"Minor Irrigation Tanks in South India: Design, Restoration and Sustainable Use: A Comprehensive Review"

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Abstract:

Water is the lifeblood of agriculture, and in South India, minor irrigation tanks have fulfilled this role for centuries. These small reservoirs are built to capture and store rainfall, providing farmers with much-needed water. However, over time, many tanks have fallen into disrepair due to siltation, encroachment, and poor maintenance. This has significantly reduced their ability to support the farming communities that rely on them. This combined study examines various aspects of minor irrigation tanks, including their history, importance, and financial support schemes like NABARD's RIDF. It also explores performance evaluation methods, new design proposals, and modern restoration tools such as GIS and remote sensing. Case studies from Karnataka and Kerala demonstrate how tanks can be improved, designed, and managed more effectively. The key takeaway is clear: tanks are not outdated relics but living systems that can recharge groundwater, support crops, and strengthen rural livelihoods if they are properly cared for. Restoring old tanks, building new ones where needed, and involving farmers in their management can make tank irrigation a cornerstone of sustainable water management for the future.

Keywords: *Minor Irrigation, Tank Irrigation, Water Security, NABARD RIDF, Irrigation Efficiency, Geospatial Technology, Rural Livelihoods, South India*.

1.Introduction

Water is one of the most critical resources for sustaining life and agriculture. In India, where nearly two-thirds of the population depends directly or indirectly on farming, irrigation is essential for ensuring food security and rural livelihoods. While large dams and canal systems often receive more attention, it is the smaller, localized irrigation systems particularly minor irrigation tanks that quietly sustain millions of farmers, especially in the southern states of India. Minor irrigation tanks are small reservoirs constructed to capture and store excess rainfall during the monsoon, making water available during dry spells. They are typically earthen bunds or embankments built across streams or drainage channels to collect runoff. Historically, these tanks were community-managed systems deeply integrated into the cultural and economic fabric of rural life. They not only supplied water for irrigation but also recharged groundwater, provided drinking water for humans and livestock, and supported fisheries and local ecosystems. Their command areas are usually smaller than 2,000 hectares, making them especially suitable for the small, fragmented landholdings common in South India. Despite their importance, these systems have sharply declined in recent decades. Several factors are responsible for this deterioration, including siltation of tank beds, weakened bunds, encroachment on catchment and command areas, and a lack of regular maintenance. The failure of monsoon rains has only worsened the situation, leaving many tanks dry or functioning far below capacity. Studies from Karnataka and Kerala show that thousands of tanks that once provided reliable irrigation are now underutilized or abandoned. This has forced farmers to rely heavily on groundwater extraction, leading to alarming rates of aquifer depletion and water scarcity. Recognizing this challenge, researchers and policymakers have been revisiting the role of minor irrigation tanks and developing strategies for their revival. A key initiative in this direction has been the establishment of the Rural Infrastructure Development Fund (RIDF) by NABARD in 1995. Through RIDF, thousands of irrigation projects including tank restoration, rural roads, and watershed development have been financed across states like Himachal Pradesh, Karnataka, and Tamil Nadu. These projects demonstrate that with the right institutional and financial support, even neglected tanks can be revived to provide dependable irrigation. Evaluation studies of RIDF-supported tanks highlight benefits such as increased cropping intensity, improved incomes for small farmers, and enhanced groundwater recharge.

Another area of focus is the performance evaluation of minor irrigation schemes. Using indicators like Relative Water Supply (RWS), Relative Irrigation Supply (RIS), and Standardized Gross Value of Production (SGVP), researchers assess whether tanks are delivering water efficiently, equitably, and sustainably. Case studies from Kerala, such as the Kanniparamba and Vellannur schemes, reveal that while water availability is often sufficient, inefficiencies in delivery and farmers' tendency to overuse water reduce overall productivity. These findings underscore the need for farmer participation, better scheduling of irrigation, and institutional reforms to maximize tank benefits. Design innovation has also emerged as a response to the challenges facing traditional tanks. In drought-prone districts like Bagalkot in Karnataka, engineers have proposed and designed new minor irrigation tanks to supplement failing older structures. Such projects combine hydrological data, topography, and rainfall analysis to build tanks that are better suited to local conditions. By strategically constructing new tanks upstream of silted or damaged ones, water storage capacity can be restored, groundwater recharge enhanced, and more land brought under irrigation. These engineering interventions demonstrate that tank irrigation is not just about preserving old systems but also about adapting them to contemporary needs.

Modern technology has added another dimension to tank management. Geospatial tools, such as GIS and remote sensing, are now being used to map, prioritize, and plan the restoration of thousands of tanks at a regional scale. A study in Karnataka applied GIS to classify tanks based on bund condition, turbidity, siltation levels, and weed infestation. This helped authorities decide which tanks required urgent intervention and what type of restoration activity such as desilting, bund strengthening, or catchment treatment was most appropriate. Such tools not only save time and resources but also ensure that restoration projects are scientifically guided and yield maximum benefits. Together, these research efforts paint a holistic picture: minor irrigation tanks remain one of the most valuable yet underutilized water resources in India. They are more cost-effective compared to large irrigation projects, easier to implement, and highly suitable for small-scale farmers. They offer multiple co-benefits irrigation, groundwater recharge, ecosystem services, and even drinking water supply. However, their sustainability depends on a combination of technical innovation, institutional support, financial investment, and active community participation.

In summary, the reviewed literature highlights four key directions for the future of minor irrigation in India:

- Restoration of existing tanks through desilting, bund strengthening, and catchment treatment.
- Performance evaluation to ensure water is used efficiently and equitably.
- Design of new tanks in regions facing chronic drought and siltation issues.
- Use of modern technologies like GIS and remote sensing to plan and monitor tank systems at scale.

By bringing together these approaches, minor irrigation tanks can once again become reliable sources of water, strengthen rural livelihoods, and contribute to national food security. As climate change and population growth intensify pressure on India's water resources, revitalizing these traditional yet adaptable systems is not only practical but essential.

2. Literature Review

Minor irrigation tanks have been a part of South India's farming landscape for centuries. These small water bodies, built across streams and low-lying areas, once ensured that farmers had water for their crops, drinking needs, and livestock even in dry months. They also helped recharge groundwater and supported village ecosystems. Over the years, however, many of these tanks have declined. Silt has reduced their storage capacity, bunds have weakened, and some have even been encroached upon. The result has been greater pressure on groundwater and reduced reliability of irrigation. Researchers have studied this issue from different angles. Niasi (2018) [8] stressed how important minor irrigation still is, pointing out that it contributes nearly 60% of India's irrigation potential. For farmers in drought-prone regions, tanks are often the only dependable source of water. Beyond irrigation, they serve a wider role in maintaining wetlands, biodiversity, and rural water supply. But the same study also warned that neglect and poor upkeep have made many tanks less effective than they once were. Other researchers have focused on measuring performance. Chandran and Ambili (2016) [7], in their study of tanks in Kerala, found that the problem was not just about water storage but also about how the water was used. Even when tanks had enough water, farmers often applied it inefficiently, and those at the tail end of canals received less. Using indicators such as Relative Water Supply and Standardized Gross Value of Production, they showed that management and scheduling are just as important as storage in ensuring tank efficiency. On the engineering side, Bangi (2016) [2] presented a case study from Bagalkot, Karnataka, where a new tank was designed to serve drought-hit farmland. The design included stronger bunds, surplus weirs for flood safety, and lined canals to cut down water loss. This project highlighted how carefully planned new tanks can give farmers a reliable water source and revive agricultural production in areas facing repeated crop failures.

Financing has also played a big role. A government study on projects funded through NABARD's (2001) [9] Rural Infrastructure Development Fund (RIDF) showed that access to timely funds allowed states to restore and build thousands of small schemes, including tanks. Farmers in areas covered by these projects benefited from higher cropping intensity, more stable incomes, and better groundwater recharge. The lesson here is clear: technical designs only succeed when backed by strong financial and institutional support. Modern technology is now being added to the mix. Kumar and colleagues (2016) [5] used Geographic Information Systems (GIS) and remote sensing in Karnataka to map and prioritize tanks. Instead of working on all tanks at once, they identified the ones in greatest need those with heavy siltation, bund damage, or weed growth. This approach made restoration efforts more efficient and easier to monitor. Taken together, these studies show a common pattern. Tanks are still essential for agriculture and rural life, but they face serious challenges of neglect and misuse. At the same time, the research proves that solutions exist through better management, innovative engineering, reliable funding, and the smart use of technology. What emerges from the literature is not just a picture of decline, but also a roadmap for revival.

3. Justification:

3.1. Significance:

Minor irrigation plays a far more important role in India's water management than is often recognized. According to national planning statistics, nearly 60% of the country's total irrigation potential comes from minor irrigation sources such as tanks, wells, and tube wells. This means that while large dams and canal networks are highly visible, it is these smaller and decentralized systems that sustain the majority of India's farmers. In drought-prone and semi-arid regions, minor irrigation tanks serve as lifelines. Farmers in these areas cannot depend solely on unpredictable monsoon rainfall. Tanks store water during the rainy season and release it gradually during dry months, ensuring that crops like paddy, banana, and vegetables receive water at the right time. This stability helps safeguard food production even in years of weak rainfall.

Beyond agriculture, tanks also provide multiple co-benefits. Many rural villages depend on tank water for drinking, livestock, and household use during summers. They also play a vital role in groundwater recharge. When water is stored in tanks, a significant portion percolates through the soil, replenishing aquifers and reducing the pressure on borewells. In regions where groundwater over-extraction is a serious concern, tank-based recharge acts as a natural safety net. From a broader perspective, tank irrigation supports rural livelihoods and social stability. By securing water for farming, tanks indirectly support employment, reduce migration to cities, and contribute to food security for local communities. In short, tanks are not merely irrigation structures; they are multi-functional assets central to the survival and prosperity of rural India.

3.2. Advantages:

One of the strongest arguments for focusing on minor irrigation is their cost-effectiveness. Compared to major dams and canal projects, tanks are much cheaper to build and maintain. They require less land acquisition, face fewer environmental hurdles, and can be implemented within shorter time frames. This makes them highly suitable for states and districts with limited resources. Minor irrigation tanks are also better suited to India's agricultural landscape, which is dominated by small and fragmented farms. Large canal systems often fail to serve marginal farmers at the tail end of distribution networks. In contrast, localized tanks directly benefit smallholders within their command area. This ensures that irrigation is more equitable and accessible.

Another significant advantage is that tanks encourage community participation and ownership. Historically, villages managed their tanks collectively, sharing responsibility for maintenance and water distribution. Reviving this participatory model strengthens local institutions like Water User Associations (WUAs) and reduces dependence on external agencies. When farmers feel a sense of ownership, they are more likely to maintain the system responsibly. In addition, minor irrigation tanks provide important ecological benefits. Many tanks double as wetlands, supporting aquatic life, migratory birds, and biodiversity. By storing surface water, tanks also reduce dependence on over-extracted groundwater, which in turn helps maintain ecological balance. During heavy rainfall, tanks act as buffers by holding excess runoff, thereby reducing flood risks downstream. In essence, tanks contribute simultaneously to agricultural productivity, environmental conservation, and disaster risk reduction.

3.3. Applications:

The applications of minor irrigation tanks extend across multiple sectors, making them highly versatile systems. Their primary use is, of course, in crop irrigation. Crops such as paddy, banana, sugarcane, and vegetables are highly water-dependent and require assured irrigation at critical growth stages. Tanks help provide this timely water supply, ensuring higher yields and stable income for farmers.

Tanks are especially critical in drought-affected districts like Bagalkot in Karnataka, where frequent crop failures due to low rainfall have devastated rural communities. In such regions, building new tanks or restoring old ones can transform barren lands into productive fields, reduce farmer distress, and stabilize local economies. Case studies from Bagalkot show that even a single well-designed tank can support hundreds of farmers by irrigating silted command areas and recharging groundwater for wells.

Beyond farming, tanks are valuable for watershed management and flood control. By capturing runoff during the monsoon, they reduce soil erosion, prevent downstream flooding, and improve soil moisture in surrounding areas. This watershed effect extends benefits beyond the immediate command area, supporting forestry, grazing lands, and rural water supply. With the advent of modern technology, tanks also find application in large-scale restoration and planning using GIS (Geographic Information Systems) and remote sensing. Government agencies can now map thousands of tanks across a state, classify them based on siltation, turbidity, or bund condition, and prioritize them for intervention. Such systematic planning ensures that limited funds are directed where they are needed most, maximizing impact.

In addition, tanks are increasingly being recognized for their role in climate resilience. As rainfall patterns become more erratic due to climate change, localized storage systems like tanks provide flexibility and security. By diversifying water sources surface storage, groundwater recharge, and community access tanks make rural systems more resilient to droughts and floods alike.

4. Case studies

4.1. Kerala: Evaluating Tank Efficiency

A study of two irrigation schemes in Kerala, Kanniparamba and Vellannur, showed that the problem is not always about water shortage. The tanks had enough water stored, but farmers were using it inefficiently. Some took more than their share, while others at the tail-end of the canals received very little. Researchers used indicators like water supply and crop output to measure performance, and their results made one thing clear: tanks need not just water but also better management and farmer coordination to deliver benefits fairly.

4.2. Karnataka: Designing New Tanks for Drought Areas

In Bagalkot district of Karnataka, drought had left large areas of farmland unproductive. To tackle this, engineers designed a new minor irrigation tank with a strong earthen bund, surplus weir for flood safety, and lined canals to reduce water loss. This tank was planned to irrigate about 120 hectares of crops like paddy and vegetables. The project proved that new tanks, when carefully designed using local rainfall and catchment data, could give farmers a reliable water source even in areas hit by repeated droughts.

4.3. RIDF Funding: The Role of Finance

Money is often the biggest barrier to reviving tanks. A study on irrigation projects under the Rural Infrastructure Development Fund (RIDF), financed by NABARD, showed how important timely funding can be. Tanks restored with this support saw better water availability, higher cropping intensity, and improved farmer incomes. Although this study focused on Himachal Pradesh, its lessons are equally relevant in South India: without financial backing and proper planning, even the best-designed projects remain on paper.

4.4. Karnataka: Using GIS for Smarter Restoration

Another study in Karnataka took a modern approach by using GIS and satellite data. Instead of randomly selecting tanks for repair, researchers mapped hundreds of them and classified them by their condition bund stability, weed infestation, siltation, and turbidity. This allowed planners to decide which tanks needed urgent work, such as desilting or bund strengthening, and which could wait. By combining fieldwork with geospatial tools, restoration became not only faster but also more cost-effective.

5.Implementation:

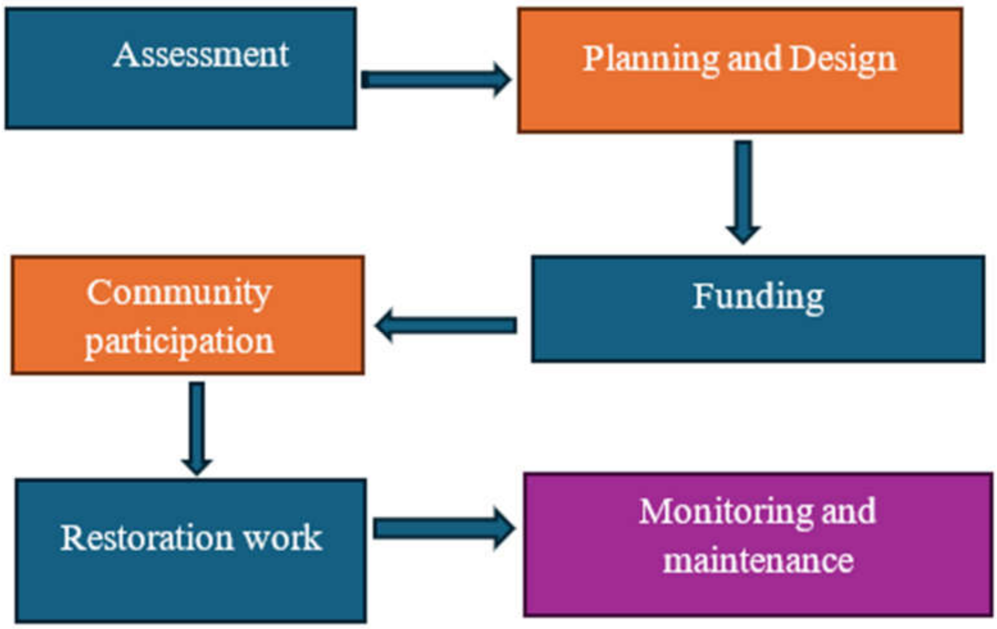

Figure 2: Flow chart of above implementation of minor irrigation.

5.1. Assessment:

The first step is to conduct a detailed assessment of existing tanks and potential new sites. This involves field surveys to document the physical condition of the tank bund, sluice gates, surplus weirs, and canal networks. Equally important is measuring the extent of siltation, which directly reduces the storage capacity of the tank. In many older tanks, decades of neglect have resulted in reduced water holding capacity by more than half. Assessments also include mapping encroachments in the catchment and command areas, identifying damaged canals, and understanding the cropping patterns of farmers who depend on the tank. This baseline information helps planners understand the scale of intervention required.

5.2. Design/Redesign:

Once tanks are prioritized, the next stage is engineering design or redesign. This could involve preparing new layouts for bund strengthening, upgrading sluice gates, or lining canals to reduce seepage. In cases where existing tanks are beyond repair or heavily silted, proposals for new minor irrigation tanks are developed. Engineers must carefully consider rainfall patterns, catchment hydrology, soil type, and crop water requirements. A well-prepared design balances storage capacity with the water needs of the Cultural Command Area (CCA). In some projects, tanks are designed upstream of older ones to rejuvenate silted command areas and increase groundwater recharge.

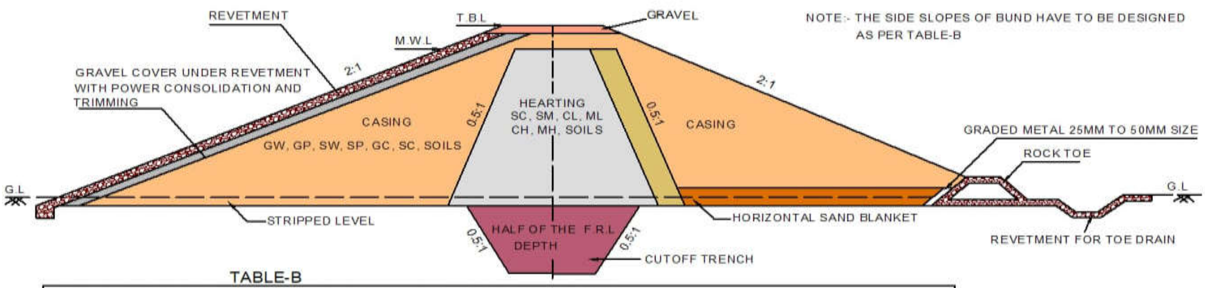

TABLE-B

RECOMMENDED SLOPES FOR SMALL ZONED EARTH FILL DAMS ON STABLE FOUNDATIONS

SL.N	CASE	CASING SOIL CLASSIFICATION	HEARTING SOIL CLASSIFICATION	UP STREAM SLOPE	DOWN STREAM SLOPE
1	ZONEL SECTION WITH 0.5:1 SLOPES FOR HEARTING SOILS	GW, GP, SW(GRAVELLY) SC, GC, SP	SC, SM, CL ML, CH, MH	2:1	2:1
2	ZONEL SECTION WITH 1:1 SLOPES FOR HEARTING SOILS	GW, GP, SW(GRAVELLY) SC, GC, SP	CL, ML CH, MH	2.5:1 3:1	2.5:1 3:1

EARTHEN DAM SECTION 7.5 M TO 10.4 M HEIGHT

(Source: irrigation picture from net resources)

Figure 1: Design of minor irrigation tank

5.3. Funding:

No irrigation project can proceed without financial backing. In India, most tank restoration projects are supported through government schemes and financial institutions. The Rural Infrastructure Development Fund (RIDF) managed by NABARD is a major source of funding, along with state irrigation budgets and special programs such as the Pradhan Mantri Krishi Sinchayee Yojana

(PMKSY). Proposals prepared by engineers and planners are reviewed for technical feasibility, financial viability, and socio-economic benefits before loans or grants are sanctioned. Since minor irrigation tanks are relatively low-cost compared to major dams, they offer excellent returns on investment, making them attractive for funding.

5.4. Community Role:

One of the most critical aspects of successful implementation is involving local communities. Historically, tanks were managed collectively by farmers, but in recent decades, this practice has weakened. Reviving this tradition through Water User Associations (WUAs) or village committees is essential. Farmers are encouraged to participate in planning, contribute labour or resources during restoration, and share responsibility for future maintenance. This participatory model not only reduces dependency on external agencies but also builds a sense of ownership. When communities feel responsible, tanks are less likely to fall into neglect again.

5.5. Restoration Work:

With plans and funds in place, actual restoration work begins. This can include:

- Desilting to restore lost storage capacity.
- Strengthening or raising bunds to prevent breaches during heavy rains.
- Repairing sluice gates and surplus weirs for controlled water distribution.
- Canal lining to reduce seepage losses and improve water use efficiency.
- Catchment area treatment, such as afforestation and check dams, to reduce future siltation.

The exact mix of activities depends on the condition of each tank. For example, tanks in drylands may require large-scale desilting, while those in semi-arid zones may need bund reinforcement and canal redesign.

Conclusion:

Minor irrigation tanks may be old, but they are not outdated. In fact, they are more relevant today than ever before. With water scarcity growing, these small but powerful systems can help bridge the gap between rainfall and crop needs. Studies from South India show that with proper design, financial support, and community involvement, tanks can once again deliver reliable irrigation, recharge aquifers, and improve rural livelihoods. The path forward lies in combining tradition with technology: reviving ancient tanks, designing new ones where needed, and using tools like GIS to manage them smartly. If managed well, tanks can truly deliver on the promise of “more crop per drop” and support sustainable agriculture in water-stressed regions.

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