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Assessment and Suggested Management of Water Resources in an Arid Region, Béchar, Southwestern Algeria

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Abstract

The Béchar region is located in the southwest of Algeria, characterized by an arid climate with a Saharan tendency. It is subject to an increasing demand for water, like all the great agglomerations, due to economic and demographic development. The present work is a detailed estimate of groundwater and superficial water in the Béchar region, for an appropriate management and adequate use of this resource. The water resources come mainly from the DjorfTorba dam and Turonian aquifer, with a flow estimated at more than 500 l/s. Moreover, the superficial resources are an important part of the water heritage of the Béchar region, with a permanent flow of various streams that carry a considerable volume, with important hydraulic structures allowing the mobilization of a certain volume. It will be a basic tool, essential for effective water management in dryland environments. It will also raise awareness of the need to manage water resources in order to reconcile socio-economic development and preserve aquatic environments, and balance different uses to ensure sustainable development. The results will contribute to the design of an integrated water management model that could be generalized for arid zones.

Keywords:

Arid zone, Water resources, Integrated Management, Sustainable development

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1. Introduction

Water is the foundation of life, playing a crucial role in the environment and all human activities, including domestic, industrial, and agricultural uses. Water resources mainly come from groundwater and surface water (Bouchelkia and Meddi, 2015; Achite et al., 2022; Benameur and Hamdi, 2024; Ibraheem et al., 2025). With population growth, urban expansion, and industrial progress, the water demand continues to rise, posing significant challenges to the management of available water resources. In developed countries, water availability is subject to major seasonal variations such as droughts and floods, necessitating effective strategies for its sustainable management (Aissaoui et al., 2018; Aouati et al., 2023; Alekya, 2024). Despite this vast reserve, the amount of freshwater directly accessible for human consumption is limited. Additionally, ecosystems responsible for replenishing and purifying water are increasingly threatened by human activities and climate change. Achieving sustainable development in the water sector presents a significant challenge, as it requires meeting the needs of present generations without

compromising the ability of future generations to access water. Key challenges include rising water demand, difficulties in managing available resources, and deteriorating water quality due to pollution and climate variability (Benamara and Bouabdallah, 2017; Lachache et al., 2018; Belalite and Athamena, 2022; Athamena et al., 2023; Lachache et al., 2023).

In arid and semi-arid regions, water resources are a critical factor for economic development and environmental stability. Arab Maghreb countries, including Algeria, face severe water scarcity, with Algeria being one of the North Mediterranean nations experiencing increasing difficulties in securing water resources. The country's hydrological system is characterized by irregular water flows throughout the year, as well as sudden and intense floods that negatively impact both the environment and infrastructure. The Béchar region serves as a clear example of these challenges, as it is subject to a combination of human-induced and natural factors that exacerbate water scarcity. The growing demand for water for agriculture and domestic consumption, coupled with rapid population growth, leads to the over-extraction of groundwater and alters its natural characteristics. These factors make it essential to implement effective policies for sustainable water management (Benhamza, 2012; Lachache et al., 2018; Lachache et al., 2023).

The objective of this study is to assess the availability, distribution, and current management practices of water resources in the Béchar region, Southwestern Algeria—an arid zone facing increasing water demand. The research aims to propose a sustainable and integrated water resource management model that reconciles socio-economic development with the preservation of aquatic ecosystems, ensuring long-term water security for the region.

2. Materials and Methods

A. Study Area

In southwestern Algeria, the Béchar region is situated in the southern hemisphere of the pre-Saharan Atlas, approximately 950 km southwest of the capital, Algiers. This study area lies at the gateway to the historic caravan trade route known as the Saoura Valley, spans an area of approximately 161,400 km² (Fig. 1). As of the 2022 national census, the population of Béchar province is estimated at around 328,000 inhabitants, with this region experiences an arid climate with Saharan influences, characterized by irregular precipitation averaging 101.02 mm per year over the period 1978–2020 (Lachache and Merzougui, 2016). The lowest recorded temperature is 4°C in January, while the highest reached 40°C in July, with an annual average of 27°C (Kharfia, 2014; Kabou et al., 2015). The average evaporation rate is 306 mm, and evapotranspiration values consistently exceed precipitation levels, leading to persistent drought conditions throughout the year.

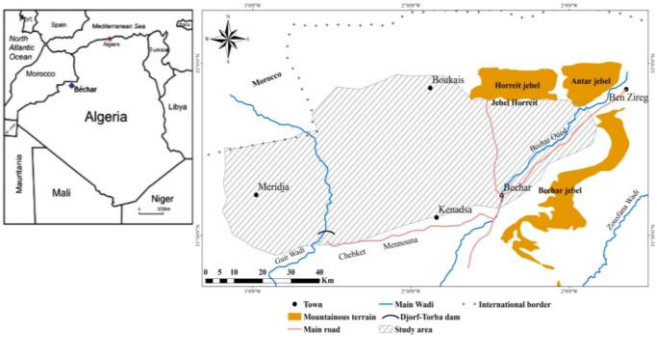

Fig. 1: Study area.

B. Geological and hydrogeological context

The study area is an excellent open-air laboratory of great geological diversity (Fabre, 1976). Several authors have been interested in the geological study of Béchar region (Menchikoff,1936; Deleau, 1951; Mekkaoui, 2000; (Menchikoff N., 1936; Deleau P., 1951; Mekkaoui, 2000). They demonstrated that the geological formations of Bécharrégion constituted a wide range of varied terrains, starting from the Precambrian to the present (Quaternary) (Fig. 2). The land consists of several aquifer complexes and different formations (Benaradj, 2012). North of the study area, and more precisely at the level of Boukais City, this zone has the oldest outcrop, whose predominant volcanic terms are basalt, andesite, dolerite, and rhyolite (Byramjee, 1956), and the core of the anticline Ben Zireg (northeast) is represented by deposits of Combro-Ordovician and Gothlandian. The Devonian deposits are more abundant in outcrops identified at the cliff of Koudiat El Haïdoura (Grouz), at the level of Talzaza, at of Maïder El Mehadjib, at Soltane El Betoum, and Ben Zireg (Menchikoff, 1936; Perrodon, 1957). At the center of our zone, the outcrops of the Carboniferous terrains are the most widespread outcrops and best studied (Deleau, 1951; Pareyn, 1961). They constitute the main

reliefs of the area (Djebel Antar, Djebel Horreït, Djebel Béchar, and Chabket Mennouna) and also constitute the bedrock of Béchar City. The successive orogenesis is represented by conglomerates and Permian-Triassic polygenic breccias, followed by calcareous-clay lagoon deposits and gypsum for the Jurassic (Mekkaoui, 2000). Cretaceous lands are generally in the form of a cuesta (cuesta for RasSmar, Bezazil El Kelba, and cuesta for the DjorfTorba dam). These are sandy-clay lands evolving towards marls and massive limestones; the Upper Cretaceous is represented by evaporite (halite and gypsum) holding clays (Idrotecneco, 1976).

This zone contains four aquifers (Turonian, infero-fleux and Quaternary, Carboniferous limestones and Carboniferous sandstones). The Turonian aquifer is important just in extension (> 450 km²), although its thickness is low; it nevertheless provides an appreciable flow, which contributes to the power of this zone. The output values of this aquifer are 100 à 110 l/s; on the other hand, the input value is 50 l/s with a deficit of about 60 l/s (Abdesselem, 2017). The infero-fleux and Quaternary aquifer are linked and capture the deposits of infereux of Bécharwadi and lacustrine limestones of the Quaternary. On the other hand, the Carboniferous aquifer's water flow has a not negligible component to Guirwadi. The water points of this aquifer generally give a flow of order 1 at 5 l/s.

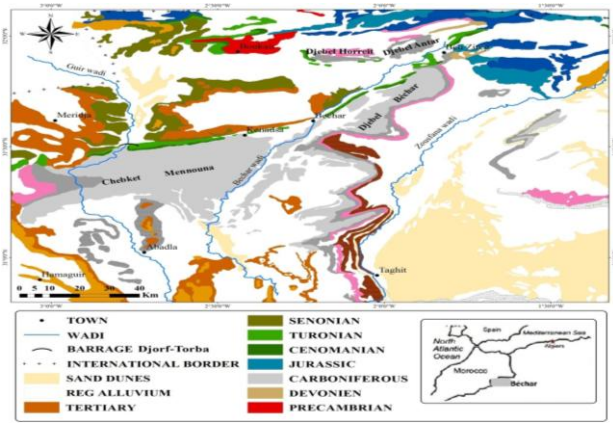

Fig. 2: Geology of the study area.

3. Methodology

In this study area, we have selected all the information and developed a database on water resources (surface and underground). This information is obtained by collecting archived data from the various organizations related to the field of water. Furthermore, we have used a long climatic series over a period of 37 years (1978 – 2020). The water balance of the study area is calculated from an empirical formula, and evapotranspiration is calculated through the use of the formula of Thornthwaite and Turc (2020).

4. Results and Discussion

At the level of Bechar region has an average annual rainfall of 101.6 mm/year for the period (1978 - 2020), average evapotranspiration of 306 mm, and infiltration estimated to be -5.34 mm. On the other hand, the run-off obtained is 0.2 mm of annual rainfall. Negative values of the excess and seepage show a deficit in the water balance. The pluviothermal diagram of Béchar station for the period 1978 - 2020 (Fig.3) confirms a dry period dominating the whole year, since the two curves do not grow.

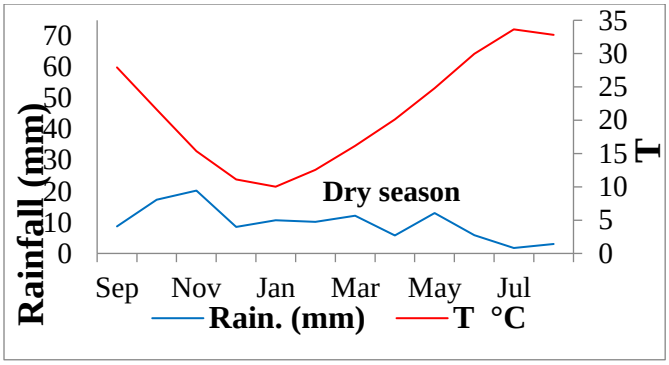

Fig.3: Pluviothermic diagram of the study area (1978 – 2020).

A. Water resources assessment

Surface water

At the level of our study area, two superficial sources of various sizes have been identified. They are mainly constituted by the DjorfTorba Dam, which has a capacity of 360 million m^3 with a regulated volume of 100 hm^3/year, of which 16 million m^3 are intended for drinking water supply in the city of Béchar and Kénadsa, and about 50 million m^3/year for irrigation of the agricultural area of the Abadla zone (Lachache et al., 2018). Otherwise, the Ouakda dike has a capacity estimated at 400 000 m^3, intended mainly for irrigating the agricultural perimeters of the plain of Ouakda(Kabour, 2011).

Underground waters

Béchar region currently contains a total of 58 wells and 271 drillings, with a flow estimated at 339.5 l/s. These are divided into four aquifers of

varying sizes; the most important of them is the Turonian aquifer. This aquifer is the primary underground water resource in terms of significance and exploitation, supplying 20% of the region's drinking water. The most utilized catchment field of this aquifer is located in the Ouakda area and consists of nine wells with a total flow of approximately 116 l/s. The Carboniferous sandstone aquifer, primarily composed of Visean and lower Namurian formations, constitutes the uppermost layer of thick dolomitic limestone and sandstone deposits. Drilling conducted by SONAREM has revealed the presence of at least two superimposed layers, each with a thickness of 50 meters and a transmissivity ranging from 10^{-7} to 10^{-4} m²/s. The Carboniferous limestone aquifer includes lower Namurian limestones along the western slope of the Grand Carboniferous Anticline, as well as submerged formations in the Zousfana and Mennouna-Djenien anticlines. Additionally, the Infero-Flow and Quaternary aquifers have an average piezometric level ranging from 5 to 10 meters.

B. Water needs

One of the major concerns of the public authorities in the study region is to solve the equation between water resources and meeting the needs of the population. The assessment of this ever-growing water demand depends on several socio-economic factors such as demographics, standard of living, habitat type, and socio-cultural habits. Therefore, logically, the demand for drinking water should be correlated with the number of inhabitants.

C. Drinking water supply

Needs are generally a function of population and are estimated based on a variable water endowment ranging from 150 to 240 l/day/inhabitant (Kabour, 2011, supplied for 10 hours per day. Therefore, increasing deficits and decreasing consumption flows lead to a reduction in the satisfaction rate. Fig. 4 below represents the current drinking water supply situation in the Béchar region. There is a persistent water stress in the chief town of Béchar with a deficit rate of 45%, while Taghit, Moughel, and Boukais experience moderate deficits ranging from -2.71% to -15%. However, some areas still show an excess.

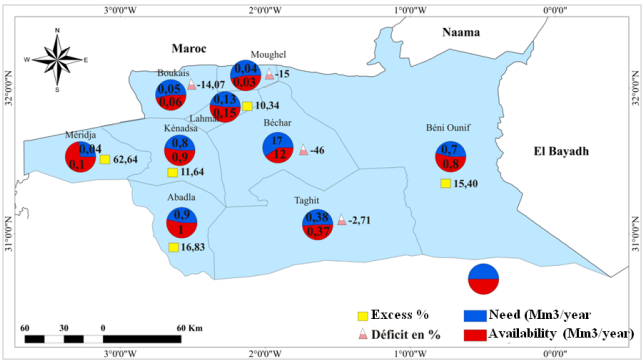

Fig.4: Spatial distribution needs and availability (Mm^3/year) in 2022.

D. Agricultural water supply

Areas of agriculturally equipped and irrigated land are located along the Béchar region; they are estimated to be 61239.50 hectares divided into eight different sectors that are Béchar, Kénadsa, Abadla, Méridja, Boukais, Lahmar, Taghit, and Moughel; these irrigated perimeters are managed by the Directorate of Water Resources and Agricultural Services of Béchar. All agricultural land in the Béchar region consumes a total volume of water estimated to be 215 l/s.

E. Vision and suggested management strategy for water resources in the region

Currently, the need to manage water resources to reconcile socio-economic development and preservation of aquatic environments and to balance the different uses to guarantee sustainable development, in the overall objective of ensuring a balance between supply and demand, this model is based on four actions (Lachache et al., 2018):

-Improving the functioning knowledge of the local aquifer system.

-Making management a priority for these water potential and removals of a strategic interest.

-Improvement of the distribution and use of drinking water and providing for a continuous power supply in the network of cities.

-Valorization and reuse of wastewater for irrigation present a plausible variant; it can recover an annual volume of 14 Mm^3/year.

F. For a better knowledge of underground water resources

Certain environments must first be subject to upgrades in information:

-Identification of the feeding area and recharge at the level of different aquifer systems.

-Regional aquifer system (limits, mechanisms, operation, water quality, etc.).

-Influence of climate change on alluvial aquifers and infero-flux (exploitation, salinities, vulnerability of their qualities).

-Realization of a database and a GIS on all water resources.

Groundwater monitoring is essential in three aspects: piezometry, installation of a network of water quality observations, and finally, control.

Recovery and reuse of wastewater

The reuse of wastewater for irrigation represents a viable and sustainable alternative. To support this approach, the implementation of wastewater treatment facilities -such as lagoon systems or settling ponds designed in accordance with established technical standards- is planned.

As a part of the integrated water management model adapted to Saharan regions, the baseline data collected from hydraulic networks and agricultural operations must be systematically analyzed and processed to transform them into actionable information. Temporal data analysis enables the estimation of seasonal components of the water balance, which is then summarized in monitoring bulletins.

Furthermore, the integration of this data into Geographic Information Systems (GIS) allows for its combination with other datasets—such as environmental, land use, and economic information- facilitating the automated production of thematic maps that support informed decision-making. Fig. 5 below exhibits a sketch for the water administration in the Béchar region.

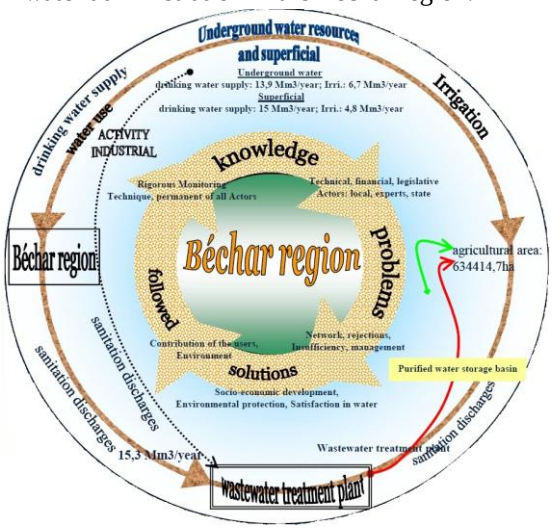

Fig. 5: Water resources management model for the Béchar region.

5. Conclusion

Management of water resources in the Béchar region is a systematic process for sustainable development and monitoring the use of water resources in the context of social, economic, and environmental objectives; all the constraints of development must find their solutions in this model:

-Preserve water resources durably.

-Satisfy the needs of the drinking water supply and irrigation.

-Ensure the balance of the ecosystem.

This model is in the course of application in the Béchar area. It is recommended to:

-Accomplish a demographic study at the consumption zone level, where it will be necessary to understand the evolution of water consumption.

-Give priority to organization and consultation between the different local structures involved in water management for patrimonial and shared management of the water resources.

-Establish a detailed report and rigorous water resources of this region.

-Mathematical simulation of the underground flow is highly recommended.

Integrated water resources management is needed to ensure better water governance, particularly in an arid environment. Integrated water resources management is a long-term process that requires adaptation to the environment; therefore, its implementation should lead to a major change in the way water. All those whose activities are related to water from close and afar should fit with the time.

6. Acknowledgments

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7. Conflict Of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

8. References

Abdesselem, K., 2017. Impact of Urban Discharges on the Environment and Water Resources in the Béchar Region (Southwest Algeria). MSc. Thesis, Mohamed Khider– Biskra University, 55 P.

Achite, M., Caloiero, T. and Toubal, A. K., 2022. Rainfall and runoff trend analysis in the Wadi Mina Basin (Northern Algeria) using non-parametric tests and the ITA method, Sustainability, pp. 9892. https://doi.org/10.3390/su14169892

Aissaoui, M., 2018. Hydrochemical characteristics of the waters of the Seybouse River and its tributaries in the Guelma region—quantification of the degree of pollution. MSc. Thesis, University of Annaba, 70 P.

Aouati, H., Demdoum, A., and Kada, H., 2023. The impact of climate change on groundwater quantity and quality in a semi-arid environment: a case study of Ain Azel plain (Northeast Algeria), Acta Geochimica, pp. 1065–1078. https://doi.org/10.1007/s11631-023-00633-7

Athamena, M., Athamena, A., and Menani, M. R., 2023. Study of the thermal sources of the Bellezma mounts, eastern Algeria, Algerian Journal of Environmental Science and Technology, pp. 3309-3323.

Belalite, H. and Athamena, A., 2022. Calculation of water needs of the main crops and water resources available in a semi-arid climate, case of Zana Gadaïne plain, Northeastern Algeria, Algerian Journal of Environmental Science and Technology, pp. 77-88.

Benamara, A. and Bouabdallah, F., 2017. Thermo mineral waters of Hammam Meskoutine (north-east Algeria): composition and origin of mineralization, Journal of Water and Land Development, pp. 47–57, https://doi.org/10.1515/jwld-2017-0037

Benameur, F. and Hamdi, A. B., 2024. Study of Water Quality and Geochemistry in Complex Terminal Aquifers throughout the Guerrara Region of Algeria Applying GIS and Statistical Methods, African Journal of Biological Sciences, pp. 13809-1385,

Benaradj, A., 2012. Geological Specificity of the Oranian Saharan Atlas (Béchar), 2nd International Conference on the Geology of the Sahara – Mineral, Hydrocarbon, and Water Resources, December 3–5, Ouargla, Algeria, Proceedings, pp. 19–29.

Benhamza, M., 2012. Water Scarcity and Desertification in Algeria: Challenges for Sustainable Development. Journal of Arid Environments, pp. 54-61. https://doi.org/10.1016/j.jaridenv.2011.12.010

Bouchelkia, H., and Meddi, M., 2015. Climate Change Impact on Water Resources in Algeria: Case of Seybouse Basin, Water Resources Management pp. 73-86,

Byramjee, R. and Meindre, A., 1956. The Guettara Manganese Deposit. Manganese Symposium, 20th International Geological Congress, Mexico, pp. 179-196.

Alekya, Ch., 2024. Water quality index using the efficacy and precision of this machine learning-based approach, African Journal of Biological Sciences pp. 2135-2142,

Deleau, P., 1951. The Coal Basins of the South Oranais in the Colomb-Béchar-Abadla Region. Series 2, Strat. No. 20, Bulletin of the Geological Map Service of Algeria, France, 277 p.

Fabre, J., 1976. Introduction to the Geology of the Algerian Sahara and Neighboring Regions. National Publishing and Distribution Company, Algeria,421 P.

Ibraheem, R., Baddi, F. and Aahed, Y., 2025. Hydrogeochemistry and Health Risk Assessments of Surface and Groundwater Around Industrial District in Qayarah Area, Northern Iraq, Iraqi National Journal of Earth Science, pp. 137-156, https://doi.org/10.33899/earth.2024.143727.1154

Idrotecneco, 1976. Hydrogeological Study of the Béchar Region, Internal Report, DHWB, 170 P.

Kabour, A., 2011. Assessment and Management of Water Resources in an Arid Region: Case of the City of Béchar (Southwest Algeria), Larhyss Journal, pp. 7-19.

Kabour, A., Hani A. and Chebah, L., 2015. Groundwater hydrochemistry and effects of anthropogenic pollution in Béchar city (SW Algeria), Desalination Water Treatment, pp. 1-10, https://doi.org/10.1080/19443994.2015.1060899

Kharfia, B., 2014. Study and Means of Flood Control in the Béchar Oued Watershed (Algeria), Journal of Remote Sensing and GIS, pp. 72-77,

Lachache, S., Derdour, A., Maazouzi, I., Amroune, A., Guastaldi, E., and Merzougui, T., 2023. Statistical approach of groundwater quality assessment at Naama region, south-west Algeria, Larhyss Journal, pp. 125-144.

Lachache, S. and Merzougui, T., 2016. Hydrogeological and Hydrochemical Characterization of the Meridja Region Using GIS (Béchar Region, Southwest Algeria). 3rd Edition of the International Symposium for GIS Users. Oujda, November 22-23, 2016, Morocco. Mohammed First University, Oujda.

Lachache, S., Nebou, M., Merzougui, T., and Amroune, A., 2018. Hydrochemistry and origin of principal major elements in the groundwater of the Béchar–Kénadsa basin in arid zone, South–West of Algeria, Journal of Water and Land Development, pp. 77-87, https://doi.org/10.2478/jwld-2018-0008

Mekkaoui, A., 2000. Edge of the Atlantic Trough–Saharan Platform During the Lower and Middle Jurassic (Southern Grouz, Charef-Fendi), Southwestern Algeria, MSc. Thesis, Oran University, Algeria, 210 P.

Menchikoff, N., 1936. Geological Studies on the Southern Algerian-Moroccan Borders, Revue de géographie physique et de géologie dynamique, pp. 131-149.

Pareyn C. 1961. The Carboniferous Massifs of the Southern Oranian Sahara. Volume I, Stratigraphy and Tectonics, National Center for Scientific Research, Paris, France. 362 P.

Perrodon, A., 1957. Geological Study of the Sublittoral Neogene Basins of Western Algeria, MSc. Thesis, University of Lorraine, France, 328 P.

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تقييم واقتراح ادارة الموارد المائية في منطقة بشار القاحلة، جنوب غربي الجزائر

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الملخص

تقع منطقة بشار في جنوب غربي الجزائر، وتتميز بمناخ قاحل ذي نزعة صحراوية. وهي تخضع لطلب متزايد على المياه مثل جميع التجمعات الكبرى بسبب التطور الاقتصادي والديمغرافي. يقدم هذا العمل تقديرًا تفصيليًا للمياه الجوفية والسطحية في منطقة بشار، من أجل إدارة مناسبة واستخدام كفء لهذا المورد. تأتي الموارد المائية بشكل رئيسي من سد جرف طربة والخزان الجوفي الطوروني، بتدفق يقدر بأكثر من 500 لتر/الثانية. بالإضافة إلى ذلك، تشكل الموارد السطحية جزءًا مهمًا من التراث المائي لمنطقة بشار، مع تدفق دائم لمجارٍ مائية مختلفة تحمل حجمًا كبيرًا، إلى جانب وجود منشآت هيدروليكية مهمة تسمح بتعبئة حجم معين من المياه.هناك حاجة إلى تطبيق نموذج متكامل لإدارة الموارد المائية. سيكون هذا النموذج أداة أساسية لا غنى عنها للإدارة الفعالة للمياه في البيئات الجافة. كما سيسمح بزيادة الوعي بضرورة إدارة الموارد المائية من أجل التوفيق بين التنمية الاجتماعية والاقتصادية والحفاظ على البيئات المائية، وتحقيق التوازن بين الاستخدامات المختلفة لضمان التنمية المستدامة. ستساهم النتائج في تصميم نموذج متكامل لإدارة المياه يمكن تعميمه على المناطق القاحلة.

الكلمات المفتاحية:

منطقة قاحلة، موارد مائية، إدارة متكاملة، تنمية مستدامة

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