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Review Article

WOMEN AS CUSTODIANS OF INDIGENOUS WATER KNOWLEDGE IN TELANGANA, INDIA: TRADITIONAL PRACTICES, GENDER RELATIONS, AND PATHWAYS TO CLIMATE-RESILIENT WATER CONSERVATION

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Abstract

This review examines women as custodians of indigenous water knowledge in Telangana, India, and evaluates how traditional practices, gender relations, community institutions, and contemporary water policy can be brought together within an integrated knowledge perspective for climate-resilient water conservation. A qualitative evidence-synthesis design was used to analyse 57 secondary sources, including peer-reviewed studies, government and institutional reports, and documented case studies. Feminist political ecology, participatory governance, and traditional ecological knowledge provide the analytical framework. The evidence shows that rural women hold intergenerational knowledge of water harvesting, quality assessment, purification, conservation, and tank stewardship, yet limited land ownership, restrictive social norms, and weak representation constrain their formal decision-making power. Mission Kakatiya has generated documented hydrological and economic gains, including groundwater recovery and improved agricultural and fishery outcomes; however, the absence of gender-disaggregated monitoring limits claims about women-specific programme effects. Case evidence from iJal Small Water Enterprises and women's participation in tank restoration shows how technical training, local knowledge, and institutional participation can reinforce one another. The review argues that an integrated knowledge approach should connect indigenous ecological knowledge with contemporary hydrological management while giving women meaningful authority in governance. Such integration can strengthen climate resilience, reduce gendered water burdens, and advance Sustainable Development Goal 6 in semi-arid Telangana.

Keywords: *Indigenous water knowledge, integrated knowledge systems, gender and water governance, traditional ecological knowledge, Mission Kakatiya, climate resilience, Telangana*

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1 Introduction

Water scarcity is a major challenge in the twenty-first century, and climate change intensifies existing vulnerabilities in water-stressed regions. India supports nearly 18 per cent of the global population with about 4 per cent of the world's freshwater resources (NITI Aayog, 2019), creating acute pressure on rural water security and disproportionately affecting women (UNDP, 2025, World Bank, 2023). Telangana, located on the semi-arid Deccan Plateau, illustrates these pressures particularly clearly because communities have long relied on decentralised water-management systems in which women have played important but frequently under-recognised roles. These concerns also bear directly on Sustainable Development Goal 6 (SDG 6), which calls for the availability and sustainable management of water and sanitation for all.

The interaction of women and water within Indian society is entrenched in cultural, social, and ecological relations (Agarwal, 1992). Traditionally, women have been the principal water providers and household water managers in rural agrarian environments, maintaining household water security through collection, purification, and conservation (Climate Investment Funds, 2021). This gendered relationship with water has produced substantial bodies of traditional knowledge encompassing local hydrology, seasonal water availability, water quality evaluation, and sustainable management systems.

Telangana offers a distinctive setting for examining women's roles in water management because of its historical and ecological context. Tank irrigation expanded under the Kakatiya dynasty, which ruled parts of the Deccan from the twelfth to the fourteenth century CE. Historical scholarship attributes the construction of more than 5,000 tanks to this period (Guda, 2024), while the contemporary minor-irrigation inventory records 46,531 tanks, combining surviving historical structures with later additions and defining the restoration universe of Mission Kakatiya (Kumari, 2025). These tanks, locally known as cheruvulu, functioned not only as irrigation works but also as community-managed socio-ecological systems. Women's contributions to their maintenance, household water security, and local knowledge systems have been substantial, although formal accounts have often overlooked them.

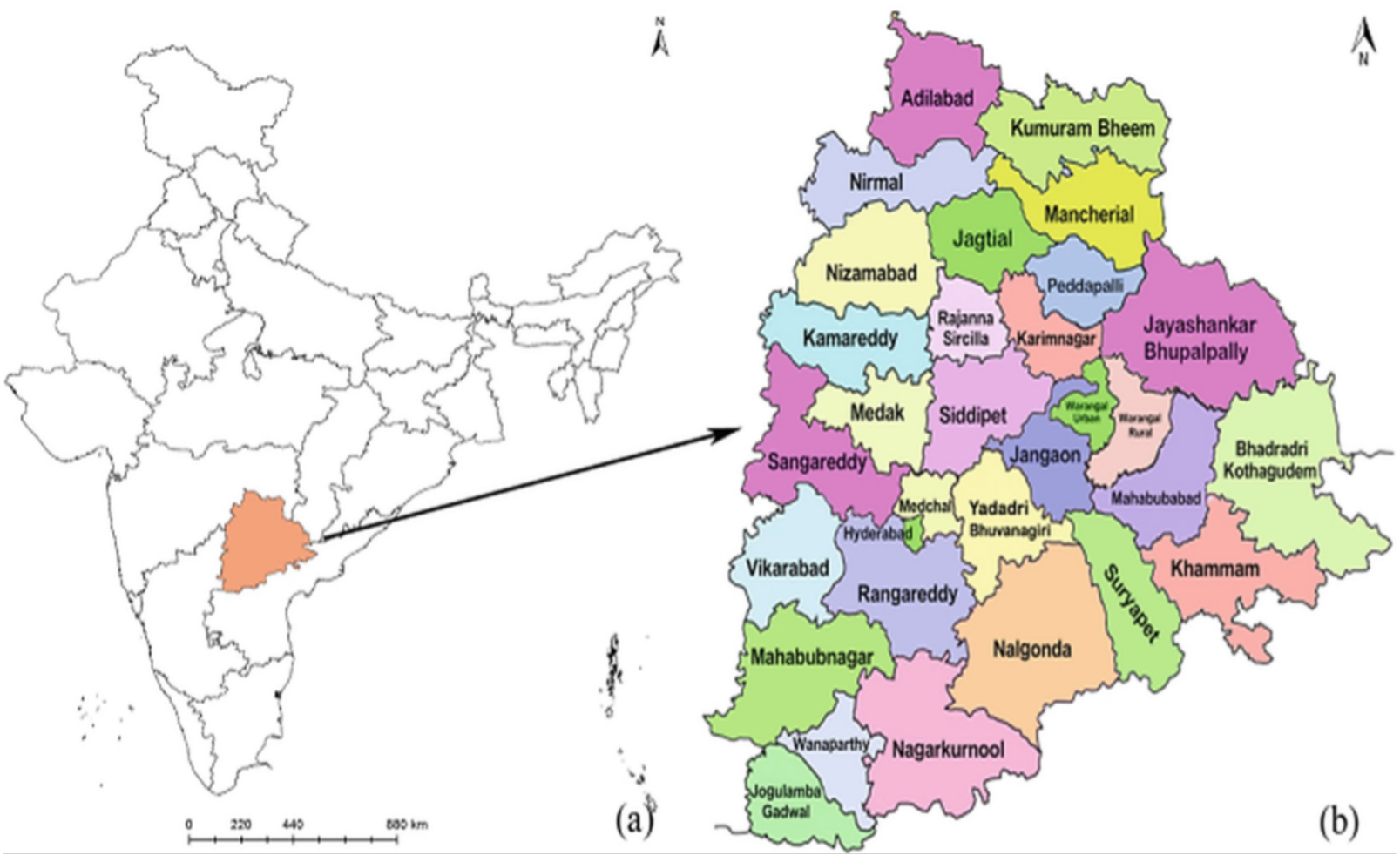
Indigenous water knowledge has emerged as a topic of contemporary interest in climate change adaptation. With the increasing frequency and unpredictability of extreme weather, practices refined over centuries can be highly instructive for building climate resilience (Pandey et al., 2003). Indigenous women, as the bearers of this knowledge, are increasingly recognised as key agents of change in climate adaptation strategies; nevertheless, their input continues to be marginalised in formal policy and planning (SPRF, 2024).

The literature establishes three broad points: women are primary managers of domestic water in many rural settings; their participation can improve water-programme outcomes; and indigenous water practices embody locally adapted principles of sustainability. Important gaps nevertheless remain. Research has paid limited attention to how traditional water knowledge is transmitted and eroded across generations, how caste, class, and gender shape authority in water governance (Nightingale, 2011), how large restoration programmes such as Mission Kakatiya affect women specifically, and how lessons from global indigenous water systems can be translated to the Telangana context.

These gaps converge in Telangana: a semi-arid state with a millennium-old tank heritage, a flagship restoration programme explicitly invoking that heritage, and a large rural female workforce whose practical knowledge remains weakly represented in formal governance. This article brings feminist political ecology and participatory governance into a single analytical frame and uses a structured synthesis of secondary evidence to connect women's traditional water knowledge, the institutions that marginalise or enable it, and pathways for incorporating that knowledge into climate-resilient conservation policy. **Figure 1** locates the study area and highlights the regional setting of the analysis, including Medak and Warangal, which feature in the case studies.

Within an integrated knowledge perspective, these concerns are not treated as separate domains. Indigenous and gendered experiential knowledge, historical water infrastructure, hydrological monitoring, community institutions, and public policy are understood as interacting components of water governance. This framing allows the study to ask not only whether traditional practices remain technically relevant, but also whether contemporary interventions create institutional space for the people who hold and transmit that knowledge, especially women.

Figure 1: **Location map of the study area, Telangana State, India.**



2 Research Objectives

- To document and analyse women's traditional water knowledge (harvesting, quality evaluation, purification, and conservation) in Telangana and its intergenerational transmission amid evolving socio-economic and environmental conditions.
- To investigate gender relations and barriers in water governance in Telangana, and to assess the effectiveness of policy interventions such as Mission Kakatiya in reducing gender disparities and enhancing women's roles as water custodians.

3 Hypotheses

Grounded in participatory governance and feminist political ecology, and informed by the literature on gender and water management, the study evaluates the following analytical hypotheses:

- **H1.** Rural women in Telangana possess rich, intergenerationally transmitted traditional water knowledge that is crucial for household water security and community resilience, yet this knowledge remains underrepresented in formal water governance.
- **H2.** Integrating women's traditional water knowledge with formal governance through gender-responsive policies such as Mission Kakatiya significantly enhances water management outcomes, including groundwater recharge, agricultural productivity, and climate adaptation capacity.

4 Literature Review and Integrated Knowledge Framework

4.1 Integrated Knowledge, Feminist Political Ecology and Participatory Governance

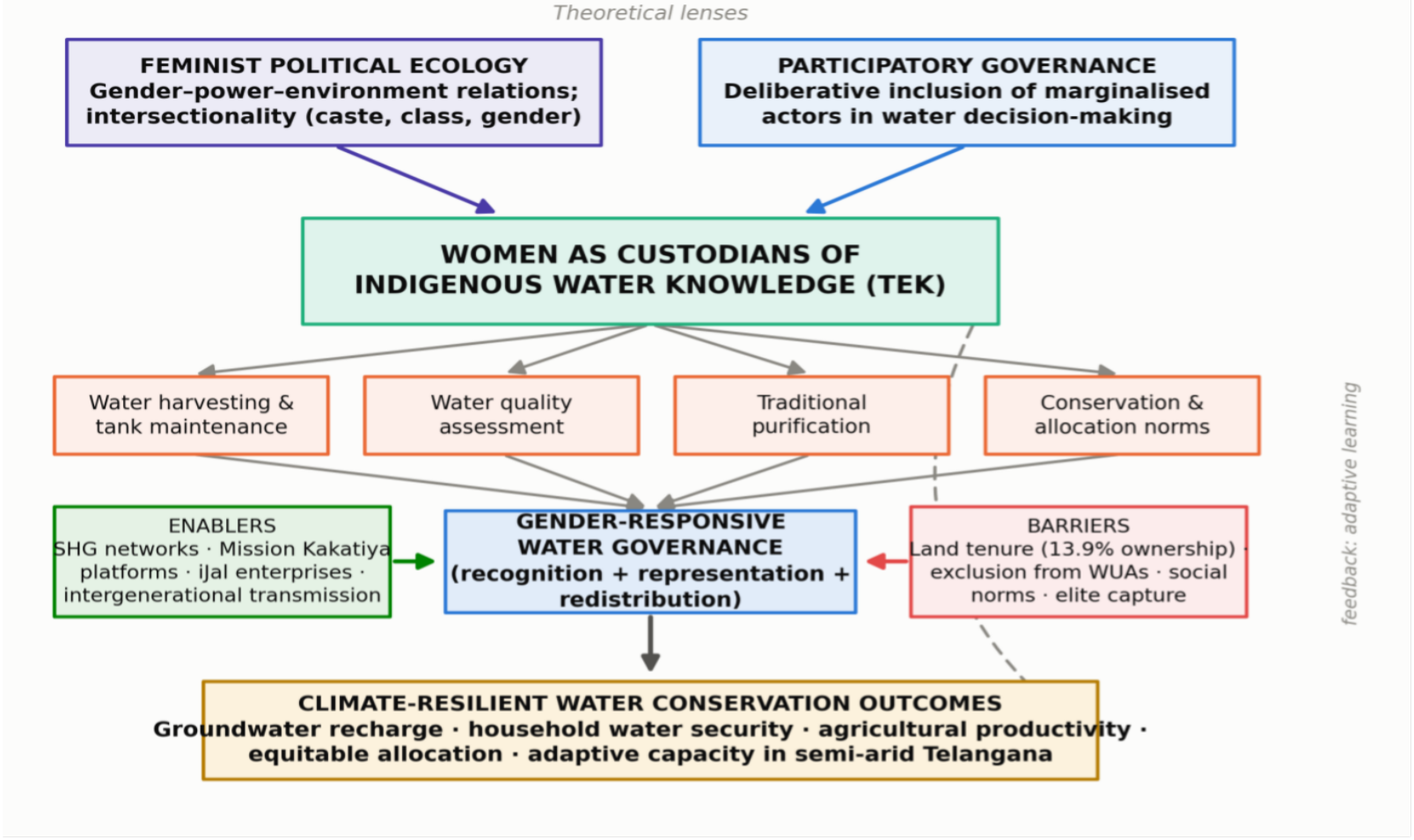
For this review, integrated knowledge refers to the deliberate connection of complementary knowledge domains rather than the replacement of one system by another. Traditional ecological knowledge contributes place-based observations, practices, and social memory; hydrological and programme data provide contemporary evidence on water availability and infrastructure performance; feminist political ecology identifies the

gendered power relations that shape access and authority; and participatory governance clarifies the institutional conditions under which diverse knowledge-holders can influence decisions. Reading these domains together provides the analytical bridge between indigenous knowledge systems and present-day water policy.

This paper employs two complementary theoretical approaches to examine the gendered dimensions of water governance in Telangana: participatory governance theory and feminist political ecology. Participatory governance theory emphasises democratic engagement through deliberative forums and the incorporation of diverse stakeholders, especially those who are underrepresented, into decision-making processes (Fischer, 2000, Waheduzzaman, 2019), argues that participatory governance is a constructive approach to basic service provision, such as water, because it fosters transparency, inclusivity, and consensus-based decision-making. Critics such as Cooke and (Kusabs & Quinn, 2008), however, caution that participation is not always equitable: decision-making is frequently captured by local elites, and marginalised groups find their voices constrained. (Agarwal, 2001), influential analysis of 'participatory exclusions' further demonstrates that formally inclusive community institutions can continue to silence women through membership rules, meeting norms, and entrenched gender hierarchies, a caution of direct relevance to water user associations in Telangana.

Feminist political ecology (FPE), founded as a distinct analytical tradition by (Rocheleau et al., 1996), provides a perspective for analysing the complex relationships between gender, power, and the environment (Adams et al., 2018). FPE illuminates how gender relations, power dynamics, and environmental change jointly shape rural water governance. According to (Truelove, 2011), FPE explores the power dynamics that restrict women's access to and control over water-related decisions and resources, while also recognising women's agency and their ability to contest inequitable governance systems. (Sultana, 2011) extends this tradition by showing that water access is mediated not only by institutions but also by embodied and emotional geographies of suffering, labour, and social obligation. The intersectional orientation of FPE acknowledges that women's experiences in water governance are shaped by multiple axes of difference, including caste, class, ethnicity, and age, thereby enabling more precisely targeted responses to water inequality (Nightingale, 2011).

Figure 2: **Conceptual framework of the study: theoretical lenses, knowledge domains, mediating enablers and barriers, and climate-resilience outcomes.**



4.2 Traditional Ecological Knowledge and Water Management

Traditional Ecological Knowledge **(TEK)** denotes the cumulative body of knowledge, practice, and belief that develops through adaptive processes and is transmitted through cultural inheritance (Berkes, 2008, Berkes et al., 1998), theorises **TEK** as a knowledge process that is continually generated and regenerated as individuals engage with the environment, observe, learn, and adapt. In a widely cited formulation, (Berkes et al., 2000), demonstrate that **TEK** functions as a system of adaptive management, incorporating feedback learning mechanisms that parallel, and frequently anticipate, modern adaptive governance approaches. (Gadgil et al., 1993), similarly argue that indigenous knowledge systems encode conservation practices of demonstrable ecological value. This dynamism underscores the applicability of indigenous knowledge systems to climate change response and adaptation.

TEK in water management encompasses indigenous water harvesting, storage, distribution, and conservation practices that have evolved in response to local environments. The study by (von Oppen & Subba Rao, 1987), shows that rural Indian women are deeply ecologically knowledgeable through their caregiving, agricultural, and domestic responsibilities, contributing to environmental resilience despite their marginalisation in formal decision-making. In their detailed analysis of indigenous water management in Rajasthan (a state in north-western India), (Sharma et al., 2023), report that traditional forms of water management, such as rainwater harvesting, stepwells, and community-based water delivery, have sustained agricultural productivity in arid areas for centuries; (Mishra, 2001), classic documentation of Rajasthan's johads (earthen check dams for rainwater harvesting) and kunds (underground or semi-underground rainwater storage structures) reaches parallel conclusions about the sophistication of vernacular hydraulic design.

According to the (Climate Investment Funds, 2021), report on empowering indigenous women, women's traditional knowledge spans edible wild vegetables, medicinal and herbal plants, sustainable harvesting, water resource management, homestead gardens, and weather forecasting using bio-indicators. Climate adaptation is one field to which these knowledge systems are especially relevant, since they represent locally suitable, time-tested strategies for coping with environmental variability. (Kaur et al., 2019), accordingly emphasise that indigenous knowledge systems must be integrated into modern water management practice in rural India to achieve sustainable water governance.

4.3 Gender Politics in Water Governance: Global Perspectives

The gendered dimensions of water access and management are well established in the international literature (Chandrakala Prashanth, 2025, Zwarteveen, 1997), showed that irrigation systems often allocate water rights through property and membership regimes that bypass women, while (Cleaver, 1998), demonstrated that women's participation is frequently channelled through informal institutions that formal policy fails to recognise. Meinzen-Dick and (Zwarteveen, 1997), documented across South Asia that water user associations can reproduce rather than correct gendered exclusions from irrigation governance. In India, (O'Reilly, 2006), showed that drinking-water interventions may alter, and sometimes deepen, gendered labour burdens even while modernising supply. Studies also indicate that rural women devote substantial time to water-related activities and that climate change can intensify this burden (Asian Development Bank, 2014, Punnoli, 2025), similarly reports persistent gender gaps in water-management leadership and argues that initiatives designed and implemented with women's meaningful participation are more likely to be effective and sustainable.

Research by (IFPRI, 2025) shows that women's involvement in water management has quantifiable community impacts. A study conducted in 56 villages of Madhya Pradesh revealed that in villages where women led water management programmes, non-leader women's participation was 20.7% higher, and a 10 per cent increase in women's participation was associated with a 14.4% greater likelihood of instituting dam management rules. Similarly, a study in Nepal by (Joshi, 2024), established that although policy mandates 33% representation of women in water user associations, it lacks monitoring mechanisms and budgetary support for capacity building; without such institutional reinforcement, representation requirements have limited effect.

(Franks & Cleaver, 2007) propose a framework for analysing water governance in poor communities that considers five interacting elements: resources (allocative and authoritative), mechanisms (negotiated arrangements organising access), outcomes (social relations and routine practices), processes (negotiation and decision-making) and agents (who shape and are shaped by these factors in gender-specific ways). This model emphasises the mediating role of formal institutions, technologies, social resources, and power relations in determining access to water, with gender playing a pivotal role in shaping both access and governance outcomes.

4.4 Knowledge Gaps in Gender and Water Governance

Although the literature on gender and water governance continues to expand, several gaps remain. First, while the advantages of women's involvement in water management are well recorded globally, there is a dearth of research on how caste, class, and gender intersect in determining water access in the South Indian

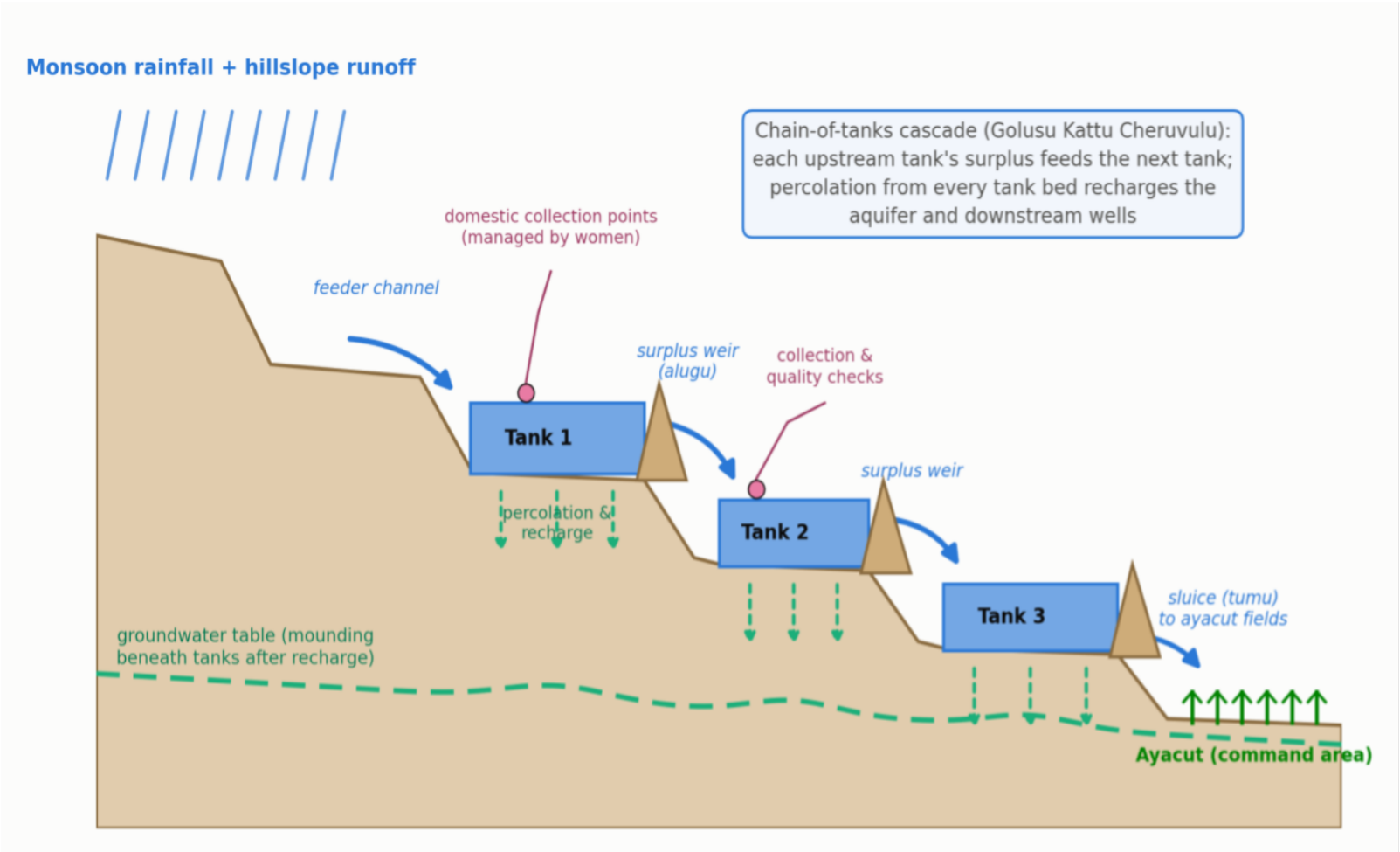
states. Second, documentation of women's traditional water knowledge has concentrated on domestic water management, with limited attention to women's roles in agricultural water management and climate adaptation. Third, the hydrological and economic outcomes of policy interventions such as Mission Kakatiya have been investigated, but little is known about gender-differentiated outcomes or the extent to which these interventions have increased women's participation in water governance.

Fourth, participatory governance theory and feminist political ecology have been applied mostly in African and other South Asian settings; few studies have deployed them to understand water governance in the Deccan Plateau region. Fifth, comparative studies capable of translating lessons from global indigenous water practices into gender-responsive water governance for a specific regional setting, such as Telangana, remain scarce. This paper addresses these gaps by offering an in-depth analysis of women's custodianship of indigenous water knowledge in Telangana through the combined lenses of participatory governance and feminist political ecology.

4.5 Tank Irrigation Systems in Telangana: Historical Legacy and Contemporary Restoration

The history of irrigation in Telangana is closely interwoven with the tank irrigation methods developed under the Kakatiya dynasty. Historical scholarship records that the Kakatiyas constructed more than 5,000 tanks employing a chain-of-tanks *(Golusu Kattu Cheruvulu)* configuration that provided decentralised control over water management across the Deccan Plateau (Guda, 2024). The tanks were deliberately interlinked so that rainfall and runoff were captured sequentially, while community-based management systems distributed water equitably and sustained the infrastructure over time **(Fig. 3)**. Comparable South Indian tank institutions have been analysed as long-enduring common-property regimes in the sense elaborated by (Mosse, 2003, Ostrom, 1990), demonstrates for Tamil Nadu that tanks were simultaneously hydraulic works and instruments of statecraft and social order, while (Shah, 2003), documents how tank technologies embodied locally negotiated social designs. Early economic evaluations by (von Oppen & Subba Rao, 1987), established the productivity rationale of tank irrigation across semi-arid India. The typical structural anatomy of a cheruvu, in plan and section, is illustrated in **Fig. 4**.

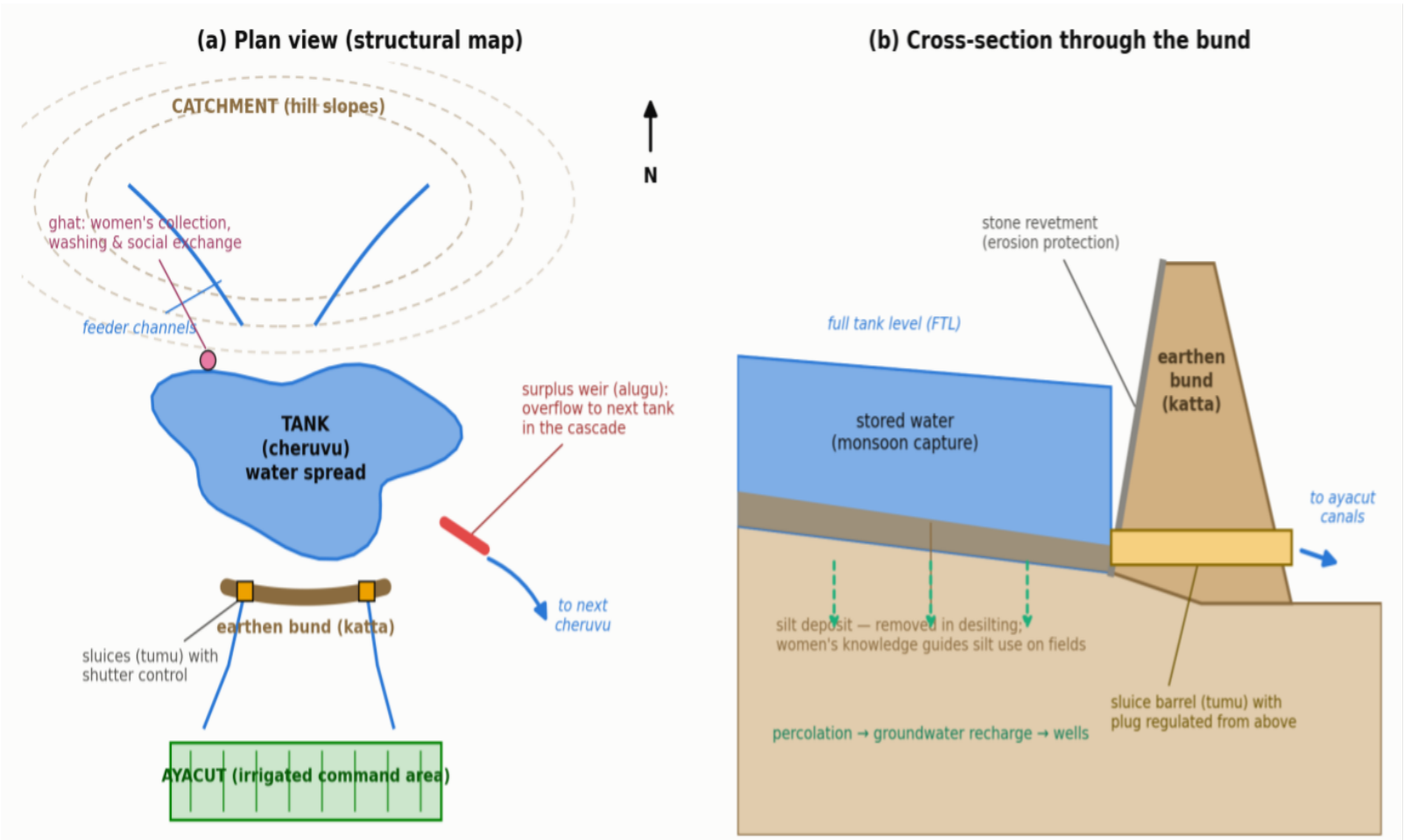
Figure 3: **Mechanism of the Kakatiya-era chain-of-tanks cascade *(Golusu Kattu Cheruvulu)*: sequential capture of monsoon runoff, surplus-weir transfers between tanks, percolation-driven groundwater recharge, and sluice-fed irrigation of the ayacut.**



The post-independence period was marked by a strategic shift toward large-scale irrigation projects and the gradual neglect of minor irrigation sources. This historical marginalisation weighed heavily on Telangana and contributed to groundwater decline, low agricultural productivity, and agrarian distress (Kumari, 2025). Recognition of this crisis led to the launch of the flagship programme Mission Kakatiya in 2015, which set out

to restore the state's 46,531 minor irrigation tanks through community participation and the integration of traditional knowledge. ICRISAT estimates, as synthesised by the Centre for Development Policy and Practice (CDPP, 2025), report a 78.5% increase in household agricultural income and 36–39% increases in fish yields in restored-tank areas; gender-differentiated effects, however, remain inadequately studied.

Figure 4: **Structural map of a traditional Telangana tank (cheruvu): (a) plan view showing catchment, feeder channels, water spread, bund, sluices, surplus weir, and ayacut; (b) cross-section through the earthen bund showing the sluice barrel, stone revetment, silt deposit, and recharge pathways.**



5 Comparative Indigenous Water Practices: Resilience and Transferable Lessons

Indigenous communities across the globe have developed elaborate water management systems suited to diverse ecological conditions, and these systems hold considerable significance for conservation in the face of climate change (Pandey et al., 2003). This section provides a comparative overview of native water practices in Africa, Australia, Latin America, and Asia, exploring methods, resilience mechanisms, and lessons transferable to water security in Telangana.

5.1 Indigenous Water Management in Africa

Indigenous communities across arid and semi-arid Africa have developed water-harvesting and soil-moisture conservation practices adapted to highly variable rainfall. In Burkina Faso and Mali, the rehabilitation of zai pits—small planting and water-conservation pits typically filled with organic matter—helps retain runoff in degraded soils. Organic material can attract termites whose channels improve soil structure and infiltration, and the combined use of zai pits and interplanted trees has been associated with higher yields and improved food security (WaterLex, 2019).

In southern Tunisia, traditional rainwater harvesting uses tabias—earthen and stone embankments—together with dry-stone retaining walls placed along slopes to intercept runoff and sediment. Water retained behind these structures contributes to groundwater recharge and supports cultivated jessour terraces. Their customary governance treats water as a shared social resource, illustrating how local institutions can support long-term water management when rules, maintenance responsibilities, and ecological conditions remain aligned (Hill & Woodland, 2003).

5.2 Aboriginal Water Knowledge and Practices in Australia

Australian Aboriginal peoples maintain deep spiritual and practical connections with water, regarding it as a sacred endowment central to identity, culture, and life. **The Echuca Declaration of 2007** is a powerful statement of the necessity of water to creation, affirming that many ancestral beings are creations of water and dwell in water. For First Nations peoples, rivers are the veins of Country, carrying water to nourish every component of the sacred landscape, with wetlands acting as kidneys that filter water as it moves through the land (MLDRIN, 2010, Moggridge et al., 2019).

The Brewarrina Aboriginal fish traps *(Baiame Ngunnhu)* are among the oldest known human constructions on earth and demonstrate advanced knowledge of river hydrology and fish ecology. The nearly half-kilometre structure of dry-stone weirs and ponds, built in the shape of a net across the Barwon River, is effective in catching fish while balancing the ecology. Still in use today, the traps remain a cultural gathering point and demonstrate how indigenous water infrastructure can serve multiple purposes across millennia (Commonwealth of Australia, 2005).

5.3 Latin American Indigenous Water Practices

In the Peruvian Andes, native communities developed the Zanja system, an advanced network of channels and terraces that collects and allocates water down steep mountain slopes. The system is sustained by collective labour, ensuring equitable distribution while preventing soil erosion. The associated practice of planting Queñual trees improves water retention and ecosystem stability at high altitudes, showing how indigenous practice integrates forestry with water management (IMC, 2025).

The Mixteca region of Mexico offers another example of indigenous water innovation. Since 1988, the Water Forever programme has proceeded from the recognition that sustainable water management must serve both human needs and ecosystem health. The programme integrates pre-Hispanic, colonial, and modern technologies into hybrid methods including contour trenches for aquifer recharge, reforestation, and household-level watershed harvesting (Toledo & Solis, 2001).

5.4 Indigenous Water Practices in Asia and the Pacific

In India, communities in Ladakh—a high-altitude cold-desert region in the Indian Trans-Himalaya—have built ice stupas, artificial glaciers that store winter flows and release water to crops in spring. Local water stewards divert streamflow to shaded locations, prolonging the persistence of seasonal ice and maximising water supplies. The innovation addresses glacier retreat and shifting precipitation patterns, illustrating how traditional knowledge can be adapted to contemporary climate challenges (IMC, 2025).

Wetlands *(repo, the Māori term for wetlands)* have long been used by the Māori of Aotearoa New Zealand to regulate water quality. These lands are densely populated with indigenous flora and micro-organisms that filter runoff and sediment, and they carry cultural and spiritual meaning. Today, constructed wetlands based on traditional processes are used to treat wastewater and stormwater, integrating engineering with mātauranga Māori *(Māori Indigenous knowledge systems)* and whakapapa (genealogy and the relational connections among people, land, and the more-than-human world) (Kusabs & Quinn, 2008). Contemporary indigenous-led water-technology initiatives echo the same principle of rooting infrastructure in traditional knowledge (IC Magazine, 2025).

5.5 Comparative Analysis and Lessons for Telangana

A comparative reading of indigenous water systems worldwide reveals a number of shared principles applicable to the water management challenges of Telangana **(Table 1)**. First, effective indigenous systems are marked by community-based governance with clearly articulated rights and responsibilities, consistent with the design principles for enduring commons identified by (Ostrom, 1990). Second, global indigenous practice underscores the importance of embedding water management within broader ecosystem stewardship. Third, indigenous knowledge systems emphasise flexibility and innovation in responding to changing conditions. Fourth, indigenous water management exhibits differentiated gender roles that, across cultures, consistently acknowledge women's knowledge in water quality assessment, conservation, and domestic water security. Having moved from the Sahel's zai pits to the ice stupas of the Himalaya, the discussion can now be drawn together systematically: **Table 1** provides the comparative overview of technique, design features, and climate-resilience functions against which the Telangana tank system.

Table 1 demonstrates that indigenous water systems vary considerably in design, yet share three institutional features: adaptation to the local ecology, collective responsibility for operation and maintenance, and the integration of water management with soil, agriculture, or ecosystem conservation. The Telangana tank system is therefore not presented as an isolated historical practice; it is set beside other systems to identify

transferable governance principles. At the same time, the comparison should not be read as implying that all indigenous systems are equivalent or universally sustainable: their outcomes depend on local institutions, resource rights, ecological conditions, and social relations.

Table 1: A comparative overview of indigenous water practices in different regions

Region	Technique	Key Features	Climate Resilience
Africa (Burkina Faso)	Zai Pits	Organic-filled pits with termite activity	Improved infiltration in rocky lands
Africa (Tunisia)	Tabias	Stone dams for sediment trapping	Groundwater recharge systems
Australia	Fish Traps	Dry-stone weirs across rivers	Sustainable harvesting for millennia
Latin America (Peru)	Zanja System	Terraced channels on slopes	Equitable mountain water distribution
Latin America (Mexico)	Atajadizo	Embankments for sediment capture	Integrated soil–water management
Asia (Ladakh)	Ice Stupas	Artificial glaciers for spring release	Addressing glacier retreat
Pacific (New Zealand)	Wetlands (Repo)	Natural filtration systems	Wastewater treatment integration
India (Telangana)	Tank Systems	Interconnected water bodies	Decentralised water management

Source: Chandrasekara et al. (2025), Water-related traditional and indigenous practices.

6 Material and Methods

This study uses a qualitative evidence-synthesis design based on structured document analysis and case-study synthesis. The evidence base comprises peer-reviewed articles, government policy documents, reports from international organisations, publications of non-governmental organisations (NGOs), and selected media or institutional reports that address traditional water management, gender relations, and indigenous knowledge in Telangana and comparable settings.

Searches were conducted between January and June 2025 using Google Scholar, Scopus, JSTOR, ResearchGate, and institutional repositories of the Telangana Irrigation and Command Area Development Department, the Telangana Ground Water Department, NITI Aayog, and the Ministry of Rural Development. Search strings combined terms including "indigenous water knowledge", "gender and water governance", "traditional ecological knowledge", "tank irrigation", "Mission Kakatiya", "stepwells", and "climate resilience" with the geographic qualifiers "Telangana", "Deccan", and "India". Sources were included when they substantively addressed water management, gender, or indigenous knowledge; were available in English; were traceable to an identifiable author or institution; and, where empirical claims were made, disclosed an underlying data or monitoring source. Promotional, undated, or unverifiable materials were excluded. Screening of titles, abstracts, and full texts reduced the initial pool of several hundred records to the 57 sources cited in this article.

Case studies were selected purposively when they documented women's involvement in water management and/or the use of traditional knowledge. The final set includes the iJal Small Water Enterprises programme, Mission Kakatiya restoration initiatives, and community-based conservation of traditional water infrastructure. Analysis used thematic coding around four domains: traditional practices, gender dynamics, barriers to participation, and pathways to climate-resilient conservation. Both authors coded the material independently and resolved divergent coding through discussion. Where sources conflicted, the discrepancy was retained rather than suppressed, with greater evidentiary weight given to official monitoring data and peer-reviewed analyses. Non-peer-reviewed materials were retained only when the issuing organisation had an established field presence, the evidence was traceable to named programmes or primary monitoring, and the claim could be cross-checked against at least one independent source.

This approach enables triangulation across historical, policy, hydrological, and gender-focused evidence while retaining the contextual detail required for a regional analysis of Telangana.

7 Results and Discussion

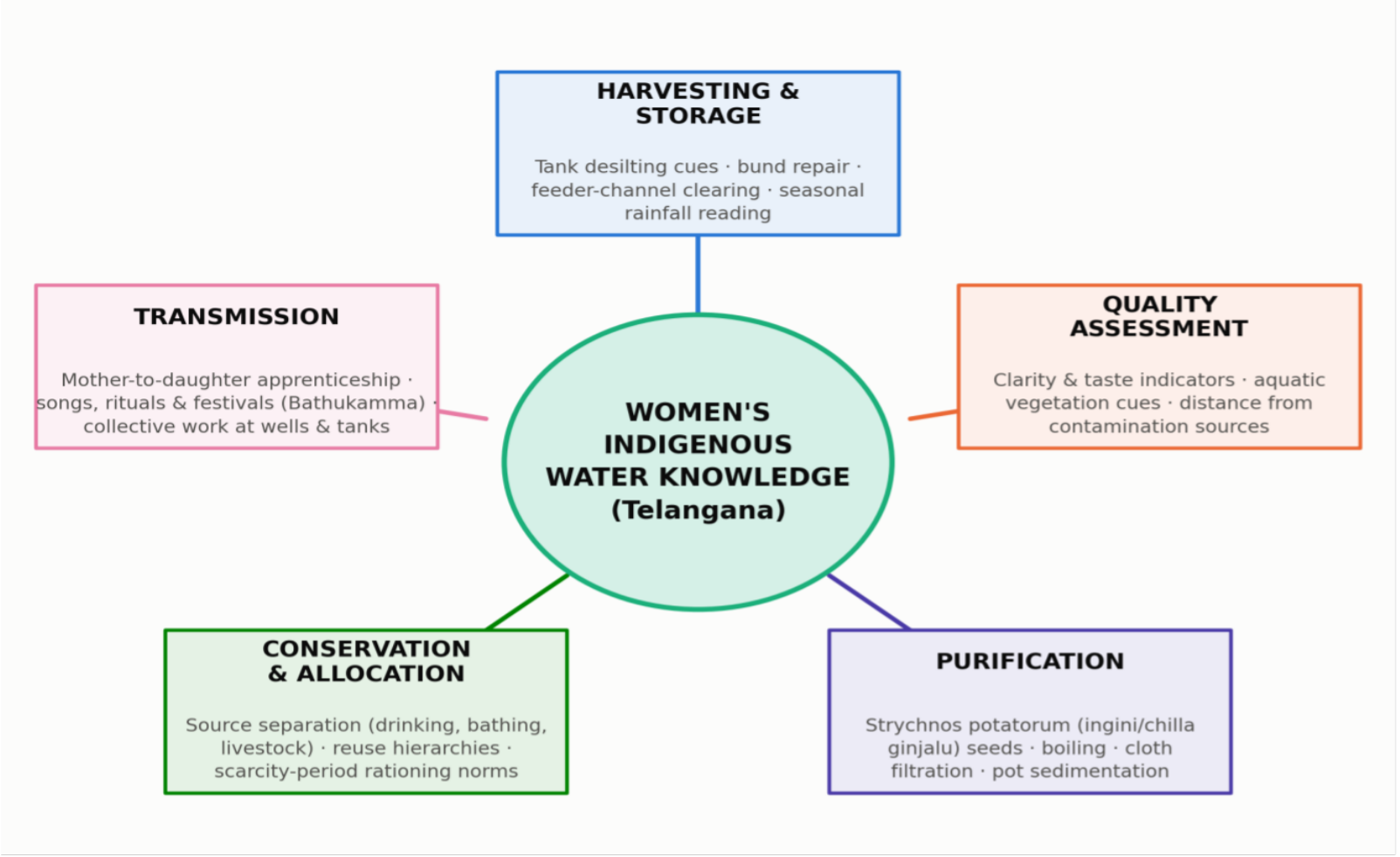
7.1 Women's Traditional Water Knowledge

The analysis indicates that women in Telangana hold a rich body of traditional water knowledge acquired over long periods of direct engagement with water sources. This knowledge spans several domains, including water harvesting, quality evaluation, purification, and conservation practices adapted to the semi-arid Deccan environment **(Fig. 5)**.

Traditional water harvesting knowledge encompasses local understanding of the hydrological cycle, the seasonal availability of water, and the appropriate timing of tank desilting and repair. Tank maintenance activities have historically involved women, including the eradication of invasive vegetation, repair of bunds, and clearing of feeder channels. A further aspect of this knowledge is the spatial organisation of water collection according to use, with women maintaining the customary separation of collection points for drinking, bathing, washing, and livestock (Climate Investment Funds, 2021).

The assessment of water quality is a key component of women's traditional knowledge. Studies record that women use multiple indicators to evaluate quality, including water clarity, the presence of aquatic vegetation, water depth, and distance from sources of contamination. Traditional purification techniques employ natural materials such as the seeds of Strychnos potatorum (the clearing-nut tree, locally *ingini*) for clarification, boiling for disinfection, and cloth filtration **(Fig. 5)**.

Figure 5: **Thematic diagram of the domains of women's indigenous water knowledge in Telangana and their principal constituent practices**



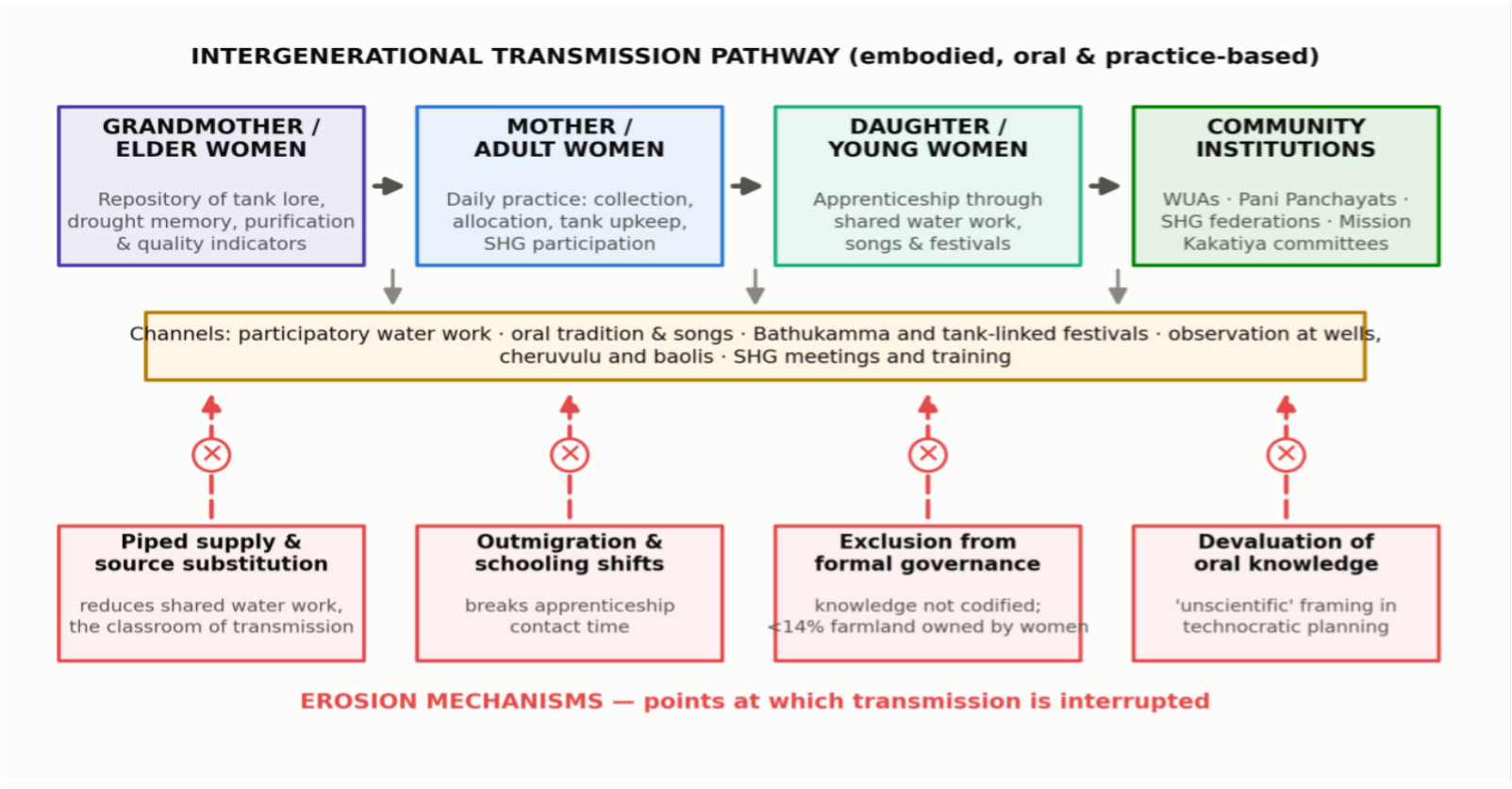
7.2 Gender Dynamics and Barriers to Participation

Despite their extensive practical knowledge, women in Telangana face substantial disadvantages in formal water governance. Land ownership is a major structural constraint: women in India hold only 13.9% of farmland even though they account for more than 42% of the agricultural workforce (Mongabay India, 2025). Limited ownership restricts access to credit, irrigation services, and standing in water user associations, reinforcing the participation gap illustrated in **Figure 8**.

Social norms and cultural practices further restrict women's involvement in water governance. Conventional gender roles assign women responsibility for domestic water management while reserving decision-making for men. This division produces the paradox in which women are the principal providers of water

yet exert little influence over water resource allocation and management (Agarwal, 1992, UNDP, 2025). Beyond institutional exclusion, the same processes threaten the intergenerational transmission of knowledge itself: piped supply schemes, outmigration, and the technocratic devaluation of oral knowledge interrupt the practice-based apprenticeship through which water knowledge passes from mothers to daughters **(Fig. 6)**.

Figure 6: **Mechanism of intergenerational transmission of women's water knowledge and the principal points at which transmission is being eroded**



7.3 Mission Kakatiya: Water Security and Gendered Implications

Mission Kakatiya, initiated in 2015, is a major policy intervention for restoring Telangana's tank irrigation heritage. The programme seeks to rehabilitate all 46,531 minor irrigation tanks through desilting, bund repair, sluice restoration, and rehabilitation of feeder channels. Analysis of programme outcomes demonstrates substantial effects on water security with critical gender dimensions; the causal pathway from restoration works to biophysical, economic, and gendered outcomes is depicted in **Fig. 7**.

Groundwater monitoring data show significant changes in water availability following tank restoration. Ground Water Department studies record water-level rises of 0.80 to 2.87 metres per year in tank influence zones, with an average of 1.27 metres per year (Madhnure et al., 2023). The economic effects have been equally significant: ICRISAT analyses record a 78.5% increase in household agricultural income in tank ayacut areas (the command area served by an irrigation tank) and 36–39% increases in fish output (CDPP, 2025). The principal quantitative results are summarised in **Table 2** and visualised in **Fig. 8**.

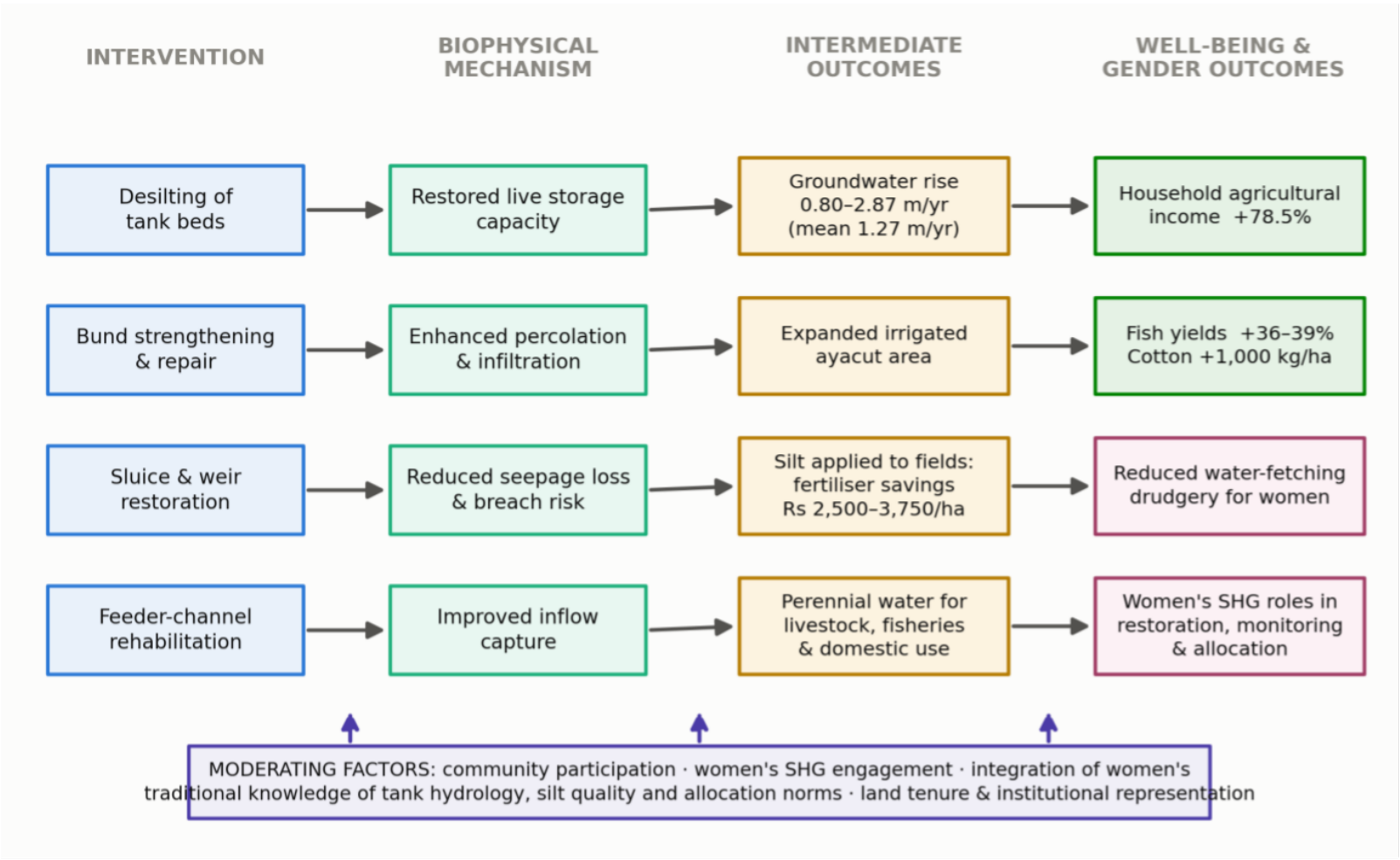
Table 2: Summary of key results of the Mission Kakatiya restoration works

Indicator	Value	Source
Tanks restored (2015–2023)	27,472 tanks	Ground Water Department
Average groundwater rise	1.27 m/year	Madhnure et al. (2023)
Agricultural income increase	78.5%	ICRISAT, in CDPP (2025)
Fish yield improvement	36–39%	CDPP (2025)
Fertiliser cost savings	Rs 2,500–3,750/ha	ICRISAT, in CDPP (2025)
Cotton yield increase	1,000 kg/ha	Government of Telangana (2024)

Source: Government of Telangana (2024); Madhnure et al. (2023); CDPP (2025).

Table 2 summarises the principal documented outcomes of Mission Kakatiya. The restoration of 27,472 tanks between 2015 and 2023, an average groundwater rise of 1.27 metres per year in tank-influence zones, and reported income and yield gains show that reviving a decentralised tank system can generate measurable hydrological and economic benefits. At the same time, these indicators do not directly establish the gender-specific mechanism proposed in **H2** because the official outcome data are not disaggregated by sex or by women's level of participation. The evidence therefore supports **H2** only in a qualified sense: the broader restoration model is associated with improved water-management outcomes, while the incremental contribution of women's knowledge and decision-making remains insufficiently measured. This absence of gender-disaggregated monitoring is itself a governance finding and identifies a priority for future programme evaluation.

Figure 7: **Mechanism-of-impact pathway of Mission Kakatiya tank restoration, from intervention through biophysical mechanisms and intermediate outcomes to well-being and gender outcomes, with moderating factors.**

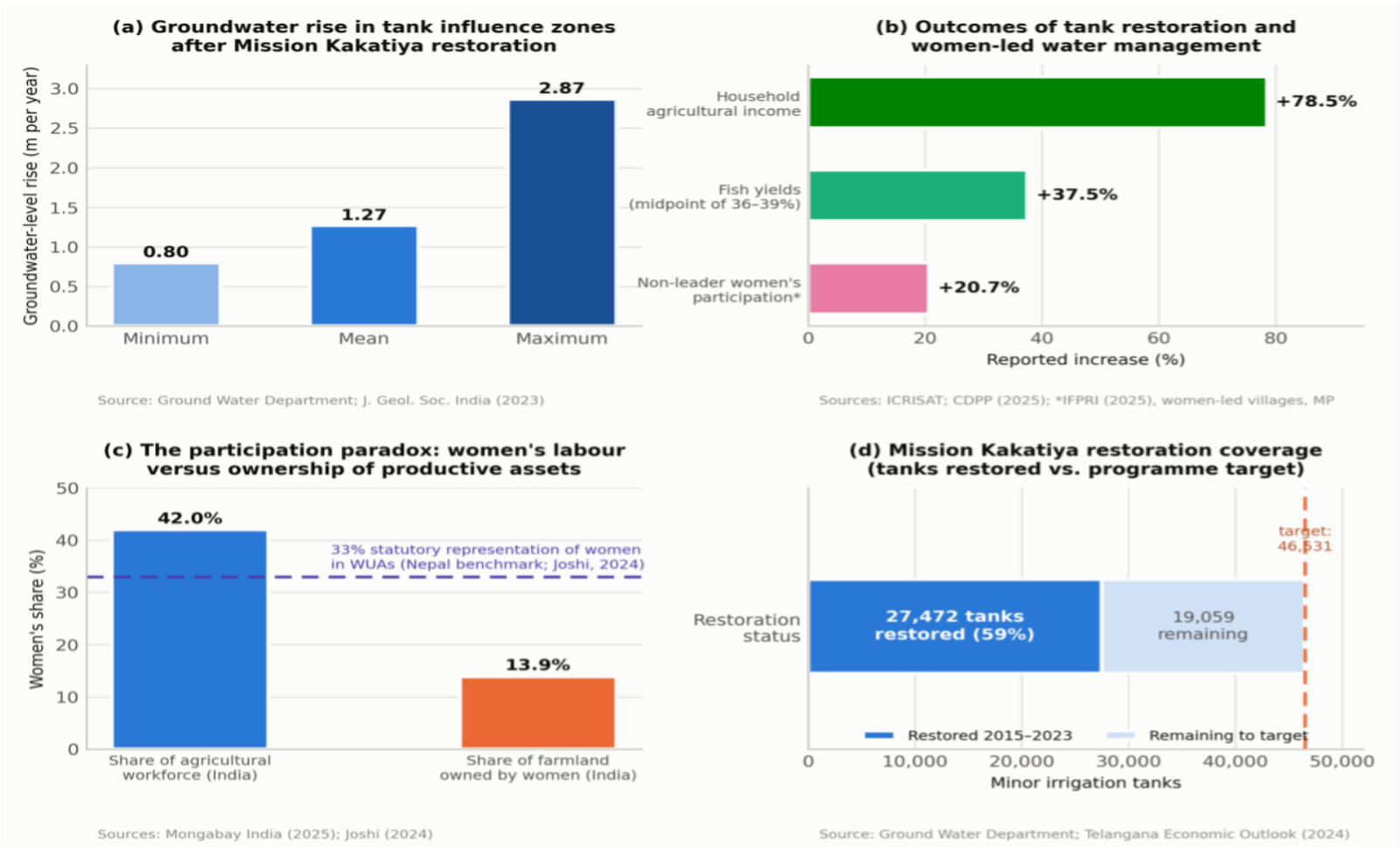


7.4 Integrated Knowledge Interpretation of the Findings

The findings show that water security in Telangana is produced through the interaction of several knowledge domains. Women's embodied and intergenerational knowledge informs everyday decisions about source selection, water quality, purification, conservation, and the timing of tank-related activities. Historical tank design contributes a locally adapted hydrological logic, while contemporary groundwater monitoring and programme evaluation provide measurable evidence of changes in storage, recharge, income, and production. Mission Kakatiya therefore illustrates a form of knowledge integration in which inherited infrastructure is renewed through modern public investment and technical monitoring. However, this integration remains institutionally incomplete when women's knowledge is used informally but women themselves remain weakly represented in formal decision-making and programme monitoring.

The case evidence also indicates that integration is most meaningful when knowledge is linked to authority and capability. The iJal model combines local water knowledge with treatment technology, financial management, and women-led enterprise, while women's participation in tank maintenance connects domestic and agricultural water experience with collective allocation decisions. These examples do not establish a universal causal effect, but they demonstrate a plausible governance pathway: traditional knowledge becomes more effective when institutions recognise its holders, provide technical support, and create decision-making space. In this sense, integrated knowledge is both epistemic and institutional; it concerns what forms of knowledge are combined and who is authorised to use them in shaping water policy and practice.

Figure 8: **Quantitative evidence panel: (a) groundwater-level rise in tank influence zones; (b) reported outcome increases from tank restoration and women-led water management; (c) the participation paradox between women's agricultural labour and asset ownership; (d) Mission Kakatiya restoration coverage against the programme target**



8 Case Studies

8.1 iJal Small Water Enterprises

The iJal Small Water Enterprises (SWEs) programme, implemented by Safe Water Network India in partnership with the Global Water Partnership, provides a community-based model for linking women's entrepreneurship with water service delivery. Water treatment stations established in the Medak and Warangal districts are operated by women's Self-Help Groups (SHGs), supplying safe drinking water while also creating livelihood opportunities.

A 2019 assessment of 28 women operators across ten iJal stations documented substantial changes in the social and economic status of participants. The programme demonstrated that rural women with little formal education can be successfully trained in water treatment technology, financial management, and micro-enterprise operation. Participants reported greater confidence, greater decision-making authority within households, and enhanced social recognition (GWP, 2021).

8.2 Women's Involvement in Tank Restoration

The implementation of Mission Kakatiya has created opportunities for women to participate in tank restoration, although the degree of involvement differs across regions. The programme's emphasis on community participation has enabled women's SHGs to take part in maintenance activities, foreshore plantation, and the monitoring of restoration outcomes.

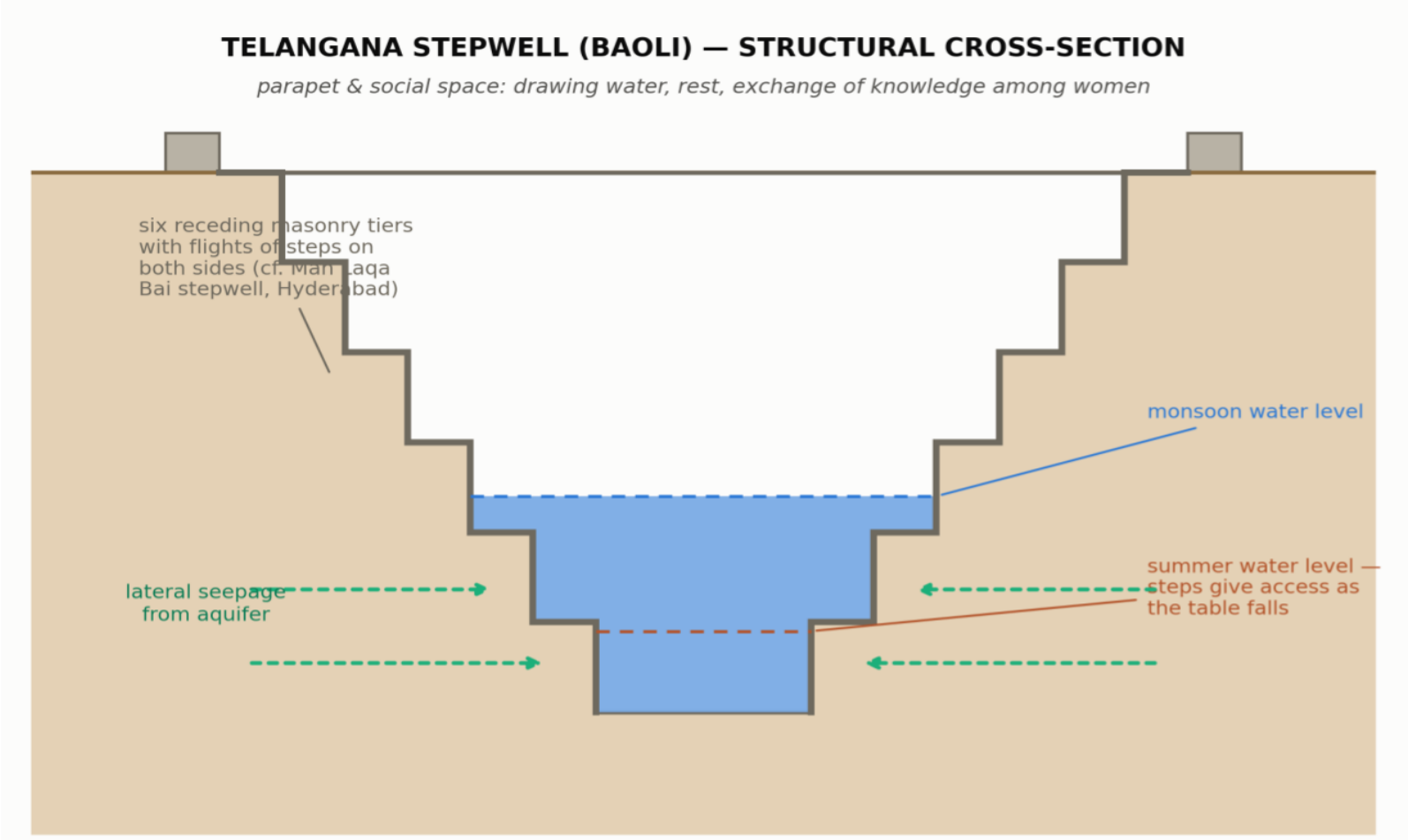
In several districts, women have been organised into committees for tank maintenance and the equitable distribution of water. These committees are significant in resolving conflicts, particularly when water is scarce and competition for the resource intensifies. Household water requirements and crop water requirements are also allocated more fairly because of women's knowledge of both domestic and agricultural needs.

8.3 Conservation of Traditional Stepwells

The stepwells *(baolis, stepped wells descending to groundwater)* of Telangana constitute a significant yet neglected component of historical water systems. Historical research records that stepwells were constructed in most houses and neighbourhoods of the older quarters of Hyderabad and served as essential sources of drinking water during dry seasons (IJISRT, 2024). The structures also functioned as social spaces where women could meet, rest, and exchange knowledge **(Fig. 9)**.

The Mah Laqa Bai stepwell, a six-tiered structure with flights of steps on both sides and a central platform, exemplifies the engineering and architectural excellence of historical water systems. In 2023, the Telangana government partnered with Osmania University to conserve this culturally and historically important structure.

Figure 9: **Structural cross-section of a Telangana stepwell (baoli), showing the receding masonry tiers, seasonal water levels, lateral aquifer seepage, and the social space historically used by women**



9 Policy Implications and Recommendations

9.1 Policy Implications

Three implications follow from the analysis before any recommendation is advanced. First, women's traditional water knowledge is a governance resource, not merely a cultural inheritance: where it has been institutionally engaged—in the iJal stations and in tank-maintenance committees—measurable gains in water security, livelihoods, and equity have followed. Second, restoration programmes that revive traditional infrastructure without gender-disaggregated monitoring, as **Table 2** shows for Mission Kakatiya, systematically understate both their own benefits and their unfinished business; what is not measured cannot be governed. Third, the attainment of SDG 6 in semi-arid India runs through gender-responsive water governance: household water security, the stated object of the Goal, is administered in practice by women, and policies that bypass them bypass the point of delivery (FWWB India, 2025). On the basis of these implications, and of the global comparative review, the following recommendations are advanced.

9.2 Policy Recommendations

9.2.1 Empowering Women in Water Governance

Women's water knowledge and rights should be formally acknowledged within water governance structures. This entails mandatory representation of women in water user associations, Pani Panchayats, and irrigation committees. Quotas for women in leadership positions, on the Maharashtra model, merit serious consideration so that involvement is substantive rather than symbolic; the international evidence reviewed above cautions that quotas require accompanying capacity budgets and monitoring if they are to escape the trap of participatory exclusion (Agarwal, 2001, Joshi, 2024).

Capacity-building programmes should target women water managers with technical skills in water quality testing, infrastructure maintenance, and financial management. The experience of the iJal programme shows that, with appropriate training and support, rural women can successfully operate complex water treatment systems.

9.2.2 Integrating Traditional Knowledge with Modern Conservation

Participatory research with women knowledge-holders should be undertaken to document and validate traditional water knowledge systematically. Such documentation must inform the design of climate adaptation strategies, and interventions must build on locally relevant practices rather than imposing external solutions.

9.2.3 Gender-Responsive Interventions to Enhance Climate Resilience

Climate adaptation planning must acknowledge the gendered nature of water scarcity impacts and develop interventions that address women's specific vulnerabilities. This involves reducing drudgery through improved water access, offering women alternative livelihoods during droughts, and providing access to climate information and early warning systems.

9.2.4 Addressing Structural Barriers

Land tenure reform must prioritise women's ownership, since ownership of land and access to water are closely correlated. Joint land titling schemes and reforms of inheritance law can contribute to a more equitable distribution of water resources and decision-making power.

10 Limitations and Future Research

The study is limited by its reliance on secondary evidence, uneven documentation of women's roles across districts and communities, and the restricted availability of gender-disaggregated programme indicators. Some evidence comes from NGO, institutional, and policy reports rather than peer-reviewed studies; the screening procedure reduced this risk through source traceability and cross-verification, but it cannot eliminate differences in data quality. The design supports analytical synthesis and triangulation but does not permit causal attribution of Mission Kakatiya outcomes to women's participation. Future research should combine participatory field methods with household- and community-level data disaggregated by gender and, where possible, caste, class, age, land tenure, and location. Such work could directly test the socio-hydrological pathways proposed in this article and examine how indigenous knowledge is transmitted, transformed, or lost under changing water-supply and livelihood conditions.

11 Conclusion

This study demonstrates that women in Telangana hold substantial traditional ecological knowledge relevant to water harvesting, quality assessment, purification, conservation, and climate resilience. The evidence strongly supports **H1**: women's water knowledge is extensive and intergenerational, yet remains underrepresented in formal governance. **H2** receives qualified support. Mission Kakatiya and related community initiatives are associated with measurable hydrological and economic improvements, and case studies show that women can contribute effectively when they are given institutional roles, technical training, and decision-making space. However, the lack of gender-disaggregated programme indicators prevents a direct causal estimate of how much women's participation contributes to Mission Kakatiya's measured outcomes.

The Kakatiya tank systems remain an important example of decentralised water management adapted to semi-arid conditions. Their contemporary restoration through Mission Kakatiya creates an opportunity to combine historical infrastructure, community knowledge, and modern monitoring. Reported outcomes—including groundwater recovery and higher agricultural and fishery returns—demonstrate the continued relevance of

tank restoration, while the gender evidence shows that infrastructure renewal alone is insufficient without institutional recognition of women's knowledge and rights.

The comparative review further shows that indigenous water systems in different regions share recurring principles: ecological adaptation, collective responsibility, integration of water with wider ecosystem management, and locally embedded knowledge. The zai pits of Burkina Faso, Aboriginal fish traps in Australia, Andean channel systems, Māori wetland practices, and the tank systems of Telangana differ in design and social context, but each illustrates how durable water management depends on the fit between technology, institutions, and local ecology. The case studies reinforce the practical value of gender-responsive governance. iJal demonstrates how women's participation in water-service delivery can build technical capacity, livelihoods, confidence, and social recognition. Women's involvement in tank restoration and water-allocation committees similarly indicates the value of combining domestic and agricultural water knowledge. Yet weak land tenure, restrictive social norms, and inadequate formal representation continue to limit women's influence.

Climate-resilient water policy in Telangana should therefore treat women's indigenous water knowledge as both an ecological resource and a governance asset within an integrated knowledge system. Participatory documentation, meaningful representation in water institutions, gender-disaggregated monitoring, secure resource rights, and access to technical training can connect traditional knowledge with contemporary hydrological science and conservation practice. Future field-based research should test these pathways with primary, gender-disaggregated evidence across districts and social groups. Such an approach would strengthen water security, improve the institutional quality of knowledge integration, and advance progress toward SDG 6 in semi-arid regions.

12 Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

13 Funding Statement

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14 Authors' Contribution

Chandrashekar Konda (CK) and Anand Gopagani (RSB): relevant information collected, research designed, conceptualization, methodology, and interpretation.

15 AI Declartion

Artificial intelligence tools were not used for conceptual framing, analysis, or interpretation of this study. AI assistance was limited to grammar and typographical checking, and to generating figures and images relevant to the data and study.

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