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Editorial: Ecosystem and Hydrological Responses in Mountain Environments to the Changing Climate

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Editorial on the Research Topic

Ecosystem and Hydrological Responses in Mountain Environments to the Changing Climate

Worldwide the resilience of mountain ecosystems to transient changes in climate and anthropogenic footprint has been reduced (Schirpke et al., 2017; Chettri et al., 2020). The reduced resilience has a direct impact on the sustenance of the biotic and abiotic resources that include snow, glaciers, permafrost, soils, forests, alpine meadows, alpine lakes and streams, and associated fauna. The prevailing warming scenario and increased anthropogenic interferences have not only led to the degradation of the pristine montane landscapes but increased the risk of the communities to various climate-induced disasters posing a threat to the life and infrastructure downstream. Landscape degradation primarily manifests through land system changes (Prăvălie, 2021), vegetation composition and distribution changes (Li et al., 2021), eutrophication of water bodies (Dar et al., 2021), and increased frequency of hazards associated with Earth surface processes (Smiraglia et al., 2016). The cumulative effects of the anthropogenic footprint and exacerbated warming in high-elevation environments have also resulted in enhanced glacier melt, glacier area loss, formation of new-moraine dammed lakes, and destabilization of permafrost that could affect upstream-downstream linkages and also increase the vulnerability of downstream communities to Glacial Lake Outburst Floods (GLOFs), Landslide Lake Outburst Floods (LLOFs), snow avalanches, glacier detachments, landslides, debris flows and rock-ice avalanches (Kääb et al., 2021; Shugar et al., 2021; Zheng et al., 2021).

In the context of climate change and an increased anthropogenic footprint on mountain landscapes and ecosystems, this special issue invited articles focusing on vegetation dynamics, land system changes, catchment-scale processes affecting aquatic ecosystems, mountain hydrology, and cryosphere-related hazards utilizing remote sensing techniques, field surveys, analytical laboratory experiments, and geospatial models to characterize the earth-surface processes, biodiversity changes, and associated ecosystem services better.

In this research topic, we collated five scientific contributions that describe the state and processes affecting the high-mountain environments. This special issue comprises articles addressing issues like land degradation, glacier hydrology, glacial lake evolution, organic matter production, and hydrochemistry of aquatic ecosystems in the Himalayas, Pamirs, and Rockies. High diversity is observed among the authors of these five contributions: 32 authors from 24 research and academic institutes in six countries participated in this work (**Figure 1**).

The contribution by Garg et al. emphasizes the differential retreat of a lake-terminating and a land-terminating glacier in the Zanskar mountain range of Trans-Himalayan Ladakh, India, utilizing

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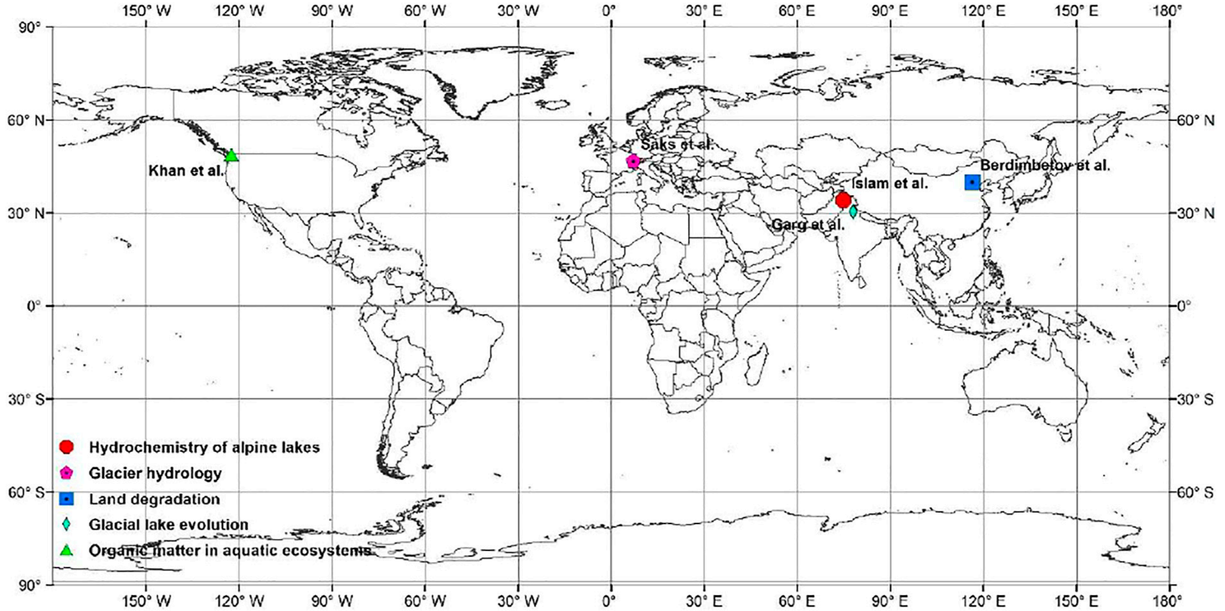

FIGURE 1 | Topical and geographical distribution of contributions in this research topic.

remote sensing data from 1977 to 2018. The authors suggest glacier topography and associated valley geomorphology for the formation of the proglacial lake associated with Dulung Glacier. The expansion of the proglacial lake is accompanied by the accelerated melt of the Dulung glacier, as indicated by geodetic mass changes (0.47 m w.e.a^{-1}) and shrinkage (0.3% a^{-1}). On the contrary, the land-terminating Chilung Glacier shows a moderate degeneration (geodetically qualified ice loss of −0.28 m w.e.a^{-1} and shrinkage of 0.2% a^{-1}). The paper suggests that the proglacial lake has a substantial impact in enhancing the sensitivity of Dulung Glacier to climate change compared to the Chilung Glacier. The authors conclude that the current lake expansion scenario would further enhance Dulung Glacier's degeneration and the associated GLOF hazard.

Another contribution by Saks et al. on glacial hydrology in Tien Shan, Central Asia, is aimed to understand the glacier and its meltwater runoff variations between 1981 and 2019 using a simplified energy balance approach and a distributed model forced using ERA 5 reanalysis data for the two catchments. They used *in situ* hydrological data, satellite-derived snow cover, stake measurements, and geodetic mass changes to validate the model output. These authors suggested that the glacier volume decreased by 14% and 12% mostly between 1996 and 2019 for the two catchments indicating a strong regional variability in glacier-climate interactions in Central Asia.

The contribution by Berdimbetov et al. assessed land degradation and its driving factors in the Aral Sea Basin between 1982 and 2015 using the Normalized Difference Vegetation Index (NDVI) as a proxy. Further, the residual trend indicated that precipitation variations have dominant control over land degradation, followed by soil moisture and temperature. The land system transformations in the basin revealed by conversion of water spread and forest into scrubland and barren lands are the major contributors of contemporary land degradation. They concluded that an extensive analysis of land degradation could assist in formulating robust policy interventions for preventing and mitigating the impacts of land degradation in the Aral Sea basin.

Khan et al. evaluated the contribution of nitrogen and phosphorus loading and phytoplankton abundance as drivers of the formation of dissolved organic matter and the associated disinfection byproducts in 30 reservoirs of Colorado. They revealed that the concentration of total nitrogen was directly proportional to chlorophyll-a and total organic carbon concentration and that the dissolved organic matter in the reservoirs indicated contribution from phytoplankton. Their analysis also pointed out that the reservoirs with higher total organic carbon (>4 mg C L^{-1}) were mostly located in the plains characterized by higher agricultural runoff and wastewater discharges compared to mountainous reservoirs. The research suggested that the additive effect of high total organic carbon concentration and microbial characteristics resulted in a higher potential to produce two classes of disinfection byproducts (trihalomethanes and haloacetic acids). The authors suggest that these findings provide a limnological context supporting the recent guidelines concerning the drinking water supplies in Colorado.

Islam et al. assessed the limnochemistry and plankton diversity of five high-altitude lakes of Kashmir Himalaya, India. This research article constitutes a comprehensive effort to characterize and understand the phytoplankton, periphyton assemblages, water quality, bathymetry, morphometry, and land use/land cover (LULC) of the high-altitude mountain lakes. Their analysis of LULC indicated that the lake catchments are covered by pastures, exposed rocks, and perennial snow and glaciers. Bathymetric analysis of the investigated lakes revealed that the maximum depths vary between 8 and 84 m with excellent water quality. The research helped in generating baseline information about high-altitude lakes of data-scarce Kashmir Himalaya that can act as a foundation for long-term limnological research.

As a concluding remark, we believe that research contributions under this research topic can contribute to a better understanding of the ecosystem and hydrological responses in mountain environments to the changing climate. They can also support policymaking in formulating strategies at the local level towards achieving some of the key goals under the United Nations Sustainable Development Goals.

AUTHOR CONTRIBUTIONS

The idea of and concept of this research topic came from IR. However, the target areas evolved through brainstorming discussions among the guest editors. IR drafted the initial version of this editorial. All authors contributed to the writing process of the editorial and approved the final version.

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