Global Assessment of Exploitable Surface Reservoir Storage under Climate Change

Lu Liu
Energy, Matthew Gidden and Edward Byers and Simon Parkinson and Yusuke Satoh and Keywan Riahi
University of Maryland / Joint Global Change Research Institute
Email: liuemma2@umd.edu

Introduction. Surface water reservoirs provide us with reliable water supply systems, hydropower generation, flood control, and recreation services. Reliable reservoirs can be robust measures for water security and can help smooth out challenging seasonal variability of river flows. Yet, reservoirs also cause flow fragmentation in rivers and can lead to flooding of upstream areas, thereby displacing existing land-uses and ecosystems. The anticipated population growth, land use and climate change in many regions globally suggest a critical need to assess the potential for appropriate reservoir capacity that can balance rising demands with long-term water security.

Methodology. In this research, we assessed exploitable reservoir potential under future climate and human development constraints by deriving storage-yield relationships for 235 river basins globally. The storage-yield relationships map the amount of storage capacity required to meet a given water demand based on concurrent 30-year inflow and evaporation sequences estimated at a 0.5 degree global resolution. Runoff data is simulated with a Global Hydrological Model forced with output from a bias-corrected General Circulation Model run under four future Representative Concentration Pathways. Additionally, the impacts of evaporative losses on reservoir storage are estimated for each climate scenario. The calculated capacity is then combined with spatially-explicit environmental constraints, and human development scenarios to derive exclusion zones that limit the storage capacity expansion potential in each basin.

Results and conclusions. We investigated the global potential and reliability of surface water reservoirs across different climate change scenarios and human development pathways to identify river basins where reservoir expansion will be particularly challenging. 30 to 35% of reservoir potential may be unavailable because of alternative land-uses which results in reduction in potential exploitable storage that accounts for ~ 50% of the existing storage. The majority of basins in Europe display abundant per capita storage potential, but relatively low reliability for maintaining historical maximum firm yields. Basins in Asia show high reliability for producing firm yield yet low exploitable storage per capita (Figure 1). On average, evaporation loss from potential reservoirs account for approximately 9% of the total potential storage volume. This portion of water loss accounts for 2 to 33% of potential storage depending on the basin. The framework established by this study will provide scientific support for long-term planning of water infrastructure, and will help decision makers to understand the reliability of infrastructure systems particularly sensitive to future water availability and global environmental change.

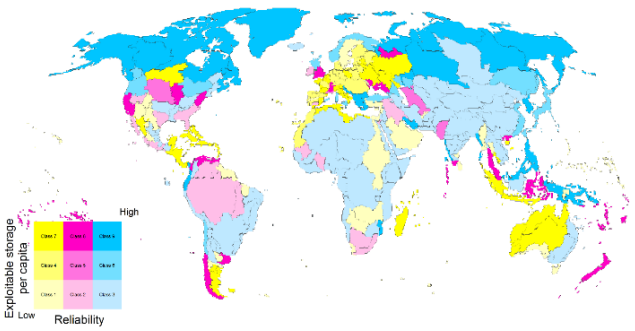

Figure 1. Bivariate map showing reliability and exploitable storage per capita by basin under SSP1 population trajectory in year 2050