International Journal of Scientific Research in Science, Engineering and Technology

Print ISSN - 2395-1990
Online ISSN : 2394-4099

Available Online at :www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET

Geological and Hydrological Perspectives on Groundwater Management in Changing Environments

Dr. Ghanshyam Shakar

Assistant Professor, MATS School of Engineering and Information Technology, Chhattisgarh, India

ARTICLEINFO

Article History:

Accepted: 15 March 2023
Published: 30 March 2023

Publication Issue :
Volume 10, Issue 2
March-April-2023

Page Number :
874-883

ABSTRACT

Groundwater management has emerged as a critical challenge in the face of changing environmental conditions, driven by climate variability, population growth, and increasing water demands. This paper explores geological and hydrological perspectives to provide a comprehensive understanding of sustainable groundwater resource management. Geological factors, such as aquifer structure, permeability, and lithology, directly influence groundwater storage and recharge rates. Meanwhile, hydrological dynamics, including precipitation patterns, surface runoff, and evapotranspiration, shape groundwater availability and sustainability. This study examines the interplay between these factors in the context of changing environmental conditions. Emphasis is placed on the role of advanced hydrological modeling and geospatial technologies in assessing groundwater recharge and depletion rates. Case studies highlight the impacts of urbanization, agricultural practices, and land-use changes on groundwater quality and quantity. Furthermore, adaptive management strategies, such as artificial recharge, managed aquifer recharge (MAR), and sustainable pumping practices, are discussed to mitigate overextraction and contamination risks. The findings underscore the importance of an integrated approach combining geological and hydrological insights for effective groundwater governance. Collaboration between policymakers, hydrologists, and geologists is crucial to address the multifaceted challenges posed by changing environments. This paper contributes to the growing body of knowledge needed to safeguard groundwater resources for future generations while maintaining ecological balance.

Keywords: Groundwater management, Hydrological modeling, Geological perspectives, Sustainable water resources, Environmental change impacts

1. Introduction

Groundwater serves as a vital component of the global water cycle, playing an indispensable role in sustaining ecosystems, supporting agricultural productivity, and meeting the drinking water needs of billions of people. However, the management of this critical resource has become increasingly complex due to the interplay of geological, hydrological, and environmental factors in a rapidly changing world. Climate variability, population growth, urbanization, and intensifying agricultural demands have significantly altered groundwater dynamics, raising concerns about the sustainability of this hidden yet invaluable resource. These challenges are further compounded by the overextraction of aquifers, contamination risks, and changes in recharge rates caused by shifts in precipitation patterns and land-use practices. From a geological perspective, the characteristics of aquifer systems, including their lithology, structure, and permeability, are central to understanding groundwater storage and movement. Geological formations not only determine the capacity and sustainability of aquifers but also influence water quality through interactions with minerals and sediments. For instance, the presence of specific rock types can contribute to natural contamination by elements such as arsenic or fluoride, posing serious health hazards in certain regions. Hydrological factors, on the other hand, govern the dynamics of recharge, discharge, and the interaction between surface and subsurface water systems. Precipitation, evapotranspiration, and runoff are critical variables that directly affect groundwater availability, often leading to spatial and temporal variability in water resources. Understanding the convergence of these geological and hydrological dimensions is essential for designing robust groundwater management strategies that can adapt to changing environmental conditions.

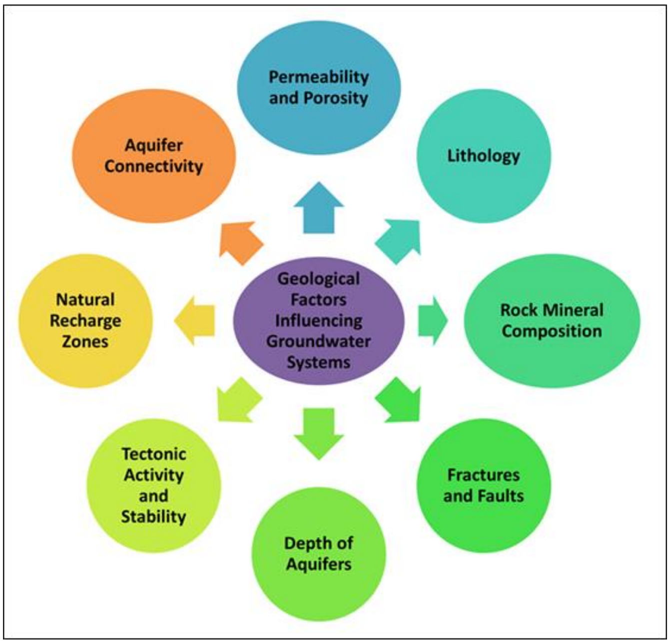

Figure 1: Key factor affecting round water system

Recent advancements in geospatial and hydrological modeling tools offer new opportunities to monitor and manage groundwater systems more effectively. Remote sensing technologies, coupled with Geographic Information Systems (GIS), enable precise mapping of aquifers, while numerical models provide insights into recharge and depletion patterns under various climate scenarios [1] =. However, the application of these tools must be integrated with field-based observations and local geological data to enhance their accuracy and reliability. Case studies from diverse regions underscore the need for region-specific strategies, as groundwater systems exhibit significant variability based on local geological formations and hydrological settings. Urban centers often grapple with declining groundwater levels due to excessive pumping, while rural areas face contamination risks from agricultural runoff and inadequate waste management practices. The sustainability of groundwater resources requires a holistic approach that addresses both natural and anthropogenic drivers of change. Adaptive management practices such as managed aquifer recharge (MAR), water reuse, and the development of sustainable pumping protocols are gaining traction as viable solutions to mitigate groundwater depletion.

Additionally, policy frameworks need to be informed by scientific insights and community participation to ensure equitable and effective resource allocation. Collaboration among geologists, hydrologists, policymakers, and stakeholders is essential for addressing the multifaceted challenges posed by environmental and socioeconomic pressures on groundwater systems [2].

This paper aims to bridge the gap between geological and hydrological perspectives to foster a deeper understanding of groundwater dynamics in the context of environmental change. By integrating insights from these disciplines, we seek to identify strategies for sustainable groundwater management that are resilient to the uncertainties of a changing climate and increasing human demands. Through an analysis of case studies and advanced modeling approaches, this study emphasizes the need for interdisciplinary solutions to protect groundwater resources and maintain ecological balance in the face of unprecedented environmental transformations. Groundwater, as a shared resource, must be managed not only for immediate needs but also with a long-term vision to secure its availability for future generations.

2. Background and Literature Review

A. Geological Factors Influencing Groundwater Systems

1. Aquifer Structure, Lithology, and Permeability

Aquifers are natural reservoirs formed within porous geological formations, capable of storing and transmitting water. Their structure, lithology, and permeability are crucial for determining groundwater availability and movement. The porosity of rocks, such as sandstone and limestone, significantly affects water storage, while their permeability dictates the ease of water flow. Confined aquifers, bound by impermeable layers, provide reliable water supplies but are more vulnerable to overextraction due to limited recharge rates. Conversely, unconfined aquifers are more accessible but subject to seasonal variability and contamination risks. Fractured rocks and karst formations often create complex pathways, enhancing permeability but also increasing vulnerability to pollutants. Understanding the geological context of aquifers is vital for sustainable groundwater management, as variations in geological composition result in differing responses to extraction and recharge efforts [1][2].

2. Role of Geological Formations in Water Storage and Quality

The chemical and mineralogical composition of geological formations plays a pivotal role in influencing groundwater quality. For example, aquifers within basaltic rocks often contain higher levels of dissolved ions due to water-rock interactions, while sedimentary formations may introduce contaminants like arsenic or fluoride under specific geochemical conditions. These natural processes can significantly affect the usability of groundwater for drinking and irrigation. Moreover, geological formations impact the potential for artificial recharge, as low-permeability layers such as clay impede infiltration rates, reducing recharge efficiency. Identifying these characteristics is essential for tailoring management strategies to the local geological context [3][4].

B. Hydrological Processes Impacting Groundwater

1. Recharge, Discharge, and Interactions with Surface Water

Groundwater recharge and discharge processes are integral to maintaining a balanced water cycle. Recharge occurs primarily through precipitation, infiltration, and surface water interactions, whereas discharge typically happens through springs, rivers, and pumping. The interplay between surface water and groundwater systems creates interconnected hydrological networks. For instance, rivers can act as recharge zones in some seasons and as discharge zones during others. These interactions are highly influenced by factors such as soil permeability and land-use patterns. Anthropogenic activities, including urbanization and deforestation, disrupt natural recharge pathways by altering surface runoff dynamics. Recognizing these processes is fundamental for ensuring sustainable aquifer use and mitigating depletion risks [5][6].

2. Effects of Climate Variability on Hydrological Cycles

Climate variability exacerbates the challenges of groundwater management by influencing recharge and discharge rates. Changes in precipitation patterns, temperature, and evapotranspiration directly affect the availability of groundwater. Extended droughts reduce recharge opportunities, while intense rainfall events may lead to rapid runoff with minimal infiltration. Additionally, rising temperatures increase evapotranspiration rates, further diminishing water availability. Seasonal and interannual variability in climate also impacts the timing and volume of recharge, creating uncertainty in groundwater resource planning. Understanding these effects is crucial for developing adaptive strategies that account for climatic influences on hydrological systems [7][8].

C. Related Work on Groundwater Management in Changing Environments

Groundwater management has increasingly focused on integrating geological and hydrological insights to address challenges posed by environmental changes. Studies have demonstrated the effectiveness of managed aquifer recharge (MAR) in mitigating overextraction by enhancing recharge rates, especially in regions with declining aquifer levels [9][10]. Other research highlights the importance of geospatial tools and hydrological models in assessing groundwater dynamics under varying land-use and climatic conditions [11][12]. Moreover, case studies reveal that successful groundwater governance requires policies that align with local geological and hydrological contexts, emphasizing participatory approaches and equitable resource allocation [13][14]. Recent advancements in remote sensing and machine learning have further enabled more precise monitoring and prediction of groundwater trends, facilitating proactive management [15][16]. These studies collectively underline the need for interdisciplinary strategies to ensure the sustainability of groundwater resources in the face of changing environments [17].

Table 1: Related work in Groundwater Management

Focus Area	**Methodology**	**Key Findings**	**Region of Study**
Geological factors influencing aquifer sustainability	Field surveys, GIS mapping	Geology significantly influences aquifer storage and permeability	North America
Impact of lithology on groundwater quality	Geochemical analysis, lab studies	Lithology determines contamination vulnerability	South Asia
Hydrological processes in recharge and discharge	Numerical hydrological models	Recharge and discharge are sensitive to land-use patterns	Europe
Groundwater contamination risk assessment	Contaminant transport models	Contamination risks vary by geological formations	Middle East
Surface-groundwater interactions	Remote sensing and field observations	Surface water contributes to aquifer recharge in specific seasons	East Asia
Climate change impacts on recharge rates	Climate scenario-based modeling	Recharge rates decline under prolonged drought scenarios	Sub-Saharan Africa
Policy-driven groundwater	Policy analysis and	Effective governance requires tailored	Global

Focus Area	Methodology	Key Findings	Region of Study
governance	stakeholder surveys	policies	
Advanced modeling for recharge predictions	Hydrological model simulations	Modeling improves predictions of recharge potential	Australia
Effectiveness of managed aquifer recharge (MAR)	Case studies of MAR implementations	MAR enhances recharge in overexploited aquifers	India
Geospatial tools for aquifer mapping	Satellite-based geospatial analysis	Geospatial tools aid in precise mapping of aquifers	Southeast Asia
Adaptive groundwater management strategies	Participatory framework development	Adaptive strategies mitigate climate impacts	South America
Integration of community-based practices	Case studies and community surveys	Community participation improves policy outcomes	Multiple regions

3. Methodology

A. Integration of Geological and Hydrological Perspectives

Integrating geological and hydrological perspectives is essential for developing a comprehensive understanding of groundwater dynamics. Geological insights provide information on the physical characteristics of aquifers, such as lithology, structure, and permeability, which influence water storage and movement. Meanwhile, hydrological perspectives focus on processes like recharge, discharge, and interactions between surface and groundwater systems. Combining these two disciplines allows for a more nuanced approach to groundwater management, enabling precise identification of recharge zones, assessment of aquifer sustainability, and mitigation of contamination risks. For instance, the geological understanding of impermeable layers aids in predicting flow patterns, while hydrological models incorporate climatic and precipitation data to forecast recharge rates. This interdisciplinary approach enhances decision-making and ensures that management practices align with the unique geological and hydrological conditions of each region.

B. Data Collection Techniques

1. Use of Remote Sensing, GIS, and Field Surveys

Remote sensing and Geographic Information Systems (GIS) are powerful tools for collecting spatial data on aquifers and their surrounding environments. Satellite imagery provides insights into land-use changes, vegetation cover, and potential recharge zones, while GIS facilitates the integration and visualization of diverse datasets. Field surveys complement these methods by providing on-the-ground validation and direct measurements of groundwater levels, flow rates, and aquifer characteristics. Together, these techniques offer a robust framework for understanding groundwater dynamics and monitoring changes over time.

2. Sources of Data: Geological Maps, Hydrological Records, Climate Datasets

Geological maps and hydrological records serve as foundational resources for analyzing aquifer structures and water movement. These maps reveal the spatial distribution of rock types, fault lines, and other geological features influencing groundwater flow. Hydrological records, including data on precipitation, runoff, and river discharge, provide critical information for modeling recharge and depletion patterns. Climate datasets, such as temperature and rainfall trends, are essential for assessing the impacts of climate variability on groundwater resources. Integrating these data sources ensures a comprehensive assessment of groundwater systems, enabling more accurate predictions and targeted management interventions.

C. Analytical Tools

1. Hydrological Modeling for Recharge and Depletion Analysis

Hydrological models are indispensable for analyzing groundwater recharge and depletion patterns. These models simulate the movement of water through surface and subsurface systems, incorporating variables like precipitation, evapotranspiration, and soil permeability. By using tools such as MODFLOW or HEC-HMS, researchers can evaluate the impacts of land-use changes, climate variability, and human activities on groundwater systems. Scenario-based modeling further aids in predicting future trends, guiding sustainable management strategies.

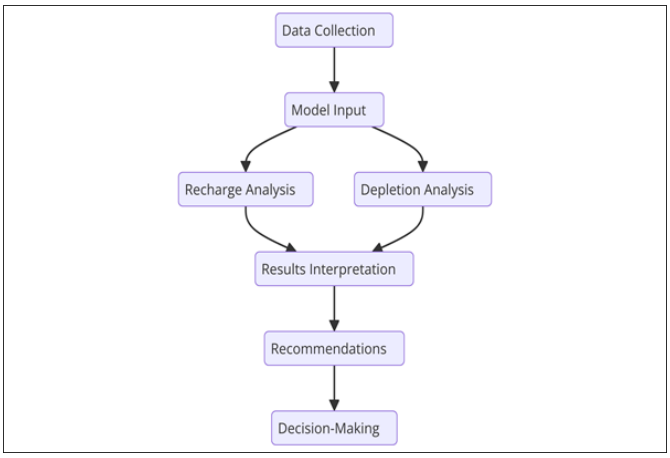

Figure 2: Representation of hydrological modeling system and their relationships

2. Geological Characterization of Aquifers Using Spatial and Laboratory Methods

Characterizing aquifers requires a combination of spatial analysis and laboratory techniques. Spatial methods, such as seismic surveys and geophysical imaging, provide detailed information on aquifer geometry, depth, and connectivity. Laboratory analysis of rock and water samples offers insights into mineral composition, porosity, and permeability, which influence water quality and flow dynamics. By integrating these methods, researchers can develop a holistic understanding of aquifer properties, ensuring that management practices are tailored to the specific characteristics of each groundwater system.

4. Key Challenges in Groundwater Management

A. Overextraction and Declining Aquifer Levels

Overextraction of groundwater has emerged as a critical challenge, particularly in regions with high water demand and limited recharge potential. Intensive pumping for agricultural, industrial, and domestic use has led to significant declines in aquifer levels, disrupting the balance between groundwater recharge and extraction. This issue is particularly pronounced in areas reliant on nonrenewable fossil aquifers, where recharge is negligible, and water levels continue to drop. Overextraction not only reduces water availability but also exacerbates issues such as land subsidence and reduced water pressure, which can lead to the intrusion of saline water in coastal regions. Moreover, aquifer depletion increases the energy costs of pumping, placing additional financial burdens on users. Addressing this challenge requires the adoption of sustainable pumping practices, implementation of managed aquifer recharge (MAR), and stricter regulations on water use, combined with public awareness campaigns to promote conservation.

B. Contamination Risks from Natural and Anthropogenic Sources

Groundwater contamination poses a severe threat to water quality and public health. Natural sources, such as the dissolution of arsenic, fluoride, or other minerals, can render groundwater unfit for consumption. Anthropogenic activities further exacerbate this problem, with agricultural runoff introducing nitrates and pesticides, while industrial effluents and improperly managed landfills contribute heavy metals and toxic chemicals. In urban areas, leakage from sewer systems can contaminate shallow aquifers, while in rural regions, the lack of proper sanitation infrastructure often results in microbiological contamination. Contaminated groundwater is challenging to remediate and can remain unsafe for decades. Effective management strategies include regular monitoring, stricter regulations on waste disposal and pesticide use, and the promotion of alternative farming practices such as organic agriculture. Artificial recharge methods must also be carefully designed to prevent introducing contaminants into aquifers.

C. Impacts of Urbanization, Land-Use Change, and Agricultural Practices

Urbanization and changing land-use patterns have drastically altered groundwater recharge and availability. Urban development often replaces permeable surfaces with impervious ones, such as roads and buildings, reducing the natural infiltration of rainwater into aquifers. In addition, the high water demand of urban centers exacerbates the overextraction of nearby groundwater resources. Land-use changes, such as deforestation and the conversion of wetlands to agricultural or urban areas, disrupt natural recharge processes and increase surface runoff. Intensive agricultural practices, characterized by water-intensive crops and inefficient irrigation systems, further deplete groundwater levels. Excessive use of fertilizers and pesticides also leads to contamination. To mitigate these impacts, urban planning should prioritize green infrastructure, such as permeable pavements and rainwater harvesting systems, while promoting sustainable agricultural practices, including crop rotation, drip irrigation, and water-efficient farming techniques.

D. Effects of Climate Change on Groundwater Recharge and Availability

Climate change is a significant driver of groundwater challenges, as it alters precipitation patterns, increases evapotranspiration, and amplifies the frequency and intensity of extreme weather events. Prolonged droughts reduce groundwater recharge opportunities, while intense rainfall often results in rapid runoff rather than effective infiltration. Rising global temperatures also accelerate evapotranspiration, reducing the amount of water available for aquifer replenishment. Seasonal shifts in precipitation further complicate recharge dynamics, leading to uncertainty in water resource planning. In coastal regions, sea-level rise driven by climate change exacerbates the risk of saltwater intrusion into freshwater aquifers. Adapting to these challenges requires integrating climate projections into groundwater management strategies, implementing water conservation measures, and investing in innovative technologies like artificial recharge systems and advanced hydrological modeling. Developing adaptive policies that align with regional climate variability is essential for ensuring the long-term sustainability of groundwater resources.

Table 2: Summary Of Key Challenges In Groundwater Management

Challenge	Description	Mitigation Strategies
Overextraction and Declining Aquifer Levels	Excessive pumping leads to declining water levels, land subsidence, and increased energy costs for extraction.	Implement managed aquifer recharge (MAR) and sustainable pumping practices; promote water conservation.
Contamination from Natural Sources	Natural contamination includes dissolved arsenic, fluoride, and other minerals affecting groundwater quality.	Monitor groundwater quality regularly; develop strategies to mitigate natural contamination hotspots.
Contamination	Human activities such as agricultural runoff	Enforce regulations on waste disposal and

from Anthropogenic Sources	and industrial waste introduce nitrates, pesticides, and heavy metals.	pesticide use; promote alternative farming methods.
Urbanization Impacts	Urban areas reduce infiltration due to impervious surfaces, increasing water demand and reliance on groundwater.	Adopt green infrastructure, such as permeable pavements and rainwater harvesting in urban planning.
Land-Use Changes	Deforestation and wetland conversion disrupt natural recharge processes and increase surface runoff.	Encourage reforestation and preserve wetlands to enhance natural recharge processes.
Agricultural Practices	Inefficient irrigation and water-intensive crops deplete groundwater; fertilizers and pesticides contribute to contamination.	Implement water-efficient farming techniques like drip irrigation; promote crop rotation.
Climate Change Impacts on Recharge	Droughts reduce recharge opportunities, and intense rainfall leads to runoff rather than infiltration.	Integrate climate projections into groundwater management; invest in artificial recharge systems.
Climate Change Impacts on Availability	Rising temperatures accelerate evapotranspiration, reducing water available for recharge and increasing uncertainty.	Develop adaptive policies and conservation measures; improve hydrological modeling techniques.
Saltwater Intrusion	Sea-level rise exacerbates saltwater intrusion into coastal aquifers, compromising freshwater resources.	Monitor coastal aquifers and control extraction rates; build barriers to prevent saltwater intrusion.

5. Case Studies

A. Diverse Regions to Illustrate Challenges and Solutions

1. Urban Areas with High Water Demand and Overextraction Issues

Urban centers around the world face severe groundwater challenges due to high population densities and intensive water demand. Cities like Mexico City, Jakarta, and Bangkok suffer from rapid groundwater depletion caused by overextraction to meet domestic, industrial, and municipal needs. Overpumping in these regions has resulted in aquifer declines, land subsidence, and an increased risk of saltwater intrusion in coastal areas. For example, Jakarta has sunk by more than 2.5 meters in the past two decades due to extensive groundwater pumping. Solutions include adopting integrated urban water management systems that combine groundwater use with alternative sources like surface water and desalination. Additionally, cities have begun implementing recharge mechanisms such as rainwater harvesting and artificial recharge zones, alongside strict regulations to monitor and control groundwater extraction rates.

2. Rural and Agricultural Regions Facing Contamination and Water Scarcity

In rural and agricultural regions, groundwater contamination and scarcity are prevalent due to unsustainable farming practices and inadequate waste management systems. Punjab, India, is a notable example where intensive agriculture has led to overextraction and nitrate pollution from excessive fertilizer use. Similar patterns are observed in parts of sub-Saharan Africa, where limited water infrastructure compounds the issue. Mitigation strategies include promoting water-efficient irrigation techniques like drip irrigation, reducing reliance on chemical fertilizers by encouraging organic farming, and ensuring regular monitoring of water quality.

Community-led initiatives and government subsidies for sustainable agricultural practices have shown promise in addressing these challenges.

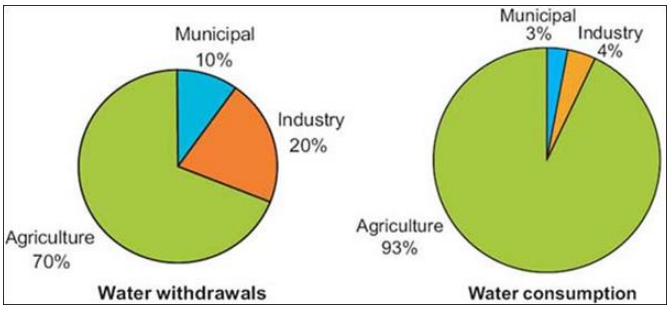

Figure 3: Comparison of water consumption in different sector Vs Agriculture

3. Regions Experiencing Significant Impacts of Climate Variability

Climate variability has exacerbated groundwater challenges in regions such as California, Australia, and the Sahel. Prolonged droughts in California have led to a critical decline in aquifer levels, with the Central Valley aquifer system under immense stress. Similarly, Australia's Murray-Darling Basin faces fluctuating groundwater availability due to extreme droughts and erratic rainfall patterns. In the Sahel, decreasing rainfall combined with high evaporation rates has limited recharge opportunities, leading to acute water shortages. Adaptive management strategies in these regions include the integration of climate models into groundwater planning, the construction of managed aquifer recharge (MAR) systems, and the use of water markets to allocate resources efficiently. Governments and local communities have also invested in reforestation and watershed management to enhance natural recharge processes.

6. Conclusion

Groundwater management is at a critical juncture as environmental changes, population growth, and human activities increasingly strain this vital resource. Geological and hydrological perspectives provide a comprehensive framework for addressing the complexities of groundwater sustainability, emphasizing the interplay between aquifer properties, recharge dynamics, and external stressors such as climate change, urbanization, and agricultural practices. Understanding the geological characteristics of aquifers such as permeability, lithology, and structural features enables precise identification of storage capacities and contamination risks. Simultaneously, hydrological insights into recharge rates, discharge processes, and surface-groundwater interactions are essential for predicting the availability and quality of groundwater over time. Key challenges such as overextraction, contamination, and the impacts of climate variability demand proactive and adaptive strategies. The adoption of advanced technologies, including remote sensing, GIS, and hydrological modeling, has proven effective in monitoring and managing groundwater systems. These tools, combined with region-specific approaches, enable more accurate predictions of recharge and depletion patterns, guiding sustainable extraction and recharge practices. Integrating community participation, policy interventions, and scientific insights is critical for equitable and effective resource management. This research underscores the importance of interdisciplinary collaboration among geologists, hydrologists, policymakers, and stakeholders in addressing the multifaceted challenges facing groundwater systems. Sustainable management strategies, such as managed aquifer recharge (MAR), water-efficient agricultural practices, and green urban infrastructure, offer promising solutions for balancing human needs with environmental preservation. As climate change continues to disrupt natural recharge processes, the integration of geological and hydrological perspectives will remain central to ensuring groundwater sustainability for future generations. By adopting a holistic approach, it is possible to safeguard this invaluable resource while fostering resilience against emerging global water crises.

REFERENCES

[1]. Falcone, P.M.; Imbert, E.; Sica, E.; Morone, P. Towards a bioenergy transition in Italy? Exploring regional stakeholder perspectives towards the Gela and Porto Marghera biorefineries. Energy Res. Soc. Sci. 2021, 80, 102238.

[2]. Doloi, H.K. Understanding stakeholders' perspective of cost estimation in project management. Int. J. Proj. Manag. 2011, 29, 622–636.

[3]. Choudhury, S.; Pattnaik, S. Emerging themes in e-learning: A review from the stakeholders' perspective. Comput. Educ. 2020, 144, 103657.

[4]. Simeoni, U.; Corbau, C. A review of the Delta Po evolution (Italy) related to climatic changes and human impacts. Geomorphology 2009, 107, 64–71.

[5]. Mollema, P.; Antonellini, M.; Gabbianelli, G.; Laghi, M.; Marconi, V.; Minchio, A. Climate and water budget change of a Mediterranean coastal watershed, Ravenna, Italy. Environ. Earth Sci. 2012, 65, 257–276.

[6]. Ezquerro, P.; Tomás, R.; Béjar-Pizarro, M.; Fernández-Merodo, J.A.; Guardiola-Albert, C.; Staller, A.; Sánchez-Sobrino, J.A.; Herrera, G. Improving multi-technique monitoring using Sentinel-1 and Cosmo-SkyMed data and upgrading groundwater model capabilities. Sci. Total Environ. 2020, 703, 134757.

[7]. Béjar-Pizarro, M.; Guardiola-Albert, C.; García-Cárdenas, R.P.; Herrera, G.; Barra, A.; López Molina, A.; Tessitore, S.; Staller, A.; Ortega-Becerril, J.A.; García-García, R.P. Interpolation of GPS and geological data using InSAR deformation maps: Method and application to land subsidence in the alto guadalentín aquifer (SE Spain). Remote Sens. 2016, 8, 965.

[8]. Bonì, R.; Herrera, G.; Meisina, C.; Notti, D.; Béjar-Pizarro, M.; Zucca, F.; González, P.J.; Palano, M.; Tomás, R.; Fernánd, J.; et al. Twenty-year advanced DInSAR analysis of severe land subsidence: The Alto Guadalentín Basin (Spain) case study. Eng. Geol. 2015, 198, 40–52.

[9]. Golden, H.E.; Sander, H.A.; Lane, C.R.; Zhao, C.; Price, K.; D'Amico, E.; Christensen, J.R. Relative effects of geographically isolated wetlands on streamflow: A watershed-scale analysis. Ecohydrology 2016, 9, 21–38.

[10]. Singh, M.; Tandon, S.K.; Sinha, R. Assessment of connectivity in a water-stressed wetland (Kaabar Tal) of Kosi-Gandak interfan, north Bihar Plains, India. Earth Surf. Proc. Landf. 2017, 42, 1982–1996.

[11]. Chai, J.C.; Shen, S.L.; Geng, X. Effect of initial water content and pore water chemistry on intrinsic compression behavior. Mar. Georesour. Geotechnol. 2019, 37, 417–423. [Green Version]

[12]. Lin, S.S.; Shen, S.L.; Lyu, H.M.; Zhou, A. Assessment and management of lake eutrophication: A case study in Lake Erhai, China. Sci. Total Environ. 2021, 751, 141618.

[13]. Fatichi, S.; Rimkus, S.; Burlando, P.; Bordoy, R. Does internal climate variability overwhelm climate change signals in streamflow? The upper Po and Rhone basin case studies. Sci. Total Environ. 2014, 493, 1171–1182.

[14]. Lyu, H.M.; Shen, S.L.; Zhou, A.; Zhou, W.H. Flood risk assessment of metro systems in a subsiding environment using the interval FAHP–FCA approach. Sustain. Cities Soc. 2019, 50, 101682.

[15]. Wu, M.; Hu, Y.; Wu, P.; He, P.; He, N.; Zhang, B.; Zhang, S.; Fang, S. Does soil pore water salinity or elevation influence vegetation spatial patterns along coasts? A case study of restored coastal wetlands in Nanhui, Shanghai. Wetlands 2020, 40, 2691–2700.

[16]. Zhang, X.; Dong, Q.; Costa, V.; Wang, X. A hierarchical Bayesian model for decomposing the impacts of human activities and climate change on water resources in China. Sci. Total Environ. 2019, 665, 836–847.

[17]. Lin, S.S.; Shen, S.L.; Zou, A.; Zhang, N. Ensemble model for risk status evaluation of excavation system. Autom. Constr. 2021, 132, 103943.