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Editorial

Editorial on Hydrology and Water Resources in Agriculture and Ecology

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The agricultural sector uses the largest share of freshwater, accounting for over 70% of the global freshwater withdrawals, and this proportion can be up to 90% in arid and semi-arid regions [1]. Irrigation uses most of the agricultural water withdrawal and contributes greatly to global food security. Irrigation water diverted or pumped from water sources (rivers, reservoirs, and groundwater aquifers, etc.) is conveyed to croplands through artificial canals or pipe systems, which has a great impact on the hydrological processes in an irrigation district. Consequently, agricultural hydrological processes on the cropland and irrigation district scales are complicated due to the integrated impacts of natural and anthropogenic factors. Salt transport and balance associated with hydrological processes are also key factors influencing crop production on irrigated land. Modeling water flow and salt transport in croplands [2] and irrigation districts [3] has been a major topic in agricultural hydrology, which provides the basis for the spatiotemporal allocation of irrigation water for greater water use efficiency, crop yields, and/or benefits [4].

In recent decades, with the increasing water requirements for domestic and industrial uses, the water available for agriculture and natural ecosystems has been decreasing in most parts of the world, which has been further intensified by climate change. A systemic study on hydrology and water resources in agriculture and ecology will provide a basis for food security and ecosystem security. The main research fields cover water–heat–salt–nutrients transport in the soil–plant–atmosphere continuum (SAPC), agro-hydrological modeling, evapotranspiration modeling in croplands and irrigation district scales, eco-hydrology, water–salt balance and non-point source contamination modeling in an irrigation district, the high-efficient use of water resources for agriculture, interactions among water, agriculture, and natural ecosystems, and remote sensing applications in agricultural and ecological hydrology.

This Editorial refers to the topic "Hydrology and Water Resources in Agriculture and Ecology". This topic highlights new opportunities and challenges for hydrological modeling and the high-efficient use of water resources in agriculture and ecology in a changing environment.

Seventy manuscripts were submitted for the topic, and all of them were subject to the rigorous review process of participating journals. After the review and revision processes, 28 papers were finally accepted for publication and inclusion in this topic, including 10 in *Hydrology*, 6 in *Remote Sensing*, 4 in *Sustainability*, and 8 in *Water*.

As shown in Table 1, the contributions are diverse in the research fields, types of study areas, and geographical regions. The research fields can be classified into crop water requirement (four contributions), drought assessment (three), ecohydrology and environmental hydrology (three), river hydrology (three), forest hydrology (two), groundwater

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(two), soil water (two), channel leakage (one), cropland hydrology (one), drainage (one), hydrodynamics (one), hydropedology (one), nutrient loss (one), soil physics (one), water balance (one), and water footprint (one).

Table 1. Analysis of the published papers on this topic.

No.	Journal	Research Field	Focus	Type of Study Area	County /Region
1	Water	River hydrology	Impacts of climate change and human activities on streamflow	River Basin	China
2	Water	Groundwater	Recharge channels for sowing water in mountain aquifers	Mountain range	Spain
3	Remote Sensing	Drainage	Effect of controlled tile drainage on growth and yield of spring barley	Experimental fields	Czech
4	Remote Sensing	Environmental hydrology	Relationship between hydrological connectivity and water quality	River Basin	China
5	Sustainability	Ecohydrology	Relationship of zooplankton population growth and environmental factors	Reservoir	China
6	Hydrology	Hydropedology	Impact of hydropedological characteristics on streamflow in mountain catchments	Mountain catchments	South Africa
7	Water	Cropland hydrology	Effects of straw mulching on runoff and soil loss in slope farmland	Experimentalsoil tank	China
8	Remote Sensing	River hydrology	Impact of land use/cover changes on water balance components in plateau watersheds	River Basin	Pakistan
9	Remote Sensing	Drought assessment	Impact of drought on summer maize yield	Region	China
10	Hydrology	Crop water requirement	Water footprint assessment for irrigated paddy cultivation	Irrigation Scheme	Sri Lanka
11	Hydrology	River hydrology	Trends and variabilities in rainfall and streamflow	River Basin	Sri Lanka
12	Remote Sensing	Drought assessment	Remote sensing-based drought monitoring	River Basin	Kingdom of Saudi Arabia
13	Sustainability	Hydrodynamics	Selection of operation mode for irrigation canal headwork	River and canal section	China
14	Remote Sensing	Ecohydrology	Relationship between hydrological processes and ecological evolution	River Basin	China
15	Water	Crop water requirement	Estimation methods for daily crop coefficient of winter wheat	Lysimeter	China
16	Hydrology	Soil physics	Interaction of soil–water–atmosphere on soil crack characteristics	Experimental plot	Brazil
17	Water	Drought assessment	Drought assessment for spring maize	Region	China
18	Hydrology	Forest hydrology	Rainfall partitioning in Amazon Forest	Experimental plot	Brazil

Table 1. *Cont.*

No.	Journal	Research Field	Focus	Type of Study Area	County /Region
19	Sustainability	Nutrient loss	Potential runoff loss risk of nutrients in surface water of saline–alkali paddy	Mesocosm	China
20	Hydrology	Crop water requirement	Sensitivity of reference evapotranspiration to meteorological variables	Island	USA
21	Water	Soil water	Water and salt transport in freeze–thaw soil	Lysimeter	China
22	Hydrology	Forest hydrology	Hydrological properties of litter in different vegetation types	Forest	Brazil
23	Hydrology	Soil water	Photovoltaic-powered soil moisture sensor	Cropland	Brazil
24	Hydrology	Water balance	Large-area water budget analysis and drought monitoring	Countries	USA & Horn of Africa
25	Hydrology	Groundwater	Evolution of tunneling hydro-technology	Globe	Globe
26	Sustainability	Channel leakage	Model for estimating channel leakage	Channel reach	China
27	Water	Water footprint	Water footprint of animal breeding industry	Country	China
28	Water	Reference evapo-transpiration	Reference evapotranspiration estimation method	Lysimeter	USA

The study areas range from experiment sites (lyismeter and experimental plot), river/channel reach, administrative/geographic region, and countries to groups of countries or the globe that cover the globe (one contribution), one country group (one), and nine countries (twenty-six), including Brazil (four), China (thirteen), Czech (one), the Kingdom of Saudi Arabia (one), Pakistan (one), South Africa (one), Spain (one), Sri Lanka (two), and the USA (two).

Moreover, the methods used in these 28 contributions cover laboratory/field experiment analysis, statistical and regression analysis, and conceptual and physical-based hydrological models used in the cropland, regional, watershed, and country scales. There are 27 research papers and 1 review paper (contribution 25) among the 28 published papers on this topic.

Among the 28 contributions, contributions 1 and 11 fall within the scope of river hydrology. Contribution 1 analyzed the spatiotemporal variations of air temperature, precipitation, and potential evapotranspiration in the upper Yongding River Basin in North China based on historical data and assessed the impacts of climate change and human activities on streamflow using the double mass curve method and the Budyko framework for actual evapotranspiration estimation. The results show that human activities contribute more to streamflow changes than climate change in the two studied sub-watersheds. Contribution 11 analyzed the trend of change points in rainfall and streamflow in the Nilwala River Basin of Sri Lanka and explored their linkages. The results are helpful for water resources and hydropower planning.

Contributions 2 and 25 fall within the scope of groundwater. Contribution 2 presented an example of nature-based solutions for water scarcity problems in the Sierra Nevada Range of Spain, a system that uses recharge channels for sowing water in mountain aquifers that is harvested downstream. The authors postulated that this system can be an effective

adaptation measure to climate change in similar regions. Contribution 25 reviewed the history of tunneling hydro-technology for groundwater development across the globe over the past several thousand years and discussed emerging trends and challenges of tunneling hydro-technologies in the future.

Contribution 3 evaluated the effect of controlled tile drainage (CTD) on the growth and yield of spring barley at a study site in Central Bohemia, Czech Republic, in 2021 based on vegetation indices calculated from unmanned aerial vehicle (UAV) imagery. The results indicate that CTD can improve spring barley development and grain yield due to higher soil moisture than free tile drainage practice.

Contribution 4 assessed the hydrological connectivity and its influence on water quality in the Bosten Lake Basin of Northwest China. The results indicate that improved hydrological connectivity is beneficial to improving water quality.

Contributions 5 and 14 fall within the scope of ecohydrology. Contribution 5 analyzed the relationship between zooplankton population growth and water environmental factors based on monitoring data in the Shanxi Reservoir in Southeast China. The results show that zooplankton can be taken as an integrated indicator for the assessment of the water environment and ecosystem health. Using an improved SWAT model and comprehensive ecosystem quality (EQ) assessment model, Contribution 14 analyzed the distribution and evolutionary characteristics of hydrological process factors and EQ in the Ulagai River Basin of Northeast China and identified their synergy relationships.

Contribution 6 analyzed the hydropedological characteristics of three mountain catchments in South Africa and their influence on the flow dynamics of the soils. The results indicate that the drying and wetting cycles of a wetland system have a great influence on the baseflow connectivity and the overland flow during wetter periods.

Contribution 7 explored the influences of rainfall pattern, soil structure, and straw mulching on near-surface hydrology and soil erosion in a slope farmland based on a simulated rainfall experiment. The results highlight the roles of rainfall pattern and straw mulching on runoff and soil erosion in slope farmland.

Contribution 8 simulated river flows in the Potohar Plateau of Pakistan using the SWAT model under classified historical and projected future land use/cover maps. Water balance analyses indicate that the land use/cover changes tend to decrease the surface runoff and water yield due to increases in percolation, lateral flow, sub-surface flow, and evapotranspiration.

Contributions 9, 12, and 17 fall within the scope of drought assessment. Contribution 9 obtained the loss risk curve cluster of drought frequency–drought resistance capacity–yield loss rate for summer maize in Benbu of China, which is effective in the quantitative assessment of drought disasters from a physical mechanism perspective. Contribution 12 assessed the drought regime in the Al-Lith Watershed of the Kingdom of Saudi Arabia with Landsat-derived indices and standardized precipitation evapotranspiration index (SPEI). The results indicate that the vegetation health index (VHI) is more appropriate for drought assessment in data-scarce regions. Contribution 17 developed a standardized crop water deficit index based on SPEI and the crop water deficit index (CWDI) and assessed drought for spring maize in the Songnen Plain of Northeast China.

Contributions 10, 15, 20, and 28 fall within the scope of crop water requirements. Contribution 10 assessed the water footprint for irrigated paddy cultivation in the Walawe Irrigation Scheme, Sri Lanka. The results highlight the necessity of improving irrigation practice to reduce excess water usage in the study region. Contribution 15 compared three methods to estimate the stage-wise crop coefficient for winter wheat in East China based on lysimeter measurement, and appropriate method for each growth stage were suggested. Contribution 20 analyzed the sensitivity of meteorological variables in the Penman–Monteith reference evapotranspiration equation for Puerto Rico. Contribution 28 assessed different machine learning (ML) models for reference evapotranspiration estimation in highly advective environments, and the genetic algorithm-optimized extreme

learning machine performed better than other models and was recommended for reference evapotranspiration estimation at different time scales.

Contribution 13 simulated water flow and sediment transport in rivers and canal reaches under two operation conditions for irrigation canal headwork through hydrodynamic and sediment modeling. Based on the simulation results, an appropriate operation condition was recommended.

Contribution 16 assessed the soil characteristics and dynamics governing the crack formation and healing processes and quantified the soil moisture limits on soil swelling and shrinking in a vertic soil in a semiarid region of Brazil under natural conditions.

Contributions 18 and 22 fall within the scope of forest hydrology. Contribution 18 analyzed the dynamics and seasonality of litter stocks, water retention capacity, effective water retention, and water content of litter in Amazonian forests. The results are helpful for understanding the impact of sustainable forest management on the hydrological dynamics of litter. Contribution 22 studied the hydrological properties of litter in vegetation covers of *Eucalyptus* sp. plantations, agroforestry, and restoration forests, and highlighted the role of litter composition and species-specific characteristics in the hydrological functions of litter.

Contribution 19 explored the effect of nitrogen-fertilizer types on the potential risks of nitrogen and phosphorus losses through runoff. Carbon-based slow-release fertilizer is recommended for the study region to control nitrogen and phosphorus losses.

Contributions 21 and 23 fall within the scope of soil water. Contribution 20 analyzed the effect of soil texture on soil water flow and salt transport during the freezing-thawing period with a shallow groundwater table based on a lysimeter experiment. Contribution 23 developed an automated soil water tension sensor for soil moisture measurement, which can be used in real-time monitoring of soil moisture and is essential for precision irrigation.

Contribution 24 updated the agro-hydrologic VegET model by considering snow accumulation and melt processes and analyzed water budget in the conterminous United States and the Greater Horn of Africa. The model simulations can be used in drought monitoring and evaluating the impact of changing environments on agriculture and water resources.

Contribution 26 developed a multiple regression model for estimating the channel leakage process by considering the dynamic change in the main driving factors, which provides the basis for irrigation water management and control of the channel flow.

Contribution 27 assessed the water footprint of the animal breeding industry and driving forces at the provincial level in China and identified effective strategies for water footprint reduction.

Several research gaps can be detected from the contributions to this topic.

First, most studies focused on only one or several agro-hydrological processes, while few studies integrated all major hydrological processes into cropland or irrigation district scales that are influenced by both natural and anthropogenic factors. Integrated agro-hydrological models for the cropland and irrigation districts should be further studied.

Second, conflict between water uses for natural ecosystems and humans is unavoidable in areas short of water resources, especially in arid and semiarid regions. How to balance water uses in different sectors and allocate limited water resources optimally are key challenges in water resource management.

Third, nutrient losses associated with water flow from cropland not only waste a large amount of fertilizer and lower the nutrient use efficiency, but also result in pollution in water bodies and groundwater aquifers, together with contaminants from other sources. Controlling non-point source pollution from agriculture requires models for simultaneous water flow and nutrients/contaminants transport.

Fourth, soil salinization is a major threat to crop growth and food security in salinization-prone regions. How to regulate soil water and salt regimes in cropland/irrigation districts through appropriate irrigation and drainage practices will provide suitable soil conditions for crop growth and alleviate the negative influence of salt accumulation in croplands.

Fifth, the combination of data-driven algorithms and physical-based models is a new trend in hydrology and other disciplines. However, no paper used this method on this topic.

Finally, remote sensing technology has provided numerous data for agricultural hydrology research, especially in irrigation districts or on regional scales. Several papers on this topic used remote sensing data in drought assessment, but the application of remote sensing in other fields is less frequently used in this topic. More studies are expected to use remote sensing data in agro-hydrological modeling.

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