

Institutional Determinants of Post-Project Sustainability in Converged Watershed Development: Evidence from Telangana, India

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Abstract

Watershed development programmes in semi-arid India reliably raise water tables and yields while projects are running, but whether these gains survive the withdrawal of the implementing agency is rarely observed. This paper examines the post-closure sustainability of four Integrated Watershed Management Programme (IWMP) clusters in Nalgonda district, Telangana, six to seven years after project closure, in villages that also received Mission Kakatiya tank restoration and MGNREGS earthworks. Drawing on a 2023–24 survey of 387 households (237 beneficiaries, 150 matched controls) in 32 villages, focus-group discussions, a structure audit, departmental water-level monitoring and an independent State Level Nodal Agency audit, it classifies each micro-watershed as sustainable, transitional or vulnerable using three criteria: a Community Participation Index, the share of structures in working order, and the post-closure water-table trend. The share of structures in full working order fell from 94 per cent at closure (2017) to 71 per cent in 2024, about four percentage points a year. Only 11 of 32 micro-watersheds (34 per cent) are sustainable; 13 are transitional and 8 vulnerable, with sustainability ranging from 83 per cent of micro-watersheds in Shaligowraram to 9 per cent in Thipparthi under a common rainfall regime. The variables that separate the categories are institutional: the age of the village federation at sanction, the identity and continuity of the implementing agency, and the time elapsed since its exit. The findings extend the institutions-over-structures thesis to the 2008 Common Guidelines architecture and argue for a funded post-closure consolidation phase and a state-level sustainability index.

Keywords: watershed development; post-project sustainability; common-pool institutions; programme convergence; Mission Kakatiya; semi-arid Deccan; India; mixed methods

1. Introduction

Watershed development has been the principal instrument of Indian rainfed-agriculture policy for three decades. Since the Common Guidelines of 1995 and their revision in 2008, more than 50 million hectares have been treated on a watershed basis, and meta-analyses of several hundred projects report mean benefit–cost ratios around two and internal rates of return above twenty per cent (Joshi et al., 2008; Wani et al., 2008). The evidence on impact is therefore no longer in serious dispute. What remains unresolved is durability. Kerr (2002) and Vaidyanathan (2006) argued two decades ago that the gains from watershed treatment persist only where community institutions survive the project, and the most recent official assessment of the current programme cycle names post-project consolidation as the binding constraint on long-run outcomes (Department of Land Resources, 2024). Yet almost all published evaluations are cross-sectional and conducted within a year or two of closure, when construction-period wages, new structures and a functioning implementing agency are still visible. Whether the water table, the structures and the committees are still there a decade later is rarely observed.

The problem has become more pressing rather than less. The Watershed Development Component of the Pradhan Mantri Krishi Sinchayee Yojana (WDC-PMKSY 2.0, 2021–2026) has adopted a saturation approach on the evidence that concentrated treatment is more durable than the fragmented project approach of its predecessor (NABARD, 2022), and states such as Telangana have layered their own tank-restoration programmes over the central watershed scheme, so that a single landscape now receives several overlapping treatments (Government of Telangana, 2015–2024). Convergence of this kind raises the stakes of sustainability: if the institutional arrangements for the years after closure are absent, the erosion of gains applies to a larger public investment. It also complicates evaluation, because the outcome to be sustained is the joint product of several programmes.

This paper asks a narrower question than the impact literature and answers it with a design that impact studies rarely have. It asks what proportion of the micro-watersheds treated in one district between 2010 and 2017 remain sustainable six to seven years after closure, what distinguishes those that do from those that do not, and whether the distinguishing factors are institutional, physical or agro-climatic. The setting is four contiguous mandals of Nalgonda district, Telangana, chosen because they share a rainfall regime and a hard-rock aquifer but differ in implementing agency, in the age of the village institutions the programme could work through, and in the time elapsed since the agency withdrew. This within-district, cross-institutional design allows the institutional and the agro-climatic explanations of sustainability to be separated in a way that multi-state comparisons cannot.

The paper makes four contributions. It provides a post-closure observation window of six to seven years, longer than any evaluation of the 2008 Guidelines architecture reviewed here. It measures sustainability at the level of the individual micro-watershed with a transparent three-criterion typology anchored to an independent external audit. It identifies the institutional variables that discriminate between sustainable and unsustainable units under a common rainfall regime. And it documents the rate at which physical assets decay once the implementing agency leaves, a parameter that has not previously been quantified for Indian watersheds and that directly informs the design of a consolidation phase. The remainder of the paper reviews the literature and sets out the conceptual framework (Section 2), describes the study area (Section 3) and the data and methods (Section 4), presents results (Section 5), discusses them against theory and prior evidence (Section 6), and draws policy implications, limitations and conclusions (Sections 7–9).

2. Literature and Conceptual Framework

2.1 From impact to sustainability

The watershed-evaluation literature has passed through three phases. The first established that participatory treatment produces measurable biophysical and economic gains: Kerr (2002), comparing participatory and non-participatory watersheds across Andhra Pradesh, Karnataka and Maharashtra, found significant gains in recharge, cropping intensity and productivity; Reddy et al. (2004) reported water-table rises of 1.5–4.5 m and irrigated-area gains of 12–30 per cent in Andhra Pradesh; and Joshi et al. (2008) and Singh et al. (2014) set the benchmark ranges of 15–40 per cent for cropping-intensity gains and 20–80 per cent for productivity. The second phase qualified the gains on distributional and hydrological grounds. Reddy and Soussan (2004) showed that recharge benefits accrue disproportionately to well-owning farmers, Hope (2007) that household uptake depends on credit and labour-market access, and Batchelor et al. (2003), Calder et al. (2008), Bouma et al. (2011) and Glendenning et al. (2012) that upstream harvesting can impose downstream costs, so that net benefits must be judged at basin as well as plot scale. The third phase, still thin, concerns what happens after the project ends. Kerr et al. (2002) found that watersheds with strong, autonomous institutions retained a much larger share of their assets and functions five years after closure than those where institutions were weak; Vaidyanathan (2006) concluded that programmes heavy on engineering and light on institution-building failed; and Shah (2013) identified the chronic maintenance-financing gap that opens once operation and maintenance pass to the Gram Panchayat. Rao (2000) had warned earlier that "success" in Indian watershed parlance had come to mean budget absorption and coverage rather than sustained livelihoods.

What the third phase lacks is longitudinal observation under the current institutional architecture. The 2008 Common Guidelines, revised in 2011, created a new structure — Watershed Committees, User Groups, a Watershed Development Fund, a Project Implementing Agency contracted for a fixed cycle, and a State Level Nodal Agency — and prescribed closure reports, post-closure progress reports and a mid-term sustainability audit. Whether this architecture produces more durable outcomes than the Hariyali model that Sivanna (2009) criticised for hollowing out technical capacity has not been tested with village-level data more than five years after closure.

2.2 Institutions and the durability of collective assets

The theoretical basis for expecting institutions to matter more than structures lies in the common-pool-resource literature. Recharged groundwater, restored tanks and treated commons are subtractable and difficult to exclude from; their maintenance is a collective-action problem that Ostrom (1990) showed is solved, where it is solved, by locally crafted rules, monitoring and graduated sanctions rather than by external engineering. Agrawal (2001) synthesised the conditions under which such institutions endure — small, clearly bounded groups, past experience of cooperation,

low-cost enforcement, and supportive external authority — and Ostrom (2009) placed them within a social-ecological systems framework in which resource units, resource systems, users and governance systems interact. Meinzen-Dick (2007) cautioned that no single institutional form is a panacea for water and that the fit between institution and local context determines performance. Two implications follow for watershed sustainability. First, a programme that must create institutions from nothing within a five-year cycle is asking for a level of collective action that the literature associates with long-established groups; a programme that can attach itself to existing federations of self-help groups or tank-farmer associations inherits the prior cooperation that Agrawal identifies as decisive. Second, the exit of the external agency removes what Ostrom calls nested support, so that the trajectory after closure is a test of whether the local institution had become self-sustaining.

2.3 Convergence in Telangana

Telangana has been an unusually active watershed state. Undivided Andhra Pradesh attracted the largest share of national watershed funding through the 1990s and 2000s, which Springate-Baginski et al. (2001) attributed to institutional creativity rather than technical superiority, and Clement and Chandrappagari (2014) documented the gap between guideline and practice in its implementation. Since state formation in 2014, Mission Kakatiya has restored minor irrigation tanks across the state in five phases, and evaluations report yield gains from silt application and groundwater improvements in restored commands (Fasi, 2019; Gumma et al., 2023; Reddy et al., 2018 place the programme within the wider Indian tank-rehabilitation evidence). Where restored tanks are the terminal storages of treated micro-watersheds, the watershed and tank programmes operate on one hydrological unit, and MGNREGS earthworks add a third funding stream. No published study reviewed here reports village-level sustainability outcomes for IWMP clusters that also received Mission Kakatiya restoration, and none compares institutionally distinct clusters within one district under a common rainfall regime.

2.4 Conceptual framework

The paper treats sustainability as the maintenance of three interdependent stocks after external support is withdrawn: the physical stock of structures, the hydrological stock of recharged groundwater, and the institutional stock of functioning committees, user groups and maintenance arrangements. The stocks are linked: structures maintain recharge, institutions maintain structures, and recharge sustains the private returns that give households a reason to maintain institutions. Three groups of factors act on the stocks. Institutional factors are the quality and continuity of the implementing agency, the strength and age of the village institutions it could work through, the stability of the Gram Panchayat, and whether any arrangement existed for the post-closure years. Physical factors are the siting and quality of structures and the maintenance regime left behind. Contextual factors are rainfall, soils, slope and the pre-treatment condition of the land. The empirical question is which group discriminates between micro-watersheds that retain their stocks and those that lose them, and the design holds the contextual group approximately constant so that the institutional and physical groups can be compared.

3. Study Area

Nalgonda district lies in southern Telangana between 16°25' and 17°50' N and 78°40' and 80°05' E, on the granite-gneiss basement of the Deccan Plateau, with mean annual rainfall of 778 mm (1991–2020) and a coefficient of variation of 24 per cent. It has the highest net sown area in the state (3.78 lakh ha in 2022–23), received large watershed investment under the Drought Prone Areas Programme and IWMP, and has seen systematic Mission Kakatiya tank restoration since 2015. The four sample mandals — Nakrekal, Shaligowraram, Thipparthi and Kattangoor — form a contiguous block of about 705 km² in the north-eastern quadrant of the district, on the Musi sub-basin and the district's principal aquifer corridor (Figure 1). Three of the four receive 750–778 mm of rain; Thipparthi receives about 1,035 mm because of orographic enhancement by the Somaraju Cheruvu hill complex. Pediplained granite-gneiss with slopes below 3° dominates the terrain; vertisols occupy the pediplain and luvisols the pediment margins; before treatment, static water levels of 32–42 m below ground level reflected an over-drawn borewell economy with about twelve wells per square kilometre in Nakrekal.

The four IWMP clusters were sanctioned between 2010–11 and 2011–12 and closed in 2017 (Sarvaram, sanctioned a year later, closed in 2018). Three implementing configurations are represented: the DHAN Foundation, a non-

governmental organisation with a pre-existing federation of women's self-help groups and tank-farmer associations, implemented Utkur (Shaligowraram) and Sarvaram (Thipparthi) and worked with the District Water Management Agency (DWMA) in Mangalpally (Nakrekal); Access Livelihoods Consulting India worked with DWMA in Eduloore (Kattangoor) and promoted a farmer producer organisation there in 2017. The DHAN federation predated the IWMP cycle by several years in Shaligowraram but had entered Thipparthi only in 2009. The four clusters therefore differ in the age of the village institution at sanction, the identity of the agency and the time since its exit, while sharing terrain, aquifer and, with the exception of Thipparthi's higher rainfall, climate.

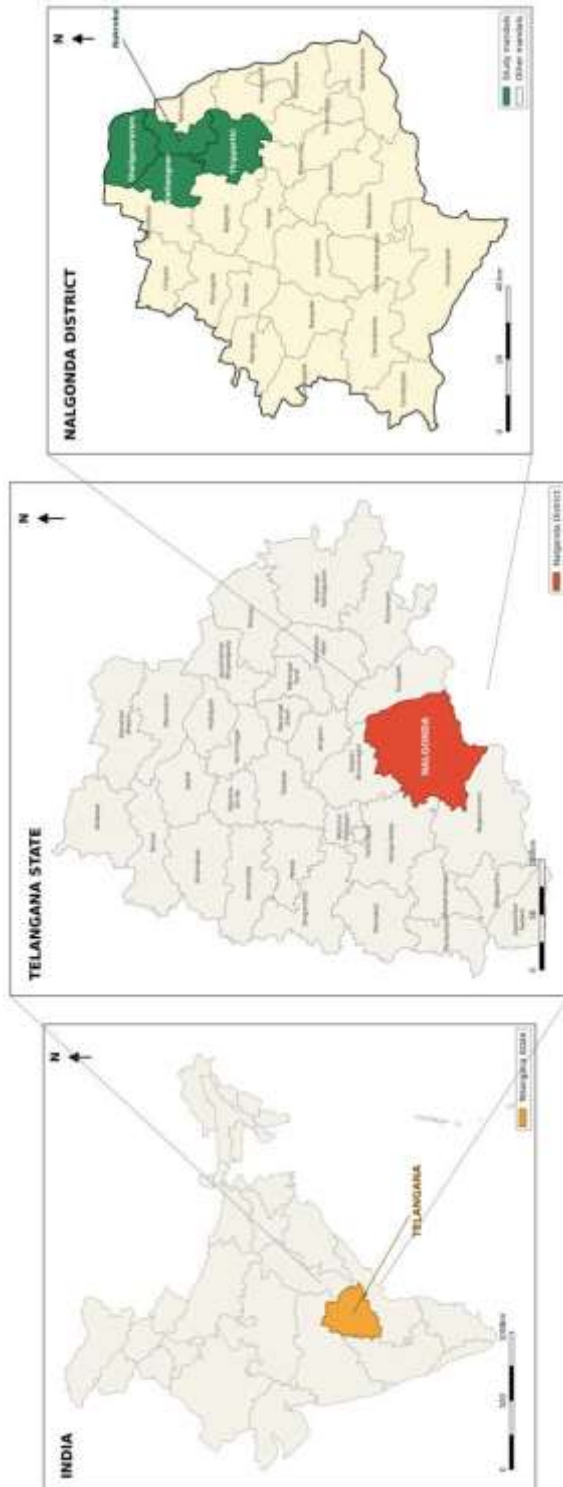


Figure 1. Location of the four study mandals within Nalgonda district, Telangana, India (composite location map). Source: Census of India 2011 administrative boundaries and Survey of India digital topographical database; map prepared by the authors.

4. Data and Methods

4.1 Research design

The study combines a retrospective before–after comparison with a contemporaneous matched comparison group, embedded in a village-level record spanning 2010–2024, and a mixed-methods strategy in which qualitative evidence is used to explain rather than to supplement the quantitative record. For the sustainability question that is the focus of this paper, the design is a cross-institutional comparison: four clusters under a common rainfall regime and a common treatment package, differing in institutional history, observed six to seven years after closure. The unit of classification is the micro-watershed village ($n = 32$), and the unit of explanation is the cluster ($n = 4$).

4.2 Sampling and data collection

A multi-stage stratified sampling design selected the four mandals purposively for institutional and agro-ecological diversity, the 32 treated villages (7 in Nakrekal, 6 in Shaligowraram, 11 in Thipparthi, 8 in Kattangoor) from the sanctioned micro-watershed registers, and matched comparison villages in the same mandals by propensity-score matching on geographical area, net sown area, 2011 population, social-group composition, mean annual rainfall and the absence of any watershed work between 2010 and 2024. Households were drawn by stratified random sampling from Project Implementing Agency beneficiary registers (treated) and Mandal Revenue Office rosters (comparison), stratified by land-holding category. The realised sample is 387 households: 237 beneficiaries and 150 comparison households, distributed 98:98:98:93 across the four mandals (Table 1). Small and marginal cultivators constitute 61 per cent and landless households 14.7 per cent of the sample, and Scheduled Caste and Scheduled Tribe households 25.9 per cent; the treated and comparison cohorts are balanced on these characteristics.

Primary data were collected during the 2023–24 field season through a structured household schedule; a village schedule administered to the Watershed Committee, Gram Panchayat and self-help-group federation in each village, including an inventory of every structure built under IWMP and Mission Kakatiya and its present condition; focus-group discussions in each of the 32 villages between October 2023 and March 2024 with six to eight participants (the Watershed Committee president or sarpanch, two SHG-federation leaders, two lead farmers of each sex, and one or two long-standing residents); key-informant interviews with the DWMA Project Director, Mandal Development and Revenue Officers and DHAN field staff; water-level measurement in selected open and bore wells in May–June 2024; and a transect walk across each anchor micro-watershed. A spot-check of the principal structures was repeated in November 2024 after an unusually heavy monsoon. Secondary data comprise the Detailed Project Reports (2011–2014), DWMA monitoring reports (2010–2017), the Annual Progress Reports on completed clusters submitted to the State Level Nodal Agency (2018–2024), the SLNA Mid-Term Sustainability Audit of 2022 conducted by NABCONS with the Centre for Economic and Social Studies, Mission Kakatiya programme records and MGNREGS convergence registers. All respondents gave informed verbal consent in Telugu; no personally identifying information is reported.

Table 1. Sample clusters, implementing agencies and realised household sample by mandal

Mandal	IWMP cluster (implementing agency)	Sanction / closure	Treated villages	Treated households	Comparison households	Total
Nakrekal	Mangalpally (DHAN Foundation with DWMA-Nalgonda)	2010–11 / 2017	7	60	38	98
Shaligowraram	Utkur (DHAN Foundation)	2010–11 / 2017	6	59	39	98
Thipparthi	Sarvaram (DHAN Foundation)	2011–12 / 2018	11	58	40	98
Kattangoor	Eduloore (ALC India with DWMA-Nalgonda; FPO from 2017)	2010–11 / 2017	8	60	33	93

Mandal	IWMP cluster (implementing agency)	Sanction / closure	Treated villages	Treated households	Comparison households	Total
Total	—	—	32	237	150	387

4.3 Measures

Three measures underpin the typology. The Community Participation Index (CPI) is constructed at village level from four measures of current institutional functioning — Watershed Committee meetings held in the preceding year, the percentage of members attending regularly, the percentage of beneficiaries participating in maintenance, and the percentage willing to contribute to maintenance — together with the gender balance of committee, user-group and SHG membership; each is scored 0–100 and the village CPI is the composite on a 0–100 range. The structure-condition measure is the percentage of structures built under IWMP and Mission Kakatiya that were in full working order at the 2024 audit, from the village inventory and transect walk. The water-table trend is the direction of the static water level in the village observation well since closure, from the SLNA monitoring network and the 2024 field readings, classified as rising, stable or declining. The CPI is deliberately a measure of current activity; because activity decays with time since the implementing agency withdrew, a mandal with a middling mean CPI can contain villages above the upper threshold and vice versa, and the typology is therefore applied to village scores rather than mandal means.

4.4 The sustainability typology

A micro-watershed is classified as Sustainable when at least two of the three indicators meet the upper threshold (CPI above 70; more than 80 per cent of structures functional; water table rising or stable) and none falls to the lower threshold; as Vulnerable when at least two fall to the lower threshold (CPI below 55; less than 50 per cent functional; declining water table); and as Transitional otherwise (Figure 2). The classification was validated at cluster level against the independent SLNA audit of 2022, which classified completed clusters as Sustainable, Transitional or Vulnerable on a comparable basis and had no access to the present study's data. Qualitative data from the focus groups and interviews were coded around five themes — drivers of participation, barriers to maintenance, inter-group equity, gender dynamics and convergence — and used to explain the distribution of categories. Because the departmental monitoring series were furnished in aggregate, the comparisons reported are of means and proportions and their consistency across independent evidence streams rather than of formal significance tests; the implications of this choice are discussed in Section 8.

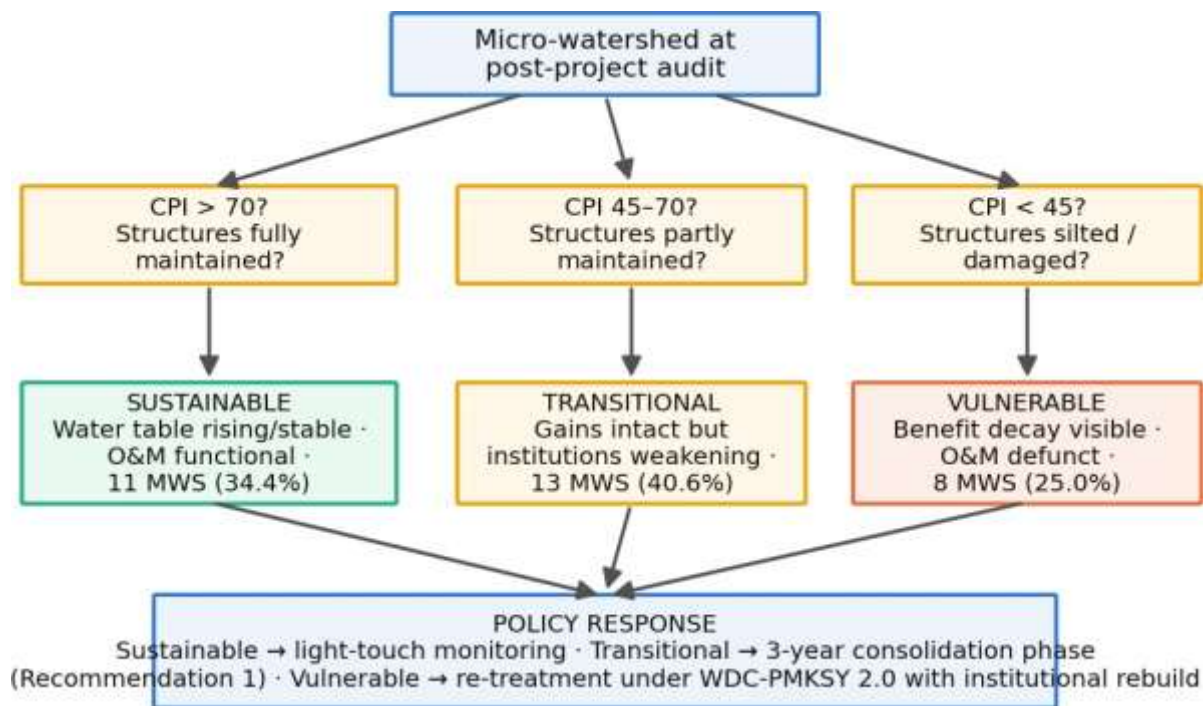


Figure 2. Decision tree of the three-criterion sustainability typology and the differentiated policy response attached to each category. Source: authors.

5. Results

5.1 The post-closure trajectory of physical assets

The Annual Progress Reports and the 2024 audit allow the condition of the physical stock to be traced from closure (Figure 3a). The share of check dams, percolation tanks and other structures in full working order across the four clusters fell from 94 per cent at closure in 2017 to 84 per cent in 2020, 76 per cent in 2023 and a mean of 71 per cent at the May–June 2024 spot-check, a loss of roughly four percentage points a year. The hydrological stock has held better: the recovery in static water level measured at closure has largely persisted, with the cluster means settling 4.5–6.5 m above the pre-treatment position in the SLNA observation wells. The two stocks diverge because a recharge structure continues to function for some years after it is damaged, whereas the committees that would repair it lose their reason to meet as soon as construction wages cease. The cluster-level condition in November 2024 (Figure 3b; Table 2) ranged from 82 per cent functional in Utkur to 62 per cent in Sarvaram, and the 2024 monsoon, more than 50 per cent above the ten-year mean in every mandal, breached three of eight Mission Kakatiya tanks in Utkur, cracked a percolation tank and breached the Nakrekal Pedda Cheruvu twice in Mangalpally, cracked two check dams in Eduloore, and destroyed foreshore and avenue plantations in Sarvaram. Structures designed against the 1971–2010 rainfall record were tested by a storm outside their design assumptions, and the damage fell most heavily where maintenance was already weakest.

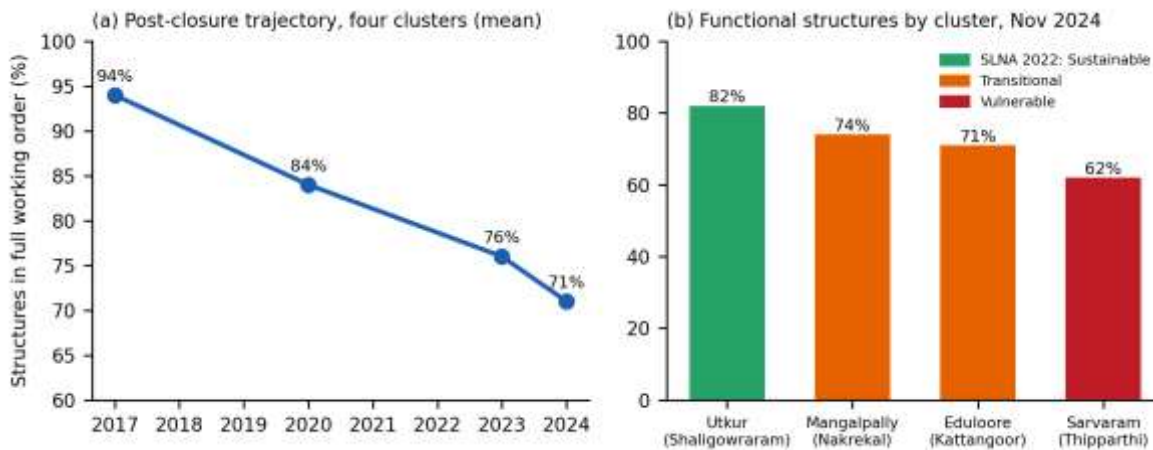


Figure 3. (a) Share of IWMP and Mission Kakatiya structures in full working order across the four clusters, 2017–2024, from DWMA Annual Progress Reports and the 2024 field audit; (b) functional structures by cluster in November 2024, coloured by the SLNA 2022 audit category. Source: authors, from DWMA-Nalgonda (2018–2024) and field audit.

Table 2. Post-closure sustainability status of the four IWMP clusters, November 2024

Cluster (mandal)	SLNA audit 2022	Structures functional (%)	Water-table trajectory since closure	2024 monsoon damage
Utkur (Shaligowraram)	Sustainable	82	Stable–rising	Minimal; 3 of 8 Mission Kakatiya tanks breached at embankment/spillway
Mangalpally (Nakrekal)	Transitional	74	Stable	Moderate; Tettekunta percolation tank cracked; Nakrekal Pedda Cheruvu breached twice
Eduloore (Kattangoor)	Transitional	71	Stable	Moderate; check dams at Naragudem and Pandenapally cracked
Sarvaram (Thipparthi)	Vulnerable	62	Declining	Substantial; foreshore and avenue plantations lost

5.2 The institutional stock

Current institutional activity measured by the CPI (Table 3; Figure 4b) ranges from 78 in Kattangoor, where the committee meets 6.4 times a year, 48 per cent of members attend regularly and 68 per cent would pay for maintenance, to 48 in Nakrekal, where the committee meets barely twice a year, attendance has fallen to 12 per cent and only a third would contribute. Thipparthi (64) and Shaligowraram (56) occupy the middle. The ordering is not the ordering of accumulated welfare gain, on which Shaligowraram leads on every perception domain and Thipparthi trails; it is the ordering of the age of the most recent institutional intervention. Kattangoor's producer organisation, formed in 2017, is the newest institution in the sample and the only one whose promoting agency was still active at the survey; Shaligowraram's federation, the oldest, has partly faded in the decade since DHAN's contracted role ended; Nakrekal, where DHAN worked alongside the district agency rather than through its own federation, has decayed furthest. Participation, in other words, decays with time since the implementing agency left unless it is deliberately renewed.

Table 3. Community Participation Index and its components by mandal, 2023–24

Mandal	Committee meetings per year	Regular attendance (%)	Participation in maintenance (%)	Willing to pay for maintenance (%)	Composite CPI (0–100)
Nakrekal	2.4	12	8	32	48
Shaligowraram	3.8	22	16	44	56
Thipparthi	4.2	24	18	48	64
Kattangoor	6.4	48	38	68	78
Sample mean	4.2	26.5	20.0	48.0	61.5

The focus groups explain the decay in consistent terms across all 32 villages. Participation during construction rested on four drivers: the wage employment the works provided through IWMP and MGNREGS; the visible deterioration of wells and the lengthening tankering season, which created urgency; the reach of the implementing agency, decisive where DHAN's federation gave the package a ready-made institution; and the leadership of a respected committee president. Five connected factors then weakened participation after closure. The agency's withdrawal removed the force that kept the committee active, and in most villages the Gram Panchayat could not take its place; the committee lost any financial reason to meet once wages stopped; presidents who led the construction phase died, withdrew or migrated without a prepared successor; panchayat politics intruded where the sarpanch and the committee belonged to different camps; and monsoon damage after 2018, with no mechanism to repair it, left a sense that the effort would not last. Participants also reported an equity problem that the household data do not reveal: the villages of a cluster did not always receive a fair share of its works, and the president's own village usually did best, which weakened the programme's standing elsewhere in the cluster.

5.3 The distribution of sustainability

Applying the typology to the 32 micro-watershed villages (Table 4; Figure 4a) classifies 11 (34.4 per cent) as Sustainable, 13 (40.6 per cent) as Transitional and 8 (25.0 per cent) as Vulnerable. A third of the treated units therefore retain functioning institutions, sound structures and a stable or rising water table six to seven years after closure; two in five still hold their gains but are losing the institutions and structures that produced them; and a quarter have already begun to lose the gains themselves. The distribution across mandals is highly uneven. Shaligowraram has five of six units Sustainable and none Vulnerable (83 per cent sustainable); Thipparthi has one of eleven Sustainable and five Vulnerable (9 per cent); Nakrekal (29 per cent) and Kattangoor (38 per cent) lie between. The cluster-level ranking agrees with the independent SLNA audit of 2022, which judged Utkur Sustainable, Mangalpally and Eduloore Transitional and Sarvaram Vulnerable, and that agreement between an external audit and the present classification, built from different data, is the principal check on the findings.

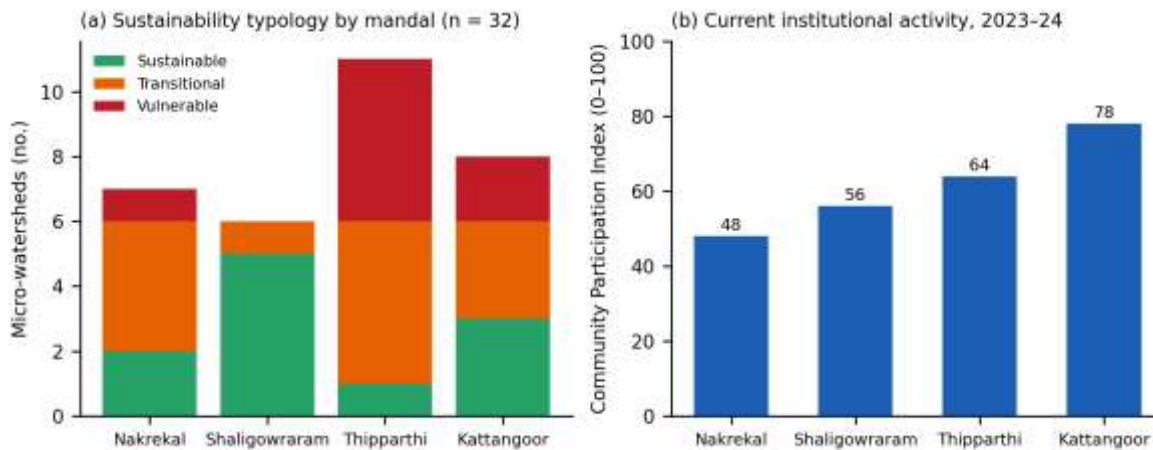


Figure 4. (a) Distribution of the 32 micro-watershed villages across the sustainability typology by mandal; (b) Community Participation Index by mandal, 2023–24. Source: authors, from the village schedule, structure audit and SLNA observation-well records.

Table 4. Sustainability typology of the 32 micro-watershed villages: criteria and distribution by mandal

Mandal	Sustainable (CPI > 70; > 80% functional; water table rising/stable)	Transitional	Vulnerable (CPI < 55; < 50% functional; water table declining)	Total	Sustainable (%)
Nakrekal	2	4	1	7	28.6
Shaligowraram	5	1	0	6	83.3
Thipparthi	1	5	5	11	9.1
Kattangoor	3	3	2	8	37.5
All	11 (34.4%)	13 (40.6%)	8 (25.0%)	32	34.4

5.4 What discriminates the categories

The contextual factors vary little within the tract. All four mandals share the pediplained granite-gneiss terrain, slopes below 3°, and the same treatment package of borewell recharge, contour trenching, loose-boulder check dams, gabions, mini-percolation tanks, horticulture plots and tank restoration (Table 2 of the fuller record, summarised here in Table 5); the differences in outcome cannot be explained by differences in what was built. The one contextual variable that does vary — rainfall, a third higher in Thipparthi — runs the wrong way: the wettest mandal has the smallest water-table recovery (3.5 m against 6.9 m in Kattangoor) and the worst sustainability record, because heavier rain does more damage to unmaintained structures. The physical factor — structure condition — is itself an outcome of maintenance rather than an independent cause, since the same designs decay at different rates in different clusters. The three variables that do separate Sustainable from Vulnerable units are institutional. The first is the age of the village federation at sanction: Shaligowraram's cascade villages entered the programme with a DHAN federation of women's SHGs and tank-farmer associations that had existed for years, whereas DHAN had entered Thipparthi only in 2009 and Sarvaram was sanctioned a year later than the others, leaving little for the programme to attach itself to. The second is the identity and continuity of the implementing agency: the units implemented through an agency's own federation have held better than those implemented through the district agency, and the newest institution (the Kattangoor producer organisation) sustains the highest current activity. The third is the time elapsed since the agency's withdrawal, which the CPI gradient tracks. On this evidence money spent on institutions buys more durability than the same money spent on structures.

Table 5. Treatment package executed in the sample micro-watersheds, 2010–2024 (numbers of works aggregated by mandal)

Type of work	Nakrekal	Shaligowraram	Thipparthi	Kattangoor
Borewell recharge structures	15+	10	18	12
Loose-boulder check dams	8	6	10	7
Gabion structures	5	4	7	4
Rock-fill dams	3	2	4	3
Mini percolation tanks	6	4	8	5
Recharge pits (open well)	10	8	14	10
Sunken ponds	4	3	6	4
Continuous contour trench (km)	2.5	1.8	4.2	2.6
Staggered contour trench (km)	1.8	1.4	3.1	1.9
Horticulture plantation lots	4+	3	6	4
NADEP compost pits	30+	22	45	28
Tank restoration (Mission Kakatiya)	12	8	11	9

6. Discussion

6.1 Institutions over structures, a decade on

The central finding reproduces, under the 2008 Guidelines architecture and a decade later, the proposition that Kerr et al. (2002) and Vaidyanathan (2006) advanced for the earlier participatory era: the durability of watershed gains is determined by institutions rather than by structures. The present study adds three things to that proposition. It specifies which institutional variables matter — the age of the village institution at sanction, the identity and continuity of the agency, and the time since exit — and shows that they discriminate even when rainfall, terrain and the treatment package are held constant. It quantifies the rate of physical decay once external support is withdrawn, roughly four percentage points of functional structures a year, which is the parameter a consolidation phase must be designed against. And it shows that the 2008 architecture, with its Watershed Development Fund, closure reports and post-closure progress reports, has not solved the problem: the reports document the decay without arresting it, and the Fund, as Shah (2013) anticipated, cannot meet the cost of de-silting a percolation tank every three or four years.

The pattern is consistent with the common-pool-resource literature. Agrawal's (2001) conditions for enduring institutions — prior experience of cooperation and supportive external authority — are exactly those that distinguish Shaligowraram from Thipparthi: the former inherited a federation with years of cooperative history and the latter had to create one within a single cycle and then lost the nested support that Ostrom (1990, 2009) identifies as necessary when the agency withdrew. Meinzen-Dick's (2007) argument that institutional fit rather than institutional form determines performance explains why the same Guidelines produced an 83 per cent sustainability rate in one mandal and 9 per cent in another. The finding that the newest institution sustains the highest current activity, while the oldest sustains the highest accumulated welfare, resolves an apparent contradiction in the data: the CPI measures a flow that decays from the date of the last external input, whereas the typology and the external audit weigh a stock that accumulates from the date of the first. Evaluations that use only one of these will misread the other.

6.2 Convergence and the sustainability of a joint asset

Convergence with Mission Kakatiya and MGNREGS was, by the participants' account, the most effective feature of the package, and restored tanks are the terminal storages of the treated micro-watersheds. It has an unexamined cost for sustainability. Where the funding streams that built the asset are administered by different departments, the

maintenance responsibility for the joint asset is nobody's, and in three of the four mandals the departments returned to working separately once the officer who had arranged the cooperation was transferred. The 2024 monsoon breached restored tanks in the most sustainable cluster and IWMP structures in the least, and no standing arrangement existed to repair either. This is consistent with recent reporting that Mission Kakatiya's maintenance regime weakened after 2023 and with the observation of Reddy et al. (2018) that tank rehabilitation benefits depend on a continuing maintenance regime that Indian programmes have rarely institutionalised. Convergence multiplies impact while the programmes run and multiplies exposure after they close.

6.3 Climate and design assumptions

The 2024 monsoon anomaly is a reminder that the sustainability problem is not purely institutional. Structures designed against the 1971–2010 rainfall record met a storm more than 50 per cent above the ten-year mean, and the damage exposed spillways and bunds sized for gentler events. Guidance on climate-resilient watershed design already calls for design return periods to be revised against the post-2015 record (ICAR-CRIDA, 2024), and the intensification of extreme rainfall over central and southern India documented in the climate literature makes the point general rather than local. The interaction with institutions is direct: a well-maintained structure survives an anomalous storm that destroys a neglected one, so climate stress converts institutional weakness into physical loss.

6.4 Comparison with prior evidence

The impact magnitudes observed in the same villages — a 5.1 m mean water-table recovery against a 0.3 m decline in matched comparison villages, cropping intensity rising from 109 to 138 per cent, and net household income rising 82 per cent against 40 per cent in the comparison cohort — lie within the range reported by Joshi et al. (2008), Reddy et al. (2004) and Singh et al. (2014), and they are not the contribution of this paper. What the impact record establishes is that the units now classified as Transitional or Vulnerable did produce large gains; the sustainability finding is not that the programme failed but that its returns are being allowed to depreciate. The share of units retaining their institutions (34 per cent) is of the same order as the retention rates Kerr et al. (2002) reported for weak-institution watersheds five years after closure, which suggests that the 2008 architecture has not shifted the underlying distribution.

7. Policy Implications

Four recommendations follow directly from the evidence and can be implemented within the existing WDC-PMKSY 2.0 structure. First, the State Level Nodal Agency and the Department of Land Resources should fund a three-year post-closure consolidation phase in which the implementing agency, or a successor body where the district agency implemented in-house, retains a defined presence and mandate to help committees run a maintenance plan; at an estimated 8–10 per cent of project outlay the cost is small against the value of moving the 40 per cent of units now Transitional into the Sustainable class before they decay further. The consolidation phase should carry rules for allocating works fairly among the villages of a cluster, since intra-cluster inequity was the participants' principal grievance. Second, each cluster's Watershed Development Fund should be capitalised by a one-time matching grant, tied to user contributions, until its annual income meets the maintenance the structures actually require, with the fund held by the Watershed Committee and audited through the Gram Sabha. Third, a standing convergence committee at mandal level, chaired by the Mandal Revenue Officer and including the watershed programme, Mission Kakatiya, MGNREGS, the Jal Jeevan Mission and the agriculture and animal-husbandry departments, should publish an annual joint works and maintenance calendar, so that cooperation no longer depends on which officers are posted. Fourth, the capacity-building allocation should rise from 5 to 10 per cent of outlay, be protected from diversion, and reserve at least two-fifths for the consolidation phase, because the evidence shows that institutions rather than structures determine durability. Two further measures would make the problem visible: a climate-resilient re-design audit at the mid-cycle review against the latest return-period rainfall, and an annual state Watershed Sustainability Index, modelled on the typology used here, that places every completed micro-watershed in one of three categories and guides where consolidation and re-treatment money is spent.

8. Limitations and Future Research

The four mandals were selected purposively for institutional and agro-ecological diversity, so the findings characterise the Mandal-types in the sample rather than the district or state statistically. The CPI measures current activity in a single survey year and would be strengthened by a repeated measure. The sustainability classification rests on thresholds that are transparent but necessarily judgemental; its agreement with the independent SLNA audit at cluster level mitigates but does not remove this. The effects of IWMP, Mission Kakatiya and MGNREGS cannot be separated, so the asset whose sustainability is assessed is a joint one. The departmental monitoring series were furnished in aggregate, which precludes formal tests on the village-level classification; the argument rests on the direction, size and cross-source consistency of the differences. Finally, the 2024 monsoon was anomalous and the November 2024 spot-check records damage that may or may not be repaired. None of these limitations bears on the central contribution, which is the documented decay of the physical stock after closure and the institutional character of the variables that distinguish the units that have resisted it. Future research should follow the same 32 villages over the next decade to establish whether Transitional units recover or decline; test the structures across the plateau against updated rainfall projections; examine the women's federations after closure, since the strongest institutions in this sample were built on them; and compare the cost-effectiveness of watershed treatment, tank restoration and MGNREGS earthworks to guide how convergence money is divided.

9. Conclusion

Six to seven years after closure, the watershed clusters of four Nalgonda mandals show that Indian watershed development has solved its engineering problem and not its institutional one. The works were built, the water table rose and has largely held, and households in every cluster gained more than their matched comparators. But the physical stock is depreciating at about four percentage points a year, only a third of the micro-watersheds retain the institutions, structures and hydrology that make the gains self-sustaining, and the units that have held are those where the programme could attach itself to a village institution that already existed and where the implementing agency's presence was longest and most recent. Rainfall, terrain and the treatment package do not explain the difference; the age, identity, continuity and exit of institutions do. For a programme that spends about five per cent of its budget on institutions and half on structures whose value depends on them, the implication is direct: the decisive years are the ones after the money stops, and the simplest remedy is to stay for three more.

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