The Effects of Hydropower Plants on River Ecosystem Services

ENVIRONMENTAL VALUATIONS NEEDED FOR THE IMPLEMENTATION OF THE ENERGY STRATEGY 2050

- **Energy Strategy 2050:** the Swiss Federal Office of Energy (SFOE) plans to increase the yearly hydropower production from currently 36’300 to 38’600 gigawatt hours in 2050, by modernizing or expanding existing hydropower plants, or constructing new ones
- The **impact of hydropower on river ecosystems** needs to be evaluated
- The role of river **ecosystem services** for human well-being needs to be considered
- **Environmental valuations** are proposed as a tool for informed decision-making

Increasing role of hydropower in Switzerland

In Switzerland, the demand for electricity has multiplied by the factor 6 since 1950 (Fig. 2). Today, 56% of the produced energy comes from hydropower. Additionally, with 97%, it covers almost the whole proportion of electricity production coming from renewable sources. Therefore, hydropower can be defined as the most important renewable energy source in the country.

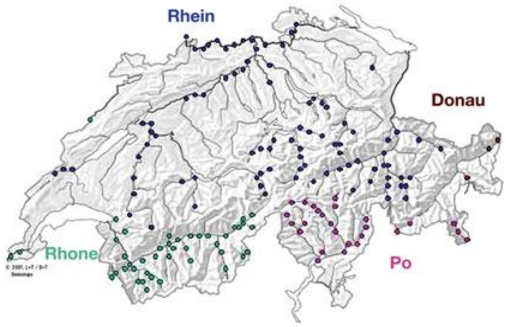


Figure 1: Hydropower plants in Switzerland (www.swv.ch)

Benefits of hydropower:

- 56% of Switzerland’s energy supply is produced by hydropower
- It is a renewable energy source
- Continuous fresh water supply
- Flood regulation
- Recreational opportunities

In Switzerland, only about 10 % of the water bodies are still natural or unused, therefore they are very precious and need to be protected. At the same time, the SFOE aims to increase hydropower production even more in the near future (from 36’300 to 38’600 gigawatt hours per year) within the framework of the *Energy Strategy 2050*. This increase requires not only the expansion of already existing hydropower plants but also the construction of new installations. As a consequence, there will be more pressure on the already used as well as on yet still unused river ecosystems.

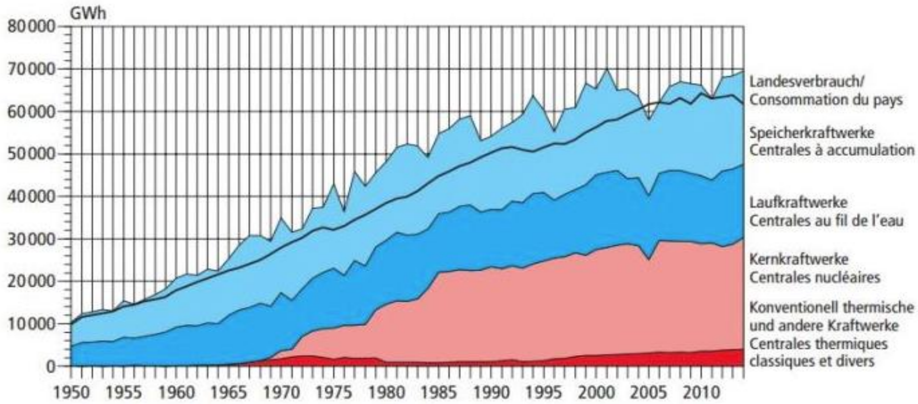


Figure 2: The demand for electricity (black line) and the contribution of hydropower (blue) in Switzerland from 1950-2014 (BFE, 2015, www.swv.ch)

Why do we need to take ecosystem services into account?

"All ecosystems are shaped by people, directly or indirectly and all people, rich or poor, rural or urban, depend on the capacity of ecosystems to generate essential ecosystem services. In this sense, people and ecosystems are interdependent social-ecological systems" (Aronson *et al.*, 2015)

The ecosystem service approach has been widely recognized since the Millennium Ecosystem Assessment (MEA, 2005), especially among policy makers, conservationists and scientists. Figure 3 shows an analytical framework of ecosystem services based on the Common International Classification of Ecosystem Services (CICES) and how they influence human well-being.

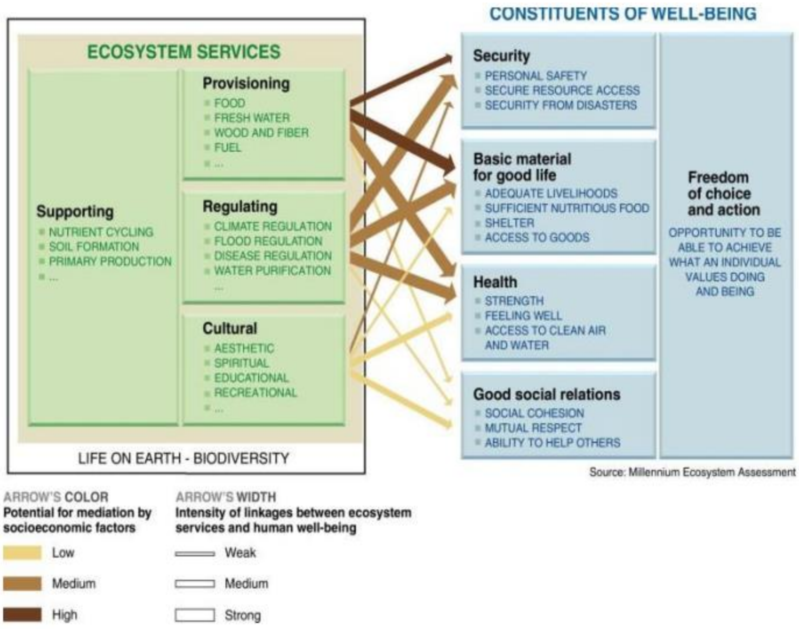


Figure 3: The simple framework of the MEA (2005) to (left) categorize Ecosystem Services and (right) how they contribute to human well-being (Vermaat et al., 2013).

Rivers and the ecosystem services approach

Definitions:

Natural capital: consists of all components of the natural environment that provide a long-term stream of ecosystem services benefiting human welfare.

Ecosystem services: the benefits obtained from an ecosystem that increase human well-being (MEA, 2005).

Total economic value (TEV): the summed value of the ecosystem service benefits provided in a given state.

First and foremost, in Switzerland, only about 10 % of the water bodies are still natural or unused, therefore they are very precious and need to be protected according to the BAFU. From an economic perspective, river ecosystems and biodiversity can be seen as **natural capital**, and this capital generates a constant flow of **ecosystem services** to people (Costanza and Daly, 1992). Table 1 summarizes the most important ecosystem services provided by an undisturbed river ecosystem.

In order to ensure a long-term provision of these services to our society, the **total ecological value** of a river ecosystem needs to be considered when taking decisions about its management. Environmental valuations can be a useful tool to assess the value of undisturbed river ecosystems, and serve as a holistic tool for informed decision-making. In the context of the Energy strategy 2050, environmental valuations can be used to calculate the costs and benefits of different management options for river management.

Table 1. The CICES classification of ecosystem services based on the broad MEA types (Vermaat et al., 2013; adapted from Weber, 2011)

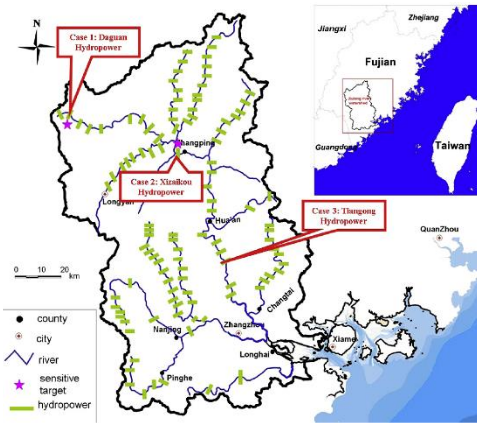
MEA type	Class	Generic examples
Provisioning	Nutrition	Plant and animal food stuffs, potable water
	Materials	Biotic and abiotic materials
	Energy	Renewable bio-fuels, renewable abiotic energy sources (hydropower, wind, tidal)
Regulation (and maintenance)	Regulation of wastes	Bioremediation, dilution, sequestering
	Flow regulation	Flow of air, water or mass
	Regulation of the physical environment	Atmospheric, water quality, soil quality
	Regulation of the biotic environment	Life cycle maintenance and habitat protection, pest and disease control, gene pool protection
Cultural	Symbolic	Aesthetic, heritage, religious and spiritual
	Intellectual and experiential	Recreation and community activities, information and knowledge

Arguments for considering environmental valuations in decision-making

"Just as private investors choose a portfolio of capital to manage risky returns, we need to choose a level of biodiversity and natural capital that maintains future flows of ecosystem services in order to ensure enduring environmental quality and human well-being*…"* (TEEB 2010)

- Sustainable development requires a holistic approach (integrating economic, socio-cultural and environmental arguments) (Costanza, R. 1992).
- Environmental valuations allow a traceable and transparent justification for the decisions of policy makers.
- They are based on scientific data provided by environmental economists.
- It lowers the risk of underestimating the complexity of the problem and the impact of any decision. Services provided by ecosystems are usually interlinked; when an ecosystem is managed mostly by focusing on one service "other services are nearly always affected negatively" (Aronson *et al*., 2015).
- Future generations require us to take the ecosystem services approach into account. *"We do not inherit the earth from our ancestors; we borrow it from our children*" (famous Native American proverb).
- Environmental valuations can provide an opportunity to measure the impact of the decision made by the community. Namely the "option value" generated by the TEV, is key to verify that our decision has no regime shift in the ecosystem with irreversible negative consequences for human well-being (Aronson *et al*., 2015).

A case study example - Valuing the effects of hydropower development on watershed ecosystem services:



A study done by researchers in China used different valuation methods of selected ecosystem service categories and indicators. This analytical framework was applied to case studies to evaluate the effect of three hydropower plant projects in the Jiulong river watershed (Wang et al. 2009). At the same time, they calculated the benefits of hydropower development and compared the two.

Figure 4: The location of the three hydropower projects in the Jiulong river watershed.

What the study shows:

- Biodiversity loss and water quality degradation were the major negative impacts on watershed ecosystem services caused by hydropower projects.
- The negative impacts on watersheds are too high to be neglected.
- There is a considerable average environmental cost (0.206 Yuan/kW h), which cannot be covered by the existing water resource fee in China.
- For sustainable hydropower development, there is a need for new methods such as compensatory payments for ecosystem services

How to target the best outcome? The social-ecological problem

Hydropower plants have several impacts on river ecosystems by altering water flow and creating obstacles for aquatic species living in the affected water system. As a result, not only biodiversity and ecology of these systems are threatened but also the provision of the ecosystem services linked to them. Therefore, hydropower plants should be modernized and built in an environmentally friendly way to mitigate negative effects on the environment. This consequently also benefits the society by ensuring the provision of ecosystem services. While doing so, costs and benefits should be evaluated in order to find the best mitigation options for hydropower plants:

- Modernizing existing plants: by upgrading them to gain back some of the benefits of river ecosystem and making them more performant,
- Expanding existing plants: by upgrading them to be more performant so as not to affect other river ecosystems,
- Building new modernized plants: to achieve the goal of producing more energy while still lowering the impact of hydropower plants on river ecosystem.

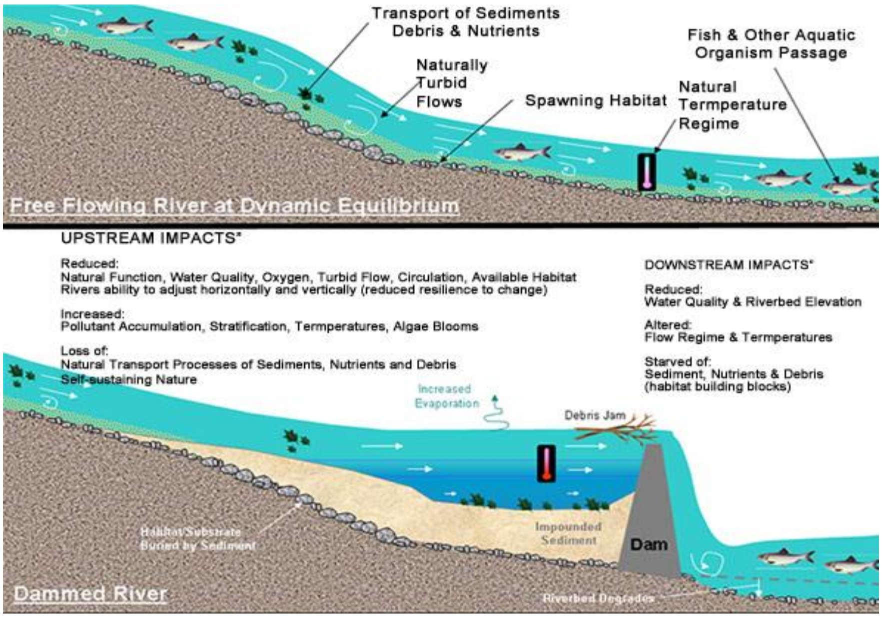


Figure 5: The potential effects of hydropower plants on river ecosystem services (www.geo41.com).

Conclusion

- Because 90% of Switzerland's rivers are already degraded, the conscientious planning of hydropower plants is all the more important
- Valuations of river ecosystems must not only happen on a regional scale, but also on a national or international scale
- When considering different options for expanding the hydropower capacity, environmental valuations must always be part of the cost benefit analysis
- The ecosystem services approach is the best way to make informed decisions in the policy making process

Sources

Costanza, R. & Daly, H.E. (1992). Natural Capital and Sustainable Development. Conservation Biology. 6(1):37-46

Guihua Wang, Qinhua Fang, Luoping Zhang, Weiqi Chen,, Zhenming Chen, Huasheng Hong. (2009). Valuing the effects of hydropower development onwatershed ecosystem services: Case studies in the Jiulong RiverWatershed, Fujian Province, China. Estuarine, Coastal and Shelf Science 86 (2010) 363–368. doi:10.1016/j.ecss.2009.03.022

James Aronson, Leon Braat, John Gowdy, Roy Haines-Young, Edward Maltby, Aude Neuville, Stephen Polasky, Rosimeiry Portela, Irene Ring. (2015) The economics of ecosystems and biodiversity. Chapter 2, p4.

Jan Vermaat , Erik Ansink , Marta Catalinas Perez , Alfred Wagtendonk , Roy Brouwer. (2013) Valuing the ecosystem services provided by European river corridors – an analytical framework. REFORM Deliverable 2.3.

Millennium Ecosystem Assessment (MA) (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

TEEB (2010). Chapter 5: The economics of valuing ecosystem services and biodiversity. In The Economics of Ecosystems and Biodiversity: ecological and economic foundations. Kumar, P. (ed.), Earthscan, London and Washington. Available at http://www.teebweb.org/our-publications/teeb-study-reports/ecological-and-economic-foundation