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Editorial

Editorial for Special Issue "Advances in the Ecohydrology of Arid Lands"

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Ecohydrology is an emerging, cross disciplinary subfield of hydrology devoted to the mutual interactions between water and ecosystems [1]. Today, the important questions of what these interactions mean for human society and how human society impacts these interactions are also part of this subject. The specific climatic/geographic focus here is arid lands broadly defined as water deficit regions where potential evapotranspiration (PET) exceeds precipitation (P). Such lands exceed 41% of the world's terrestrial area and are found on all continents except Antarctica [2]. Their range is from the climatic/vegetation classifications deserts and semi-deserts that are excessively dry most of the time through True Steppes to Wooded Steppes, Mediterranean areas and Tropical Savannas which suffer from moderately dry conditions parts of the year. Some mountainous regions and parts of polar lands also at times experience arid conditions.

Arid lands are of great contemporary concern as human-influenced climate change, considered by many experts as Humanity's greatest existential threat, is so strongly and negatively affecting them with, among other consequences, more frequent and severe drought and devastating fires. The experience of the state of California in the United States is a prime example of this, where, in recent years, economic losses from drought and fire ran into the tens of billions of dollars accompanied by significant human fatalities. Moreover, drought in northwestern China in recent years has caused ecological degradation and sandstorms. The monetary losses and deaths are expected to become higher as the climate warms. Ecohydrology has contributed to a better understanding and mitigation of these phenomena and will do so even more in the future.

An interesting and instructive example of the value of ecohydrology in better understanding and managing water in arid areas of the planet has been the effort to partially rehabilitate the northern part of the Aral Sea. The author of this editorial has been involved with research on this subject since the early 1980s, including on-site field research, data gathering and the publication of results.

The Aral Sea lies among the deserts and steppes of Central Asia. It was the world's fourth largest lake in surface area in 1960, but owing to human actions (primarily expanded irrigation in its basin) has steadily shrunk over ensuing decades with enormous negative ecological, economic and human welfare consequences [3]. Efforts were begun by the former Soviet Union in the late 1980s to address the problem, and after the breakup of the USSR in 1991, international organizations of the UN, the World Bank and various developed nations joined the effort. It rapidly became apparent that restoring the sea to its former size was impossible in any realistic near-term scenario, owing to costs and lack of the necessary water. However, a plan to partially revitalize the northern part of the lake was viewed as attainable as its level could be raised and stabilized by placing a regulating dam in the former strait separating the Small (north) Aral from the Large (south) Aral [3–5]. A locally constructed, closed-earthen dike had demonstrated the feasibility of the concept in the 1990s but catastrophically failed in 1999 as the water level behind the dam rose so high that the facility was breached during a major wind storm.

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The World Bank, in collaboration with the Government of Kazakhstan, on whose territory the Small Aral is located, developed a full plan and engineering design by the early 2000s. The work involved flow measurements of the influent river (Syr Darya) as well as accompanying studies of and data gathering on the limnology, biology and fishery potential of the Small Aral Sea. A Russian hydroengineering company with considerable foreign experience built the key engineering facilities needed (Kok-Aral Dike and Dam) between 2003 and late 2005. The main component of the plan is a well-designed, engineeringly sound 13 km earthen dike with a concrete flow control dam with adjustable flow regulating gates to control outflow and the level of the Small Aral.

So far, the plan seems a considerable success. It raised the level of the Small Aral by two meters and increased the area by 18%. This led to a drop in salinity to levels characteristic of the pre-desiccation situation and allowed the return of native fish species to the lake from the Syr Darya Delta and its associated lakes. Fish catches have grown rapidly and allowed a thriving fish canning and export industry to develop in Aralsk—the former major port on the Small Aral [6]. Fresh and canned fish are supplied locally and to surrounding regions. One highly prized species, the Pike-perch (Sudak in Russian) is made into filets, frozen in local plants and exported to countries in the European Union, where it commands a high price. The revitalization of the Small Aral and its positive impacts on the lake's ecology and fisheries has been a boon to the local and regional economy and the welfare of the population living near the Small Aral.

The intent is to implement a second stage of the Small Aral Project. Two plans are being evaluated to further improve the ecology and fishery significance of the Small Aral. One would raise the level of one part of the Small Aral, and the other would raise the entire water body. Clearly, sufficient inflow is available for the former plan. The latter effort is a closer call, although a recent study seems to suggest it is feasible [4]. Ecohydrological research should play a key role in determining which variant is best, taking in to account not only physical but economic and social priorities.

The subfield of ecohydrology is changing rapidly. The intent of this SI is to present scientifically accurate information on the current state of leading ecohydrology-oriented research on arid lands that represents contemporary best thinking in the field. The five research articles included (and cited below) by no means cover the diversity of the field but rather provide an introduction to leading current research. The intended audience is broad, including not only those involved in this field but also those engaged in the more traditional aspects of hydrology, biology, ecology, geography, engineering, water management, agriculture, urban planning and other relevant fields.

Articles in the Special Issue

Ndiaye, P.; Bodian, A.; Diop, L.; Deme, A.; Dezetter, A.; Djaman, K. Evaluation and Calibration of Alternative Methods for Estimating Reference Evapotranspiration in the Senegal River Basin. Hydrology 2020, 7(2), 24; https://doi.org/10.3390/hydrology7020024. https://www.mdpi.com/2306-5338/7/2/24. Reference evapotranspiration (ETo) is a key element of the water cycle in tropical planning and management of water resources, hydrologic modeling, and irrigation management. This research assesses 20 methods for computing ETo.

Nabih, S.; Tzoraki, O.; Zanis, P.; Tsikerdekis, T.; Akritidis, D.; Kontogeorgos, I.; Benaabidate, L. Alteration of the Ecohydrological Status of the Intermittent Flow Rivers and Ephemeral Streams due to the Climate Change Impact (Case Study: Tsiknias River). Hydrology 2021, 8(1), 43; https://doi.org/10.3390/hydrology8010043. https://www.mdpi.com/2306-5338/8/1/43. Climate change projections predict the increase in no rain periods and storm intensity, resulting in a high alteration of Mediterranean rivers. Intermittent flow rivers and ephemeral streams, such as the Tsiknias, are especially vulnerable to spatiotemporal variation in climatic parameters, land use changes, and other anthropogenic factors.

Guerreiro, M.; Maia de Andrade, E.; Palácio, H.; Brasil, J.; Ribeiro Filho, J. Enhancing Ecosystem Services to Minimize Impact of Climate Variability in a Dry Tropical Forest with Vertisols. Hydrology 2021, 8(1), 46; https://doi.org/10.3390/hydrology8010046.

https://www.mdpi.com/2306-5338/8/1/46. Increased drought and variable rainfall patterns may alter the capacity to provide ecosystem services such as biomass production and clean water provision. The impact of these factors in a semi-arid region with dry tropical forests whose soils are mainly vertisols is the focus of this study.

Tsutsui, H.; Sawada, Y.; Onuma, K.; Ito, H.; Koike, T. Drought Monitoring over West Africa Based on an Ecohydrological Simulation (2003–2018). Hydrology 2021, 8(4), 155; https://doi.org/10.3390/hydrology8040155. https://www.mdpi.com/2306-5338/8/4/155. Food production in West Africa has sharply declined in recent years owing to agricultural drought. We simulated ecohydrological variables contributing to the drought using the Coupled Land and Plant hydraulics Model.

Frau, D.; Moran, B.; Arengo, F.; Marconi, P.; Battauz, Y.; Mora, C.; Manzo, R.; Mayora, G.; Boutt, D. Hydroclimatological Patterns and Limnological Characteristics of Unique Wetland Systems on the Argentine High Andean Plateau. Hydrology 2021, 8(4), 164; https://doi.org/10.3390/hydrology8040164; https://www.mdpi.com/2306-5338/8/4/164. We describe the hydroclimatological and limnological characteristics of 21 wetlands on the High Andean Plateau of Argentina, synthesizing information gathered over 10 years (2010–2020).

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