

E-GOVERNANCE AND DIGITAL INCLUSION IN RURAL COMMUNITIES: A COMPARATIVE STUDY OF ESTONIA AND INDIA

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ABSTRACT

Achieving SDG 9 (Industry, Innovation and Infrastructure) requires building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. Target 9.1 calls for developing quality, reliable, sustainable and resilient infrastructure to support economic development and human well-being, with a focus on affordable and equitable access for

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all. Target 9.C aims to significantly increase access to information and communications technology and to provide universal and affordable internet access.

E-governance, the use of information and communications technology to deliver government services, exchange information, facilitate citizen participation, and improve administrative efficiency, has emerged as a transformative tool for public sector reform. However, the digital divide between urban and rural communities remains a persistent global challenge. Rural areas have lower internet access, lower digital literacy, weaker infrastructure, and higher poverty rates, which limit their ability to benefit from e-governance.

This study conducts a comparative analysis of e-governance and digital inclusion in rural communities in Estonia and India, two countries with contrasting digital trajectories, population scales, and rural development contexts. Estonia, a small high-income country, is widely recognized as the world's most advanced digital society, with infrastructure including X-Road, digital ID, i-Voting, e-Tax, and e-Health. India, a large lower-middle-income country, has made significant e-governance progress through Aadhaar (biometric digital identity), DigiLocker, UMANG, and BHIM-UPI, but faces persistent digital inclusion challenges in rural areas.

Using a qualitative comparative case study methodology, the study analyzes secondary data from government reports, international indices, peer-reviewed literature, and program evaluations over the period 2000 to 2025. The study finds that Estonia's success is underpinned by political commitment, early investment in digital infrastructure, mandatory digital ID, interoperability through X-Road, a small population, and universal digital skills training. India's progress is constrained by massive scale, heterogeneous languages, infrastructure deficits, low digital literacy, and uneven implementation across states.

The study concludes that e-governance can transform rural service delivery but requires universal digital identity, interoperable data exchange, last-mile connectivity, digital access points, digital literacy at scale, and citizen trust. Recommendations for both countries and the international community are provided.

Keywords: E-governance; digital inclusion; rural communities; Estonia; India; SDG 9; digital identity; X-Road; Aadhaar; BharatNet

RÉSUMÉ

La réalisation de l'ODD 9 (Infrastructure, industrialisation et innovation) nécessite de développer des infrastructures résilientes, de promouvoir une industrialisation inclusive et durable, et de favoriser l'innovation. La cible 9.1 appelle à développer des infrastructures de qualité, fiables, durables et résilientes pour soutenir le développement économique et le bien-être humain. La cible 9.C vise à accroître considérablement l'accès aux technologies de l'information et de la communication (TIC) et à fournir un accès universel et abordable à l'internet.

L'administration en ligne, qui utilise les TIC pour fournir des services gouvernementaux, échanger des informations, faciliter la participation citoyenne et améliorer l'efficacité administrative, est devenue un outil de transformation pour la réforme du secteur public. Cependant, la fracture numérique entre les communautés urbaines et rurales reste un défi persistant à l'échelle mondiale. Les zones rurales ont un accès internet plus faible, une littératie numérique moins développée, des infrastructures plus fragiles et des taux de pauvreté plus élevés, ce qui limite leur capacité à bénéficier de l'administration en ligne.

Cette étude mène une analyse comparative de l'administration en ligne et de l'inclusion numérique dans les communautés rurales en Estonie et en Inde, deux pays aux trajectoires numériques, aux échelles de population et aux contextes de développement rural contrastés. L'Estonie, un petit pays à revenu élevé, est largement reconnue comme la société numérique la plus avancée au monde, avec une infrastructure comprenant X-Road, la carte d'identité numérique, le vote électronique, e-Tax et e-Health. L'Inde, un grand pays à revenu intermédiaire inférieur, a réalisé des progrès significatifs en matière d'administration en ligne grâce à Aadhaar (identité numérique biométrique), DigiLocker, UMANG et BHIM-UPI, mais elle est confrontée à des défis persistants d'inclusion numérique dans les zones rurales.

En utilisant une méthodologie qualitative d'étude de cas comparative, l'étude analyse des données secondaires provenant de rapports gouvernementaux, d'indices internationaux, de la littérature évaluée par les pairs et d'évaluations de programmes sur la période 2000 à 2025. L'étude révèle que le succès de l'Estonie repose sur un engagement politique fort, un investissement précoce

dans les infrastructures numériques, une carte d'identité numérique obligatoire, l'interopérabilité via X-Road, une petite population et une formation universelle aux compétences numériques.

Les progrès de l'Inde sont limités par l'échelle massive du pays, l'hétérogénéité des langues, les déficits d'infrastructure, la faible littératie numérique et la mise en œuvre inégale selon les États.

L'étude conclut que l'administration en ligne peut transformer la prestation de services en zone rurale, mais nécessite une identité numérique universelle, un échange de données interopérable, une connectivité de dernier kilomètre, des points d'accès numériques, une littératie numérique à grande échelle et la confiance des citoyens.

Mots-clés : Administration en ligne; inclusion numérique; communautés rurales; Estonie; Inde; ODD 9; identité numérique; X-Road; Aadhaar; BharatNet

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1. INTRODUCTION

Achieving SDG 9 (Industry, Innovation and Infrastructure) requires building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. Target 9.1 calls for developing quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. Target 9.C aims to significantly increase access to information and communications technology and to provide universal and affordable internet access.

E-governance, the use of information and communications technology to deliver government services, exchange information, facilitate citizen participation, and improve administrative efficiency, has emerged as a transformative tool for public sector reform. E-governance can reduce corruption through digital records and automated processes, increase convenience by providing services at home without travel, lower costs through paperless operations and reduced queues,

improve transparency through public data and audit trails, and enable citizen participation through online consultations and e-voting.

However, the digital divide between urban and rural communities remains a persistent global challenge. Rural areas have lower internet access, lower digital literacy, weaker infrastructure, and higher poverty rates. Without digital inclusion, e-governance risks exacerbating inequalities: urban citizens benefit from online services, while rural citizens are excluded, forced to travel to government offices, wait in queues, pay bribes, or forgo services entirely.

This study examines two countries that offer profound and contrasting insights into e-governance and digital inclusion in rural communities: Estonia and India.

Estonia, a small high-income country in Northern Europe with a population of 1.3 million and a GDP per capita of \$38,000, is widely recognized as the world's most advanced digital society. Estonia regained independence from the Soviet Union in 1991, inheriting minimal digital infrastructure. Within 30 years, Estonia transformed into a digital powerhouse. Key e-governance infrastructure includes X-Road (a decentralized data exchange layer), digital ID (a mandatory electronic identity card for all citizens), i-Voting (internet voting in national elections since 2005), e-Tax (pre-filled tax declarations filed online), and e-Health (digitized health records and e-prescriptions). Rural digital inclusion in Estonia is high: 95 percent of rural areas have 4G mobile broadband coverage, 500 public libraries provide free internet access, and 85 percent of adults can use e-services.

India, a large lower-middle-income country in South Asia with a population of 1.4 billion, a GDP per capita of \$2,500, and more than 600,000 villages, has made significant e-governance progress. India's digital infrastructure, known as India Stack, includes several components. Aadhaar is a biometric digital identity for 1.3 billion citizens, making it the world's largest digital identity system. It enables direct benefit transfers, reducing corruption and eliminating ghost beneficiaries. DigiLocker provides digital document storage for driving licenses, passports, educational degrees, and health records. UMANG offers over 1,700 government services in more than 100 languages. BHIM-UPI is the world's largest real-time payment system, with 10 billion monthly transactions. However, digital inclusion challenges in rural India are substantial. Internet penetration is only 30

percent in rural areas compared to 70 percent in urban areas. Digital literacy is low, with only 35 percent of the rural population able to use a computer. Infrastructure gaps remain, as BharatNet has connected only 60 percent of villages with poor-quality fiber optic broadband.

The contrast between Estonia and India illuminates critical questions for e-governance, digital inclusion, rural communities, and SDG 9, which this study addresses.

2. LITERATURE REVIEW

The literature on e-governance spans public administration, information systems, development studies, and political science.

2.1 Estonia's E-Governance Transformation

Estonia's e-governance success is extensively documented. The e-Estonia Briefing Centre (2023) provides an authoritative overview of the country's digital infrastructure. Drechsler (2018) argued that Estonia's small size, post-Soviet greenfield opportunity, and political will were critical success factors. Kalvet (2012) traced the evolution of Estonia's e-governance, highlighting the role of the Tiger Leap program (1996) in equipping all schools with computers and internet access.

Kattel and Mergel (2018) examined Estonia's governance model, noting that X-Road's decentralized architecture was a deliberate design choice to avoid the privacy risks of centralized databases. Tammpuu and Masso (2018) studied citizen trust in e-governance in Estonia, finding that 95 percent of citizens trust the system, attributing this trust to transparency features such as audit logs.

2.2 India's E-Governance Infrastructure: India Stack

The literature on India's e-governance is dominated by the India Stack framework. Nilekani (2020) provided an insider account of Aadhaar's design and implementation, arguing that biometric identity was necessary to eliminate duplicate identities in a country of 1.4 billion people. Chawla (2019) analyzed Aadhaar from a legal perspective, documenting the Supreme Court's 2018 judgment that upheld Aadhaar's constitutionality but restricted its mandatory use.

Bhatia and Bhabha (2017) raised privacy concerns about Aadhaar, noting the centralization of biometric data and the risk of surveillance. The 2018 Aadhaar data breach, in which personal information of 1 billion citizens was exposed, heightened these concerns.

2.3 Rural Digital Inclusion in India

The literature on rural digital inclusion in India is substantial but often critical. Bhatnagar (2014) evaluated the Common Service Centre program, finding that while the network of 500,000 CSCs is unprecedented in scale, quality and sustainability vary widely. Mukerjee (2018) analyzed BharatNet, documenting delays, cost overruns, and quality issues. NITI Aayog (2019) evaluated PMGDISHA, finding that short course durations were insufficient to build lasting digital skills.

2.4 Comparative Studies

Comparative studies of e-governance across Estonia and India are rare. The UN E-Government Development Index (2022) ranks Estonia 8th and India 105th, but the index does not adjust for population size or income. Kattel and Mergel (2018) briefly compared X-Road with Aadhaar, noting that X-Road's decentralized architecture is more privacy-preserving but that India's scale required a centralized biometric approach. This study contributes to filling the comparative gap.

3. RESEARCH QUESTIONS

This study addresses the following research questions:

1. What are the e-governance and digital inclusion infrastructure, policies, and outcomes in Estonia and India?
2. What are the digital inclusion gaps in each country, including the rural-urban divide, age, income, education, and language barriers?
3. What explains Estonia's success and India's persistent gaps in terms of population scale, infrastructure legacy, political will, and citizen trust?

4. METHODOLOGY

This study employs a qualitative comparative case study methodology to examine e-governance and digital inclusion in rural communities in Estonia and India.

Estonia and India were selected as cases offering maximum variation. Estonia is small (population 1.3 million), high-income, post-Soviet, with one official language, and high citizen trust. India is large (population 1.4 billion), lower-middle-income, post-colonial, with 22 official languages, and trust that varies significantly by state.

The research design integrates secondary analysis of multiple data sources spanning the period 2000 to 2025. Government sources include, for Estonia, the Ministry of Economic Affairs and Communications, the e-Estonia Briefing Centre, and Statistics Estonia; for India, the Ministry of Electronics and Information Technology, UIDAI, BharatNet, CSC e-Governance Services India, and NITI Aayog. International indices include the UN E-Government Development Index, the ITU ICT Development Index, and the World Bank Digital Adoption Index. Peer-reviewed literature and program evaluations are also analyzed.

The analytical framework examines five dimensions: digital identity, interoperability layer, connectivity, digital access points, and digital literacy.

5. RESULTS

Table 1: Comparative Summary of E-Governance and Digital Inclusion

Dimension	Estonia	India
Population (2024)	1.3 million	1.4 billion
GDP per capita (USD)	\$38,000 (high-income)	\$2,500 (lower-middle-income)
UN E-Government Development Index (2022)	8th (score 0.94)	105th (score 0.61)
Internet penetration (percent of population)	92 percent	45 percent (rural 30%, urban 70%)
Mobile broadband coverage (4G)	99 percent (rural 95%)	75 percent (rural 60%)

Digital identity	Mandatory digital ID (eID) for 100 percent of citizens	Aadhaar for 1.3 billion citizens (99 percent of adults)
Interoperability layer	X-Road (decentralized, open-source)	India Stack (partial interoperability)
Online tax filing	e-Tax: 99 percent online	GSTN: 85 percent online
E-voting	i-Voting since 2005, more than 50 percent online	No (paper ballots)
Digital payments	Cards and mobile apps	BHIM-UPI: 10 billion monthly transactions
Rural digital access points	Public libraries (500 with free internet)	Common Service Centres (500,000 or more)
Digital literacy (adults)	85 percent	Rural 35 percent, urban 65 percent
Source	e-Estonia 2023; Statistics Estonia 2023	MeitY 2023; UIDAI 2023; NITI Aayog 2023

Table 2: Estonia – E-Governance and Rural Digital Inclusion

Element	Description
Post-Soviet context (1991)	Inherited minimal digital infrastructure. Opportunity to build from scratch. Political leadership committed to digital transformation.
X-Road (2000)	Decentralized data exchange layer. No central database. Enables secure queries between databases with citizen consent. Open-source since 2018.
Digital ID (eID, 2002)	Mandatory electronic identity card for all citizens. Enables legally binding digital signatures and authentication for government services.
i-Voting (2005)	World's first internet voting in national elections. More than 50 percent of votes cast online. No detected large-scale fraud.
e-Tax	Pre-filled tax declarations. Ninety-nine percent filed online in 3 to 5 minutes. Refunds issued within 5 days.

e-Health (2008)	Ninety-nine percent of health data digitized. e-Prescriptions and digital medical records accessible to patients and emergency doctors.
Tiger Leap (1996)	Program to equip all schools with computers and internet and to train teachers. Laid foundation for digital literacy.
Rural connectivity	4G coverage for 99 percent of the population (95 percent of rural areas). Government subsidizes connectivity for remote households.
Public libraries	More than 500 libraries provide free internet access and assist citizens with e-services.
Challenges	Elderly digital divide. Remote islands have last-mile connectivity gaps. Cybersecurity threats require continuous investment.

Table 3: India – E-Governance and Rural Digital Inclusion

Element	Description
India Stack	Collection of open APIs for digital infrastructure: Aadhaar (identity), UPI (payments), DigiLocker (documents), and other services.
Aadhaar (UIDAI)	Biometric digital identity for 1.3 billion citizens. Enables direct benefit transfers, reducing corruption and saving an estimated \$20 billion in leakage annually.
UPI (Unified Payments Interface)	Real-time payment system. Ten billion monthly transactions (2023), the world's largest real-time payment system. Zero cost to consumers.
DigiLocker	Digital document storage for driving licenses, passports, degrees, and health records. Legally valid.
UMANG	App providing access to 1,700 government services in more than 100 languages. More than 50 million downloads.
BharatNet	Project to connect 250,000 gram panchayats with fiber optic broadband. As of 2023, only 60 percent (150,000 villages) connected. Quality is poor.
Common Service Centres (CSCs)	More than 500,000 rural digital access points operated by Village Level Entrepreneurs. Offer e-government services, banking, insurance, and digital literacy training.

PMGDISHA	Digital literacy training program for 60 million rural households. Short courses of 10 to 20 hours. Forty million trained as of 2023.
JAM trinity (Jan Dhan-Aadhaar-Mobile)	Financial inclusion through universal bank accounts, Aadhaar identity, and mobile phones. Saved \$20 billion in leakage.
Challenges	Low rural internet penetration (30 percent). Low digital literacy (35 percent rural). BharatNet delays and poor quality. CSC sustainability issues. State disparities (Kerala high, Bihar low). Privacy concerns.

Table 4: Comparative Digital Inclusion Outcomes

Indicator	Estonia (rural)	India (rural)
Internet access (any device)	92 percent (rural 90 percent)	30 percent
Computer ownership	70 percent	5 percent
Smartphone ownership	85 percent	15 percent
Can use e-tax (self)	95 percent	15 percent
Can use digital payment	95 percent	25 percent
Has digital ID	100 percent (eID)	99 percent (Aadhaar)
Has bank account	99 percent	80 percent
Received digital literacy training	80 percent (through school system)	10 percent
Uses e-governance services	99 percent	25 percent
Trusts e-governance	95 percent	65 percent (varies by state)

6. DISCUSSION OF RESULTS

6.1. Explaining Estonia's Digital Success

Estonia's digital transformation success stems from several interrelated factors. First, political commitment at independence in 1991 drove the vision to build a modern, efficient, and transparent

state. Second, the greenfield opportunity meant there were no legacy IT systems to replace. Third, the small population of 1.3 million made it easier to deploy digital ID, train citizens, and cover rural areas with connectivity. Fourth, interoperability through X-Road, with its decentralized architecture, preserves agency autonomy and reduces privacy risk. Fifth, the mandatory digital ID achieved universal adoption. Sixth, trust in government was rebuilt through transparency features such as audit logs. Seventh, the 2007 cyberattacks made Estonia a global leader in cyber defense. Eighth, the Tiger Leap program (1996) ensured digital literacy from childhood. Ninth, continuous innovation has maintained a pipeline of new e-services.

6.2. Explaining India's Digital Progress and Persistent Gaps

India has made remarkable progress given its scale of 1.4 billion people, more than 600,000 villages, 22 official languages, and 70 percent rural population. Key achievements include Aadhaar, the world's largest digital identity system, which has saved an estimated \$20 billion in leakage through direct benefit transfers; UPI, the world's largest real-time payment system, with 10 billion monthly transactions; and CSCs, with more than 500,000 rural digital access points, an unprecedented reach.

However, persistent gaps remain. Connectivity is poor, as BharatNet has connected only 60 percent of villages with low-quality fiber optic broadband (speeds of 2 to 10 Mbps and frequent outages). Digital literacy is low, with only 35 percent of the rural population able to use a computer. PMGDISHA training is superficial, consisting of short courses of 10 to 20 hours with no follow-up. Infrastructure deficits include power outages and device poverty. Language barriers persist because most e-governance content is in Hindi and English, while many rural citizens speak only regional languages. State disparities are wide, with Kerala performing well and Bihar lagging significantly. Trust deficits, including Aadhaar privacy concerns and the 2018 data breach, have eroded trust in some segments.

Scale works against India. Training 60 million rural households through PMGDISHA is a massive undertaking, but even at that scale, only 10 percent of rural adults have been trained, compared to 85 percent in Estonia, where digital literacy has been integrated into the school curriculum since

1996. India's school system lacks computers, internet access, and trained teachers, making it difficult to replicate the Tiger Leap model.

6.3. Digital Identity: Aadhaar versus eID

Both countries have universal digital identity. Estonia's eID is a chip-based smart card using public key infrastructure, providing legally binding digital signatures. India's Aadhaar is biometric-based, primarily used for authentication rather than signatures. Aadhaar raises privacy concerns because biometric data is centralized in the UIDAI database, creating surveillance risks; a major data breach occurred in 2018. Estonia's X-Road has no central database; data stays with each agency, and only queries are made. India could adopt an X-Road-like interoperability layer, and it needs a strong data protection law, which was enacted in 2023 but with implementation pending.

6.4. Interoperability: X-Road versus India Stack

Estonia's X-Road is a mature, open-source, decentralized data exchange layer (2000). India Stack provides some interoperability but not full government-wide data exchange. India could adopt X-Road for inter-ministerial and central-state data exchange, integrating it with Aadhaar (identity), UPI (payments), and DigiLocker (documents) to create a complete infrastructure.

6.5. Rural Connectivity: Mobile versus Fiber

Estonia achieved rural connectivity through mobile broadband (4G and 5G) plus fixed wireless for remote farms. India's BharatNet (fiber to gram panchayat) is necessary but insufficient; last-mile wireless is needed. India should prioritize satellite internet for remote areas using low-earth orbit constellations such as Starlink and OneWeb.

6.6. Digital Access Points: CSCs versus Public Libraries

India's CSCs (more than 500,000) are far more numerous than Estonia's public libraries (500). However, CSC quality is variable, and many are not sustainable due to low revenue and high turnover. Estonia's public libraries are government-funded, stable, and staffed by professional librarians. India could strengthen CSC sustainability by providing reliable funding through the

Universal Service Obligation fund, standardizing equipment (ruggedized computers, solar power for off-grid locations), training VLEs, and expanding services.

6.7. Digital Literacy: School-Based versus Adult Training

Estonia's Tiger Leap program integrated ICT into the primary and secondary school curriculum, ensuring that all citizens under age 40 are digitally literate. India's PMGDISHA targets adults with short courses of 10 to 20 hours, which cannot achieve the same depth or retention. India must integrate digital literacy into the school curriculum, but government schools need computers, internet access, and trained teachers. A phased approach could prioritize upper primary and secondary classes, train teachers, and equip computer labs with low-cost, refurbished, open-source software.

6.8. Transferability: Lessons for Both Countries

India can learn from Estonia in several areas: adopt X-Road open-source for interoperable data exchange; strengthen cybersecurity through Estonia's cyber exercises and incident response protocols; implement digital ID with e-signature for legal documents; integrate digital literacy into the school curriculum; and improve CSC sustainability through government funding.

Estonia can learn from India in several areas: adopt UPI as a model for real-time payments; observe the management of large-scale biometric identity from Aadhaar; and learn from the CSC network of 500,000 rural access points for potential adaptation on a smaller scale.

6.9. Implications for SDG 9

E-governance and digital inclusion are central to SDG Target 9.1 (infrastructure) and Target 9.C (universal internet access). Estonia demonstrates that small countries can achieve universal digital inclusion with strong political will, early investment, interoperability, digital ID, and school-based digital literacy. India demonstrates that large, complex, lower-middle-income countries can make significant progress (Aadhaar, UPI, CSCs) but face persistent gaps in connectivity, literacy, quality, and trust. The international community should promote open-source e-governance solutions (X-Road), support universal digital identity with privacy safeguards, fund rural digital access points, and integrate digital literacy into school curricula globally.

7. CONCLUSION

This comparative analysis reveals that e-governance and digital inclusion in rural communities in Estonia and India have progressed along different trajectories.

Estonia, a high-income country with a small population, has achieved near-universal e-governance (X-Road, digital ID, i-Voting, e-Tax, e-Health) and high rural digital inclusion (92 percent internet access, 95 percent rural 4G coverage, public libraries as access points, digital literacy from school). Key success factors include political commitment after independence, a greenfield opportunity with no legacy systems, interoperability through X-Road, mandatory digital ID, small scale, high trust, and continuous innovation.

India, a lower-middle-income country with a massive population, has made significant progress with Aadhaar (1.3 billion digital identity), UPI (10 billion monthly payments), CSCs (more than 500,000 rural access points), and DBT (saving \$20 billion in leakage). However, persistent gaps remain: internet penetration is only 30 percent in rural areas (compared to 70 percent in urban areas), digital literacy is only 35 percent in rural areas, BharatNet has connected only 60 percent of villages with poor quality, CSC quality is variable, and state disparities are wide.

Several cross-cutting insights emerge. First, digital identity is foundational; Estonia's eID (mandatory, PKI, digital signature) and India's Aadhaar (biometric, massive scale, DBT) are essential but must include privacy safeguards such as data protection laws, no centralization of sensitive data, and audit logs. Second, an interoperability layer (Estonia's X-Road, open-source) enables seamless data exchange without a central database; India could adopt X-Road. Third, rural connectivity requires fiber to villages plus last-mile wireless (4G, 5G, satellite for remote areas). Fourth, digital access points (Estonia's public libraries, India's CSCs) require sustainable funding, training, and diverse services. Fifth, digital literacy must start in school (Estonia's Tiger Leap from 1996); adult training alone is insufficient. Sixth, citizen trust, built through privacy, transparency, and cybersecurity, is essential.

For Estonia, priorities include addressing the elderly digital divide through advanced training and assisted services, maintaining cybersecurity through continuous investment in X-Road security

and incident response, and sharing X-Road open-source with developing countries through technical assistance.

For India, priorities include completing BharatNet fiber to all 250,000 gram panchayats by the 2025 target, improving last-mile connectivity through 4G, 5G, and satellite internet for remote areas, strengthening CSC quality through VLE training, power backup, faster internet, and sustainable revenue, integrating digital literacy into the school curriculum through a National Digital Literacy Mission for Teachers, adopting an X-Road-like interoperability layer, enhancing data protection by implementing the Personal Data Protection Act, and addressing state disparities through performance-based funding for states such as Bihar, Uttar Pradesh, Madhya Pradesh, and Jharkhand.

For the international community, the lessons are clear. E-governance can transform rural service delivery, reduce corruption, increase efficiency, and empower citizens. Universal digital identity with privacy safeguards, interoperable data exchange through X-Road open-source, rural connectivity through fiber and mobile, digital access points through the CSC model, and digital literacy through school-based education are all essential. The ultimate measure of success for e-governance policy is not the number of digital ID cards issued or the volume of transactions, but whether a farmer in rural Bihar can register his land online without paying a bribe, and whether a grandmother on Hiiumaa island can file her taxes from her kitchen table.

8. LIMITS OF THE STUDY

This study has several limitations. First, reliance on secondary data from government reports, UN indices, and peer-reviewed literature means the analysis is constrained by data availability, quality, and comparability. India's rural internet penetration data vary across sources. Second, the comparative case study design cannot establish causality as rigorously as experimental methods. Third, the study does not include primary data collection, such as interviews with VLEs, CSC operators, rural citizens, or government officials, which would provide richer insights. Fourth, the study period (2000 to 2025) captures recent digital transformation but does not fully explore longer-term historical context. Fifth, the focus on national-level systems obscures subnational variation within India (Kerala versus Bihar) and within Estonia (Hiiumaa versus Tallinn). Sixth,

the study does not quantify the cost-effectiveness of CSC, BharatNet, or PMGDISHA investments. Despite these limitations, the comparative analysis provides valuable insights for policy and future research.

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10. AUTHOR CONTRIBUTIONS

SONGOTI Henri conceived the study, designed the methodology, conducted the literature review and document analysis, synthesized findings, and drafted the complete manuscript.

11. COMPETING INTERESTS

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential competing interest.

12. FUNDING INFORMATION

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13. DATA AVAILABILITY

All sources are publicly available documents cited in the bibliography and accessible through the referenced publications and organizations, including the UN E-Government Survey, ITU, e-Estonia, MeitY, UIDAI, BharatNet, and CSC.

14. DISCLAIMER

The views expressed in this article are solely those of the author and do not necessarily reflect the views of any institution or organization with which the author may be affiliated. The analysis is provided for scholarly purposes and should not be construed as policy guidance or programmatic advice.

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