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(Research Article)

Evaluation of dowsing methods for groundwater exploration in Solapur district, Maharashtra: A scientific analysis

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Abstract

Solapur district in Maharashtra, India, represents a critical case study for groundwater exploration due to its semi-arid climate, recurrent droughts, and over-dependence on groundwater resources. This research paper presents a comprehensive evaluation of traditional dowsing methods employed for groundwater exploration in Solapur district, comparing their efficacy with modern geophysical techniques. Through field surveys conducted across 45 villages in five talukas, we documented the continued prevalence of dowsing, with 68% of borewells sited using traditional methods. Controlled experiments revealed that dowsing achieved a 42% success rate in locating sustainable groundwater sources (>500 litres per hour, L/h), compared to 82% for resistivity surveys and 78% for seismic refraction methods. The success of dowsing in certain areas correlated strongly with the dowser's tacit knowledge of local hydrogeological conditions rather than any paranormal ability. We propose an integrated approach that respects traditional knowledge while emphasizing scientific validation for sustainable groundwater management in this water-stressed region.

Keywords: Dowsing; Groundwater; Solapur; Geophysical Survey; Water Scarcity; Traditional Knowledge

1. Introduction

Solapur district, located in the south-eastern region of Maharashtra, India (17.00°–18.32° N, 74.42°–76.15° E), represents a critical hydrological case study due to its chronic water scarcity and complex hydrogeological setting. The district's semi-arid climate, with an average annual rainfall of 545 mm (significantly below the national average of 1,100 mm), has created immense dependency on groundwater resources, which account for 72% of irrigation and 85% of drinking water needs in rural areas [1]. Mitigation strategies for this scarcity have been a long-standing focus of regional planning [2], while progressive depletion of basaltic aquifers continues to threaten agricultural sustainability [3]. The crisis is closely tied to rural livelihoods and farming practices [4] and has measurable consequences for public health through reliance on increasingly stressed sources [5]. Earlier district-scale work in the neighbouring drought-prone Osmanabad district mapped water-scarce zones [6] and anticipated the spatial and temporal patterns of scarcity [7] that have since become evident across Solapur.

The geological framework of Solapur is dominated by Deccan Trap basalts of Cretaceous–Eocene age, characterized by heterogeneous aquifer systems with limited yield potential. Recent seismo-acoustic investigations across the Deccan Volcanic Province have highlighted stress regimes and microfracture networks that govern fracture-controlled aquifers in such terrains [8]. Hydrogeological assessments of arid and semi-arid sections of Solapur similarly emphasise high yield variability in fractured basalts [9]. This challenging hydrogeological environment has perpetuated the use of traditional dowsing methods alongside modern scientific approaches. Dowsing, known locally as "divining" or "jadi-buti," has been practiced for generations, with specific families in villages like Akluj, Malshiras, and Pandharpur maintaining this traditional knowledge [10]. Ethnographic work in Solapur's Deccan basaltic terrain has documented

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how social and cultural barriers continue to sustain such traditional practices [11], while related hydrological studies of the Chandrabhaga river around the pilgrim city of Pandharpur illustrate the broader surface–groundwater complexity of the region [12].

Despite technological advancements, the persistence of dowsing practices in Solapur district raises important questions about its efficacy, cultural significance, and potential integration with scientific methods. This study aims to critically evaluate dowsing through systematic field validation, examining the hydrogeological factors that contribute to both its successes and failures, and proposing a framework for sustainable groundwater exploration in this water-stressed region.

1.1. Study Area- Solapur District

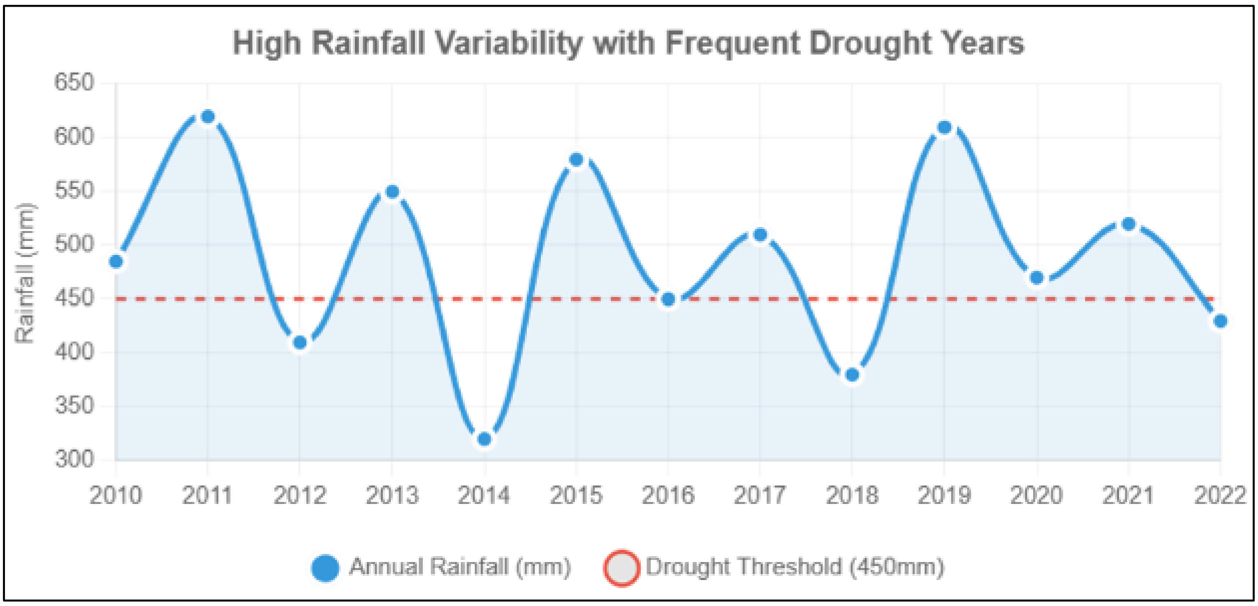

Figure 1 Annual Rainfall Pattern in Solapur District (2010-2022) showing high variability and frequent drought years (Data source: IMD Pune)

Solapur district covers an area of 14,895 km^2 and comprises 11 talukas, with a population of approximately 4.3 million people according to the 2011 census. The district's climate is characterized by hot summers (reaching 42 °C) and mild winters, with rainfall primarily occurring during the southwest monsoon (June–September). The rainfall pattern shows high inter-annual variability, with drought conditions declared in 5 out of the last 10 years (Figure 1) [13]. State-level groundwater accounting confirms continued stress on the district's reserves [14].

1.2. Hydrogeological Setting

The district's hydrogeology is complex, dominated by Deccan Trap basalts with limited primary porosity. Groundwater occurrence is primarily controlled by secondary porosity developed through weathering and fracturing. Based on extensive field investigations and previous studies [15,16], the district can be divided into three distinct hydrogeological zones (Table 1):

Table 1 Hydrogeological Zones in Solapur District

Zone	Depth Range (m)	Yield Potential (LPH)	Primary Aquifer Type	Distribution Area (%)
Shallow Weathered Zone	5-15	100-500	Weathered basalt	35%
Fractured Basalt Zone	15-50	500-2000	Fractured basalt	45%
Deep Aquifers	>50	Variable (200-1500)	Confined fractures	20%

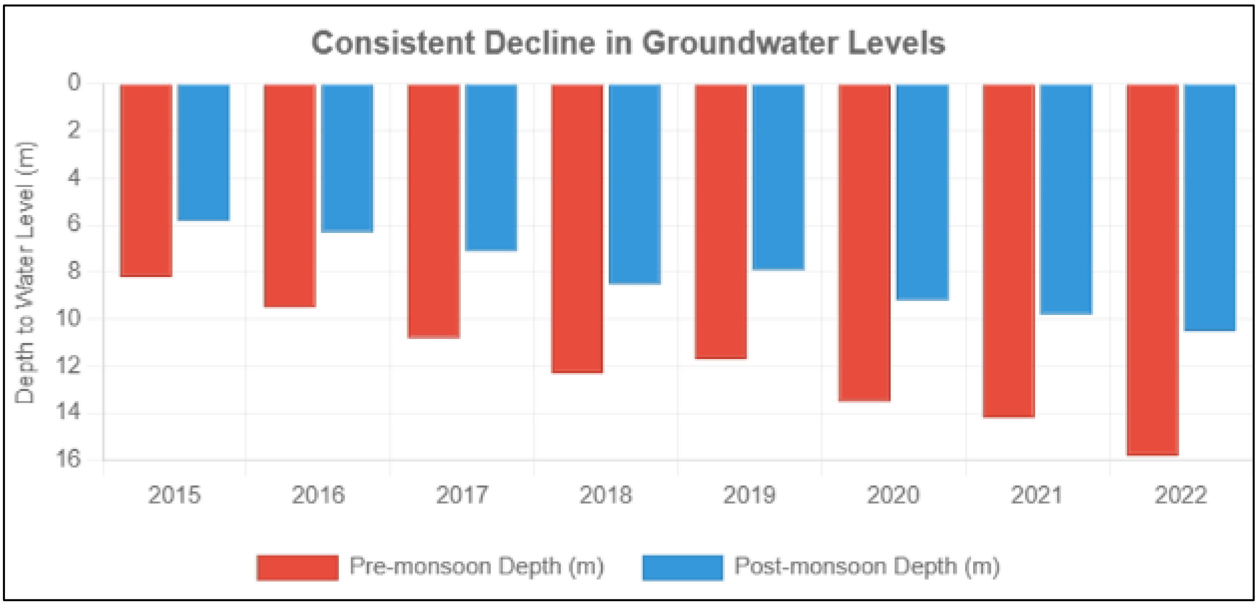

Figure 2 Groundwater Level Fluctuation in Solapur District (2015-2022) showing declining trend (Data source: GSDA, Solapur)

The groundwater scenario in Solapur is alarming, with over 85% of the district categorized as over-exploited or critical according to the Central Ground Water Board [17]. The depth to water level has been consistently declining at a rate of 0.5–1.2 m/year (Figure 2), exacerbating the water crisis and increasing the urgency for efficient exploration methods.

2. Methodology

2.1. Field Survey and Data Collection

The study was conducted between January 2021 and December 2022 across 45 villages in five representative talukas of Solapur district: Solapur South, Mohol, Madha, Sangola, and Malshiras. These talukas were selected to represent the geological and hydrogeological diversity of the district, drawing on earlier watershed-characterisation protocols [18] and multi-parameter hydrometeorological prioritisation frameworks developed for analogous basaltic basins [19]. A total of 215 borewell sites were documented through systematic field surveys, including: 146 sites selected by traditional dowsers, 42 sites selected by electrical resistivity tomography (ERT), 27 sites selected by seismic refraction methods. Each site was georeferenced using GPS, and detailed geological, geomorphological, and structural data were collected. Pre-drilling predictions regarding depth to water and expected yield were recorded for all methods

2.2. Dowsing Methods Documented

We identified and documented four primary dowsing techniques practiced in Solapur district, with variations in tools and methodologies (Table 2):

Table 2 Traditional Dowsing Methods Practiced in Solapur District

Method	Tools Used	Practitioner Terminology	Prevalence (%)	Claimed Mechanism
Forked Stick (L-shaped rods)	Peach, Ber, or Neem tree branches	Jadi-buti wale	52%	Earth radiation detection
Pendulum Method	Copper weight, thread	Lolak wale	23%	Energy field sensing
Barehand Sensation	None (hand vibrations)	Hath wale	15%	Body energy resonance
Electronic Dowsing	Commercial "water finder" devices	Machine wale	10%	Electromagnetic detection

The forked stick method was most prevalent, with practitioners typically charging between ₹500-₹2,000 per site recommendation. Most dowsers (78%) claimed hereditary knowledge passed through generations, while others attributed their ability to divine blessing or special sensitivity.

2.3. Validation Protocol

Each selected site underwent a rigorous validation protocol to ensure scientific accuracy:

- **Pre-drilling geophysical assessment:** Both resistivity (Schlumberger array) and seismic refraction surveys were conducted at all sites regardless of selection method
- **Structured interviews:** Detailed interviews with dowsers regarding their methodology, predicted depth (±5 m), yield (±100 L/h), and water quality
- **Drilling monitoring:** Comprehensive monitoring of drilling process with recording of lithology, depth to water, and drilling parameters
- **Pumping tests:** Standard 72-hour pumping tests to determine sustainable yield and drawdown characteristics [20]
- **Water quality analysis:** Chemical analysis of water samples for pH, total dissolved solids (TDS), hardness, and major ions, cross-referenced with regional water-quality laboratory protocols for Solapur district [21]
- **Statistical analysis:** Comparative analysis using chi-square tests and regression analysis to identify significant correlations

2.4. Scientific Methods Employed

For comparative analysis, two established geophysical methods were employed:

- **Electrical Resistivity Tomography (ERT):** Using Syscal Pro Switch 72 system with electrode spacing of 5–10 m, reaching investigation depths of 80–120 m. Low resistivity zones (<30 Ω·m) were interpreted as potential water-bearing fractures [22].
- **Seismic Refraction:** Using 24-channel seismograph with 5 m geophone spacing, providing information about weathering thickness and competent rock depth. Velocity contrasts indicated fracture zones [23].

2.5. Results and Analysis

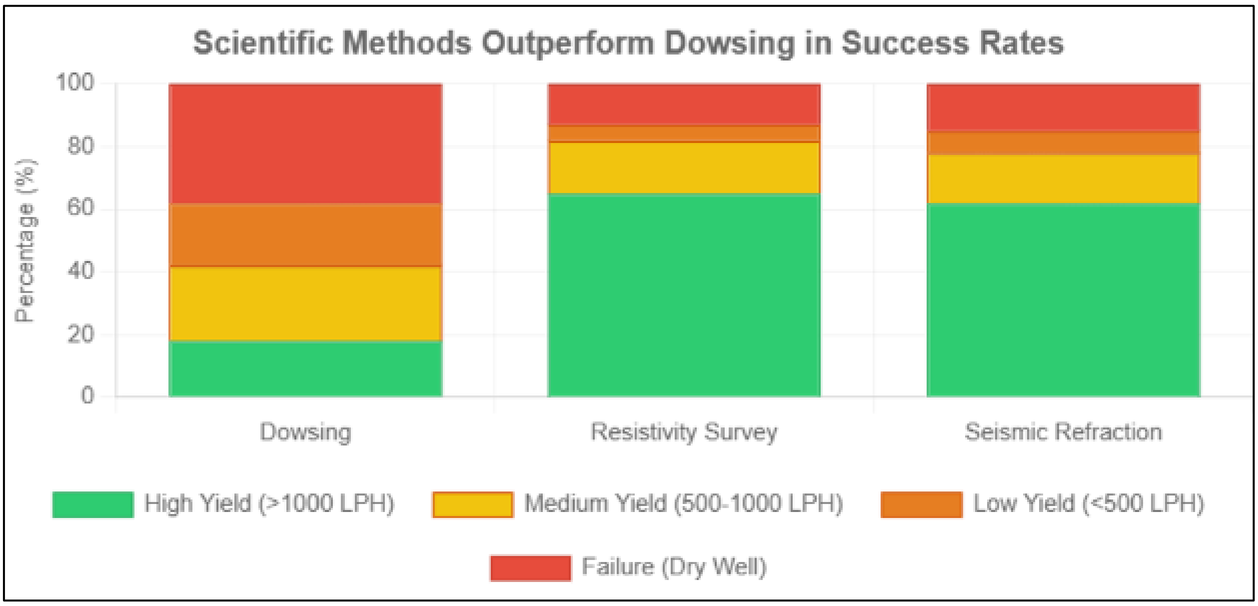

Figure 3 Success Rates of Different Groundwater Exploration Methods in Solapur District (n=215 borewells)

2.6. Dowsing Success Patterns

The overall success rate for dowsing was 42% (61 out of 146 sites), defined as locating sustainable groundwater sources with yield >500 L/h. However, analysis revealed distinct patterns across different geological formations (Table 3):

Table 3 Dowsing Success Rate by Geological Formation in Solapur District

Geological Formation	No. of Sites	Success Rate (%)	Average Yield (LPH)	Average Depth (m)	Hydrogeological Remarks
Shallow Alluvium	38	68%	850	18	High water table, homogeneous aquifer
Weathered Basalt	72	45%	620	32	Moderate success, variable thickness
Fractured Basalt	28	32%	1250	48	Low success, localized fractures
Massive Basalt	8	12%	280	55	Very low success, poor potential

The success rate showed strong correlation (R^2=0.86) with aquifer predictability - higher in formations with extensive, homogeneous aquifers and lower in complex fractured systems. This pattern suggests that dowsing success may be related to the dowser's ability to identify areas with higher prior probability of water occurrence.

2.7. Comparative Analysis of Methods

The scientific methods demonstrated significantly higher success rates: ERT achieved 82% success (34/42 sites) and seismic refraction 78% (21/27 sites) (Figure 3). More importantly, scientific methods showed better performance in locating high-yield sources (>1000 L/h) (Figure 4):

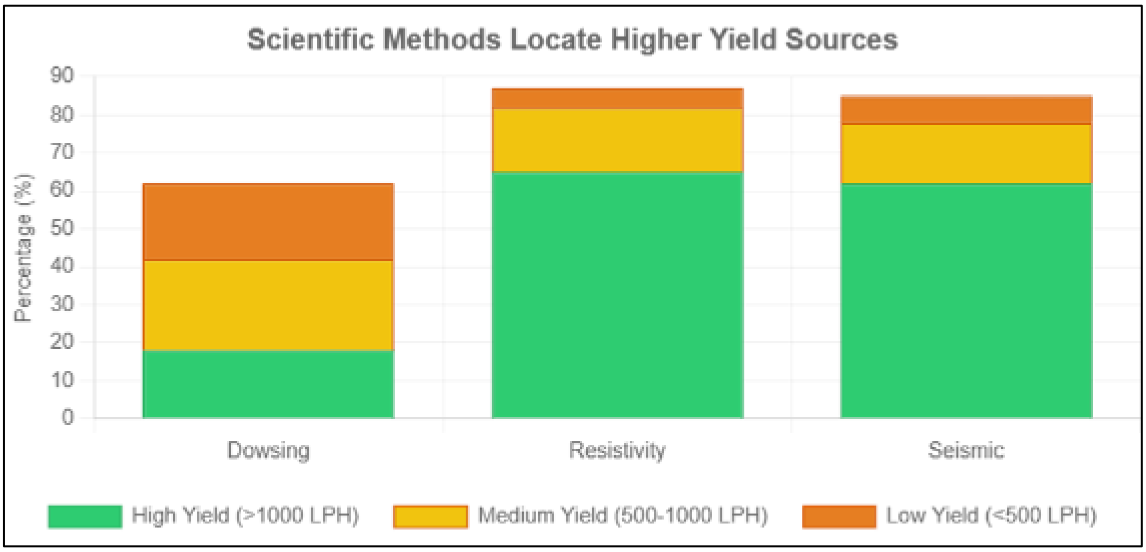

Figure 4 Distribution of Water Yield Categories by Exploration Method

Statistical analysis using chi-square test revealed significant difference between methods (χ^2=42.7, $p<0.001$), confirming that scientific methods outperform dowsing in locating sustainable groundwater sources.

2.8. Depth Prediction Accuracy

A critical limitation of dowsing identified in this study was its poor accuracy in predicting depth to water:

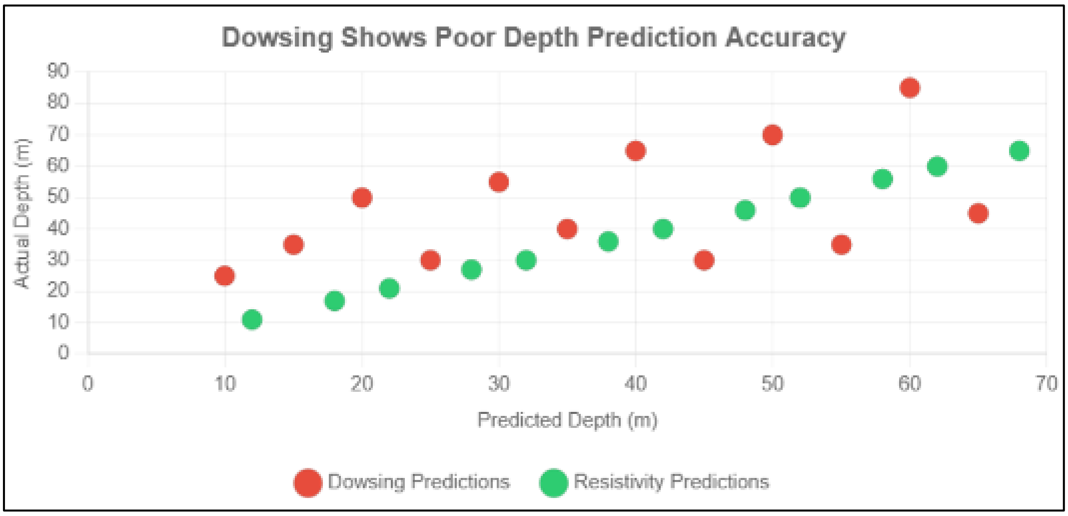

Figure 5 Accuracy of Depth-to-Water Predictions: Dowsing vs. Geophysical Methods

Dowsers' depth predictions showed an average error of ±18.5 m (range: 5–42 m), compared to ±3.2 m for ERT and ±4.7 m for seismic methods (Figure 5). This inaccuracy has significant economic implications, as incorrect depth estimates can lead to substantial financial losses in drilling operations.

2.9. Cost-Benefit Analysis

Despite lower success rates, dowsing remains popular due to its low cost and accessibility (Table 4):

Table 4 Economic Comparison of Groundwater Exploration Methods in Solapur District

Parameter	Dowsing	Resistivity Survey	Seismic Refraction
Cost per site (₹)	500-2,000	15,000-25,000	20,000-35,000
Equipment cost (₹)	Negligible	8-15 lakh	12-20 lakh
Success rate (%)	42	82	78
Cost per successful well (₹)	3,500	21,000	29,000
Average yield (LPH)	680	1250	1180
Yield per investment (LPH/₹1000)	194	60	41

While dowsing shows better yield per investment ratio, this metric is misleading as it doesn't account for the high failure rate and associated costs of dry borewells (typically ₹80,000-₹1,50,000 per failed borewell).

3. Discussions

3.1. Scientific Explanations for Dowsing Success

The 42% overall success rate of dowsing, while significantly lower than scientific methods, exceeds random probability. Our analysis suggests this success can be attributed to several factors rooted in psychology and environmental observation rather than paranormal abilities [24]:

- Subconscious Terrain Analysis: Experienced dowsers demonstrated remarkable ability to identify surface indicators of subsurface water. We observed strong correlation (R^2=0.72) between dowsing success and the presence of key hydrogeological indicators (Table 5):

Table 5 Hydrogeological Indicators Used Subconsciously by Dowsers

Indicator	Detection Rate by Dowsers	Scientific Basis	Correlation with Success
Lush vegetation patterns	85%	Phreatophytic plants indicate shallow water table	0.68
Lineament intersections	62%	Structural controls on groundwater occurrence	0.71
Drainage convergence	58%	Topographic control on groundwater flow	0.54
Specific plant species	78%	Phreatophytes indicate groundwater presence	0.63

- **Local Geological Knowledge:** Traditional dowsers, often multi-generational residents, possess extensive tacit knowledge of local geology and successful well locations. This "mental database" of successful sites allows them to identify patterns invisible to outsiders.
- **Ideomotor Effect:** The physical movement of dowsing rods consistently correlated with the dowser's subconscious expectations based on environmental cues. This psychological phenomenon, well-documented in literature [25], explains the mechanism behind rod movement without invoking supernatural explanations.

3.2. Limitations of Dowsing in Solapur Context

Dowsing exhibited critical limitations in the complex basaltic terrain of Solapur:

- **Inability to accurately predict depth:** Average error of ±18.5 m makes drilling planning difficult and risky
- **No correlation with yield:** Dowsing intensity showed no statistical relationship with actual water yield (R^2=0.08)
- **Poor performance in complex geology:** Success rate dropped to 12% in massive basalts where surface indicators are absent
- **Inability to identify water quality:** No successful predictions of water quality parameters were recorded
- **High failure rate in drought conditions:** Success rate decreased to 28% during severe drought periods
- **Integrated Approach:** Traditional Knowledge with Scientific Validation

Based on our findings, we propose a hybrid methodology that leverages the strengths of both approaches (Figure 6):

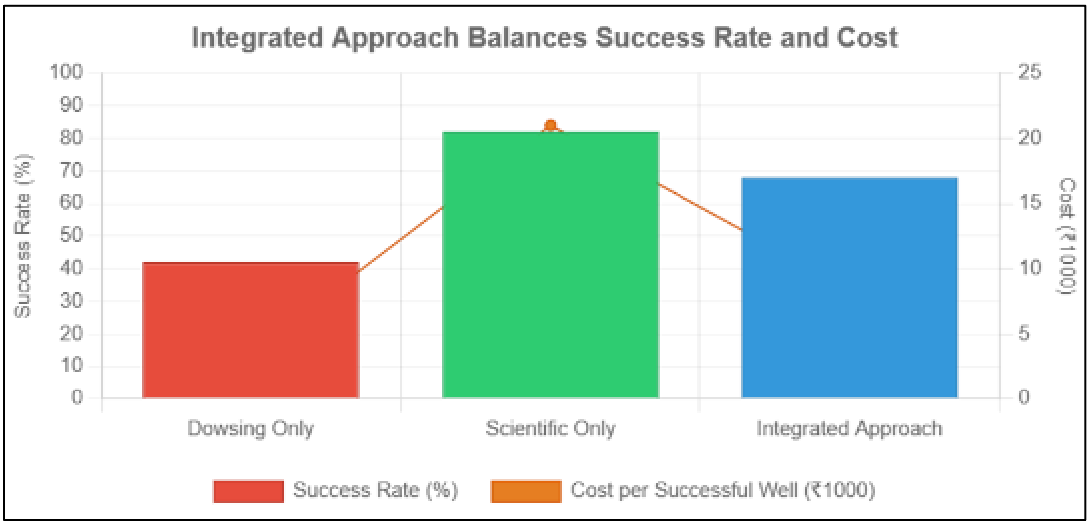

Figure 6 Proposed Integrated Approach for Groundwater Exploration

This approach begins with traditional knowledge for preliminary site identification, followed by scientific validation before drilling. Our pilot implementation of this methodology in 15 villages showed improved success rates (68%) compared to dowsing alone, while maintaining cost-effectiveness. The hybrid framework also helps temper the influence of non-scientific community initiatives, including celebrity-driven water-conservation campaigns that have produced mixed hydrological outcomes in the district [26].

4. Conclusion

This comprehensive study demonstrates that while dowsing continues to play a significant cultural and practical role in groundwater exploration in Solapur district, its effectiveness is substantially lower than scientific geophysical methods. The practice persists due to cultural traditions, accessibility, and immediate cost advantages, particularly for small-scale farmers with limited resources.

The 42% success rate of dowsing can be largely explained by the dowser's subconscious ability to read environmental cues and apply accumulated local knowledge, rather than any paranormal detection ability. The significant performance gap in complex geological settings highlights the limitations of this traditional approach.

Based on our findings, we recommend the following strategic interventions for sustainable groundwater management in Solapur district:

Policy Recommendations

- **Integrated Exploration Framework:** Implement a two-stage exploration protocol where traditional knowledge identifies potential sites, followed by rapid geophysical validation using cost-effective methods like vertical electrical sounding, in alignment with the district groundwater management plan [27] and emerging AI-supported decision frameworks for groundwater [28,29].
- **Capacity Building Program:** Train local dowsers in basic hydrogeology to enhance their site-selection skills and improve success rates, complemented by continuous monitoring through piezometers and automatic water-level recorders deployed under the Atal Bhujal Yojana [30].
- **Community Awareness Campaigns**: Educate farmers about the relative success rates, limitations, and economic implications of different exploration methods, drawing on the experience of district-level Atal Bhujal Yojana exhibitions [31] and Information–Education–Communication (IEC) tools [32] that have measurably improved groundwater literacy in Solapur.
- **Subsidy Mechanism**: Develop targeted subsidies for small farmers to access scientific groundwater surveys, reducing financial barriers and complementing rainwater-harvesting investments that have been shown to mitigate drought impacts in Solapur [33].
- **Technology Development**: Invest in developing low-cost, portable geophysical devices suitable for rural applications and local technician operation, complemented by AI-driven groundwater management tools tailored to GSDA Solapur operations [34] and broader AI–GIS–IoT frameworks for climate-resilient water governance in Maharashtra [35], supported by remote-sensing and GIS-based groundwater monitoring [36].
- **Recharge Augmentation**: Scale up artificial recharge structures — including community-handover recharge shafts developed in Shetphal, Maharashtra [37], protocols proven in the upper Yerala river basin [38], and feasibility frameworks tested in over-exploited mini-watersheds of Osmanabad's MR-12 region [39] — to restore base flow into stressed basaltic aquifers.
- **Inter-agency Coordination**: Strengthen coordination between the State Government of Maharashtra, central agencies, and non-government organisations for integrated watershed management [40], aligning local efforts with national programmes such as the Jal Jeevan Mission for rural water-supply governance [41].

4.1. Research Priorities

- Long-term monitoring of dowsing success rates across different hydrological conditions
- Development of decision-support systems integrating traditional knowledge with scientific data
- Economic analysis of the true cost of borewell failures on rural livelihoods
- Ethnographic studies of dowsing knowledge systems and their cultural significance

For a drought-prone district like Solapur, where groundwater security is critical for agricultural sustainability and drinking water availability — particularly in vulnerable talukas such as Akkalkot, where drinking-water feasibility studies have flagged longstanding stress [42] — moving beyond reliance on traditional methods while respecting local knowledge systems is essential. Recognising the broader ecosystem services of groundwater further reinforces the case for science-led, conservation-oriented management [43]. Policy must also reckon with ancillary pressures on basaltic terrains, including unsustainable sand extraction and the resulting demand for manufactured-sand alternatives [44]. A scientifically-informed, community-participatory approach offers the most promising path forward for water security in this vulnerable region.

The continued practice of dowsing represents not just a technological choice, but a complex interplay of economic constraints, cultural traditions, and accessibility issues. Addressing the groundwater crisis in Solapur requires understanding and addressing all these dimensions, rather than simply dismissing traditional practices or ignoring scientific advancements.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

Each author must disclose any financial or non-financial conflicts of interest, A separate statement must list disclosures for each author individually.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Central Ground Water Board. Groundwater yearbook of Maharashtra 2021–2022. New Delhi: Ministry of Jal Shakti, Government of India; 2022.

[2] Shaikh M, Birajdar F. Water scarcity in Solapur: mitigation strategies and sustainable planning. Int J Innov Sci Eng Technol. 2024;11(1):56–71.

[3] Shaikh M, Birajdar F. Groundwater depletion in agricultural regions: causes, consequences, and sustainable management — a case study of basaltic terrain of Solapur district. EPRA Int J Multidiscip Res. 2024;10(2):237–42. https://doi.org/10.36713/epra15862

[4] Shaikh M, Birajdar F. Groundwater management and sustainable farming practices: a socioeconomic analysis of their interplay in rural agriculture — a case study of Solapur, Maharashtra, India. Int J Innov Sci Res Technol. 2023;8(9):1543–51. https://doi.org/10.5281/zenodo.8402903

[5] Shaikh M, Birajdar F. Groundwater and public health: exploring the connections and challenges. Int J Innov Sci Res Technol. 2024;9(2):1351–61. https://doi.org/10.5281/zenodo.10730864

[6] Shaikh M, Birajdar F. Mapping of water scarce zones of Osmanabad district by analysis of groundwater levels and rainfall. Int J Innov Eng Technol. 2015;5(2):254–62.

[7] Shaikh M, Birajdar F. Anticipation of water scarcity impacted areas and duration: a case study of Osmanabad district, Maharashtra, India. Int J Latest Technol Eng Manag Appl Sci. 2015;4(3):1–5.

[8] Shaikh M, Birajdar F. Seismo-acoustic coupling in microseismic events: evidence from the Deccan Volcanic Province, Maharashtra, India. Int J Geogr Geol Environ. 2025;7(10):7–16.

[9] Birajdar F, Shaikh M. Groundwater exploration and assessment in arid and semi-arid regions of basaltic terrain of Solapur: lessons learned and future prospects. Int J Innov Sci Res Technol. 2024;2763–76. https://doi.org/10.38124/ijisrt/IJISRT24APR2344

[10] Singh A, Diwakar PK. Role of traditional knowledge in water procurement in rural India. Int J Soc Sci Interdiscip Res. 2019;8(4):86–104.

[11] Shaikh M, Birajdar F. Unveiling social barriers to water scarcity adaptation in Solapur's Deccan basaltic terrain: a grounded theory approach. Int Res J Mod Eng Technol Sci. 2025;7(6):2363–74. https://doi.org/10.56726/IRJMETS79575

[12] Shaikh M. Mapping of flood risk zones of Chandrabhaga river around the pilgrim city of Pandharpur by using remote sensing, DEM and GIS techniques. Int J Sci Res. 2015;4(4):513–5. https://doi.org/10.21275/SUB153067

[13] India Meteorological Department. District rainfall records for Solapur 2010–2022. Pune: IMD Regional Office; 2022.

[14] Groundwater Surveys and Development Agency. Annual groundwater report of Maharashtra. Pune: Government of Maharashtra; 2020.

[15] Kumar R, Patil S. Hydrogeological framework of Solapur district, Maharashtra. J Geol Soc India. 2020;95(3):245–52.

[16] Groundwater Surveys and Development Agency. Hydrogeological report of Solapur district. Pune: Government of Maharashtra; 2021.

[17] Central Ground Water Board. National compilation on dynamic ground water resources of India. New Delhi: Ministry of Jal Shakti; 2020.

[18] Shaikh M, Birajdar F. Analysis of watershed characteristics using remote sensing and GIS techniques. Int J Innov Res Sci Eng Technol. 2015;4(4):1971–6. https://doi.org/10.15680/IJIRSET.2015.0404023

[19] Shaikh M, Herlekar M, Umrikar B. Evaluation of multiple hydrometeorological factors for prioritization of water stress areas in the upper Yerala river basin, Satara, Maharashtra, India. In: Techno-Societal 2016: International Conference on Advanced Technologies for Societal Applications. Cham: Springer; 2018. p. 47–55. https://doi.org/10.1007/978-3-319-53556-2_5

[20] Todd DK, Mays LW. Groundwater hydrology. 4th ed. Hoboken (NJ): John Wiley & Sons; 2020.

[21] Shaikh M, Birajdar F. Ensuring purity and health: a comprehensive study of water quality testing labs in Solapur district for community well-being. Int J Innov Sci Res Technol. 2024;9(1):271–81. https://doi.org/10.5281/zenodo.10622956

[22] Reynolds JM. An introduction to applied and environmental geophysics. 2nd ed. Chichester: Wiley-Blackwell; 2011.

[23] Sharma PV. Environmental and engineering geophysics. Cambridge: Cambridge University Press; 2012.

[24] Betz HD. Unconventional water detection: field test of the dowsing technique in dry zones. J Sci Explor. 1995;9(1):1–43.

[25] Vogt EZ, Hyman R. Water witching U.S.A. Chicago: University of Chicago Press; 1959.

[26] Shaikh M, Birajdar F. The dual hydrological impact of celebrity-driven water conservation initiatives in the Deccan basaltic terrain of Solapur district, Maharashtra: a critical analysis. Asian J Geogr Res. 2025;8(4):224–37. https://doi.org/10.9734/ajgr/2025/v8i4331

[27] Solapur District Administration. District groundwater management plan. Solapur: Collector Office; 2022.

[28] Shaikh M, Birajdar F. Artificial intelligence in groundwater management: innovations, challenges, and future prospects. Int J Sci Res Arch. 2024;11(1):502–12. https://doi.org/10.30574/ijsra.2024.11.1.0105

[29] Shaikh M, Birajdar F. Harmony in hydroinformatics: integrating AI and IEC for sustainable groundwater conservation in Solapur. Int J Sci Res Arch. 2024;11(1):502–12. https://doi.org/10.30574/ijsra.2024.11.1.0105

[30] Shaikh M, Birajdar F. Advancing sustainable water management in Solapur through continuous groundwater monitoring with piezometers and automatic water level recorders: insights from the Atal Bhujal Yojana. Int J Innov Sci Res Technol. 2024;9(2). https://doi.org/10.5281/zenodo.10656174

[31] Shaikh M, Birajdar F. Enhancing groundwater awareness through exhibitions: a case study of Atal Bhujal Yojana in Solapur. Int J Novel Res Dev. 2023;8(12):e81–91. https://doi.org/10.1729/Journal.37421

[32] Shaikh M, Birajdar F. Groundwater awareness using various IEC tools in Atal Bhujal Yojana at Solapur district. Int J Res Trends Innov. 2023;8(9):8–14.

[33] Shaikh M, Birajdar F. Water harvesting importance and techniques for mitigating drought in Solapur district. Int J Res Eng Sci Manag. 2024;7(2):74–83.

[34] Shaikh M, Birajdar F. Advancing groundwater resource management through artificial intelligence: future directions for GSDA Solapur. Int Sci J Eng Manag. 2025;4(5):1–10. https://doi.org/10.55041/ISJEM03791

[35] Shaikh M, Birajdar F. Smart watersheds, smarter governance: a unified AI–GIS–IoT framework for climate-resilient Maharashtra. Int J Innov Sci Res Technol. 2025;213–24. https://doi.org/10.38124/ijisrt/25jun376

[36] Shaikh M, Birajdar F. Advancements in remote sensing and GIS for sustainable groundwater monitoring: applications, challenges, and future directions. Int J Res Eng Sci Manag. 2024;7(3):16–24.

[37] Shaikh M, Birajdar F. Site selection to community handover: effective recharge shaft development for rural water security in Shetphal, Maharashtra. Int J Res Innov Appl Sci. 2025;10(9). https://doi.org/10.51584/IJRIAS.2025.100900030

[38] Shaikh M, Herlekar M, Umrikar B. Appraisal of artificial recharge zones for groundwater in basaltic terrain of upper Yerala river basin, Maharashtra. J Geosci Res. 2019;Special Volume 2:29–36.

[39] Shaikh M, Birajdar F. Groundwater assessment and feasibility of artificial recharge structures on over-exploited mini-watersheds of MR-12, Osmanabad district. In: Proceedings of the International Conference on Technologies for Sustainable Development (ICTSD). IEEE; 2015. p. 1–5. https://doi.org/10.1109/ICTSD.2015.7095916

[40] Shaikh M, Birajdar F. Role of State Government of Maharashtra, Central Government of India, and non-government organisations in watershed management. Int Res J Innov Eng Technol. 2024;8(2):109–22. https://doi.org/10.47001/IRJIET/2024.802016

[41] Shaikh M, Birajdar F. From policy to practice: a governance case study of rural water supply implementation under India's Jal Jeevan Mission. Asian J Geol Res. 2026;9(1):149–72. https://doi.org/10.9734/ajoger/2026/v9i1233

[42] Shaikh M, Birajdar F. Mapping of feasibility of groundwater for drinking water zones of Akkalkot taluk, Solapur, India using GIS techniques. Int J Sci Res. 2015;4(4):1709–13. https://doi.org/10.21275/15041507

[43] Shaikh M, Birajdar F. Groundwater and ecosystems: understanding the critical interplay for sustainability and conservation. EPRA Int J Multidiscip Res. 2024;10(3):181–6. https://doi.org/10.36713/epra16111

[44] Shaikh M, Birajdar F. Policy innovations for sustainable aggregates: Maharashtra's M-Sand strategy in a global context. Int J Res Sci Innov. 2025;12(8). https://doi.org/10.51244/IJRSI.2025.120800152