Hydrological Sciences Journal

ISSN: 0262-6667 (Print) 2150-3435 (Online) Journal homepage: www.tandfonline.com/journals/thsj20

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HYDROLOGICAL SCIENCES JOURNAL
2026, VOL. 71, NO. 10, 2031–2043
https://doi.org/10.1080/02626667.2026.2663050

The coupled hydrology–human activity information (CHHAI) dataset: a global benchmark dataset for model comparison and evaluation

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ABSTRACT

To enhance hydrologic modeling, the hydrology community has developed benchmark datasets (e.g. Model Parameter Estimation Experiment, MOPEX), providing standardized data for model evaluation and parameter estimation. However, these datasets primarily focus on modeling natural hydrologic processes, leaving a critical gap in understanding the role of human influences. Here, we introduce the Coupled Hydrology-Human Activity Information (CHHAI) dataset, a benchmark dataset that integrates coupled human–water data from regions across all continents, excluding Antarctica. CHHAI incorporates data from 25 regions that cover various human impacts such as reservoir management, flood protection, river management policies, land use changes, and water use. Each basin reflects distinct challenges, providing a diverse and globally representative resource for researchers studying these processes. By offering standardized datasets for modeling and analysis, CHHAI aims to enhance our understanding of interactions between people and water and to support the development of improved strategies for managing coupled human–water systems.

ARTICLE HISTORY
Received 18 September 2025
Accepted 20 March 2026

EDITOR
A. Castellarin

ASSOCIATE EDITOR
K. Schröter

KEYWORDS
Coupled human–water systems; sociohydrology; hydrologic data; sociohydrologic modeling

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Introduction

The hydrologic modeling community has long recognized the importance of standardized benchmark datasets for calibration, validation, and evaluating model performance. Notable examples include the Model Parameter Estimation Experiment (MOPEX; Duan *et al.* 2006, Schaake *et al.* 2006) and the data provided as part of the Distributed Model Intercomparison Project (DMIP; Reed *et al.* 2004, Smith *et al.* 2013), which have facilitated systematic evaluations of hydrologic models across diverse natural basins. Building on MOPEX, the Catchment Attributes and MEteorology for Large-Sample Studies (CAMELS; Newman *et al.* 2015, Addor *et al.* 2017) dataset provides daily forcing data and streamflow for small to medium-sized watersheds in the United States. This led to efforts to provide CAMELS data for basins in other countries such as Chile (AlvarezGarreton *et al.* 2018), Great Britain (Coxon *et al.* 2020), and Brazil (Chagas *et al.* 2020). More recently, Caravan (Kratzert *et al.* 2023) standardized and aggregated the CAMELS data into a unified database while EStreams (Do Nascimento *et al.* 2024) integrated catchment data across Europe into a single dataset. Although these datasets provide widespread and long-term hydrological data, they have predominantly focused on natural hydrologic systems (Addor *et al.* 2020) or effects of climate change (Turner *et al.* 2025), largely excluding the direct influence of human activities (e.g. water withdrawals, reservoir operations, irrigation practices, and interbasin water transfers). Related efforts have begun to incorporate sociohydrologic information, including the Panta Rhei benchmark dataset, which consists of sociohydrological data on paired flood and drought events (Kreibich *et al.* 2023).

In the past few decades, particularly during the International Association of Hydrological Sciences (IAHS) scientific decade Panta Rhei – Change in hydrology and society (2013–2022; Montanari *et al.* 2013, Kreibich *et al.* 2025, Tian *et al.* 2026), the hydrology community has increasingly recognized the significant influence of human activities on the water cycle, including their role in altering streamflow patterns, groundwater dynamics, and the frequency and intensity of hydrologic extremes such as floods and droughts (Oki and Kanae 2006, Peel and Blöschl 2011, Sivapalan and Blöschl 2015, Troy *et al.* 2015b, Blair and Buytaert 2016, AghaKouchak *et al.* 2021, Kreibich *et al.* 2022). As a result, a new generation of regional and global hydrologic models has emerged, explicitly incorporating human interventions such as water withdrawals, reservoir operations, irrigation practices, interbasin transfers, and urban water use. Models developed to simulate these interactions include the Water Global Assessment and Prognosis (WaterGAP; Müller Schmied *et al.* 2021), the Water Balance Model (WBM; Wisser *et al.* 2008, Grogan *et al.* 2022), H08 (Hanasaki *et al.* 2018), the PCRaster Global Water Balance model (PCRGLOBWB; van Beek and Bierkens 2008, Sutanudjaja *et al.* 2018) and the WorldWide HYPE model (Arheimer *et al.* 2020). These models incorporate human water demand to simulate water storage, whereas the Water Evaluation and Planning System (WEAP; Sieber 2006) and the Community Water Model (CWatM; Burek *et al.* 2020) were developed to assist with water resource management. Additionally, software packages have been developed to integrate human activities into more traditional hydrological models such as VICRes (Dang *et al.* 2020) which provides tools for representing reservoirs in the Variable Infiltration Capacity model (VIC; Liang *et al.* 1994). Similarly, the widely used Soil and Water Assessment Tool (SWAT; Arnold *et al.* 1998) was created to assist water resource managers in evaluating both water supply and water quality, particularly related to agricultural pollution in watersheds. These human-integrated models aim to better reflect real-world conditions and support more representative assessments of water availability, risks, and management strategies under both current and future scenarios influenced by climate change and socioeconomic development (e.g. Bartosova *et al.* 2019). More recently, machine learning and data science have begun to further enhance hydrologic modeling in human-dominated systems (Maity *et al.* 2024). This makes it even more important to have standardized benchmark datasets tailored for evaluating and comparing the performance of such models in human-dominated systems. In the context of the Panta Rhei decadal initiative, this data challenge is a major feature of the synthesis effort that was recently completed (Kreibich *et al.* 2023, 2025, Tian *et al.* 2026).

Studies that explicitly incorporate bidirectional interactions between water systems and human activities are often referred to as sociohydrology (Sivapalan *et al.* 2012, Troy *et al.* 2015a, Blair and Buytaert 2016, Pande and Sivapalan 2017, Pouladi *et al.* 2025b, Tian *et al.* 2026) or, more broadly, as coupled human–water systems research (Li *et al.* 2017b, Wada *et al.* 2017, Konar *et al.* 2019, Reed *et al.* 2022). Regarding the most appropriate terminology (e.g. reflecting differences in disciplinary focus, modeling approaches, and conceptual frameworks), this study uses both terms interchangeably. Our primary focus is not on the specific classification of these models, but rather on addressing the critical need for benchmark datasets that can support the development, calibration, validation, and intercomparison of hydrologic models that account for human influences on water systems.

A wide range of human activities can alter the hydrologic cycle and influence natural hazard dynamics (Kreibich *et al.* 2025). These interventions not only modify the timing and magnitude of water flows but also affect how we observe, model, and manage hydrologic processes and associated risks. These influences vary between regions and cities due to differences in local needs and government policies (Salvadore *et al.* 2015, Pouladi *et al.* 2025b). Historically, people have settled near water bodies, especially rivers, making them particularly vulnerable to flooding (Kummu *et al.* 2011). In response to flooding events, communities often build levees and relocate inland to mitigate impacts. However, when memory of past floods fades, a false sense of security emerges, prompting renewed settlement closer to rivers, resulting in less frequent but more devastating flood events (Di Baldassarre *et al.* 2013). This phenomenon is termed the levee effect or safe development paradox and is one sociohydrological phenomenon among many (see, for instance, Di Baldassarre *et al.* 2019 for a list of seven relevant phenomena and 11 sub-phenomena). In contrast, populations are drawn closer to water sources during droughts (Ceola *et al.* 2023). These patterns reflect the ideas of social memory and risk awareness (Albertini *et al.* 2020).

Land cover changes can influence the water cycle. For example, urban land expansion increases impervious surfaces, leading to increased runoff and flood risk (Rose and Peters 2001, Sui and Van de Ven 2023). Similarly, expansions of agricultural land can potentially increase runoff; however, this effect depends on the characteristics of the fields (Fiener *et al.* 2011). Agricultural land can also lead to higher evapotranspiration due to greater crop coverage (Liu *et al.* 2008, Odongo *et al.* 2019), requiring the integration of crop models in hydrological modeling to improve estimations of leaf area indices and evapotranspiration rates (Zhang *et al.* 2021). Land cover change can also be reversed as seen in cases of the "pendulum swing," where systems are modified to improve human quality of life (e.g. irrigation systems) before restoration efforts return them to more natural conditions (Kandasamy *et al.* 2014). Conversely, hydrological systems can drive land cover change. For example, flood zone regulations can restrict development to certain areas, indirectly affecting runoff (Pan *et al.* 2018).

As water is a vital resource for consumption, irrigation, and hydropower generation, hydrologic modeling is critical for reservoir management. Reservoir operations substantially influence water availability by regulating streamflow and affecting upstream and downstream water supply, and because they are governed by human decision making, dam construction and reservoir releases can complicate hydrological predictions downstream (Mehran *et al.* 2017, Meira Neto *et al.* 2024). In transboundary river basins, these complications are amplified because reservoir systems are managed by multiple actors, creating feedback loops that require a comprehensive sociohydrological perspective to inform sustainable water management (Shrestha *et al.* 2022). Given these examples of human interventions in hydrologic systems, appropriate modeling approaches depend on the types of human processes specific to each region. Historically, human variables have been considered boundary conditions (Sivapalan and Blöschl 2015); however, this assumption has been deemed incorrect, as human activities can change over time, meaning that adequate data is necessary to accurately predict coupled human–water systems (Peel and Blöschl 2011).

Despite the well-documented importance of human activities in shaping the hydrologic cycle and the growing body of literature on models and tools that account for these interactions, there remains a critical gap: the absence of a standardized benchmark dataset, similar to MOPEX, for evaluating and comparing the performance of models in human-influenced systems. This need is underscored by the fact that models tend to perform worse in highly regulated areas or when human impacts are not modeled (Tijerina-Kreuzer *et al.* 2021, Mai *et al.* 2022, Meira Neto *et al.* 2024). To address this gap, we introduce the Coupled Hydrology-Human Activity Information dataset (CHHAI). CHHAI integrates coupled human–water data from diverse regions across all continents, excluding Antarctica. The variables and types of data capture a wide range of water–human challenges for each region, leading to a diverse and globally representative resource that supports context-specific analyses in case study research (Mostert 2018). The dataset can be used to reveal insights into how human impacts are affecting regions (e.g. land use change, reservoir management, water withdrawal for irrigation and use) and how communities are responding to them (e.g. flood protection, the pendulum swing, water demand management).

This effort is inspired by the second and third IAHS scientific decades, spanning 2013–2022 and 2023–2032. The second decade was titled Panta Rhei – Everything Flows; it was dedicated to understanding the changes in both hydrology and society as a coupled system (Montanari *et al.* 2013). The third decade, titled Hydrology Engaging Local People IN one Global world (HELPING), has a focus on the use of open science and local data to solve local water problems (Arheimer *et al.* 2024). By focusing on processes and challenges specific to each basin, this effort enables researchers to study localized processes while also identifying global patterns in human–water interactions.

Data and methods

CHHAI contains data for 25 regions around the world, including river and lake basins. To retrieve this data, we contacted researchers studying these regions and invited them to contribute to CHHAI. To be included, data must contain both human-related and surface hydrology data. The types of human-related data that would be accepted are broad, including water use and demand, irrigation and agriculture systems, and reservoir implementation and management. We preferred data with long periods of record; however, if a significant hydrologic or anthropogenic event occurred during the study period, a shorter record of data was accepted. Because each region has unique challenges and scenarios, different data variables and types were accepted; however, most basins have time-series data.

Information about how data for individual basins were collected is described in the papers associated with the data (see Table A1 in the Appendix or the ReadMe files). Once the data were collected, datasets were standardized to have common units (metric system) and a standard format. Time-series data are in the format required for submission to HydroShare, which is maintained by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI 2025; Horsburgh *et al.* 2016). Geospatial data are shared in either NetCDF or TIFF files, and non-formatted information about a region is provided in tables or in the ReadMe file.

The locations of 25 initial study river/lake basins and non-basin regions included in CHHAI are shown in Fig. 1. The majority of the basins and regions are located in Asia, with at least two regions in other continents. The initial regions exhibit different human impacts that can be studied with the data, such as reservoir management, flood protection, river management policies, land use changes, and water use and withdrawal. It should be noted that the human impacts shown in Fig. 1 do not completely cover all human impacts experienced by a region; rather, they cover only those represented by the data in CHHAI. More characteristics (e.g. data types and variables) of the regional datasets are listed

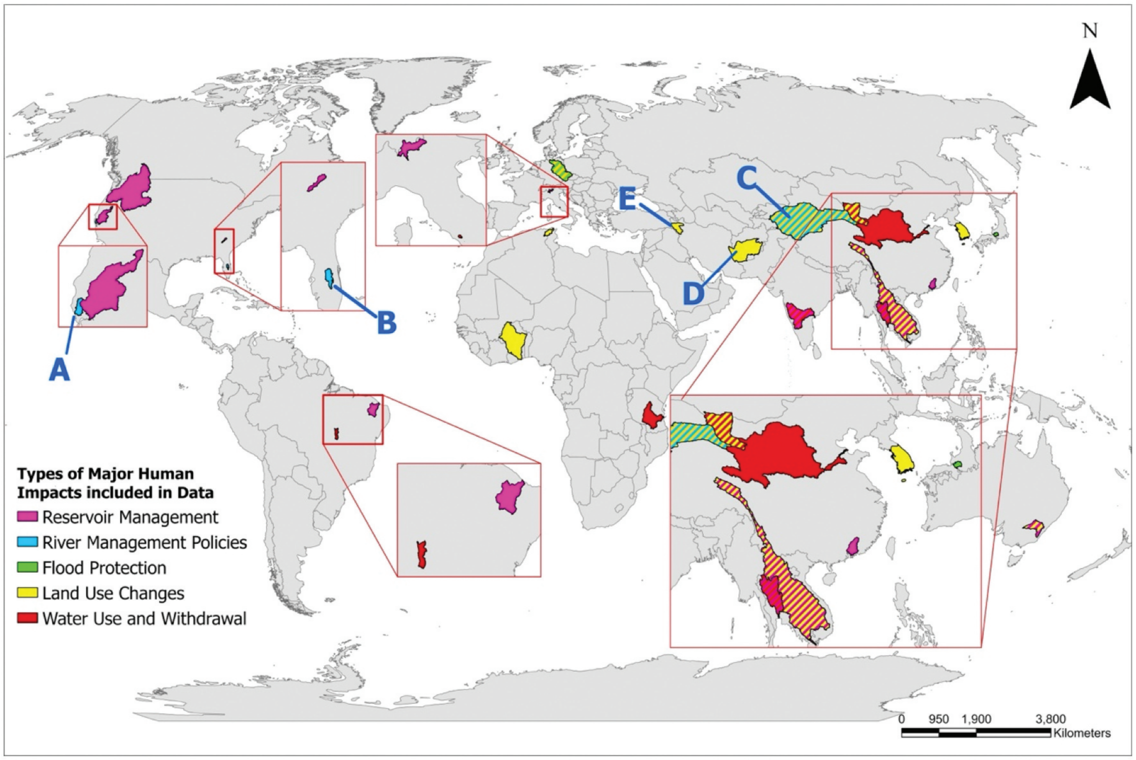

Figure 1. Locations of the 25 initial river basins, lake basins, and regions included in CHHAI. The basins are colored by the types of major human impacts included in the data for the basin. Cross-hatched colors indicate that multiple types of impacts are reflected in the basin's data. Labels A through E show the locations of the basins that are used in the "Data usage and example analysis" section (Figs 2 through 6, respectively). Map insets highlight boundaries of smaller basins for easier visibility.

in Table A1. The CHHAI dataset is available at https://doi.org/10.4211/hs.e011b48fabd2465eb5135275d2f3a93e. Data are organized as separate ZIP folders for each region (see column 6 of Table A1). The ZIP files include a ReadMe file that describes the contents of each folder.

Data usage and example analysis

This section presents example analyses for five basins to illustrate potential research questions that could be investigated using CHHAI. The examples focus on water and

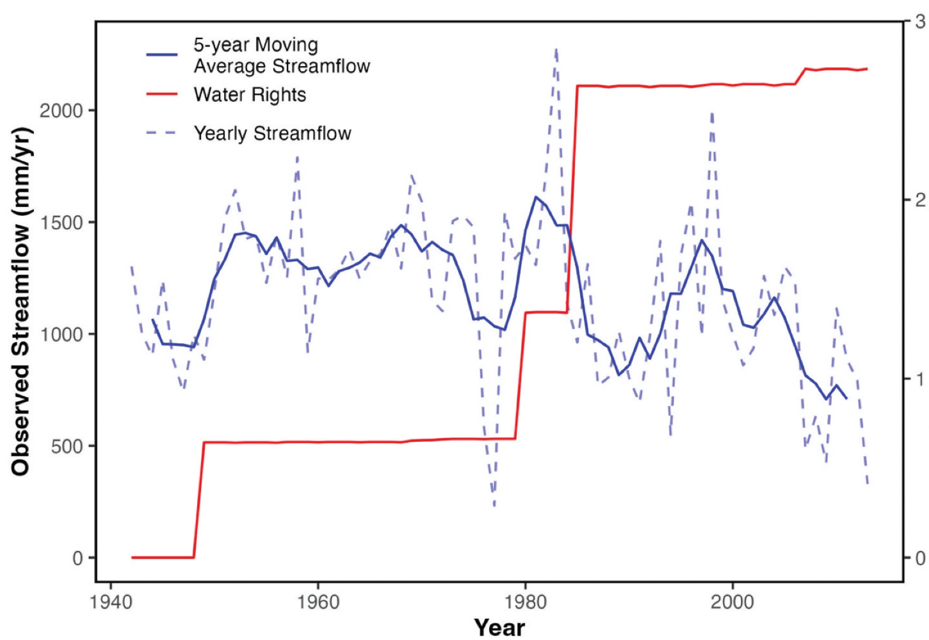

Figure 2. Observed streamflow at the Calpella gauge and average daily maximum allowable water withdrawal (water rights) for the East Fork Russian River in the United States (Label A in Fig. 1). The dashed blue line is the yearly total observed streamflow, and the solid blue line is the 5-year rolling average of the yearly streamflow. For further information on this data, see Garcia *et al*. (2024).

basin management policies and agricultural irrigation practices.

The first example is the East Fork Russian River in California, USA (label "A" in Fig. 1). This river is regulated by Lake Mendocino (formed by the Coyote Valley dam) and the Potter Valley Project, which diverts water from the Eel River to the East Fork Russian River (Garcia *et al.* 2024). In California, the daily maximum amount of allowable water withdrawal (water rights) has increased over time while streamflow in the river has experienced a slight decrease (Fig. 2). From 1979 to 1985, water rights nearly quadrupled (from approximately 0.6 mm/day to 2.6 mm/day). Before 1985, the mean observed streamflow was 1286 mm/year, and after 1985, it decreased to 991 mm/year, a reduction of almost 300 mm/year. This decrease in streamflow can be explained in part by a decline in imported water from the Potter Valley Project; however, the increase in allowed water withdrawals may also have contributed to the reduced streamflow. As there may be other causes of decreased streamflow, future researchers could investigate questions such as the following: What other changes in the watershed contributed to the streamflow decline? How did irrigators respond to changes in streamflow? As the Potter Valley Project is planned to be decommissioned (Alexander 2025), what are the potential impacts resulting from reduced water diverted into the basin? Why have water rights increased over time?

In another example, the Kissimmee River in central Florida, USA (label "B" in Fig. 1) experienced changing river management practices. In 1962, water managers started channelizing the downstream part of the river due to repeated flooding. However, this channelization was found to have negatively affected natural wetlands, and planning began to restore the river to natural conditions (Chen *et al.* 2016). During this period, there were no noticeable changes in streamflow alone in the river (Fig. 3); however, further analysis incorporating land cover and socioeconomic variables may indicate whether channelization did impact river flow. This basin is an example of the "pendulum swing" (Kandasamy *et al.* 2014, Chen *et al.* 2016), where artificial management of a river basin is reversed to return the river to a more natural state. Potential future research questions include the following: How do different river management strategies (e.g. channelization versus restoration) influence long-term streamflow dynamics and variability? To what extent do restoration efforts reverse the hydrological and ecological impacts of earlier channelization?

Similar to the water withdrawal policies in the Russian River basin, the Tarim River Basin Authority implemented water conservation policies following changes in water use and irrigated areas in the Tarim River basin in China (label "C" in Fig. 1). The Tarim River basin has been widely recognized as a canonical sociohydrological system, where irrigation expansion, ecological degradation, and policy interventions coevolved over multiple decades (Liu *et al.* 2014, Ye *et al.* 2014, 2015). Throughout the late 1900s, the Tarim River basin experienced increasing farmland and irrigation infrastructure. In response, the Tarim River Basin Authority initiated water conservation projects to constrain water use for irrigation and emergency water transfers. These transfers allocated water to downstream lakes in order to preserve vegetation (Liu *et al.* 2014). These changes, along with the resulting upstream and downstream streamflow in the Tarim river, can be seen in Fig. 4. The average trends in upstream and downstream streamflow are −7.94 million cubic meters per year and −30.7 million cubic meters per year, respectively, indicating that streamflow in the downstream portion of the basin has decreased more rapidly over time. Potential future research questions include the following: How do changes in precipitation compare with the expansion of irrigated areas in influencing streamflow within the river basin? How does the spatial distribution of expanded irrigated areas affect streamflow responses in different parts of the basin?

Other potential future research questions related to water withdrawal and river management policies are the following: How do different forms of water policies and human interventions affect long-term water availability, streamflow, and environmental health? Do the policies implemented by governments and water managers help mitigate indirect impacts, such as climate change? How do local water policies (such as

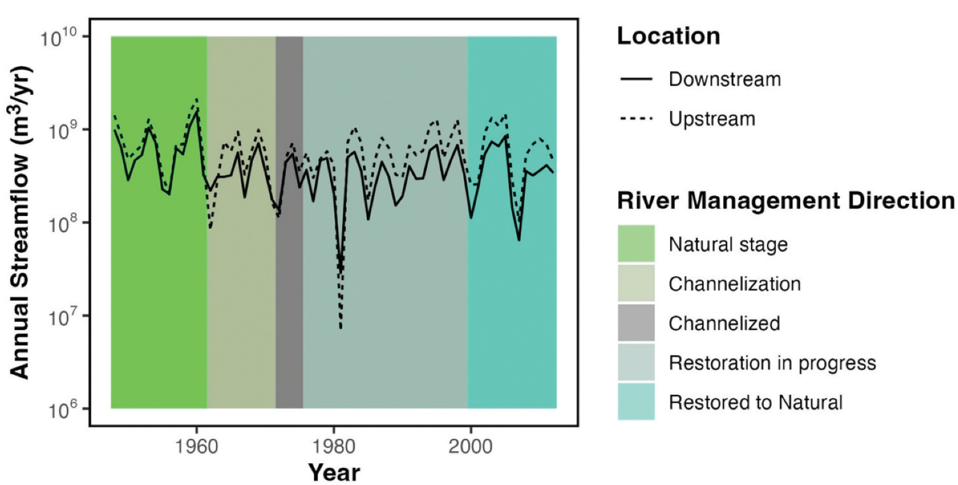

Figure 3. Downstream (solid line) and upstream (dashed line) annual streamflow for the Kissimmee River in the United States (Label B in Fig. 1). The basin's river management is shown in different colors. For more information on this data and river, see Chen *et al.* (2016).

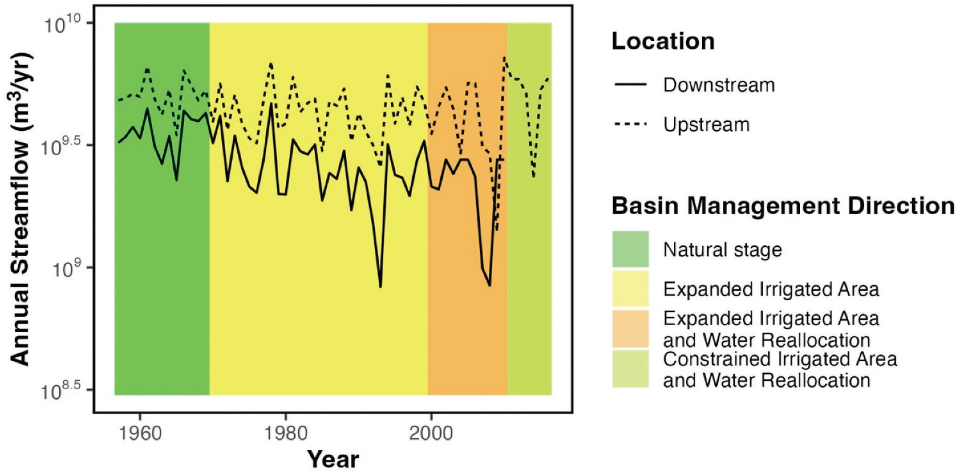

Figure 4. Downstream (solid line) and upstream (dashed line) streamflow in the Tarim River in China (Label C in Fig. 1). Irrigation and water reallocation policies are shown in color. For more information on the data and river, see Liu *et al.* (2014).

those in the Kissimmee and Tarim river basins) compare with regional policies (such as those in California and the Russian River)?

CHHAI can also be used to study the concept of anthropogenic drought (AghaKouchak *et al.* 2021), defined as drought events caused or intensified by human activities (Ashraf *et al.* 2021). The Tarim River basin (Fig. 4) is an example of anthropogenic drought, where downstream streamflow decreased even though precipitation increased in the basin (Yaning *et al.* 2009). The Helmand River basin in Afghanistan, Iran, and Pakistan (label "D" in Fig. 1) is another case of anthropogenic drought. The Hamun Lakes and Chah-nimehs are reservoirs located in the basin along the Iran–Afghanistan border. These lakes experienced a large increase in surface water storage in the early 1990s before experiencing a substantial decrease in the late 1990s. During this time frame, the amount of land used for agriculture increased (Fig. 5). After the decrease in surface water storage, agricultural area continued to expand, but there was no clear corresponding change in surface water storage. Although the significant decrease in surface water storage coincided with a drought, the drought did not cause the decrease but instead accelerated it (Modaresi Rad *et al.* 2022). Future research questions for this basin include the following: What specific anthropogenic stressors contributed to the large decrease in storage around 2000? Why did surface water storage increase dramatically in the early 1990s?

Anthropogenic drought due to overuse of water resources has also caused saline lakes worldwide to shrink. One example of lake drought (Cheng *et al.* 2025) is Lake Urmia in Iran (label

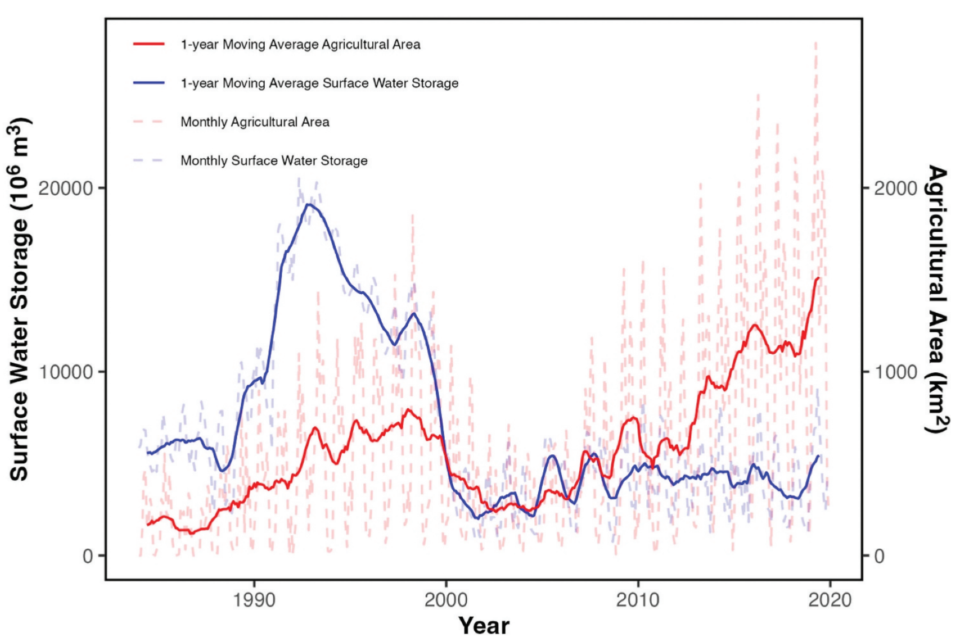

Figure 5. Surface water storage of the Hamun Lakes and Chah-nimeh lakes and the area of land for agricultural use in the Helmand River basin in Afghanistan and Iran (Label D in Fig. 1). Dashed lines are the monthly data for the surface water storage (blue) and agricultural area (red) while solid lines are the 12-month rolling average. For further information on this data, see Modaresi Rad *et al.* (2022).

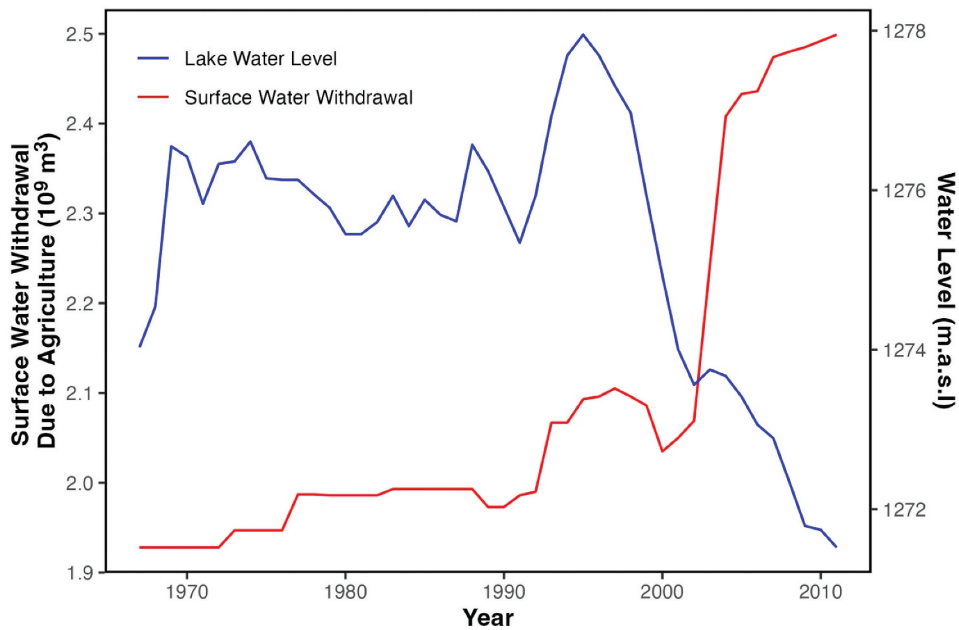

Figure 6. Surface water withdrawal due to agriculture in the basin (red) and lake water level above sea level (blue) for Urmia Lake in Iran (Label E in Fig. 1). For more information about the lake and data, see Alborzi *et al*. (2018).

"E" in Fig. 1; Alborzi *et al*. 2018; Pouladi *et al*. 2022). In the Lake Urmia basin, surface water withdrawal due to agriculture increased dramatically in the 2000s, and during the same time, the water level of the lake decreased consistently (Fig. 6). This increase and subsequent decrease in water level coincided with a similar pattern in the Helmand River basin (Fig. 5). As the basins are in the same region, there may be similar factors contributing to the decline in lake water levels. Further analysis of anthropogenic stressors in the region may reveal why the water storage and levels in the two basins declined so drastically.

Potential future research questions related to anthropogenic drought include the following: How do different types of human activities (e.g. increases in water demand) influence the onset, duration, and severity of local hydrologic droughts (e.g. see Pouladi *et al*. 2025b)? Can CHHAI help disentangle natural and anthropogenic drivers of recent historical droughts? Under what conditions do human interventions transform a meteorological drought (i.e. a deficit in precipitation) into a more severe hydrologic drought (i.e. a change in surface water storage; see Pouladi *et al*. 2025a)? What is the expected compounding impact of a meteorological drought and increasing water demand (e.g. see Mehran *et al*. 2017)?

In this section, we presented five case studies revolving around changing water policies and anthropogenic drought, and we outlined ideas for future research using CHHAI datasets related to those regions and topics. However, there are 20 other regions included in CHHAI, and we encourage researchers to analyze other human impacts, such as flood protection, land use changes, and reservoir implementation (see column 3 of Table A1). The hydrologic applications are not limited to the examples presented here. The dataset also supports comparative analyses across basins and time periods, enabling researchers to test hypotheses about how different management actions and socioeconomic pressures shape hydrologic responses under similar climate conditions. Additionally, CHHAI can be used to identify patterns across different regions and basins. For example, similarities were observed in the timing of water level changes across Lake Urmia, Hamun Lakes, and the Chah-nimehs, and it is likely that these sorts of patterns could be discovered using the data provided by CHHAI.

Many basins included in CHHAI have been the subject of earlier studies, providing an opportunity to connect the benchmark dataset with established process understanding. For example, the Helmand River and Lake Urmia basins reflect well-documented cases of anthropogenic drought and maladaptation, driven by feedbacks among infrastructure development, governance, and human water use behavior (AghaKouchak *et al*. 2021, Pouladi *et al*. 2022). In transboundary river systems, such as the Mekong River basin, prior analyses have shown how cooperation and conflict coevolve with hydrological variability, infrastructure development, and institutional change (Lu *et al*. 2021, Wei *et al*. 2022). By building on these earlier insights and identifying patterns across regions, researchers can revisit known sociohydrological phenomena and human impacts with CHHAI by using standardized, comparable data across basins, thereby facilitating synthesis and hypothesis testing beyond individual case studies.

Conclusion

The hydrology community has created standardized datasets (e.g. MOPEX, CAMELS) for modeling hydrological systems in nonregulated basins, and they have also developed hydrological models incorporating human impacts such as water use and demand. However, there is a lack of standardized datasets combining hydrologic and human variables, which is why we present a dataset that provides observations of coupled human–water systems in basins across the world. Currently, the CHHAI dataset consists of data for 25 regions from all continents, excluding Antarctica. The data reflects various human impacts on hydrological dynamics, such as land use changes, irrigation and other water uses, water policies, reservoir management and flood protection. With standardized data from basins across the world, there is potential to explore patterns in the challenges of coupled human–water systems across basins.

Although CHHAI consists of a variety of data types in different locations, it can be improved by including more data from Africa, Europe, and South America, as well as data that provides information on transboundary river management (e.g. Shrestha *et al.* 2022), river channelization (e.g. Chen *et al.* 2016), water diversion to and from rivers (e.g. Garcia *et al.* 2024), and flood protection (e.g. Paprotny *et al.* 2018, Nakamura *et al.* 2024). Currently, CHHAI does not include any data on topics such as social memory and human settlement patterns (Albertini *et al.* 2020), which would be a valuable inclusion. For this reason, CHHAI is a living dataset, and we encourage scholars performing research on coupled human–water systems to submit data to CHHAI to collaborate and share knowledge with others. As we receive more data, we will continue updating the dataset in future versions.

Beyond its immediate analytical applications, CHHAI can be viewed as a data legacy of the IAHS Panta Rhei Scientific Decade and as a foundation for future sociohydrological and coupled human–water systems research. Recent synthesis and perspective studies emphasize the need to move from isolated case studies toward shared benchmarks, comparative analyses, and solution-oriented research that explicitly links human behavior, institutions, and hydrological processes (Kreibich *et al.* 2023, Arheimer *et al.* 2024). Moreover, emerging work on societal value transitions highlights the importance of capturing long-term changes in norms, preferences, and governance alongside hydrological change (Wei *et al.* 2023). Together, these perspectives position CHHAI as an enabling platform for advancing comparative, policy-relevant, and locally grounded coupled human–water systems research aimed at improving water security and sustainability under global change.

Acknowledgements

This effort is inspired by the second and third International Association of Hydrological Sciences (IAHS) Scientific Decades: Panta Rhei – Everything Flows (2013–2022) and Hydrology Engaging Local People IN one Global world [HELPING; 20232032]. We acknowledge individuals and organizations that provided data for regions, including the Royal Irrigation Department, Thailand, which provided data for the Chao Phraya River basin.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This material is supported by the United States National Science Foundation Graduate Research Fellowship Program under Grant No. DGE2235784 and by the National Science Foundation Office of International Science and Engineering Grant No. 2114701 and NSF Grant No. 2332263.

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Data availability

The CHHAI dataset is openly available on HydroShare at https://doi.org/10.4211/hs.e011b48fabd2465eb5135275d2f3a93e.

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Appendix A. Information about the data

Table A1. Overview of CHHAI data from 25 study regions. The third column indicates the type of variables that are in the dataset. For example, "Meteorological" variables may include precipitation, evapotranspiration, temperature, and other meteorological variables. The fifth column shows the name of the folder in the HydroShare Resource where the basin's data can be found.

Basin/study region	Country	Types of variables	Data types	Time period covered	Dataset ZIP folder	Citation(s)
Helmand River	Afghanistan	Reservoir, meteorological, land use	Monthly time series	1984–2019	AFG_basin_HelmandRiver	Modaresi Rad *et al.* 2022
Murrumbidge River	Australia	Reservoir, meteorological, socioeconomic, crop production	Daily time series, yearly time series	1967–2012	AUS_basin_MurrumbidgeeRiver	Kandasamy *et al.* 2014
Formoso River	Brazil	Streamflow, other hydrological, water use, irrigation, cooperation toward water withdrawal rules	Daily time series, shapefiles	2016–2022	BRA_basin_FormosoRiver	Sousa *et al.* 2025
Jaguaribe River	Brazil	Streamflow, reservoir, meteorological, land use, water use	Yearly time series, Shapefiles	1872–2022	BRA_basin_JaguaribeRiver	Medeiros and Sivapalan 2020, Meira Neto *et al.* 2024, Pereira *et al.* 2025a, 2025b
Columbia River	Canada, United States	Streamflow, reservoir, transboundary cooperation	Monthly time series, daily time series	1990–2017	CAN_basin_ColumbiaRiver	Shrestha *et al.* 2022
Dongjiang River	China	Reservoir, streamflow	Monthly time series	1956–2011	CHN_basin_DongjiangRiver	Wu *et al.* 2021
Heihe River	China	Streamflow, meteorological, land use, water use, crop production	Daily time series, yearly time series, historical	1958–2016	CHN_basin_HeiheRiver	Lu *et al.* 2015a, 2015b, Zhao *et al.* 2016, Li *et al.* 2017a, 2021, Lu *et al.* 2018, Du *et al.* 2022
Tarim River	China	Meteorological, streamflow, land use, socioeconomic, river management	Yearly time series	1937–2025	CHN_basin_TarimRiver	Liu *et al.* 2014, 2015
Yellow River	China	Water use, water diversion	Yearly time series	2003–2020	CHN_basin_YellowRiver	Li *et al.* 2024
Elbe River	Germany and Czech Republic	Streamflow, meteorological, socioeconomic, land use, flood protection	Daily time series, yearly time series, dam information	1978–2020	DEU_basin_ElbeRiver	Paprotny *et al.* 2018, Barendrecht *et al.* 2019
Volta River	Ghana	Streamflow, meteorological, land use	Yearly time series	2003–2021	GHA_basin_VoltaRiver	Owusu *et al.* 2025
Krishna River	India	Groundwater, reservoir, meteorological, water demand	Monthly time series	1968–2013	IND_basin_KrishnaRiver	Sunkara *et al.* 2025
Lake Urmia	Iran	Other hydrological, meteorological, population, economic, land use, water use	Monthly time series, yearly time series	1955–2020	IRN_basin_LakeUrmia	Alborzi *et al.* 2018, Pouladi *et al.* 2022
Lake Bracciano	Italy	Streamflow, water use, meteorological, other hydrological	Yearly time series, daily time series	1921–2021	ITA_basin_LakeBracciano	Fiori *et al.* 2025

(*Continued*)

Table A1. (Continued).

Basin/study region	Country	Types of variables	Data types	Time period covered	Dataset ZIP folder	Citation(s)
Lake Como	Italy	Reservoir, economic, meteorological, irrigation, other hydrological	Daily time series, hourly time series, sub-hourly time series	2006–2022	ITA_basin_LakeComo	Denaro *et al.* 2017, Giuliani *et al.* 2019, Giuliani *et al.* 2020, Casale *et al.* 2021, Yang *et al.* 2023, Giuliani and Castelletti 2024, Ricart *et al.* 2024, Huang *et al.* 2025, Ricart *et al.* 2025
Kiso River Basin	Japan	Flood protection, land use	Shapefiles	1890–2009	JPN_basin_KisoRiver	Nakamura *et al.* 2024
Republic of Korea	Republic of Korea	Land use, water use	NetCDF, yearly time series, spatial data	2000–2010	KOR_region_SouthKorea	Kim *et al.* 2018
Chao Phraya River	Thailand	Reservoir, canals, streamflow, water use	Daily time series, monthly time series	1993–2019	THA_basin_ChaoPhrayaRiver	Padiyedath Gopalan *et al.* 2021, 2022a, 2022b, 2024
Medjerda River	Tunisia	Precipitation, land use	Daily time series, yearly time series, shapefiles, GeoTIFFs	1905–2020	TUN_basin_MedjerdaRiver	Trabelsi and Bel Hadj Ali 2022, Trabelsi *et al.* 2023
Rufiji River	Tanzania	Water use	Information by location	Static in time	TZA_basin_RufijiRiver	–
Lake Lanier	United States	Reservoir	Daily time series	1948–2012	USA_basin_LakeLanier	–
Russian River	United States	Streamflow, irrigation, meteorological, river management	Daily time series	1959–2022	USA_basin_RussianRiver	Garcia *et al.* 2024
Kissimmee River	United States	Streamflow, meteorology, population, economic, river management	Daily time series, yearly time series	1942–2013	USA_basin_KissimmeeRiver	Chen *et al.* 2016
Sacramento River	United States	Reservoir	Daily time series	2000–2023	USA_basin_SacramentoRiver	–
Mekong River	Vietnam, Cambodia, Thailand, Laos, Myanmar	Crop, meteorological, irrigation, land use, economic, population, streamflow, other hydrological	Shapefiles, netCDFs, GeoTIFFs, dam information, other gridded data	1961–2022	VNM_basin_MekongRiver	Dang *et al.* 2022