CLIMATE CHANGE IMPACT ON SPATIAL AND TEMPORAL FISH HABITATS AVAILABILITY

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INTRODUCTION

The impact of climate change on aquatic ecosystems is a significant concern, especially with the accelerated influence of human activity. A lot of studies concentrate on the effects of climate change on the flow regime changes, as well as the impact of these changes on aquatic ecosystems. Moreover, the influence of human activity, such as hydropower plants (HPPs) operation is also widely investigated. However, the combined effect of mentioned factors on fish habitat availability downstream of the HPPs remains insufficiently investigated so far. This study complements the gap in knowledge of the potential joint impact of climate change and the operation of HPPs on fish habitat alterations in spatial and temporal scales.

STUDY AREA, DATA AND METHODS

Lithuania distinguishes by its three main hydrological responses to local physico-geographical features; therefore, Lithuania is divided into three main hydrological regions – Western (rainfall feeding is dominant), Central (rainfall and snowmelt feeding are dominant), and South-eastern (groundwater is dominant). Four river catchments (Verknė, Širvinta, Šešupė, and Bartuva) were chosen to cover each hydrological region of Lithuania (Figure 1).

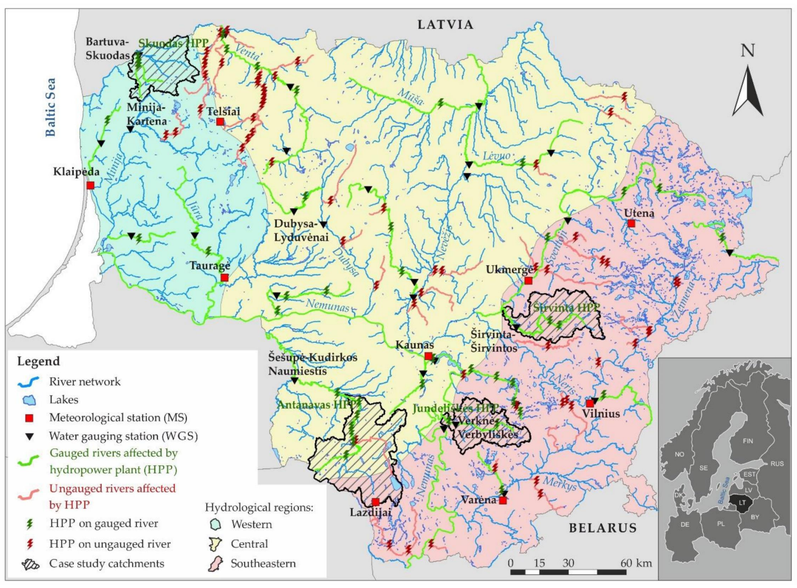

Figure 1. Study area and objects.

Hydrometeorological observations such as daily discharge data (Q, m^3/s), daily air temperature (T, °C), and daily precipitation amount (P, mm) were taken from hydrological and meteorological yearbooks of the Lithuanian Hydrometeorological Service. RCA4 regional climate model (RCM) based on three driving global climate models (EC-EARTH, HadG-EM2-ES, and MPI-ESM-LR) output of daily air temperature and precipitation amount were used for the future climate projections. The projections were simulated according to three RCP scenarios (optimistic - RCP2.6, realistic - RCP4.5, and pessimistic - RCP8.5) for the near (2021-2040) and far (2081-2100) future, as well as for the reference period (1986-2005). The daily output of meteorological data for the selected combinations of a regional climate model was extracted for 11 × 11 km grid cells from the EURO-CORDEX database.

The research involved five main stages of implementation. The first stage included the fundamental knowledge of regional differences to select reasonable pilot rivers to evaluate their potential changes in various hydrological environments. The second level covered the collection and preparation of initial data required to implement such kind of research. The third level was composed of the performance of the analysis. The fourth level involved the processing of mesoscale habitat modelling (modelling of ITH – index of temporal habitat availability) of the current situation using the MesoHABSIM (Parasiewicz et al., 2013) model and, in parallel, the streamflow simulation under climate change according to RCP scenarios.

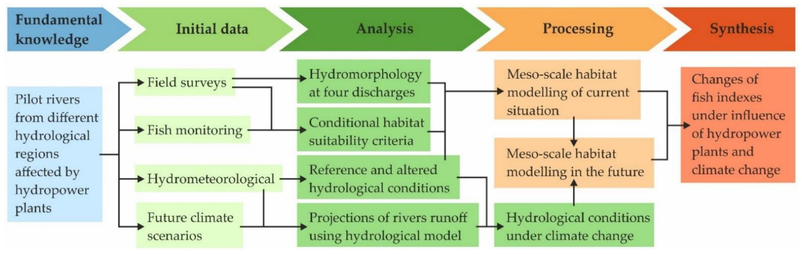

Figure 2. Workflow of this research.

RESULTS

The hugest changes were obtained for the Q_{30_min} and Q_{30_ave} situations compared to the reference period (Figure 3). The estimated deviations fluctuated between −60% and 40% for the Q_{30_min}, and in the range of ±20% for Q_{30_ave}. In the near future, the Q_{30_min} of Verknė River was almost unchanged. Whereas in the Šešupė River, the projected changes showed up to −30% deviation for all RCP scenarios. For the far future, the decrease of Q_{30_min} was projected for all rivers except Bartuva. The Bartuva was unique compared to the other rives because, in the near future, the increase of Q_{30_min} and Q_{30_ave}, and the decrease of Q_{30_ave} were estimated. Only the decrease of Q_{30_ave} values was projected for the Bartuva River in the near and far future.

Compared to the average ITH for all modelled fish species in a given river under a specific RCP scenario, the increase in the number of stress days when the area of habitat suitable for gudgeon and stone loach falls below the threshold compared to the reference period in the Širvinta and Šešupė rivers was relatively less than for other fish species under all climate change scenarios (Figure 4). Only in the Bartuva River, the relative increase in the number of stress days is similar for all fish species, except for the schneider, whose ITH values deviate to a greater extent depending on the climate change scenario.

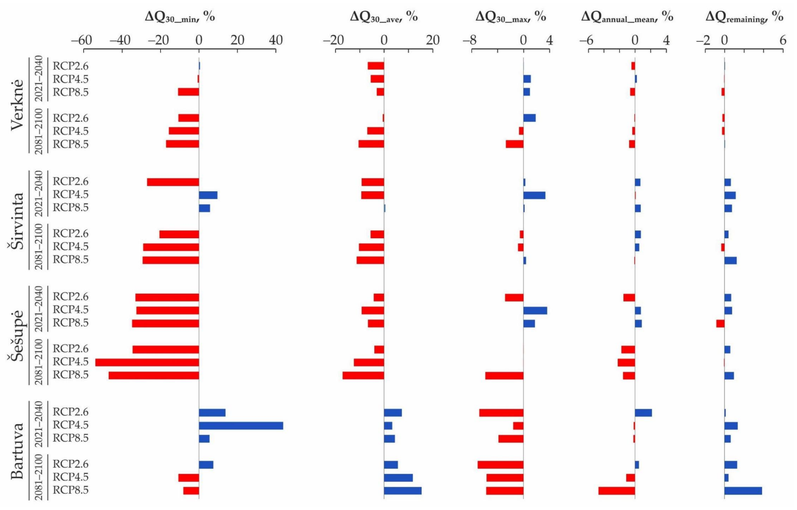

Figure 3. Deviations (%) of target discharges for near and far future according to different RCP scenarios.

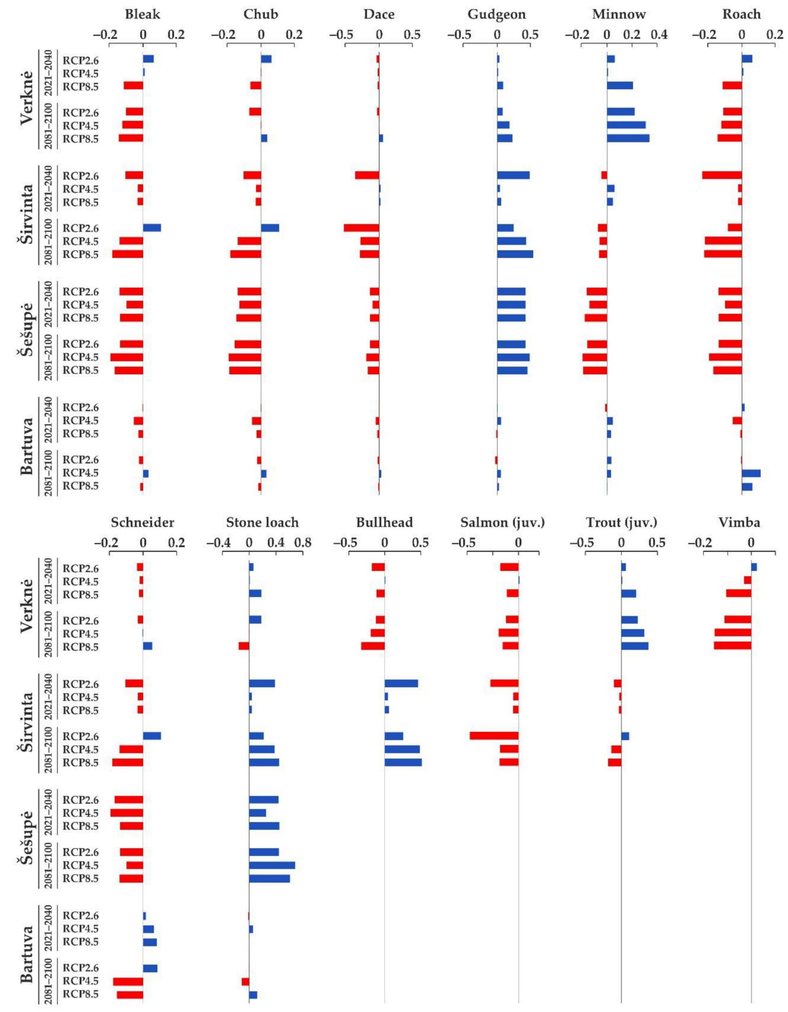

Figure 4. Deviation of ITH for individual fish species from the average of ITH of all fish species for near and far future according to different RCP scenarios.

The overall tendencies of the combined impact of hydropower operation based on selected four rivers and climate change on spatial and temporal fish habitat availability are displayed in Figure 5.

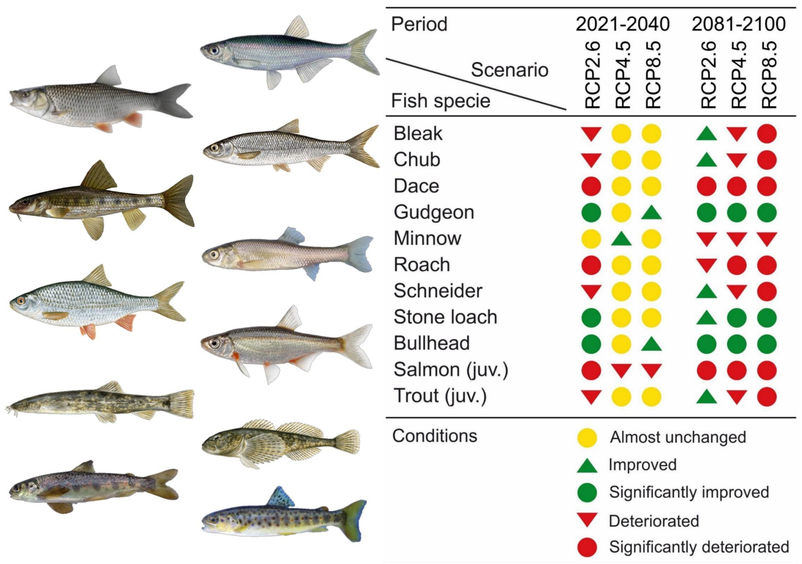

Figure 5. Joint impact of climate change and HPPs on conditions of spatial and temporal fish habitat availability.

The research is based on the previous study: Akstinas, V.; Virbickas, T.; Kriaučiūnienė, J.; Šarauskienė, D.; Jakimavičius, D.; Rakauskas, V.; Negro, G.; Vezza, P. The Combined Impact of Hydropower Plants and Climate Change on River Runoff and Fish Habitats in Lowland Watersheds. *Water* **2021**, 13, 3508. https://doi.org/10.3390/w13243508

CONCLUSIONS

- The runoff projections disclosed the high vulnerability of the Šešupė River to climate change. Since the river is strongly related to surface feeding and especially snowmelt, it is likely to increase the number of winters without snow cover due to raising temperature, therefore, the natural response to such change was felt on the lowest discharges of warm period.
- The modelling of temporal fish habitats availability showed that for some small benthic fish species, such as gudgeon and stone loach, HPP operation under climate change may be advantageous. For larger species like chub and vimba, alterations in the temporal availability of suitable habitats were more pronounced and linked to the negative side.
- The joint impact of climate change and HPPs operation on fish habitat availability indicated mostly unchanged conditions in the near future, however in the far future for most fish species the conditions may become deteriorated or significantly deteriorated according to RCP8.5.

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Reference
1. Parasiewicz, P.; Rogers, J.N.; Vezza, P.; Gortázar, J.; Seager, T.; Pegg, M.; Wiśniewolski, W.; Comoglio, C. Applications of the MesoHABSIM Simulation Model. *Ecohydraulics: An Integrated Approach* **2013**, 109–124. https://doi.org/10.1002/9781118526576.ch6