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Editorial

Water Resource Management through the Lens of Planetary Health Approach

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For eternity, water resources have proven to be the key to inclusive social development and human well-being. However, the spatio-temporal variation of this finite resource over various landscapes makes it prone to misuse and mismanagement. Rapid global changes such as urbanization, population growth, socio-economic change, change in lifestyle, evolving energy needs, and climate change have put unprecedented pressure on this finite freshwater resource. Keeping this in mind, it is argued that achieving water security throughout the world is the key to achieving sustainable development in a comprehensive manner. However, scientific studies with a holistic point of view considering persistently changing dimensions are still in their embryonic stage. Broadly, water security evolves from ensuring reliable access to enough safe water for every person (at an affordable price where market mechanisms are involved) to lead a healthy and productive life, including future generations. Moreover, there is a need to transition from water scarcity towards water security for a water-secure present and future. This transition requires a look at this complex issue and interdependencies between water, environment, human health, and governance/institutions regulating it to be more inclusive. Despite recent progress in developing new strategies, practices, and technologies for water resource management, their dissemination and implementation have been limited. The nexus approach encompasses these interdependencies, and, to promote this idea, different global frameworks are there to address global health in holistic and comprehensive ways, like one earth, one health, eco-health, and planetary health. Planetary health is the most recent one advocated by the scientific communities as well as policymakers; however, very little has been conducted to present empirical scientific evidence from the ground.

Considering the above-mentioned information gap, this special issue aimed to capture the persistently changing dimensions and new paradigms of water security, providing a holistic view, including a wide range of sustainable solutions to address water security. It discussed gaps, opportunities, challenges, and lessons learned from past experiences for achieving water security in any particular landscape. It also highlighted how recent scientific innovations in the research methodologies had made progress in realizing a planetary health framework to address the water-food-energy-health-biodiversity nexus, urban-rural nexus, regional-circular-ecological-sphere approach, etc., and address the complex issue of water security. Finally, what are the ways forward for a better science-policy interface through the inclusion of every relevant stakeholder to codesign and codelivery of various adaptation and mitigation strategies needed to achieve global goals, e.g., SDGs at a local level in a timely manner? All the above-mentioned issues were reflected through ten articles included in this issue.

The first two articles (Pradhan et al. [1] and Behera et al. [2]) discussed the status of water resources and processing governing the evolution of its quality and quantity in the data-scarce region of India. Considering water as a limiting factor for socio-economic development, especially in arid/semi-arid regions, both scientific communities and policymakers are interested in groundwater recharge-related data. Therefore, Pradhan et al. [1] used an

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integrated approach of environmental isotopes and hydrogeochemical studies to understand the recharge processes and geochemical evolution of groundwater in the fractured basement terranes of Gujarat, NW India. Based on the major ionic distribution, results suggest that the chemical weathering of silicate minerals influences the groundwater chemistry in the aquifer system. Furthermore, the chemical composition of groundwater also reflects that the groundwater has interacted with distinct rock types (granites/granulites). The isotopic signature of the groundwater reveals that the local precipitation is the main source of recharge; however, it is affected by the evaporation process due to different geological conditions, irrespective of topographical differences in the study area.

Despite being a biodiversity hotspot, the Mahanadi delta in eastern India is facing groundwater salinization as one of the main environmental threats in the recent past. Hence, Behera et al. [2] attempt to understand the dynamics of groundwater and its sustainable management options through numerical simulation (MODFLOW) in the Jagatsinghpur deltaic region. The result shows that groundwater in the study area is extensively abstracted for agricultural activities, which also causes the depletion of groundwater levels. The hydraulic head value varies from 0.7 to 15 m above mean sea level (MSL), with an average head of 6 m in this low-lying coastal region. The horizontal hydraulic conductivity and the specific yield values in the area are found to vary from 40 to 45 m/day and 0.05 to 0.07, respectively. The interaction between the river and coastal unconfined aquifer system responds differently in different seasons. The net groundwater recharge to the coastal aquifer has been estimated and varies from 247.89 to 262.63 million cubic meters (MCM) in the years 2006–2007. The model further indicates a net outflow of 8.92–9.64 MCM of groundwater into the Bay of Bengal. Further, the outflow to the sea prevents the seawater from ingress into the shallow coastal aquifer system. The findings of both of these studies provided vital information for the decision-makers or policymakers to take appropriate measures to design water budgets as well as water management plans more sustainably.

The next paper by Kadir et al. [3] aims to assess the impacts of one of the direct drivers, i.e., land use and land cover (LULC) changes on the water quality of the Surma river in Bangladesh. For this, seasonal water quality (physico-chemical parameters) changes were assessed in comparison to the LULC changes recorded from 2010 to 2019. The obtained results from this study indicated that there is a significant seasonal pattern in the water quality changes, with relatively higher concentration found in the dry season. On the other hand, analysis of LULC revealed that agricultural and vegetation classes decreased, while built-up, waterbody, and barren lands increased. The correlation between LULC and water quality parameters showed a significant relationship between them. Built-up areas and waterbodies appeared to have the strongest effect on different water quality parameters. Scientific findings from this study will be vital for decision-makers in developing a more robust land use management plan at the local level.

The next three papers by Hung et al. [4], Acharjee et al. [5], and Kumar et al. [6] discussed the effect of water pollution and its impacts on different tropic levels, human health, and the ecosystem. Excessive nutrient enrichment or eutrophication is an environmental pollution problem that occurs in natural water bodies and causes a lot of socio-economic issues. Hung et al. [4] investigated the factors responsible for eutrophication in three reservoirs in Taiwan using regression analyses. The results indicate that the main factor influencing these reservoirs is total phosphorus, and the influence of total phosphorus when interacting with other factors on water quality trophic state is more serious than that of total phosphorus per se. This implies that the actual influence of total phosphorus on the eutrophic condition could be underestimated. Furthermore, there was no deterministic causality between climate and water quality variables. Moreover, it is found that the influencing patterns for the three reservoirs are different because the type, size, and background environment of each reservoir are different, which means it is difficult to predict eutrophication in reservoirs with a universal index or equation. However, the multiple linear regression model used in this study could be a suitable quick-to-use, case-by-case model option for this problem.

Acharjee et al. [5] examined river sediment as an environmental indicator to measure the pollution level in Surma River, Bangladesh. Further, it compares potential ecological risk index values using Hakanson Risk Index (RI) and Monte Carlo Simulation (MCS) approach to evaluate the environmental risks caused by these heavy metals. The obtained results using risk index values from RI and MCS provided valuable insights into the contamination profile of the river, indicating that the studied river is currently under low ecological risk for the studied heavy metals. This study can be utilized to assess the susceptibility of the river sediment to heavy metal pollution near an urban core and to have a better understanding of the contamination profile of a river.

Microplastics (MPs) are considered an emerging pollutant in the aquatic environment; however, there is a scientific knowledge gap in this regard in several Asian regions. Considering this aforementioned information, Kumar et al. [6] carried out a systematic review to provide an insightful understanding of the spatial distribution of scientific studies on MPs in freshwater conducted across the Asian region, utilized sampling methods, and a detailed assessment of the effects of MPs on different biotic components in freshwater ecosystems, with special focus on its potential risks on human health. The results of this review indicate that research on microplastics in Asia has gained attention since 2014, with a significant increase in the number in 2021 might be because of excessive plastic pollution during the COVID-19 situation. Moreover, these research works are concentrated in China, followed by India and South Korea. When talking about the type of research works, it was also found that most of the studies focused primarily on reporting the occurrence levels of MPs in freshwater systems, such as water and sediments, and aquatic organisms, with a lack of studies investigating the human intake of MPs and their potential risks to human health. Notably, comparing the results among different countries is a challenge because diverse sampling, separation, and identification methods were applied to estimate MPs. This review study suggests that further research on the dynamics and transport of microplastics in biota and humans is needed, as Asia is a major consumer of seafood products and contributes significantly to the generation of plastic litter in the marine environment. Moreover, there is a need for further research on policy and governance frameworks to address this emerging water pollutant more holistically.

The next four papers were based on different management methodologies for water resources and their interlinkages with other socio-ecological components. Considering the water-sensitive socio-economic growth in the Vietnamese Mekong Delta, Minh et al. [7] utilized MIKE 11 to quantify the spatio-temporal dynamics of water quality parameters. Results show that locations near cage culture areas exhibited higher BOD5 values than sites close to pond/lagoon culture areas due to the effects of numerous point sources of pollution, including upstream wastewater and out-fluxes from residential and tourism activities in the surrounding areas, all of which had a direct impact on the quality of the surface water used for aquaculture. Moreover, as aquacultural effluents have intensified and dispersed over time, water quality in the surrounding water bodies has degraded. The findings suggest that the effective planning, assessment, and management of rapidly expanding aquaculture sites should be improved, including more rigorous water quality monitoring, to ensure the long-term sustainable expansion and development of the aquacultural sector in the Long Xuyen Quadrangle in particular and the Vietnamese Mekong Delta as a whole.

Considering the water resources as a limiting factor for socio-economic development, especially in arid/semi-arid regions, Shyam et al. [8] carried out the assessment of groundwater reserves, which was carried out in the Udaipur district, Aravalli range, India using an integrated approach of remote sensing, GIS, and field-based spatial modeling. Results show that the principal aquifer for the availability of groundwater in the studied area is quartzite, phyllite, gneisses, schist, and dolomitic marble, which occur in unconfined to semi-confined zones. Furthermore, all primary chemical ingredients were found within the permissible limit, including granum. We also found that the dynamic GW reserves of the area are 637.42 mcm/annum, and the total groundwater draft is 639.67 mcm/annum. The deficit GW reserves are 2.25 mcm/annum from an average rainfall of 627 mm; hence, the stage of

groundwater development is 100.67% and categorized as over-exploited. However, as per the relationship between reserves and rainfall events, surplus reserves are available when rainfall exceeds 700 mm. It was concluded that enough static GW reserves are available in the studied area to sustain the requirements of the drought period. For the long-term sustainability of groundwater use, controlling groundwater abstraction by optimizing its use, managing it properly through techniques such as sprinkler and drip irrigation, and achieving more crop-per-drop schemes, will go a long way to conserving this essential reserve and creating maximum groundwater recharge structures.

Considering the emergence of different nexus approaches to understanding the dynamics and co-evolution of water and human systems, Nguyen et al. [9] developed a social-hydrological approach to enhance the water supply resilience in Con Dao Island, Vietnam. It used a water-balance model involving the Water Evaluation and Planning (WEAP) tool to conduct a scenario-based evaluation of water demands. In doing so, we assessed the impacts of socio-economic development, such as population growth and climate change, on increasing water demand. The modeling results showed that the existing reservoirs—the main sources to recharge the groundwater—play a critical role in enhancing water supply resilience on the island, particularly during the dry season. In addition, future water shortages can be solved by investment in water supply infrastructures in combination with the use of alternative water sources, such as rainwater and desalinated seawater. The findings further indicate that while the local actors have a high awareness of the role of natural resources, they seem to neglect the impacts of climate change. To meet the future water demands, this paper also gave some potential suggestions like upgrading and constructing new reservoirs, mobilizing resources for freshwater alternatives, and investing in water supply facilities as among the most suitable roadmaps for the island. In addition, strengthening adaptive capacity, raising awareness, and building professional capacity for both local people and officials are strongly recommended. The research concludes with a roadmap that envisages the integration of social capacity to address the complex interaction and co-evolution of the human–water system to foster water-supply resilience in the study area.

Inhabitants of low-lying islands face increased threats due to climate change as a result of their higher exposure and lesser adaptive capacity. Sagar Island, the largest inhabited estuarine island of Sundarbans, is experiencing severe coastal erosion, frequent cyclones, flooding, storm surges, and breaching of embankments, resulting in land, livelihood, and property loss, and the displacement of people at a huge scale. Hence, Bera et al. [10] assessed climate change-induced vulnerability and risk for Sagar Island, India, using an integrated geostatistical and geoinformatics-based approach. Based on the IPCC AR5 framework, the proportion of variance of 26 exposure, hazard, sensitivity, and adaptive capacity parameters was measured and analyzed. The results showed that 19.5% of mouzas (administrative units of the island), with 15.33% of the population in the southern part of the island, i.e., Sibpur–Dhablat, Bankimnagar–Sumatinagar, and Beguakhali–Mahismari, are at high risk (0.70–0.80). It has been concluded that the island has undergone tremendous land system transformations and changes in climatic patterns. Therefore, there is a need to formulate comprehensive adaptation strategies at the policy- and decision-making levels to help the communities of this island deal with the adverse impacts of climate change. The findings of this study will help adaptation strategies based on site-specific information and sustainable management for the marginalized populations living on similar islands worldwide.

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