



Rural development through smart village models & ICT adoption: A capability analysis

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Abstract

This study critically examines Smart Village frameworks in India through the lens of international experience, national initiatives, and recent ICT adoption surveys. It reviews six functional dimensions governance, technology, resources, services, quality of living, and tourism and analyses the digital adoption barriers that shape rural transformation. Drawing on secondary data from NABARD (2024) ^[7], MeitY (2023) ^[15], and the World Bank (2024) ^[12], the paper proposes a capability-based assessment model that links ICT access with social and institutional freedoms. The findings highlight that digital infrastructure alone is insufficient; community capability, institutional coordination, and adaptive learning determine whether Smart Villages become sustainable engines of rural development. Policy recommendations emphasize inclusive digital literacy, resilient local institutions, and performance frameworks aligned with Sen's (1999) ^[19] capability approach to ensure that Smart Villages evolve as integrated, participatory systems of growth and human empowerment.

Keywords: Smart villages, ICT adoption, rural development, capability approach, digital inclusion

1. Introduction

Rural development remains central to India's long-term growth agenda. Nearly two-thirds of the population continues to reside in rural areas where disparities in connectivity, service access, and productive opportunities persist (World Bank, 2023) ^[14]. Since the launch of *Digital India*, multiple programs from BharatNet to the National Rural Livelihood Mission have attempted to close the digital divide and stimulate inclusive economic activity (MeitY, 2023; NABARD, 2024) ^[15, 7]. Within this landscape, the idea of the *Smart Village* has emerged as a strategy that integrates technology with human capability. Rather than replicating urban "smart-city" templates, Smart Villages are conceived as adaptive rural ecosystems that combine ICT, governance reform, and community participation to enhance well-being (FAO, 2021; OECD, 2023) ^[16, 17]. Globally, Smart Village initiatives have been promoted by the European Union, UNDP, and the FAO as models for digitally enabled rural resilience. Their common premise is that technological inclusion must expand people's substantive freedoms the ability to access education, markets, and local decision-making rather than merely deliver services (UNDP, 2022) ^[18]. This interpretation aligns closely with Amartya Sen's (1999) ^[19] capability approach, which views development as the expansion of human choices and agency. Applying this framework to India's context allows for a multidimensional understanding of how ICT adoption contributes not

only to income or efficiency but also to empowerment and sustainability.

Indian experiments such as Gujarat's *Smart Village Mission*, the *Digital Gram* initiative in Rajasthan, and pilot projects under NABARD's Rural Innovation Fund have provided early evidence that institutional design and local capacity are decisive factors (NABARD, 2024; World Bank, 2024) ^[7, 12]. Successful villages exhibit participatory governance, localized entrepreneurship, and digital service delivery co-managed by community-based organizations. However, national assessments indicate uneven outcomes due to infrastructural bottlenecks, digital-literacy gaps, and limited integration between departments (MeitY, 2023) ^[15]. These constraints echo findings from global pilots where technological adoption failed without parallel investment in governance and capability development (FAO, 2021; OECD, 2023) ^[16, 17].

This paper therefore undertakes a capability-based analysis of Smart Village models in India. It synthesizes empirical insights from government reports, World Bank evaluations, and academic studies to identify enabling and constraining factors across six dimensions governance, technology, resources, services, quality of life, and tourism. By framing ICT adoption as a pathway to expand rural capabilities rather than as a purely technical upgrade, the study seeks to contribute to policy design that is

socially embedded, institutionally coherent, and economically inclusive.

2. Literature Review

The Smart Village idea in India has gradually evolved from an infrastructure-centric vision focused on roads, power, and sanitation to a multidimensional model linking technology, governance, and social capability. Early experiments such as Gujarat's *Smart Village Mission* emphasized physical infrastructure and awards for visible progress, yet subsequent initiatives like Maharashtra's *Smart Gaon Project* and the *Shyama Prasad Mukherji Rurban Mission* under the Ministry of Rural Development have shifted toward digital service delivery, participatory governance, and institutional capacity building (MeitY, 2023; NABARD, 2024) ^[15, 7]. This transition mirrors global learning that sustainable rural transformation depends on both physical and informational connectivity (World Bank, 2024; FAO, 2021) ^[12, 16].

2.1 International frameworks

Globally, Smart Village strategies have emerged as responses to rural depopulation and unequal access to opportunity. The European Union's *Smart Villages Policy* emphasizes digital inclusion, renewable-energy use, and social innovation at the local-governance level (OECD, 2023) ^[17]. In Southeast Asia, Indonesia's Banyuwangi model demonstrates a six-dimension framework governance capacity, ICT adoption, resource sustainability, social-service delivery, quality-of-life enhancement, and tourism promotion which serves as a comparative template for India's context. Evaluations by the FAO (2021) ^[16] note that these dimensions succeed when policy incentives align with local initiative and when community digital literacy exceeds the minimum operational threshold. The UNDP (2022) ^[18] further stresses that Smart Village programs must enhance agency and choice, not simply deploy technology, thus resonating with Sen's (1999) ^[19] capability approach that views development as the expansion of freedoms.

2.2 Indian research and evidence

Empirical studies in India reveal uneven progress across states. MeitY's (2023) ^[15] *Digital India Report* found that while over 250,000 Gram Panchayats were connected through the BharatNet fibre backbone, only about 40 percent offered regular digital-governance services. A multi-state survey of 400 Smart Villages indicated that 61 percent had basic internet connectivity, 38 percent provided online citizen services, and 29 percent maintained functional e-governance dashboards, while overall digital literacy among residents remained below 40 percent. These figures illustrate that ICT access alone does not guarantee effective participation or institutional use.

Academic analyses echo this finding. Mishra (2022) and Kumar *et al.* ^[20] highlight that villages demonstrating stronger ICT penetration also record higher Gram Sabha participation and improved

service-delivery outcomes. Conversely, fragmented coordination between Panchayati Raj Institutions, line departments, and civil-society actors constrains sustainability (World Bank, 2023) ^[14]. Capability-based assessments proposed by Singh and Dey (2021) ^[21] and supported by NABARD (2024) ^[7] recommend shifting measurement from infrastructure counts to multidimensional indicators such as ICT-adoption depth, citizen inclusion, and environmental resilience.

2.3 Gaps and challenges

Despite policy momentum, most Smart Village pilots remain donor-driven or project-based with limited mechanisms for scale or maintenance. Financial sustainability often depends on short-term grants, and local entrepreneurs struggle to monetize digital services. Institutional fragmentation persists: PRIs handle governance, while ICT infrastructure falls under MeitY, and livelihood programs under the Ministry of Rural Development. Without convergence, the benefits of digitization risk remaining isolated. International literature underscores similar patterns, warning that technology roll-outs without community ownership produce transient outcomes (FAO, 2021; OECD, 2023) ^[16, 17]. In summary, the literature converges on a clear insight: Smart Villages thrive where technological access interacts with human capability, institutional trust, and collective learning. The next section therefore outlines the capability-based analytical framework adopted in this study to examine India's Smart Village trajectory within these six interlinked dimensions.

3. Methodology

This study employs a *mixed-method synthesis* that integrates comparative framework analysis with secondary quantitative and qualitative data on Smart Village and ICT adoption programs in India. The primary datasets include progress reports from the Ministry of Rural Development's *Rurban Mission*, NABARD's (2024) ^[7] evaluations of rural infrastructure and innovation pilots, and MeitY's (2023) ^[15] *Digital India Annual Report*. State-level programme documents from Gujarat, Maharashtra, and Karnataka were examined alongside peer-reviewed literature and international case studies from the FAO (2021), OECD (2023), and World Bank (2024) ^[16, 17, 12].

Additionally, the analysis incorporates results from a structured SPSS-based survey of 400 Smart Villages across Gujarat, Maharashtra, Kerala, Tamil Nadu, and Rajasthan. The survey data provided comparative evidence on ICT penetration, digital literacy, and governance integration.

A capability-based thematic coding approach was used to interpret findings under four analytical dimensions

1. Governance capacity and ICT integration
2. Citizen participation and digital literacy
3. Resource sustainability and service delivery
4. Institutional sustainability and stakeholder collaboration

These dimensions align with Sen's (1999) ^[19] capability framework, positioning technology not as an end but as an enabler of agency, inclusion, and adaptive learning. Case illustrations from selected villages such as Palli (Jammu & Kashmir) and Hiware Bazar (Maharashtra) highlight context-specific dynamics of capability expansion through ICT adoption.

4. Findings

4.1 Governance Capacity and ICT Integration

The study reveals that the success of Smart Villages is strongly associated with local governance capability and the presence of ICT "champions." Villages where Panchayat leaders or trained digital coordinators actively manage e-governance systems show significantly higher transparency and service-delivery outcomes (NABARD, 2024) ^[7]. In Maharashtra's Smart Gaon initiative, nearly 92 percent of participating Gram Panchayats maintained fully digitized Gram Sabha records, online grievance portals, and automated public-works tracking. These results validate MeitY's (2023) ^[15] observation that leadership and institutional ownership matter more than technology availability alone.

However, gaps remain under the Rurban Mission. Ministry of Rural Development (MoRD, 2023) ^[15] monitoring data indicate that only 47 percent of Rurban clusters operate functional e-governance dashboards. Several clusters still depend on manual documentation and fragmented portals managed by separate departments. This unevenness reflects deeper structural issues: limited technical staff, irregular connectivity, and lack of integration between MeitY and MoRD systems. International evidence supports this finding. FAO (2021) and OECD (2023) ^[17, 16] highlight that digital-governance platforms fail when not embedded within local institutional ecosystems. The Indian experience thus reinforces the view that ICT systems must be nested in participatory institutions capable of sustaining them beyond the project cycle.

4.2 Citizen Participation and Digital Literacy

Citizen engagement remains the weakest link in India's Smart Village framework. Survey data from 400 villages show that only 38 percent of residents used online public-service platforms, while 29 percent had participated in digital Gram Sabha consultations. Gender and social disparities are significant: just 22 percent of women and 18 percent of Scheduled Caste or Scheduled Tribe respondents reported confidence in using village digital systems. These figures corroborate MeitY's National Digital Literacy Mission Report, which finds that rural digital skills remain below 45 percent nationally despite broadband expansion through BharatNet. Kerala's Smart Village pilots offer a contrasting picture. Building on the long-running Akshaya Centre programme, Kerala recorded the highest digital-participation rates among the surveyed states. Training modules were community-run, gender-inclusive, and tied to service incentives such as e-payments or digital ration cards. This supports the

capability perspective that empowerment is achieved when technology strengthens individuals' ability to act, not when access alone is provided (Sen, 1999; UNDP, 2022) ^[18, 19]. Similar outcomes are documented in Indonesia's Banyuwangi model and the EU's Smart Villages initiative, where digital inclusion policies prioritize literacy before infrastructure (OECD, 2023) ^[17]. The Indian evidence therefore underscores that literacy and social learning must precede or accompany ICT roll-outs for meaningful inclusion.

4.3 Resource Sustainability and Service Delivery

Environmental sustainability emerges as another differentiating factor between short-lived pilot projects and enduring Smart Village ecosystems. Villages integrating decentralized solar micro-grids, rainwater-harvesting systems, or community solid-waste management demonstrate greater service stability (World Bank, 2024) ^[12]. Gujarat's Smart Village clusters, for instance, report measurable improvements in water security and renewable-energy adoption an outcome linked to NABARD's Rural Innovation Fund interventions in 2023-24 (NABARD, 2024) ^[6, 7].

Yet, across the full sample, only 41 percent of Smart Villages maintain operational waste-management systems, and climate-resilience planning remains minimal. Most ICT dashboards monitor economic and social metrics but omit environmental indicators. This neglect limits long-term viability, especially as rural communities face intensifying climate variability. The FAO (2021) ^[16] stresses that Smart Villages must embed environmental sustainability into digital-governance systems to ensure resilient livelihoods. Aligning India's framework with this principle would transform Smart Villages from service-delivery nodes into sustainable development units.

4.4 Institutional Sustainability and Stakeholder Collaboration

Institutional integration remains the most persistent challenge. Only 36 percent of surveyed villages reported regular collaboration between Panchayats, line departments, and civil-society partners. Where cooperation does occur, outcomes are notably better: joint planning leads to faster problem resolution, improved budget utilization, and stronger citizen trust (World Bank, 2023) ^[14]. In contrast, isolated digital interventions often fail once external funding ceases. Financial sustainability also poses serious constraints. Many Smart Village projects rely on one-time corporate social-responsibility grants or externally funded pilots without recurrent revenue models. Maharashtra and Kerala offer exceptions: both states have incorporated Smart Village maintenance costs into Panchayat development plans, institutionalizing them within state finance commissions (MoRD, 2023) ^[15]. This structural embedding aligns with OECD (2023) ^[17] findings that long-term viability depends on recurrent funding and multi-stakeholder accountability.

An additional institutional issue concerns data interoperability. Multiple ministries MeitY, MoRD, and the Ministry of Power run independent platforms that collect overlapping datasets. Without shared standards, duplication increases administrative burden. MeitY's (2023) ^[15] proposal for a unified Rural Digital Architecture seeks to resolve this fragmentation by introducing common APIs and data-exchange protocols. If implemented, such reforms could enhance coordination across development sectors including health, education, and climate resilience.

4.5 Synthesis of Findings

Overall, the evidence suggests that Smart Village success is contingent on four interdependent pillars:

1. Governance capability ICT integration thrives under committed local leadership and coherent administrative support.
2. Citizen capability Digital inclusion requires prior investment in literacy, especially for women and marginalized groups.
3. Sustainability orientation Environmental management must be built into ICT frameworks, not treated as peripheral.
4. Institutional coherence Financial and data integration mechanisms ensure continuity beyond pilot phases.

These insights affirm that the Smart Village paradigm must evolve from a technology-first model toward a capability-driven ecosystem that strengthens both human and institutional capacities. As Sen (1999) ^[19] argued, freedom of choice and agency are the true indicators of development. When digital tools expand these freedoms through informed participation, resource security, and accountable governance they transform rural settlements into resilient, self-learning communities.

Discussion

The findings affirm that India's Smart Village models possess substantial potential to transform rural governance, service delivery, and social participation. ICT-based governance tools have improved transparency and responsiveness in advanced clusters such as Maharashtra and Kerala, where integrated e-portals and participatory dashboards are actively managed (MeitY, 2023; NABARD, 2024) ^[15, 7]. These cases demonstrate that digital architecture, when combined with strong local institutions, can strengthen accountability and public trust (World Bank, 2024) ^[12].

Nevertheless, the wide variation in outcomes underscores that Smart Villages are not inherently "smart" by virtue of technology alone. Disparities in ICT adoption reflect underlying differences in leadership quality, bureaucratic support, and community capability (FAO, 2021; OECD, 2023) ^[16, 17]. Infrastructure provisioning, without parallel investments in human capital and institutional sustainability, risks producing fragmented and short-lived impacts. A coherent policy framework grounded in the capability approach can mitigate

these gaps by defining progress in terms of empowerment and agency rather than hardware deployment (Sen, 1999) ^[19].

Four policy imperatives emerge from the evidence. First, effective e-governance capacity must be institutionalized through continuous technical training and inter-departmental data integration. Second, inclusive digital literacy is essential to overcome gender and caste disparities; targeted programmes like Kerala's Akshaya model could serve as national templates (UNDP, 2022) ^[18]. Third, resource sustainability through decentralized renewable energy, waste management, and water conservation should be embedded in the Smart Village performance matrix (World Bank, 2023) ^[14]. Finally, institutional collaboration and financial viability require long-term anchoring within Panchayati Raj and state finance mechanisms to move beyond CSR-driven pilots (MoRD, 2023) ^[15].

The gender and social divides in digital participation remain particularly concerning. Without deliberate corrective strategies, Smart Village interventions may inadvertently reinforce existing inequalities. The Kerala example demonstrates that embedding maintenance, literacy, and service design within Panchayat structures can ensure continuity and inclusion.

Internationally, the six-dimension Smart Village model governance, technology, resources, services, quality of living, and tourism offers a holistic lens for Indian adaptation. Embracing this framework would enable Smart Villages to advance not only infrastructural connectivity but also social inclusion, innovation in governance, and environmental resilience.

Conclusion & Recommendations

The Smart Village movement in India represents an important step in redefining rural development through the convergence of governance reform, technological innovation, and community participation. The analysis confirms that digital infrastructure while indispensable is only one component of a broader transformation process. Villages that pair ICT systems with capable local leadership, inclusive literacy initiatives, and environmental sustainability frameworks achieve measurably higher performance across governance and service-delivery indicators (NABARD, 2024; World Bank, 2024) ^[7, 12].

From a capability-based perspective, development must be evaluated by the real freedoms people gain to participate in, influence, and benefit from digital systems (Sen, 1999) ^[19]. In this light, Smart Villages are successful when technology expands human agency rather than substitutes for it. The experience of Kerala's Akshaya centres and Maharashtra's Smart Gaon clusters illustrates that sustained results emerge where digital literacy, institutional coordination, and fiscal autonomy converge. Conversely, pilot-driven or grant-based models without systemic anchoring risk quick obsolescence once funding ends (MoRD, 2023) ^[16].

To consolidate progress, several recommendations follow:

1. **Institutional Strengthening:** Integrate Smart Village units within Panchayati Raj governance structures and link them to state finance commissions for predictable maintenance funding.
2. **Targeted Digital Literacy:** Prioritize women and marginalized groups through localized training modules and incentive-based participation.
3. **Unified Data and ICT Architecture:** Implement interoperable rural digital platforms across ministries to reduce duplication and enhance transparency (MeitY, 2023)^[15].
4. **Sustainability Mainstreaming:** Include renewable-energy use, climate-resilience metrics, and waste-management indices in Smart Village evaluation frameworks.
5. **Monitoring and Research:** Commission longitudinal studies under NABARD and the World Bank to assess capability expansion over time and identify replicable success factors.

In conclusion, Smart Villages can evolve into resilient, self-learning ecosystems when technology, governance, and human capability grow in tandem. The next policy frontier lies not in more hardware, but in nurturing the institutional and social intelligence that makes villages truly “smart.”

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