Meeting ecosystem needs while satisfying human demands

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Regulated rivers worldwide are managed to meet human water demands, including irrigation and hydropower, but resulting flows often fail to support downstream ecosystems. To further confound these management challenges, global climate warming and commensurate hydroclimatic alteration are likely to exacerbate scarcity of water resources and increase competition among its many consumers. Increasing water insecurity is due in part to the assumptions of stationarity in water engineering (Milly et al 2008), in part to increasing human population pressure (Vörösmarty et al 2010), and also in part to the sheer magnitude of anticipated hydrological alteration (Döll and Zhang 2010).

The recent publication by Zeng et al (2017) highlights the trade-offs inherent in managing water resources for multiple demands, focusing specifically on hydropower generation versus deliveries for agricultural irrigation supply. At the global scale, the authors found that over half of all installed hydropower competes with irrigation, broadly. More specifically, the authors identified specific locations where competition for water supply between these two sectors is acute, such as in India and Central Asia, due to low streamflow availability, timing of hydropower and irrigation, and evaporative water losses from the reservoirs. Reservoir operations were more synergistic in portions of China and the United States, where demand for hydropower generation and irrigation deliveries were more synchronized seasonally. The consequences for hydroclimatic alteration, such as less snow storage, more variable river discharge, and increased reservoir loss from evaporation, further exacerbate competition for scarce water resources. The analysis by Zeng and colleagues identifies regions that would benefit from expanded trade and diversified energy-water supply portfolios as climate adaptation strategies, but leaves two areas in stark need of additional scientific research: (1) identifying effective policies for balancing trade-offs in meeting water demands under changing hydroclimatic regimes, and consequently (2) developing effective means of managing ecosystems while balancing competing demands for hydropower and irrigation.

As a case in point, the most recent drought in California (see Diffenbaugh et al 2015, He et al 2017), exposed one of the world’s top agricultural economies to a protracted period of water scarcity that resulted in shocks to agricultural production and labor (Howitt et al 2014), as well as reduced hydropower generation (Gleick 2015). To date, however, few studies have addressed how food-energy-water policies could be implemented to reduce such shocks and improve socioeconomic and ecosystem resilience. In addition to improved coordination among governing agencies and their information management systems (Mount et al 2015), more fundamental changes to policy and practice are needed. Changes to improve food-energy-water system resilience include economic analyses to evaluate ecosystem service versus extraction trade-offs (Grafton et al 2013, Rheinheimer et al 2013), updating water year typologies to reflect non-stationary conditions (Null and Viers 2013, Rheinheimer et al 2016), and formal climate change contingency scenarios for hydropower operations should be adopted to balance competing needs (Viers 2011). Policies are also needed for agricultural land use planning, where groundwater exploitation and degradation has resulted in unsustainable agricultural production (Famiglietti 2014, Rosenstock et al 2014).

As the analysis by Zeng et al (2017) makes clear, global water security will be dependent upon several interacting forces that govern water managed for hydropower, irrigation, and ecosystems. Wada and Bierkens (2014) and others have also made it clear that the future sustainability of human water use is doubtful. Thus, the value of such water is likely to increase in the near term and likewise climate adaptation strategies are likely to modify current decision making. Choices for which lands remain in production, or which ones receive surface water irrigation supply at the expense of the environment, will be difficult. It is not a zero sum game, however. Given that hydropower dams are expected to more than double over the next 15 years globally (Zarfl et al 2014), water management strategies that balance ecosystem needs with human demands are urgently needed. A new scientific push toward getting "more
pop per drop’ in environmental flow management is focusing on key functional flow components like peak magnitude flows, dry-season low flows, wet-season initiation flows, recession flows, and interannual variability to match life history strategies of focal species (Yarnell et al 2015). A future functional flow paradigm can inform reservoir operations by actively managing for ecosystem services and biodiversity while maintaining conventional operations like flood control, hydropower generation, and irrigation supply. While trade-offs are inevitable, science can help identify compatible water management actions that not only buffer against the worst effects of climate change, but meet ecosystem needs while satisfying human demands.

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