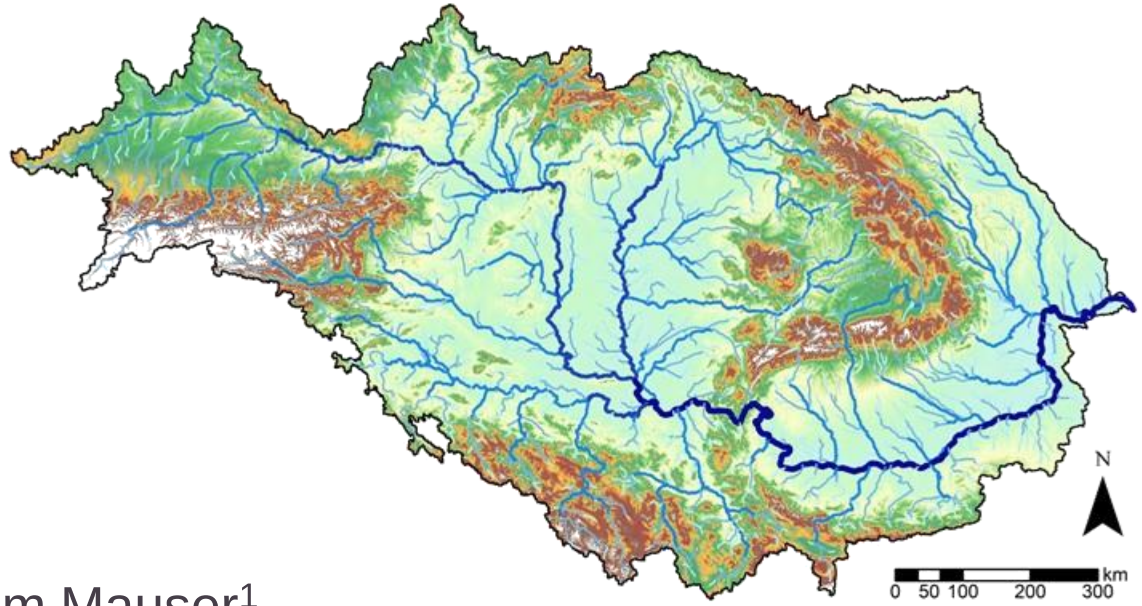
Virtual Water Values (ViWA)

ViWA

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

The Danube River Basin – Food-Water-Energy Assessment



Elisabeth Probst[1], Wolfram Mauser[1]

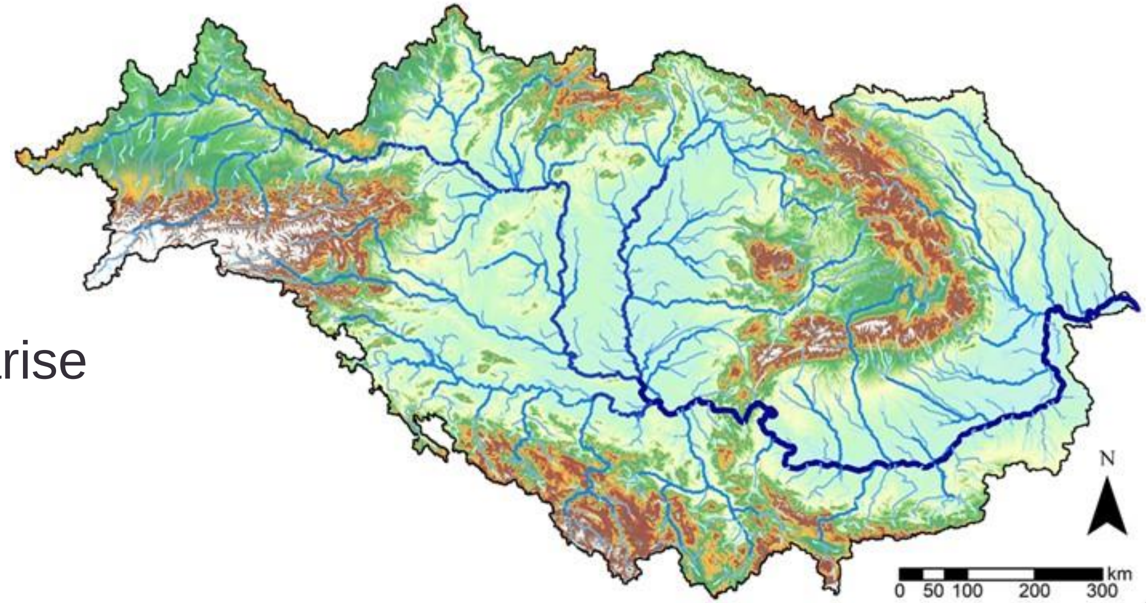
[1]Department for Geography, Ludwig-Maximilians-Universität (LMU), Munich, Germany

Danube: Characterization & Research Questions

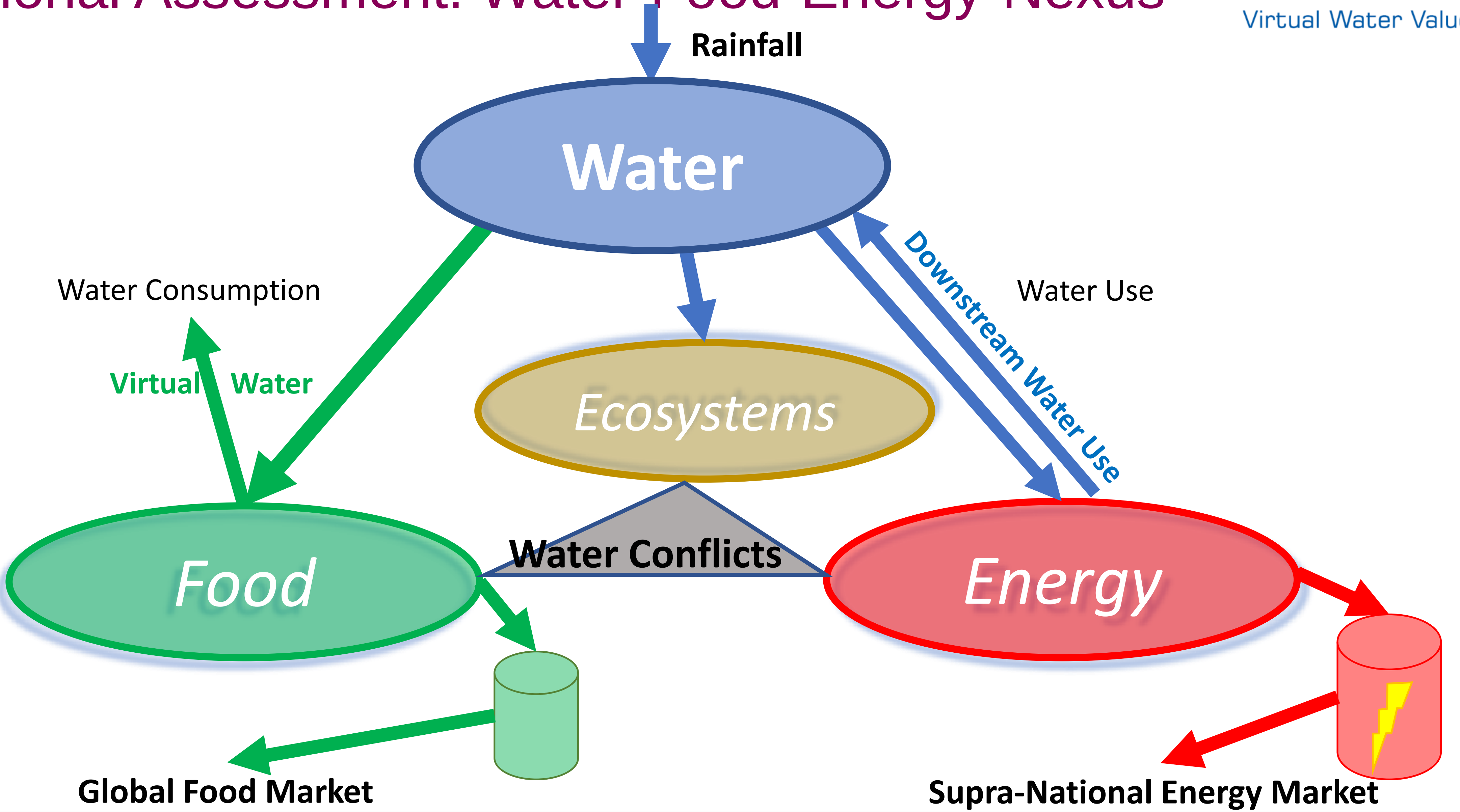
- Regionally uneven rainfall distribution: “water tower” Alps & Dinarids vs. dry regions in the Pannonian Basin & Romanian Plain (long-term annual precipitation: **~800 mm** on average**)**
- Extensive but low-intensity agricultural use in downstream regions (esp. Pannonian Basin, Romanian & Moldavian Plain)
- Presently ~1.5% of cropland is irrigated, large yield increases can be expected through irrigation in the Lower Danube (Hungary, Serbia, Romania). Rapid increase of irrigated agriculture planned by e.g. Hungary and Romania
- Water heavily used for industry, energy production, transport and households

Major Question:

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

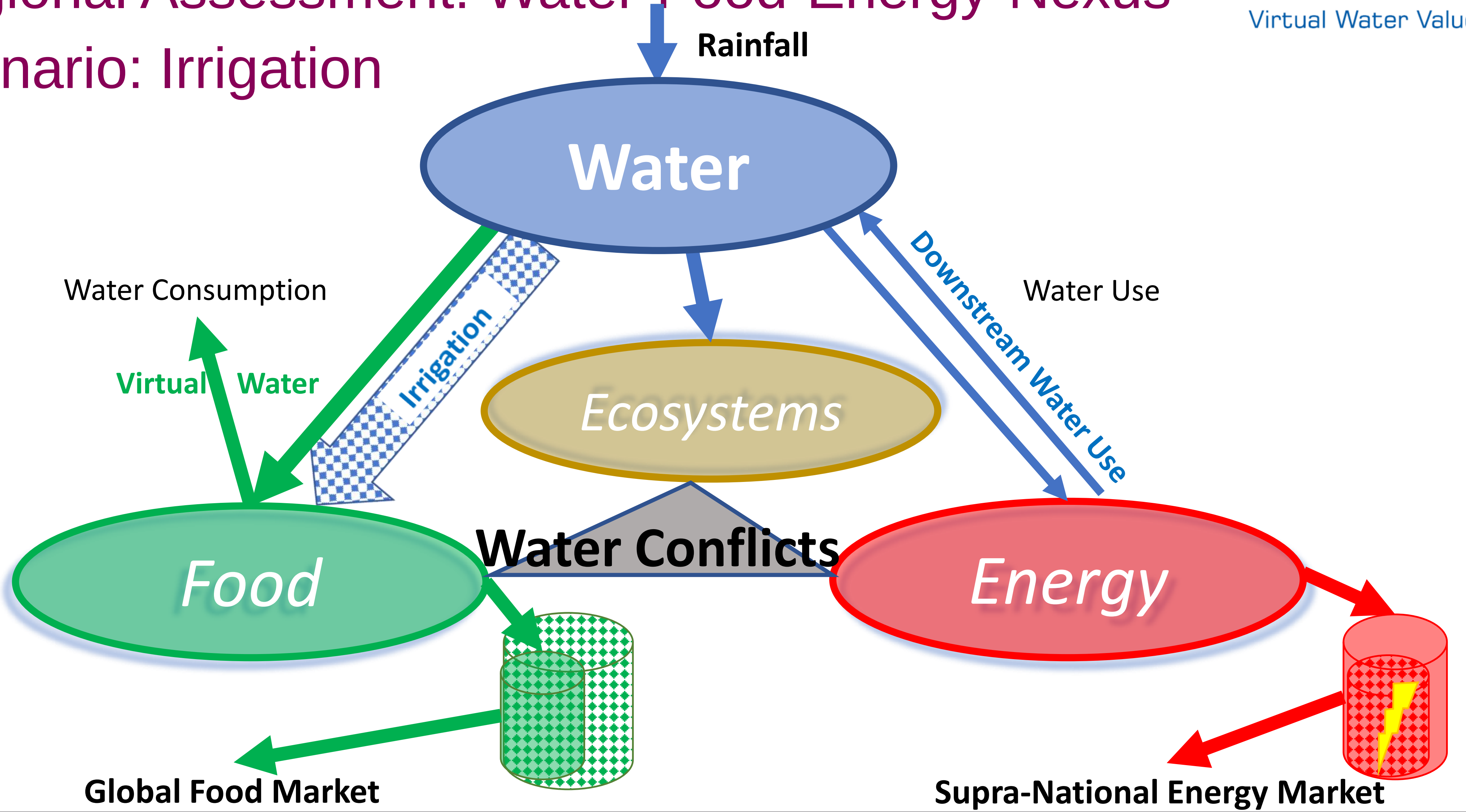


Regional Assessment: Water-Food-Energy-Nexus



Regional Assessment: Water-Food-Energy-Nexus

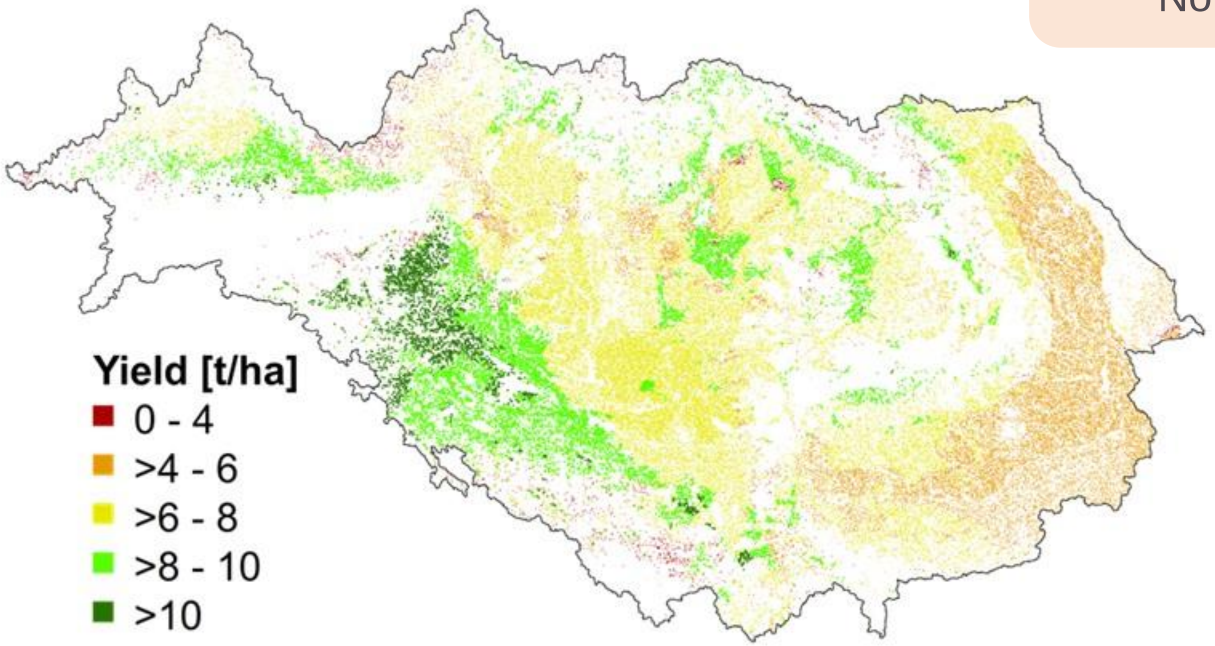
Scenario: Irrigation



Taking maize as an example: actual yield

Rainfed,
standard fertilization,
No pests

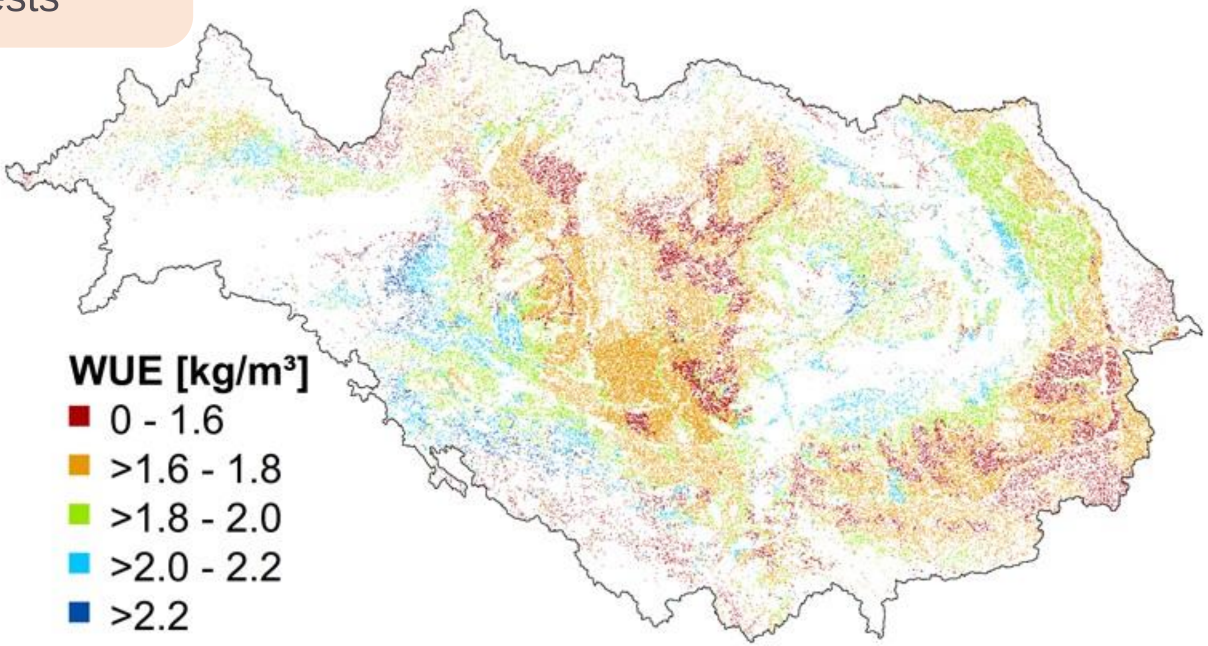
Mean actual yield (2015-2018)



Modelled maize yield: 6.9 t/ha
EUROSTAT (Danube countries): 6.8 t/ha

Total production: 40.2 Mio t

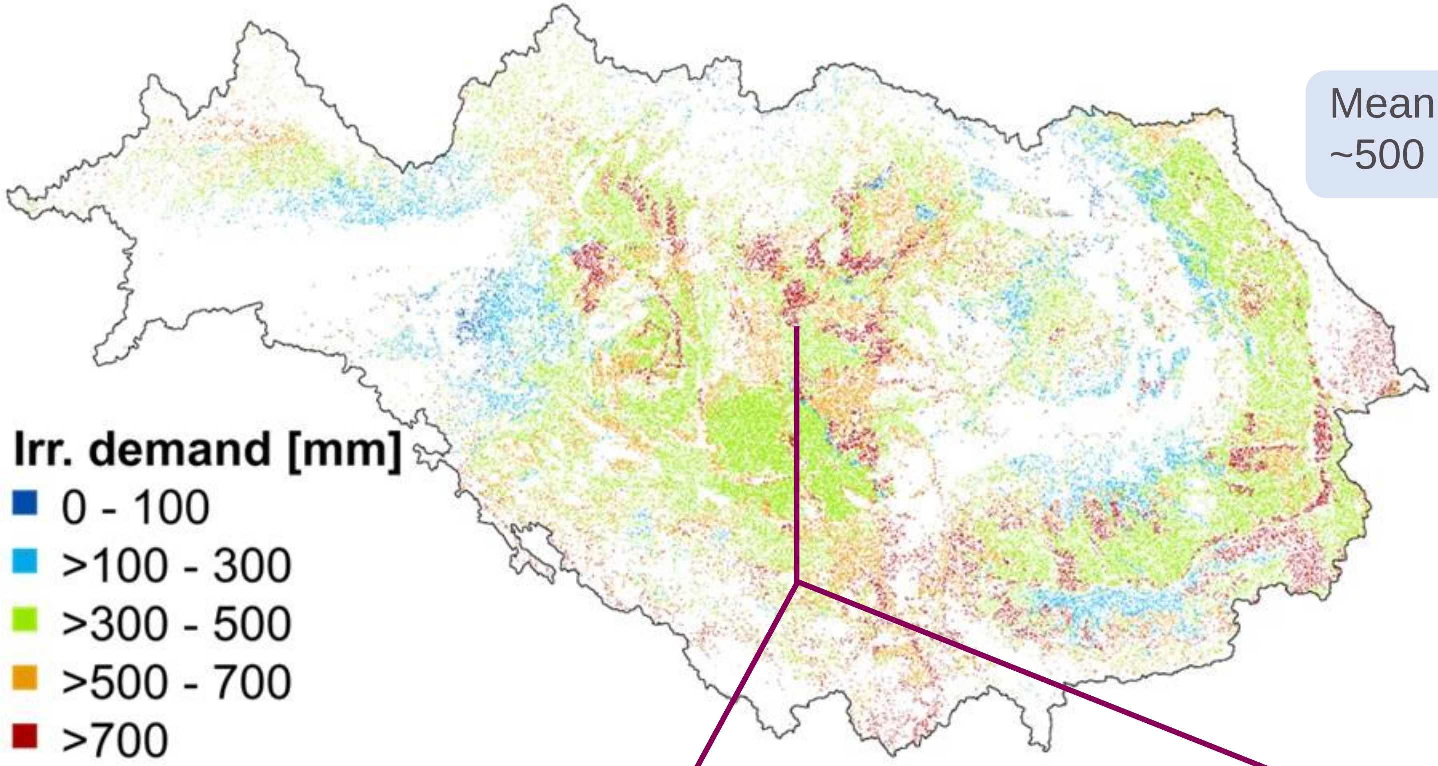
Mean actual WUE (2015-2018)



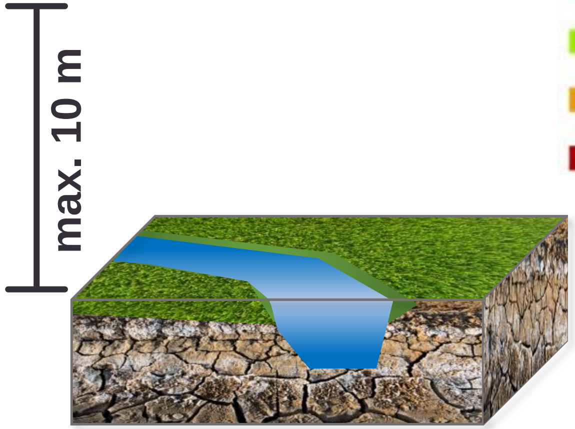
Modelled maize WUE: 1.8 kg/m³

What happens, if large-scale irrigation is introduced?

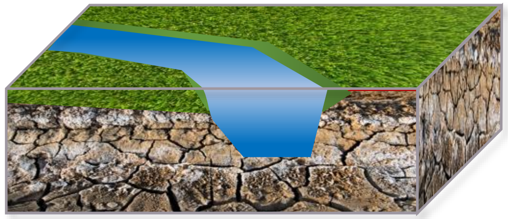
Mean irrigation demand per season (2015-2018)



Mean irrigation demand:
~500 mm/season



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



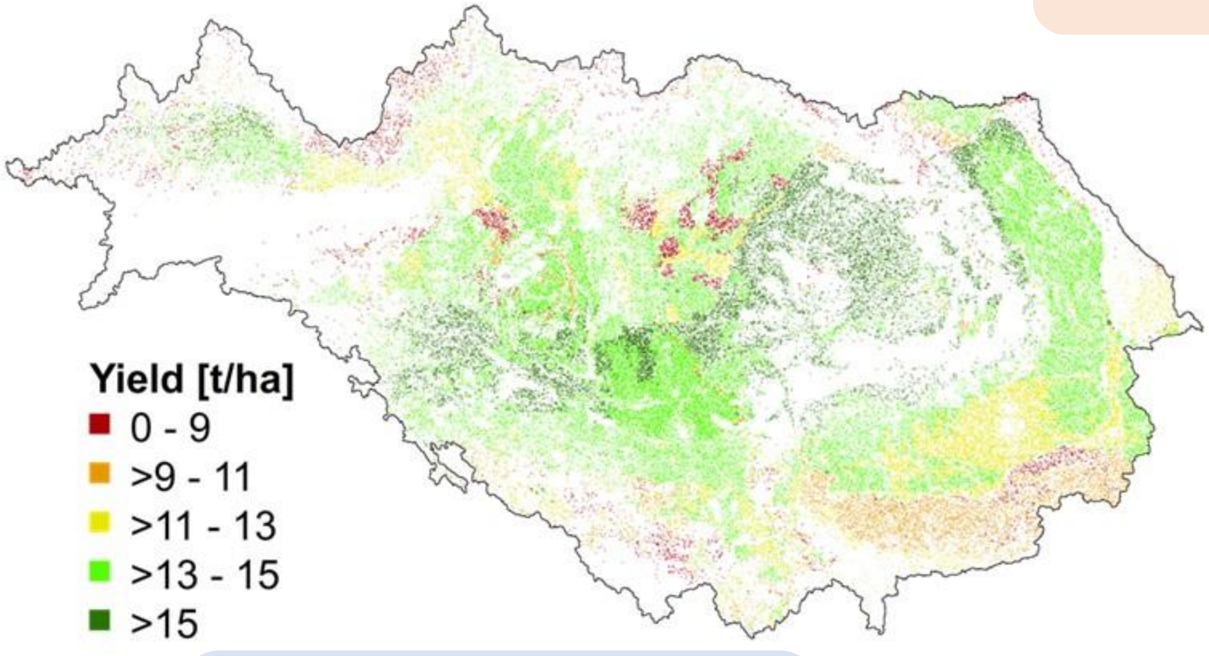
Groundwater?
Extract irrigation water from the groundwater underneath the pixel

What happens, if large-scale irrigation is introduced?

Virtual Water Values

Full irrigation,
Full fertilization,
No pests

Mean potential yield (2015-2018)

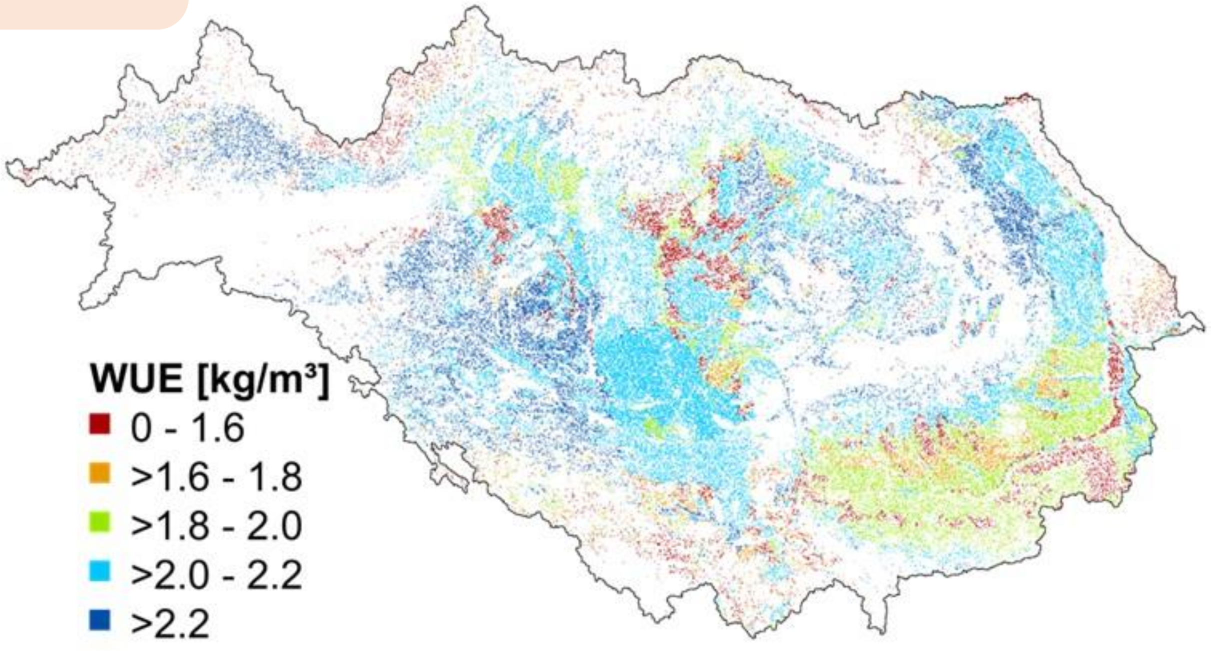


Modelled maize yield: 13.4 t/ha
Total production: 77.8 Mio t

Total irrigation water: 29 Gm³

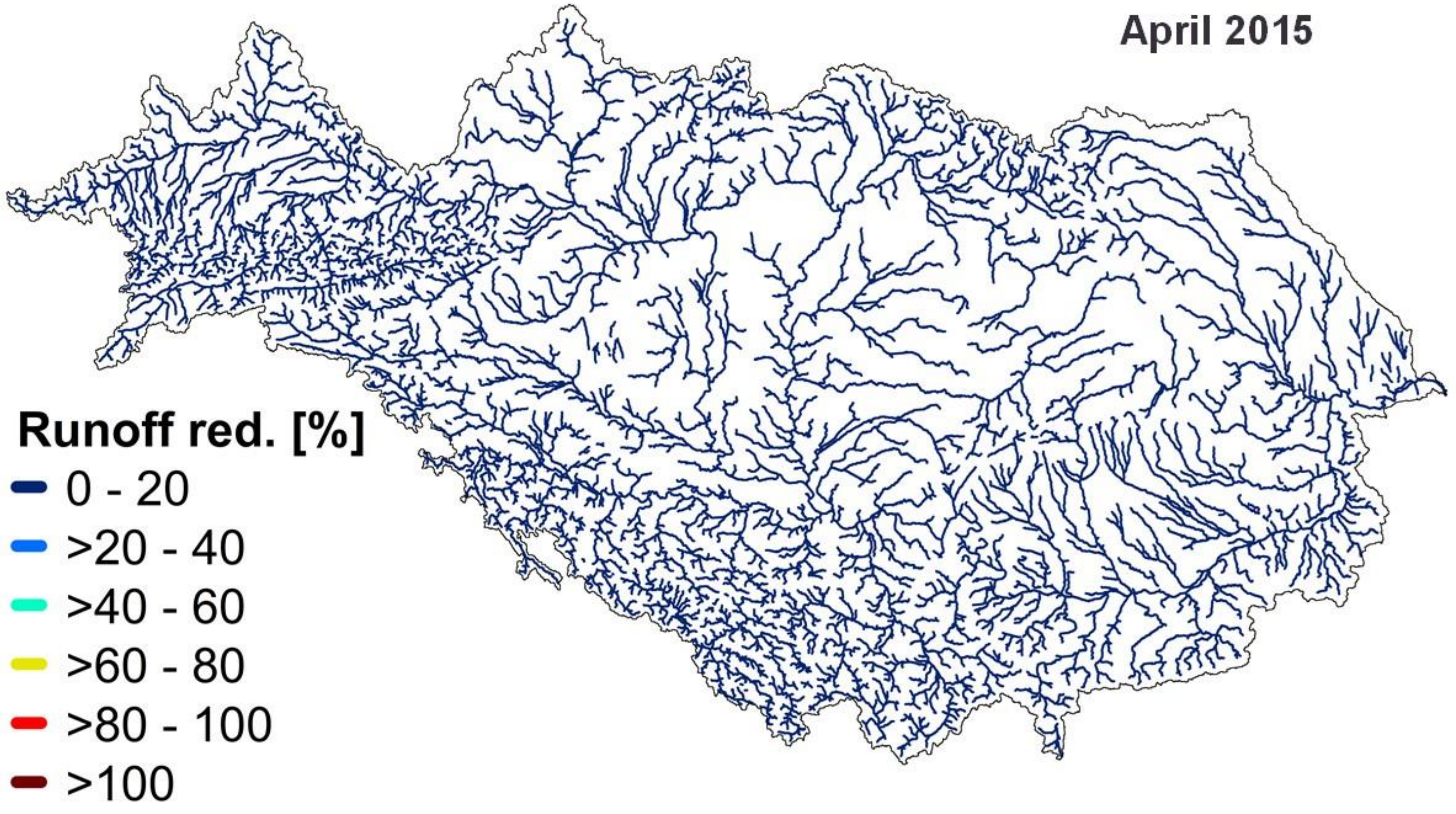
~3 km

Mean potential WUE (2015-2018)

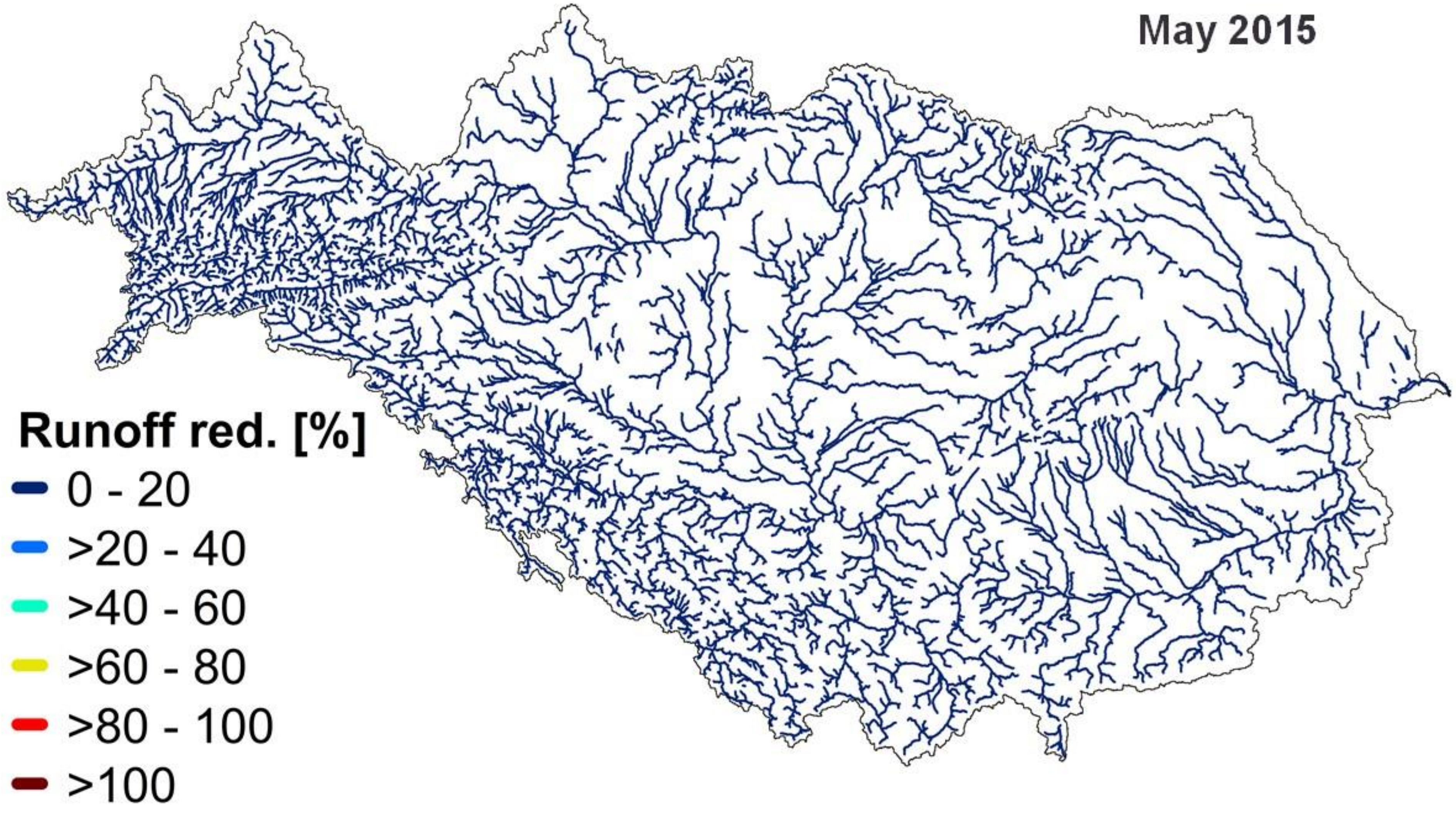


Modelled maize WUE: 2.1 kg/m³

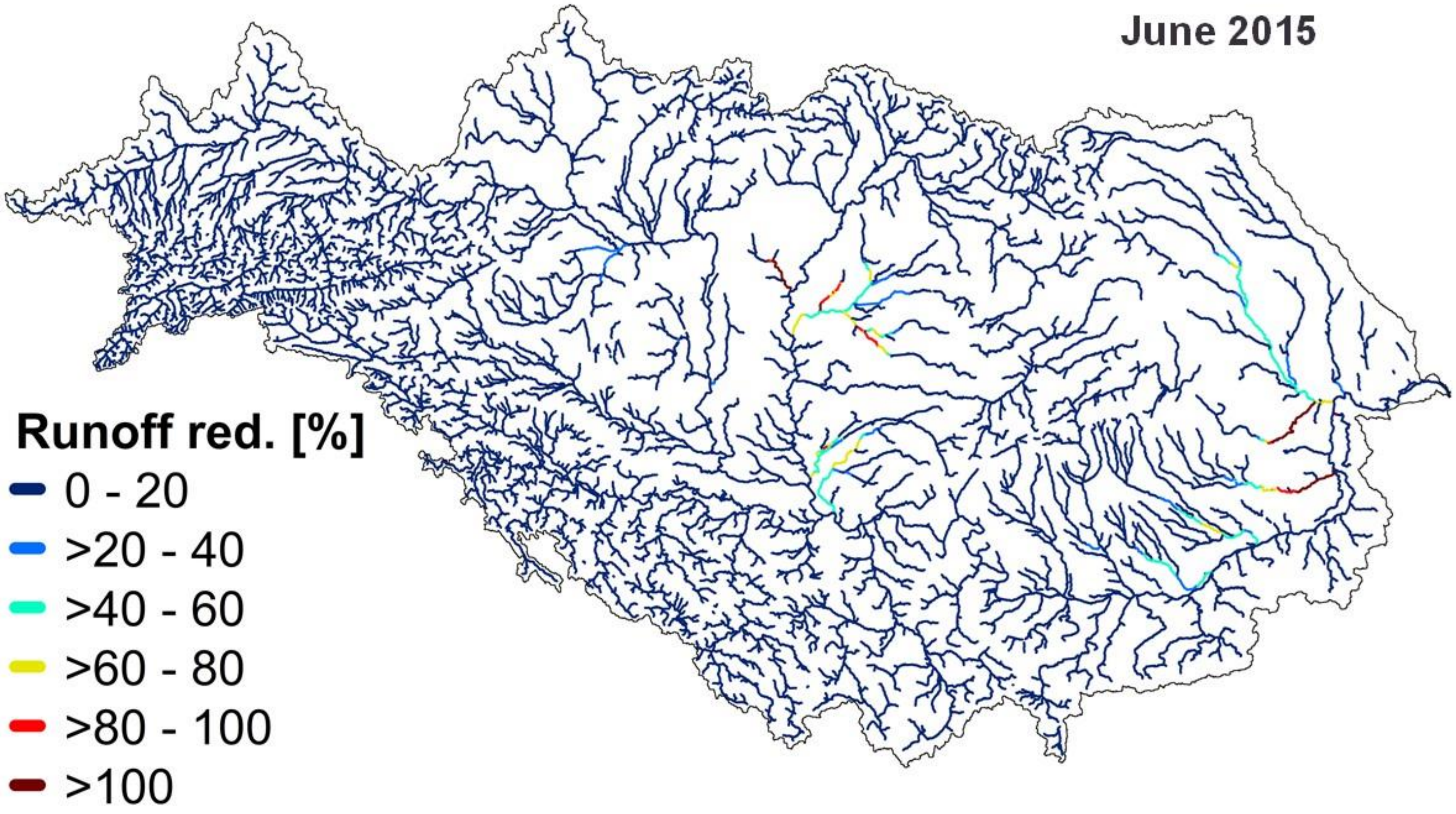
Scenario: Impact of large-scale irrigation on runoff



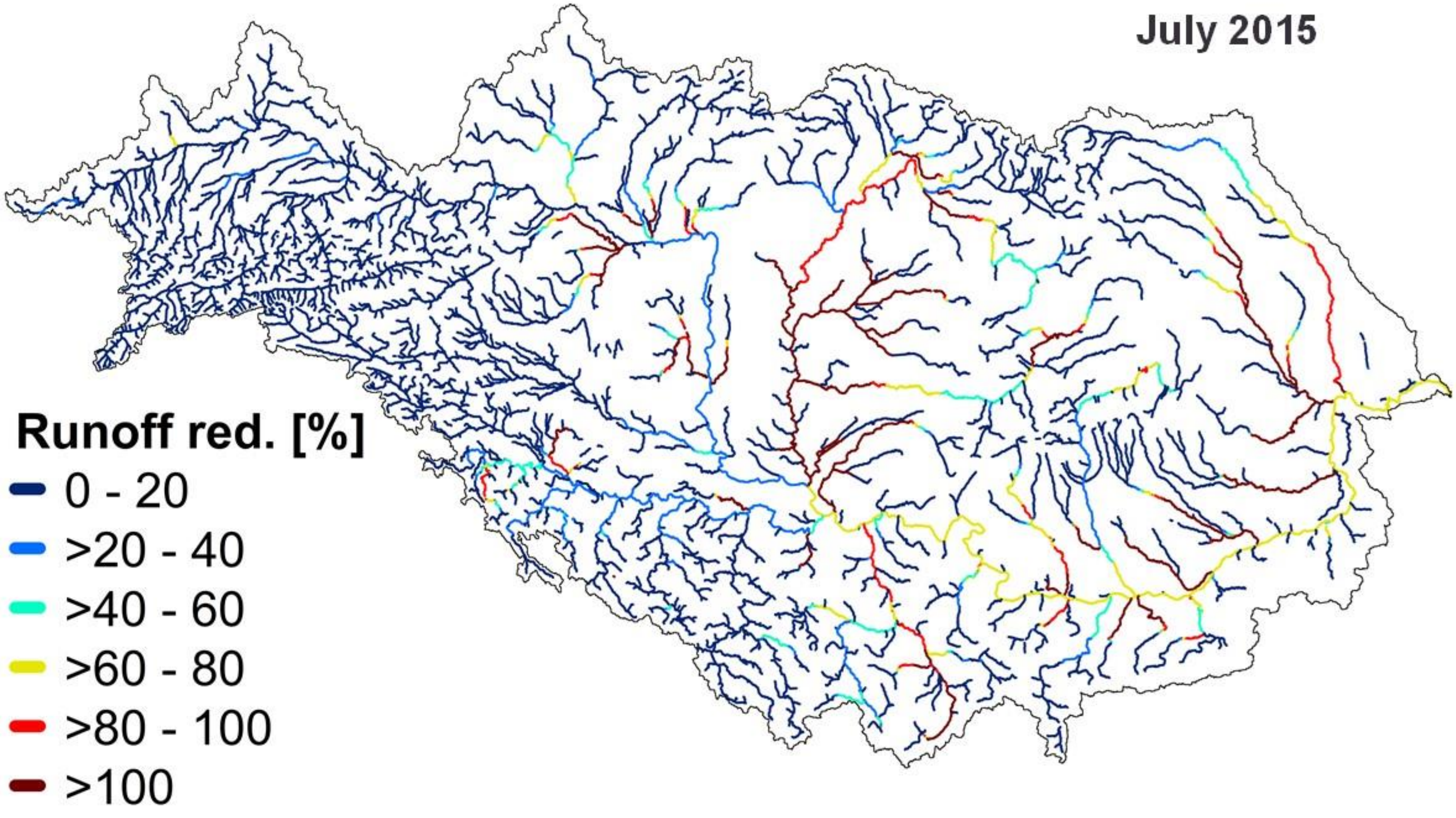
Scenario: Impact of large-scale irrigation on runoff



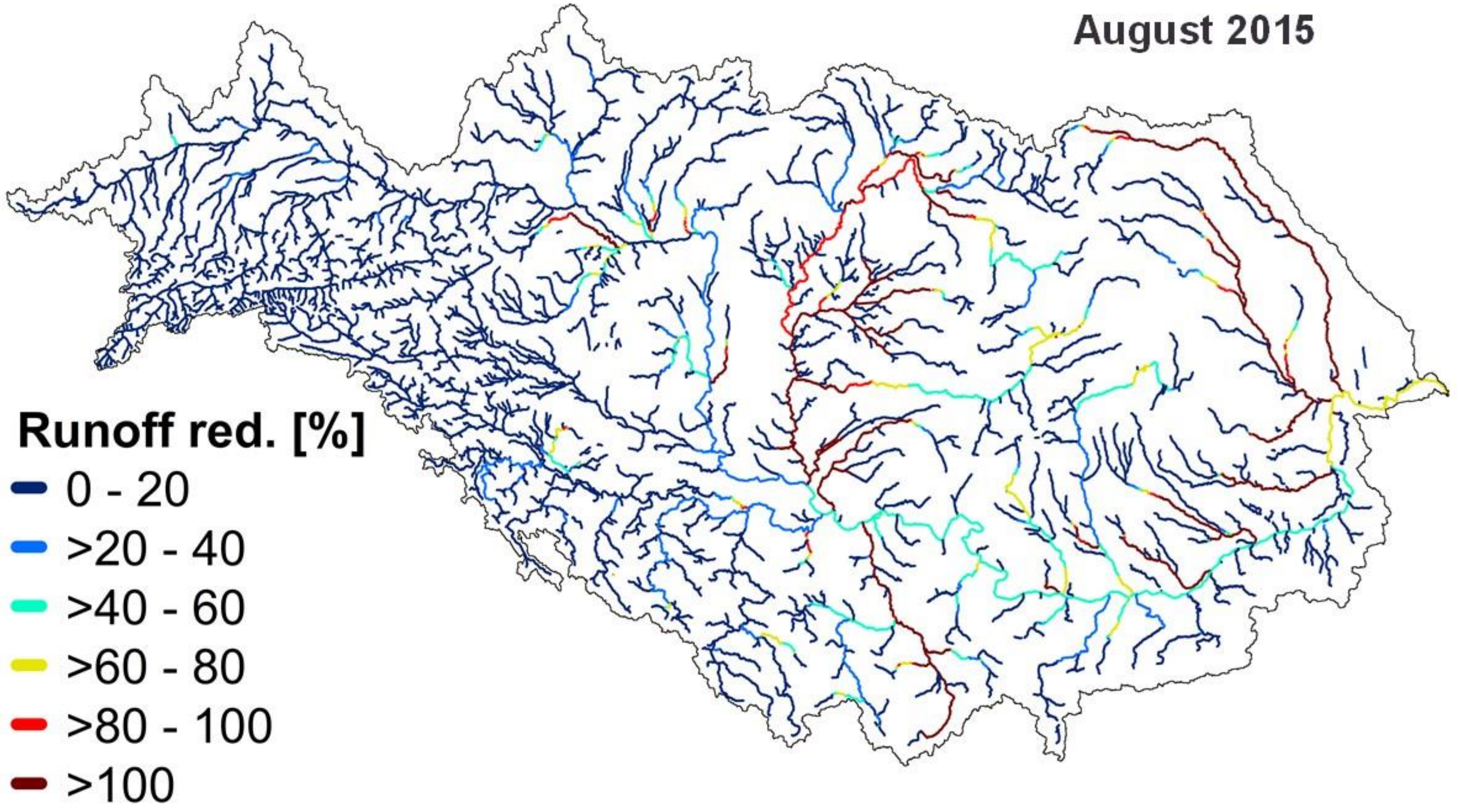
Scenario: Impact of large-scale irrigation on runoff



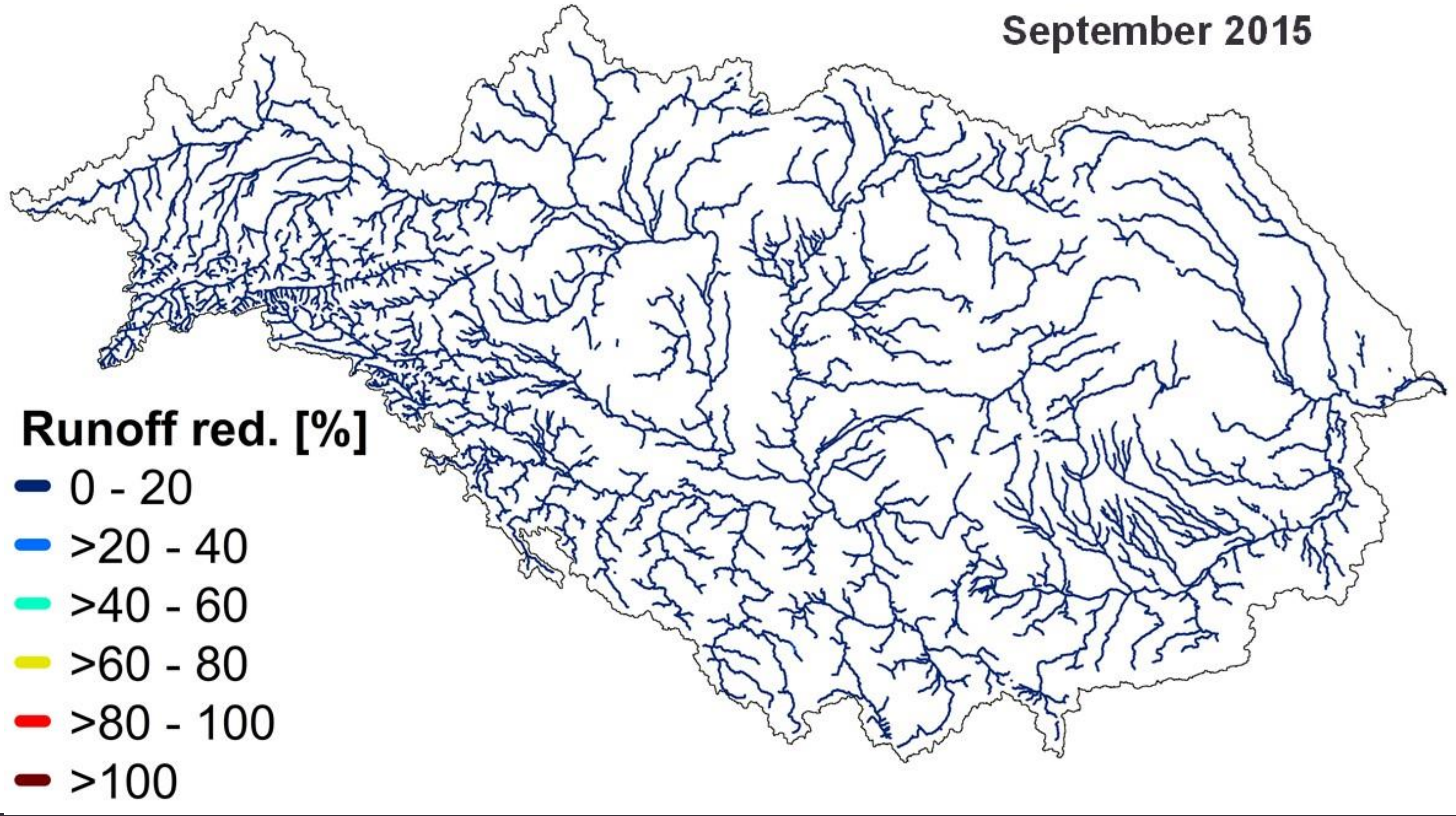
Scenario: Impact of large-scale irrigation on runoff



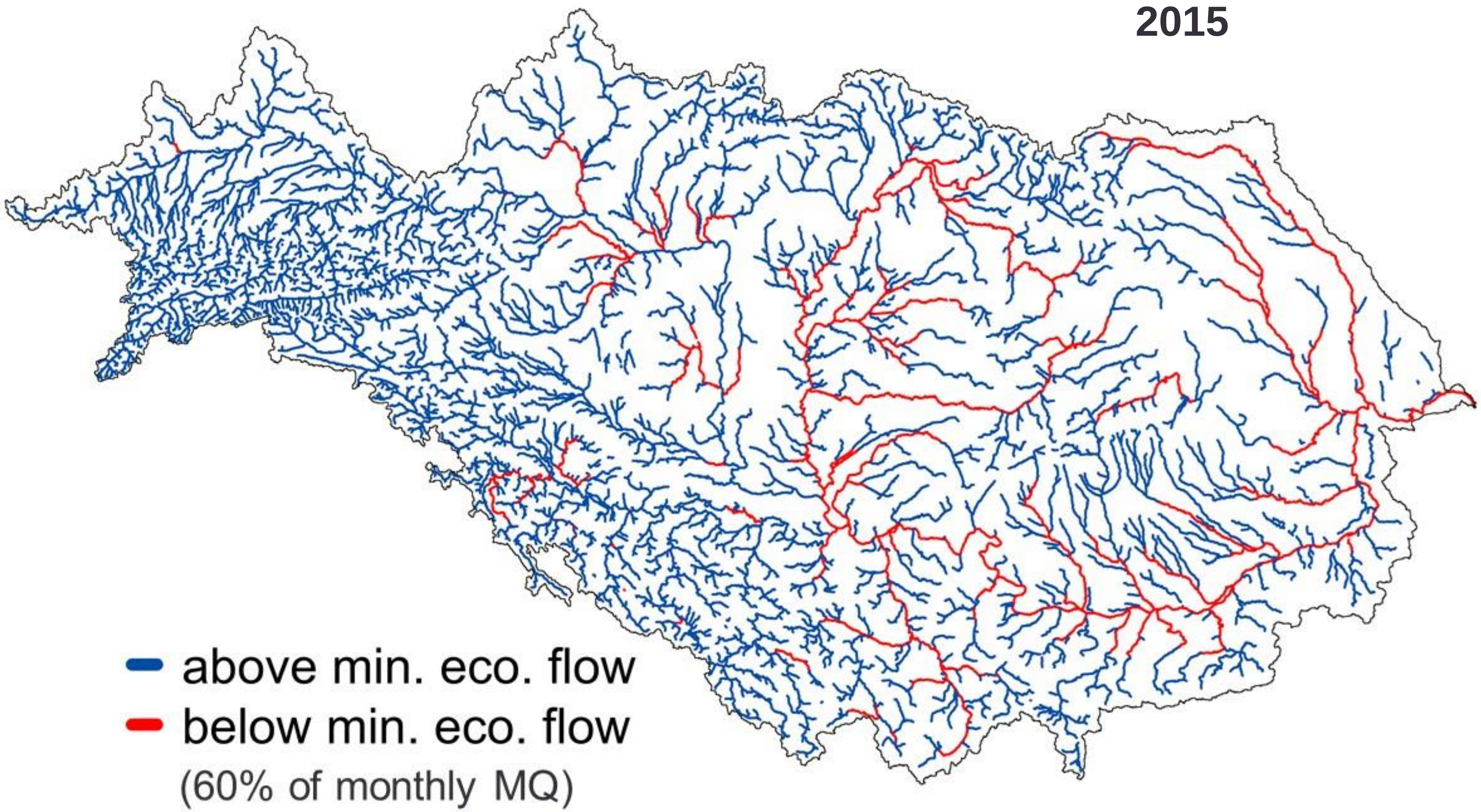
Scenario: Impact of large-scale irrigation on runoff

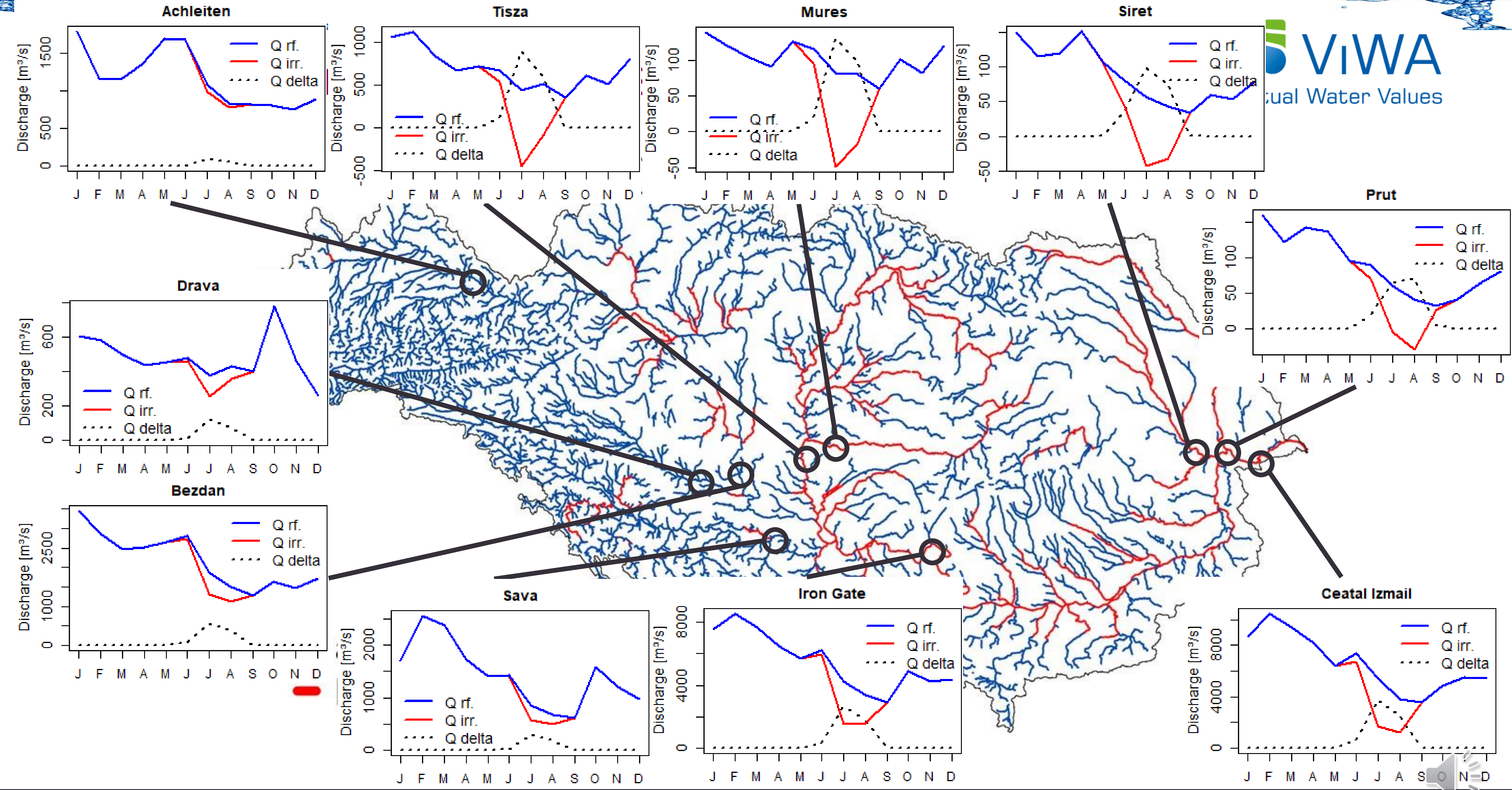


Scenario: Impact of large-scale irrigation on runoff

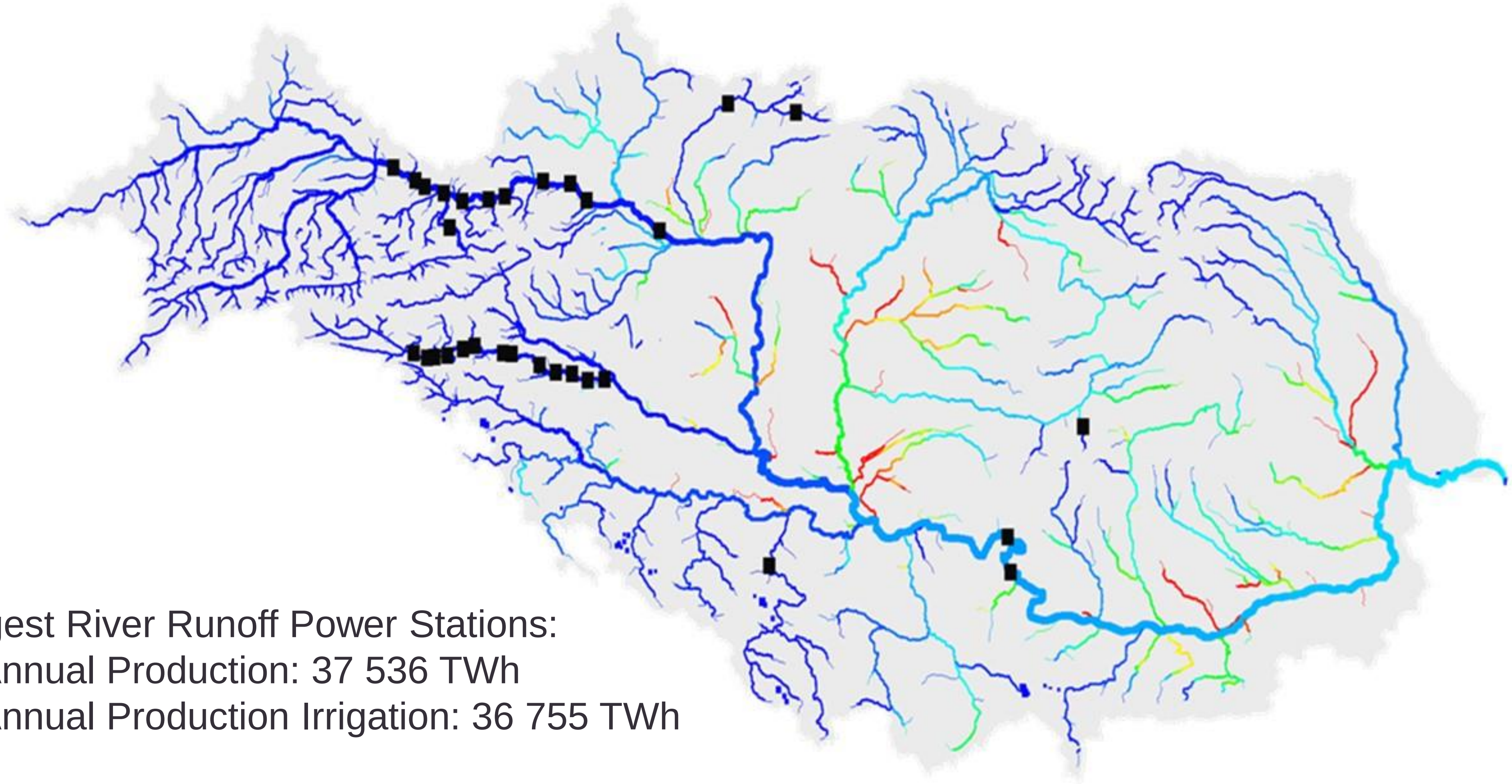


Scenario: Impact of large-scale irrigation on runoff



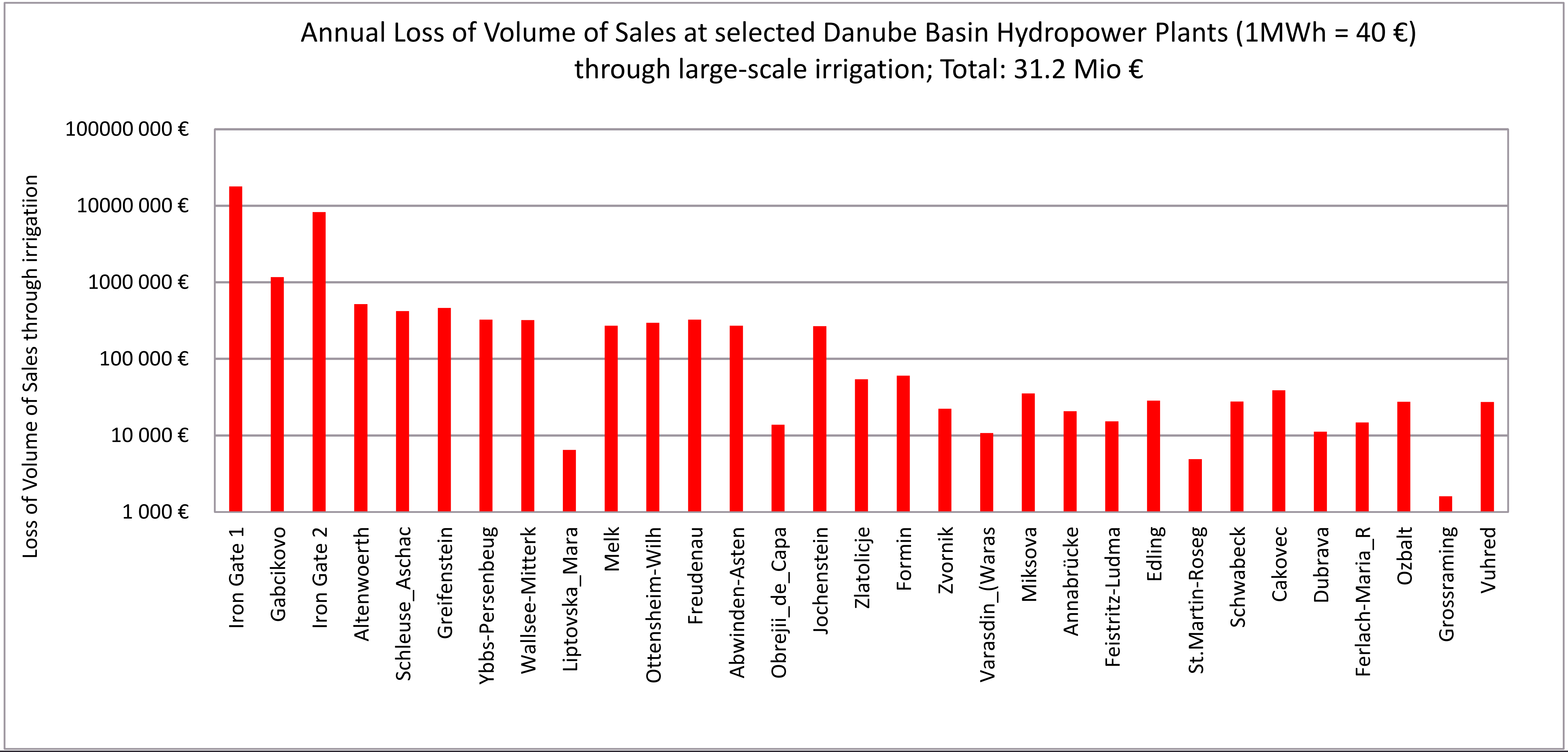

ViWA
Virtual Water Values
Achleiten
Tisza
Mures
Siret
Prut
Drava
Bezdan
Sava
Iron Gate
Ceatal Izmail
Discharge [m³/s]
Q rf.
Q irr.
Q delta
J F M A M J J A S O N D

Scenario: Impact of large-scale irrigation on hydropower

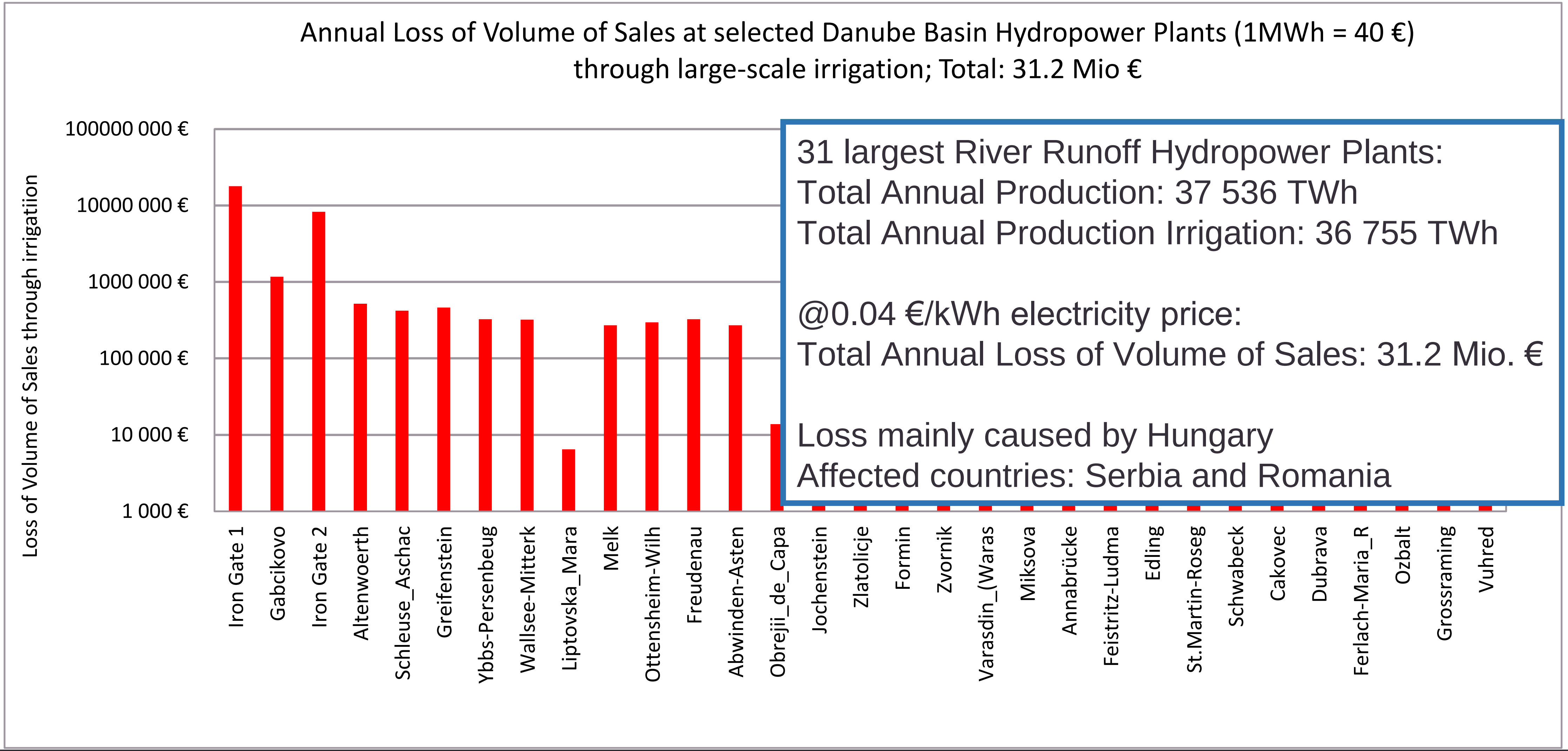


31 largest River Runoff Power Stations:
Total Annual Production: 37 536 TWh
Total Annual Production Irrigation: 36 755 TWh

Scenario: Impact of large-scale irrigation on hydropower



Scenario: Impact of large-scale irrigation on hydropower



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

Synthesis: Impact of large-scale irrigation on Danube

Integrated assessment:

1) **Water:**
   - Irrigation water withdrawal: ~29 billion m³/a, mostly in Hungary, Serbia and Romania
2) **Food:**
   - Maize production roughly doubled from ~40 to ~78 Mio. t/a

     → increase in volume of sales of ~6 Billion €/a (@ 160 €/t maize)
3) **Energy:**
   - Hydropower production is reduced from 37.5 to 36.7 PWh/a
   - → reduction in volume of sales of ~30 Mio €/a (@ 0.04€/kWh)

First indications for severe ecological consequences:

Discharge in July/August falls below min. ecological flow requirements (≙ 60% of monthly MQ = hard sustainability criterion) in most rivers in Hungary, Serbia and Romania (for more detailed assessment please see marketplace booth of LUH!)

Conclusions

- 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 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.
- Techological infrastructures for irrigation and hydropower production can be analysed in detail.

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)?
- How are thermal power plants affected by rising river temperatures related to extraction of irrigation water?
- Are there limits to the applicability of the developed tool to other regions?

Partners

Dept. of Geography, University of Munich

Prof. Dr. Wolfram Mauser (coordinator)

Institute for the World Economy, Kiel

Prof. Dr Gernot Klepper
Dr. Ruth Delzeit

Helmholtz Center for Environmental Research (UFZ), Leipzig

Prof. Dr. Sabine Attinger

Institute for Environmental Planning, University of Hanover

Prof. Dr. Christina von Haaren

Helmholtz-Zentrum Geesthacht, Climate Service Center Germany, Hamburg

Prof. Dr. Daniela Jacob
Dr. Susanne Pfeifer

Leibniz Supercomputing Centre (LRZ) of the Bavarian Academy of Sciences, Munich

Prof. Dr. Dieter Kranzlmüller
Dr. Anton Frank

VISTA Geoscience Remote Sensing GmbH, Munich

Dr. Heike Bach

Funded by

ViWA is a collaborative project of the funding program "Global Resource Water (GROW)" in the framework program FONA (Research for Sustainability) of the German Ministry for Education and Research (BMBF).