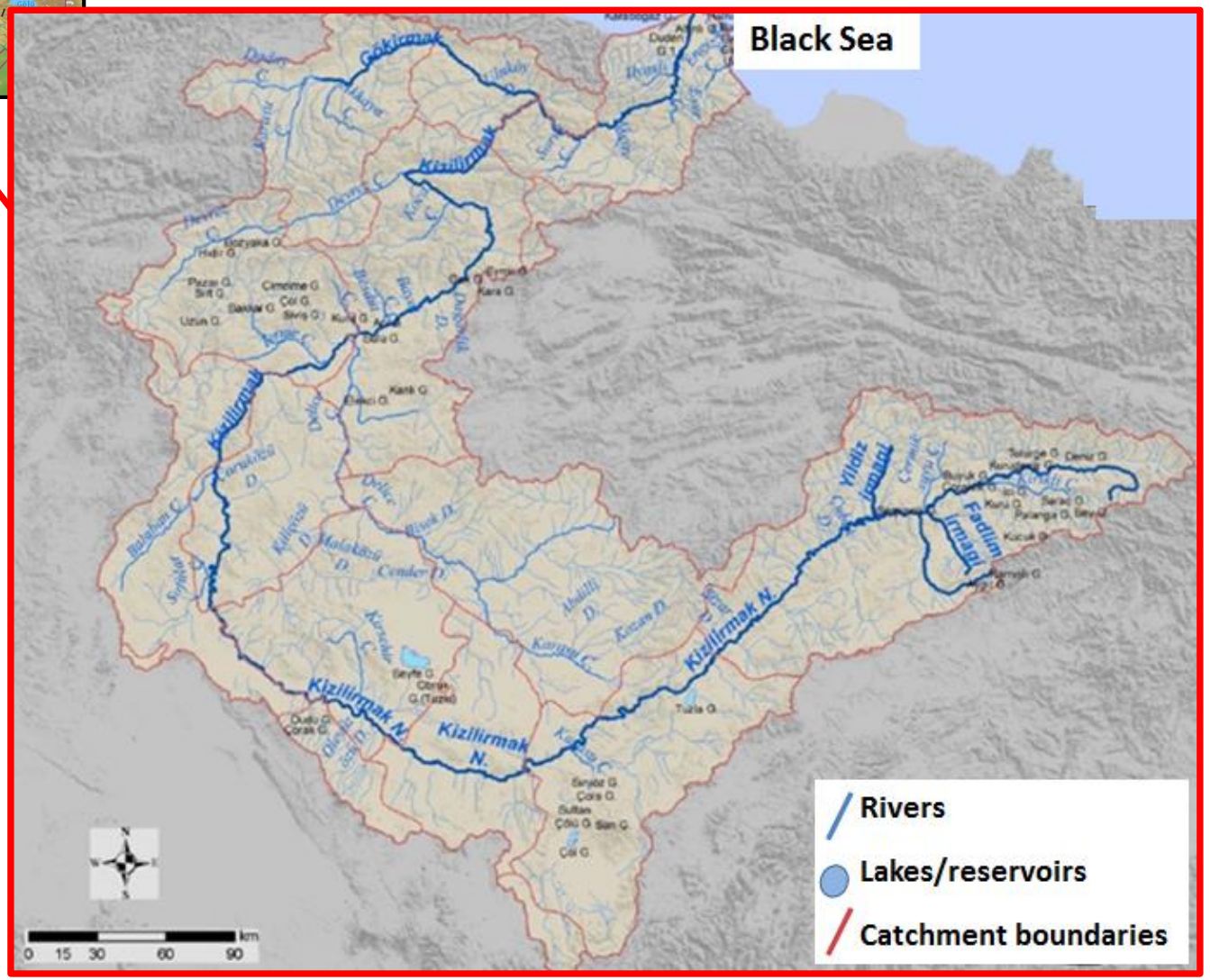
The effects of change in climate and irrigation practice on the water resources in Kizilirmak River Basin, Turkey

Tor Haakon Bakken

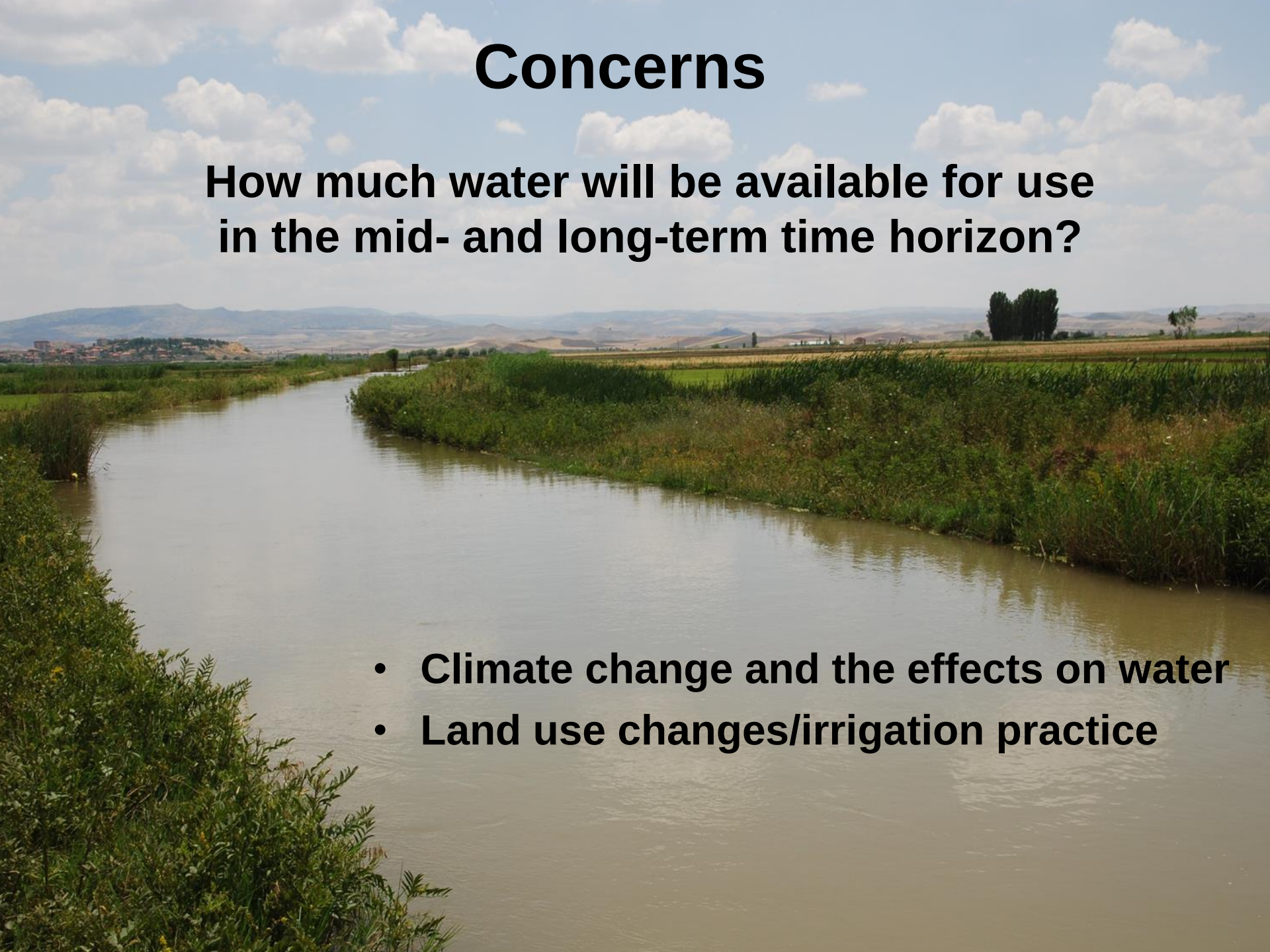
Case study Kizilirmak River Basin, Turkey

Kizilirmak River Basin, Turkey



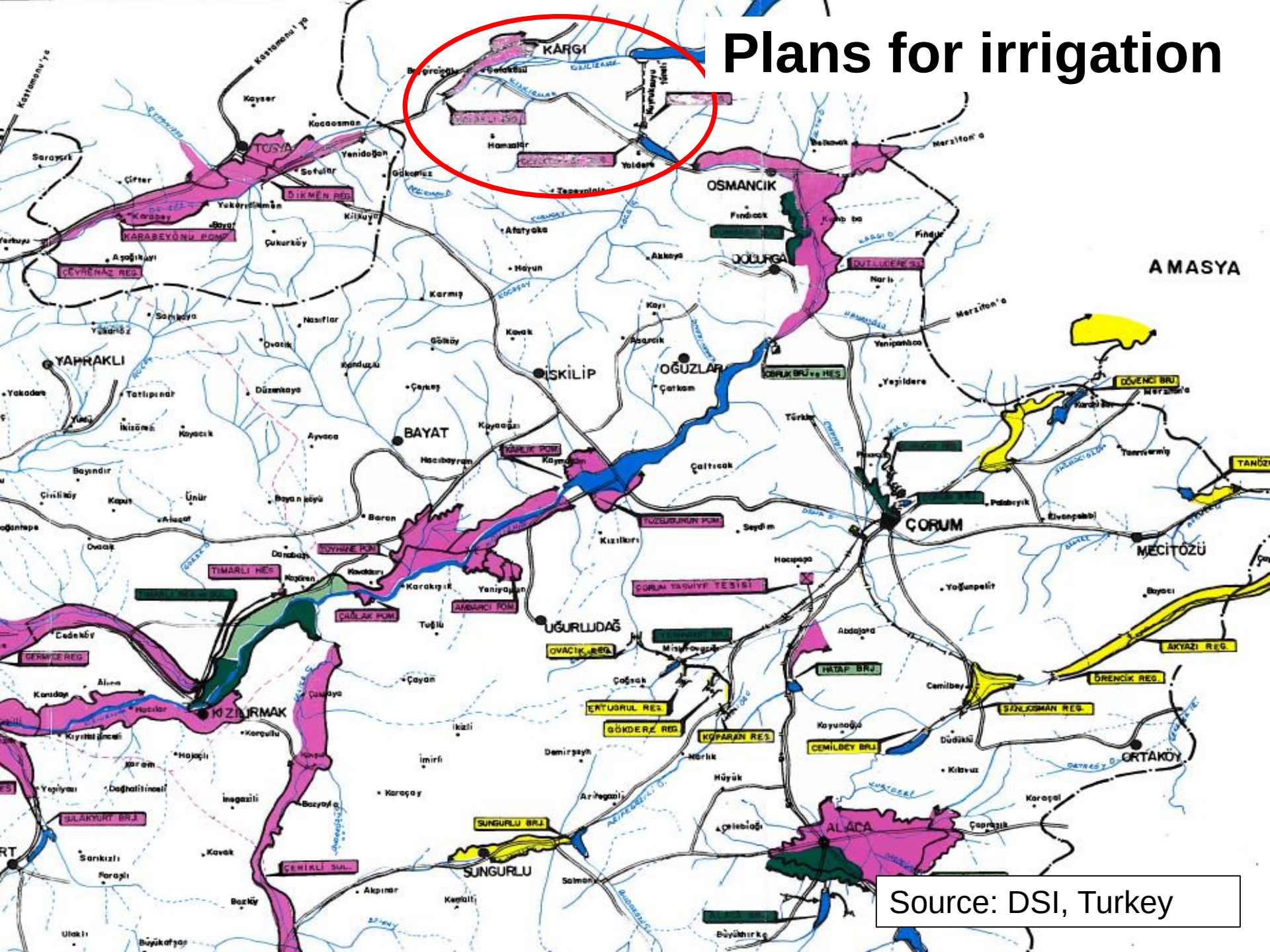
Concerns

How much water will be available for use in the mid- and long-term time horizon?



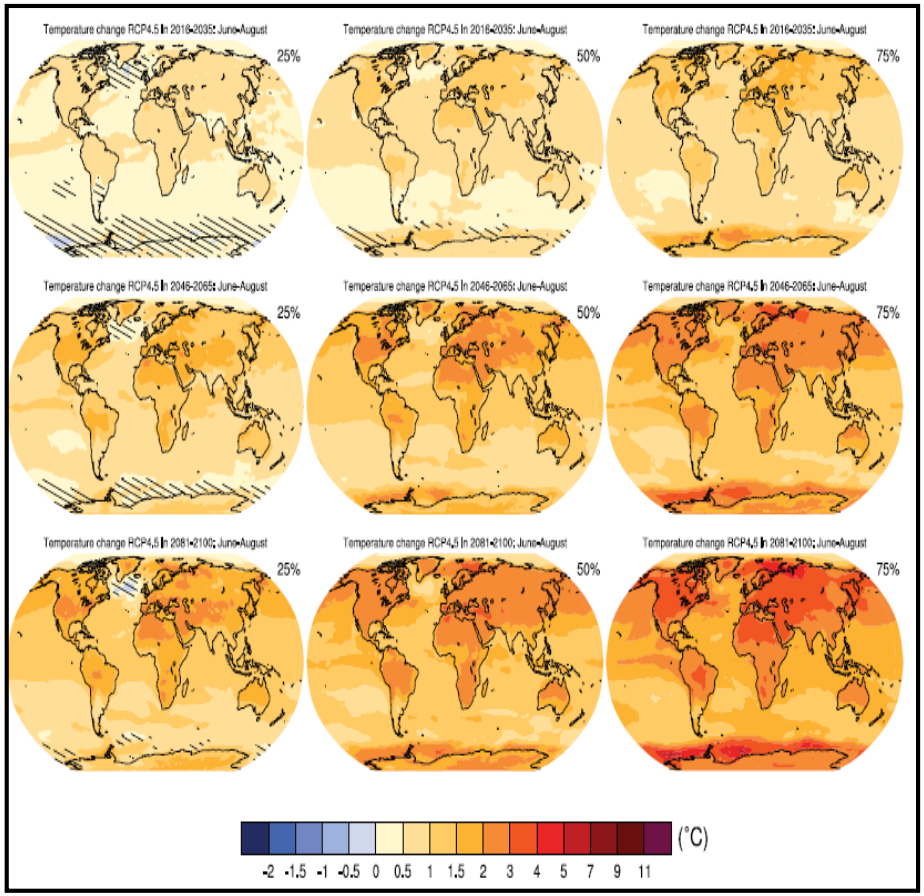
- **Climate change and the effects on water**
- **Land use changes/irrigation practice**

Plans for irrigation

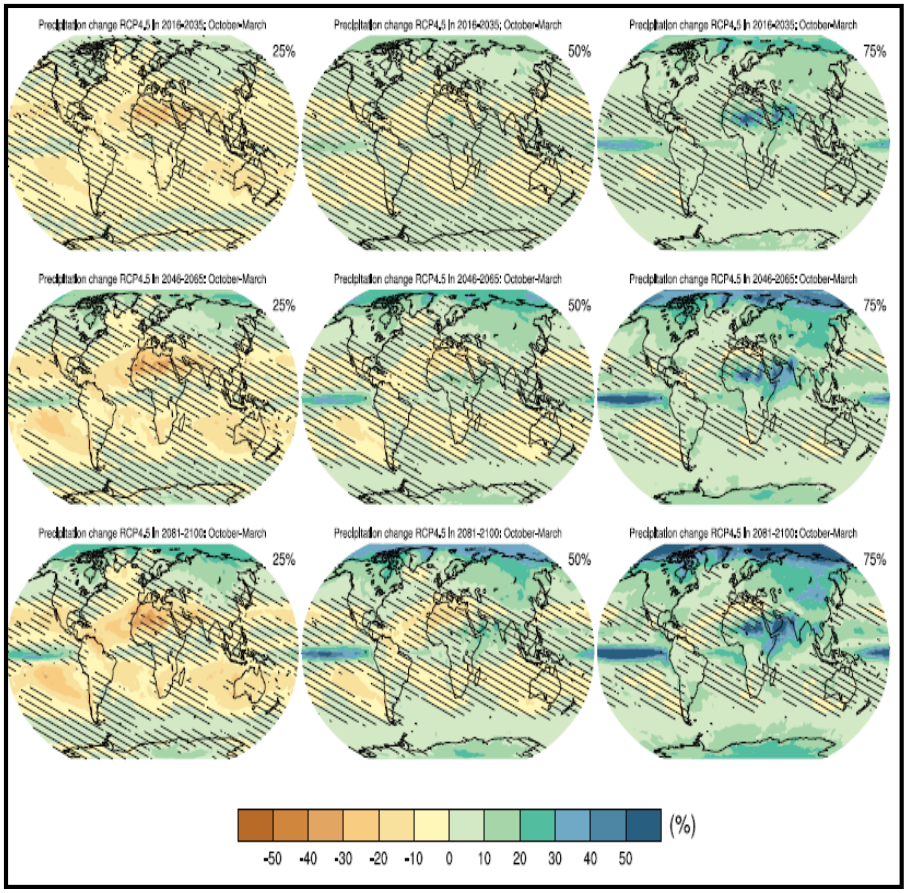


Climate change

Temperature



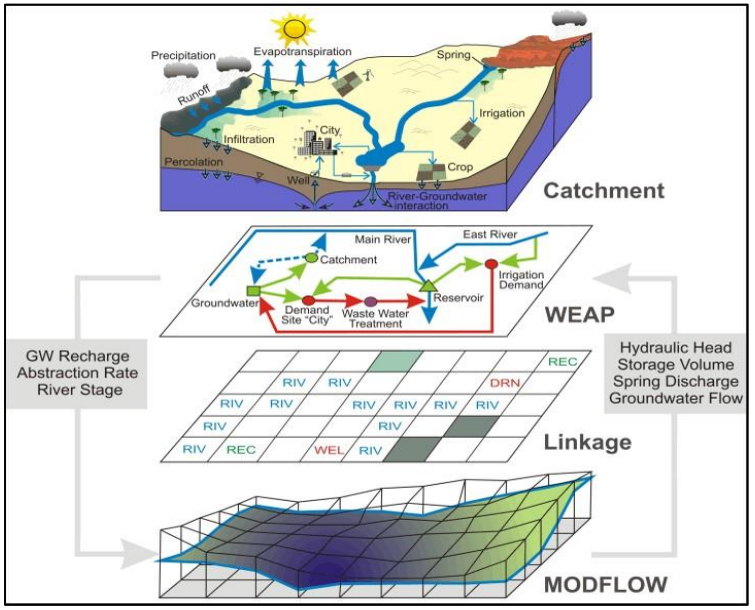
Precipitation



Source: IPCC, 2013: Annex I

WEAP - Model tool applied

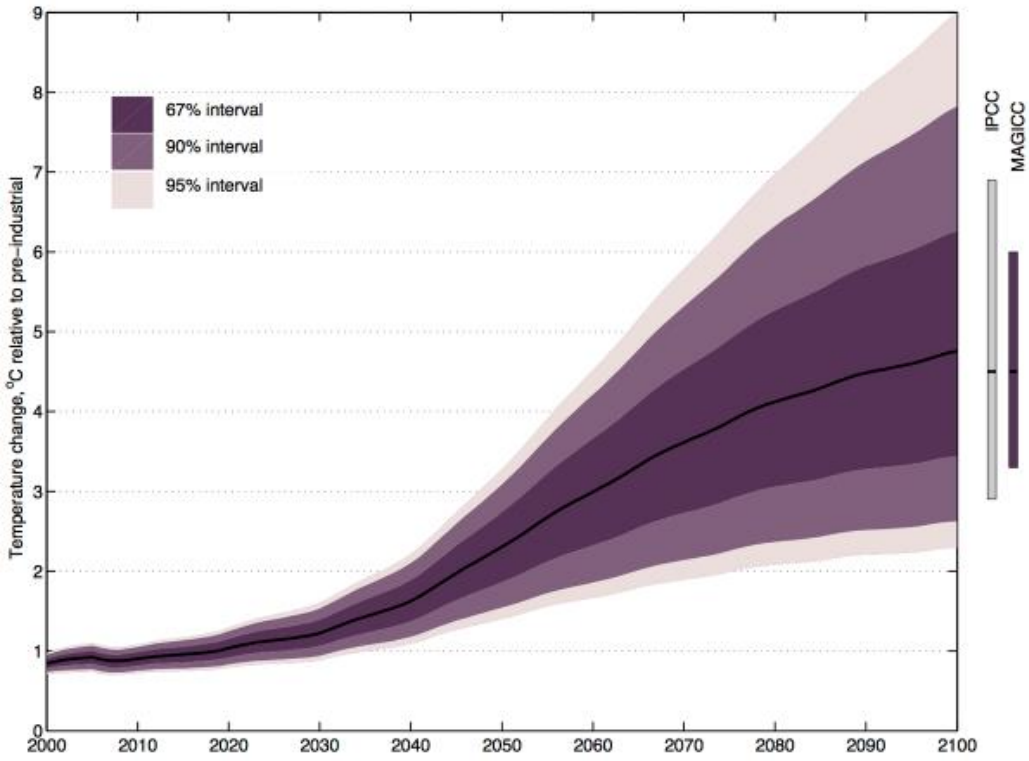
- WEAP – Water evaluation and planning tool
- Supports long-term analysis of available water resources (e.g. climate change)
- Supports the effects of policy scenarios on the water resources (e.g. changes in priorities of water use, land management practice, etc.)
- Supports dynamic linking to other tools, scripting



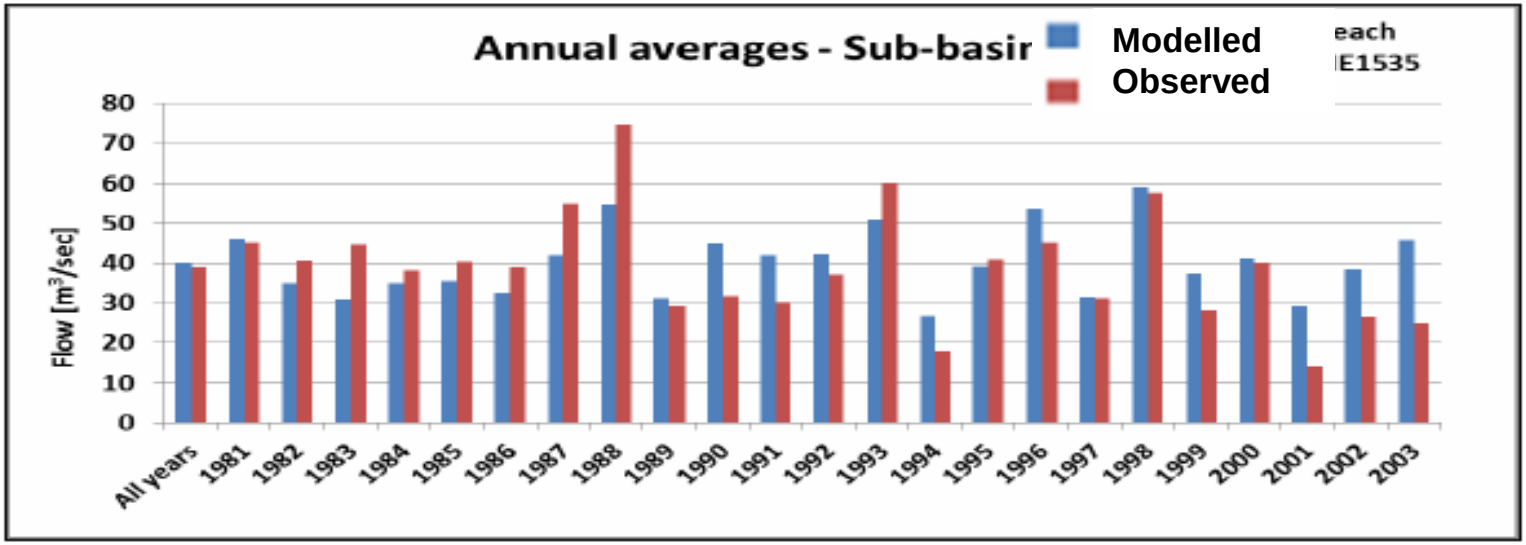
The art of modelling

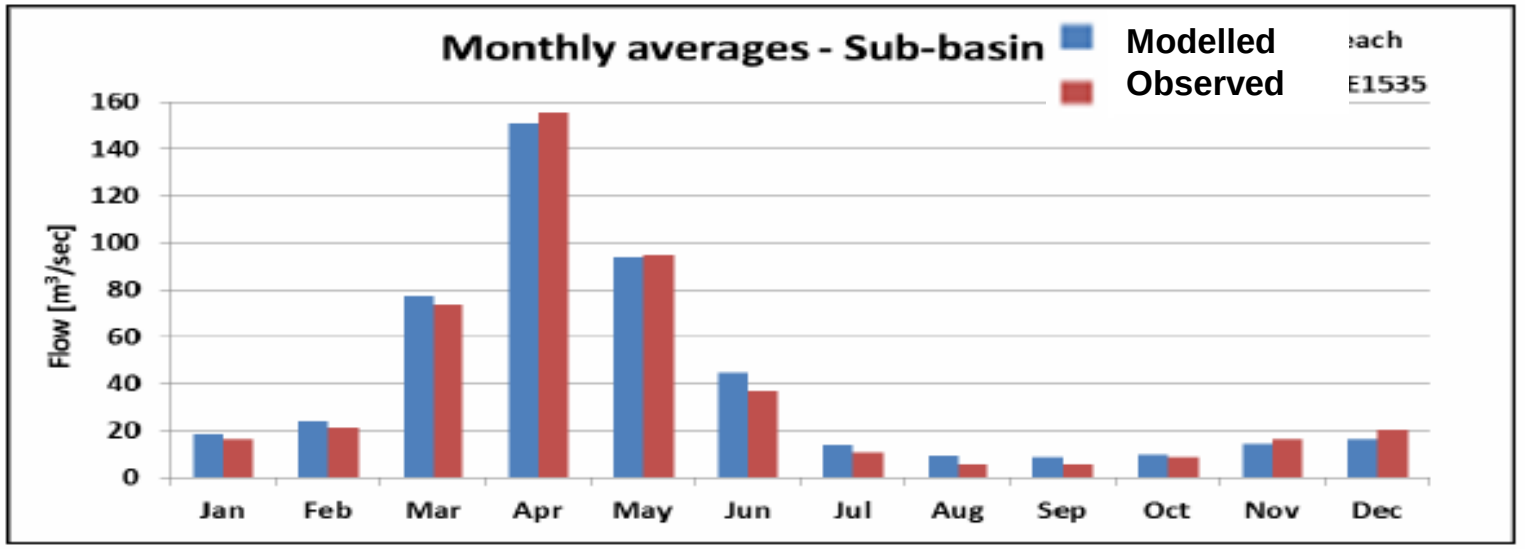
1. Input data – what is available and not available?
2. Model parameters and representation
3. What we do not know

Uncertainty!



Model calibration





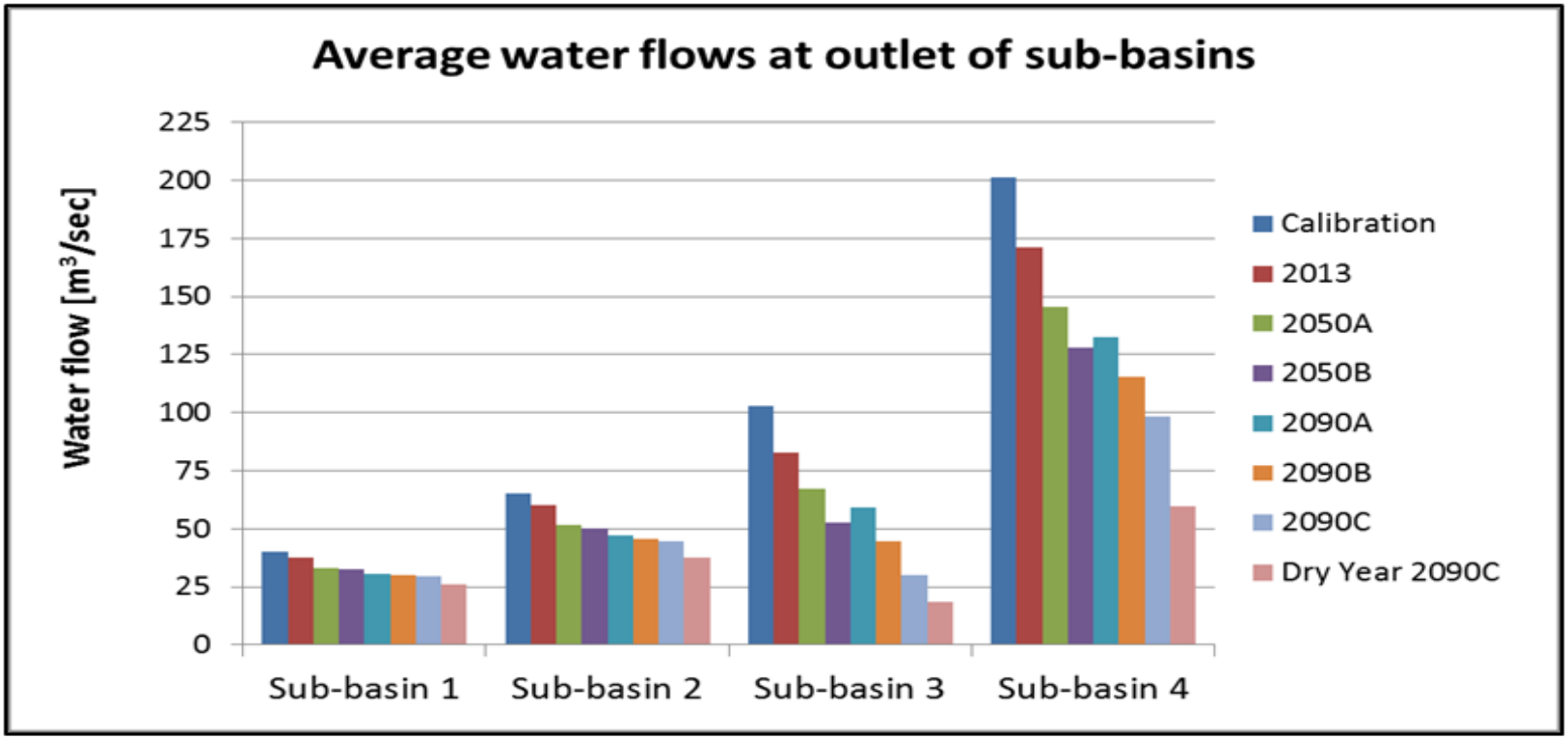
Scenario definition (RCP4.5)

	Scenario name	Temperature Summer/Winter [° C]	Precipitation Summer/Winter	Irrigation
	Year 2013	Observed	Observed	As built by 2013
2050	Year 2050A	+2.5 / +1.5	-5 % / -2.5 %	No new from 2013
2050	Year 2050B	+2.5 / +1.5	-5 % / -2.5 %	As planned
2090	Year 2090A	+3 / +2	-10 % / -5 %	No new from 2013
2090	Year 2090B	+3 / +2	-10 % / -5 %	As planned
2090	Year 2090C	+3 / +2	-10 % / -5 %	As planned + more
2090	Dry Year 2090C	+3 / +2	-10 % / -5 %	As planned + more

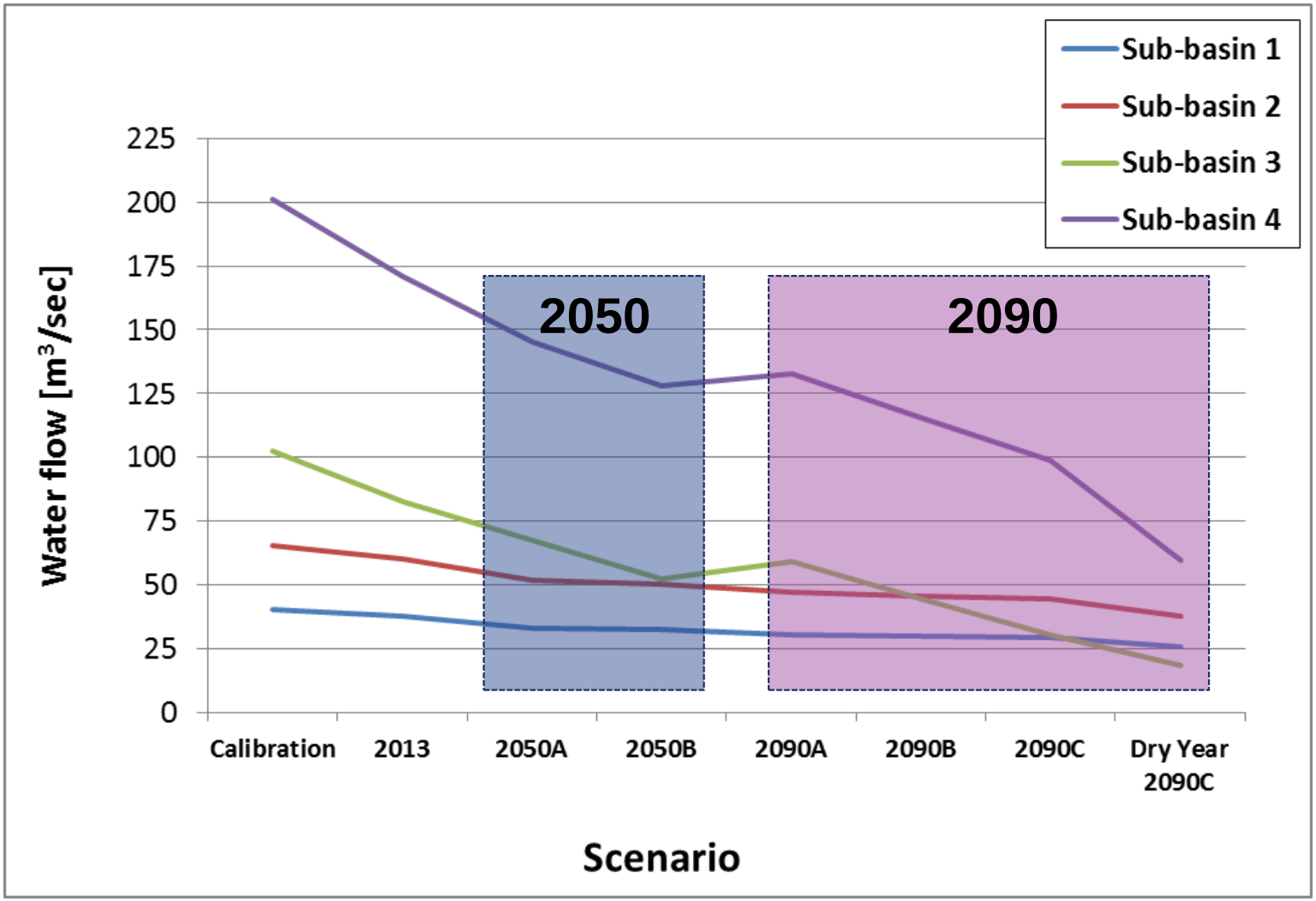
Based on: IPCC, 2013: Annex I

Scenario Results

	Scenario name	Temperature Summer/Winter [° C]	Precipitation Summer/Winter	Irrigation
	Year 2013	Observed	Observed	As built by 2013
2050	Year 2050A	+2.5 / +1.5	-5 % / -2.5 %	No new from 2013
2050	Year 2050B	+2.5 / +1.5	-5 % / -2.5 %	As planned
2090	Year 2090A	+3 / +2	-10 % / -5 %	No new from 2013
2090	Year 2090B	+3 / +2	-10 % / -5 %	As planned
2090	Year 2090C	+3 / +2	-10 % / -5 %	As planned + more
2090	Dry Year 2090C	+3 / +2	-10 % / -5 %	As planned + more



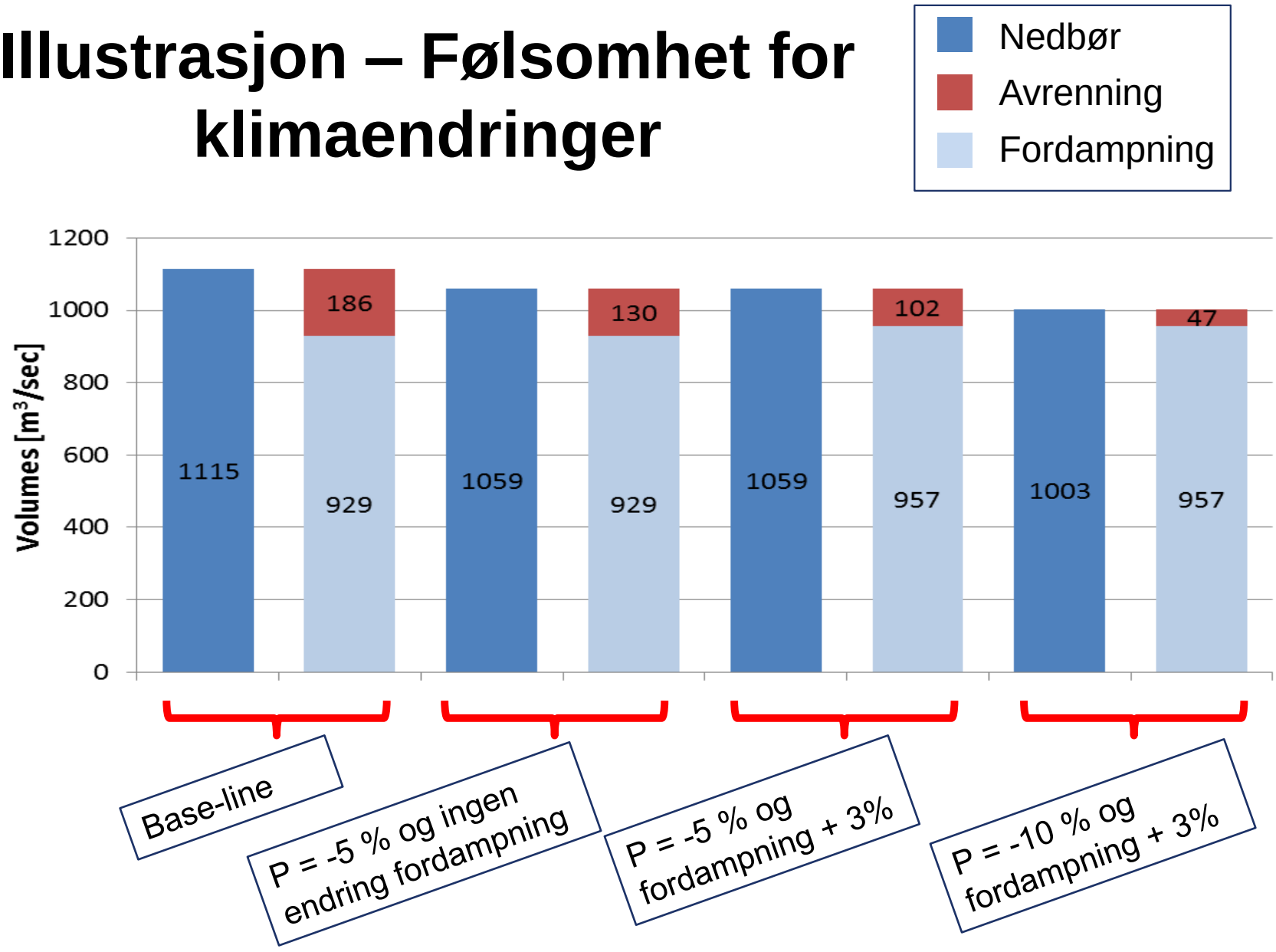
Average flow [m³/sec]



Conclusions Kizilirmak, Turkey

- The effect of climate change and irrigation will reduce the available water resources significantly. Similar trends found also by e.g. Milly et al. (2005), IPCC (2008), Lawrence and Haddeland (2012) and Maestre-Valero et al. (2013).
- The effect of climate change is stronger than irrigation in some parts of the basin, and the opposite in other parts.
- Small changes in climate will potentially make big changes in runoff when low runoff coefficients (low effective rainfall/high evaporation).
- Integrated assessment of the water resources needed in order to plan the mid- and long-term available water resources.
- The risk profile of the investment portfolio is to a large extent affected by the location of the prospects in the river basin.

Illustrasjon – Følsomhet for klimaendringer



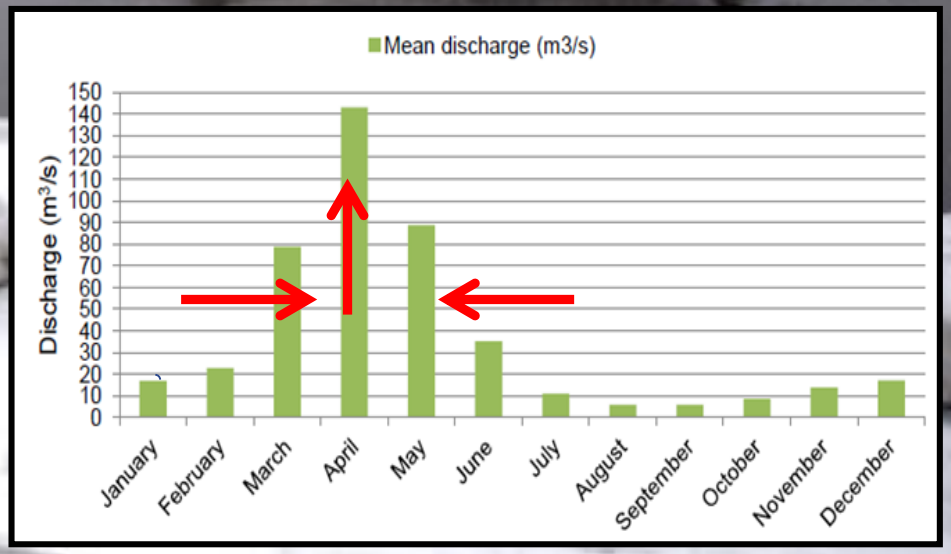
More on the role of reservoirs and the river basin internal competition

Climate change and the need for more reservoirs

Climate change can give more droughts

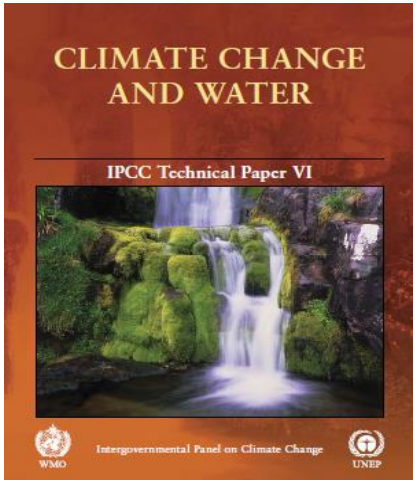

Climate change can also give more floods

Climate change can change the periodicity



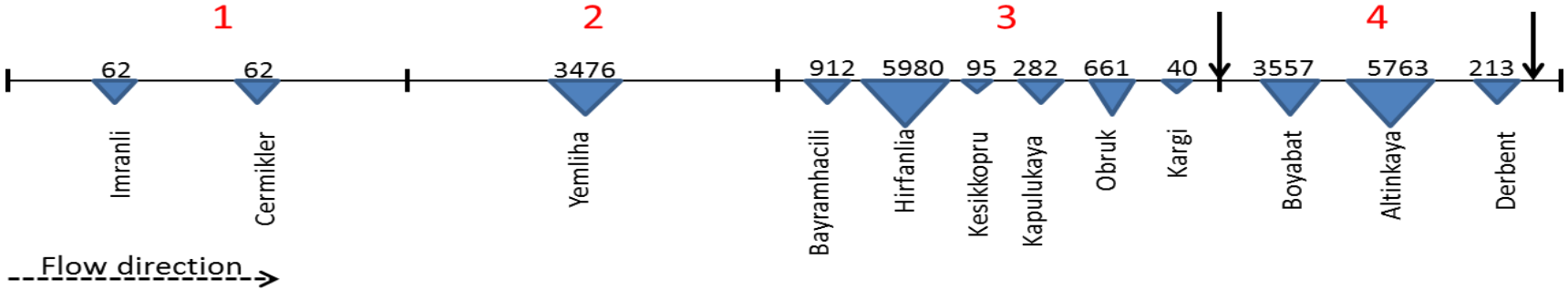
More reservoirs are needed, due to……

- Need for more renewable energy to replace fossil based fuels (e.g. hydropower)
- Need for reservoir-based power to balance intermittent sources
- Need for more irrigation to increase food production
- Need to secure water supply for a larger population with higher standard of living
- Need for protection against floods
- Supported by a large number of independent sources (e.g. IPCC, 2008)



Some more details from Turkey

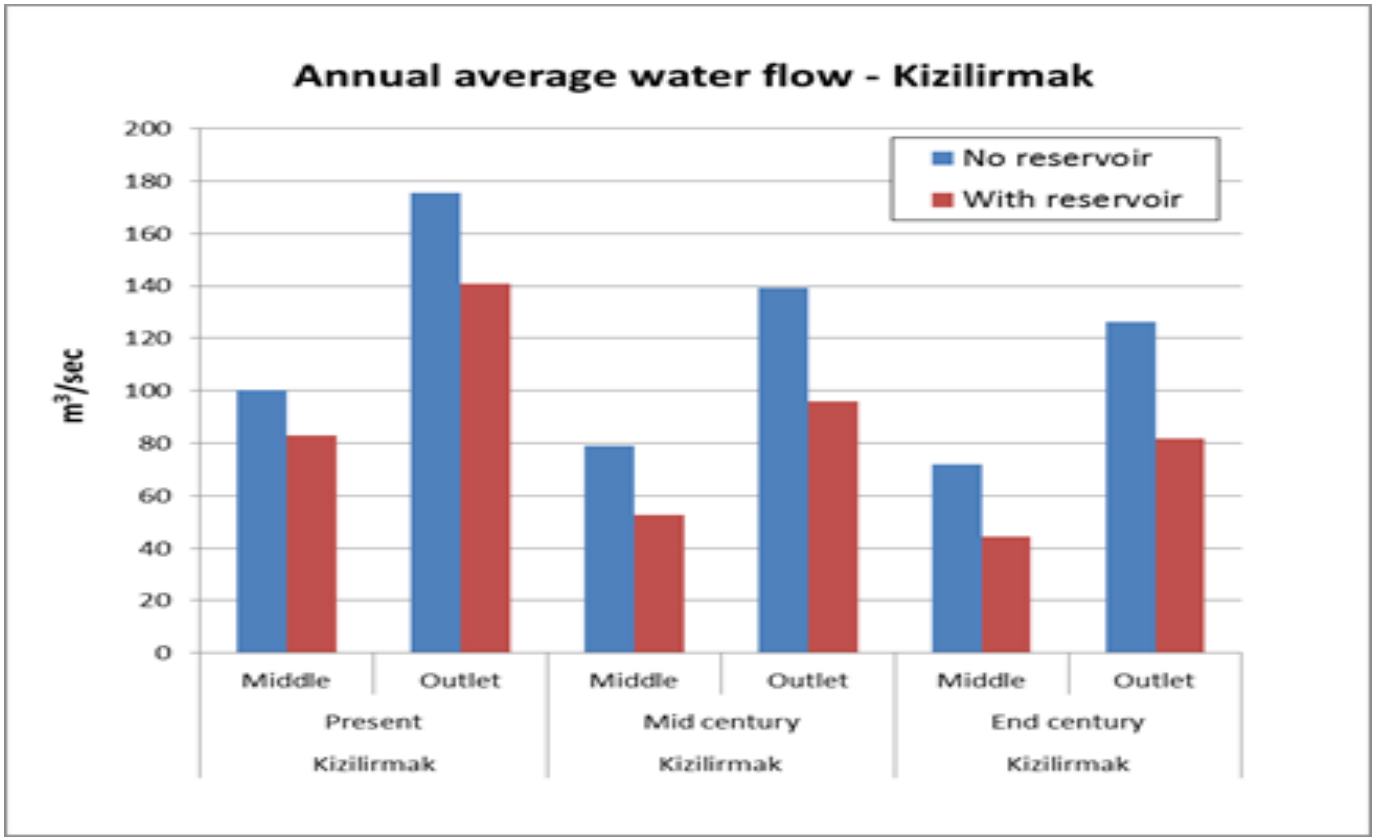
The river basin schematically presented



- Red numbers on top: sub-basin numbering
- Black numbers: volume of reservoirs in mill. m3

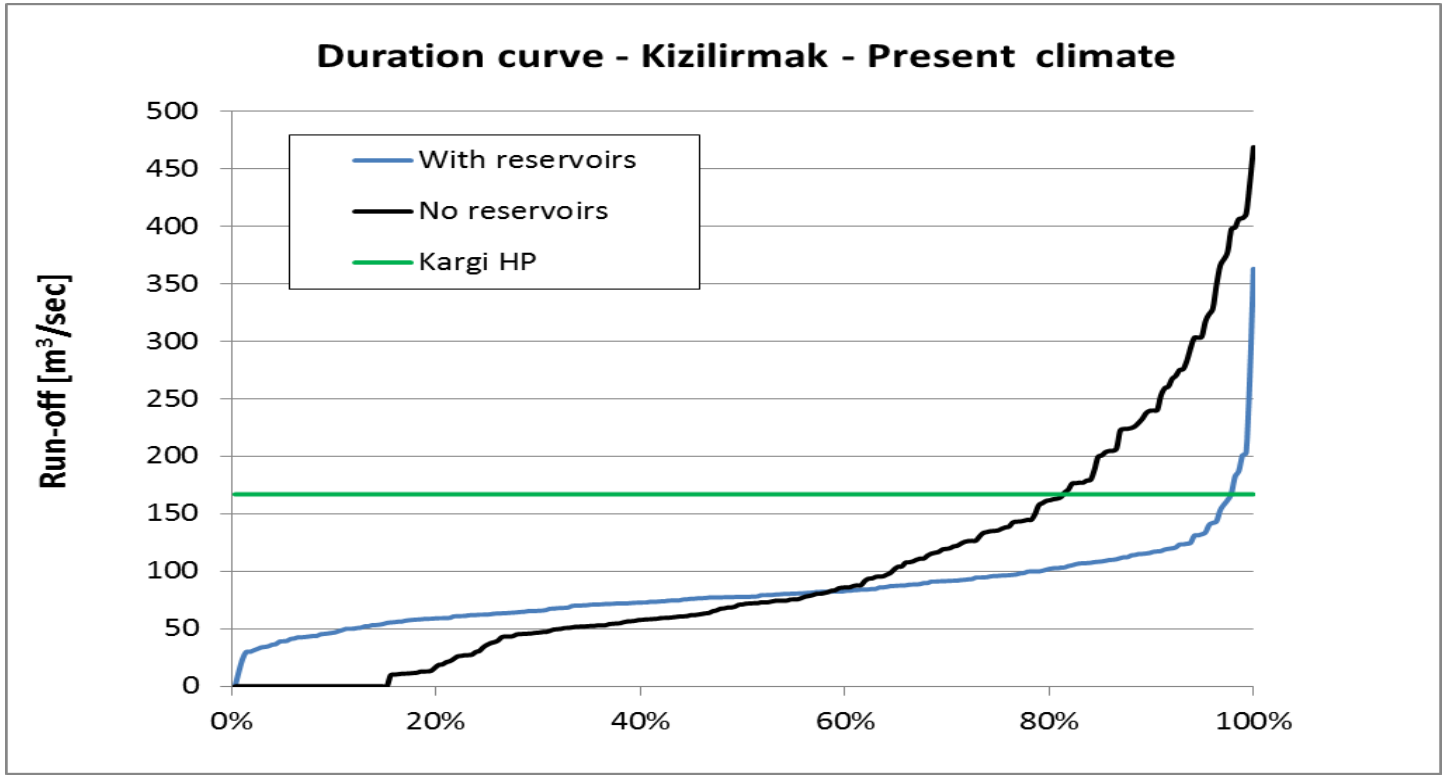
Effect of climate change

The average flow - with and without reservoirs



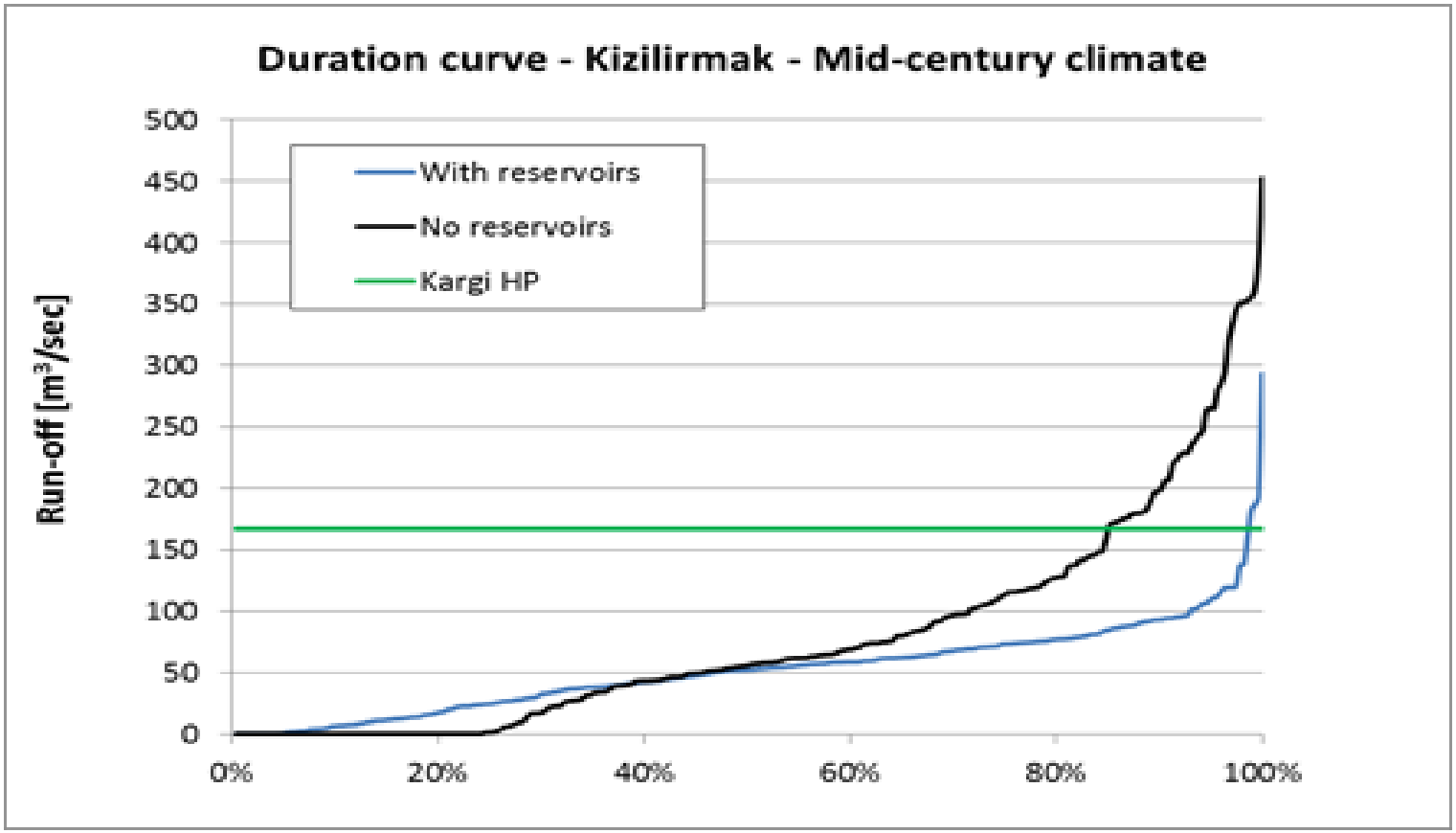
Some more details from Turkey

Present conditions (climate and irrigation)



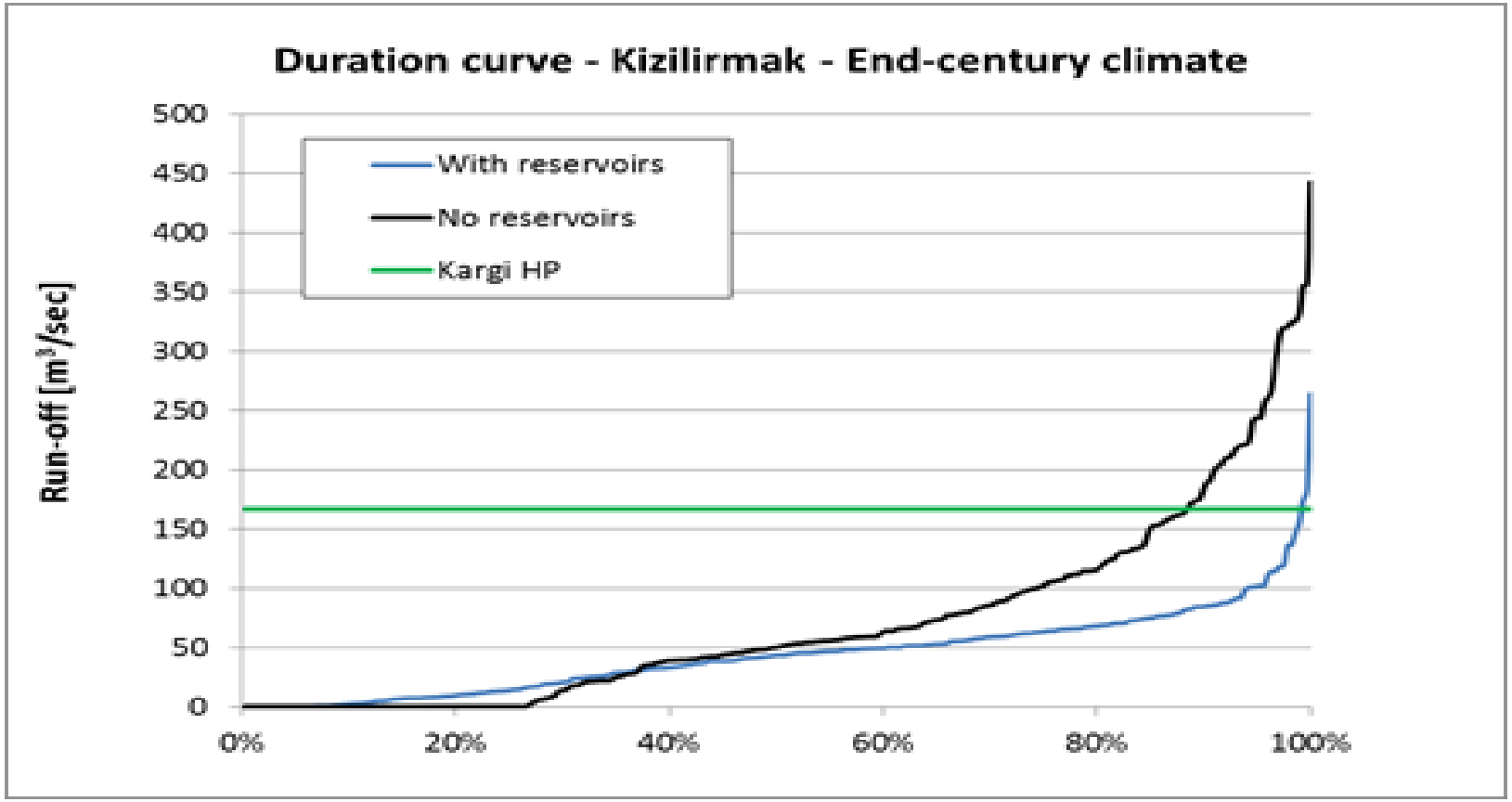
Some more details from Turkey

Mid-century conditions (climate and irrigation)

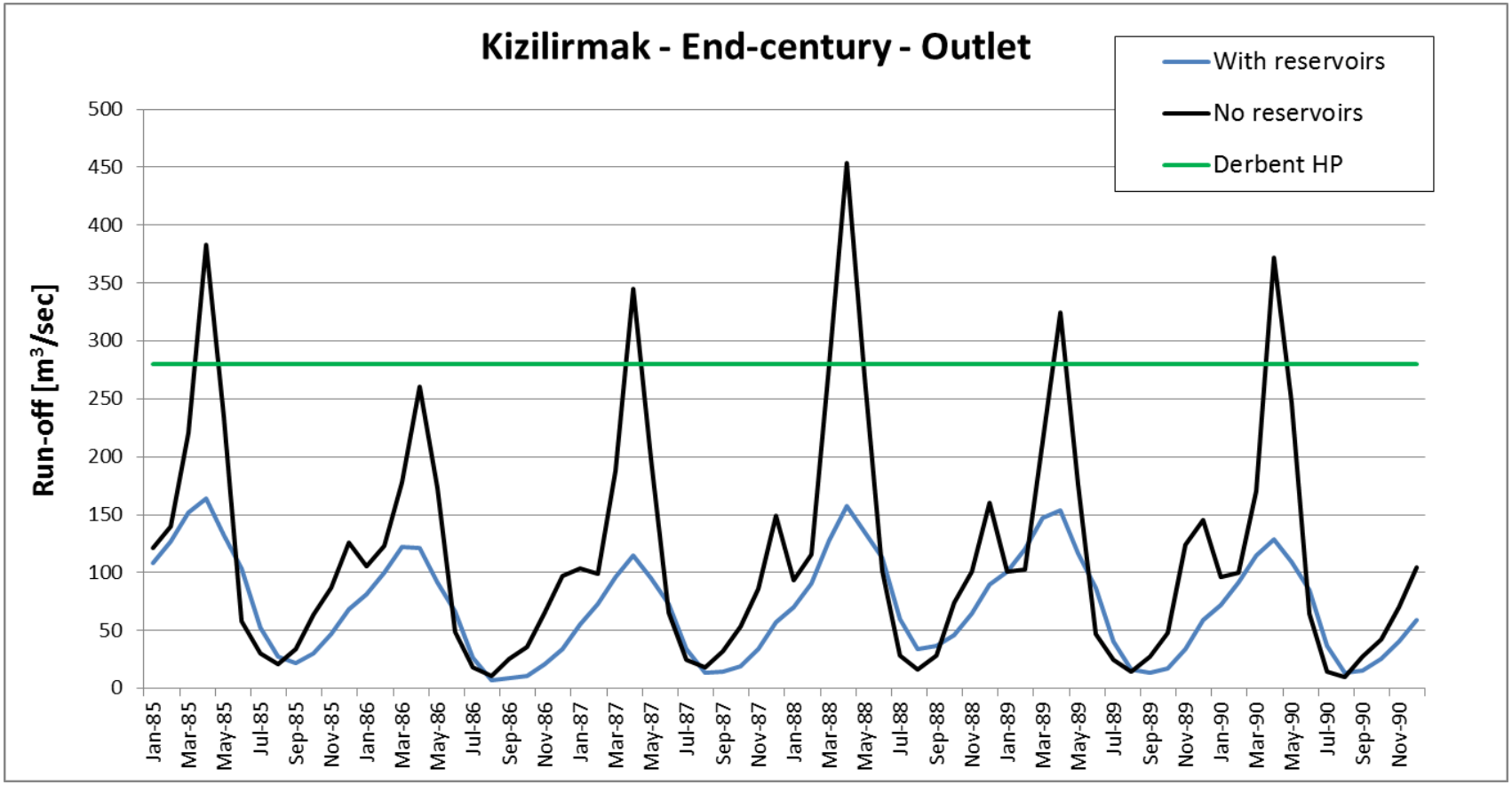


Some more details from Turkey

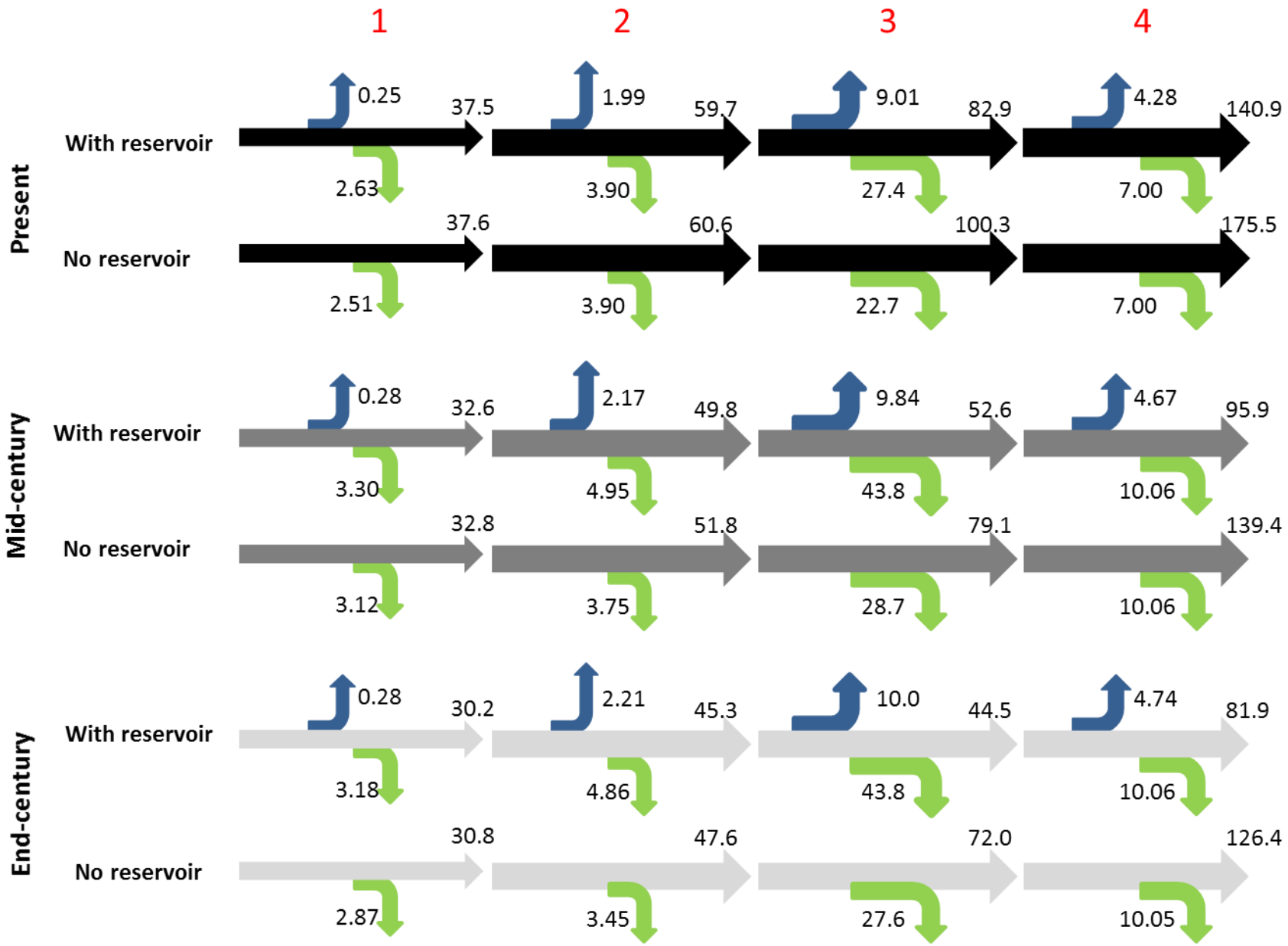
End-century conditions (climate and irrigation)



End of century

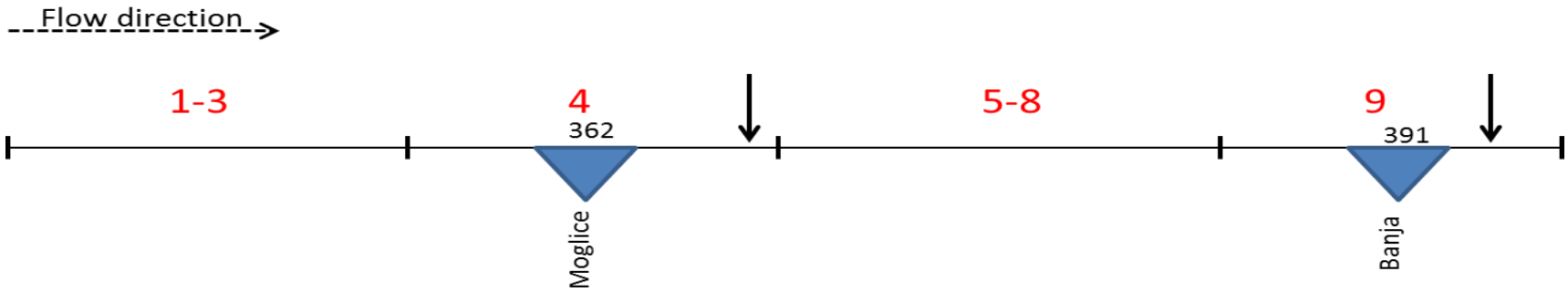


The water losses, Kizilirmak

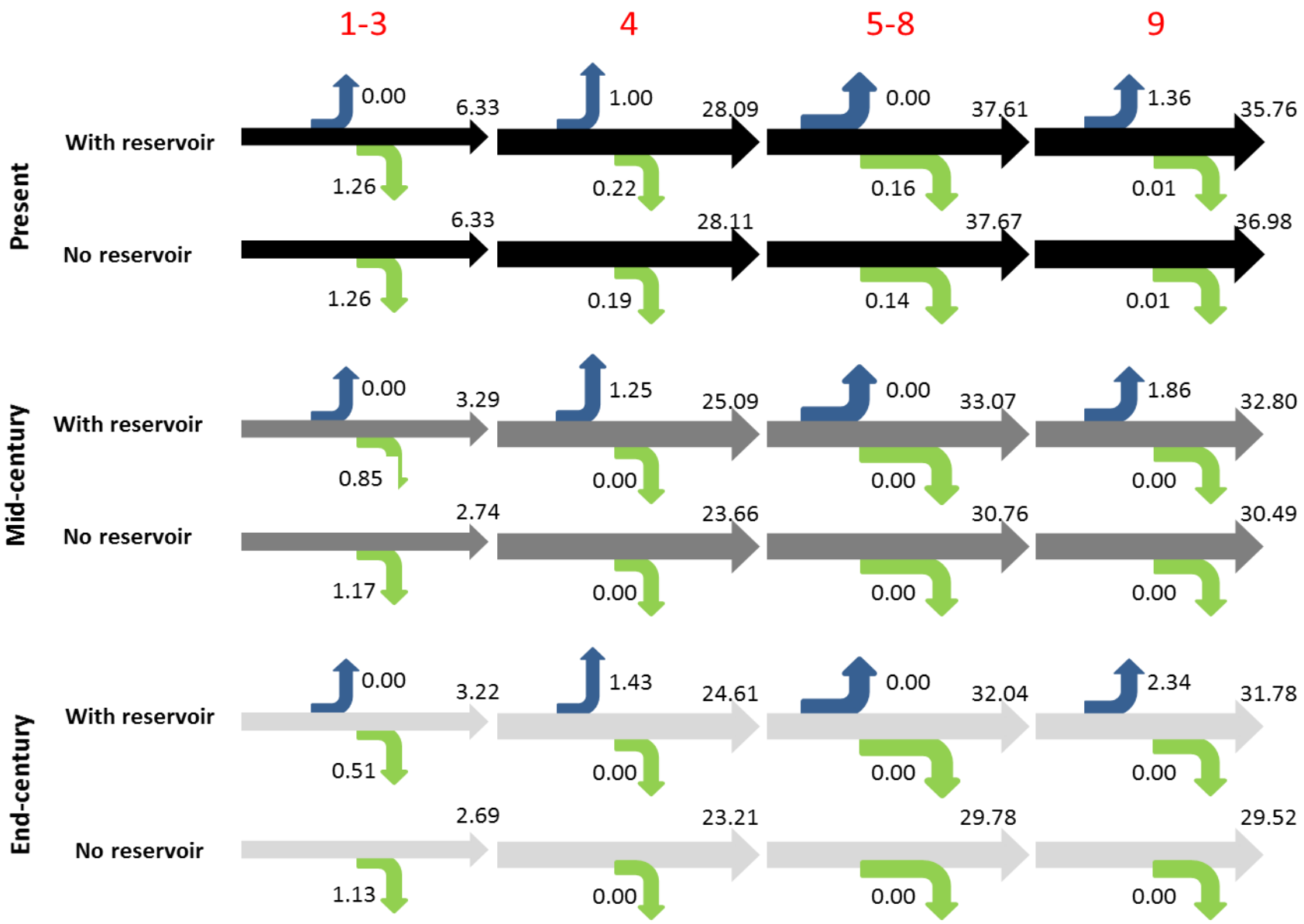


Details from Devoll, Albania

The river basin schematically presented



The water losses, Devoll



Concluding remarks - 1

- The large reservoirs upstream of Kargi HP and Derbent HP reduce the available water for power production and utilization time. Reasons: evaporation losses from reservoir and irrigation
- In Kizilirmak, the water consumption from irrigation is in the range 2-4 times larger than the gross evaporation losses from reservoir surfaces.
- Irrigation located in the upstream part of Kizilirmak River Basin is a direct threat to the power generation is the middle and lower part. Future development of new reservoirs in the upper part of the basin, even though built for the purpose of hydropower generation, might further reduce the available water resources for power production in the lower part.
- The reservoirs in Devoll clearly extend the utilization time of the power plants in this basin.
- The risk of losing water to irrigation seems limited in Devoll.
- The priorities defined for the various water use (e.g. environmental flow and other water use) very important to consider.

Concluding remarks - 2

Reservoirs can potentially improve, or reduce, the availability of water for hydropower production, depending on factors such as:

- The location of the reservoir in the river basin compared to other water uses, such as irrigated agriculture.
- The volume of the increased evaporation from the reservoir surfaces.
- The actual operation of the reservoir, i.e. timing of the filling and release.
- The priority among the water uses in the river basin and their internal location within the regulated system.
- The location and volume of the irrigation withdrawal, as the irrigation will normally benefit from upstream regulation of flow, enabling larger withdrawals of water and obtaining a higher degree of demand coverage in this sector

Hva med framtiden og magasinene?

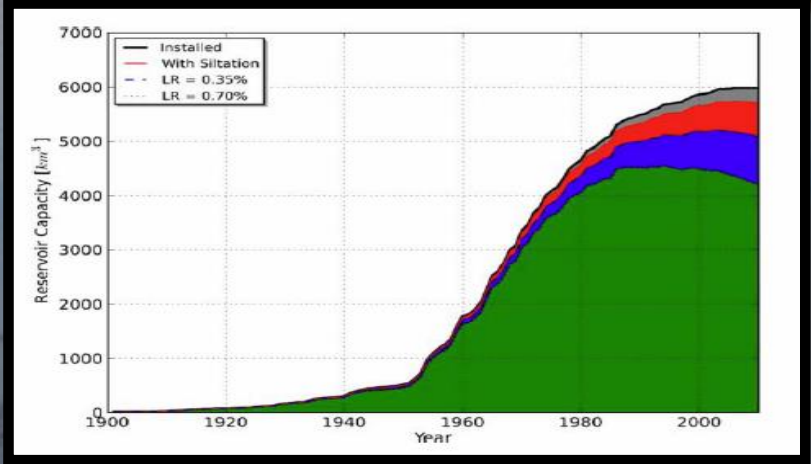
Klimaendringene kommer:

- Mindre nedbør?
- Mer intens nedbør/avrenning?
- Høyere fordampning?

Endring i forbruk/bruk:

- Flere mennesker på jorda
- Behov for mer mat/økt irrigasjon
- Tydeligere miljøkrav
- Flere flerbruksanlegg
- Mer kompleks kamp om ressursene

Verdens lagerkapasitet minker



Kilde: Wisser et al., 2013

Hva med framtiden og magasinene?

Stort mulig utfallsrom

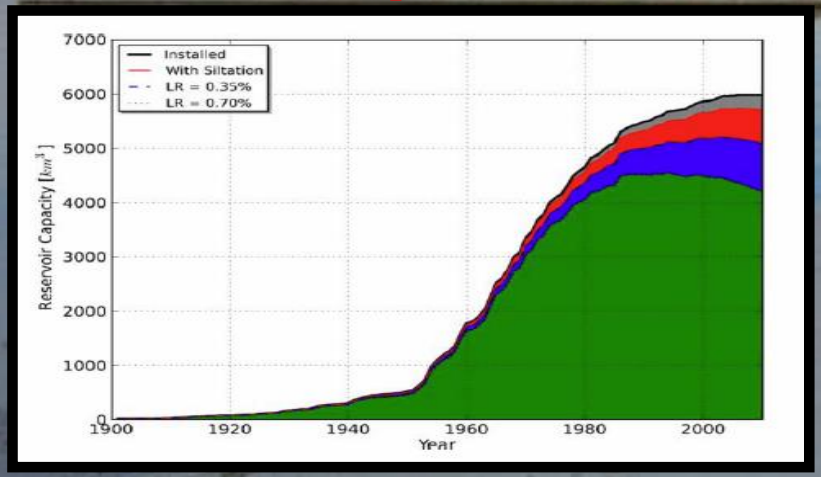
Klimaendringene kommer:

- Mindre nedbør?
- Mer intens nedbør/avrenning?
- Høyere fordampning?

Endring i forbruk/bruk:

- Flere mennesker på jorda
- Behov for mer mat/økt irrigasjon
- Tydeligere miljøkrav
- Flere flerbruksanlegg
- Mer kompleks kamp om ressursene

Verdens lagerkapasitet minker



Kilde: Wisser et al., 2013

Planlegging og bruk av framtidens vannressurser: en oppgave med enormt stort utfallsrom

Owen's Lake, California

Robuste planverktøy som tar hensyn til:

- Klima/hydrologi
- Endringer i vannbruk
- Politiske/samfunnsmessige forhold
- Andre uforutsette hendelser

-> Planlegging gjennom dialogbasert prosess





www.cedren.no

SINTEF

NTNU
100 skapende år

NINA
Norsk institutt for naturforskning

NATURHISTORISK MUSEUM
UNIVERSITETET I OSLO

NIVA

uniResearch