Reservoirs in world's water towers: Need for appropriate governance processes to reach Sustainable Development Goals

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Mountains as ‘water towers of the world’

- Provide runoff in the lowlands’ low flow season (snow- and glacier melt)

- Play an important role for SDGs
  → water, food, energy

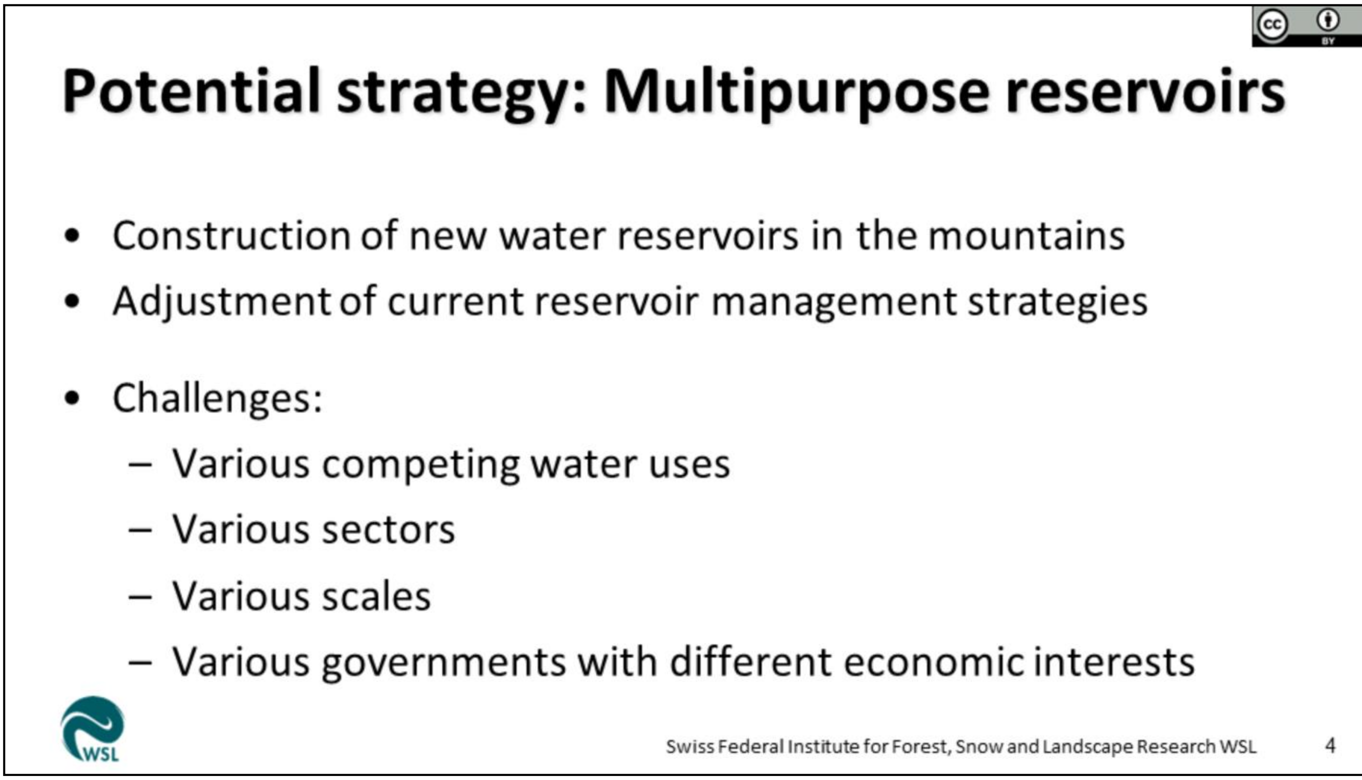
Mountains play an essential role in storing water and providing it to downstream regions and are therefore commonly referred to as ‘water towers of the world’. In particular, they provide runoff in the lowlands’ low flow season by contributing snow- and glacier melt. Mountain runoff thus plays an important role in achieving the UN Sustainable Development Goals (SDGs), in particular regarding water, food, and energy.

‘Water towers’ under climate change

- Retreat and volume loss of glaciers
- Rising snow lines
- Changes in precipitation amount and variability

→ Mountains’ water provision service strongly challenged

The mountains’ water provision service is strongly challenged by climate change leading to the retreat and volume loss of glaciers, rising snow lines, and changes in precipitation amount and variability.



One potential strategy for addressing these changes is the construction of new water reservoirs or the adjustment of current reservoir management strategies. These strategies need to take account of various, eventually competing water uses rooted in different sectors relevant at different scales and governments with different economic interests.

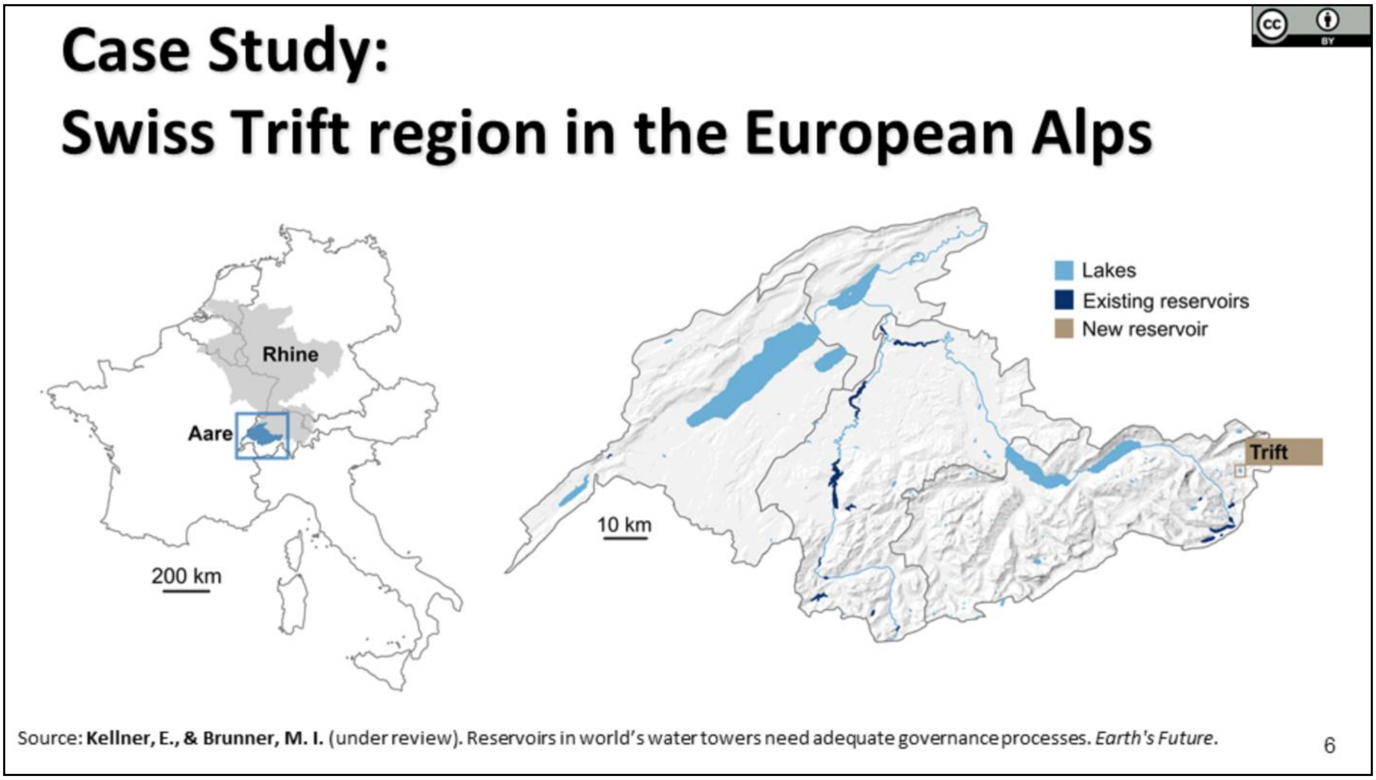
Research Question

How do governance processes lead to a coordination gap between an upstream reservoir and downstream water shortage?

Source: **Kellner, E., & Brunner, M. I.** (under review). Reservoirs in world's water towers need adequate governance processes. *Earth's Future*.

Our study assesses the governance processes related to the planning of a future reservoir in one of the most important water towers of the world, the European Alps.

We ask how governance processes lead to a coordination gap between an upstream reservoir and downstream water shortage.



To do so, we look at a case study in the Swiss Alps, the region Trift, which has recently been deglaciated and lies in the upper part of the Rhine basin.

The upstream part of the case study region is mountainous and only sparsely populated, while the downstream part is used for industry and agricultural crop production thanks to its flat topography and fertile soils. The Trift reservoir is hydrologically connected to its downstream region and the Rhine catchment via the river Aare, which provides significant ice melt contributions to the Rhine, which are particularly important in dry years. The hydrological regimes of the catchments in the upper Aare basin are characterized by glacier- and snowmelt processes and therefore high flows in summer and low flows in winter. In contrast, the hydrological regimes of the downstream catchments are rainfall-dominated with generally wet winters and dry summers. In this dry season, the downstream catchments therefore rely on inflow from the runoff-rich upstream catchments.

Qualitative and quantitative methods

- **Qualitative**: Analysis of how decision-making emerged in the governance processes of the upstream reservoir
  - Qualitative case study approach
  - 25 semi-structured interviews; document analysis
  - Qualitative content analysis
- **Quantitative**: Assessment of future hydrological conditions in the downstream region of the reservoir
  - Simulation of current and future streamflow using the hydrological model PREVAH
  - Estimation of water demand for different sectors: drinking, industry, agriculture, hydropower, and ecology
  - Estimation of current and future water scarcity (supply minus demand)

Further details: Brunner et al. (2019):
https://www.sciencedirect.com/science/article/pii/S0048969719306576?via%3Dihub

7

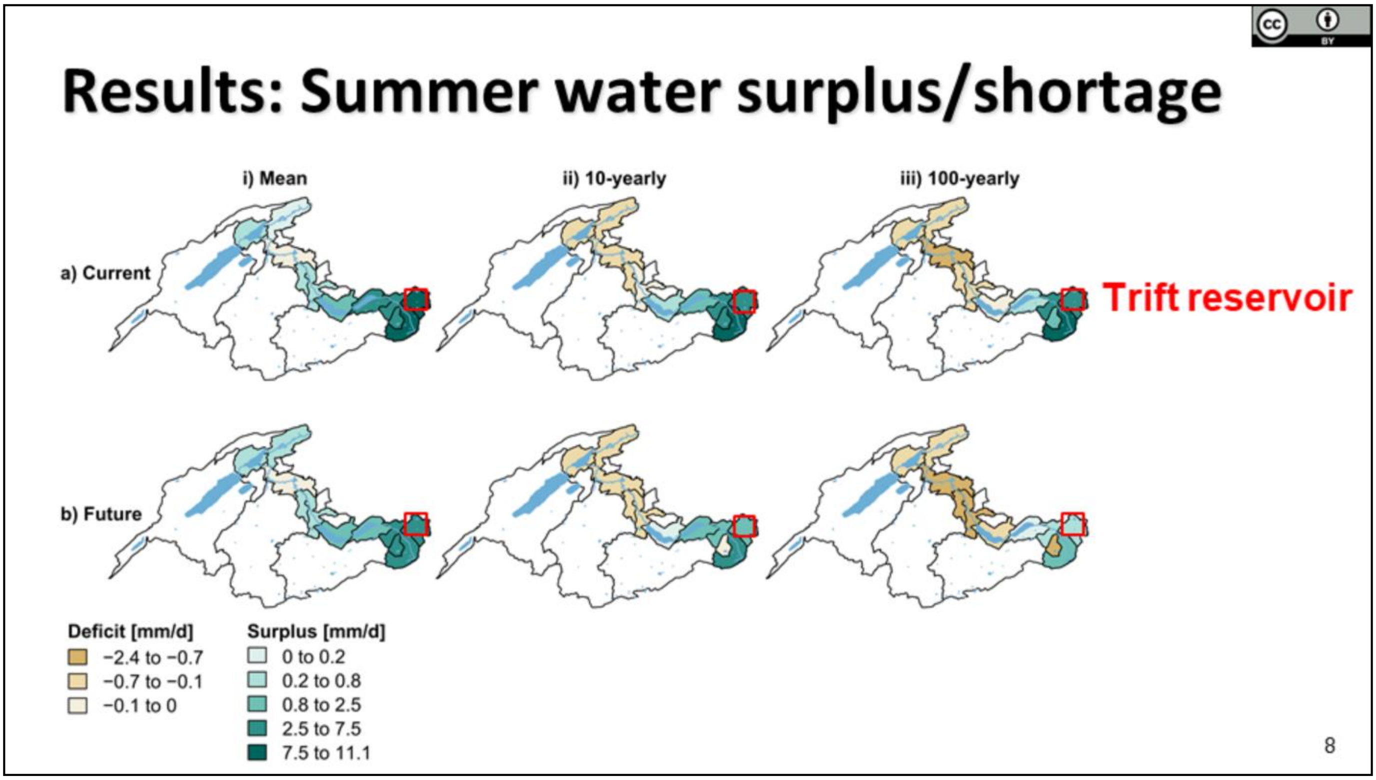
We combined qualitative and quantitative methods to analyze how decision-making emerged in the governance processes of the upstream Trift reservoir and to assess future hydrological conditions in the downstream region of the reservoir.

To analyze the governance processes in developing the concession for the Trift reservoir, we used the Institutional Analysis and Development (IAD) framework. The focal point of the IAD framework are action situations, which can be both physically and institutionally shaped. The factors shaping action situations can be biophysical conditions such as hydrological conditions; socio-economic conditions; and rules-in-use, which include formal and informal rules.

Governance processes, socio-economic conditions, and the rules-in-use were assessed by collecting empirical data. The data collection included 25 semi-structured face-to-face interviews. Additional information sources included: participatory observations of meetings, document analyses of legal materials (laws, regulations, concessions, and national, cantonal and regional strategies), and reviews of grey literature on the case (including administrative and NGOs reports and newspaper articles). The interviews were transcribed and data analyses followed the general principles of qualitative content analysis.

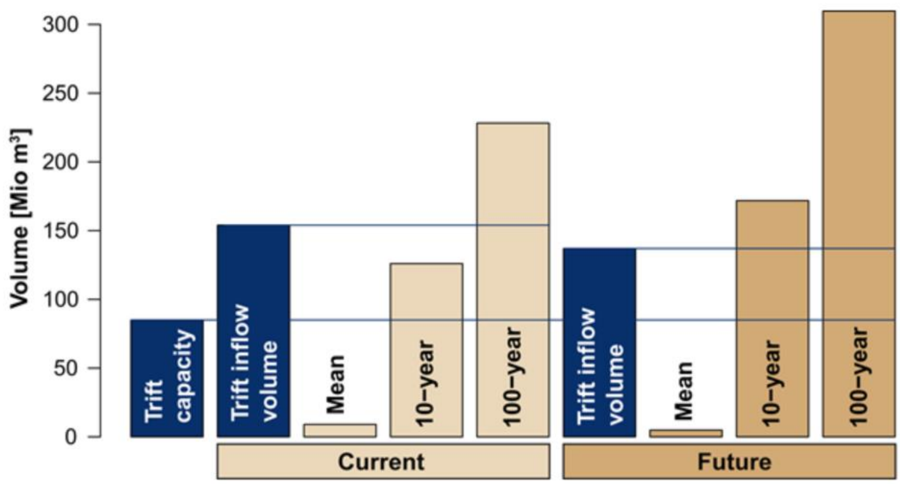
For the analysis of the hydrological conditions, we used the hydrological model PREVAH for the simulation of current and future streamflow. We estimated the water demand for different sectors: drinking, industry, agriculture, hydropower, and ecology. Based on that, we identified areas where water shortage could develop, i.e. where water demand exceeds water supply. We then looked at whether the downstream water demand could be covered by water supply from the planned reservoir.

(Further details on the quantitative analysis: Brunner et al. (2019):
https://www.sciencedirect.com/science/article/pii/S0048969719306576?via%3Dihub)



The biophysical conditions are summarized in terms of current and future summer water surplus/shortage for eleven stretches along the river Aare in order to show the changes in surplus/shortage while moving from the upstream to the lowland region. The gradients in surplus/shortage estimates under mean conditions ranged from a water surplus of 10 mm/d in the upstream region to a water shortage represented by slightly negative values in the downstream part of the catchment. The slight shortage under normal conditions became more severe when focusing on extreme conditions. In the case of a 10-yearly shortage event, the greatest part of the downstream region was found to be affected by water shortage both under current and future conditions. This shortage was projected to become even more severe in the case of a 100-yearly event.

Results: Water contribution of the reservoir



Storage and inflow volume of the Trift reservoir vs. the expected summer shortage for the downstream region

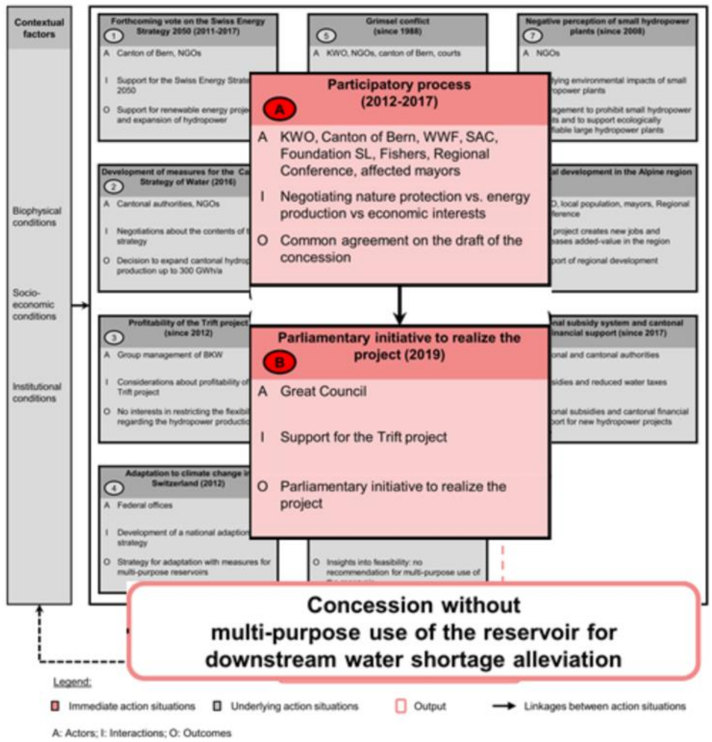
9

To assess whether the capacity and inflow of the Trift reservoir are potentially sufficient to cover downstream summer shortage, the storage capacity of the Trift reservoir and its estimated current and future inflow volume were compared to the regional downstream deficit volume. The estimated downstream shortage under current and future mean conditions was found to be much smaller than the storage capacity of the Trift reservoir. The 10-yearly downstream water shortage was under current and future conditions found to be twice the storage capacity of the Trift reservoir but equal to the annual inflow to the reservoir. In contrast, the 100-yearly downstream shortage was under current and future conditions estimated to be three times as high as this storage capacity and twice the total expected inflow volume of the reservoir.

These findings indicate that the water available in the Trift reservoir would be sufficient to cover current and future regional downstream water shortage, partly, even under extreme conditions.

(The results presented in this study were not available for decision-makers and did therefore not influence the decision-making.)

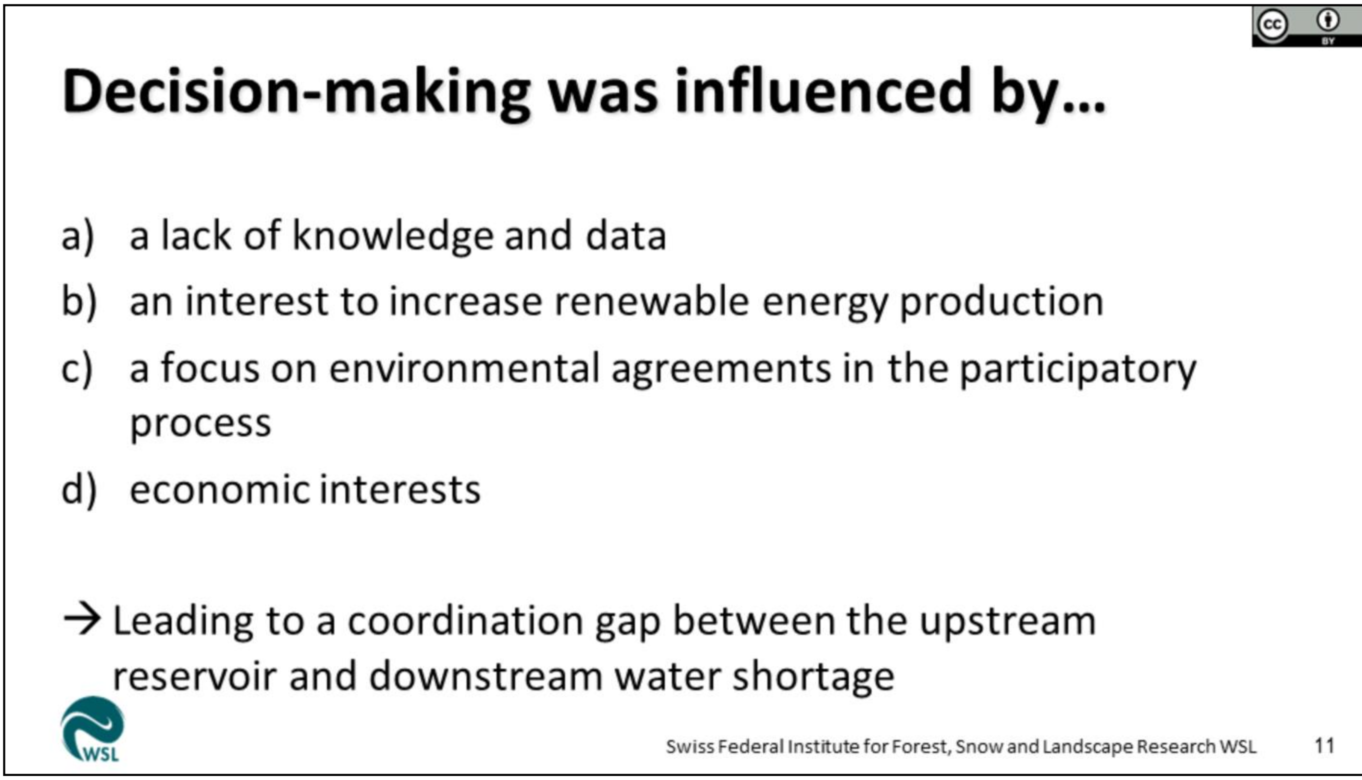
Results: Governance Processes



10

Such water transfers from highland to lowland catchments would require a multi-purpose management of the Trift reservoir, which would have to be formalized in its concession. However, such a multi-purpose management is not part of the draft of the concession. Our results show that the decision not to integrate drought management in the concession emerged as a result of eleven interdependent processes of social interaction within the Trift area and in adjacent action situations.

The social interactions within two action situations had immediate relevance for decision-making: (A) the participatory process and (B) the parliamentary initiative.



Four main factors influenced the decision in favour of hydropower production - instead of a multi-purpose use:

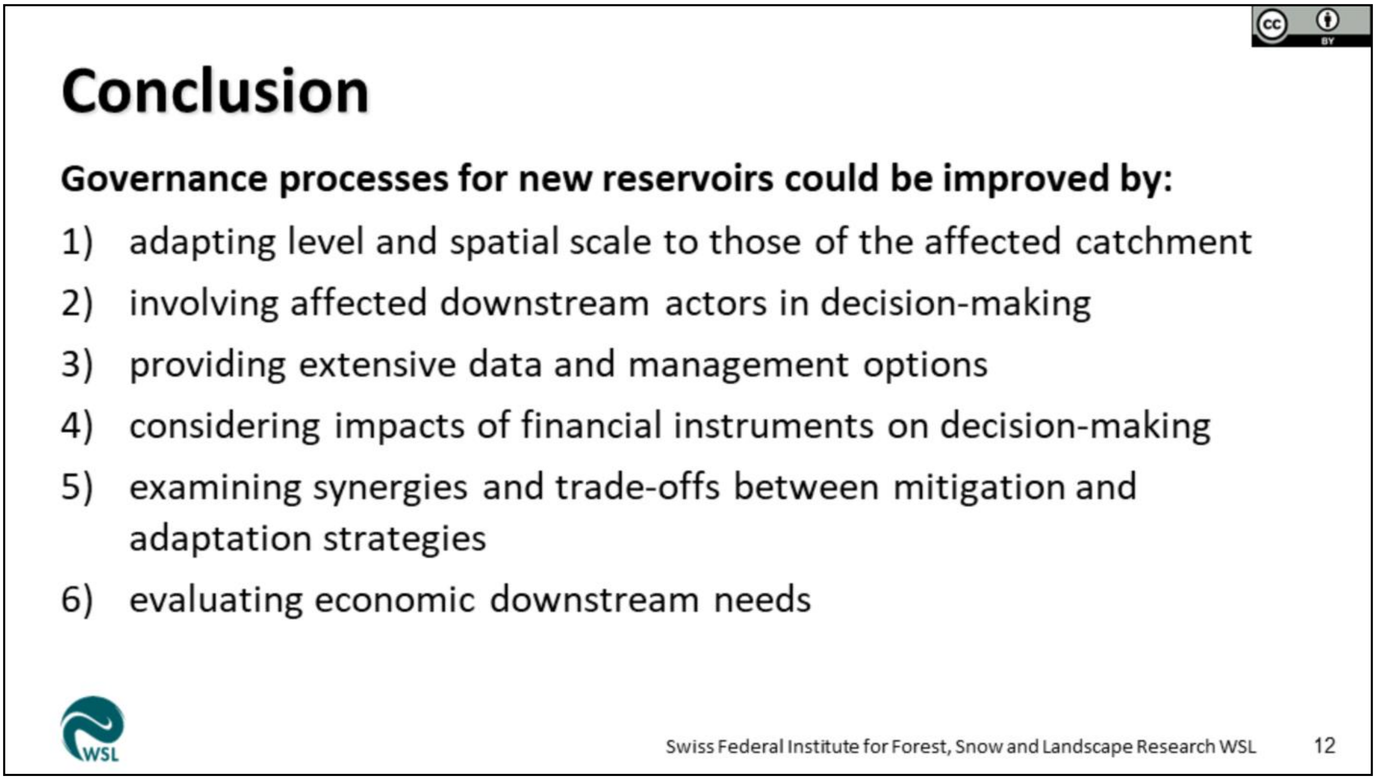
(1) a lack of knowledge, awareness and available data about future downstream water shortages,

(2) a strong interest in phasing-out nuclear energy and increasing renewable energy production,

(3) a focus on reaching consensus on environmental issues with the NGOs in the participatory process, and

(4) strong economic interests in hydropower production.

The resulting concession without the consideration of drought management leads to a coordination gap between the upstream reservoir and downstream water shortage.



We conclude that immediate action is required towards balancing upstream and downstream water needs in governance processes.

Such balancing can be achieved by improving governance processes for new reservoirs by:

(1) adapting their level and spatial scale to those of the affected catchment,

(2) involving affected downstream actors in decision-making,

(3) providing extensive data on the biophysical conditions at a relevant scale for current and future drought scenarios and management options for multi-purpose reservoirs,

(4) considering impacts of financial instruments, such as national subsidies, on decision-making,

(5) examining synergies and trade-offs between mitigation and adaptation strategies and other trade-offs, when addressing the potential contributions of a reservoir in a long-term perspective, and

(6) valuating economic downstream needs.

It is essential that the future sustainable management of reservoirs for the world's important and vulnerable water towers, considers both upstream and downstream water needs to reach the UN Sustainable Development Goals. Such an integration of different water uses in the planning of new reservoirs needs to be tackled through integrative polycentric governance processes with state and non-state actors across scales.

Kellner, E., & Brunner, M. I. (under review). Reservoirs in world's water towers need adequate governance processes. *Earth's Future*.