# POWER PRODUCTION VS RIVER GOOD STATUS: HYDROpot_integral as a tool to simultaneously assess hydropower potential and ecological potential

PRODUCTION D'ÉNERGIE VS BON ÉTAT DE LA RIVIÈRE : HYDROpot_integral comme outil pour évaluer simultanément le potentiel hydroélectrique et le potentiel écologique

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## RÉSUMÉ

L'hydroélectricité est l'épine dorsale de la production d'électricité en Suisse et joue un rôle clé dans la stratégie de transition énergétique. Cependant, l'hydroélectricité a un impact considérable sur l'environnement et il existe des contradictions entre la protection des habitats et des écosystèmes et la production d'énergie renouvelable respectueuse du climat. L'évaluation de l'impact environnemental et sa comparaison avec l'importance de l'hydroélectricité ne sont toujours pas normalisées. En considérant cinq bassins versants à méso-échelle, nous utilisons HYDROpot_integral comme un outil global pour évaluer si un tronçon de rivière est approprié pour l'utilisation de l'hydroélectricité ou quelle est sa valeur de protection. Sur la base de géodonnées écologiques et socio-économiques, une valeur correspondante est attribuée à l'état actuel de chaque tronçon de rivière et à son potentiel hydroélectrique. HYDROpot_integral sert d'outil d'aide à la décision: la limite entre l'utilisation de la force hydraulique et la protection est ajustable et permet la création de scénarios.

## ABSTRACT

Hydropower is the backbone of Switzerland's electricity production and plays a key role in the energy transition strategy. However, hydropower does have a considerable impact on the environment and there are contradictions between habitat and ecosystem protection and climate friendly renewable energy production. The assessment of the environmental impact and its comparison with hydropower importance is still not standardized. By looking at five mesoscale catchments, we use HYDROpot_integral as a global tool to assess whether a river reach is suitable for hydropower use or what its protection value is. Based on ecological and socio-economic geodata, both the current state of each river reach and the hydropower potential is assigned a corresponding value. HYDROpot_integral serves as a decision-making tool: the boundary between hydropower use and protection is adjustable and allows the creation of scenarios.

## KEYWORDS

decision making, ecosystem protection, GIS, hydropower, integral water management

# 1 POWER PRODUCTION VS RIVER GOOD STATUS

## 1.1 Introduction

The steadily growing demand for energy and the simultaneous pursuit of decarbonisation are increasing interest in the expansion of renewable energies worldwide. In Switzerland, various funding projects have been launched to promote technologies in the field of renewable energies and their application as quickly as possible. With the introduction of a funding instrument in 2009, the number of projects submitted to produce renewable energies increased rapidly. The applications for small hydropower plants (≤ 10 MW) were correspondingly numerous. However, the assessment of the environmental impact and its comparison with hydropower importance is still not standardized.

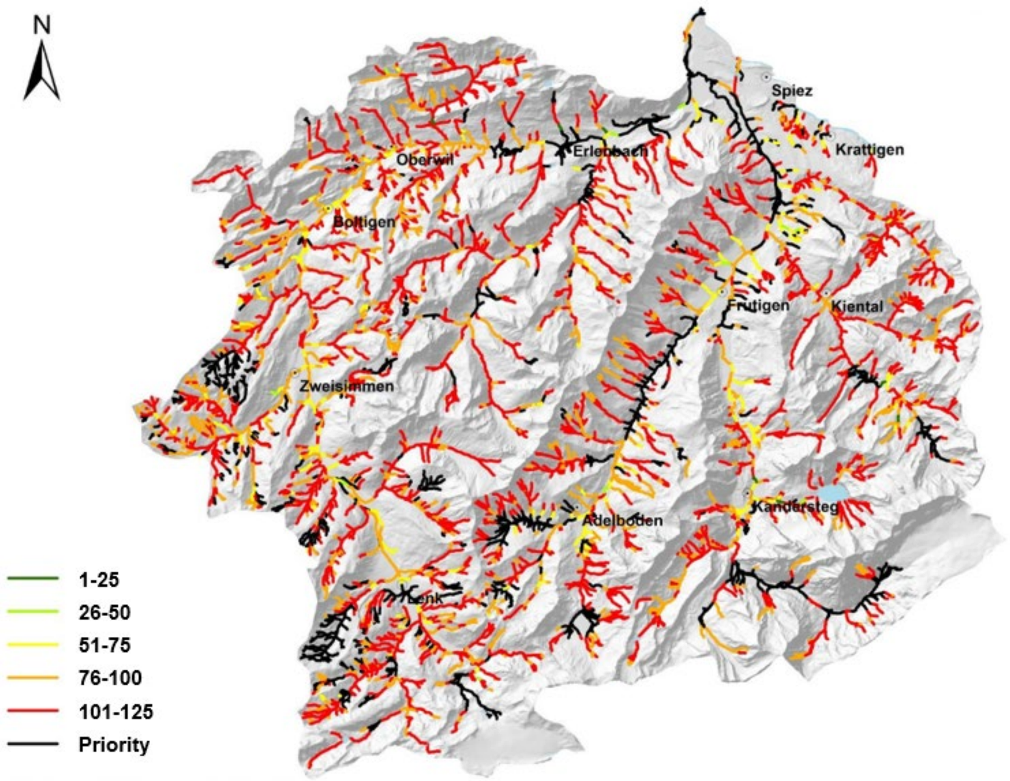
To provide a basis for decision-making, a methodology was developed to determine the overall hydropower potential of a region. A detailed assessment of each river reach, and the systematic and holistic assessment of small hydropower projects at a regional scale are combined here. The HYDROpot_integral methodology was developed as part of Carol Hemund's dissertation (2012) at the University of Bern. It allows the evaluation of river reaches holistically, regarding ecological, social, economic and cultural criteria. In particular, it is possible to classify river reaches into those that are more suitable for hydropower production (=”Use”) and those that are more suitable for protection.

## 1.2 Material and method

The method relies on 80 geodata sets. These must be available for the entire study area and be as up to date as possible. As diverse as the eco-system functions of a river reach are, as numerous are the required data sets. The holistic assessment is the key element of the entire assessment procedure. Its aim is to quantify the importance of the ecosystem functions in terms of services. In terms of length, rivers are divided into river reaches of a maximum length of 450 m, which corresponds to the average reach length in the ecomorphological assessment of Swiss rivers. The ecosystem functions are divided into three types: regulating, cultural and provisioning functions. Accordingly, the assessment of the functions is divided into three parts and three values are assigned to each river reach. The more functions there are and the greater their performance, the higher these values are and the more important the corresponding functions are. Hence, these values quantify the importance of the ecosystem functions and the ecological, cultural and economic ecosystem services of each river reach. The concatenation of ecosystem services results in a value that can occur in 125 different versions due to the chosen five-level value scale; i.e. each digit of the three-digit number sequence can be assigned a value between 1 and 5. Each of the 125 combinations, and thus each river reach, has its own characteristics determined by the assessments of the three function types. To record the suitability, the combinations are ranked according to their ecological, cultural and economic ecosystem services. These rules mean that the combination that is most suitable for hydropower production at minimum cost in terms of ecological and cultural ecosystem services is ranked first; rank 125 indicates the highest ecological and cultural ecosystem services and the lowest economic services and is therefore most suitable for protection (see Figure 1). A river reach that is excluded from hydropower use due to legislation, a so-called priority reach, is given rank 126 from the outset and specially marked. In our study, we look at five mesoscale test catchments from different biogeographical regions of Switzerland (Hirschi et al. 2013). We show the example of an Alpine catchment here (Figure 1 and 3). There is a high number of priority reaches but also river reaches more suitable for small hydropower use.

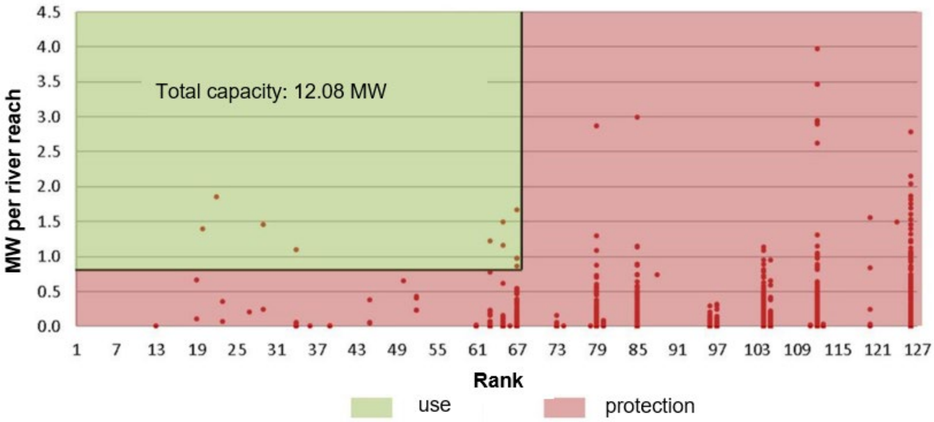
## 1.3 Results

The test catchment shown here (Figures 1) contains a large number of priority reaches (black), but also some reaches that have a relatively high hydropower potential.



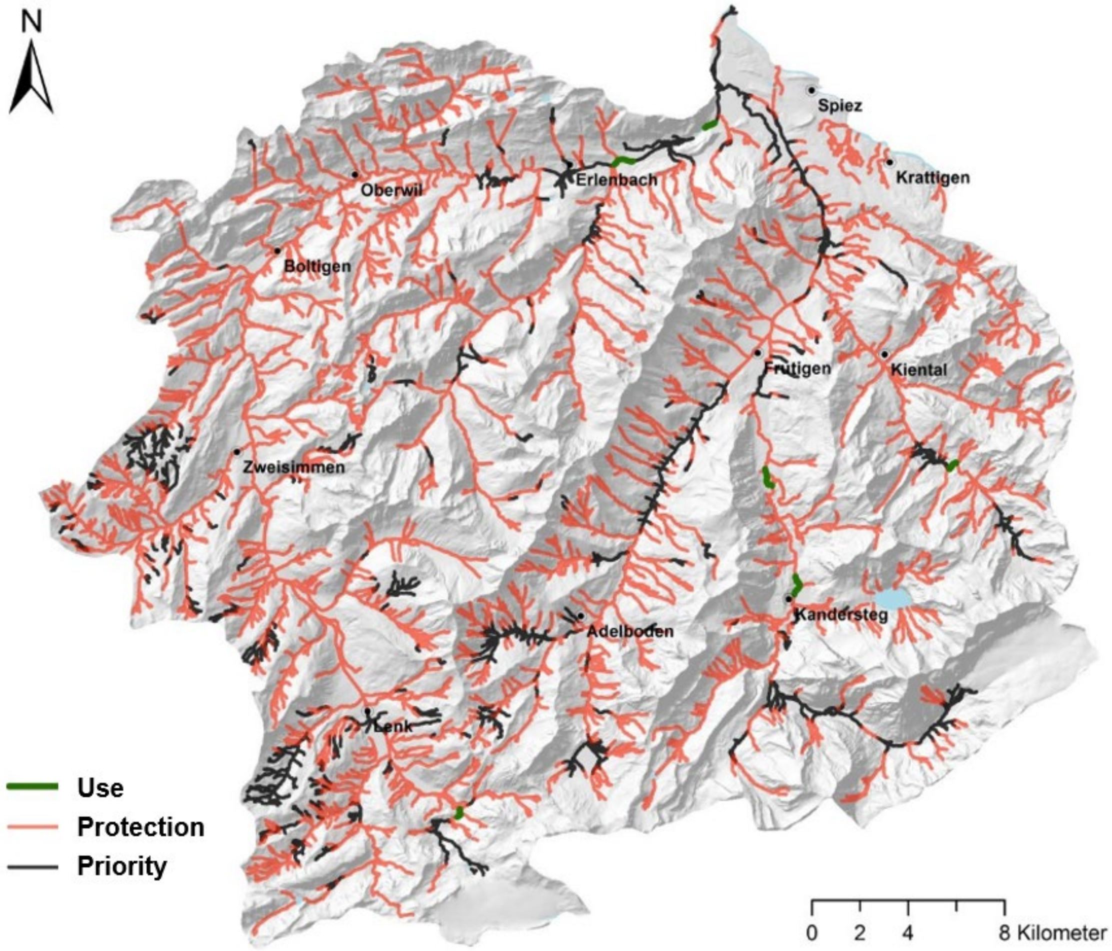

Quantification of ecological, cultural and economic ecosystem services in one of the five test catchments. Rank 1 is most suitable for hydropower production at minimum cost in terms of ecological and cultural ecosystem services; rank 125 indicates the highest ecological and cultural ecosystem services and the lowest economic services and is therefore most suitable for protection; the black ones exclude use by law.

There are more river reaches with higher ranks, indicating higher ecological and cultural ecosystem services and the lower economic services and therefore more suitable for protection (see Figure 2). If we set the rules at rank 67 and a capacity of at least 0.7 MW per river reach, this results in a total capacity of around 12 MW.




Comparison of ranks [1:125 & 126] and hydropower potential [MW]. The rules in this scenario are set at rank 67 and a minimum capacity of 0.7 MW per river reach. In green are the river reaches that are more suitable for hydropower use, the river reaches in red are more suitable for protection.

To achieve this capacity, eight river reaches, some are coherent, would have to be used (see Figure 3). However, this recommendation is problematic if we consider the green river reaches at the catchment outlet: These are exactly between two floodplains of national importance and have been designated as a priority reaches. Their use would conflict with the undiminished protection of these floodplains and would make power plant planning considerably more difficult. It is therefore important to aggregate the results over larger river reaches, to also stronger respect the disconnectivity.




The 12 MW scenario of the test catchment. A green river reach is more suitable for hydropower use, a red river reach is more suitable for protection and the black ones exclude use by law. The boundary between protection and hydropower use in this scenario is set at rank 67 and a minimum capacity of 0.7 MW.

## 1.4 Conclusion

The results from the five mesoscale test catchments show the feasibility of the present method, to provide comprehensive and meaningful bases that can support the decision-making process. The more diverse the river reaches to be assessed, the more differentiated the results become. Our analyses show that the HYDROpot_integral method can be applied in any region of Switzerland. By considering relevant ecosystem functions of rivers, the method leads to an integral assessment that meets the scientific quality criteria of reproducibility. Overall, the assessment method is to be understood as a flexible GIS-based working tool that makes it possible to present the protection and use of river reaches objectively and to make recommendations regarding hydropower potential. However, the method cannot conclusively assess the effective usability of the hydropower potential of individual river reaches. For this, detailed clarifications by appropriate experts or an environmental impact assessment are inevitable.

## LIST OF REFERENCES

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