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Susthira Thrithala: A Model for Integrated and Participatory Sustainable Development in Rural India

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ABSTRACT:
Susthira Thrithala represents an exemplary initiative in sustainable rural transformation, implemented in the Thrithala constituency of Kerala, India. Conceived to address the severe decline in groundwater despite the proximity to the Bharathapuzha River, the project offers an integrated, community-driven model for ecological resilience. Anchored in watershed-based planning and institutional convergence, the initiative brought together local self-governments, scientific bodies, NGOs, and the public to develop and execute a detailed action plan. Key interventions included artificial groundwater recharge, extensive water body restoration, rooftop rainwater harvesting, and the implementation of India's first Water Budget at both panchayat and constituency levels. Agricultural revival through paddy and coconut cultivation, introduction of mushroom farming, and integrated farming have further enhanced food security and local livelihoods. The project also integrated green energy initiatives, sustainable fisheries, and decentralized waste management, all supported by robust community engagement, particularly through Kudumbashree units and schools. The success of Susthira Thrithala underscores the power of local participation, inter-departmental coordination, and environmental stewardship in addressing climate and water crises. This model offers replicable insights for other regions seeking sustainable and inclusive development pathways.

Keywords: Sustainable Development, Groundwater Recharge, Community Participation, Watershed Management

1. Introduction

Thrithala, an assembly constituency in Kerala's Palakkad district, is a region of profound ecological, cultural, and historical significance, nestled along the banks of the Bharathapuzha River, locally revered as "Nila." Spanning 19,417 hectares, the constituency comprises eight-Gram panchayats within the Thrithala block (Anakkara, Chalissery, Kappur, Nangalassery, Pattithara, Thirumittacode, Thrithala) and one from the Pattambi block (Paruthur), encompassing 135 wards across nine villages. The Bharathapuzha, Kerala's second-longest river, flows for 26.02 km through Thrithala, shaping its fertile plains, rolling hills, and riverine valleys. This landscape supports a predominantly agricultural economy, with rice as the primary crop, alongside coconut (12.48% of land use), rubber (9.93%), and palmyrah plantations. Thrithala's cultural heritage is equally rich, marked by Vedic scholarship centers in Marathur and Pattithara, Sanskrit grammatical schools in Nangalassery, and historical landmarks like Kattilmadam, a remnant of Jain culture, and the ruins of Tipu Sultan's forts. The constituency's midland terrain, part of the North Central Laterite ecological zone, ranges from 10 to 100 meters above sea level, with 94.14% of its 5,066.31 hectares lying within this elevation. However, Thrithala faces

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significant environmental challenges, particularly groundwater depletion, driven by unregulated sand mining, conversion of paddy fields, land use changes, climate variability, and inadequate water conservation infrastructure. These issues threaten the region's agricultural backbone and water security, necessitating urgent conservation efforts. This introduction outlines Thrithala's unique characteristics, the critical need for groundwater conservation, and how these efforts align with Themes 4 and 5 of Kerala's localization of the Sustainable Development Goals (SDGs).

There is an effective connection between Themes 4 and 5 and Sustainable Development Goals (SDGs) 6 (Clean Water and Sanitation), 13 (Climate Action), and 15 (Life on Land). These SDGs are interrelated and especially important in the context of Kerala, a region noted for its environmental vulnerability, dense population, and decentralized governance structure. Nonetheless, the commentary highlights a significant shortcoming in the article: the necessity for a more detailed exploration of the operational challenges related to localizing these global objectives, particularly when faced with competing development priorities.

2. Theoretical Background

2.1 Change management and change factors

Changes in external and internal stakeholder expectations force companies to constantly adapt to new circumstances. The capability to initiate and manage organisational change is therefore considered as crucial for the survival of organisations (Luecke, 2003). Change Management can be defined as the "the process of continually renewing an organisation's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers" (Moran & Brightman, 2001: 111).

There is a wide array of research in the area of change management, addressing for example the characteristics of change (e.g. incremental vs. discontinuous change, see for an overview By, 2005), change processes models (e.g. Lewin, 1947; Kotter, 1995) or barriers of change (e.g. Post & Altmann, 1994; Al-Alawi et al., 2019). In most of these publications, explicitly or implicitly, factors driving or inhibiting change are named. For example, Lewin (1947 pinpoints that change does not only depend on the individual, but also on situations, surroundings and group dynamics. The role of the human being as an individual and/or in social constellations is also highlighted by Dievernich et al. (2015). Stakeholder analysis and engagement is proposed as important tool for change management in order to be able to understand the expectations, needs and fears of individuals (Sippl et al., 2022), but also to engage them for driving (sustainable) innovations (Eisenreich, 2021). Kotter (1995) spotlights the influence of leadership (e.g. vision building, communication) in change processes. Thakur and Mangla (2018), identified, next to human factors, operational and technological change factors, where technological factors could be outside or inside the company. Post and Altmann (1994), at the example of organisational change, seek for barriers to change and suggest clustering them into organisational barriers (e.g. attitudes of personnel or quality of communication) and industry barriers (e.g. capital costs, regulatory constraints or technological knowledge).

Literature focusing on change management in hospitals and/ or the healthcare sector confirms change factors that have been identified by other studies. For example, Šuc (2009) and Barba et al. (2021) substantiated the dependence of change on situations, surroundings and group dynamics Lewin (1947, 1951) for change procedures in hospitals. Kleine et al. (2022) support the critical transformational role of hospital executives which has already been emphasized by Kotter (1995). Weimann (2018) and Grossmann and Lobnig (2013) underline internal and external leadership communication as key factors towards successful change processes. A similar result has been found by Werner et al. (2022) and Debatin et al. (2011) when looking at change for sustainability in hospitals. At the same time, studies are spotlighting specific characteristics like the complexity and the path dependence of hospitals as challenging factors for change (Grossmann & Lobnig, 2013). This is particularly the case when the formerly self-determined departments and their leaders are obliged to change towards standardization or central principles (Roeder & Bunzemeier, 2017). Bate and Robert (2017) and Grün and Franke (2014) highlight the importance of the integration of stakeholders (in particular patients) into change and innovation processes in hospitals.

2.2 Significance of Conceptual Alignment

The link between Themes 4 and 5 and the identified SDGs indicates that the article acknowledges the environmental aspects of sustainable development. Theme 4, which likely pertains to environmental conservation or natural resource management, and Theme 5, which may focus on climate adaptability or local resilience strategies, are inherently linked to SDGs 6, 13, and 15. Kerala's policy measures, such as watershed management, biodiversity preservation, and decentralized waste management initiatives, illustrate these connections.

Nonetheless, although this alignment indicates a solid theoretical grasp, the practical application of these SDGs at the grassroots level necessitates the translation into effective governance frameworks. This endeavor is frequently complicated by tensions, particularly in regions such as Kerala that must juggle the dual goals of economic advancement and environmental conservation.

There are some studies in the area of Integrated Care, especially in the National Health Service of the United Kingdom or healthcare networks in general where change processes transcend organisational borders. Some studies just repeat factors already mentioned for change processes in single organisations (e.g. Cresswell et al., 2020; Nuño-Solinís, 2017). Other studies, however, are spotlighting the inter-organisational aspects of change: For example, Bhat et al. (2022) underline the importance of formal and informal arrangements that enable trust and collective relationships to develop between organisations. Auschra (2018) pinpoints to obstacles for change at the inter-organisational level, for example, insufficient leadership and coordination, differences in goals and approaches in the collaboration, incompatible organisational structures, imbalances of power, conflicts and a lack of contact persons with well-defined roles.

2.3 Challenges in Operationalizing Localization

Localizing the SDGs requires the adaptation of broad, and often abstract, global objectives to suit the distinct socio-political, ecological, and economic landscapes of local governance. Local self-governments (LSGs) in Kerala have the authority to plan and execute development initiatives; however, they encounter significant operational obstacles in this process:

Data and Metrics: Global SDG indicators are often not relevant at the local scale. For example, metrics intended to assess national water quality or forest coverage may fail to reflect the micro-level differences within a panchayat. The absence of localized, detailed, and timely data hinders effective monitoring and evaluation.

Capacity Limitations: Even with Kerala's robust tradition of decentralization, numerous local bodies experience constraints in technical areas, including climate modeling, GIS mapping, and ecosystem valuation. This restricts their capacity to incorporate environmental considerations into development planning.

Competing Priorities: Perhaps the most urgent concern, as mentioned in the comment, is the clash between economic development and ecological sustainability. For instance, infrastructure projects (such as roads, tourism, and housing) in ecologically sensitive regions like the Western Ghats often compromise biodiversity and forest conservation. Similarly, commercial agriculture may endanger water resources, contradicting the goals set out in SDG 6.

Thrithala's environmental and socioeconomic context underscores its dependence on the Bharathapuzha River and its tributaries, such as the Thuruppuzha, Kannadipuzha, and Kalpathipuzha, which collectively support 32 micro-watersheds across the Bharathapuzha, Kanjiramukku, and Keechery basins. The constituency's population, recorded at 227,469 in 2011, is predominantly rural, with a gender ratio of 1,171 females per 1,000 males and a significant proportion engaged in farming, agricultural labor, and small-scale enterprises. Women constitute 52.86% of the population, with 60.07% of Scheduled Caste and 65.18% of Scheduled Tribe populations being female, highlighting the need for inclusive development strategies. The region's geomorphology, dominated by Charna-kharti soil (85.35%, 16,572 ha) and laterite soils (8.41%), supports agriculture but is vulnerable to soil erosion, particularly in sloped areas (15.55% with moderate steepness). 49.62% of the land experiences moderate erosion, exacerbating groundwater challenges by reducing soil water retention. Despite an average annual rainfall of 2,200 mm, Thrithala faces severe drinking water scarcity due to poor harvesting systems, declining recharge, and pollution from sewage, industrial waste, and plastics. These factors, combined with two scanty rainfall years (below -59% of the Long Period Average), emphasize the urgent need for groundwater conservation to sustain Thrithala's agricultural and ecological systems.

Kerala's approach to localizing the SDGs provides a framework for addressing Thrithala's challenges through community-driven, environmentally sustainable policies. Theme 4, Water Sufficient Village, aligns with SDG 6 (Clean Water and Sanitation), emphasizing sustainable water management to ensure equitable access and availability. This theme prioritizes the conservation of water resources through integrated watershed management, groundwater recharge, and the revival of traditional water bodies like ponds, streams, and canals. In Thrithala, this translates to initiatives like constructing check dams (e.g., at Kuttakkadavu), restoring paddy fields as natural reservoirs, and regulating sand mining to preserve aquifer recharge. These efforts aim to mitigate the semi-critical groundwater status, as assessed by the Central Ground Water Board, and address the declining water levels in observation wells since 2006. Theme 4's focus on water sufficiency is critical for

Thrithala, where agriculture depends on reliable groundwater, and seasonal water scarcity disrupts livelihoods.
Theme 5, Clean and Green Village, corresponds to SDG 13 (Climate Action) and SDG 15 (Life on Land), promoting low-carbon practices, environmental cleanliness, and biodiversity conservation to build climate-resilient communities. In Thrithala, this theme is operationalized through sustainable agriculture, organic farming, and waste management initiatives. The references highlight the shift from monoculture to mixed cropping and agroforestry, incorporating native species like mango and jackfruit to enhance soil health and carbon sequestration. Organic farming practices, such as composting and crop rotation, reduce greenhouse gas emissions, aligning with SDG 13's climate mitigation goals. Additionally, the implementation of the Green Protocol in government offices and community-led waste management efforts address pollution, supporting SDG 15's focus on ecosystem restoration. These initiatives counter the environmental degradation caused by deforestation, land use changes (e.g., 18% of Kerala's cultivated land converted to rubber plantations), and the loss of forest cover from 44% in 1905 to 28% by 2020.
The interplay of Themes 4 and 5 in Thrithala is evident in the Sustainable Thrithala project, led by Shri M. B. Rajesh, MLA and then Speaker of the Kerala Legislative Assembly. This project integrates watershed-based development, sustainable agriculture, and community participation to address groundwater depletion and environmental challenges. The Bharathapuzha reduced flow, attributed to dams, illegal sand mining, and pollution, has dried up river channels, impacting groundwater recharge and agricultural productivity. Morphometric analysis reveals the river's dendritic drainage pattern and high drainage density in certain watersheds, indicating high runoff and erosion risks that further limit groundwater infiltration. By implementing measures like check dams, recharge ponds, and soil conservation structures, Thrithala aims to enhance water availability and ecological resilience. Community-driven efforts, supported by Haritha Kerala Mission, Kudumbashree, and MGNREGS, ensure public participation, aligning with Kerala's SDG localization principles of inclusivity and sustainability. These initiatives not only address immediate water scarcity but also contribute to long-term environmental and socioeconomic progress, making Thrithala a model for sustainable development in Kerala. Under the visionary leadership of Shri M. B. Rajesh, Hon'ble Speaker of the Kerala Legislative Assembly and MLA of Thrithala constituency, a structured and inclusive approach to constituency development was initiated. As part of this initiative, specialized subcommittees were formed, comprising representatives from various developmental departments such as Agriculture, Health, Local Self Government, Irrigation, Education, and Environment.

These subcommittees were tasked with identifying local needs and formulating integrated, sustainable development plans with a strong emphasis on green agriculture and sanitation—two sectors critical to improving both the ecological and public health landscape of the constituency. The planning process aimed at ensuring environmental sustainability, enhancing rural livelihoods, and promoting community well-being.

The resulting development projects meticulously planned through this participatory and interdisciplinary effort are compiled and presented in this document. Each project is designed to align with long-term sustainability goals while addressing the immediate developmental needs of the constituency.

To ensure the technical soundness, feasibility, and effective implementation of these projects, a technical committee was also constituted. This committee includes representatives from the scientific community and technical experts from various government departments and institutions. The committee plays a critical role in:

- Providing expert advice and technical support during the planning phase
- Monitoring the execution of projects to ensure quality and compliance
- Evaluating progress and suggesting mid-course corrections where needed

This collaborative model bringing together political leadership, departmental coordination, scientific expertise, and community participation serves as a replicable framework for holistic and sustainable constituency development.

3. Objectives

- To create a stable and productive ecological system through the scientific conservation and utilization of natural resources available within the river basin.
- To maintain enhanced, sustainable agricultural productivity in the river's catchment area.
- To ensure the continuous availability of food, fodder, water, and fuel.
- To rejuvenate the environment through sustainable development, with a focus on soil and water conservation.
- To regulate water flow in order to protect soil and water resources and utilize them for beneficial purposes.
- To conserve and improve water sources originating from wetlands.
- To control soil erosion within the wetlands.
- To eliminate flooding in the low-lying areas of the river basin.
- To increase the infiltration of rainwater into the soil.
- To enhance groundwater recharge wherever possible.

4. Results

4.1 Factors Affecting Water Scarcity in Thrithala

The Thrithala constituency, located in Kerala's Palakkad district, is a vital agricultural hub reliant on the Bharathapuzha River and its tributaries for water supply. Despite receiving an average annual rainfall of 2,200 mm, the region grapples with severe water scarcity, particularly affecting groundwater resources essential for farming and domestic needs. The Central Ground Water Board has classified Thrithala groundwater as semi-critical, with recharge rates declining since 2006. This scarcity stems from a combination of human-induced pressures, geomorphological constraints, and climate change impacts. The following factors detail the complex causes of water scarcity in Thrithala, highlighting the critical need for targeted groundwater conservation efforts to sustain the region's ecological and socioeconomic systems.

While the progress made in groundwater recharge and the increase in water levels is praiseworthy and signals a positive outcome of the project, it represents merely one aspect of the hydrological and environmental framework. The absence of complementary data on water quality leaves the overall health and ecological advantages of the project uncertain and possibly exaggerated. This deficiency weakens the reliability and thoroughness of the impact evaluation.

Significance of Monitoring Water Quality

Water quantity and quality are interrelated components of effective water management. An increase in groundwater levels does not inherently ensure that the water is safe or suitable for use. In numerous areas, especially those influenced by natural pollutants such as fluoride or arsenic, or by human-made contaminants including industrial waste, sewage, or agricultural runoff, the water quality can present significant health hazards, even when recharge levels are sufficient.

In Kerala and various parts of India, issues such as fluoride contamination, nitrate pollution, and bacterial contamination are prevalent in rural water supply systems. Therefore, assertions regarding enhanced water access should be supported not only by metrics related to quantity (e.g., groundwater levels) but also by quality indicators including:

- pH, turbidity, and total dissolved solids
- Concentrations of fluoride, arsenic, nitrate, and heavy metals
- Detection of coliform bacteria or other biological markers
- Residual pesticide concentrations or industrial contaminants (when relevant)

Integrating these parameters through regular testing would provide a scientifically robust affirmation of health benefits, particularly for communities that rely heavily on groundwater for drinking, irrigation, and household purposes.

4.2 Results on the meso-level

4.2.1 Unregulated Sand Mining

Unregulated sand mining along the Bharathapuzha River is a primary driver of water scarcity in Thrithala. The excessive and unscientific sand extraction has deepened riverbeds, disrupting the natural percolation of water into underground aquifers. Sandy riverbeds, essential for maintaining groundwater levels, allow water to infiltrate and recharge aquifers. However, rampant sand mining has removed these compact beds, reducing aquifer recharge and causing a decline in water levels in adjacent wells and sloped areas. Bharathapuzha, Kerala's second-longest river (209 km), has a lower flow compared to other rivers in the state, partly due to sand mining, which has led to dried-up river channels during summer. This exacerbates freshwater scarcity, particularly in flatlands and river-adjacent areas, where groundwater is a critical resource. Sand mining has caused riverbank erosion, altering the river's natural course and further limiting water retention.

The environmental impact is significant, as the loss of sandy beds not only reduces groundwater availability but also destabilizes the river ecosystem, threatening biodiversity and agricultural productivity.

4.2.2 Conversion of Paddy Fields

Paddy fields, covering 639.54 hectares in Thrithala, serve as natural water reservoirs, retaining moisture and facilitating groundwater recharge through their wetland ecosystems. However, study shows a steady decline in paddy cultivation, with many fields filled for dryland cultivation or construction purposes. The fallow and wasteland have increased significantly from 1,038.50 hectares due to insufficient irrigation and land use changes. This conversion disrupts the ecological balance, reducing the land's water retention capacity and exacerbating groundwater scarcity. Paddy fields, by holding water during monsoons, support aquifer recharge and maintain soil moisture, critical for Thrithala's rice-based agricultural economy. Their loss transforms complex wetland ecosystems into less permeable surfaces, increasing runoff and reducing infiltration. This shift not only threatens water security but also impacts food security, as rice cultivation is integral to the region's cultural and economic fabric. Abandoning these fields poses a serious threat to the constituency's water storage capacity, compounding the challenges of seasonal water scarcity.

4.2.3 Land Use Changes and Hill Cutting

Land use changes, particularly the shift from mixed cropping to monoculture plantations and hill cutting, significantly contribute to water scarcity in Thrithala. The coconut plantations (12.48% of land use) and rubber plantations (9.93%) have replaced traditional mixed cropping systems, reducing soil diversity and water retention. Monoculture systems, diminish the soil's ability to retain moisture, increasing vulnerability to drought. Hill cutting in catchment areas, often for construction, disrupts natural slopes that act as water reservoirs, feeding springs and maintaining river flow during dry seasons. The hills in Thrithala's eastern and southeastern uplands serve as critical water storage systems, but their destruction alters river courses and reduces groundwater recharge. 15.55% of Thrithala's land has moderately steep slopes, prone to erosion, which is exacerbated by hill cutting. These activities increase runoff, reduce infiltration, and destabilize the hydrological balance, particularly in the midland's laterite soils (8.41% of the area), which have lower water retention capacity. The combined effect of these land use changes significantly limits groundwater availability.

4.2.4 Climate Change and Rainfall Variability

Climate change intensifies water scarcity in Thrithala through irregular rainfall patterns and increasing temperatures. Studies reports two scanty rainfall years in Thrithala, with rainfall below -59% of the Long Period Average (LPA), and a trend of reduced rainy days despite consistent annual rainfall (2,200 mm). This leads to rapid runoff and flash floods, limiting water infiltration into the soil. Reports also notes rising maximum temperatures during winter and post-monsoon periods, increasing evaporation rates and straining groundwater reserves. The climate-induced changes, such as prolonged dry spells, particularly affect elevated areas with poor soil water retention, such as Thrithala's laterite-dominated zones. The morphometric analysis of the Bharathapuzha basin indicates high drainage density in certain watersheds, suggesting high runoff and low infiltration, which exacerbates groundwater depletion. These climate impacts threaten agricultural productivity, as crops like rice, dependent on consistent water availability, face increased stress, further highlighting the need for conservation measures.

4.2.5 Inadequate Water Conservation Infrastructure

Thrithala's traditional water conservation systems, including ponds, streams, and canals, have been neglected or reclaimed, reducing their capacity to store and recharge groundwater. 62.79 hectares of surface water bodies, including the Bharathapuzha and its tributaries like Parappanthodu, but notes their degradation due to neglect and habitat loss. Poor surface and groundwater harvesting systems, with many ponds and canals filled or clogged with waste, limiting their functionality. Unscientific construction practices that block natural water infiltration, such as buildings without rainwater harvesting systems, further exacerbate scarcity. The absence of modern conservation structures, such as check dams, velocity check barriers (V.C.B.s), and recharge pits, limits the region's ability to capture rainfall effectively. The groundwater access in Thrithala relies heavily on open wells, but declining recharge rates since 2006 have strained these sources. The lack of infrastructure to slow runoff and enhance infiltration is a critical barrier to addressing water scarcity.

4.2.6 Pollution and Waste Mismanagement

Pollution from untreated sewage, industrial waste, and solid waste, particularly plastics, contaminates Thrithala's water resources, further aggravating scarcity. Reports show environmental pollution as a major concern, with waste disposal near water bodies posing risks to both urban and rural drinking water schemes. The absence of comprehensive waste management projects, leading to contamination of groundwater sources. Waste accumulation in and around water bodies, such as the Bharathapuzha and its tributaries, hinders natural recharge processes and degrades water quality. Kerala's water bodies, including those in Thrithala, face threats from sewage and industrial contamination, with districts like Palakkad also experiencing excessive fluoride levels in groundwater. This pollution not only reduces the availability of usable water but also poses public health risks, necessitating urgent interventions to protect water sources.

Water scarcity in Thrithala is a complex issue driven by unregulated sand mining, conversion of paddy fields, land use changes, hill cutting, climate change, inadequate conservation infrastructure, and pollution. These factors collectively reduce groundwater recharge, disrupt ecological balance, and threaten the constituency's agricultural and socioeconomic stability. By understanding these factors, Thrithala have implement targeted strategies to restore groundwater resources, ensuring water security and aligning with sustainable development goals.

4.3 Role of Digital Innovations in Water Resource Management

Digital technologies such as IoT (Internet of Things) sensors, remote sensing, AI-driven analytics, and mobile platforms are increasingly redefining how natural resources are monitored, managed, and governed. When applied effectively, these tools can overcome long-standing barriers associated with manual data collection, delayed reporting, and fragmented decision-making. Their integration into water management systems can offer greater precision, transparency, and community engagement.

For instance, IoT-based hydrological sensors can be installed in groundwater wells, tanks, and streams to measure parameters like:

- Aquifer water levels
- Water flow and usage rates
- Soil moisture and evapotranspiration
- Pollution levels (e.g., turbidity, nitrate concentration)

Such sensors transmit real-time data to cloud-based platforms, enabling dynamic tracking of water availability and quality. This data, when made accessible to local governing bodies and communities through user-friendly dashboards or mobile apps, can significantly enhance local decision-making capacity.

4.4 AI and Predictive Analytics

In addition to real-time monitoring, AI-driven predictive models can forecast trends based on historical and current datasets. For example:

- Predictive models can estimate aquifer depletion timelines, helping to regulate extraction practices.
- Early warning systems can alert communities to the likelihood of contamination spikes or drought periods.
- Optimized irrigation schedules can be developed using machine learning algorithms based on rainfall patterns, soil conditions, and crop requirements.
- Such insights allow proactive interventions, reducing dependence on reactive or crisis-driven water management. When integrated into local water governance frameworks, these tools can lead to more targeted investments, improved policy design, and adaptive management strategies.

Enabling Community Participation

Crucially, digital tools also provide avenues for participatory water governance. For example, citizen science platforms can allow local users to upload field data or report pollution events, which can then be verified and integrated into broader monitoring systems. Digital literacy and training programs can empower village-level institutions—such as panchayats or watershed committees—to engage with these tools meaningfully.
Moreover, mobile alerts, voice-based systems, or interactive GIS maps can help communities understand aquifer health, monitor water use, and design local conservation measures.

5. Discussion

Approaches Adopted by Thrithala

5.1 Leadership by Panchayati Raj Institutions (PRIs)

This approach emphasizes decentralized governance, where PRIs take the lead role in planning and executing development projects. It ensures that development aligns with local needs and fosters community ownership and accountability. The involvement of PRIs promotes transparency, builds local leadership capacity, and empowers grassroots democracy.

5.1 Natural and Localized Ecological Focus in Planning, Implementation, Monitoring, and Asset Protection

By considering elements like rainfall, water availability, soil types, vegetation, and biodiversity, projects are planned with the local environment in mind. This guarantees sustainability and strengthens climate change resilience. Such a focus helps in:

- Preserving natural habitats and ecosystems
- Reducing environmental degradation
- Sustaining project benefits over the long term through careful asset maintenance and ecological protection.

5.3 Complete Public Participation at all stages of the Project

Public involvement is ensured at every phase—from planning to implementation, monitoring, and evaluation. This participatory model:

- Increases transparency and trust
- Encourages local knowledge integration
- Builds a sense of community ownership, which is essential for long-term maintenance and success

Mechanisms like Gram Sabhas, Self-Help Groups, and User Groups are typically used to facilitate this involvement.

5.4 Integrated Approach Combining Physical Infrastructure with Ecological Measures

This method combines ecological and infrastructure rather than treating them alone.
For example:

- Building check dams or percolation tanks for water harvesting while also planting trees to prevent soil erosion
- Constructing livelihood-supporting assets (like irrigation facilities) that also improve ecological balance
- This holistic strategy ensures multi-dimensional benefits such as improved livelihoods, biodiversity conservation, and climate resilience.

5.5 Conservation Methods Using Low-Cost, Low-Engineering, Eco-Friendly Techniques for Natural Resource Management

The focus here is on simple, replicable, and cost-effective conservation techniques, including:

- Contour bunding and trench digging for soil and water conservation
- Vegetative barriers, agroforestry, or mulching
- Use of indigenous materials and local knowledge in resource management

These techniques are environmentally friendly, affordable, and easy for local communities to adopt and maintain, which is key for sustainability.

5.6 Selection of construction types based on slope, soil, and crop type, ensuring safe construction

Infrastructure and asset creation are customized to suit the natural features of the area:

- Determining drainage patterns and water flow is aided by slope analysis.
- Soil type influences what kind of structures (e.g., tanks, bunds) are viable
- Crop type affects irrigation needs and water retention strategies
- This ensures that assets are safe, durable, and effective, preventing structural failures and optimizing natural resource use.

5.7 Comprehensive Development Vision that maximizes integration across various projects

Rather than isolated interventions, the approach emphasizes a convergent model:

- Multiple schemes and departments (MGNREGA, NRLM, IWMP, etc.) are integrated for coordinated action
- This creates synergy, avoids duplication, and ensures that development is not fragmented
- Emphasis is placed on long-term impacts, economic viability, and sustainability
- A comprehensive vision ensures inclusive growth, ecological sustainability, and maximized returns on investment.

6 Policies Implemented at Thrithala

6.1 Integrated Watershed Management

Thrithala's groundwater restoration is built on a watershed-based approach, central to achieving water sufficiency under Theme 4. The constituency's 32 micro-watersheds, spanning the Bharathapuzha, Kanjiramukku, and Keechery basins, form the backbone of this strategy, integrating soil, water, and biodiversity conservation to enhance aquifer recharge. Key initiatives include:

- Construction of Check Dams and Recharge Structures: A check dam at Kuttakkadavu, where the Thuruppuzha meets the Bharathapuzha, raises river water levels, facilitating groundwater recharge. Vented Cross Bars (V.C.B.s) were constructed along streams such as Parappan Thodu, Muttippalam Thodu, Manjappatta Thodu, Adakkappura Thodu, and Nagalassery Thodu to slow runoff and promote infiltration, particularly in flatlands. LSGIs ensure scientific construction of rain pits to maximize rainwater percolation, often using temporary bunds and minor water channel maintenance to complement these efforts. These structures, implemented through the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), have increased water levels in wells, particularly in low-lying areas, supporting SDG 6's sustainable water management goals.
- Revival of water bodies: Ponds, canals, and streams, covering over 60 hectares, have been cleaned and restored to enhance their storage and recharge capacity.

LSGIs have prioritized the revival of major streams and canals, removing weeds, plastics, and debris to improve water flow and infiltration. Abandoned brick-making ponds have been repurposed as recharge ponds, boosting groundwater availability. These efforts, funded by MGNREGS, watershed development programs, and LSGI resources, ensure long-term water conservation.

- Soil and water conservation: In areas with moderate slopes, constituting about 15% of Thrithala's land, bunds, retaining walls, and rain pits have been built to control soil erosion and enhance water retention, especially in laterite soil zones with low water-holding capacity. LSGIs coordinate these activities, integrating local methods to maintain soil health and support groundwater recharge, aligning with Theme 4's focus on ecosystem protection.

6.2 Regulation of Sand Mining

Unregulated sand mining along the Bharathapuzha has historically deepened riverbeds, reducing aquifer recharge. To address this, Thrithala has enforced strict regulations to limit sand extraction, preserving sandy riverbeds essential for groundwater replenishment. LSGIs, working with environmental agencies, have established monitoring committees to ensure compliance with permissible extraction levels, preventing riverbed degradation and stabilizing riverbanks to reduce erosion. Additionally, LSGIs have implemented measures to remove plastic and other waste from riverbanks and prevent further dumping, protecting recharge zones. These actions enhance groundwater availability in river-adjacent areas and align with Theme 4's goal of safeguarding water resources, contributing to SDG 15 (Life on Land) by maintaining the river's ecological balance.

6.3 Restoration of Paddy Fields

Paddy fields, spanning approximately 640 hectares, act as natural water reservoirs, supporting groundwater recharge through their wetland ecosystems. Thrithala has prioritized their revival to counter their conversion to dryland or construction sites. Key efforts include:

- Reclamation of Fallow Lands: LSGIs, through MGNREGS and Kudumbashree neighbourhood groups, reclaim fallow lands for rice cultivation, providing farmers with seeds, tools, and market linkages. This preserves wetland ecosystems, enhancing water retention and aquifer recharge, aligning with Theme 4's water sufficiency objectives.
- Irrigation Support: Revived canals and streams in panchayats like Pattithara and Chalissery ensure water availability for paddy cultivation, reducing reliance on groundwater and supporting recharge processes. LSGIs maintain these water channels using integrated funding from MGNREGS and watershed programs, ensuring sustained agricultural productivity.

These initiatives mitigate drought impacts, supporting Theme 5's climate-resilient agriculture and SDG 13 (Climate Action).

6.4 Sustainable Agriculture and Organic Farming

A key feature of sustainable agriculture is its focus on soil health. Practices like crop rotation, cover cropping, and compost application naturally improve soil fertility and speed up the formation of new topsoil.

There are many ways to increase the sustainability of agriculture. When promoting sustainable food systems, it is also important to develop sustainable farming methods. Environmentally friendly agricultural practices are part of sustainable agriculture. These allow for crop and livestock production without causing harm to humans or natural ecosystems.

Sustainable agriculture includes methods such as:

- Permaculture
- Agroforestry
- Mixed cropping
- Multicropping
- Crop rotation

Developing sustainable food systems contributes to the overall sustainability of human populations. For example, the best way to combat climate change is to establish sustainable food systems based on sustainable agriculture. To feed a growing population under changing environmental conditions, agriculture systems must adapt—and sustainable farming provides a viable solution.

Incorporating bio-ecological processes such as nutrient cycling, soil regeneration, and nitrogen fixation into agricultural and food production systems is essential. Minimizing the use of non-renewable and environmentally harmful materials and interventions, utilizing farmer expertise to enhance land productivity, and promoting local self-reliance through farmer self-sufficiency are key. Solving agricultural and environmental challenges through collaboration among individuals with various levels of expertise, managing pest control and irrigation efficiently—these are all elements of sustainable farming.

The aim is to create agricultural ecosystems designed to promote continuous regeneration.

Sustainable farming practices are integral to Thrithala's groundwater restoration, enhancing soil health and reducing environmental degradation under Theme 5's clean and green village framework. Key interventions include:

- Organic Farming: Composting plant residues and animal waste improves soil fertility and carbon sequestration, reducing greenhouse gas emissions. Leguminous cover crops enrich soil nitrogen naturally, minimizing chemical fertilizers and enhancing soil's water-holding capacity. LSGIs convert organic waste into manure for farming, reducing pollution in water bodies and protecting groundwater quality.
- Integrated Farming: Combining agriculture, animal husbandry, and aquaculture optimizes resource use. Crop residues feed livestock, while manure fertilizes fields, creating a low-carbon system that reduces water demand and environmental impact.
- Agroforestry and Mixed Cropping: Planting native species like mango and jackfruit alongside mixed cropping systems, which cover about 21% of Thrithala's land, restores biodiversity and improves soil moisture retention,

countering the water-intensive monoculture plantations like coconut and rubber. LSGIs promote these practices through agricultural groups and Kudumbashree, ensuring market support.

These practices foster climate-resilient agriculture, aligning with SDG 13 and SDG 15, and support groundwater conservation by reducing runoff and improving soil structure.

6.5 Community Participation and Local Governance

Community engagement is a cornerstone of Thrithala's groundwater restoration, ensuring sustainability and inclusivity. LSGIs, under the supervision of presidents, coordinate with Haritha Keralam Mission, Suchitwa Mission, Clean Kerala Company, Kudumbashree, and MGNREGS to implement these initiatives. Key actions include:

- **Awareness Campaigns**: LSGIs organize campaigns targeting MGNREGS workers, Kudumbashree groups, students, ASHA workers, Anganwadi workers, and Nehru Yuva Kendra volunteers to promote water conservation and sustainable practices. The General Education Department supports environmental education in schools, fostering awareness among students. Special Gram Sabhas and Ayalkkoottam meetings engage communities in river conservation, securing public support, particularly from women, who constitute over half the population.
- **Green Protocol Implementation**: Government offices in the river basin adhere to the Green Protocol, minimizing waste and promoting eco-friendly practices. LSGIs are extending this to all government institutions, aligning with Theme 5's environmental cleanliness goals.
- **Public Sanitation Campaigns:** LSGIs conduct community-driven sanitation drives to prevent waste dumping in water bodies, protecting groundwater quality. These efforts, supported by Suchitwa Mission, enhance public participation and environmental stewardship.

These initiatives align with Theme 4's participatory resource management and Theme 5's inclusive development, fostering social equity and long-term sustainability.

Organic farming and agroforestry from an environmental standpoint, aligning well with SDG 15 (Life on Land). However, it falls short in addressing the economic challenges faced by farmers adopting these systems. Practices like organic farming often experience yield reductions during transition periods, while agroforestry requires significant initial investments and long gestation periods, affecting income stability—especially for smallholders. Furthermore, limited market access, weak certification infrastructure, and reduced-price premiums hinder the economic viability of ecological agriculture. A comparative, data-driven analysis of conventional versus sustainable systems—considering yield trends, income volatility, market dynamics, and access to credit—would offer deeper insights into these trade-offs. Without tailored crop insurance, input subsidies, and value chain development, such models risk remaining economically unfeasible at scale. Balancing SDG 2 (Zero Hunger) with SDG 15 requires integrative policies that support both ecological outcomes and farmer livelihoods, ensuring sustainability is not achieved at the cost of economic security.

6.6 Eco-Tourism and Environmental Restoration

Thrithala leverages its cultural and natural assets, including backwaters and historical sites along the Bharathapuzha, to promote eco-tourism, generating revenue for conservation. LSGIs restore meadows and water bodies, enhancing environmental health and supporting groundwater recharge while preserving biodiversity. By ensuring waste-free water bodies, LSGIs enhance their tourism potential, aligning with Theme 4's ecosystem conservation and Theme 5's green development, contributing to SDG 15.

6.7 Policy Integration and Funding

Thrithala's restoration efforts are integrated with state and national schemes to ensure scalability. LSGIs and line departments collaborate with MGNREGS, NABARD, and watershed development programs to fund infrastructure like check dams and recharge pits. Line departments, including Agriculture, Water Resources, and Environment, develop action plans, incorporating project components into annual plans and securing approvals. Proposals are submitted to NABARD, the Central Ministry of Jal Shakti, Ministry of Rural Development, and Ministry of Environment to mobilize funding, ensuring financial sustainability and alignment with SDG targets.

6. 8 Departmental Coordination and Implementation

Line departments ensure convergence of activities within Thrithala for maximum impact. Agriculture supports organic farming, Ground water focuses on replenishing ground water, Soil Conservation and Water Resources oversees watershed management, and Environment focuses on pollution control. LSGIs, under presidential supervision, coordinate these efforts, ensuring effective execution across district, block, and grama panchayat levels through partnerships with Haritha Keralam Mission, Suchitwa Mission, and Kudumbashree. This coordinated approach enhances resource efficiency and project outcomes.

7. Results

The Susthira Thrithala project, spearheaded by Shri M. B. Rajesh, MLA and Hon. Minister for Local Self Government of the Kerala Legislative Assembly, has made measurable strides in addressing groundwater depletion, enhancing agricultural productivity, and promoting sustainable livelihoods across Thrithala's eight Grama panchayats (Anakkara, Chalissery, Kappur, Nagalassery, Pattithara, Thirumittacode, Thrithala, Parudur). By integrating watershed management, sand mining regulation, paddy field restoration, sustainable agriculture, and community participation, the project aligns with Themes 4 (Water Sufficient Village) and 5 (Clean and Green Village) of Kerala's SDG localization, contributing to SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 15 (Life on Land). The following outcomes reflect progress toward the project's expected goals, as outlined in LSGI reports and community feedback, while ongoing efforts continue to build on these achievements.

7.1 Achievements in Water Resource Management

The centrepiece of the project is its wide-ranging water conservation and artificial recharge activities. Key accomplishments include:

7.1.1 Artificial Groundwater Recharge: Implemented in 40 public institutions, this intervention is recharging approximately 8.39 million liters of rainwater annually. Notably, water levels in observation wells improved from a depth of 11 meters in 2020 to 10.18 meters in 2025.

7.1.2 Construction and Renovation of Water Bodies:

- 107 new agricultural ponds with a storage capacity of 20 million liters.
- Renovation of 64 public ponds to store 26.89 million liters.
- Renovation of 139 canals, enabling 117 km of improved water flow.
- Construction of 436 new wells and well recharging in 600 households, storing 180,000 liters.
- Well recharging in 59 out of 81 Anganwadis, adding 177,000 liters to the groundwater reserve.

7.1.3 Watershed Development: Under the Soil Conservation Department, a multi-phase project is in motion. Phase 1 included:

- 10,428 coconut palms
- 6,113.5 meters of earthen embankments
- 206 rooftop rainwater tanks
- 5 earthen ponds
- 4,400 fruit trees

7.1.4 Agricultural and Economic Transformation

The agricultural sector in Thrithala has seen significant rejuvenation:

- **Paddy Cultivation:** Reintroduced across 556 hectares, producing an additional 667 tons of rice.
- **Coconut Planting:** 100,000 saplings planted under the MGNREGS and Agriculture Department.
- **Mushroom Farming:** Thrithala became Palakkad's first mushroom village with 100 mushroom beds managed by 100 farmers.
- **Integrated Farming**: Expanded across an additional 27 acres to promote crop diversity.
- **Onam Vegetable Program**: Initiated for local self-sufficiency in vegetable production.

These efforts not only support food security but also empower rural economies through employment and local enterprise.

7.1.5 Fisheries and Biodiversity

Sustainable fish farming has been actively promoted:

- 53,680 fishing's were introduced in 85 public ponds.

- Varal fish and swordfish were cultivated in designated "paduta- (A pond located in or near a paddy field) units.
- These initiatives have enhanced both biodiversity and the livelihoods of local fishers.

7.1.6 Green Energy and Climate Action

Thrithala is progressing toward becoming a green energy constituency:

- Solar Energy: 3,807 kilowatts of solar energy are being produced from rooftop installations, reducing carbon footprint and dependency on traditional energy sources.
- Waste Management and Clean Living
- The constituency has made strides in solid waste management through collaboration with the Suchitwa Mission and Clean Kerala Company:
- 234 Mini Material Collection Facilities (MCFs) have been installed—more than the initial 50.
- User fee collection exceeds 70% in 120 out of 135 wards; 42 wards achieved 100%.
- 281 tons of non-biodegradable waste were safely collected and disposed of, reducing carbon emissions by 16%.

7.1.7 Community Participation and Institutional Collaboration

A significant feature of Susthira Thrithala is the synergy between people and institutions:

- Community Involvement: Kudumbashree units, employment-guaranteed workers, resident associations, and local businesses are actively involved.
- Cloth Bag Campaign: Traders distributed 25,000 reusable cloth bags, contributing to the anti-plastic movement.
- School Engagement: Sustainability clubs in schools empower students, teachers, and parents to be environmental stewards.
- Business Support: Local businesses contributed seedlings for green spaces like Vidyavanam.
- Institutional Integration and Replicability

One of the unique strengths of the Susthira Thrithala model is its seamless institutional integration. A convergence of efforts from departments including Agriculture, Fisheries, Irrigation, Social Forestry, Biodiversity Board, Animal Husbandry, and Education ensures resource optimization and impact amplification.

The constituency also holds the distinction of being the first in India to prepare a Water Budget at both the gram panchayat and Constituency level - offering a blueprint for data-driven water governance.

7.1.8 Foundation for Scalable Development

Thrithala's integrated approach, leveraging 32 micro-watersheds and coordinated through LSGIs, establishes a framework for sustainable resource management. Collaboration with MGNREGS, NABARD, and state schemes ensures financial viability, supporting the expected goal of holistic development. While Thrithala's interventions show promise for adaptation in other Kerala panchayats facing groundwater challenges, ongoing evaluations are assessing scalability to ensure alignment with regional needs and SDG targets.

8. Conclusion

Decentralized water governance initiatives, though effective, frequently encounter sustainability issues when there is a change in political leadership or when funding priorities alter. These uncertainties can hinder maintenance efforts, impede progress, and compromise long-term results. To foster resilience, the article could suggest mechanisms like community-endowed trust funds, which guarantee financial stability regardless of government fluctuations. Furthermore, legally mandated conservation strategies—implemented through local governance structures—can formalize accountability and protect project objectives. Integrating these structural safeguards into the governance framework would not only improve accountability but also encourage community ownership and continuity. This important perspective would enhance the article's conclusion, providing practical guidance for replicability and lasting impact, while reinforcing the notion that institutional synergy should be integrated with resilience planning to achieve sustainable success in diverse political and economic contexts.

The Susthira Thrithala project stands as a model of decentralized, participatory, and sustainable development. By effectively managing its natural resources, particularly rainwater, and integrating agricultural revival with community empowerment, Thrithala has shown what is possible when vision meets action. The project's emphasis on using every drop of rainwater, reviving traditional water systems, and fostering institutional synergy offers valuable lessons for other regions facing ecological stress.

In its commitment to ensuring that not a single drop of rainwater goes unutilized, Thrithala is setting a precedent for holistic development. With ongoing efforts and community resolve, the constituency is well on its way to becoming a green, resilient, and self-sufficient region - a beacon for sustainable rural transformation.

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