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From Digital to Smart Villages: Concept, Characteristics, and Development Pathways in Rural Bangladesh and Global South

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Abstract: *The implementation of smart villages serves as an essential advancement from the digitalization-based efforts to improve rural areas in the Global South that face continual economic, governance, and service delivery exclusion from their rural citizens. The existing projects in Bangladesh, which aim to establish digital villages through improving connectivity and e-service delivery, lack both a clear definition of smart village elements and a verified method for developing these elements. The study introduces a local particularity framework that scientists use to define smart villages and to create local pathways for developing these villages in Bangladesh. The Global South uses smart village development as its main approach to achieving rural transformation but Bangladesh has developed only limited methods to evaluate this development within its areas facing climate threats and institutional inconsistencies. The study defines smart villages through multiple dimensions by creating the Smart Village Index (SVI) that evaluates rural development based on infrastructure and governance and digital services and livelihood innovation and social inclusion and climate resilience. The research team conducted their study through a mixed-method approach which included village-level surveys and institutional assessments and GIS-based spatial profiling and comparative case analysis to investigate five village clusters in Bangladesh which included Kaliganj (Gazipur) and Mithapukur (Rangpur) and Shyamnagar (Satkhira) and Char Kukri Mukri (Bhola) and a remote haor settlement (Sunamganj). The research results show that rural areas experience major differences in development because peri-urban and institutionally dense villages achieve better smartness scores than ecologically vulnerable char and wetland areas which remain outside digital access despite having infrastructure development. The study demonstrates that smart village development requires more than technology diffusion which interacts with governance capabilities and livelihood diversity and inclusion patterns and environmental threats. The study introduces a new theoretical framework to understand rural smartness through ICT4D and development-as-freedom while the study proposes a phased Vision 2041 Smart Village Roadmap for Bangladesh as its policy recommendation. Smart villages need a new definition which sees them as development ecosystems*

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that enable rural equalization while building pathways for sustainable development instead of their current role as technological demonstration sites.

Keywords: Smart villages; Smart Village Index (SVI); Rural digital transformation; Bangladesh; ICT4D; Vision 2041; Rural governance; Digital inclusion; Climate resilience; Global South development; GIS-based rural mapping; Sustainable rural futures.

INTRODUCTION

Rural transformation has become a central concern in contemporary development discourse, particularly in the context of the Global South where rural populations continue to experience structural disadvantages in access to resources, services, and opportunities. Over the last two decades, digital technologies have been increasingly promoted as catalysts for rural development, giving rise to concepts such as digital villages, e-villages, and connected communities. The smart village concept has developed into a complete development framework which aims to connect rural areas through sustainable and open access to resources. The European Union and academic communities have adopted this concept as a vital topic for their research, yet developing countries like Bangladesh face challenges in establishing theoretical frameworks and real-world applications of the concept.

Bangladesh presents a particularly significant case for examining smart village development. The country has experienced rapid urbanization yet 60 percent of its people continue to live in rural areas where their livelihoods depend on agriculture and informal work in climate-sensitive regions. Rural Bangladesh faces persistent challenges such as poverty, limited access to quality education and healthcare, governance inefficiencies, and vulnerability to climate change. The nation has developed digital infrastructure and mobile networks while e-governance projects have expanded under the Digital Bangladesh program which later transformed into Smart Bangladesh and Vision 2041. The digital inclusion initiatives created essential foundational elements for their development yet their main focus remained on providing infrastructure and services instead of transforming rural governance and socio-economic systems.

Digital villages maintain essential functions through information and communication technologies that include internet access and digital service centers and mobile applications. Digital villages are typically characterized by the presence of information and communication technologies (ICTs), such as internet connectivity, digital service centers, and mobile-based applications. The elements that people need for development to succeed become necessary yet they fall short of providing what people need for their development journey to succeed. The current definition of smart villages has evolved to include socio-technical systems because the definition now contains all digital elements that exist in local systems with human governance activities and eco-friendly sustainable development practices. The ICT for Development (ICT4D) scholarship has begun to recognize

that technological development does not automatically create development in societies; development needs to be studied through the lens of technological impacts on social, economic, political, and cultural systems (Heeks, 2017).

Smart villages originated in European rural areas that developed the concept to address their problems of population decline and service reductions and regional disparities (Visvizi & Lytras, 2018). These studies prioritize research on digital public services that include smart mobility and renewable energy and innovation ecosystems. The direct application of these models to developing nations will create problems because the models use technocratic approaches and urban-centric thinking. The rural development problems in Bangladesh become entangled with poverty and social exclusion and governance capacity and climate vulnerability. The creation of smart villages needs a complete redesign process that establishes theoretical foundations based on scientific research through actual field studies.

Several important theoretical frameworks intersect with the smart village concept because it exists as a complete understanding of multiple essential connections between different domains. The ICT4D literature shows how digital technologies create better access to information and markets and services for users while warning about the social conflicts that occur due to digital divides and power imbalances between different groups (Qureshi, 2019). Sen's capability approach provides a normative lens for assessing development in terms of people's freedoms and abilities to achieve valued ways of living, rather than in terms of technological inputs alone (Sen, 1999). The Sustainable Livelihoods Framework shows how rural life depends on three main elements that include assets and institutions and the state of vulnerability in the area. The digital tools in smart villages create better human abilities for people to develop their abilities while enhancing local governance systems and creating sustainable livelihoods.

The empirical research on smart villages needs a stronger theoretical foundation to study smart villages within Bangladesh and the rest of South Asia. Bangladesh rural digitalization research currently centers on specific projects that include Union Digital Centers and mobile financial services and e-agriculture platforms. The initiatives have improved access to information and services yet their effects remain unstudied within the smart village framework that needs to cover all governance aspects and social inclusion elements and economic transformation processes and environmental sustainability requirements. Policymakers tend to confuse digitalization with smartness while they disregard the complex factors that shape rural development.

This research project will study smart village development in rural Bangladesh by completing context-specific analysis work that exists as an unfulfilled research requirement. The three interconnected research questions will show how the study reveals its findings:

(1) What conceptually distinguishes a smart village from a digital village in the context of rural Bangladesh?

(2) What core characteristics define smart villages when examined through empirical evidence from selected rural communities? and
(3) What development pathways facilitate the transition from digital to smart villages?

The study will use its six research questions to present theoretical arguments that support practical solutions for ongoing discussions about digital transformation in rural areas.
By addressing these questions, the study aims to contribute both theoretically and practically to ongoing debates on rural digital transformation.

The significance of this research is threefold. First, at the theoretical level, it contributes to ICT4D and rural development scholarship by clarifying the conceptual boundaries of the smart village concept and situating it within established development frameworks. Second, at the empirical level, it provides grounded evidence from Bangladesh, offering insights into how smart village characteristics manifest in practice across different rural contexts. Third, at the policy level, it informs national and local strategies aligned with Vision 2041 and the Sustainable Development Goals (SDGs), particularly those related to poverty reduction (SDG 1), quality education (SDG 4), decent work (SDG 8), reduced inequalities (SDG 10), and sustainable communities (SDG 11).
In doing so, the article positions Bangladesh not merely as a case of policy implementation but as a theoretically meaningful site for rethinking smart villages in the Global South. Rather than treating smart villages as scaled-down versions of smart cities, the study argues for an adaptive, inclusive, and locally grounded model of smartness—one that prioritizes human capabilities, community participation, and sustainability alongside digital innovation. Such an approach is essential for ensuring that rural digital transformation contributes to long-term development rather than reproducing existing inequalities in new technological forms.

LITERATURE REVIEW

Rural Development and Digital Transformation in the Global South

The field of development studies specifically focuses on rural development in the Global South because rural communities face multiple forms of deprivation that stem from poverty and inadequate infrastructure and ineffective institutional structures and their susceptibility to environmental disasters. The traditional methods for rural development focused on agricultural development as the primary driver for economic growth that would improve access to essential services and help the government combat poverty through its education programs. The combination of globalization and technological progress has created new pathways for rural development that enables digital technologies to drive economic diversification, enhance service delivery, and promote social inclusion (Unwin, 2009). The process of digital transformation has emerged as a major policy focus that uses information and communication technologies (ICTs) to create solutions that eliminate the technology gaps between rural and urban areas.

The Global South uses digitalization to drive its development through e-governance and mobile banking and e-health and digital agriculture projects. The empirical studies show that ICTs help rural communities by providing better information access and decreasing their transaction expenses and increasing their market access (Aker & Mbiti, 2010). The researchers observed that digital technologies have different effects on development that depend on the specific circumstances of each location and the capabilities of institutions and people. The presence of socio-economic structures in society creates a situation where digital solutions will only reinforce existing social divides instead of improving the living conditions of rural communities (Heeks, 2017).

From Digital Villages to Smart Villages: Conceptual Evolution

The digital village concept emerged from early ICT4D initiatives that aimed to provide rural communities with access to digital services and connectivity. Digital villages exist when their residents have internet connections and their communities operate digital service centers, mobile platforms, and e-government facilities according to World Bank standards (World Bank, 2016). The initiatives work toward building inclusive systems yet their method of execution focuses on developing infrastructure and delivering services while their success criteria depend on measuring access instead of evaluating the development progress of their initiatives.

The smart village model represents a new way of thinking which requires a complete transformation of existing systems. European Union policy makers created smart villages to function as modern rural areas that would use digital technology together with community expertise and social connections to tackle their population decline and diminishing services and economic downturns (Visvizi & Lytras, 2018). Smart villages use technology to connect multiple sectors that include governance systems and entrepreneurial activities and social development and environmentally sustainable practices. The new approach moves away from using technology as a final goal to see technology as a tool that enables communities to achieve their development objectives.

The smart village concept remains open to interpretation because researchers view it differently based on their unique contexts. The researchers believe that smart villages should be seen as customized solutions that evolve from the specific requirements, available resources, and institutional frameworks of each community (Zavratnik, Kos, and Stojmenova Duh, 2018). The specific perspective applies to developing nations that experience rural issues that differ significantly from European patterns thus requiring local policy adaptation instead of direct policy implementation.

Theoretical Perspectives Informing Smart Village Studies

Smart village scholarship draws on multiple theoretical traditions. The effective use of digital technology requires understanding its impact on social, economic, and political systems according to ICT for Development (ICT4D) that provides the basic framework for analysis. The early ICT4D

research faced criticism for its techno-determinism yet the following research followed an approach that examined socio-technical systems together with power relationships and user empowerment (Heeks, 2017). The smart village model connects to the local institutional framework by establishing the requirement to use technology within the area.

Sen's capability approach enables the analysis of smart villages because it defines development as the extension of human rights instead of the accumulation of technological assets (Sen, 1999). A village becomes 'smart' when its digital tools improve the ability of its residents to pursue their educational and healthcare and livelihood and citizenship activities. The empirical studies that applied the capability approach on ICT interventions showed that literacy and gender norms and social inclusion had a strong impact on the outcomes of the programs (Zheng & Walsham, 2021). The Sustainable Livelihoods Framework explains how rural development results from the interaction between assets (human, social, natural, physical, and financial) and institutional frameworks and vulnerability situations. The smart village initiatives that ignore climate risks and land tenure issues and governance restrictions will only create temporary advantages that lack future viability. The smart village framework requires sustainability and resilience practices to be integrated especially for climate-vulnerable nations such as Bangladesh.

Smart Villages, Governance, and Local Institutions

Smart villages differ from digital villages because they use governance systems to create their unique identity elements. The smart village model depends on participatory governance and local leadership together with institutional coordination to advance rural development according to smart village literature (OECD, 2020). Digital tools enable organizations to improve their service delivery through transparent processes and accountable systems yet their efficiency relies on the operational capabilities of organizations and the commitment of political leaders to the process.

The research from Europe and India showed that smart village development was most successful when local communities participated in the decision-making process that allowed them to customize solutions to their specific needs (Komninos et al., 2021). The use of top-down technology solutions creates a situation where infrastructure remains underused which reduces their social benefits. The findings support the assertion that public service innovation needs citizens to work alongside government officials to create better services.

In the Global South, governance challenges such as bureaucratic fragmentation, resource constraints, and political patronage complicate smart village implementation. Consequently, scholars argue for hybrid governance models combining state support, community initiatives, and partnerships with non-governmental and private actors (Ansell & Gash, 2008). This governance perspective is particularly relevant for Bangladesh, where local government institutions play a critical yet under-researched role in rural digital transformation.

Empirical Evidence from the Global South and South Asia

The Global South and South Asia provide empirical data, which demonstrates their essential value. Researchers have started to study smart village systems in the Global South despite existing limitations. Research from India shows how smart village programs can help people access education and healthcare services and agricultural markets through digital platforms while also presenting difficulties with digital literacy and sustainable development (Patnaik & Bhowmick, 2020). African research identifies three key elements, which establish smart rural development: renewable energy systems, mobile service networks, and citizen-led innovation activities (Stojmenova Duh et al., 2020). The majority of research conducted in South Asia concentrates on specific industrial advancements instead of studying complete smart village frameworks. The research on mobile financial services and e-agriculture and telemedicine shows beneficial outcomes but demonstrates ongoing gender and class differences in how people access and utilize these services (Aker & Mbiti, 2010). The research results require organizations to develop integrated frameworks that help them combine their digital initiatives with multiple digital projects.

Rural Digitalization and Smart Village Initiatives in Bangladesh

Through Union Digital Centers and mobile financial services and e-governance platforms Bangladesh has achieved significant advancements in rural digitalization. Research shows that these programs have increased government service access and information availability and financial inclusion for people living in remote locations (Islam & Grönlund, 2017). The existing literature assesses these programs as separate entities while neglecting their relationship to smart village implementation.

The research about rural ICT usage in Bangladesh reveals multiple obstacles, which include limited digital literacy among users and gender-based access restrictions and poor infrastructure conditions and insufficient coordination between institutions (Zaman et al., 2020). Digital interventions face sustainability problems because of two major factors: the population's vulnerability to climate change and their situation of unstable livelihoods. Local innovation development has created new evidence through youth and micro-entrepreneurs who develop innovations. These innovations can become smart village developments when supported by proper governance structures and implementation of appropriate policies.

Research Gaps and Analytical Implications

The reviewed literature reveals several critical gaps. Researchers who study developing countries face difficulties because they need to define the differences between digital villages and smart villages. Researchers need to conduct studies that evaluate entire villages instead of focusing on specific sectors in their existing research about Bangladesh. The current research on rural digital transformation fails to provide adequate theoretical frameworks for understanding governance structures and human capability development and sustainable resource management.

Researchers need a comprehensive analytical framework that combines six areas: technological systems, governance structures, human resource development, economic activities, social integration, and environmental protection. This study responds to these needs by advancing a context-sensitive smart village framework and empirically examining development pathways in rural Bangladesh, which helps both theoretical, and policy discourses about rural transformation in the Global South**.**

Conceptual Framework

Rethinking the Smart Village Concept in the Global South

The concept of the *smart village* has gained prominence as an extension of digital and smart development discourses; however, its application in the Global South requires careful theoretical reorientation. In much of the existing literature, smart villages are framed as rural counterparts of smart cities, emphasizing digital infrastructure, innovation ecosystems, and service efficiency. While such attributes are relevant, this urban-centric transposition risks overlooking the structural realities of rural societies in developing countries, where poverty, livelihood insecurity, institutional fragility, and environmental vulnerability are central development constraints. Consequently, a conceptually robust framework for smart villages in Bangladesh must move beyond technological determinism and incorporate human, social, institutional, and ecological dimensions.

This study conceptualizes smart villages as *socio-technical systems* in which digital technologies function as enabling tools rather than defining features. Drawing on ICT for Development (ICT4D) scholarship, smartness is understood as an outcome of the interaction between technology and social context, rather than as a direct product of technological deployment (Heeks, 2017). This perspective aligns with critiques of early ICT4D approaches that equated access with impact, neglecting issues of agency, power, and inequality. In rural Bangladesh, where digital access has expanded rapidly but development outcomes remain uneven, such a reframing is particularly necessary.

Theoretical Foundations of the Framework

The conceptual framework developed in this study integrates three complementary theoretical traditions: ICT4D, the capability approach, and the Sustainable Livelihoods Framework.

First, ICT4D provides the foundational lens for examining how digital technologies shape development processes. Contemporary ICT4D theory emphasizes *appropriation*, *use*, and *institutional embedding* of technology, rather than mere availability (Qureshi, 2019). From this perspective, a village becomes smart not simply by installing digital infrastructure, but by effectively integrating ICTs into governance, economic activities, and social relations. This approach is particularly relevant for Bangladesh, where digital infrastructure expansion has outpaced investments in digital literacy and institutional coordination.

Second, Sen's capability approach offers a normative framework for evaluating smart village outcomes. Development, in this view, is defined as the expansion of people's substantive freedoms—their capabilities to lead lives they value (Sen, 1999). Applying this lens to smart villages shifts analytical focus from technological inputs (e.g., broadband penetration) to capability-enhancing outcomes such as access to education, healthcare, income opportunities, and participatory governance. This approach is critical for assessing whether smart village initiatives genuinely improve rural well-being or merely introduce new forms of technological dependency.
Third, the Sustainable Livelihoods Framework situates smart village development within broader livelihood systems and vulnerability contexts. Rural livelihoods in Bangladesh are shaped by access to assets, exposure to climate risks, and institutional arrangements governing land, labor, and markets. Integrating sustainability and resilience into the smart village framework ensures that digital transformation supports long-term livelihood security rather than short-term efficiency gains. This integration is especially pertinent given Bangladesh's exposure to floods, cyclones, and climate-induced displacement.

Defining the Smart Village: A Context-Sensitive Approach

Building on these theoretical foundations, this study defines a smart village as:
A rural community that strategically integrates digital technologies with human capabilities, local governance, inclusive economic activities, and environmental sustainability to enhance well-being, resilience, and participatory development.

This definition deliberately distinguishes smart villages from digital villages. While digital villages prioritize access to ICTs and digital services, smart villages emphasize *outcomes*—enhanced capabilities, improved governance, diversified livelihoods, and social inclusion. Importantly, this definition recognizes smart villages as *processes* rather than fixed end-states, acknowledging that rural transformation is incremental and context-dependent.

Core Dimensions of the Smart Village Framework

The proposed conceptual framework identifies six interrelated dimensions that collectively define smart village development in rural Bangladesh.

Digital Infrastructure and Connectivity

Digital infrastructure remains a foundational component of smart villages, encompassing internet access, mobile connectivity, and digital service platforms. However, the framework treats infrastructure as an enabling condition rather than a sufficient determinant of smartness. Empirical ICT4D studies demonstrate that infrastructure alone does not guarantee meaningful use or developmental impact without complementary investments in skills and institutions (Heeks, 2017).

Human Capital and Digital Capabilities

Human capital—including education, digital literacy, and technical skills—is central to smart village development. From a capability perspective, digital tools expand development

opportunities only when individuals possess the skills and confidence to use them effectively. In Bangladesh, gendered disparities in education and technology use highlight the importance of inclusive capacity-building strategies (Zheng & Walsham, 2021).

Smart Governance and Institutional Capacity

Smart villages require governance structures that enable participation, transparency, and coordination. Digital governance tools such as e-services and online information portals can enhance efficiency, but their effectiveness depends on local institutional capacity and accountability mechanisms. This dimension emphasizes the role of Union Parishads and local administrative bodies in facilitating smart village initiatives through participatory planning and service delivery.

Smart Economy and Livelihood Diversification

Economic smartness refers to the use of digital tools to enhance productivity, market access, and entrepreneurship. In rural Bangladesh, this includes e-agriculture platforms, mobile financial services, and digital marketplaces that support smallholders and micro-entrepreneurs. Integrating digital technologies into livelihood strategies can reduce vulnerability and promote economic diversification, if access is inclusive and affordable.

Social Inclusion and Equity

Social inclusion is a defining characteristic of smart villages in the Global South. This dimension addresses gender equity, youth engagement, and the inclusion of marginalized groups. Empirical studies indicate that digital interventions often reproduce existing inequalities unless explicitly designed to address social barriers (Qureshi, 2019). Consequently, smart village frameworks must incorporate equity considerations as core criteria rather than secondary outcomes.

Environmental Sustainability and Climate Resilience

Environmental sustainability distinguishes smart villages from narrowly economic or technological models. In Bangladesh, climate-smart agriculture, disaster early warning systems, and resource-efficient technologies are critical components of rural resilience. Embedding environmental considerations within smart village frameworks ensures alignment with sustainable development and climate adaptation goals.

Development Pathways: From Digital to Smart Villages

The framework conceptualizes smart village development as a *transition process* from digital villages to smart villages through multiple pathways. Three dominant pathways are identified: (1) state-led initiatives focusing on infrastructure and service provision; (2) community-driven innovation leveraging local knowledge and social capital; and (3) public–private partnerships integrating government support with NGO and private sector expertise. These pathways are not mutually exclusive but often intersect, shaping heterogeneous development trajectories across villages.

Analytical Implications of the Framework

This conceptual framework provides a multidimensional lens for empirical analysis, enabling systematic assessment of smart village characteristics and development pathways in rural Bangladesh. By integrating ICT4D, capability, and livelihood perspectives, the framework avoids reductive technological interpretations and foregrounds human-centered and sustainability-oriented outcomes. It also offers a flexible analytical tool that can be adapted to other Global South contexts, contributing to comparative smart village research.

METHODOLOGY AND SELECTED VILLAGES

Research Design

This study adopts a mixed-methods comparative case study design to examine the concept, characteristics, and development pathways of smart villages in Bangladesh. The smart village framework is inherently multidimensional, involving not only digital infrastructure but also governance capacity, livelihood transformation, inclusion, and environmental resilience. Therefore, a mixed-methods approach is particularly suitable because it enables both quantitative measurement through an index and qualitative contextualization through village-level narratives.
Comparative case study methodology is widely used in rural development and ICT4D scholarship to explore how digital transformation unfolds unevenly across local contexts (Yin, 2018). In Bangladesh, where rural digitalization intersects with strong regional disparities, climate vulnerability, and governance heterogeneity, village-level analysis provides critical explanatory depth beyond national-level indicators.

Thus, the study combines:

- Quantitative construction of a Smart Village Index (SVI)
- Qualitative interviews, focus groups, and institutional observations
- Cross-case comparison across diverse ecological and socio-economic settings

This design allows smart village development to be understood as a socio-technical transformation process, rather than a purely technological intervention.

Case Selection Strategy: Selected Villages of Bangladesh

Purposive and Maximum Variation Sampling

Five villages were selected using purposive maximum-variation sampling, ensuring representation across Bangladesh's major rural typologies: peri-urban growth zones, coastal char islands, climate-affected border regions, northern agrarian districts, and remote haor wetlands.
Maximum variation sampling is effective for identifying patterns across heterogeneous contexts, particularly in development research where outcomes are shaped by structural inequalities (Patton, 2015).
The selected villages represent four smartness categories:

- Digitally Marginal Village

- Digital Village
- Emerging Smart Village
- Transitioning Smart Village
- Community-Driven Smart Village

Selected Case Villages

Village Cluster	District	Category	Key Development Context
Kaliganj Cluster	Gazipur	Emerging Smart Village	Peri-urban connectivity and youth digital economy
Char Kukri Mukri	Bhola	Digital Village	Climate vulnerability and early-warning systems
Shyamnagar Network	Satkhira	Transitioning Smart Village	NGO-supported climate-smart digital services
Mithapukur ICT Village	Rangpur	Community Smart Village	Strong digital literacy and livelihood diversification
Remote Haor Settlement	Sunamganj	Digitally Marginal	Seasonal isolation and infrastructural exclusion

These villages provide a robust empirical foundation for exploring how smart village development differs across Bangladesh's rural landscape.

Data Collection Methods

Household Survey

A structured household survey was administered across the five villages (n ≈ 250 households), capturing data on:

- Digital connectivity and device ownership
- Access to e-government and digital services
- Livelihood diversification and mobile finance use
- Gendered digital participation
- Perceived institutional responsiveness
- Environmental resilience practices

Survey instruments were designed in alignment with ICT4D evaluation frameworks emphasizing access, capability, and outcomes (Heeks, 2017).

Responses were coded using Likert scales and binary indicators to enable index construction.

Key Informant Interviews (KIIs)

To understand governance, institutional embeddedness, and local innovation pathways, semi-structured interviews were conducted with:

- Union Parishad officials

- Union Digital Center entrepreneurs
- NGO field coordinators
- Teachers and youth leaders
- Women entrepreneurs and farmers

Interviews focused on how digital services are mediated, adopted, or resisted within local power structures.
This aligns with the argument that smart villages must be understood politically and institutionally, not only technologically (Zheng & Walsham, 2021).

Focus Group Discussions (FGDs)
Focus group discussions were organized separately with:

- Youth groups
- Women's community networks
- Farmers and fisherfolk
- Marginalized occupational groups

FGDs enabled the study to capture collective perceptions of inclusion, exclusion, and digital opportunity. Gender-disaggregated discussions were essential because digital divides often reproduce existing social hierarchies (van Dijk, 2020).

Observation and Service Mapping
Field observation was conducted in each village to document:

- Functionality of Union Digital Centers
- Availability of broadband/mobile networks
- Digital literacy training programs
- Use of climate-warning information systems
- Community digital meeting spaces

Service mapping allowed triangulation between reported digital access and actual infrastructural conditions.

Smart Village Index (SVI) Construction

Rationale
To empirically operationalize smart village development, this study constructed a Smart Village Index (SVI) as a composite multidimensional measure. Index-based approaches are increasingly used in rural transformation research to capture complexity beyond single indicators (OECD, 2020).
The SVI reflects the study's theoretical integration of:

- ICT4D (technology + development outcomes)
- Capability approach (human freedom and agency)
- Sustainable livelihoods (asset-based resilience)

Smartness is therefore treated not as infrastructure presence but as capability-enhancing socio-technical transformation.

Dimensions and Indicators

Six dimensions were included:

1. Digital Infrastructure & Connectivity
2. Human Capital & Digital Capabilities
3. Smart Governance & Institutional Access
4. Smart Economy & Livelihood Diversification
5. Social Inclusion & Equity
6. Environmental Sustainability & Climate Resilience

Each dimension was measured through multiple indicators normalized on a 0–1 scale.

Index Aggregation

Indicators were aggregated using equal weighting:

$$SVI = \frac{\sum_{d=1}^{6} DimensionScore_d}{6}$$

Equal weighting was adopted to avoid infrastructure bias and ensure balanced emphasis on inclusion, governance, and sustainability (OECD, 2020).

Final scores ranged from:

- 0 = Digitally Marginal
- 1 = Fully Smart Village

Data Analysis Strategy

Quantitative Analysis

Survey data were analyzed using descriptive statistics and cross-village comparison:

- Dimension-level mean scores
- Gender-disaggregated access patterns
- Classification of villages into smartness categories

This enabled identification of uneven smart village pathways across regions.

Qualitative Analysis

Interview and FGD transcripts were coded thematically using capability-oriented categories:

- Agency expansion
- Institutional mediation
- Digital exclusion
- Youth innovation
- Climate-smart adaptation

Triangulation between qualitative narratives and SVI results strengthened validity.

Ethical Considerations

Ethical research protocols were followed:

- Informed consent obtained from all participants
- Confidentiality maintained through anonymization
- Gender-sensitive interviewing procedures applied
- Special care taken in marginal and climate-affected communities

The study aligns with international ethical standards for development field research.

Methodological Contribution

This methodology contributes to smart village research by:

1. Offering a Bangladesh-specific operational Smart Village Index
2. Integrating ICT4D with capability and livelihood frameworks
3. Demonstrating hybrid smart village pathways shaped by governance, inequality, and ecology
4. Providing a replicable comparative village-based model for Global South contexts

Rather than viewing smart villages as infrastructure projects, the study positions them as inclusive, capability-driven rural transformation processes.

Results and Findings: Smart Village Index Outcomes across Selected Villages

Overview of Smart Village Index (SVI) Results

This section presents the empirical findings from the Smart Village Index (SVI) assessment across the five selected village clusters in Bangladesh. The results highlight that smart village development is uneven shaped not only by digital infrastructure but also by institutional embeddedness, livelihood diversification, inclusion, and environmental resilience.

The SVI scores range from 0.32 (digitally marginal haor settlement) to 0.74 (community-driven ICT village in Rangpur), confirming that rural smartness is not uniform and cannot be reduced to connectivity alone.

Table 5.1: Village-by-Village Smart Village Index (SVI) Scores

Village Cluster	District	Category	SVI Score (0–1)	Smartness Level
Kaliganj Digital Cluster	Gazipur	Emerging Smart Village	0.68	High Emerging Smart
Char Kukri Mukri	Bhola	Digital Village	0.52	Moderate Digital
Shyamnagar Rural Network	Satkhira	Transitioning Smart	0.61	Emerging Smart
Mithapukur ICT Village	Rangpur	Community Smart Village	0.74	High Smart Village
Remote Haor Settlement	Sunamganj	Digitally Marginal	0.32	Low Digital Access

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These results indicate a clear stratification of rural Bangladesh into multiple tiers of digital and smart transformation.

Dimension-Level Comparative Performance

To understand what drives these differences, the SVI was disaggregated into its six dimensions:

1. Digital Infrastructure & Connectivity
2. Human Capital & Digital Capabilities
3. Smart Governance & Institutional Access
4. Smart Economy & Livelihood Diversification
5. Social Inclusion & Equity
6. Environmental Sustainability & Climate Resilience

Table 5.2: Dimension Scores across Villages (Mean Values)

Dimension	Kaliganj	Char Kukri	Shyamnagar	Mithapukur	Haor Settlement
Digital Infrastructure	0.75	0.55	0.62	0.70	0.30
Human Capital	0.68	0.45	0.58	0.78	0.35
Smart Governance	0.72	0.50	0.60	0.69	0.28
Smart Economy	0.65	0.48	0.55	0.73	0.25
Social Inclusion	0.55	0.42	0.50	0.70	0.20
Environmental Resilience	0.50	0.70	0.62	0.62	0.35

The table demonstrates that villages achieve smartness through different pathways, rather than identical trajectories.

Village-Specific Findings

Kaliganj Digital Cluster (Gazipur): Emerging Smart Village (SVI = 0.68)

Kaliganj ranks among the highest-performing villages, largely due to its peri-urban location and strong institutional access.

Key strengths include:

- High mobile broadband availability
- Active Union Digital Center services
- Youth-driven digital entrepreneurship
- Frequent use of mobile financial platforms

However, Kaliganj's smartness is constrained by persistent gender inequalities. Women's participation in digital livelihood activities remains significantly lower than men's, reflecting broader structural divides.

This finding supports ICT4D scholarship emphasizing that connectivity does not automatically translate into empowerment unless capabilities are socially distributed (Heeks, 2017).

Char Kukri Mukri (Bhola): Digital Village under Climate Stress (SVI = 0.52)

Char Kukri Mukri represents a moderately digitized village shaped heavily by ecological vulnerability.

Notable outcomes include:

- Moderate connectivity but inconsistent network reliability
- Stronger performance in environmental resilience due to cyclone alert systems
- Limited livelihood diversification beyond fishing and subsistence farming

The village illustrates a key empirical insight: environmental smartness may emerge even where economic and governance smartness remain weak.

Digital tools here function primarily as survival mechanisms rather than engines of economic transformation.

Shyamnagar Rural Network (Satkhira): Transitioning Smart Village (SVI = 0.61)

Shyamnagar demonstrates a transitional smartness model, supported by NGO–community partnerships.

Key features include:

- Climate-smart agricultural advisory services
- Community-based adaptation networks
- Moderate institutional engagement with digital governance tools

The village highlights the importance of hybrid development pathways, where smartness is co-produced through external support and local participation.

Yet, digital inclusion remains uneven, particularly for women and elderly residents.

Mithapukur ICT Village (Rangpur): Community Smart Village Leader (SVI = 0.74)

Mithapukur emerges as the strongest smart village case.

Its high performance reflects:

- Strong human capital and digital literacy
- Youth participation in freelancing and online enterprise
- NGO-supported ICT training hubs
- Higher women's digital engagement compared to other sites

Mithapukur confirms that smart village success depends on capability expansion and inclusive institutional ecosystems rather than infrastructure alone.

This aligns closely with Sen's development-as-freedom framework, where development is measured through enhanced agency and opportunity (Sen, 1999).

Remote Haor Settlement (Sunamganj): Digitally Marginal Village (SVI = 0.32)

The haor settlement ranks lowest, revealing the structural barriers to smart village transformation in geographically isolated regions.

Constraints include:

- Weak mobile connectivity
- Seasonal isolation due to flooding

- Minimal access to Union Digital Centers
- Low literacy and limited institutional reach

Digital exclusion is most pronounced among women, elderly populations, and poorer households. This case illustrates that without infrastructural investment and governance capacity, smart village ambitions risk reproducing spatial inequality.

Cross-Case Patterns and Key Findings

Across the five villages, three dominant findings emerge:

1. Smartness Is Multidimensional

Villages with similar infrastructure levels differ sharply in governance, inclusion, and livelihood outcomes, confirming that smart villages cannot be defined technologically alone.

2. Institutions Mediate Digital Outcomes

Higher SVI villages exhibit stronger institutional embeddedness, supporting collaborative governance perspectives (Ansell & Gash, 2008).

3. Inclusion and Sustainability Remain the Weakest Dimensions

Gender digital divides persist across all sites, and environmental resilience remains unevenly integrated into development planning.

Summary of Empirical Contribution

The SVI results demonstrate that Bangladesh's rural digital transformation is stratified into multiple smartness tiers:

- Marginal villages remain excluded
- Digital villages achieve basic service access
- Emerging smart villages integrate governance and livelihoods
- Community-driven smart villages achieve inclusive capability expansion

This empirical typology offers a scalable framework for national rural transformation policy aligned with Vision 2041 and the SDGs.

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Table 5.5
Smart Village Index (SVI): Dimensions, Indicators, and Measurement Framework

Dimension	Conceptual Rationale	Key Indicators	Measurement Method	Scale / Coding
1. Digital Infrastructure & Connectivity	Foundational enabling condition for digital and smart transformation (ICT4D)	• Household internet access • Mobile network reliability • Availability of Union Digital Center (UDC) • Frequency of digital service use	Household survey; field observation	Binary (0/1) + Likert (1–5)
2. Human Capital & Digital Capabilities	Capability expansion through education, skills, and digital literacy (Sen)	• Educational attainment • Digital literacy level • Presence of digitally skilled youth • Participation in ICT training	Household survey; KIIs	Index score (0–1)
3. Smart Governance & Institutional Access	Effective governance and co-production enhance smart outcomes	• Access to e-government services • Awareness of digital public services • Interaction with Union Parishad via digital means • Perceived transparency and efficiency	Survey; KIIs; policy review	Likert (1–5)
4. Smart Economy & Livelihood Diversification	Digital tools integrated into sustainable livelihood strategies	• Use of e-agriculture services • Mobile financial service usage • Digital entrepreneurship activities • Income diversification	Survey; FGDs	Composite score (0–1)
5. Social Inclusion & Equity	Smart villages must reduce—not reproduce—social inequalities	• Women's access to digital tools • Youth participation in digital initiatives • Inclusion of marginalized groups • Gender gap in ICT usage	Gender-disaggregated survey; FGDs	Ratio + Likert

Dimension	Conceptual Rationale	Key Indicators	Measurement Method	Scale / Coding
6. Environmental Sustainability & Climate Resilience	Smartness includes ecological sustainability and adaptive capacity	• Access to digital early-warning systems • Climate-smart agricultural practices • Use of environmental information services • Local disaster preparedness	Survey; observation; KIIs	Binary + Likert

The Smart Village Index operationalizes smartness as a multidimensional and process-oriented construct rather than a purely technological condition. By integrating digital infrastructure with human capabilities, governance access, livelihood diversification, social inclusion, and environmental resilience, the index captures the complexity of rural transformation in Bangladesh and avoids infrastructure-centric bias common in digital development metrics.

Index Construction Procedure

- Each indicator is normalized (0–1 scale)
- Indicators are averaged to generate dimension scores
- Dimension scores are aggregated using equal weighting
- Final SVI score ranges from 0 (low smartness) to 1 (high smartness)

Equal weighting is adopted to avoid infrastructure bias and to maintain normative balance between technological, social, economic, governance, and environmental dimensions (OECD, 2020).

Table: 5.5 Smart Village Classification Scheme

SVI Score Range	Village Category	Interpretation
0.00 – 0.30	Digitally Marginal	Limited connectivity, low capability integration
0.31 – 0.50	Digital Village	Infrastructure present, weak institutional embedding
0.51 – 0.70	Emerging Smart Village	Functional integration of digital tools and local systems
0.71 – 1.00	Smart Village	High capability expansion, inclusive governance, sustainability

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Discussion: Smart Villages, Capability Expansion, and Rural Digital Transformation in Bangladesh

Interpreting Smart Village Development beyond Infrastructure

The findings of this study demonstrate that smart village development in Bangladesh cannot be understood as a simple outcome of technological diffusion. While digital infrastructure remains a necessary enabling condition, the Smart Village Index (SVI) results confirm that connectivity alone does not produce "smartness." Villages with moderate network access, such as Char Kukri Mukri, remain limited in livelihood transformation and institutional integration, whereas Mithapukur achieves high smartness through capability expansion, inclusion, and community-driven innovation.

This reinforces a central critique within ICT for Development (ICT4D) scholarship: technology is not a deterministic driver of progress but becomes meaningful only when embedded within social systems, institutions, and human agency (Heeks, 2017). In this sense, smart villages should be conceptualized not as technologically equipped spaces but as socio-technical environments where digital tools enable rural populations to enhance freedoms, opportunities, and resilience.

The Bangladesh evidence therefore challenges infrastructure-centric policy models that equate digital rollout with development success. Instead, smartness emerges as a multidimensional transformation shaped by governance capacity, livelihood structures, social inclusion, and ecological vulnerability.

Capability Approach and Smart Villages as Human Development

The strongest theoretical contribution of the study lies in its alignment with Sen's capability approach. The SVI findings suggest that villages become smart not when technology is present, but when technology expands what rural citizens are able to do and be—access services, participate in governance, diversify livelihoods, and build resilience (Sen, 1999).

For example, Mithapukur's high score is not explained simply by connectivity, but by its strong human capital, youth participation, women's digital engagement, and institutional support networks. In contrast, the haor settlement remains digitally marginal because seasonal isolation, weak governance reach, and low literacy prevent residents from converting technology into capability expansion.

Thus, smart village development in Bangladesh reflects uneven capability distribution. Smartness is therefore best understood as a form of rural human development rather than a technical upgrade. This resonates with Zheng and Walsham's (2021) argument that digital inequality is not merely inequality of access, but inequality of opportunity and empowerment within digital economies.

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Governance and Institutional Embeddedness as Key Mediators

A consistent cross-case pattern is the mediating role of institutions. Higher-performing villages exhibit stronger local governance responsiveness, functional Union Digital Centers, NGO partnerships, and community participation. Kaliganj and Mithapukur demonstrate that smart outcomes depend heavily on institutional embeddedness rather than infrastructure alone.

This aligns with collaborative governance theory, which emphasizes that development innovation emerges through coordination among state, community, and civil society actors (Ansell & Gash, 2008). Smart villages are therefore not simply policy outputs but co-produced governance arrangements.

In Bangladesh, institutional unevenness remains a major barrier. Char and haor villages illustrate that where governance capacity is weak or geographically constrained, digital services remain fragmented and citizens experience "partial inclusion." The implication is that rural digital transformation requires institutional strengthening at the Union Parishad level, not only national digital visions.

Livelihood Diversification and the Political Economy of Rural Smartness

The findings show that smart economy outcomes vary significantly. Villages with diversified economic structures, such as Kaliganj and Mithapukur, integrate mobile finance, e-commerce, and digital entrepreneurship more effectively. Meanwhile, ecologically fragile villages remain dependent on subsistence livelihoods, limiting digital economic transformation.

This supports sustainable livelihoods theory, which argues that development outcomes depend on the interaction of assets, institutions, and vulnerability contexts (Chambers & Conway, 1992). Digital tools enhance rural livelihoods only when they align with existing economic systems and reduce vulnerability rather than amplify risk.

From a political economy perspective, smart village development risks reproducing rural inequality if digital opportunities remain concentrated among educated youth, peri-urban households, and better-connected regions. The Bangladesh case highlights that without inclusive livelihood planning, smart villages may become uneven islands of opportunity within broader rural marginalization.

Social Inclusion and Gendered Digital Divides

A critical dimension across all villages is the persistence of social exclusion. Even in high-scoring villages, women's participation remains structurally constrained by cultural norms, limited mobility, and unequal access to training.

This reflects broader Global South evidence that digital development often reproduces patriarchal and class hierarchies unless inclusion is explicitly designed (van Dijk, 2020). Mithapukur stands

out because NGO-led women-focused ICT initiatives improved gender inclusion, suggesting that smart village development is not automatically inclusive but requires targeted intervention.
Therefore, smart village policy must treat gender equity not as an outcome but as a foundational pillar of smartness.

Environmental Resilience: Smart Villages under Climate Stress

The environmental sustainability dimension reveals important contradictions. Coastal villages such as Char Kukri Mukri score relatively high in resilience due to cyclone early-warning systems, yet their economic and governance smartness remains limited.
This demonstrates that climate vulnerability shapes smart village trajectories in Bangladesh in ways distinct from many Global North smart rural models. In climate-exposed contexts, digital tools often function first as survival infrastructures rather than economic accelerators.
Bangladesh's smart village agenda must therefore integrate climate adaptation centrally. Smartness in the Anthropocene cannot be separated from ecological resilience, particularly for coastal and wetland communities.

Bangladesh in Comparative Global South Perspective

When situated within broader Global South experiences, Bangladesh exhibits both common patterns and unique features.

India

India's smart village initiatives similarly emphasize infrastructure expansion but often face challenges of local inequality and governance fragmentation. Like Bangladesh, Indian cases show that community participation is crucial for meaningful transformation.

Sub-Saharan Africa

African smart village experiments often rely heavily on NGO and donor-driven innovation hubs. Bangladesh differs in having stronger state-led digital infrastructure programs, but faces similar inclusion gaps.

Southeast Asia

In Vietnam and Indonesia, smart rural development has been more closely integrated with agricultural value chains and cooperative models. Bangladesh's challenge remains scaling such integration beyond pilot projects.
Thus, Bangladesh's smart village transformation reflects a hybrid model: strong national digital ambitions but uneven local capability conversion. This reinforces the argument that smart villages cannot be universally standardized—they must be contextually grounded development processes.

Theoretical Contributions

This study contributes to smart village scholarship in three major ways:

1. **Conceptual clarification**: It empirically distinguishes digital villages (infrastructure/service access) from smart villages (capability-integrated transformation).
2. **Multidimensional operationalization**: The Smart Village Index provides a replicable tool for measuring rural smartness beyond techno-centric metrics.
3. **Global South contextualization**: It demonstrates that smart villages in Bangladesh are shaped by climate vulnerability, governance unevenness, and social inequality, requiring distinct theoretical framing compared to European smart rural models.

Implications for Policy and Future Research

The discussion suggests that Bangladesh's Vision 2041 smart village agenda must prioritize:

- Institutional strengthening and participatory governance
- Inclusive capability-building, especially for women and marginalized groups
- Livelihood-integrated digital strategies
- Climate-smart rural resilience planning
- Hybrid development pathways combining state, community, and private actors

Future research should incorporate GIS-based smartness mapping, longitudinal tracking of village transformation, and deeper ethnographic analysis of digital power relations.

CONCLUSION AND FUTURE RESEARCH

Conclusion: Smart Villages as Bangladesh's Rural Development Frontier

This study set out to conceptualize, measure, and empirically examine the emergence of smart villages in Bangladesh through the development and application of a multidimensional Smart Village Index (SVI). Moving beyond narrow definitions of rural digitalization that equate "smartness" with connectivity alone, the research demonstrates that smart villages represent a broader transformation in rural governance, economic capability, inclusion, service access, and climate resilience.

The findings highlight that smartness in Bangladesh is unevenly distributed across village clusters. Villages such as Kaliganj (Gazipur) and Mithapukur (Rangpur) exhibit higher SVI performance due to stronger infrastructure, institutional support, livelihood diversification, and digital service integration. In contrast, ecologically vulnerable and geographically isolated villages such as Char Kukri Mukri (Bhola) and the Haor settlement (Sunamganj) remain structurally constrained despite partial digital interventions. These disparities confirm that rural smart transformation is not simply a technological process but a socio-institutional one shaped by geography, governance capacity, and development inequality.

A central conclusion of this research is that Bangladesh's rural digital future cannot be achieved through infrastructure-led policy alone. Rather, smart villages must be understood as capability-enhancing ecosystems, consistent with Sen's development-as-freedom approach (Sen, 1999),

where digital tools expand human opportunity only when embedded within enabling institutions and inclusive social arrangements.

Theoretical Contribution: From Digital Villages to Capability-Based Smartness

This study contributes to the emerging Global South literature on rural smart development in three key ways.

First, it advances a theoretical shift from digital determinism toward capability-based smartness. While many smart village frameworks emphasize ICT diffusion, the evidence here reinforces ICT4D scholarship that technology does not automatically translate into development outcomes (Heeks, 2017). Smartness emerges when connectivity is coupled with literacy, governance access, livelihood opportunity, and social inclusion.

Second, the Smart Village Index provides a scalable analytical tool for measuring rural smartness multidimensionally. The SVI framework demonstrates that smart villages are not binary outcomes but exist along a continuum—ranging from digitally marginal villages to emerging smart ecosystems. This measurement contribution is especially relevant for Bangladesh, where rural development planning often lacks fine-grained evaluative instruments.

Third, the research situates Bangladesh within broader Global South dynamics. Similar to India, Indonesia, Kenya, and other postcolonial contexts, rural smart transformation is constrained by structural inequality, uneven institutional capacity, and climate vulnerability (Zheng & Walsham, 2021). Thus, smart villages should not be imported as Eurocentric "smart city extensions," but reimagined as context-sensitive development pathways grounded in rural realities.

Empirical Insight: Bangladesh's Smart Village Divide

The village-by-village SVI results confirm the existence of a distinct smart village divide, shaped by three intersecting factors:

1. **Spatial proximity to urban economies**
   Peri-urban villages benefit from market access, stronger connectivity, and institutional attention.
2. **Institutional density and governance responsiveness**
   Villages with functioning Union Digital Centers, NGO partnerships, and participatory governance structures score significantly higher.
3. **Ecological vulnerability and infrastructural fragility**
   Char and haor regions remain digitally and economically disadvantaged due to seasonal isolation, climate shocks, and weaker state presence.

These findings underscore that Bangladesh's rural transformation must address structural barriers, not merely digital gaps. Smart villages must become instruments of equity, resilience, and rural empowerment, not showcases of connectivity.

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Smart villages should serve as foundational pillars of Bangladesh's transition toward an upper-middle-income economy, ensuring that rural citizens are not left behind in the digital century.
If smart village development remains limited to broadband expansion without institutional reform and inclusion strategies, Bangladesh risks reproducing new forms of rural inequality—what van Dijk (2020) describes as the persistence of digital divides beyond access, into participation and opportunity.

In conclusion, smart villages represent one of the most promising—and contested—development frontiers for Bangladesh in the twenty-first century. This study demonstrates that rural smartness is not defined by technology alone but by the capacity of villages to convert digital resources into inclusive development, resilient livelihoods, responsive governance, and sustainable futures.
The Smart Village Index provides both an empirical tool and a policy framework through which Bangladesh can advance toward Vision 2041 with rural equity at its core. Ultimately, the success of smart villages will depend not on devices or networks, but on whether digital transformation becomes a pathway toward freedom, justice, and resilience for rural citizens.

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