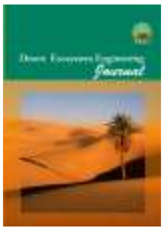
DEEJ (2026) 15(2) 1-2

University of Kashan

Desert Ecosystem Engineering Journal

Journal homepage: http://deej.kashanu.ac.ir



Evaluating the Effectiveness of Integrated Demand Management Scenarios for Controlling Aquifer Depletion: A Case Study of the Qorveh–Dehgolan Basin

Adel Soltani[1*], Milad Soltani[2]

Receive: 2026/01/26 Accept: 2026/05/20

Extended Abstract

Introduction Groundwater depletion has emerged as a critical challenge in arid and semi-arid regions, driven by the synergistic effects of agricultural expansion, rapid population growth, climate variability, and unsustainable abstraction practices. In Iran, where agriculture accounts for approximately 90% of total water consumption, diminishing precipitation and prolonged droughts have severely intensified pressure on aquifer systems. The Qorveh–Dehgolan basin, located in northwestern Iran, serves as a prominent example of a highly stressed system where persistent water deficits and over-exploitation of groundwater have led to significant declines in aquifer storage. Given projected climate change scenarios, reduced surface water availability and escalating water demand are expected to further exacerbate groundwater stress. Consequently, evaluating the efficacy of integrated demand-side management strategies is essential for achieving long-term water sustainability. This study aims to quantitatively assess the impacts of individual and combined demand management scenarios on groundwater storage dynamics in the Qorveh–Dehgolan basin under both historical and projected climate conditions.

Materials and Methods

The Qorveh–Dehgolan basin covers approximately 7,246 km² and includes three main alluvial aquifers: Dehgolan, Qorveh, and Charduli. Water demands are dominated by agriculture, which accounts for more than 95% of total annual water use, while domestic and industrial demands are fully supplied by groundwater. The integrated Water Evaluation and Planning (WEAP) model was applied to simulate surface water–groundwater interactions over the historical period 2007–2021. Model calibration and validation were conducted using observed streamflow data at the Hasan Khan hydrometric station, yielding satisfactory performance (NSE = 0.82 for calibration and 0.79 for validation). To assess future climate impacts, outputs from three CMIP6 global climate models under SSP2.6, SSP4.5, and SSP8.5 scenarios were downscaled using the LARS-WG weather generator for the period 2026–2045. The IHACRES rainfall–runoff model was employed to estimate future inflows to the Soural, Siah-Sang, and Ghocham reservoirs, and these inflows were incorporated into the WEAP model. Five groundwater demand management scenarios were defined and simulated: (1)

1. Faculty of Member Department of Agricultural Technology and Engineering, Payame Noor University, Tehran, Iran, Corresponding author: soltani@pnu.ac.ir

2. Ph.D. Watershed Management and Engineering, Sari Agricultural Sciences and Natural Resources University, Sari, Iran

DOI: 10.22052/deej.2026.258197.1133

installation of smart water meters, (2) sealing of illegal wells, (3) revision of groundwater abstraction permits, (4) regulation of unlicensed wells, and (5) a combined scenario integrating all measures. The impacts of these scenarios on aquifer storage trends were quantitatively evaluated.

Results

The Qorveh–Dehgolan basin, spanning approximately 7,246 km², encompasses three primary alluvial aquifers: Dehgolan, Qorveh, and Charduli. Water consumption is predominantly agricultural, accounting for over 95% of total annual demand, while domestic and industrial requirements are exclusively met through groundwater extraction. To simulate surface water–groundwater interactions, the Water Evaluation and Planning (WEAP) model was employed for the 2007–2021 historical period. The model was calibrated and validated against observed streamflow data at the Hasan Khan hydrometric station, demonstrating satisfactory performance (Nash–Sutcliffe Efficiency [NSE] = 0.82 and 0.79, respectively). To project future climate impacts, outputs from three CMIP6 global climate models under SSP2.6, SSP4.5, and SSP8.5 pathways were downscaled using the LARS-WG weather generator for the 2026–2045 period. Furthermore, the IHACRES rainfall–runoff model was utilized to estimate future inflows to the Soural, Siah-Sang, and Ghocham reservoirs, which were subsequently integrated into the WEAP framework. Finally, five demand-side management scenarios were simulated: (1) installation of smart water meters, (2) decommissioning of illegal wells, (3) revision of groundwater abstraction permits, (4) regulation of unlicensed wells, and (5) a combined scenario encompassing all aforementioned measures. The potential impacts of these strategies on aquifer storage trends were quantitatively assessed.

Discussion and Conclusion

Our results demonstrate that groundwater depletion in the Qorveh–Dehgolan basin is primarily driven by agricultural water deficits, a trend likely to intensify under projected climate change. While individual demand-side measures yield measurable benefits, their isolated implementation remains insufficient to effectively counteract long-term aquifer depletion. The superior performance of the combined scenario underscores the necessity of integrating regulatory, technical, and monitoring-based interventions to achieve significant groundwater recovery. Notably, the volume of groundwater saved under the combined scenario closely approximates the average annual agricultural water deficit in the basin, suggesting that comprehensive demand management can substantially mitigate pressure on both groundwater and surface water resources. This finding is particularly salient in regions characterized by pronounced summer aridity, where groundwater serves as a critical buffer against seasonal water scarcity. Ultimately, this study confirms that an integrated approach to groundwater demand management provides a robust and pragmatic pathway toward hydrological sustainability in water-stressed basins. The proposed framework not only addresses current depletion but also enhances long-term resilience to climate variability. Furthermore, these findings offer transferable insights for other arid and semi-arid regions in Iran and beyond, where comparable hydro-climatic and socio-economic conditions prevail.

Keywords: Integrated Water Resources Management, Climate Change, Aquifer, WEAP Model, Water Scarcity.