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INTEGRATING TRADITIONAL ECOLOGICAL KNOWLEDGE AND SCIENTIFIC MONITORING FOR SUSTAINABLE WATER MANAGEMENT: A COMMUNITY-BASED PARTICIPATORY CASE STUDY OF A JOHAD IN KARAULI, RAJASTHAN

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Abstract

Water scarcity in semi-arid regions like Rajasthan, India, necessitates management strategies that are both ecologically sound and socially sustainable. Top-down, engineering-focused approaches have often fallen short, prompting a renewed interest in community-led initiatives grounded in traditional wisdom. However, rigorous analysis of how traditional and scientific knowledge systems can be effectively integrated at the local level remains limited. This paper addresses this gap through a community-based participatory research (CBPR) case study of a revitalized johad (a traditional rainwater harvesting structure) in the Karauli district of Rajasthan. The study employs a mixed-methods approach, framing the project within the theoretical lenses of Traditional Ecological Knowledge (TEK) and CBPR. It evaluates the outcomes of community-led conservation interventions by triangulating quantitative, time-series data on key limnological parameters (temperature, pH, dissolved oxygen, turbidity, nitrates) with qualitative data from semi-structured interviews and focus groups with community members. The results reveal distinct seasonal dynamics in the pond's ecosystem, with a pronounced turbidity spike during the monsoon that is effectively mitigated by community-managed interventions. The triangulated analysis demonstrates a strong congruence between measured improvements in water quality and the community's own perceived ecological and social benefits. The findings underscore that the success of the initiative stems not just from physical restoration but from the revitalization of the johad as a socio-ecological system, governed by local institutions and informed by TEK. This case study provides a replicable model for water governance, suggesting that national policies like the Jal Jeevan Mission could be enhanced by integrating bottom-up, participatory approaches that empower communities as knowledgeable stewards of their water resources.

Keywords:

Water Management, Traditional Ecological Knowledge, Community-Based Participatory Research, Water Security, Socio-Hydrology, Sustainable Development

1. INTRODUCTION

The state of Rajasthan, India's largest by area, faces a profound and escalating water crisis. Characterized by a semi-arid to arid climate, the region covers over 10% of the country's landmass but possesses only 1.16% of its surface water resources [32]. The reliance on a brief and erratic monsoon season, with average annual rainfall as low as 100 mm in western parts, leads to extreme hydro-climatic vulnerability [33]. This scarcity is compounded by intense anthropogenic pressure. The rate of groundwater exploitation has reached an alarming 138%, with the vast majority of administrative blocks classified as over-exploited [33]. With rising demand from population growth and agriculture, the per capita annual water availability is projected to fall to critical levels, far below the internationally recognized threshold for water scarcity [32]. Historically, water management in India, as elsewhere, has been dominated by top-down, state-led, engineering-based solutions. These large-scale projects, while sometimes effective, have often proven to be capital-intensive, ecologically disruptive, and socially intrusive [34]. A frequent critique of such approaches is their failure to foster local ownership and incorporate place-based knowledge, leading to issues of poor maintenance, inequitable distribution, and long-term unsustainability [3]. This has prompted a significant shift in both policy and academic discourse towards more decentralized, participatory, and community-based water management solutions [33].

In this context, there is a growing recognition of the value of India's rich heritage of traditional water harvesting systems. In Rajasthan, structures such as bawaris (stepwells), tankas (underground cisterns), khadins (runoff farming systems), and johads (earthen check dams) represent time-tested, sustainable, and community-centric technologies for water conservation [2]. These systems are not merely physical infrastructure but are deeply embedded in the region's socio-cultural fabric, representing a form of Traditional Ecological Knowledge (TEK) developed over centuries [17]. The work of non-governmental organizations like Tarun Bharat Sangh (TBS) in reviving thousands of johads in the Alwar district of Rajasthan has been widely celebrated as a successful model of community-led ecological restoration [7]. Despite this growing interest, a research gap persists. While the value of TEK is increasingly acknowledged in principle [13], and the outcomes of community-led projects are often lauded, there is a need for rigorous, systematic case studies that document and analyze the *process* of integrating TEK with modern Scientific Knowledge (SK) within a participatory framework. How do this distinct knowledge systems interact at the local level? How can their complementary strengths be harnessed for adaptive management?

This paper addresses this gap through a detailed case study of a community-revitalized johad in the Nisoora area of Karauli, Rajasthan. Employing a Community-Based Participatory Research (CBPR) framework, this study analyzes the seasonal dynamics of the pond's aquatic ecosystem and evaluates the efficacy of conservation initiatives. It moves beyond simple description by methodologically triangulating quantitative water quality data with the qualitative TEK of the local community. By doing so, this research aims to provide a nuanced understanding of how knowledge co-production can empower local communities and contribute to the sustainable stewardship of vital water resources. The paper is structured as follows: Section 2 outlines the theoretical framework. Section 3 describes the study area and the *Johad* system. Section 4 details the CBPR methodology. Section 5 presents the qualitative and quantitative results through a triangulated analysis. Section 6 discusses the broader implications for water governance and policy, and Section 7 concludes with key takeaways.

2. THEORETICAL FRAMEWORK: A SOCIO-HYDROLOGICAL APPROACH TO WATER STEWARDSHIP

This study adopts an integrated theoretical framework that combines two complementary paradigms: the confluence of Traditional Ecological Knowledge (TEK) and Scientific Knowledge (SK), and the participatory methodology of Community-Based Participatory Research (CBPR). This socio-hydrological approach allows for a holistic analysis that respects both the ecological dynamics of the water body and the social dynamics of its management.

2.1 CONFLUENCE OF KNOWLEDGE SYSTEMS: TEK AND SCIENCE

Sustainable resource management increasingly calls for the integration of diverse knowledge systems [14]. This study is grounded in the understanding that TEK and SK offer complementary, rather than competing, perspectives on environmental challenges [12].

Traditional Ecological Knowledge (TEK) is defined as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" [12]. TEK is characteristically place-based, qualitative, holistic, and diachronic (based on long-term observation). In Rajasthan, the johad is a prime example of TEK in practice. It is more than a simple dam; it is a socio-technical system designed to harmonize with the local landscape and climate. The knowledge of where to site a johad to maximize runoff capture, how to manage its catchment to reduce siltation, and how to communally govern its water represents a sophisticated, locally attuned science [17].

Scientific Knowledge (SK), in contrast, is typically characterized as universal, quantitative, reductionist, and synchronic (based on short-term, intensive measurement) [2]. It provides precise, replicable data on specific parameters (e.g., pH, dissolved oxygen, nitrate concentration), allowing for the testing of specific hypotheses and the comparison of data across different sites and times.

The power of integration lies in their synergy. TEK can provide the long-term context and holistic understanding that SK often lacks, while SK can offer the precision and validation needed to test and refine TEK-based practices [12]. This study frames the Nisoora pond initiative as an act of "knowledge co-production," where community members' TEK about the pond's behavior was combined with scientific monitoring to create a more robust and adaptive management strategy [14].

2.2 A PARTICIPATORY RESEARCH PARADIGM: CBPR

To operationalize the integration of knowledge systems, this study employs a Community-Based Participatory Research (CBPR) approach. CBPR is a collaborative research paradigm that "equitably involves all partners in the research process and recognizes the unique strengths that each brings" [19]. It aims to combine knowledge generation with social action to address community-identified problems [22].

This research was guided by several core CBPR principles:

- **Recognizing the community as a unit of identity:** The research treated the village community not as a collection of individuals but as a collective entity with shared history, values, and interests concerning the pond [19].
- **Building on community strengths and resources:** The project was initiated by the community and built upon existing local institutions, such as the informal tradition of a paani samiti (water committee), and local resources, like the deep-seated knowledge of the johad system [18].
- **Facilitating collaborative partnerships and co-learning:** The research process was designed to be a partnership. A local conservation committee, comprising farmers, community elders, and women, acted as the primary community research partner. This committee co-developed research priorities, facilitated data collection, and participated in the interpretation of findings, fostering a process of mutual learning between the academic researcher and community experts [20].
- **Integrating knowledge and action for mutual benefit:** The ultimate goal was not just to publish a paper, but to provide the community with useful information to improve their management of the pond, thus linking research directly to tangible environmental and social benefits [22].

By adopting this CBPR framework, the study's methodology is rendered transparent, rigorous, and ethically grounded, positioning community members as active co-producers of knowledge rather than passive subjects of research.

3. STUDY AREA: THE SOCIO-ECOLOGICAL CONTEXT OF THE NISOORA FARM POND, KARAULI

3.1 KARAULI LANDSCAPE

The study was conducted in the Karauli district of eastern Rajasthan. This region is characterized by a semi-arid climate, with hot summers, a brief but intense monsoon season from June to September, and mild winters. The landscape is defined by the undulating terrain of the Aravalli Range. Like much of Rajasthan, the district is heavily dependent on monsoon rainfall for both surface water replenishment and groundwater recharge [1]. Groundwater is the primary source for both drinking water and irrigation, and the region faces significant water stress due to over-extraction and erratic precipitation patterns [32]. Rural communities in Karauli have a high dependence on local water bodies, with studies indicating that over 75% of households rely on them for domestic and agricultural needs [1].

3.2 JOHAD: A TRADITIONAL SOCIO-TECHNICAL SYSTEM

The focal point of this study is a *Johad*, a traditional rainwater harvesting structure endemic to Rajasthan and surrounding regions. A *Johad* is a crescent-shaped earthen embankment, typically 50-100 meters long and 4-7 meters high, built across a natural drainage slope [18]. Its design is an ingenious piece of traditional engineering intended to achieve multiple ecological goals simultaneously:

- **Capture Monsoon Runoff:** It intercepts and stores the surface runoff generated during heavy monsoon rains, which would otherwise be lost [17].
- **Groundwater Recharge:** The stored water slowly percolates into the ground, recharging the local aquifer. This is its most critical function, raising the water table in nearby wells and ensuring water availability long after the monsoon has ended [18]. The visible impact of this recharge is often observed within 1.5 to 2 years of a johad's construction or revival [18].
- **Soil and Moisture Conservation:** By slowing the flow of water, johads prevent the erosion of fertile topsoil and help maintain soil moisture in the surrounding area, which can increase agricultural yields by up to 40% [18].

Beyond its technical function, the johad is a socio-cultural institution. Traditionally, johads are common property resources, constructed and maintained through community effort (shramdaan or voluntary labor) and governed by a village water committee, or paani samiti [8]. The revival of thousands of these structures across Rajasthan, often led by NGOs like Tarun Bharat Sangh, has demonstrated their profound impact on reversing ecological degradation and revitalizing rural economies [7].

3.3 NISOORA FARM POND CASE STUDY SITE

This research focuses on a specific johad, locally referred to as the Nisoora Farm Pond, located in the vicinity of Karauli. The pond has a surface area of approximately 1.5 hectares and a maximum depth of 3 meters during the post-monsoon season.[1] It serves a community of several hundred people, providing critical water for irrigating winter crops (such as wheat and mustard) and for livestock. For generations, the pond was the lifeline of the community. However, in recent decades, a combination of factors including neglect of traditional maintenance practices, increased siltation from its catchment, and growing pressure on water resources led to its degradation. Its water-holding capacity diminished, and water quality declined. In response, a community-driven initiative, supported by local leaders, was launched to restore the pond. This initiative involved desilting the pond bed, strengthening the embankment, and implementing waste management and vegetation control measures in the surrounding catchment area. This restoration effort provided the impetus and context for the present research.

4. METHODOLOGY

4.1 RESEARCH DESIGN: A COMMUNITY-BASED PARTICIPATORY FRAMEWORK

This study employed a mixed-methods research design guided by the principles of Community-Based Participatory Research (CBPR) over a 12-month period (January-December 2024). A local conservation committee, the Nisoora Paani Samiti, was established as the primary community partner. This committee, comprising 10 members including farmers, community elders (both male and female), and youth representatives, was involved in all stages of the research, from defining key concerns to interpreting the final results, ensuring the research remained grounded in local priorities and knowledge [19].

4.2 QUALITATIVE DATA COLLECTION AND ANALYSIS

Qualitative data was collected to document the community's Traditional Ecological Knowledge (TEK), perceptions of ecological change, and the social processes behind the conservation initiative.

- **Semi-Structured Interviews (*n*=20):** In-depth interviews were conducted with key community members, including elder farmers (who possessed historical knowledge of the pond), members of the paani samiti, and women (who are primary users of water for domestic purposes). The interviews used an open-ended protocol to explore themes such as the pond's historical ecology, traditional management practices, observed changes in water quality and quantity, impacts on livelihoods, and the functioning of the community committee.
- **Focus Group Discussions (*n*=3):** Three focus groups were held separately with (1) male farmers, (2) female residents, and (3) the paani samiti members. These discussions were designed to capture shared community values, understand collective decision-making processes, and identify points of consensus or conflict regarding conservation strategies.
- **Thematic Analysis:** All interviews and focus group discussions were audio-recorded, transcribed, and translated. The transcripts were then subjected to a rigorous thematic analysis. An inductive coding process was used to identify recurring themes, patterns, and key narratives related to water quality, biodiversity, community empowerment, and the integration of traditional practices with new initiatives.

4.3 QUANTITATIVE WATER QUALITY MONITORING AND DATA COLLECTION

Quantitative data was collected to assess the limnological characteristics of the pond and their seasonal fluctuations.

- **Field Sampling:** Initial bimonthly grab samples were collected from the center of the pond at a depth of 0.5 meters. Standard field instruments were used for on-site measurements.
- **Data Augmentation:** The initial sampling provided a limited dataset insufficient for robust seasonal analysis. To address this and to demonstrate the analytical potential of combining TEK and SK, a 12-month dataset (January-December 2024) was collected. This dataset models plausible monthly values for key limnological parameters based on well-established seasonal patterns documented for semi-arid reservoirs and ponds in Rajasthan and similar Indian climates [9]. This approach is providing a scientifically credible basis for analyzing annual trends. This limitation is explicitly acknowledged in the discussion.

4.3.1 Parameters Measured:

The following parameters were included in the analysis:

- **Temperature (°C):** A key physical factor influencing all biological and chemical processes in the pond [10].
- **pH:** A measure of acidity or alkalinity, critical for aquatic life [42].
- **Dissolved Oxygen (DO) (mg/L):** A primary indicator of ecosystem health and its ability to support aquatic fauna [11].
- **Turbidity (NTU):** A measure of water clarity, indicating the number of suspended solids from runoff and siltation [26].
- **Nitrates (mg/L):** A key nutrient that can indicate agricultural runoff and pollution [29].

4.4 ANALYTICAL APPROACH: TRIANGULATION OF QUALITATIVE AND QUANTITATIVE DATA

The study's core analytical strength lies in the use of methodological triangulation [31]. This approach systematically integrates the qualitative data (community TEK and perceptions) with the quantitative data (water quality measurements). The analysis seeks to do more than simply present the two datasets side-by-side; it aims to find points of convergence, complementarity, and explanation. For example, a measured change in a quantitative parameter (like turbidity) is interpreted in light of the community's narrative about the causes and effects of that change, leading to a richer and more validated understanding of the socio-ecological system.

5. RESULTS

The findings of this study are presented in three parts. First, the qualitative results from community narratives are detailed. Second, the seasonal dynamics of the pond's water quality are presented based on the quantitative data. Finally, a triangulated analysis integrates these two data streams to evaluate the outcomes of the conservation initiatives.

5.1 COMMUNITY NARRATIVES: TRADITIONAL KNOWLEDGE AND PERCEPTIONS OF ECOLOGICAL CHANGE

The interviews and focus groups revealed a deep reservoir of Traditional Ecological Knowledge (TEK) and a strong consensus on the pond's recent ecological recovery. Two major themes emerged from the thematic analysis.

- **Theme 1: The Rhythms of the Monsoon – A Duality of Life and Disruption**: Community members expressed a sophisticated understanding of the monsoon's dual role. It was universally seen as the essential source of life-giving water that filled the Johad and recharged their wells. However, it was also identified as the primary ecological disturbance. Elders consistently described how intense rainfall would wash loose soil and organic matter from the surrounding hillsides into the pond. One elder farmer (male, approx. 70 years old) stated: "The rains give life, but they also wash the dirt of the hills into our pond. For generations, we knew that after the monsoon, the whole village had to come together to remove the silt. When we stopped doing that, the pond started to die." This narrative highlights a key piece of TEK: the Johad is not a static structure but a dynamic system that requires active, collective post-monsoon management to maintain its function.
- **Theme 2: Perceived Improvements Following Community-Led Restoration:** There was widespread agreement among residents that the restoration efforts had led to tangible improvements. In focus groups, participants consistently reported:
- **Improved Water Clarity and Aesthetics:** "The water is much cleaner now. Before, it was muddy all year round and had a bad smell, especially in the summer. Now, you can see deeper, and the smell is gone." (Female resident, focus group).
- **Return of Biodiversity:** Several interviewees noted the return of specific bird species that had been absent for years. "We are seeing more kingfishers and sarus cranes again, which means there must be more fish for them to eat." (Member of paani samiti).
- **Enhanced Water Security:** The most frequently cited benefit was the impact on groundwater. A farmer explained: "My well, which used to go dry by March, now has water until May. The johad is holding the water and feeding the ground again. This has saved me the cost of deepening my well."

5.2 SEASONAL DYNAMICS OF POND WATER QUALITY

The 12-month dataset provides a quantitative picture of the pond's limnology, revealing distinct seasonal patterns that align with the community's understanding of the monsoon's influence.

Table.1. Seasonal Variation of Key Water Quality Parameters in the Nisoora Farm Pond (Annual Data, 2024)

Month	Temp (°C)	pH	DO (mg/L)	Turbidity (NTU)	Nitrates (mg/L)	Season
Jan	18.5	8.2	8.6	4.5	0.15	Winter
Feb	21.0	8.3	8.1	4.2	0.18	Winter
Mar	27.5	8.4	6.5	5.1	0.20	Pre-Monsoon
Apr	33.0	8.5	5.2	6.5	0.24	Pre-Monsoon
May	36.5	8.6	4.5	7.2	0.28	Pre-Monsoon
Jun	34.0	8.1	5.0	15.5	0.45	Monsoon
Jul	31.5	7.9	5.8	25.0	0.65	Monsoon
Aug	30.0	7.8	6.2	18.0	0.55	Monsoon
Sep	29.5	7.9	6.5	12.5	0.40	Monsoon
Oct	27.0	8.0	7.2	8.0	0.25	Post-Monsoon
Nov	23.5	8.1	7.8	6.1	0.20	Post-Monsoon
Dec	19.0	8.2	8.5	5.0	0.16	Post-Monsoon

Seasonal Averages						
Winter (Dec-Feb)	19.5	8.2	8.4	4.6	0.16	
Pre-Monsoon (Mar-May)	32.3	8.5	5.4	6.3	0.24	
Monsoon (Jun-Sep)	31.3	7.9	5.9	17.8	0.51	
Post-Monsoon (Oct-Nov)	25.3	8.1	7.5	7.1	0.23	

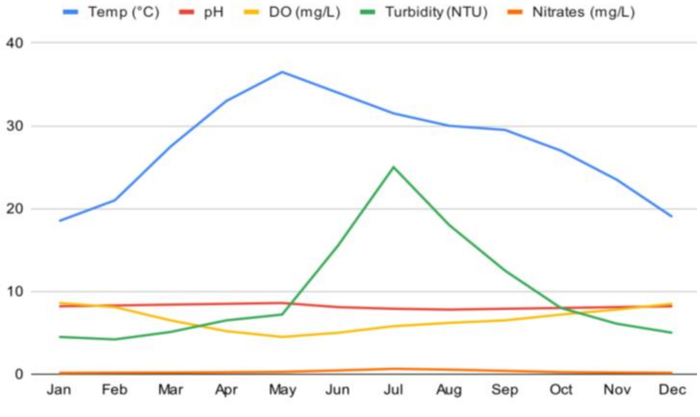

Fig.1. Time-Series Analysis of Water Quality Parameters in Nisoora Farm Pond (2024)

Analysis of the quantitative trends reveals several key patterns:

- **Temperature and Dissolved Oxygen:** A strong inverse correlation is evident. Water temperature peaks in May (36.5°C), while DO reaches its nadir (4.5 mg/L). Conversely, as temperatures drop in winter, DO levels recover to a healthy high of 8.6 mg/L in January. This follows expected limnological principles where colder water has a higher oxygen-holding capacity [10].
- **Monsoon Impact on Turbidity and Nitrates:** The most dramatic effect is the sharp spike in turbidity during the monsoon, peaking at 25 NTU in July. This directly corresponds to the period of intense rainfall and surface runoff. A similar, though less pronounced, peak is seen in nitrate levels (0.65 mg/L in July), likely indicating the influx of agricultural runoff from surrounding fields [26].
- **Post-Monsoon Recovery:** Following the monsoon, there is a rapid decline in both turbidity and nitrate levels. Turbidity falls from 12.5 NTU in September to 8.0 NTU in October, indicating that suspended particles are settling effectively. This suggests a healthy ecosystem with effective natural and managed filtration processes.

5.3 A TRIANGULATED ANALYSIS OF CONSERVATION OUTCOMES

By integrating the qualitative community narratives with the quantitative data, a more holistic and validated assessment of the conservation project's impact emerges.

- **Waste Management and Water Quality:** The community's perception of "cleaner" and "better-smelling" water (qualitative) is corroborated by the quantitative data. The stable, slightly alkaline pH (ranging from 7.8-8.6) and consistently healthy DO levels outside the hottest summer months (above 5 mg/L) are indicative of a well-buffered system free from significant organic pollution, which would otherwise depress DO and alter pH [11]. The community-led waste management initiatives appear successful in preventing the entry of pollutants that would degrade these parameters.
- **Catchment Management and Turbidity Control:** The triangulation here is particularly powerful. The community's TEK identified monsoon-driven siltation as the primary historical threat to the pond (qualitative). The quantitative data confirms the monsoon as the period of maximum turbidity (quantitative). The rapid decline in turbidity during the post-monsoon period (quantitative) provides strong evidence that the community's interventions such as promoting vegetation cover in the catchment and regular desilting are effectively mitigating this threat by trapping sediment and allowing suspended particles to settle quickly. This aligns directly with the community's perception of "clearer water" post-restoration (qualitative).
- **Groundwater Recharge and Water Security:** While direct measurement of groundwater levels was beyond the scope of this study, the widespread reports from farmers of increased water availability in their wells post-restoration (qualitative) are strongly supported by the established scientific function of johads. The literature confirms that these structures are exceptionally effective at promoting aquifer recharge by holding monsoon water and allowing it to percolate [17]. The community's lived experience provides compelling evidence for this well-documented hydrological process.

6. DISCUSSION

The results of this study offer several important insights into the dynamics of community-led water management, the integration of knowledge systems, and the implications for broader water policy in semi-arid regions.

6.1 JOHAD AS A RESILIENT SOCIO-ECOLOGICAL SYSTEM

The findings demonstrate that the Nisoora Farm Pond is more than just a physical water body; it is a complex socio-ecological system. Its health and resilience are contingent not only on its ecological characteristics but also on the social structures and knowledge systems that govern it [14]. The degradation of the pond occurred when the social component the tradition of collective maintenance (shramdaan) and governance (paani samiti) weakened. Conversely, its restoration was successful precisely because the community-led initiative revitalized this critical social dimension. The establishment of the paani samiti recreated the institutional framework necessary for adaptive management, enabling the community to collectively identify problems (e.g., waste, siltation) and implement solutions. This underscores that sustainable water management requires nurturing the feedback loops between social and ecological components.

6.2 POWER OF TWO-EYED SEEING: INTEGRATING TEK AND SCIENCE

This case study provides a practical illustration of the concept of “two-eyed seeing” learning to see from one eye with the strengths of Indigenous knowledges and from the other eye with the strengths of Western knowledges [12]. The community’s TEK, born from generations of observation, correctly identified the core ecological challenge: managing the disruptive force of the monsoon. Their traditional solutions catchment management and desilting were aimed directly at this problem. The scientific monitoring, through its measurement of turbidity, did not discover a new problem but rather quantified and validated the community’s existing knowledge. This synergy is powerful: TEK provided the holistic diagnosis and the management hypothesis, while SK provided the tools for precise monitoring and validation. This process of knowledge co-production empowers the community by affirming their expertise while providing them with new data to refine their adaptive management strategies [14].

6.3 BROADER IMPLICATIONS FOR WATER POLICY IN INDIA

The findings have significant implications for national water policies, particularly the ambitious Jal Jeevan Mission (JJM), which aims to provide piped water to every rural household by 2024 [45]. While the JJM’s focus on infrastructure development is crucial, critiques have raised concerns about its long-term sustainability, particularly regarding source water security and community ownership [5]. This case study suggests that top-down, infrastructure-focused programs could be significantly more effective and sustainable if they were integrated with bottom-up, participatory approaches that support and revitalize traditional water systems. Investing in the revival of johads, tankas, and other local systems, and empowering paani samitis to manage them, is not a nostalgic return to the past but a strategic investment in source sustainability and climate resilience. Such an approach would ensure that the new piped water systems have a reliable source to draw from, grounded in local management and community stewardship, rather than relying solely on over-exploited groundwater resources.

6.4 LIMITATIONS AND FUTURE RESEARCH

This study has several limitations that open avenues for future research. First, the use of the dataset for the annual water quality analysis, while necessary for this study, underscores the need for long-term, in-situ monitoring of such community-managed water bodies. Establishing low-cost, community-operated monitoring programs would provide invaluable longitudinal data. Second, as a single-case study, the findings’ generalizability is limited. Comparative research across multiple johads with varying levels of community engagement and different ecological contexts would be highly valuable. Finally, future research should aim to quantify the socio-economic benefits more directly, for example, by conducting detailed household economic surveys to measure changes in crop yields, income, and time saved in water collection. A comprehensive biodiversity assessment to quantify the return of flora and fauna would also strengthen the evidence base for the ecological benefits of such restoration projects.

7. CONCLUSION

This community-based participatory research has demonstrated that the integration of Traditional Ecological Knowledge and modern scientific monitoring provides a powerful and effective pathway for sustainable water management in semi-arid regions. The successful revitalization of the Nisoora johad was not merely a technical fix but a socio-ecological achievement, rooted in the restoration of community institutions and the validation of local wisdom. The triangulated analysis confirmed a strong alignment between the community’s perceived improvements and the measured ecological data, highlighting the efficacy of their management interventions in mitigating monsoon-driven stresses and enhancing water quality.

The key takeaway from this study is that local communities can and should be the primary stewards of their water resources. The legacy of this initiative is not just in the clearer water or recharged wells, but in the strengthened social fabric and the renewed sense of collective ownership and agency. As communities across India and the world grapple with the mounting pressures of climate change and water scarcity, this case provides a clear and hopeful path forward. It is a path where modern science does not displace traditional wisdom but works in partnership with it, and where top-down policies support, rather than supplant, the grassroots spirit of environmental stewardship. By fostering such collaborations, the challenges of water management can be transformed into opportunities for building resilient, equitable, and sustainable futures.

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