NANGARHAR UNIVERSITY
INTERNATIONAL JOURNAL OF BIOSCIENCES
ORIGINAL ARTICLE
e-ISSN: 2957-9988
NUIJB Special Issue, 2024

Received: 21 Dec 2023 Accepted After Revision: 22 Jan 2024 Published Online: 10 Feb 2024

Impacts of Climate Change on Groundwater Resources in Afghanistan: A Case Study of Kandahar Province

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ABSTRACT
This paper presents a case study examining the impacts of climate change on groundwater resources in the Kandahar province of Afghanistan. The study assesses the vulnerability of groundwater sources to changing climatic patterns and explores the implications for water availability, quality, and sustainability in the region. Through a combination of field surveys, hydrogeological investigations, and analysis of climatic data, the research aims to provide insights into the specific challenges faced by Kandahar province in managing its groundwater resources in the context of a changing climate. The findings of the study reveal the significant influence of climate change on groundwater availability, with altered precipitation patterns and increasing temperatures leading to shifts in recharge rates and aquifer dynamics. Moreover, the study examines the potential exacerbation of water stress, groundwater depletion, and saltwater intrusion in coastal areas due to rising sea levels and changing rainfall patterns. The insights derived from this case study contribute to a deeper understanding of the complex interactions between climate change and groundwater resources, providing valuable knowledge for policymakers, water resource managers, and stakeholders involved in sustainable water management and climate adaptation initiatives in Afghanistan.

Keywords: Climate change, Groundwater, Impacts, Water resources, Kandahar

INTRODUCTION
Water is a vital natural resource that is essential for sustaining life and supporting various ecological, social, economic, and cultural functions (Ullah *et al*., 2022). It plays a critical role in agriculture, food production, human health, industrial processes, energy production, and environmental sustainability (Shaukat *et al*., 2022). Access to clean and safe water is crucial for promoting public health, reducing the spread of diseases, and improving overall well-being (Xie *et al*., 2022). However, water resources are facing various challenges, including water scarcity, pollution, overexploitation of aquifers, and unequal access to water resources (Noman *et al*., 2022). Climate change is exacerbating these challenges, leading to changing precipitation patterns, increased temperatures, and more frequent extreme weather events. Groundwater resources are a crucial component of the Earth's hydrological cycle, serving as a vital source of freshwater for human consumption, agriculture, industry, and ecosystem maintenance (Shrestha *et al*., 2016). Groundwater is stored in underground aquifers and plays a significant role in sustaining surface water bodies, such as rivers and lakes, during dry periods (Ali *et al*., 2012). It is particularly important in arid and semi-arid regions where surface water may be limited (Ullah *et al*., 2021). The sustainable management of groundwater resources is essential to ensure long-term water availability and prevent depletion of aquifers (Nistor, 2019). However, groundwater resources are increasingly threatened by over-extraction, contamination from industrial and agricultural activities, as well as the impacts of climate change (Shahid *et al*., 2017).Understanding the status of groundwater resources, assessing the impacts of human activities and climate change, and developing effective management strategies are critical for ensuring the resilience and sustainability of groundwater supplies (Nistor, 2019). This includes implementing measures to monitor and regulate groundwater use, promoting water-efficient practices, and protecting recharge areas. Additionally, addressing pollution sources and promoting the use of alternative water sources can help safeguard groundwater quality (Ullah *et al*., 2021). Climate change is one of the most pressing global issues of our time, with far-reaching impacts on natural resources and human societies. In Afghanistan, a country already facing severe water scarcity, climate change is exacerbating the problem and putting additional pressure on groundwater resources (Shahid *et al*., 2017).

The paper will examine the current groundwater situation in the province, assess the impacts of climate change on groundwater availability, quality, and recharge, and identify potential adaptation measures to mitigate the negative impacts. The findings of this research will contribute to a better understanding of the complex interactions between climate change and groundwater resources in Afghanistan and provide insights for policymakers and stakeholders to develop effective strategies for sustainable groundwater management in the face of climate change. To address these challenges, there is a need for collaborative efforts to promote sustainable water management practices, protect and preserve water resources, and ensure equitable access to water resources for all.

MATERIALS AND METHODS

Study area

Kandahar province is located in the southern part of Afghanistan and is one of the country largest provinces, covering an area of approximately 54,000 square kilometers. It is known for its historical significance and has been a center of trade and agriculture for centuries. The province is characterized by a semi-arid to arid climate, with hot summers and relatively mild winters. Kandahar is an important agricultural region, known for its production of fruits, particularly pomegranates and grapes, as well as wheat and other crops. The province also has significant mineral resources, including deposits of chromite, marble, and other minerals. **Figure 1** shows the map of study area.

Figure 1: Location map of study area (Kandahar, Afghanistan).

Data collection

The study involved the collection of both primary and secondary data. Primary data was collected through field surveys, including drilling of boreholes, installation of piezometers, and water quality sampling. Secondary data was obtained from various sources, including government agencies, research institutions, and international organizations. The data collected included climatic data, hydrogeological data, and socio-economic data.

Hydrogeological investigation

The hydrogeological investigation involved the characterization of the aquifer system, including the identification of aquifer properties such as hydraulic conductivity, transmissivity, and storability. The study utilized geophysical methods such as resistivity surveys and electromagnetic surveys to delineate the subsurface geology and identify potential groundwater recharge areas.

Climate Analysis

The current study has analyzed the long-term climatic data to identify trends and patterns in precipitation, temperature, and evapotranspiration. The data was obtained from the Afghanistan Meteorological Department and other relevant sources.

Modeling

The present work has utilized groundwater modeling software to simulate the behavior of the aquifer system under different scenarios of climate change and groundwater use. The modeling was used to evaluate the impacts of climate change on groundwater resources, including changes in water availability, quality, and sustainability.

Data analysis

The collected data was analyzed using statistical and geospatial analysis techniques to identify patterns and trends in the data and to develop maps and visualizations to aid in the interpretation of the results. The combination of these methods provided a comprehensive understanding of the impacts of climate change on groundwater resources in the Kandahar province of Afghanistan, highlighting the need for adaptive strategies and sustainable groundwater management practices to mitigate the adverse impacts of climate change on water resources.

RESULTS AND DISCUSSION

Past trend of water resources in Kandahar

The previous data of the groundwater level in Kandahar province is reviewed and compared with the recent GWMs data as given in **Figure 2**, the summary of time series groundwater level fluctuations, and EC reductions in the long run. Since, the starting time of monitoring wells until now, the data in Table 6 show that the depth of groundwater water level has progressively declined due to climate change, over-exploitation of groundwater, improper land use, and poor management. The improper human activities and climate change had the following impacts on the groundwater resources in Kandahar province, Afghanistan. The groundwater and surface water interaction were affected and most of the springs and Karezes dried up. Irrigated land converted to non-irrigated land due to dried-up Karezes and springs. The groundwater table declined due to an excessive discharge trend in the last few decades as well as the water quality deterioration increased seriously in study area. The above impacts have resulted in the replacement of surface water with groundwater resources to support socioeconomic development and environmental security.

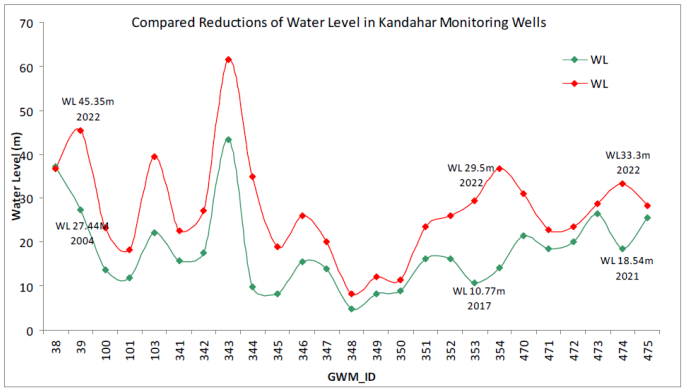

Figure 2. Compared the reduction of water level in Kandahar province GWM Wells

GWM-39 time series data analysis

GWM-39 is located in Hous-i-Madad village, Zharai district of Kandahar province. The water levels (WL) were measured between March 2005 to December 2022 with a stoppage from mid-2007 to mid-2022. Due to the high threat of security, the teams couldn't measure the water level and other physical parameters of water. The water level variations with time hydro-graph as shown in Figure 3, shows that the water level has been progressively declining due to climate change, over-exploitation of groundwater, high evapotranspiration, and low recharge. The minimum depth of WL was 27.44m (March 2005), the maximum depth of WL was 45.35m (December 2022), and the time series decline in the water table was 13.45m (Jun 2017-Dec 2022). The water level declined at a rate of 2.69m/year. The water level rose when the area received an amount of annual precipitation that directly and indirectly infiltrated the groundwater, however, this rise was unstable due to the short period of precipitation (April-May). The trend shows a continuous decline in water level of study area.

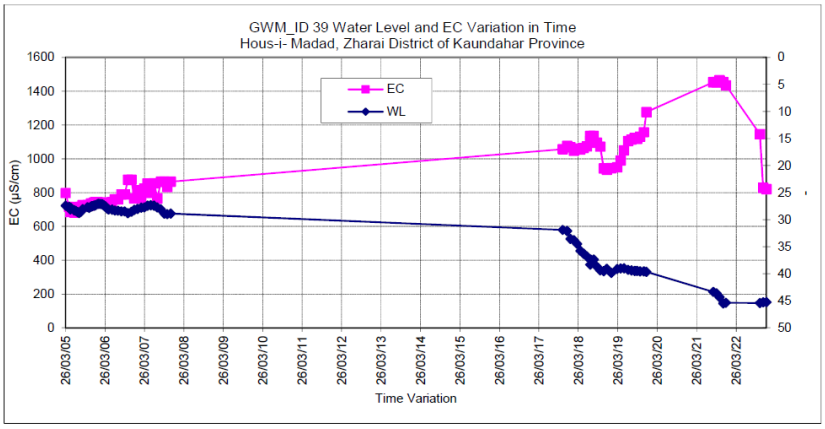

Figure 3: GWM-39 shows the water level and EC variation in time Hydrograph of Zharai district

CONCLUSION

The case study of Kandahar province in Afghanistan has provided valuable insights into the impacts of climate change on groundwater resources and the associated challenges for sustainable water management. The investigation revealed that climate change poses significant risks to the availability, quality, and sustainability of groundwater in the region**.** In conclusion, the case study of Kandahar province in Afghanistan underscores the significant vulnerability of groundwater resources to the impacts of climate change. The findings emphasize the urgent need for adaptive strategies, integrated water resource planning, community engagement, and capacity building to address the challenges posed by changing hydrological conditions. Proactive measures are essential to safeguard groundwater sustainability, support agricultural livelihoods, and ensure water security in the region.

Acknowledgment: Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the Manuscript. The names of funding organizations should be written in full.

Conflict of Interest: All authors express no conflict of interest in any part of the research.

Funding: This research received no external funding.

Authors Contributions: Jamil Rahmati: as conceptualization, methodology, software, Mohammad Bayer Darmel: Analysis, investigation, resources, Sajid Ullah: Original draft preparation, review and editing, Asghar ghaforzai: Supervision, project administration and funding acquisition.

REFERENCES

Ali, R., McFarlane, D., Varma, S., Dawes, W., Emelyanova, I., Hodgson, G. and Charles, S., 2012. Potential climate change impacts on groundwater resources of south-western Australia. *Journal of Hydrology*, *475*, pp.456-472.

Nistor, M.M., 2019. Climate change effect on groundwater resources in South East Europe during 21st century. *Quaternary International*, *504*, pp.171-180.

Noman, M., Haziq, M.A., Safi, B.U., Ullah, S., Rukh, G., Faiq, M.E., Ullah, Z., Bibi, S.D., Shaukat, S., Emiliya, H. and Rahim, Z., 2022. Lead (II) adsorption from aqueous systems using visible light activated cobalt doped zinc oxide nanoparticles. *Digest Journal of Nanomaterials & Biostructures (DJNB)*, *17*(3).

Shahid, S., Alamgir, M., Wang, X.J. and Eslamian, S., 2017. Climate change impacts on and adaptation to groundwater. In *Handbook of drought and water scarcity* (pp. 107-124). CRC Press.

Shaukat, S., Hassani, M.A., Yadgari, M.Y., Ullah, S., Iqbal, M.S., Khan, F., Bibi, S.D., Ullah, Z., Rukh, G., Sabir, M. and Hussain, S.A., 2022. Green synthesis of silver nanoparticles and its application towards As (V) removal from aqueous systems. *Digest Journal of Nanomaterials & Biostructures (DJNB)*, *17*(4).

Shrestha, S., Bach, T.V. and Pandey, V.P., 2016. Climate change impacts on groundwater resources in Mekong Delta under representative concentration pathways (RCPs) scenarios. *Environmental science & policy*, *61*, pp.1-13.

Ullah, S., Noman, M., Rahimi, M., Stanikzai, A.G., Ayub, S., Din, Z.U., Emiliya, H., Esmati, S., Zahoor, F. and Khan, S., 2021. A comprehensive review of climate change impacts on water resources: A global perspective. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, *15*(3), pp.43-48.

Ullah, S., Shams, D.F., Ur Rehman, S.A., Khattak, S.A., Noman, M., Rukh, G., Bibi, H., Ateeq, M., Bibi, N., Ali, L. and Fazil, P., 2022. Application of visible light activated thiolated cobalt doped ZnO nanoparticles towards arsenic removal from aqueous systems. *Digest Journal of Nanomaterials & Biostructures (DJNB)*, *17*(2).

Xie, P., Zahoor, F., Iqbal, S.S., Ullah, S., Noman, M., Din, Z.U. and Yang, W., 2022. Elimination of toxic heavy metals from industrial polluted water by using hydrophytes. *Journal of Cleaner Production*, *352*, p.131358.