

Editorial

Impacts of Climate on Renewable Groundwater Resources and/or Stream–Aquifer Interactions

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1. Introduction

The evaluation of aquifer recharge is essential to make a quantitative evaluation of renewable groundwater resources required to implement proper water policies aimed at maintaining stream–aquifer interactions, guaranteeing water supply to human activities, and preserving groundwater-dependent ecosystems at different spatial and temporal scales and climate conditions. As another hydrological variable, aquifer recharge is intrinsically uncertain and may integrate different water fluxes with different hydrological origins. Aquifer recharge may include (i) natural sources from precipitation, aquifers transference, river losses, and snow melting; (ii) unpremeditated human-induced sources from irrigation and urban returns and losing channels and reservoirs; and (iii) premeditated human-routed sources from artificial infiltration practices and returns derived from non-conventional water sources such as wastewater reuse and desalination. Weather-land attributes, human-water requirements, and global-climatic forces determine the magnitude of natural sources, the existence of additional human-induced sources when water is used, and the need for human-routed sources in contexts of water scarcity. In short, these drivers determine the renewable fraction of the groundwater resource in a given groundwater body.

However, a temporal perspective to understand how climate determines the aquifer recharge sources and the groundwater renewability is needed because resources on many groundwater bodies may be variably related to natural aquifer recharge produced during past climates. Therefore, for similar large groundwater storage, the influence of climate may extend over the last millennium in drylands with very low recharge rates and over the last centuries and decades in temperate mid-terrestrial-latitude semiarid and sub-humid regions, respectively. Current global climatic forces, which include the increasing influence of floods and droughts in different terrestrial latitudes and the variable human influence, condition water resources management policies in the near future. Finally, global climate scenarios foresee the thresholds for water availability ahead.

In this wide “aquifer-recharge–climate” framework, this Special Issue was aimed at reporting all influences of climate (past, current, and future) on natural, unpremeditated, and premeditated aquifer recharge sources over different aquifer and landscape typologies at different spatial and temporal scales.

2. Contributions

Since the call for papers was announced in March 2019, and after a rigorous peer-review process, six papers have been accepted for publication [1–6]. To gain a better insight into the essence of the Special Issue, we offer brief highlights of the published papers below.

The paper “Potential Impacts of Future Climate Change Scenarios on Ground Subsidence” [1] develops a new method (a parsimonious approach) to assess the impact of climate change scenarios on land subsidence related to groundwater level depletion in detrital aquifers. The Vega de Granada aquifer in southern Spain was the case study chosen. Historical subsidence was estimated using remote sensing techniques, whereas local climate change scenarios for the future horizon (2016–2045) were generated by applying a bias-correction approach. The method will allow for anticipating sustainable adaptation strategies for land subsidence in vulnerable detrital aquifer areas during critical drought periods to be assessed.

The paper “Numerical Approaches for Estimating Daily River Leakage from Arid Ephemeral Streams” [2] studies the patterns of river infiltration and the associated controlling factors in an approximately 150-km section of the Donghe River (lower Heihe River, China) by using a combination of field investigations and modeling techniques. In this arid region, the simulated infiltration was most sensitive to the aquifer hydraulic conductivity and the maximum evapotranspiration rate. Both hydraulic parameters of riverbeds and evapotranspiration parameters were equally important for quantifying the flux exchange between arid ephemeral streams and underlying aquifers. Findings are of interest to help maintain riparian ecosystems in arid regions.

The paper “Coupling SWAT Model and CMB Method for Modeling of High-Permeability Bedrock Basins Receiving Interbasin Groundwater Flow” [3] couples the Soil and Water Assessment Tool model and the chloride mass balance (CMB) method to improve the modeling of streamflow in high-permeability bedrock basins receiving interbasin groundwater flow (IGF), i.e., the naturally occurring groundwater flow beneath a topographic divide contributing to the streamflow. The Castril River basin in southern Spain was the case study chosen. In this headwater area, which has null groundwater exploitation, the mean yearly IGF was about 0.5-fold of the mean yearly baseflow. This paper provides a way to identify IGF in high-permeability bedrock basins.

The paper “The Ecosystem Resilience Concept Applied to Hydrogeological Systems: A General Approach” [4] discusses the role of resilience of hydrogeological systems affected by either climate and/or anthropic actions in order to understand how anticipating negative changes (transitions) and preserving its services. The paper reports typical human actions modifying groundwater dynamics of hydrogeological systems in recent decades, which can be increased by climate change with delayed effects on groundwater quantity and quality as rivers that have dried up, wetlands that have disappeared, leaving their buckets converted into farmland, and aquifers that have been intensively exploited for years.

The paper “Climate-Dependent Groundwater Discharge on Semi-Arid Inland Ephemeral Wetlands: Lessons from Holocene Sediments of Lagunas Reales in Central Spain” [5] analyzes the water balance of wetlands, which are systems highly sensitive to climate change and human action. The Lagunas Reales in central Spain, a semiarid inland wetland endangered by both climate and human drivers, was the case study chosen. Studying the Holocene sedimentary record found that past arid periods produced greater surface freshwater inflow and low contribution of deep saline groundwater. During past wet periods, deep saline groundwater discharge increased wetland water salinity. The paper analyzes the wetlands resilience to natural and human-induced changes.

The paper “Using the Turnover Time Index to Identify Potential Strategic Groundwater Resources to Manage Droughts within Continental Spain” [6] identifies groundwater (GW) bodies with low vulnerability to pumping to be used as potential buffer values for sustainable conjunctive use management during droughts. In each GW body, GW vulnerability was obtained using the natural turnover time index as the storage capacity divided by recharge. For the historical period and near future (until 2045), this approach was applied to the 146 Spanish GW bodies at risk of not achieving a good quantitative status, according to the target of the European Water Framework Directive. The paper contributes to sustainable adaptation strategies to adapt to climate change.

3. Conclusions

The Guest Editors envision that published papers in this Special Issue would be of interest to researchers and practitioners and help identify further research routes. We also hope that the readers can find the material of this Special Issue both interesting and inspiring when exploring the field of impacts of climate (past, current, and future) on natural, premeditated, and unpremeditated aquifer recharge sources determining the renewable fraction of the groundwater resource. The findings and methods presented in this collection of papers contribute to the increasing interest in some associated problematics concerning stream–aquifer interactions in drylands and mountainous areas, the resilience of groundwater-dependent ecosystems to future climate change and human action, land-subsidence problems in the future, and the influence of climate change on groundwater resources availability and its implication for sustainable groundwater management policies ahead.

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