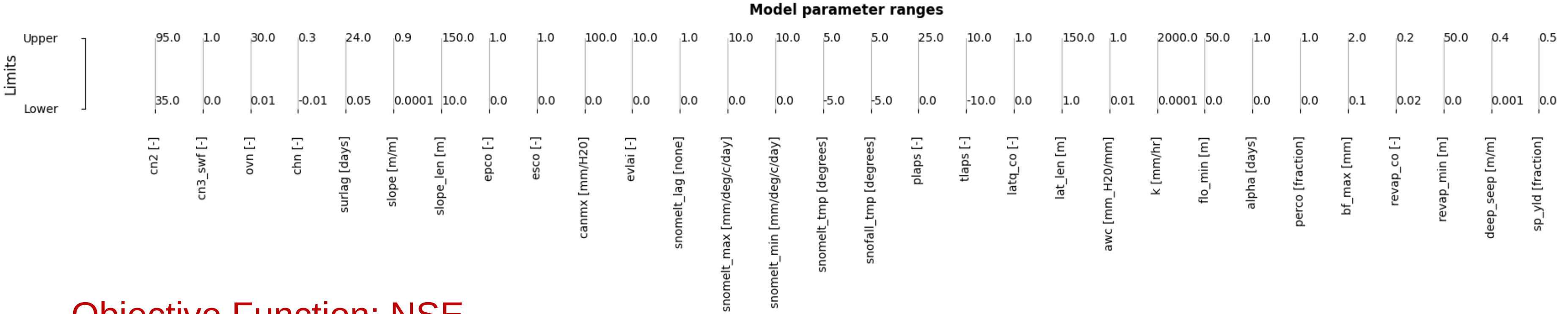
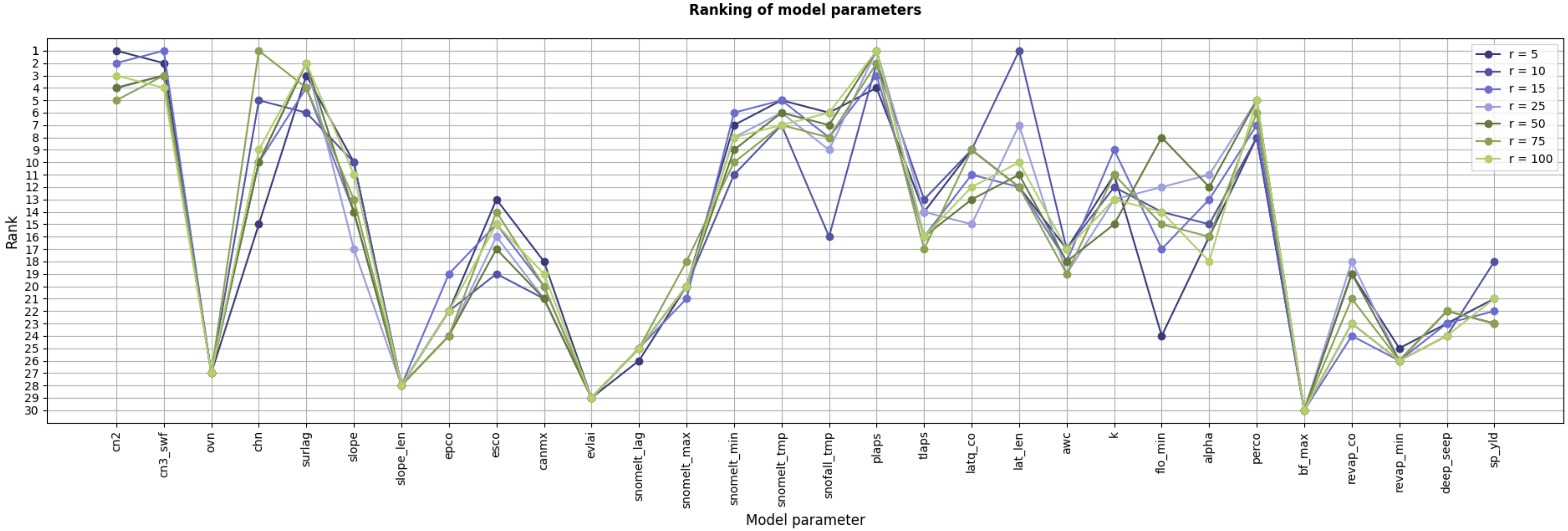


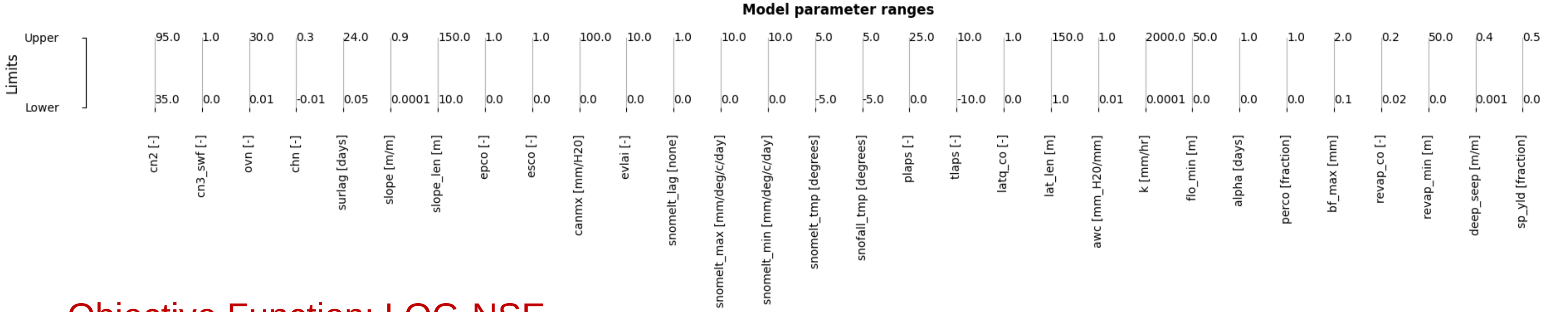

*Figure 8: Spatial coupling of SWAT+ and WEAP model.*

# 5 Preliminary results

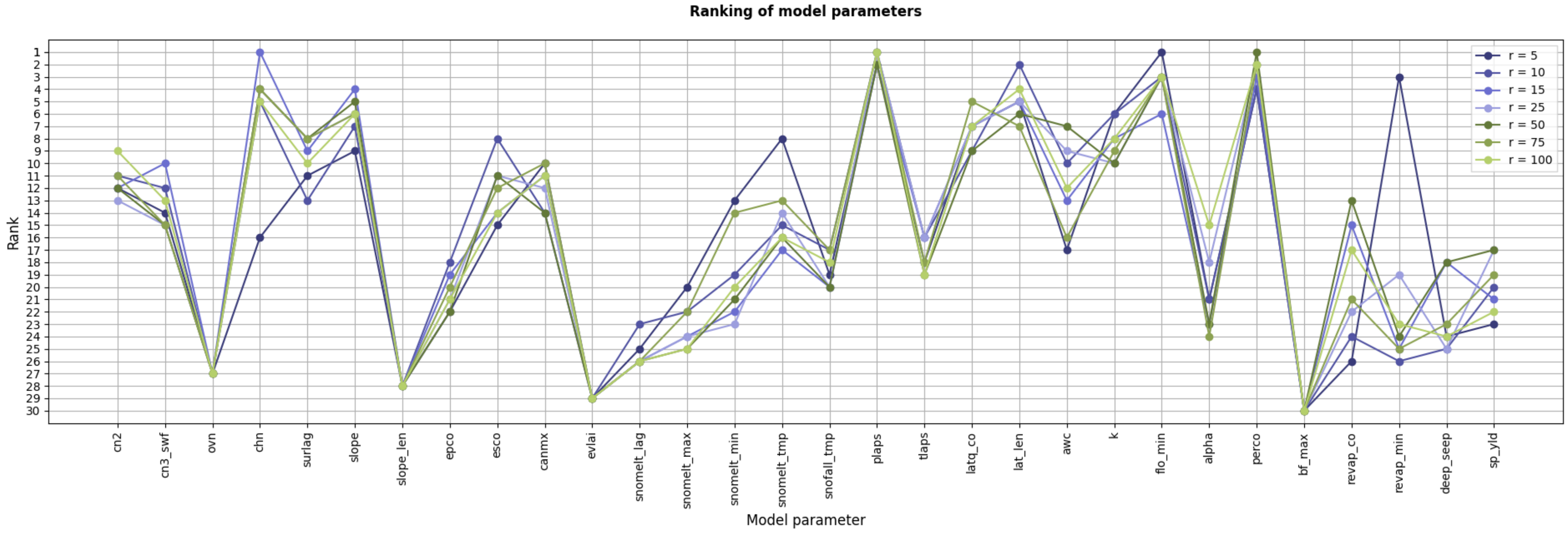



# Objective Function: NSE






# Objective Function: LOG-NSE



# 6 Outlook

Use **gwflow** and SWAT+

Perform **calibration** and **validation**

→ **prevailing conditions**

Perform **adaptation strategies**

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Thank you for your attention.

# **Morris Method:** Screening


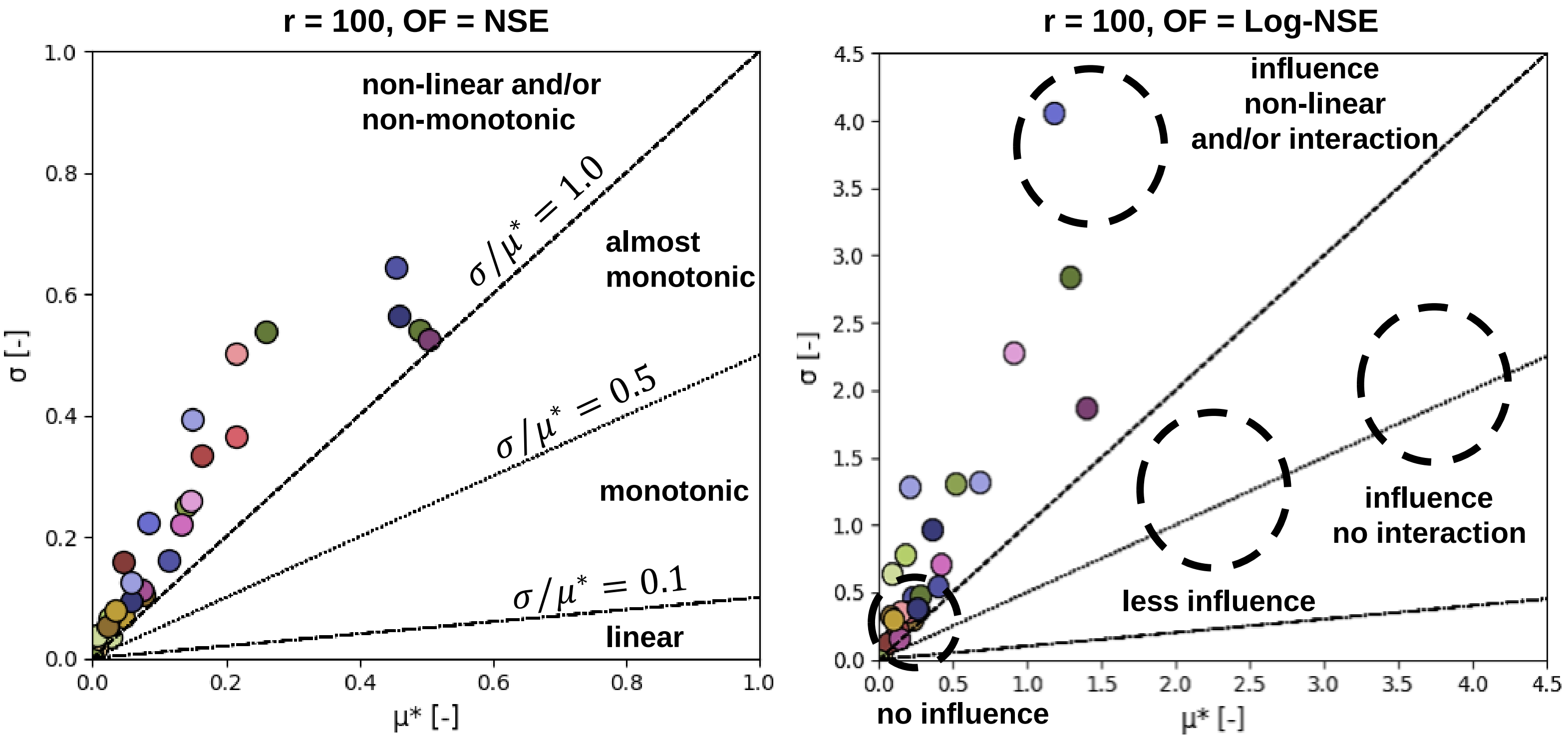


*Figure 17: Screening of the model parameters for r = 100 and different objective functions (OF): (a) NSE, (b) Log-NSE.*

# Blue and green water calculation in SWAT

$$BW = WY + GS$$

$$GW = GWF + GWS = ET + SW$$

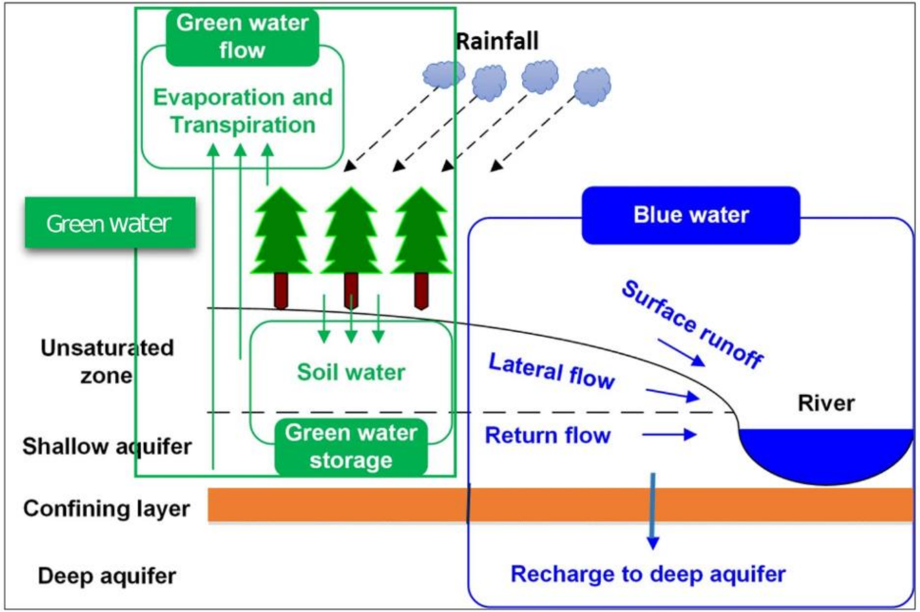


*Figure 9: Schematic diagram of blue and green water components (Hordofa et. al. 2023).*

Where, GWF is green water flow and GWS is green water storage. GS is the difference between total amount of water recharge to aquifers (GW_RCHG) and the amount of water from aquifer that contributes to the main channel flow (BF) (Veettil and Mishra 2016).

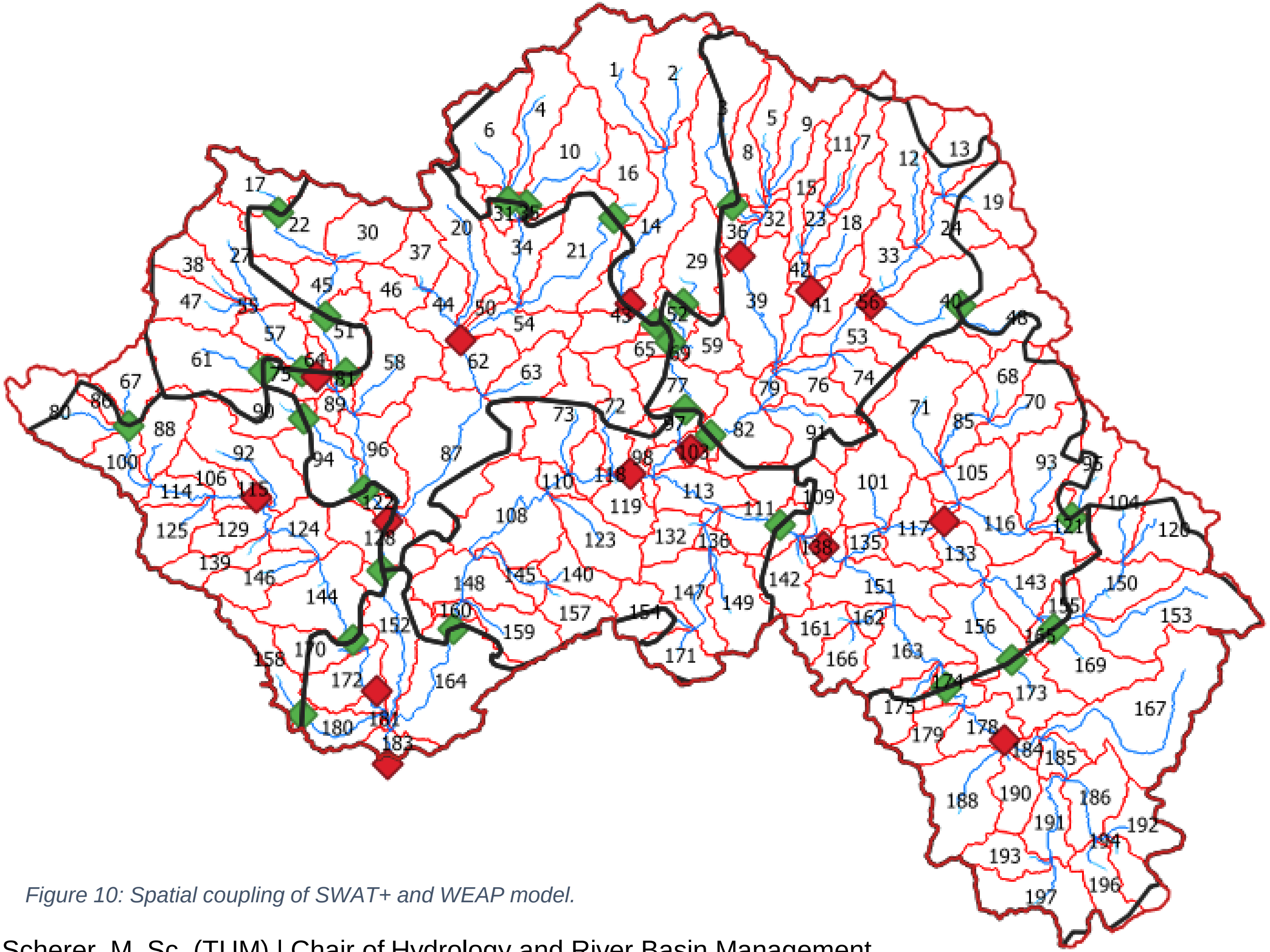

*Figure 10: Spatial coupling of SWAT+ and WEAP model.*