Fronteiras: Journal of Social, Technological, and Environmental Science
http://periodicos.unievangelica.edu.br/fronteiras/
ISSN 2238-8869

Article

Potential Areas for Subsurface Dams (SD)" Installation: Strategies for Water Security in the Semi-Arid Region of Rio Grande do Norte

Vanessa Tainara da Cunha[1], Joel Medeiros Bezerra[2], Rafael Oliveira Batista[3], Douglas Pereira Ferreira[4], Francisco Éder Rodrigues de Oliveira[5], Jeane Cruz Portela[6], Nildo da Silva Dias[7], Phâmella Kalliny Pereira Farias[8], Joilma Maria de Souza[9], Luiz Fernando de Sousa Antunes[10]

[1] PhD in Soil and Water Management. Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-1825-0097. Email: vanessatianra62@gmail.com
[2] Adjunct Professor at the Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-8150-4125. Email: joel.medeiros@ufersa.edu.br
[3] Associate Professor IV at the Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-3083-6808. Email: rafaelbatista@ufersa.edu.br
[4] Master's Degree in Soil and Water Management. Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-4042-2051. Email: eng.amb.douglas@gmail.com
[5] Master's degree in Soils and Ecosystem Quality. Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-7011-4818. Email: francisco.oliveira55920@alunos.ufersa.edu.br
[6] Associate Professor IV at the Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-9207-5530. Email: jeaneportela@ufersa.edu.br
[7] Full Professor at the Federal Rural University of the Semi-Arid Region ( ) . ORCID: 0000-0002-1276-5444. Email: nildo@ufersa.edu.br
[8] PhD from the Graduate Program in Soil and Water Management. Federal Rural University of the Semi-Arid Region. ORCID: 0000-0002-5388-4204. Email: phamella@temporarios.ufersa.edu.br
[9] Master's degree in Soil and Water Management. Federal Rural University of the Semi-Arid Region. ORCID: 0000-0001-6365-6603. Email: joilmasouza14.17@gmail.com
[10] PhD in Plant Science. Federal Rural University of Rio de Janeiro. ORCID: 0000-0001-8315-4213. Email: fernando.ufrrj.agro@gmail.com

ABSTRACT
The increasing demand for food in arid and semi-arid regions, combined with climate change, highlights the need for efficient technologies for water resource management. Underground Dams (UD) or Subsurface Dams (SD), as they are also called, emerge as an effective alternative for storing water underground, providing supply for human consumption, livestock, and agricultural activities, thereby contributing to water security. This study aimed to identify the criteria and methodologies used to select suitable sites for SD implementation. A systematic review was conducted in scientific journals, consulting databases such as SciELO, ScienceDirect, CAPES Journal Portal, and Google Scholar; from 2013 to 2024, with the selection of 12 relevant articles. The results indicate that the inefficiency of BS is often associated with inappropriate site selection. Tools such as GIS and multi-criteria methods (AHP, EDAS, and TOPSIS), combined with geological, hydrological, slope, and socioeconomic criteria, have been applied to optimize this selection. While countries such as Iran and Turkey report good results, in-depth studies in Brazil remain scarce. This work emphasizes the need for additional research and the use of technologies to identify ideal areas, promoting regional sustainability and water security.
Keywords: subsurface dam; underground dam; GIS; water management; food security; sustainability.

RESUMO
A crescente demanda por alimentos em regiões áridas e semiáridas, aliada às mudanças climáticas, reforça a necessidade de tecnologias eficientes para a gestão de recursos hídricos. As barragens subterrâneas (BS) surgem como alternativa eficaz para armazenar água no subsolo, fornecendo suprimento para consumo humano, animais e atividades agrícolas, contribuindo para a segurança hídrica. Este estudo teve como objetivo identificar os critérios e metodologias utilizados na seleção de locais adequados para implantação de BS. Realizou-se uma revisão sistemática em periódicos científicos, consultando bases como SciELO, ScienceDirect, Portal de Periódicos

Submission: September 26, 2025 Accepted: November 6, 2025 Publication: 19/12/2025

v.14, n.4, 2025 • p. 1-11. • DOI http://dx.doi.org/10.21664/2238-8869.2025v14i4.8339

da CAPES e Google Acadêmico, abrangendo 2013 a 2024, com a seleção de 12 artigos relevantes. Os resultados indicam que a ineficiência das BS está frequentemente associada à escolha inadequada do local. Ferramentas como SIG, GIS e métodos multicritério (AHP, EDAS e TOPSIS), combinadas com critérios geológicos, hidrológicos, de declividade e socioeconômicos, têm sido aplicadas para otimizar essa seleção. Observou-se que, embora países como Irã e Turquia apresentem bons resultados, ainda há escassez de estudos aprofundados no Brasil. O trabalho evidencia a necessidade de pesquisas adicionais e do uso de tecnologias para identificar áreas ideais, promovendo a sustentabilidade e segurança hídrica regional.
Palavras-chave: barragem subterrânea; SIG; gestão hídrica; segurança alimentar; sustentabilidade.

Introduction

According to projections by the United Nations (2019), the world population could reach approximately ten billion by the middle of the 21st century, which is likely to intensify challenges related to global food production and food supply. Countries located in tropical areas, including the semi-arid region of Brazil, may face a reduction in food supply and, consequently, an increase in hunger rates due to rising temperatures and more severe droughts.

Penssan (2021) points out that almost half of the population of the Brazilian semi-arid region lives in conditions of food insecurity. The same research network recorded approximately 3.67 million people in a situation of severe food insecurity during the pandemic, highlighting the social and economic vulnerability of the region.

In analyzing this worrying scenario, Hargrove et al. (2023) highlight that, for decades, the increase in demand for food has driven the expansion of irrigated agriculture. However, in arid and semi-arid regions, mechanisms have historically been developed to cope with water scarcity, a phenomenon that has intensified due to climate change. Therefore, efficient water resource management is essential, which involves not only the creation of technologies adapted to the semi-arid region, but also their proper implementation, ensuring food production and the supply of water for human and animal consumption throughout the year. This strategy contributes to maintaining productive regularity and strengthening the food security of farming families.

Among the various technologies developed for coexistence with the semi-arid region, the Subsurface Dam (SD) stands out, acting as an underground reservoir capable of meeting the water demand of productive areas during periods of irregular rainfall (Lima et al., 2013; Souza et al., 2014). This technology stands out for its low cost and simplicity of implementation, which has favored its adoption in several locations in the Brazilian semi-arid region. Its efficiency in maintaining soil moisture for several months after the rainy season has enabled the productive use of previously idle areas, allowing cultivation even during the dry season (Araújo, 2023).

Subsurface Dams (SD) can be classified into two main types: submersible dams, which form a temporary lake, and subsurface dams, which only block the flow of groundwater. In Brazil, there are three notable models of submersible dams: Embrapa, Serra Negra do Norte, and ASA Brasil (Lima et al., 2013; Ximenes et al., 2019).

To ensure the effectiveness of these dams, it is essential to consider different criteria. Hamlat et al. (2024) highlight the importance of preliminary studies on geology, hydrology, and socioeconomic aspects in the implementation process. This systematic review is necessary given the scarcity of studies on Subsurface Dams (SD) in Brazil, especially with regard to implementation criteria. This scientific gap compromises the efficient adoption of the technology and highlights the importance of further research in the area. Thus, this study aims to gather information on site selection and installation methods, promoting greater efficiency in the application of the technique and stimulating new investigations. It is assumed that a clear definition of technical, environmental, and socioeconomic criteria is essential to ensure the efficiency of Subsurface Dams (SD), both in terms of water storage and in strengthening the water and food security of communities in the semiarid region.

Methodology

The systematic review was conducted between August and December 2024, focusing on arid and semi-arid areas, which are often affected by droughts and vulnerable to water scarcity. The objective was to identify criteria and methodologies applied to the selection of suitable sites for the implementation of Subsurface Dams (SD).

Databases and tools used

The search for scientific articles was conducted in the following databases: Google Scholar, Scientific Electronic Library Online (SciELO), CAPES Journal Portal, ScienceDirect, Brazilian Digital Library of Theses and Dissertations, and Open Access Theses and Dissertations. In addition to these, artificial intelligence tools such as Litmaps and Open Knowledge Maps were used, which are useful for detecting semantic relationships and co-citations between publications.

Search strategy and inclusion and exclusion criteria

The search strategies were defined based on a combination of keywords in English, structured as follows: ("Groundwater dams" OR "Underground dams" OR "Subsurface dams") AND ("Semiarid" OR "Semi-arid") AND "Best Underground Dam Sites." In addition, on the Litmaps platform, the article "A Case Study for Determination of the Best Underground Dam Sites, Bursa Province, Turkey" was used as a reference, which allowed us to identify several studies related to the topic, based on connections through citations and thematic similarity.

The search strings were adapted according to the Boolean operators allowed by each database consulted. The Litmaps and Open Knowledge Maps tools were fundamental for identifying the most relevant articles by analyzing citation networks and thematic clusters.

Articles published between 2013 and 2024 were considered eligible, focusing on the selection of sites for the construction of Subsurface Dams (SD), presenting a clear methodology applicable to semi-arid regions, peer-reviewed, with full text available in Portuguese, English, or Spanish. Duplicate or irrelevant articles, works that addressed exclusively construction aspects, studies without site selection criteria, and publications without access to the full text were excluded.

Screening and analysis

The selection was carried out in stages: (1) reading of titles and abstracts, (2) application of inclusion/exclusion criteria, (3) complete analysis of the selected texts. The process is illustrated in Figure 1.

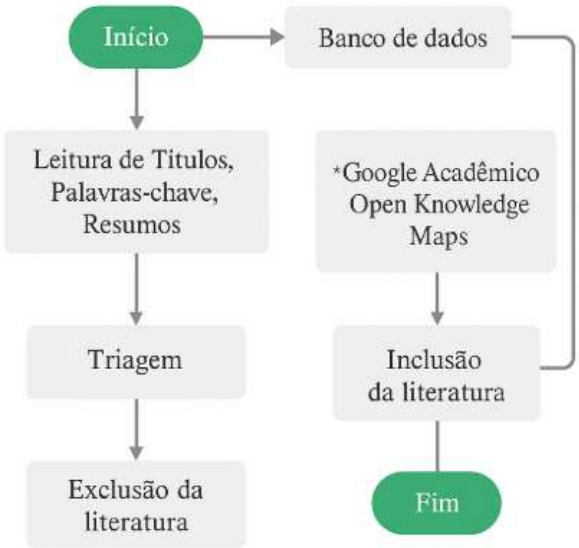

Figure 1. Timeline flowchart for the selection, inclusion, and exclusion of scientific articles addressed in the systematic review. Source: Own work, (2024)

Data organization

The data were organized using analytical tables, in which the included studies were systematized based on the following information: author, year of publication, study title, database consulted, journal of publication, language of the article, method adopted, and methodology used to select suitable sites for the construction of Subsurface Dams (SD). Despite the use of multiple databases, it was observed that most of the relevant articles

were found on Google Scholar, which can be attributed to the low scientific production on the subject in other indexed databases. This limitation was considered in the discussion of the results.

Results and Discussions

Systematic review

The evolution of Subsurface Dams (SD) as a water resource management strategy began in 1973. Initially, researchers studied salinity mitigation measures in subsurface dam environments. These studies have evolved over the last few decades, focusing on their various applications. Table 1 presents a chronological overview of the main milestones and areas of focus of research on Subsurface Dams (SD).

The water crisis has driven the search for effective solutions to ensure access to water in semi-arid regions. Since the 2000s, there has been a significant increase in the number of scientific studies on Subsurface Dams (SD) in these regions. This increase, identified by Santos and Sousa (2023) based on a survey conducted in the Scopus database, shows a trend of exponential growth in publications on the subject. This advance reflects the growing interest in sustainable water management alternatives and the adoption of technologies aimed at strengthening family farming. In this context, the proper definition of the location for the implementation of Subsurface Dams (SD), associated with the efficiency of this technology, is a central aspect for the continuity of research.

Table 1: Historical and scientific evolution of research on Underground Dams (UD) or Subsurface Dams (SD).

Year	Technical and scientific approaches to underground dams
1973	The first article on the use of underground dams to reduce groundwater salinity in the irrigation of 720,000 ha in the Murray River basin, Australia, was published.
1973 - 1990	Eight articles were published on the use of underground dams for irrigation and increasing the supply of drinking water in communities in North America, Africa, and Europe.
1991 - 2000	Fourteen published articles dealt with the hydrological, hydrogeological, and geochemical characterization of new areas, as well as the socioeconomic factors that influence the sustainability of underground dams.
2001 - 2010	There was greater interest in modeling engineering systems for groundwater storage and accumulation, contributing to assessing recharge capacity and identifying limitations in meeting demand.
2011–2022	During this period, there was a 300% increase in the number of publications compared to the previous period. A study on the ideal location for implementation is one example.

Source: Own work (2025).

Systematic review of the selection of appropriate sites for the construction of underground dams

The systematic review on different bibliographic platforms revealed a gap in Brazilian research on the selection of suitable sites for the construction of underground dams in the semiarid region. Although the technology has been in use for decades, most Brazilian studies emphasize water quality, with an emphasis on irrigation (salinity and sodicity). This demonstrates the incipience and scarcity of the investigations and highlights the need for further academic research on the subject.

Among the articles reviewed, ten were published in English and one in Portuguese (Table 2). All articles were found in the Google Scholar database and are experimental in nature. Regarding the methodologies used to select the locations for underground dams, the use of tools such as Geographic Information Systems (GIS), such as QGIS, as well as complementary technologies, such as the SWAT (Soil and Water Assessment Tool) model, and decision-making techniques such as AHP (Analytic Hierarchy Process), EDAS (Evaluation based on Distance from Average Solution), and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). The research identified was conducted in Iran, in the semi-arid region of Pernambuco in Brazil, in the province of Bushehr (Iran), in South Korea, and in the arid and semi-arid regions of Algeria and Turkey.

The selected articles were published in the journals Revista Gestão Sustentável de Recursos Hídricos, Groundwater For Sustainable Development, Revista Brasileira de Geografia Física, Environmental Earth Sciences, Water, Cleaner Production Magazine, and Journal of Mountain Science. In terms of temporal distribution, the studies were selected from the period 2013 to 2024, with one published in 2013, two published

in 2019, two in 2020, one in 2021, four in 2023, and two in 2024 (Table 2). No dissertations or theses related to the topic were found.

Table 2: Compilation of articles addressing methodologies and technologies relevant to the selection of suitable sites for the construction of underground dams (continued).

Author/year	Title	Keywords	Database	Journal	Language	Method	Methodology used in selecting the SD (UD) location
Rezaei et al. (2013)	Application of Fuzzy Multi-Criteria Decision Analysis to Evaluate and Select the Best Location for the Construction of an Underground Dam	underground dam, multi-criteria decision making, fuzzy theory, AHP	*Litmaps*	*Acta Polytechnica Hungarica*	English	Experimental	AHP
Talebi et al. (2019)	Locating suitable sites for underground dam construction using groundwater flow simulation (SWAT model) and analytical network process (ANP) (case study: Daroongar watershed, Iran)	Undergrond dams, underground flow, SWAT model, and ANP	*Open Knowledge Maps*	*Sustainable Management of Water Resources.*	English	Experimental	SWAT model
Kharazi et al. (2019)	Proper identification of underground dam sites using decision-making methods in a semi-arid region of the Iranian Semnan plain	Undergrond dams, Geographic information system, Analytic hierarchy process	Google Scholar	*Groundwater for Sustainable Development*	English	Experimental	GIS and decision-making methods such as AHP, EDAS, and TOPSIS

Table 2: Compilation of articles addressing methodologies and technologies relevant to the selection of suitable sites for the construction of underground dams (continued).

Author/year	Title	Keywords	Database	Journal	Language	Method	Methodology used in selecting the SD (UD) location
Dortaj et al. (2020)	A hybrid multi-criteria decision-making method for selecting underground dam sites in the semi-arid region of Iran	Underground dams, ELECTRE method, groundwater resources Hybrid MCDM, Borda count, and Copeland method	*Open Knowledge Maps*	*Groundwater For Sustainable Development*	English	Experimental	Hybrid method based on expert knowledge
Silva Filho et al. (2020)	Assessment of the Potential for Using Alluvium for the Construction of Underground Dams in the Semi-Arid Region of Pernambuco.	Groundwater, alluvium, underground dams, risk of salinization.	Google Scholar	Brazilian Journal of Physical Geography	Portuguese	Experimental	QGIS was used, together with SRTM and LiDAR data, to demarcate river basins
Ebrahimi et al. (2021)	Prioritizing suitable sites for underground dam construction in southeastern Bushehr province	Underground dam, ANP model, Copeland method, Boolean logic, site selection, and GIS.	Google Scholar	*Environmental Earth Sciences*	English	Experimental	Boolean methods and multi-criteria models, including AHP, TOPSIS, ANP, VIKOR, and ELECTRE III, in conjunction with the Copeland technique

Table 2: Compilation of articles addressing methodologies and technologies relevant to the selection of suitable sites for the construction of underground dams (continued).

Author/year	Title	Keywords	Database	Journal	Language	Method	Methodology used in selecting the SD (UD) location
Choi et al. (2023)	A study on the priority selection method for underground dam installation considering human and social factors using the fuzzy analytic hierarchy process in Korea.	Priority selection method, Underground dam installation, Human and social factors, Fuzzy AHP	Google Scholar	*Water*	English	Experimental	Used fuzzy AHP
Talebe et al. (2023)	GIS-based multi-criteria decision analysis for selecting groundwater dam sites in an arid and semi-arid region of Algeria	ANP model, Groundwater flow, SWAT model, and Underground dam.	Google Scholar	*Groundwater for Sustainable Development*	English	Experimental	SWAT modeling in conjunction with the analytical network process (ANP)
Rane et al. (2023)	A decision framework for selecting potential dam sites using GIS, MIF, and TOPSIS in the Ulhas River basin, India.	Dam site selection, MCDM, GIS, MIF, TOPSIS Sensitivity analysis.	Google Scholar	*Cleaner Production Magazine*	English	Experimental	GIS, Fuzzy Inference Method (FIM), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

Table 2: Compilation of articles addressing methodologies and technologies relevant to the selection of suitable sites for the construction of underground dams (conclusion).

Author/year	Title	Keywords	Database	Journal	Language	Method	Methodology used in selecting the SD (UD) location site
Sadeghiravesh et al. (2023)	Selection of suitable sites for the construction of underground dams using Multi-Attribute Utility Theory in arid and semi-arid regions.	Prioritization, GIS, Multi-attribute decision making, Arid region	Google Scholar	*Journal of Mountain Science*	English	Experimental	GIS techniques and decision-making processes for analysis.
Aras et al. (2024)	A case study for determining the best underground dam sites, Bursa province, Turkey.	Underground dams, Site selection, Multi-criteria decision analysis, Geographic Information System (GIS), Bursa, Turkey	Google Scholar	*Groundwater*	English	Experimental	GIS
Hamlat et al. (2024)	GIS-based multi-criteria decision analysis for selecting groundwater dam sites in an arid and semi-arid region of Algeria	Alluvial aquifer, Analytic hierarchy process, Arid region Oued M'zi, Groundwater dam, Water abstraction.	Google Scholar	*Groundwater for Sustainable Development*	English	Experimental	Use of GIS-based AHP.

Source: Own work (2025).

The systematic review, as summarized in Table 2, highlights the importance of constructing underground dams (UD) in rural communities, as they retain water in the soil, promoting increased productivity in semi-arid regions. However, the technology still has significant gaps, especially with regard to the appropriate choice of construction site.

Silva Filho et al. (2020) highlight that underground dams (UD) are a strategic alternative for water supply, offering benefits not only for human and animal consumption but also for food production. However, inappropriate site selection can compromise storage capacity and, consequently, the effectiveness of the system.

Chianca et al. (2023) emphasize that the implementation of dams without adequate technical criteria, disregard for construction standards, lack of community involvement, poor management, and lack of monitoring can render these structures ineffective, contributing to the degradation of water resources.

Similarly, Kharazi et al. (2019) note that site selection is often done intuitively, based solely on visual analysis or influenced by political interests, resulting in less efficient systems. In this scenario, it is essential to use methodologies that promote safe and informed decisions, ensuring the effectiveness of underground dams.

Dortaj et al. (2020) emphasize that the definition of the ideal location must consider several aspects, such as geology, hydrogeology, hydrology, and economic factors. Thus, the study of the soil and local geology should be the first step in this process.

Aras et al. (2024) identified a series of essential criteria for site selection, such as the river network, slope, proximity to roads, geological faults, presence of natural resources, irrigation areas, and water demand. However, of the 39 settlements evaluated in Bursa, only six had ideal conditions for the construction of underground dams.

Shirani et al. (2017) suggest that areas with a slope between 0% and 10% are particularly suitable for the construction of these dams. Dorfeshan et al. (2014) point out that a distance of between 20 and 50 meters from residences is an important factor in preventing contamination by solid waste.

Hamlat et al. (2024), using GIS, identified that only 1.27% of the M'zi Wadi basin is highly favorable for the construction of underground dams. Sadeghiravesh et al. (2023) selected seven locations, with Nazarabad being the most suitable, with a utility coefficient of 0.7137.

Talebi et al. (2019), using hydrological modeling and ANP, identified 17 priority sites in Fakhrabad, Iran. In Brazil, Gomes et al. (2017) highlighted the dry bed of the Boals River as a promising area due to the presence of sandy soil.

Ebrahimi et al. (2021) note that the decisive factors for site selection vary according to regional characteristics. Rane et al. (2023), applying GIS, MIF, and TOPSIS tools, identified that about 43.26% of the studied basin was highly suitable, with an AUC of 0.806.

Rane et al. (2023) reinforce the effectiveness of using Remote Sensing (RS) and GIS in site selection, corroborating the findings of Aras et al. (2024) and Sadeghiravesh et al. (2023). Similarly, Chezgi et al. (2010) and Zahedi (2013) emphasize water quantity as a crucial criterion in site selection.

Final Considerations

Underground dams (UD) are a strategic technology for ensuring water and food security in arid and semi-arid regions. However, the scarcity of in-depth studies on installation criteria in Brazil still limits their full effectiveness, especially regarding the choice of suitable locations.

This study showed that site selection is crucial to the success of the technology, highlighting the importance of integrating technical, environmental, and socioeconomic factors. Tools such as Geographic Information Systems (GIS) and multi-criteria methodologies, such as AHP, EDAS, and TOPSIS, can support safer and more efficient decisions. It is recommended that future research further explore these approaches to strengthen the sustainability of regional agriculture.

References

Aras, Egemen, et al. 2024. "A Case Study for Determination of the Best Underground Dam Sites, Bursa Province, Turkey." *Groundwater* 62, no. 5: 804–816.

Araújo Nunes, Jhon Wittor; Miranda de Queiroz, Tadeu. Análise multivariada da qualidade da água da bacia hidrográfica do rio Jauquara--MT. Boletim Goiano de Geografia, v. 43, n. 1, 2023. https://doi.org/10.5216/bgg.v43i01.64798

Chezgi, J., H. R. Murdi, and M. M. Kheirkhah Zarkesh. 2010. "Locating Suitable Sites for Construction of Underground Dam Using Multi-criteria Decision with Emphasis on Water Resources, Case Study: West Region Tehran." *Iranian Journal of Watershed Management Science and Engineering* 4: 65–68.

Chianca, C. G. C., et al. 2023. "Water Quality in Underground Dam Areas in the Semiarid Region of Rio Grande do Norte, Brazil." *Revista Caatinga* 36: 663–674.

Choi, Jung-Ryel, et al. 2023. "A Study on the Priority Selection Method for Underground Dam Installation Considering Humanities and Social Factors Using Fuzzy Analytic Hierarchy Process in Korea." *Water* 15, no. 18: 3296.

Dortaj, Amal, et al. 2020. "A Hybrid Multi-criteria Decision Making Method for Site Selection of Subsurface Dams in Semi-arid Region of Iran." *Groundwater for Sustainable Development* 10: 100284.

Dorfeshan, Farid, et al. 2014. "Locating Suitable Sites for Construction of Underground Dams Through Analytic Hierarchy Process." In *International Conference on Earth, Environment and Life Sciences (EELS-2014)*, 23–24. Dubai, UAE.

Ebrahimi, Javad, Hamid Reza Moradi, and Javad Chezgi. 2021. "Prioritizing Suitable Locations for Underground Dam Construction in South-east of Bushehr Province." *Environmental Earth Sciences* 80, no. 19: 680.

Gomes, Jorge LS, Fabio P. Vieira, and Valiya M. Hamza. 2017. "Use of Geophysical Surveys in Selection of Sites for Underground Dams in the Municipality of Jenipapo de Minas." In *15th International Congress of the Brazilian Geophysical Society & EXPOGEF*, 684–688. Rio de Janeiro: Brazilian Geophysical Society.

Hamlat, Abdelkader, et al. 2024. "GIS-based Multi-criteria Decision Analysis for Groundwater Dam Site Selection in an Arid and Semi-arid Region of Algeria." *Groundwater for Sustainable Development* 26: 101231.

Hargrove, W. L., J. M. Heyman, A. Mayer, A. Mirchi, A. Granados-Olivas, G. Ganjegunte, D. Gutzler, D. D. Pennington, F. A. Ward, and L. Garnica Chavira. 2023. "The Future of Water in a Desert River Basin Facing Climate Change and Competing Demands: A Holistic Approach to Water Sustainability in Arid and Semi-arid Regions." *Journal of Hydrology: Regional Studies* 46: 101336.

Kharazi, Pouria, Mohammad Reza Yazdani, and Payam Khazealpour. 2019. "Suitable Identification of Underground Dam Locations, Using Decision-making Methods in a Semi-arid Region of Iranian Semnan Plain." *Groundwater for Sustainable Development* 9: 100240.

Lima, A. O., N. S. Dias, M. Ferreira Neto, J. E. J. Santos, P. R. A. Rego, and F. P. Lima Filho. 2013. "Barragens Subterrâneas no Semiárido Brasileiro: Análise Histórica e Metodologias de Construção." *Irriga* 18, no. 2: 200–211.

Organização das Nações Unidas (ONU). 2019. "População Mundial Chegará a 9,7 Bilhões em 2050, Prevê ONU." *G1*, June 18, 2019.

PENSSAR - Rede Brasileira de Pesquisa em Soberania e Segurança Alimentar e Nutricional. 2021. "Fome: 47% da População no Semiárido Está Sem Acesso a Alimentos, Diz Pesquisa." *Brasil de Fato*, May 10, 2021.

Rane, Nitin Liladhar, et al. 2023. "A Decision Framework for Potential Dam Site Selection Using GIS, MIF and TOPSIS in Ulhas River Basin, India." *Journal of Cleaner Production* 423: 138890.

Rezaei, Parviz, et al. 2013. "Application of Fuzzy Multi-criteria Decision Making Analysis for Evaluating and Selecting the Best Location for Construction of Underground Dam." *Acta Polytechnica Hungarica* 10, no. 7: 187–205.

Sadeghiravesh, Mohammad Hassan, Hassan Khosravi, and Azam Abolhasani. 2023. "Selecting Proper Sites for Underground Dam Construction Using Multi-Attribute Utility Theory in Arid and Semi-arid Regions." *Journal of Mountain Science* 20, no. 1: 197–208.

Santos, Amanda de, and Francisco das Chagas de Sousa. 2023. "Barragens Subterrâneas Como Alternativa Para Garantia de Segurança Hídrica em Regiões Semiáridas: Desafios e Oportunidades." *Revista Semiárido De Visu* 11, no. 3: 616–636.

SHIRANI, Kourosh; DASTJERDI, A. Shafiey; RAHNAMARAD, Jafar. Integration of multi-criteria decision matrix and geographical information system to site selection for an underground dam. Electronic Journal of Geotechnical Engineering, v. 22, n. 1, p. 3669-3686, 2017.

Silva Filho, Eronildo Luiz, et al. 2020. "Avaliação do Potencial de Aproveitamento de Aluviões Para a Construção de Barragens Subterrâneas no Semiárido Pernambucano." *Revista Brasileira de Geografia Física* 13, no. 5: 2402–2416.

Sousa, Thiago Pereira de, Eduardo Pereira de Sousa Neto, Luana Raposo de Sá Silveira, Elias Francisco dos Santos Filho, and Patrício Borges Maracajá. 2014. "Barragem Subterrânea: Tecnologia Sustentável de Captação, Armazenamento de Água e Convívio Com o Semiárido." *Revista Terceiro Incluído* 4, no. 1: 97–103.

Talebi, Ali, et al. 2019. "Locating Suitable Sites for the Construction of Underground Dams Using the Subsurface Flow Simulation (SWAT Model) and Analytical Network Process (ANP) (Case Study: Daroongar Watershed, Iran)." *Sustainable Water Resources Management* 5: 1369–1378.

Talebi, Ali, Ali Reza Mandegar, Sara Parvizi, Hadi Poordara, and Jalal Barkhordari. 2023. "Underground Dam Site Selection Using Hydrological Modelling and Analytic Network Process." *Groundwater for Sustainable Development* 23: 100976.

Ximenes, Luciano Feijão, M. S. L. da Silva, and L. T. de L. Brito. 2019. *Tecnologias de Convivência Com o Semiárido Brasileiro*. Série Ciência e Tecnologia. 1st ed. Fortaleza: Banco do Nordeste do Brasil.

ZAHEDI, A. Determine areas suitable for underground dam construction using simulated water balance model (SWAT) and lattice analysis process (ANP) Case Study: Watershed Dargaz is shown. 2013. Tese de Doutorado. MA thesis, University of Yazd, Faculty of Natural Resources and Environment desert, watershed field. 167pp. (in Farsi).