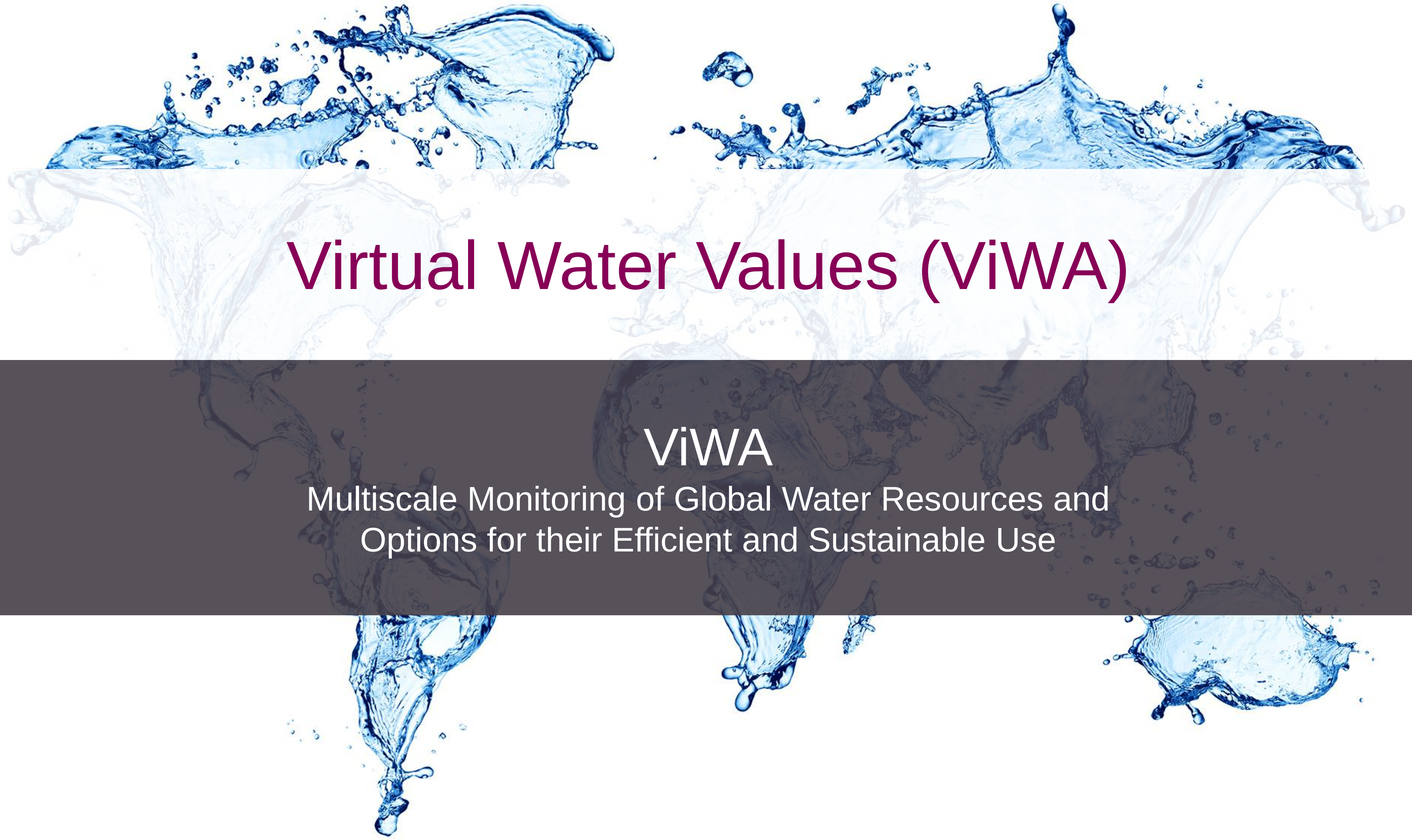
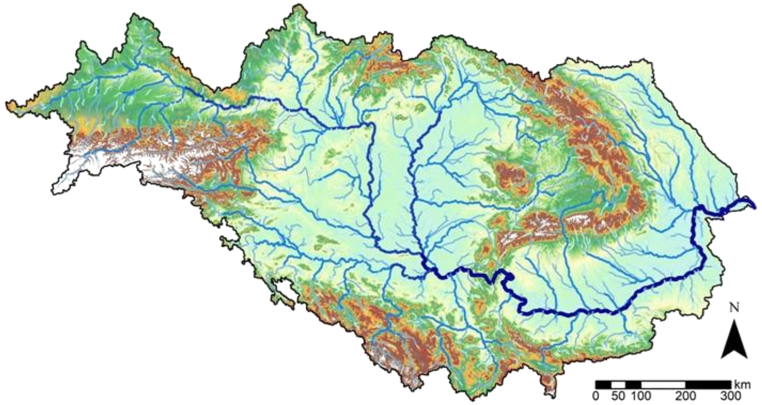


Virtual Water Values (ViWA)

ViWA

Multiscale Monitoring of Global Water Resources and
Options for their Efficient and Sustainable Use

The Danube River Basin –
Food-Water-Energy-Ecosystem Assessment



Christina von Haaren[1], Wolfram Mauser[2], Felix Neuendorf[1], Elisabeth Probst[2], Anna Schlattmann[1]

[1]Institute for Environmental Planning, Leibniz Universität Hannover (LUH), Germany

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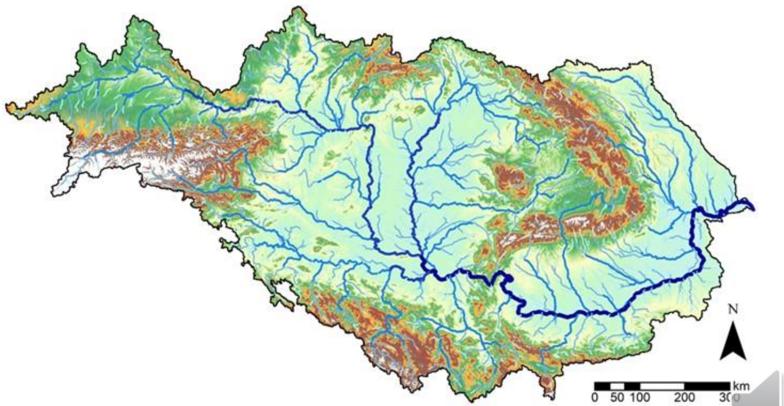
Danube: Characterization & Research Questions

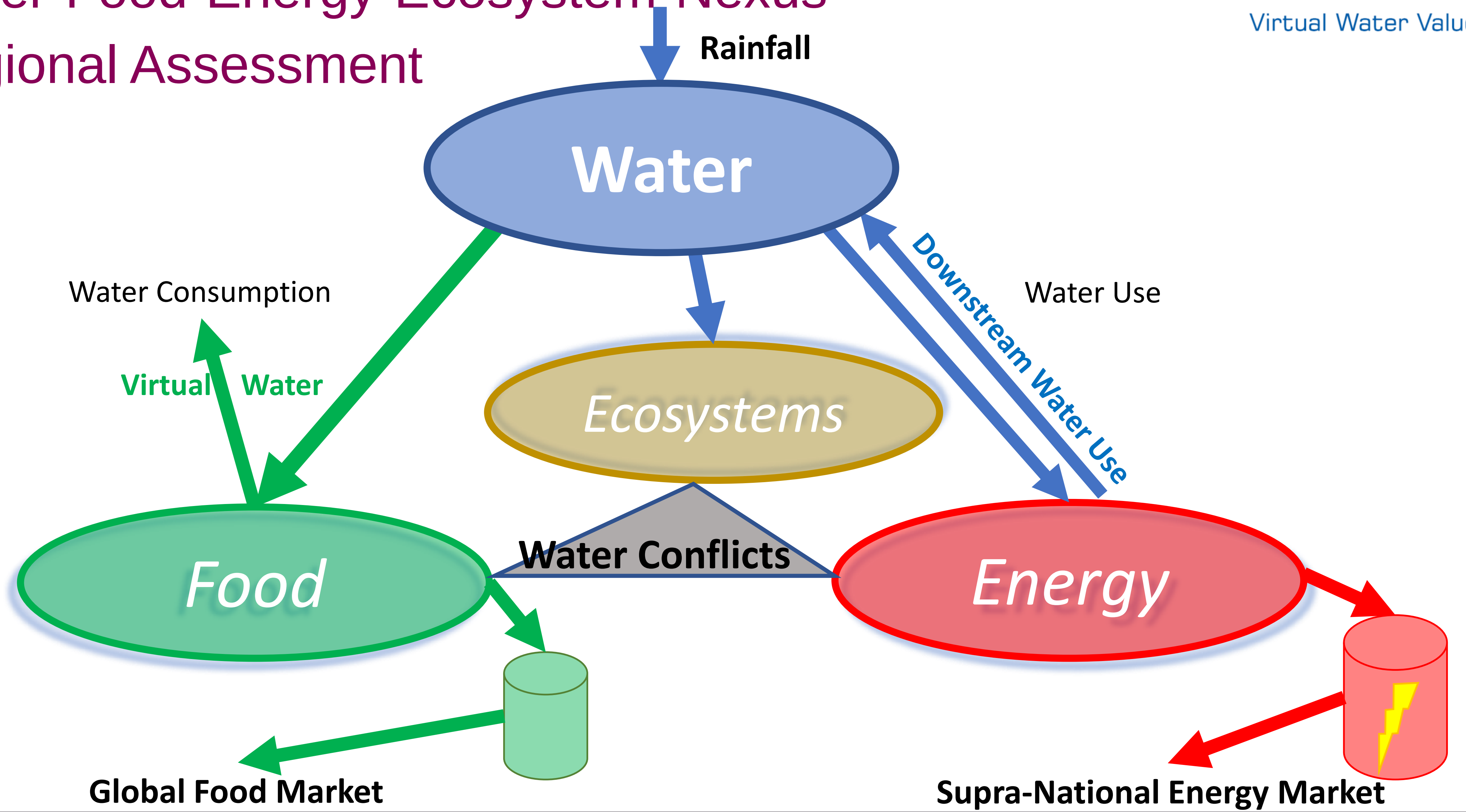
- Europe‘s second largest river basin (817,000 km²), most international river basin (covers 20 countries)
- Average annual rainfall in the Danube basin amounts to ~800 mm, but very unevenly distributed
  - → Water-rich Upper Danube vs. water-deficient Middle & Lower Danube
- Extensive but low-intensity agricultural use in Middle & Lower Danube (Hungary, Serbia, Romania), but production often limited by water shortages
  - Presently ~1.5% of cropland is irrigated, large yield increases expected through irrigation in the Lower Danube
  - Rapid increase of irrigated agriculture planned by e.g. Hungary and Romania
- 2860 Natura 2000 sites, the Danube delta is one of the world‘s largest wetlands and UNESCO World Heritage site
- All basin countries depend on the Danube waters as an economic resource → Water competition between agriculture, energy production, industry, transport and households

Major Question:

Which conflicts arise between water, food, energy and ecosystems from fully realizing irrigation potentials?

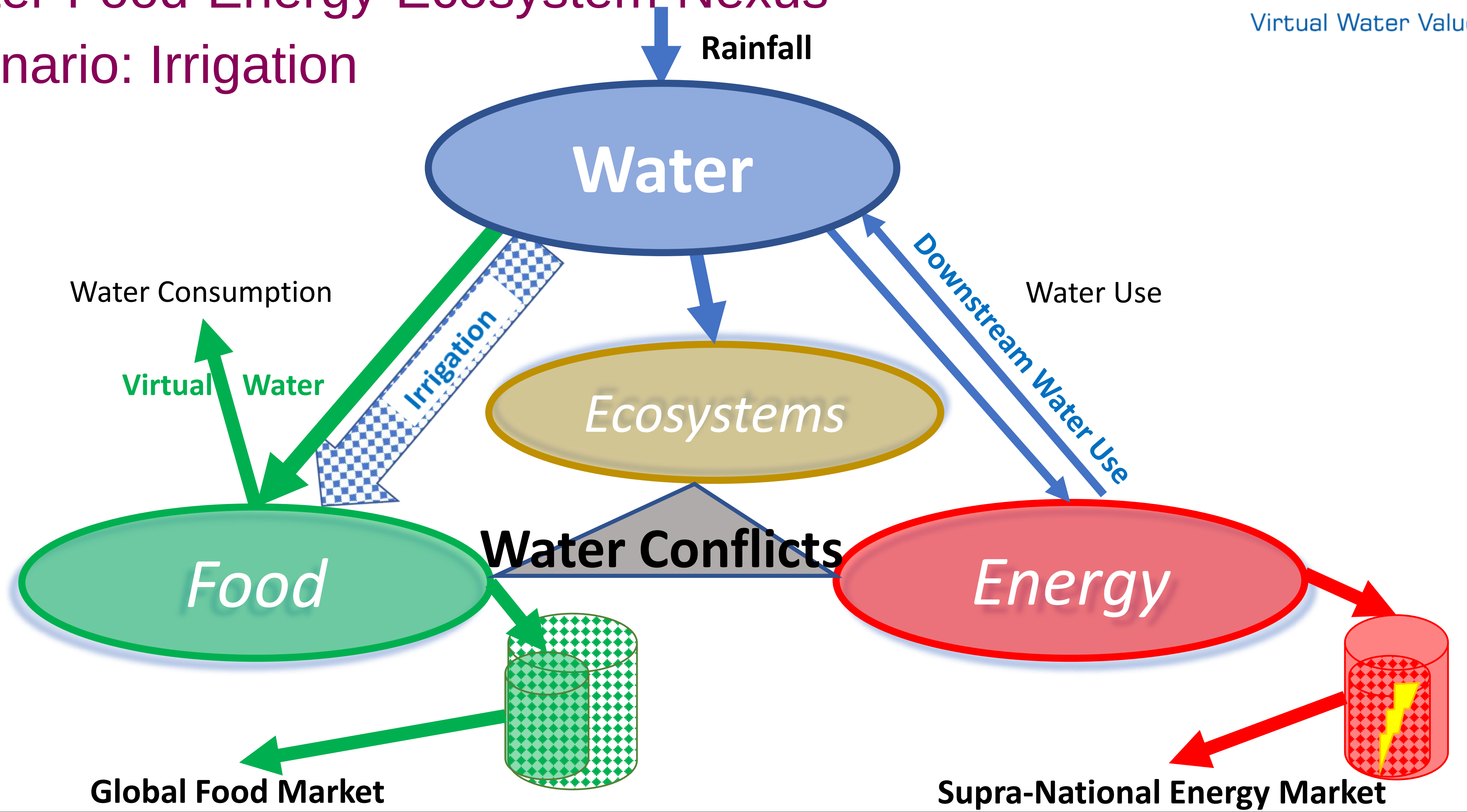


Water-Food-Energy-Ecosystem-Nexus
Regional Assessment



Water-Food-Energy-Ecosystem-Nexus

Scenario: Irrigation

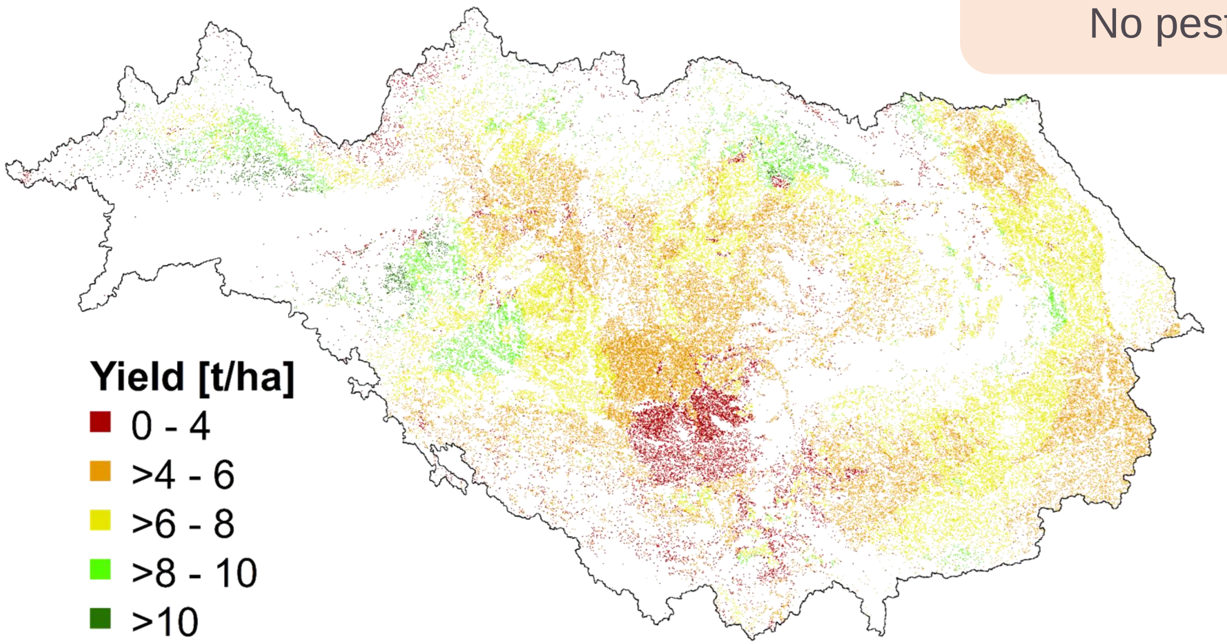


Taking maize as an example

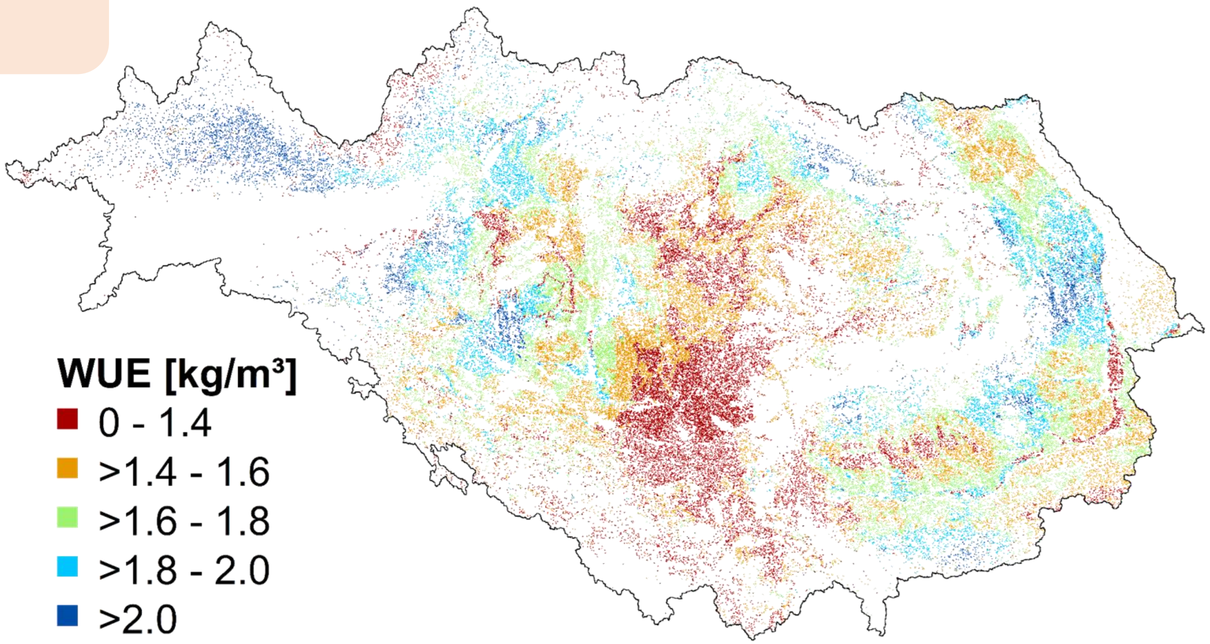
Virtual Water Values

Rainfed,
standard fertilization,
No pests

Mean actual yield (2017)



Mean actual WUE (2017)



Modelled maize yield: 5.9 t/ha

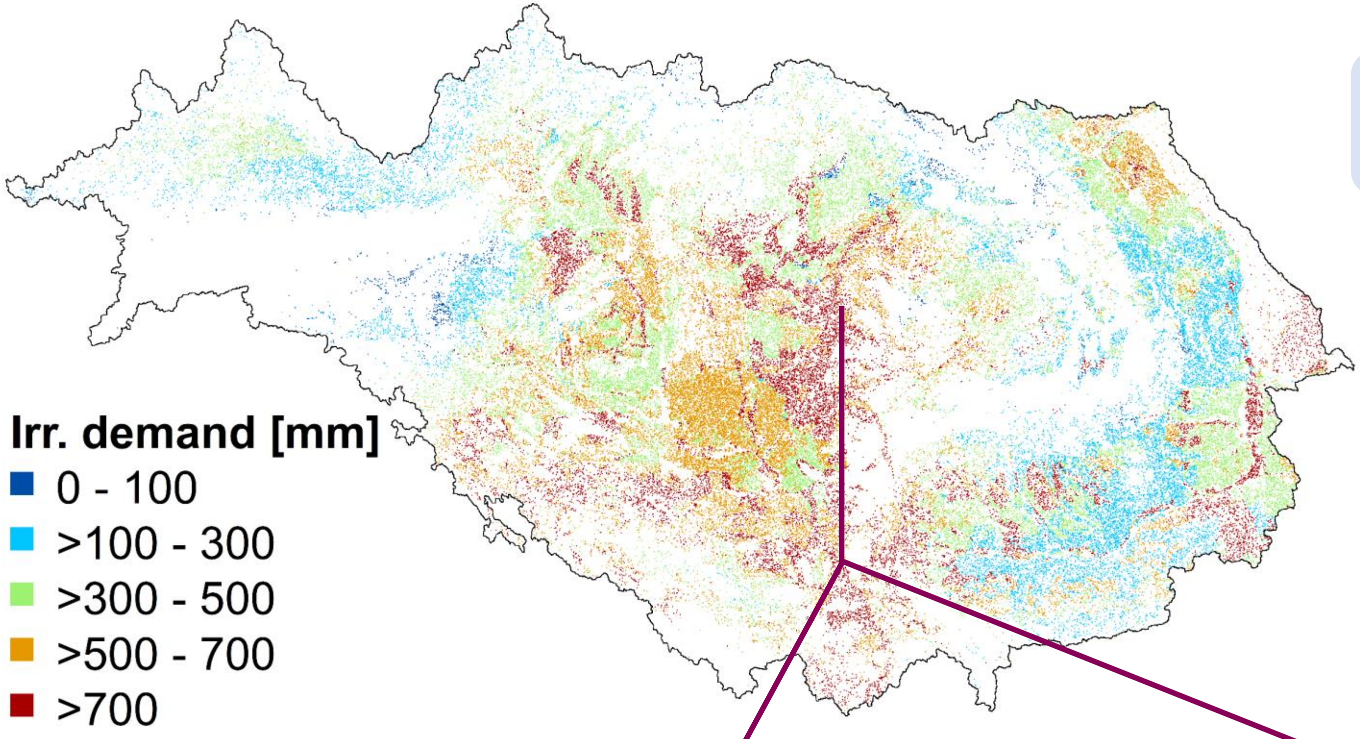
Total production: 34.4 Mio t

Modelled maize WUE: 1.7 kg/m³

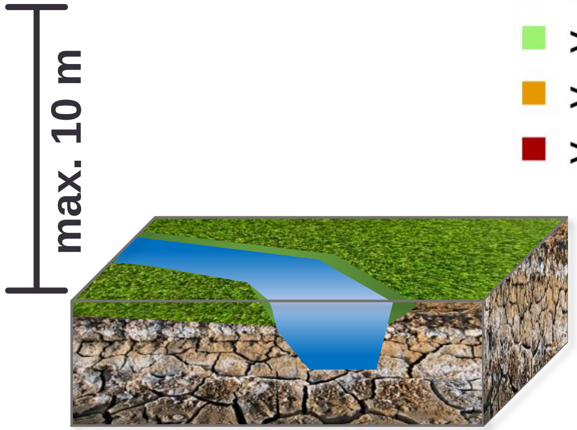
What happens, if large-scale irrigation is introduced?

ViWA
Virtual Water Values

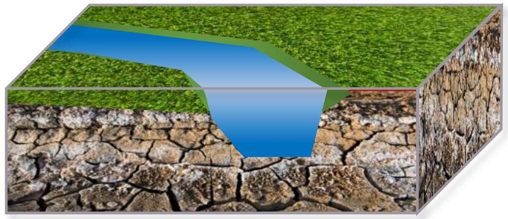
Mean irrigation demand per season (2017)



Mean irrigation demand:
512 mm/season



Surface water?
Extract irrigation water from closest extraction point in the river network



Groundwater?
Extract irrigation water from the groundwater underneath the pixel

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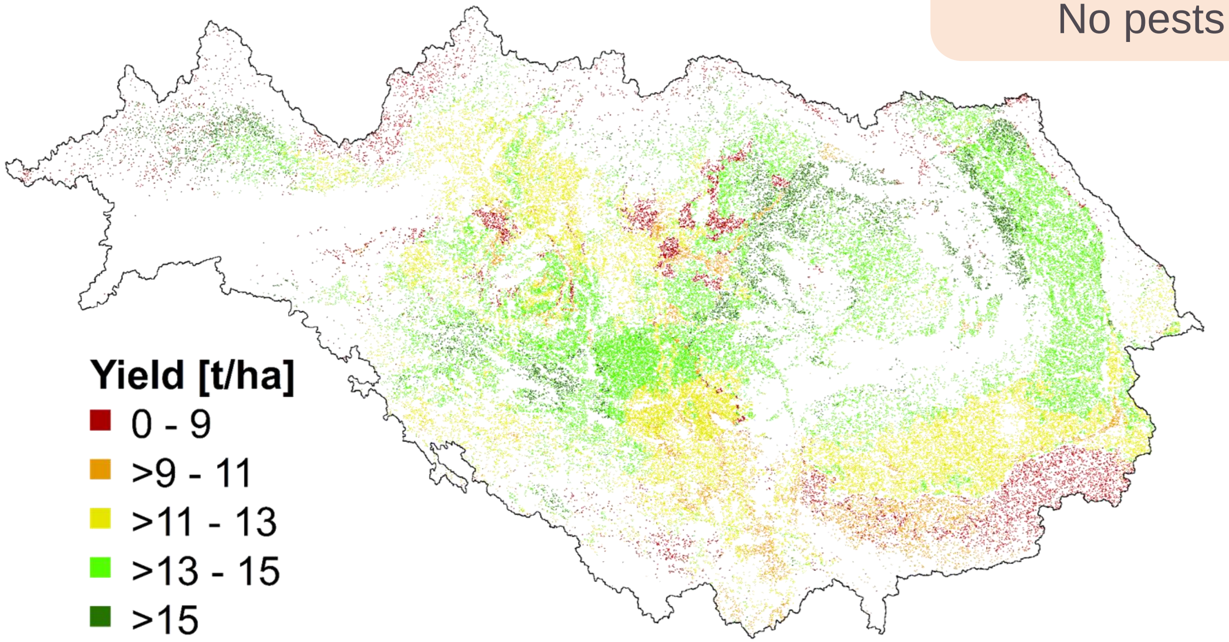
What happens, if large-scale irrigation is introduced?

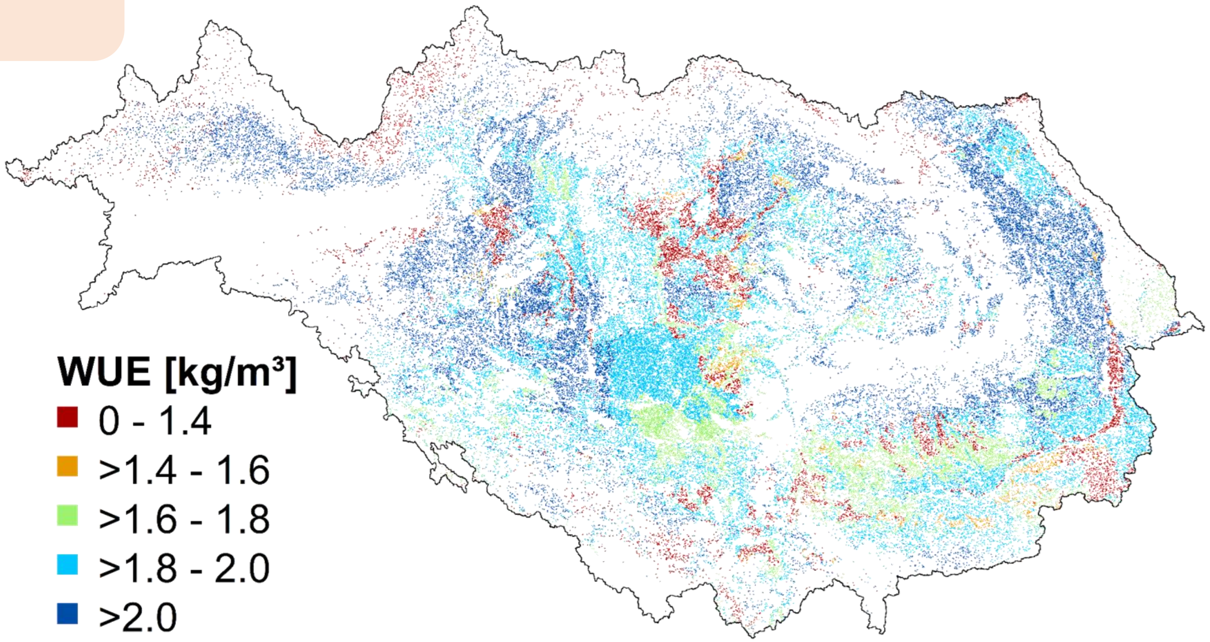
ViWA Virtual Water Values

Full irrigation,
Full fertilization,
No pests

Mean potential yield (2017)

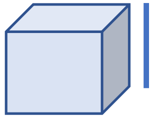


Mean potential WUE (2017)



Modelled maize yield: 12.5 t/ha
Total production: 72.9 Mio t

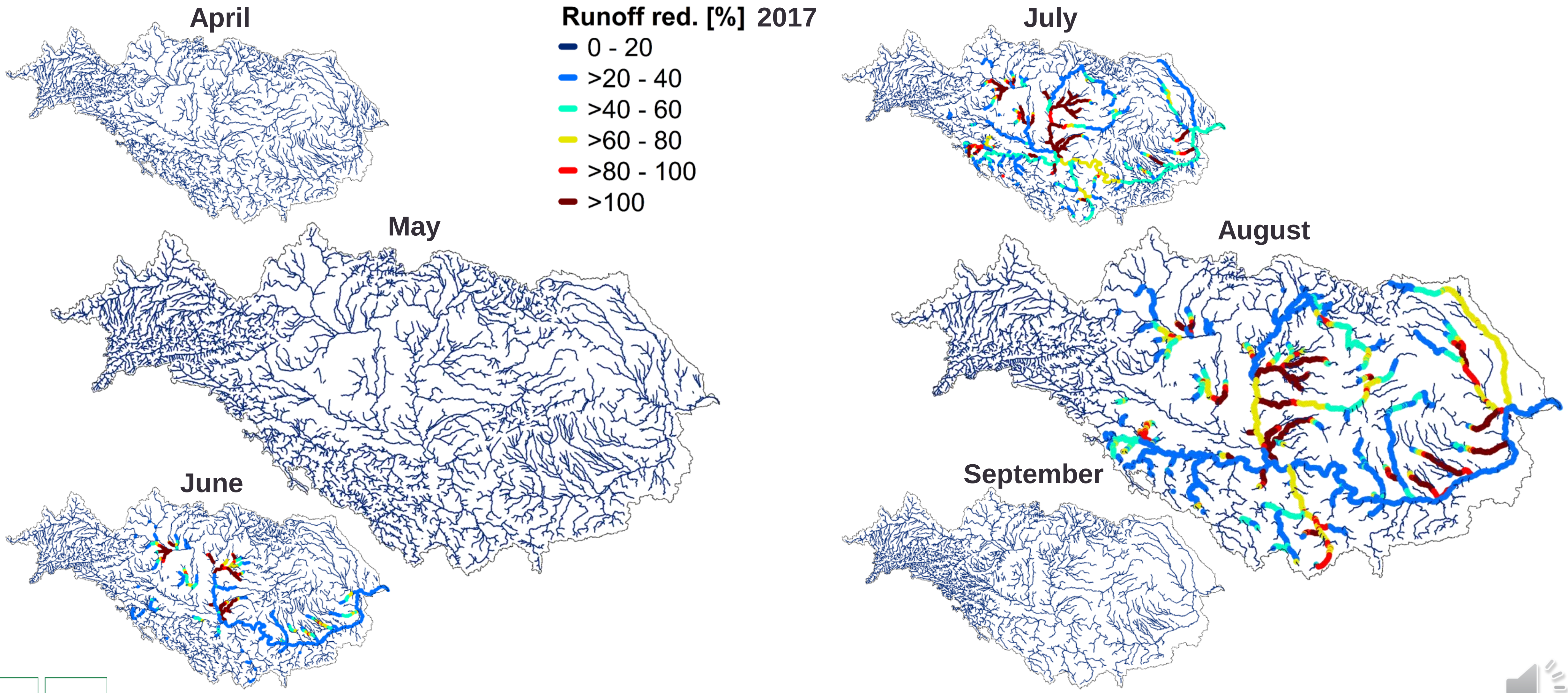
Total irrigation water: 5 Gm³

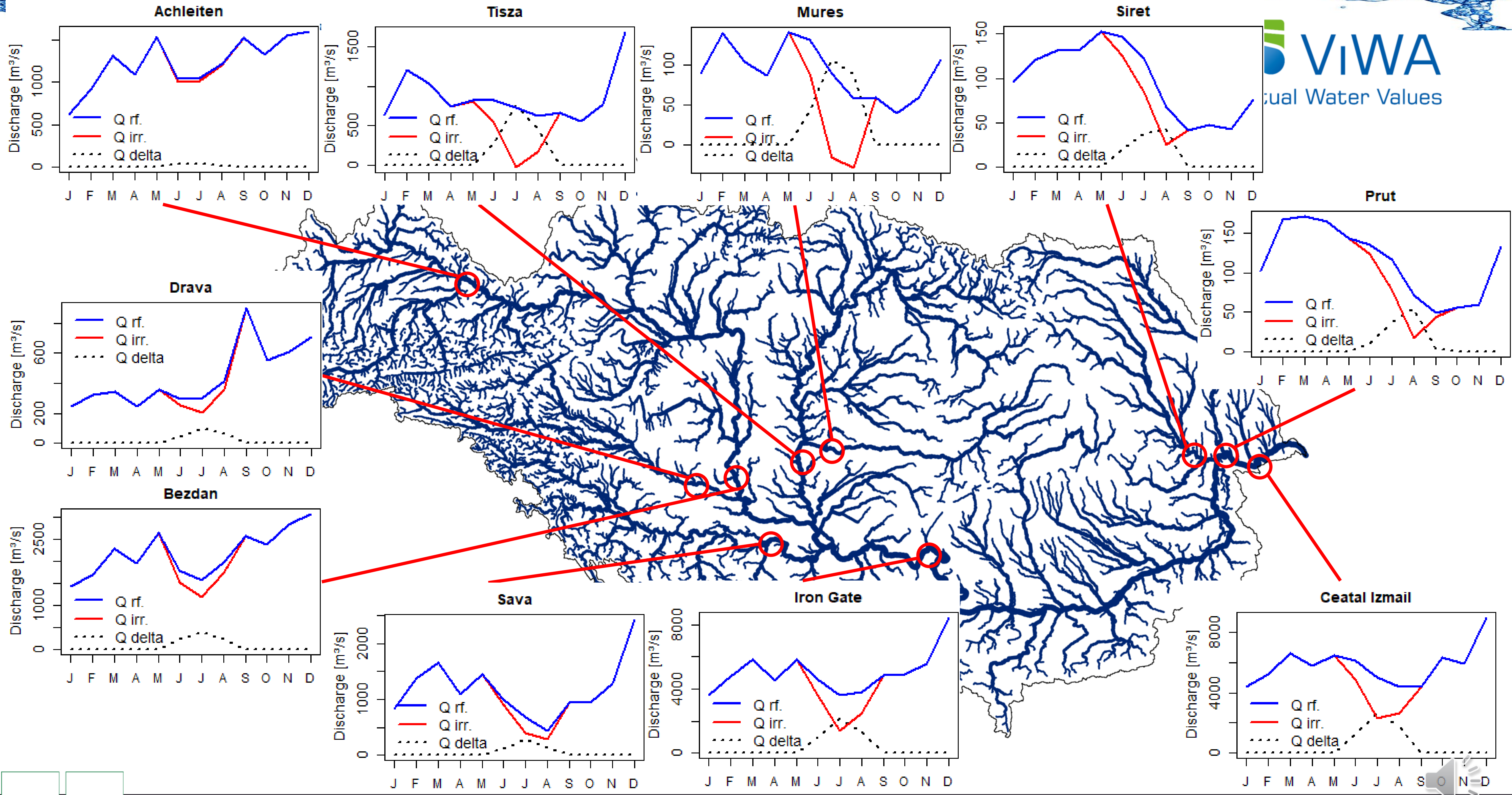


~1.71 km

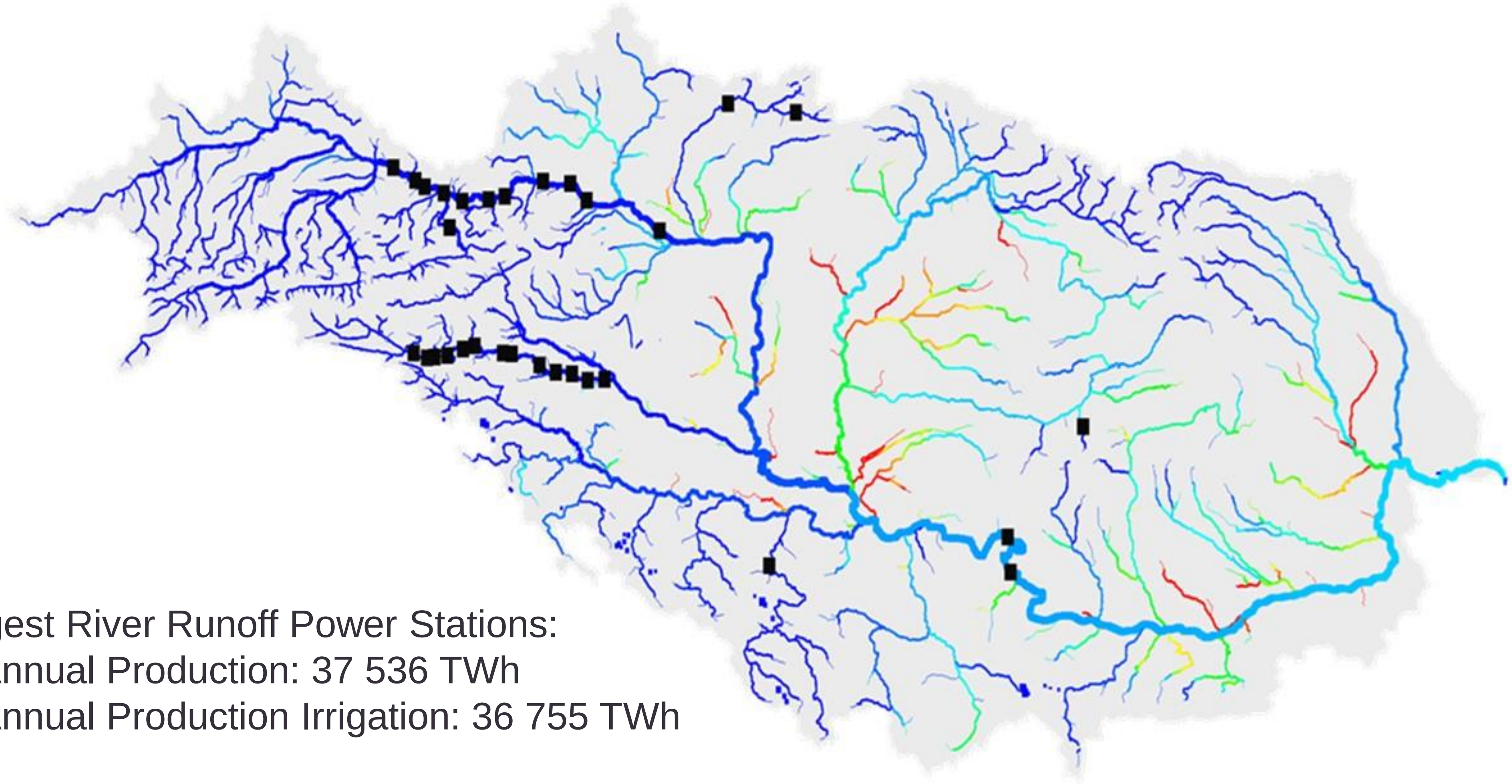
Modelled maize WUE: 1.9 kg/m³

Scenario: Impact of large-scale irrigation on runoff



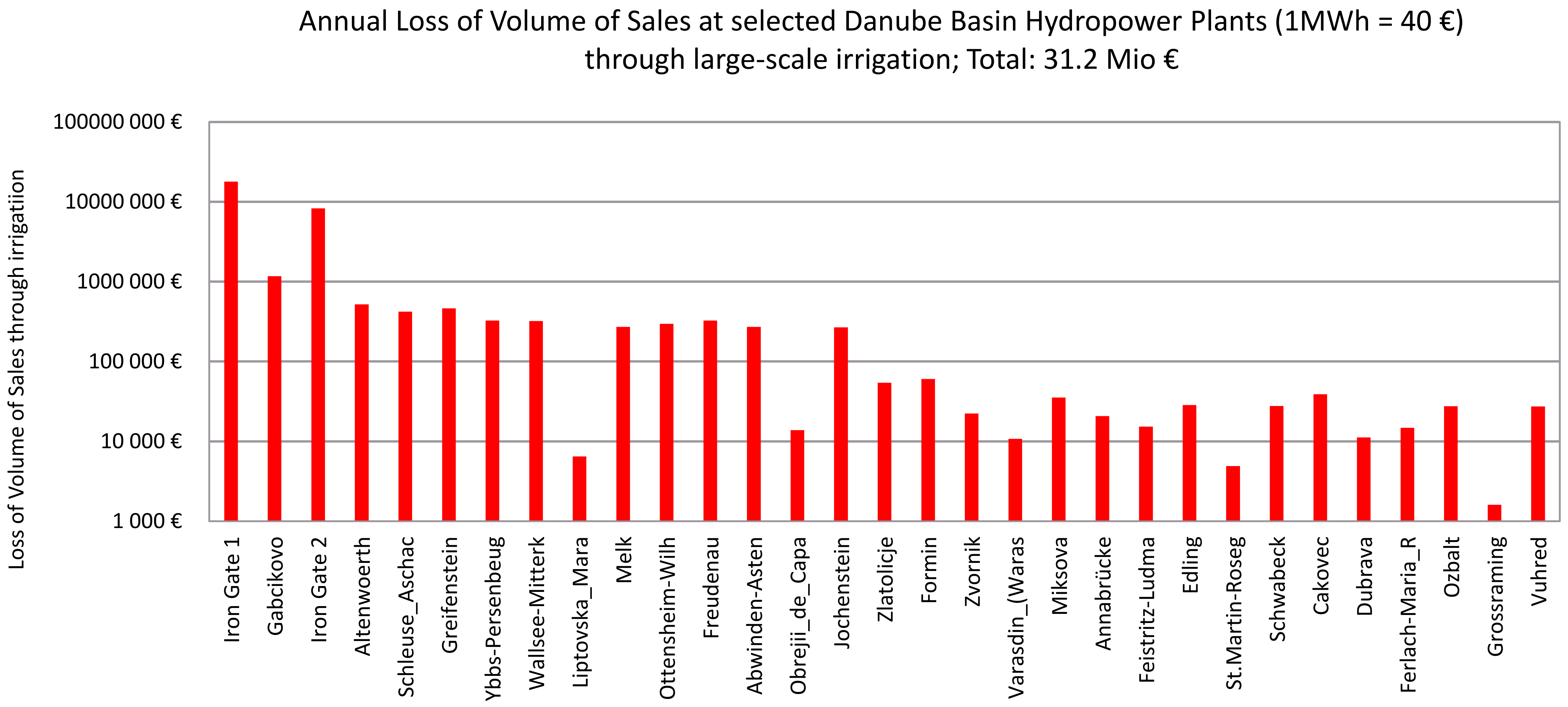

ViWA
Virtual Water Values
Achleiten
Tisza
Mures
Siret
Prut
Drava
Bezdan
Sava
Iron Gate
Ceatal Izmail
Discharge [m³/s]
Q rf.
Q irr.
Q delta
J F M A M J J A S O N D

Scenario: Impact of large-scale irrigation on hydropower



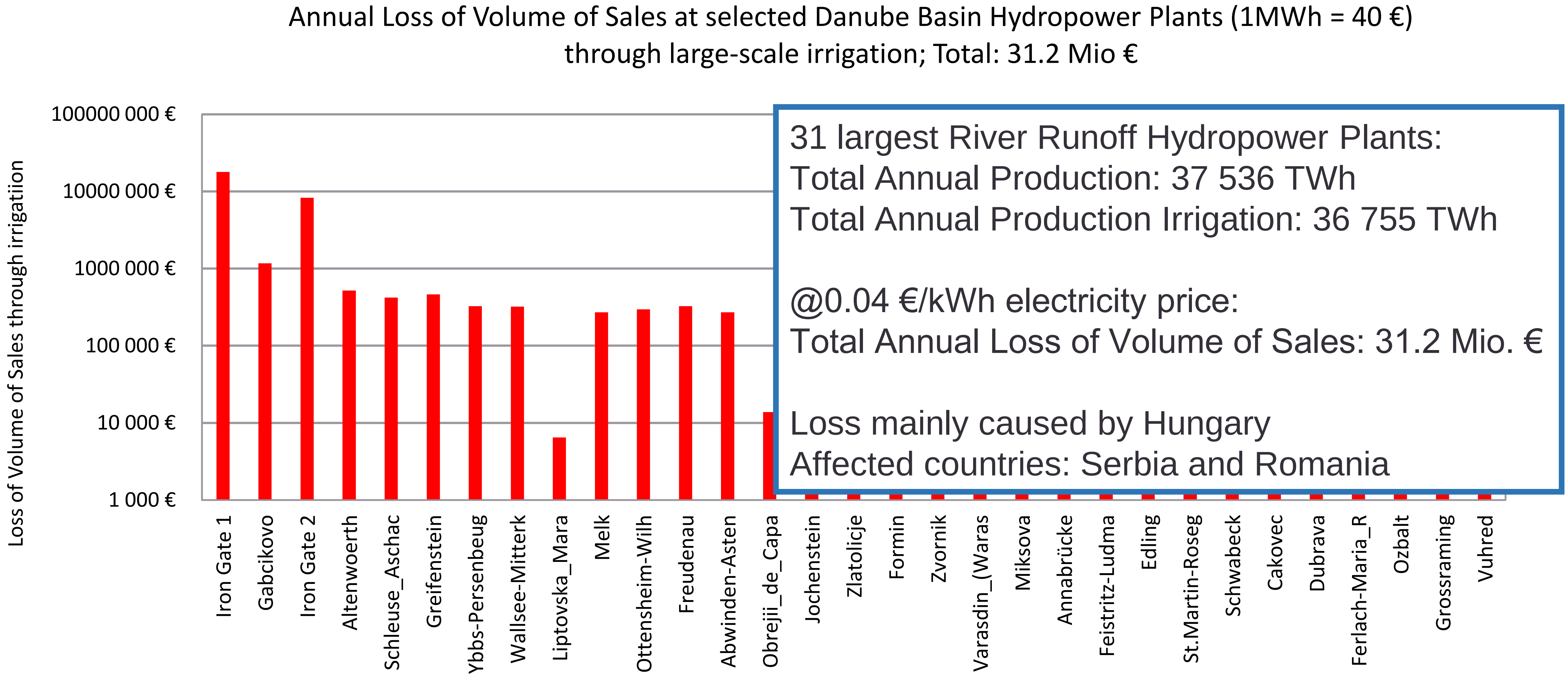
31 largest River Runoff Power Stations:
Total Annual Production: 37 536 TWh
Total Annual Production Irrigation: 36 755 TWh

Scenario: Impact of large-scale irrigation on hydropower



Scenario: Impact of large-scale irrigation on hydropower

ViWA Virtual Water Values



31 largest River Runoff Hydropower Plants:
Total Annual Production: 37 536 TWh
Total Annual Production Irrigation: 36 755 TWh

@0.04 €/kWh electricity price:
Total Annual Loss of Volume of Sales: 31.2 Mio. €

Loss mainly caused by Hungary
Affected countries: Serbia and Romania

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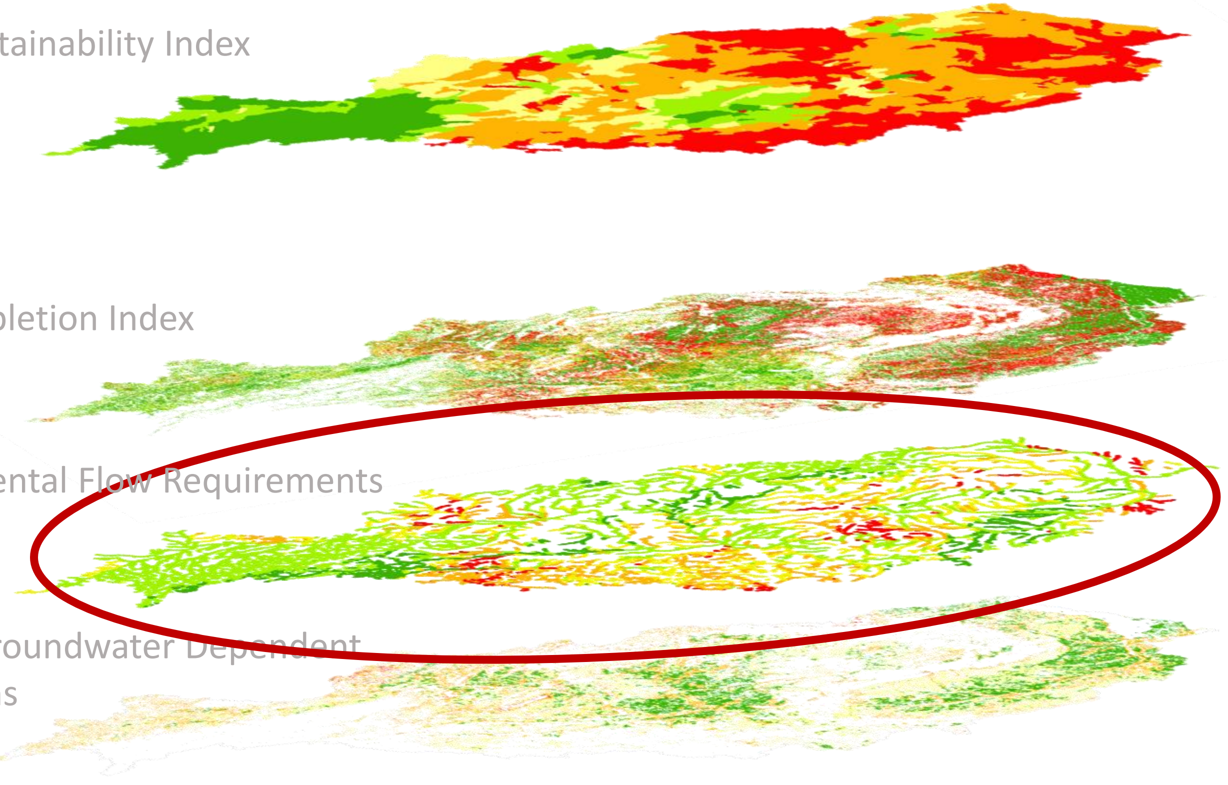
Ecological implications of maize irrigation - regionally and locally

Evaluation of sustainability of water use

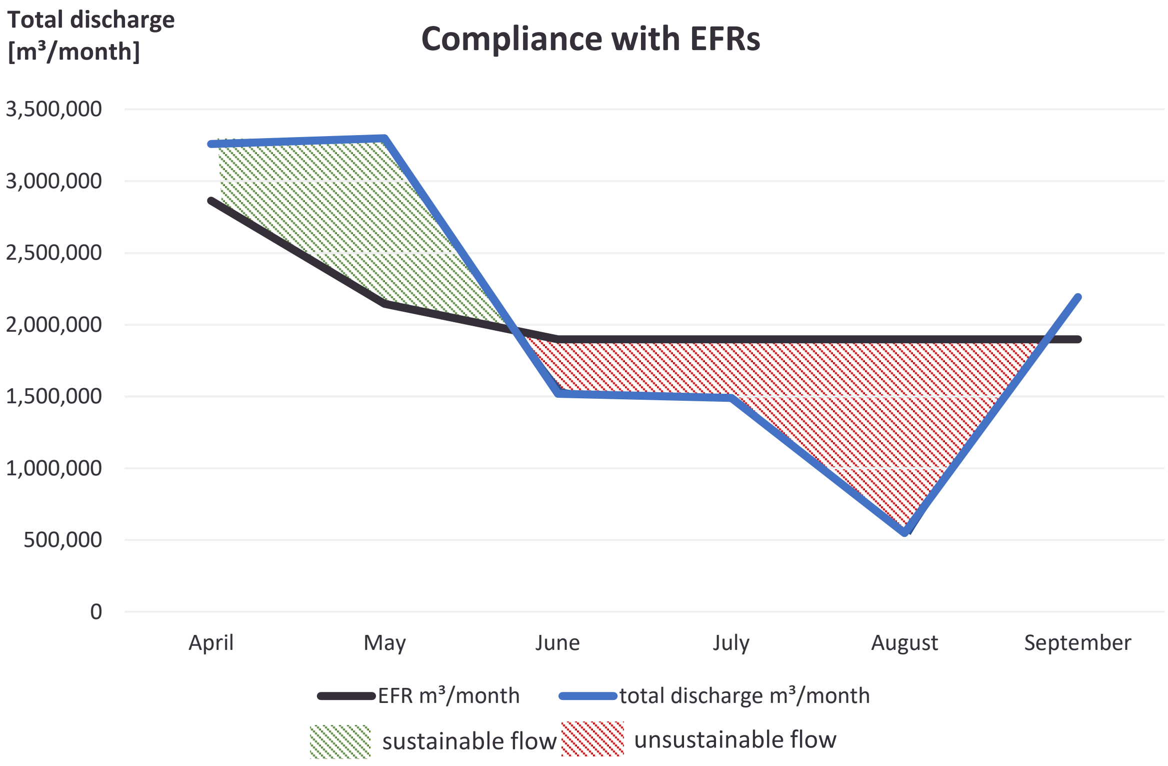
- **Ecological sustainability assessment**
  - Water Sustainability Index
- **Ecological risk assessment**
  - Water Depletion Index
  - Environmental Flow Requirements
  - Risk for Groundwater Dependent Ecosystems



Status quo assessment of ecological sustainability and ecological risk for August 2017

Criterion: Environmental Flow Requirements (EFRs)

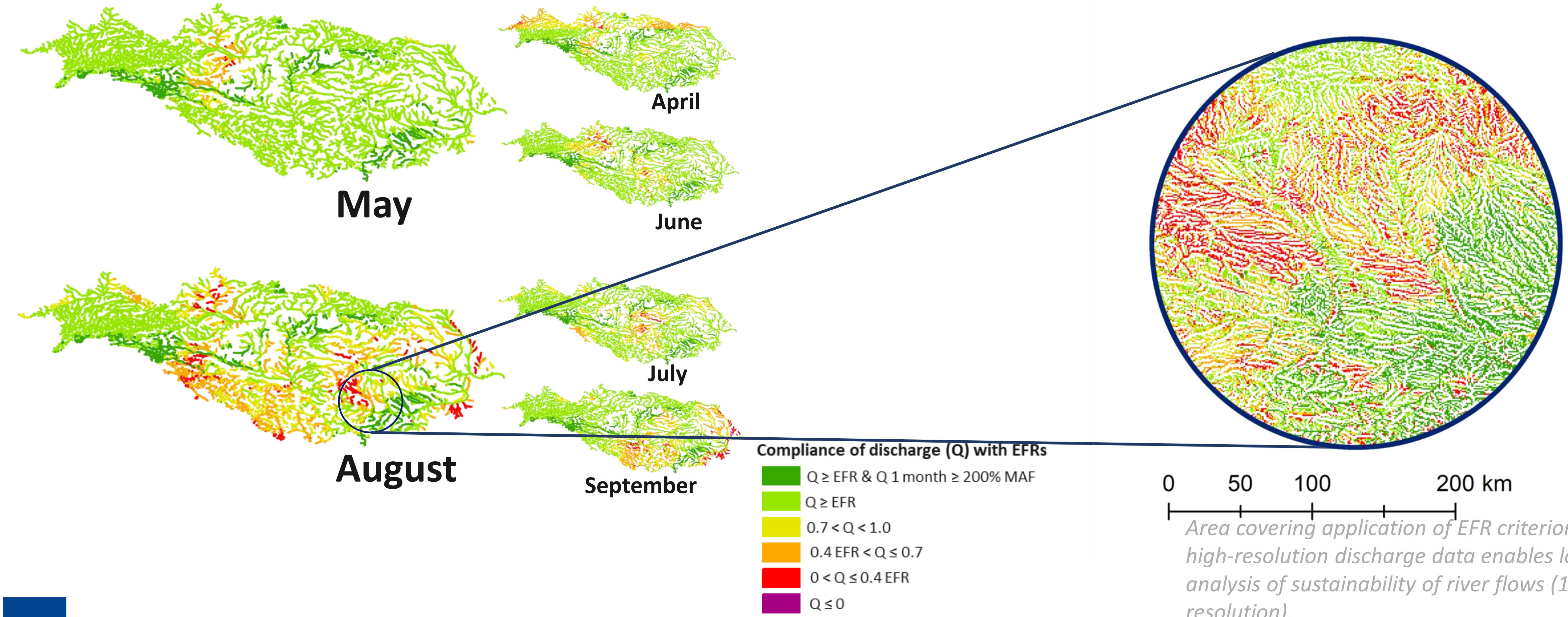
- Minimum flow to sustain aquatic and related ecosystems and their functions
- Quantitative flow requirements depend on river flow regime
- Maintaining min. flow is anchored in international and EU legislation



River flow is sustainable when the total discharge is higher than the minimum environmental flow (EFR). In the chart, the months June to August have unsustainable river flow.

Compliance with Environmental Flow Requirements (EFRs)

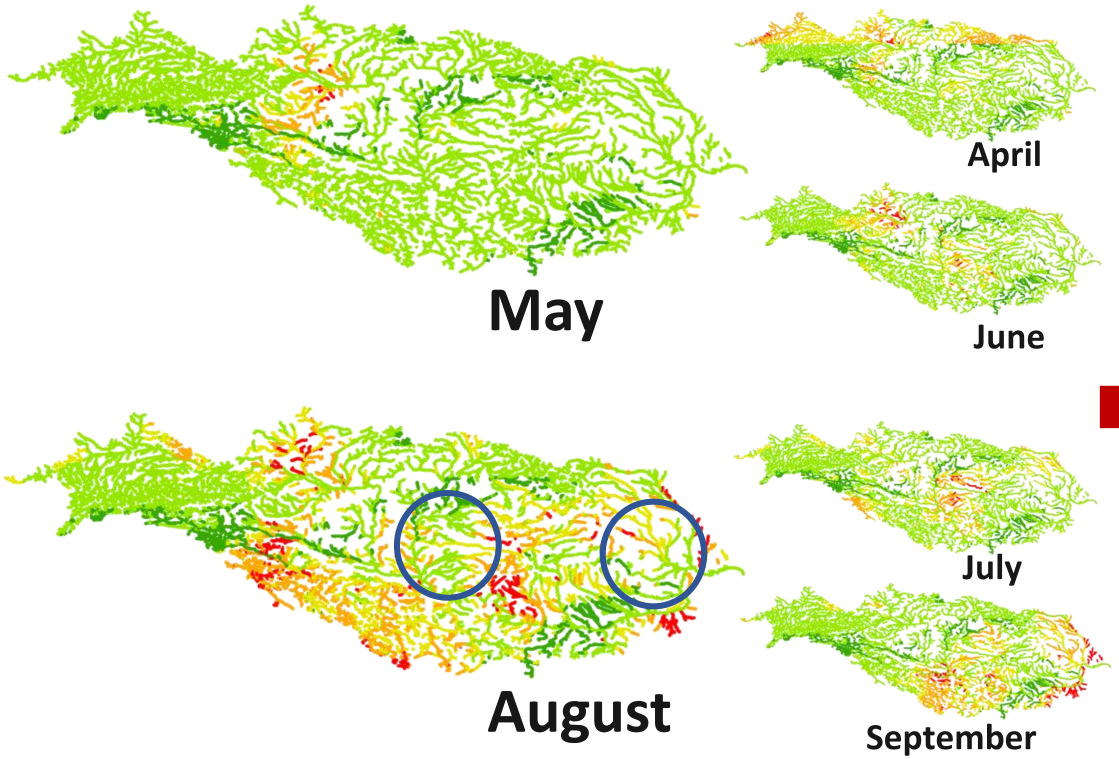
Status quo - 2017



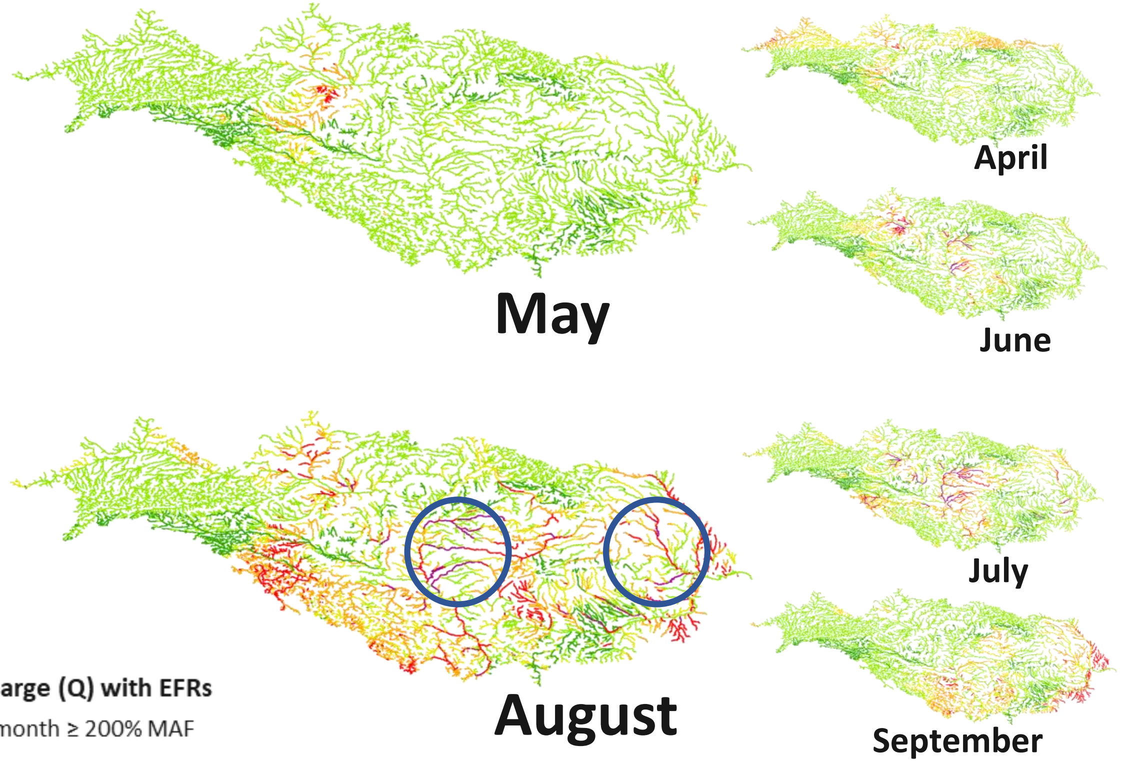
*Area covering application of EFR criterion with high-resolution discharge data enables local analysis of sustainability of river flows (1*1 km resolution).*

Compliance with Environmental Flow Requirements (EFRs)

Status quo - 2017



Maize irrigation - 2017



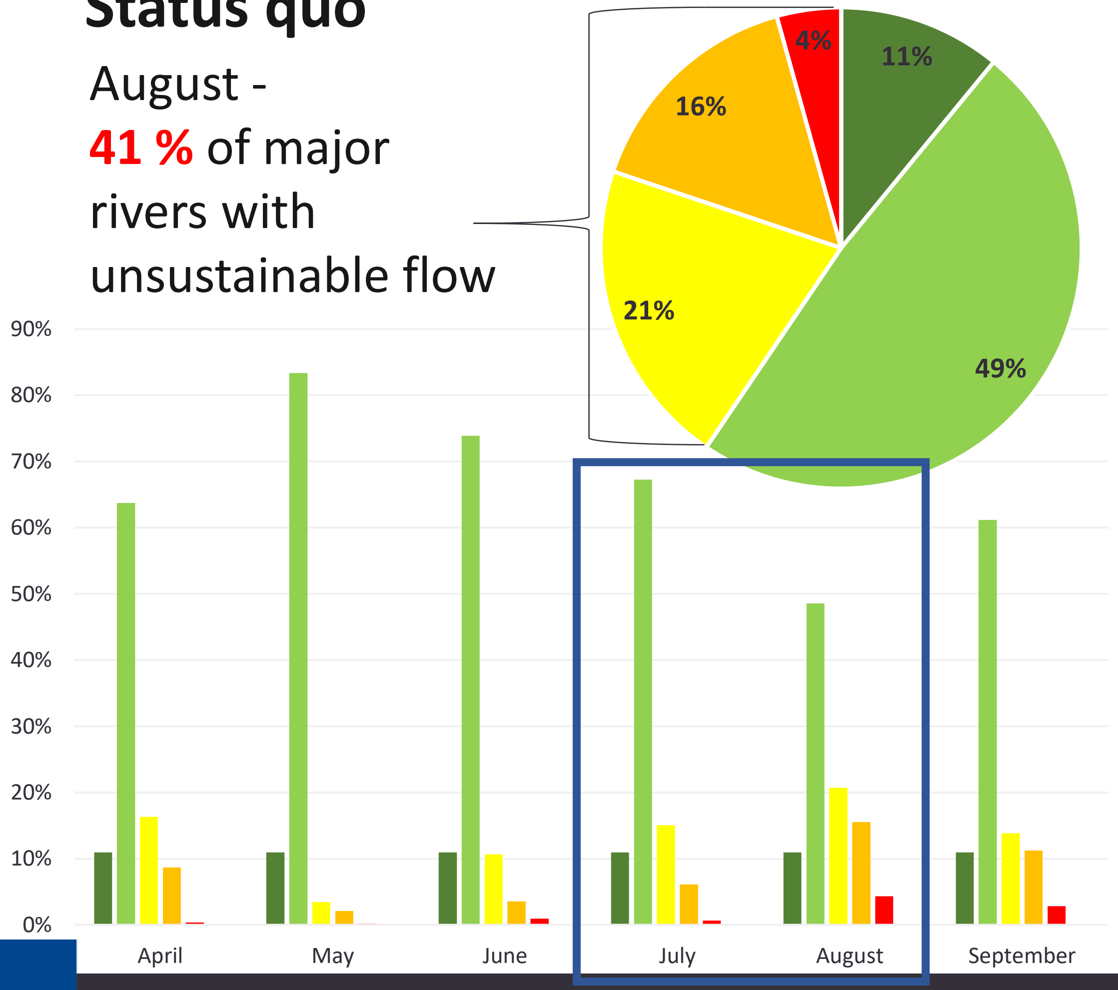
Compliance of discharge (Q) with EFRs

- Q ≥ EFR & Q 1 month ≥ 200% MAF
- Q ≥ EFR
- 0.7 < Q < 1.0
- 0.4 EFR < Q ≤ 0.7
- 0 < Q ≤ 0.4 EFR
- Q ≤ 0

Change of unsustainable river flow due to irrigation

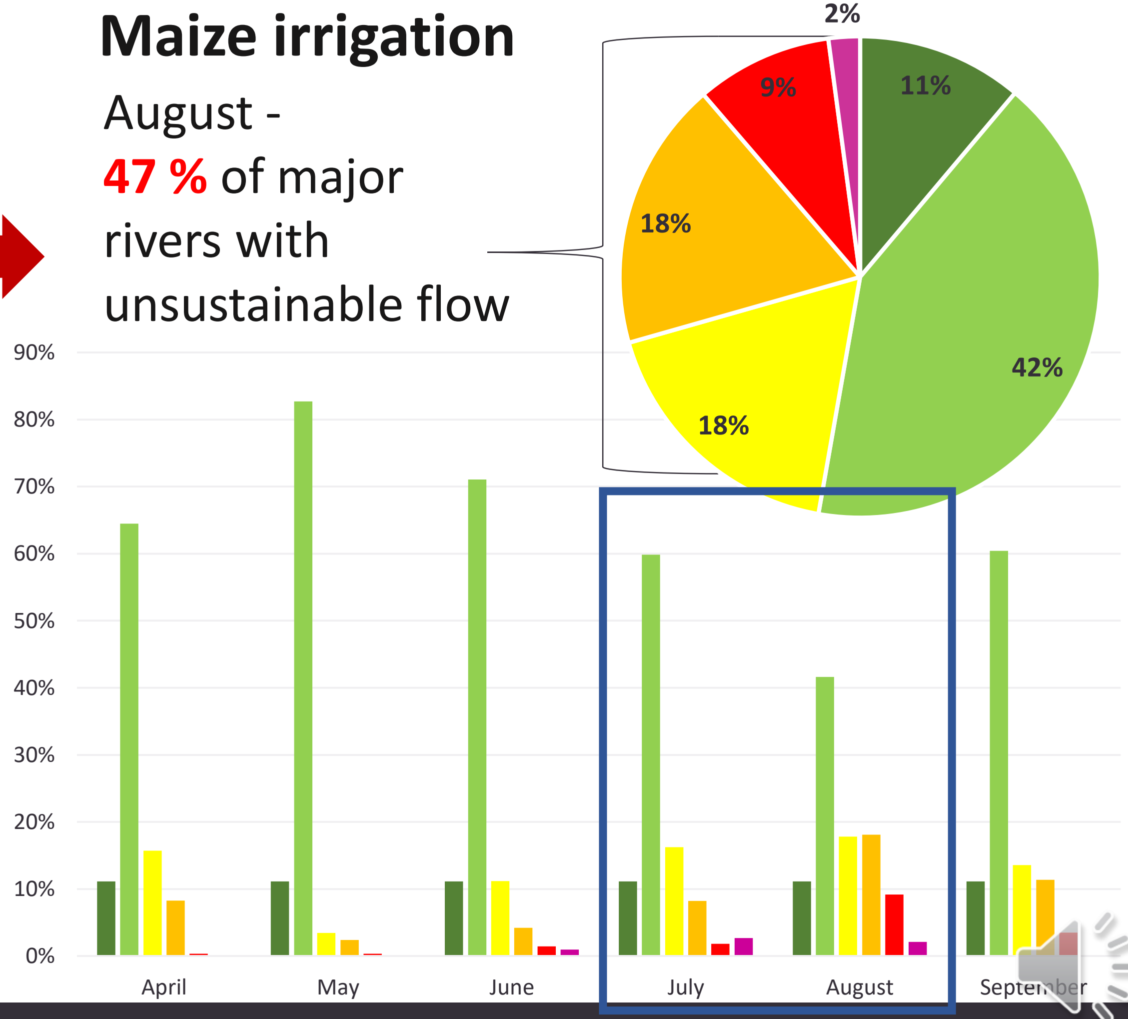
Status quo

August -
41 % of major rivers with unsustainable flow



Maize irrigation

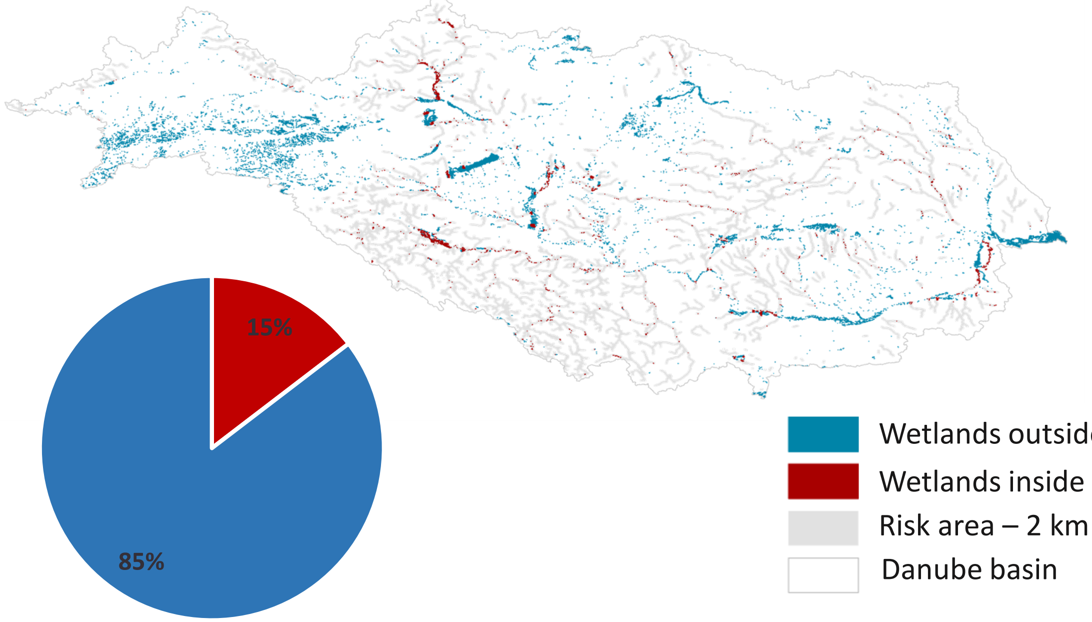
August -
47 % of major rivers with unsustainable flow



Potentially affected wetlands

- 2 % of the Danube basin is covered with water bodies or wetlands (our mapping)

Status quo - August 2017

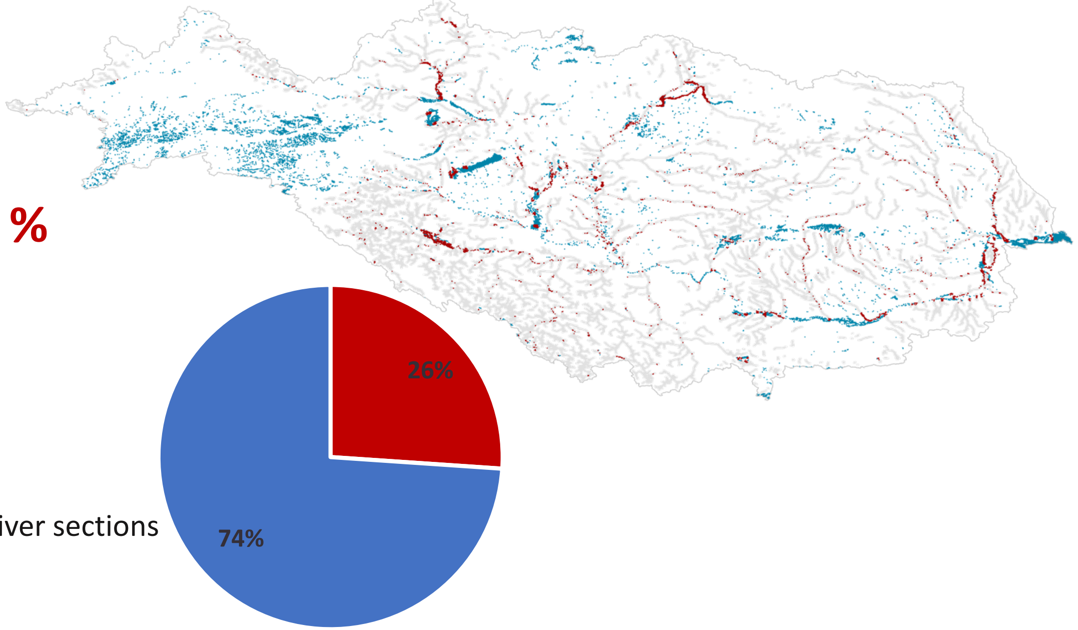


Share of wetlands inside risk areas around river sections with unsustainable flow in status quo.

Increase 11 %

Wetlands outside risk area
Wetlands inside risk area
Risk area – 2 km around unsustainable river sections
Danube basin

Maize irrigation - August 2017



Share of wetlands inside risk areas around river sections with unsustainable flow in the irrigation scenario.

Synthesis: Impact of large-scale irrigation on Danube

Integrated assessment for 2017:

1) **Water:**
   - Irrigation water withdrawal: ~5 billion m³, mostly in Hungary, Serbia and Romania
2) **Food:**
   - Maize production roughly doubled from ~34 to ~73 Mio. t

     → increase in volume of sales of ~6.2 Billion € (@ 160 €/t maize)
3) **Energy:**
   - Hydropower production is reduced from 37.5 to 36.7 PWh
   - → reduction in volume of sales of ~30 Mio €/a (@ 0.04€/kWh)
4) **Ecosystem:**
   - Aquatic ecosystems and their related functions get lost (i.e. habitat and biodiversity, climatic regulation, water provision for domestic supply)
   - → Decrease of sustainable river sections from June to August (3 % - 7 %)
   - → 11 % increase of threatened wetlands

Conclusions

ViWA
Virtual Water Values

- A new tool has been developed and applied to real world water conflicts in the large, diverse river basin of the Danube based on coupled water-food-energy-ecosystem simulations.
- The tool allows to analyse in detail the conflicts and ecological impacts that different water-use-scenarios create between the power and food sector.
- Sustainability of water use can be assessed from sub-basin to local scale based on legitimized criteria with particular consideration of biodiversity

Further Research Questions

- How to use scenario analysis to identify the point of least trade offs between boosting agricultural production through irrigation and minimizing its ecological and sectoral impacts?
- How can ecological impacts of irrigation be minimized through alternatives of inter-seasonal storage of irrigation water (e.g. reservoirs, ground water, snow)?
- What are the different impacts of surface water pumping and groundwater pumping on ecosystems well-being?

Get more information on the ViWA Webinar:
Friday 23rd 10:00 – 12:00am
GRoW Final Conference - Auditorium II

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Ecological Assessment:
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