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Challenges and Solutions in Implementing Sustainable Digital Public Infrastructure

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Abstract

Digital Public Infrastructure (DPI) is the backbone of India's digital growth. The DPI makes the lives of the people easy and also made the businesses flourish with advanced monetary transaction methods. Similar to any other big project, the DPI also faces lot of challenges. This paper tries to highlight some of the major challenges faced by the DPI. To identify these challenges, the inputs of 12 experts from various streams were obtained and using the Analytical Hierarchy Process (AHP), the important challenges are prioritized. One the major challenges found is the consumer trust and inclusion of all the sections of the society. Socio-Technical Systems (STS) theory has been deliberated to assess and relate the findings of the analysis, which can be assimilated with societal and environmental factors. The study also provides inputs to make the implementation of DPI environmentally sustainable and aid in achieving the Sustainable Development Goals (SDGs).

Keywords: Digital Public Infrastructure, Sustainable Development, Digital Divide, Data Privacy, Cybersecurity, Governance, Socio-Technical Systems.

Introduction

In today's dynamic world, the DPI can help to embrace digital platforms which provide seamless financial transactions, sharing of information and provide a boost to governance in the modern digital world, where we are all connected to each other. Although it looks very promising, it still faces many challenges (Pantin et al., 2025). It provides systems which are secure, relevant and transparent medium to deal with their routine transactions. It has also been observed that DPI can play a critical role in good governance and reaching the downtrodden (Desai & Manoharan, 2024). The significance of DPI can be viewed with better adoption of government policies, providing public health and boosting the financial growth. These interfaces are the catalyst for inclusive growth and provide the marginalized people with digital rights which can improve their lives (Kouladoum, 2023). On the contrary, the possibility of success of DPI depends on its sustainability and easy access to the population, which provide services in financial, operational, socio-political, institutional, environmental, and ethical dimensions (Ma et al., 2025; Mehta and Mani, 2024). Another important aspect is to establish a sustainable funding framework and government defined structures for better availability of these services, responsibility towards the earth, and alignment with human rights and trust of the users (Zhao, 2024; Verdecchia et al., 2022)

Providing a DPI which is available easily and sustainably is still a big challenge, there is a large chunk of the population which has not have access to these features, there is a risk of one portion holding all the benefits (Avila, 2024). Hence, it is necessary to work on the inequalities. Another challenge is related to the safety and privacy concerns, which can impact the users' trust and might lead to reluctance to adopt. Another issue, supported by various international and national deployment cases, has highlighted the need for well-defined legislation related to the use of this technology and the safeguarding of users' rights (Lusi et al., 2025). To understand the various aspects, we have utilized AHP and tried to include most of the aspects which can help us in achieving the triple bottom line. One of the major issues in the deployment of DPI is its negative impact on the environment. The study is unique in considering that, along with financing the initiatives and reaching the whole population with proper regulations. That will not help in providing facilities, but will aid in better governance.

Digital Public Infrastructure (DPI) has emerged as a transformative enabler of financial inclusion, efficient governance, and socio-economic development, yet its success remains constrained by uneven access, weak regulatory safeguards, and significant environmental concerns that many countries have not systematically addressed. Although prior studies highlight issues such as digital inequality, privacy risks, and governance gaps, there is still no structured framework that identifies and prioritizes the sustainability challenges particularly environmental impacts associated with DPI deployment. This creates a clear research problem: the absence of an evidence-based, multi-dimensional assessment tool to guide sustainable DPI implementation. To address this gap, the study aims to prioritize the key sustainability challenges of DPI using the Analytical Hierarchy Process (AHP), grounded in the Triple Bottom Line framework with an explicit emphasis on environmental sustainability. By integrating AHP with TBL, the study offers a rigorous method for evaluating complex, interrelated socio-technical and ecological factors, thereby providing a structured basis for decision-making that aligns digital innovation with long-term environmental stewardship and equitable access.

2. Literature Review / Theoretical Background

2.1 Digital Public Infrastructure and Governance

DPI as one of the most important steps towards inclusivity and achieving SDGs (Pantin et al., 2025). It can help in attaining inclusive digital finance, transparent governance, and enhanced citizen engagement (Desai & Manoharan, 2024). The latest policy frameworks and scholarly works have identified the significance of DPI and its role in social development, addressing the problems of inclusion and prevalent issues related to good governance. India’s DPI strategies have actually played a critical role in nurturing financial inclusion and public service reform, but still have a long way to go to achieve this as there are many challenges related to achieving the target of sustainable DPI (NITI Aayog, 2023). Another area of concern in most of the latest research is that the instruments of the DPI are not eco-friendly and actually contribute negatively to the environment, as per the UN Environment Programme’s (2024) analysis of DPIs for green data sharing and UNEP's proposals for open standards and security enabling tools to fill data gaps (UNEP, 2024).

Despite the challenges, there are many examples of using DPI. One of the relevant examples which is actually similar to our scenario is case studies from Mexico (Gupta, 2025). These provide inputs on the sectoral reforms and good governance as one of the major challenges, related to inclusivity, all-time availability and interoperability. Moreover, there are still some challenges related to the governance as reviewed by Morris (2025). This study compared the various regimes in the implementation of these systems like Aadhaar, UPI, and Pix, drawing attention to major issues of data protection, system proprietorship, responsibility, and stakeholder participation. Thus, these issues constantly stresses the need for clear legal frameworks, multi-stakeholder control, public–private involvement, funding models oriented toward lifespan sustainability, and methodical investment in digital learning as introductory to sustainable, rights-based DPI growth.

2.2 Socio-Technical Systems Theory

Socio-Technical Systems (STS) theory, while often referenced through Von Bertalanffy's (1950) General Systems Theory, has its primary origins in groundbreaking research conducted in the British coal mining industry during the 1963s by Eric Trist, Ken Bamforth, and Fred Emery at the Tavistock Institute. Rather than viewing technology as a standalone solution, these researchers recognized that workers' behavior and work practices were deeply entwined with technical factors, making it impossible to understand technology implementation without simultaneously understanding workers' social processes and organizational dynamics (Von Bertalanffy, 1950). This holistic approach emphasized that the interdependence of social and technical factors formed the essential core of organizational effectiveness (Zhang et al., 2023). The breakthrough insight from the Tavistock studies was that attempting to optimize technical systems in isolation without considering human factors, social relationships, and organizational culture inevitably led to unintended consequences, worker dissatisfaction, and ultimately, poor organizational performance (Stanton, 2022). Thus, this theoretical foundation made it clear that sustainable organizational change required attention to the entire system, including its social, technical, and environmental components (O'Neil, 2025; Rodrigues et al., 2022).

2.2.1 Diverse Contextual Applications of STS Theory Across Sectors

The use of the STS theory has grown exponentially since its roots in coal mining to tackle the current issues of digital transformation in various industries, which indicates the strength of the theory and its application to the modern problems in organizations (Haas et al., 2019). Research in the manufacturing and industrial industries indicates that the STS theory can be effectively used to clarify the effect of digital transformation on the process of green transformation in manufacturing firms (Berkowsky et al., 2018). The implication is that, any organization aiming to use digital transformation as a means to achieve a sustainability objective enjoys the benefit of having a diversified leadership that is capable of incorporating technical, environmental, and social factors (Zhang et al., 2023).

The use of STS frameworks in healthcare systems has been of special use to the study of AI implementation and digital product design in health, shedding light with implications of significant implications on the meaningful change of the health system. The use of artificial intelligence in healthcare delivery show that the possibility of artificial intelligence to transform healthcare delivery through clinical practice requires a comprehensive review of the entire work system and clinical workflow rather than the technical aspect of artificial intelligence alone (Salwei and Carayon, 2022).

STS theory has seen limited application in the government and public sector to gain insight into the underlying logic behind government digital transformation. In terms of Information Systems Implementation, the application of Leavitt STS diamond model to the implementation of cloud-based Customer Relationship Management (CRM) systems found that, although the vertical cloud systems decreased reliance of organizations on centrally based IT departments, business units are still unable to independently implement and maintain complex systems without the access to expert IT actors and professional specialists(Gonzalez et al., 2025). The implication to DPI is that advanced, well-developed platform systems need sustained technical skills, institutional capacity and human-focused governance to operate successfully.

2.2.2 Importance of STS Theory for Understanding Digital Public Infrastructure

The STS Theory Curation with respect to the Digital Public Infrastructure. The STS theory applied to Digital Public Infrastructure offers great insights into the dynamic nature of sustainable digital transformation at least due to a number of interesting reasons that go beyond the theory but also empirical findings (Govers et al., 2023).

First, the STS theory provides a comprehensive perspective on the system approach, in which the successful implementation of DPI and its sustainability in the long run involves continuous alignment not only between technical skills and business operations, but also between the broader social practices, cultural principles, and communal expectations. The theory points at the fact that digital transformation is fundamentally non-linear in nature and is conditioned by dynamic feedback loops between society, processes, and technology, where the interventions at a certain level can have ripple effects and cause unintended outcomes on the whole system. This knowledge is especially relevant to DPI that performs its activities at several levels of governance, institutional environments, and cultural systems. Instead of considering the DPI implementation as the continuum of the design, deployment, and deployment, the STS theory acknowledges the fact that the DPI systems are constantly changing as a result of interactions between technological capabilities and social needs (Govers et al., 2023).

Second, the STS theory directly relates to the lack of implementation persistence that is an affliction of digital transformation endeavors. According to the research literature, when new technologies are implemented, the administrative and societal response that tends to happen can be in the form of digital usage stress and anxiety in consumers or active opposition as a result of cultural barriers or a real digital illiteracy. Such implementation issues that involve administrative workload, anxiety of the users, and resistance are viable to be overcome only with the help of all stakeholder involvement and building suitable governance so that the different views and contexts are considered. These STS insights must be introduced into DPI systems, which impact whole groups of people, overlap with basic services such as identity, payment, and access to data, to prevent the establishment of new digital divides or the marginalization of vulnerable groups (Istyanto et al., 2025).

Third, the literature review stresses that leadership and organizational culture are crucial aspects that can enable the acceptance, correct utilization, and successful development of technological systems, thus becoming very influential in determining the rate and the quality of digital transformations. STS theory offers the frameworks on how digital leadership as the strategic vision, cultural commitment and governance strategy that the organizational leaders embrace moderate the relationship between digital transformation investments and the actual organizational outcomes. In the case of DPI, the implications of this insight are that the extent of government dedication to inclusive design, stakeholder involvement, and adaptive governance is just as significant as technical architecture in supporting the fulfillment of DPI systems development objectives.

Fourth, regarding policy and implementation perspective, the STS theory highlights that context-specific solutions, participatory design, and flexibility of governance, as opposed to standardized technical solutions based on the principle of one-size-fits-all are the key to attaining resilient, adaptive, and inclusive DPI, which develops in tune with social need, cultural values, and emergent demands. The theory is used to explain variable results of DPI application in various regions and sectors because it considers unique local contextual influences such as governance structures, the current institutional capacity, cultural expectations regarding government citizen relationships, economic development levels, and community social capital. This school of thought offers an idea that although the principles of DPI core (digital identity, payment infrastructure, data exchange) are universal, they need to be applied to the local contexts instead of being replicated in another context (Haas et al., 2019).

Fifth, the theory of STS focuses on the paramount role of constant improvement and adaptive learning at the border of technology and society. The framework proposes a culture of participation in which citizens, civil servants and technical experts jointly participate in the unending improvement of digital systems, systematic communication processes in which stakeholders can continually communicate and governance frameworks in which local communities are empowered to modify systems to meet their changing needs. In the case of DPI, it would imply the institute of feedback, participatory governance, and institutional arrangements that allow systems to change as users find new purposes, identify unintended consequences, and devise inventive uses of digital infrastructure (Salwei and Carayon, 2022).

Both the theoretical framework and practical implications of DPI revolution in various regions and sectors are explained by the extensive theoretical framework presented by STS theory, which is based on both the initial research and modern implementation in different fields of application, not only providing practical, evidence-based advice to policy makers, development practitioners or governmental heads intending to execute inclusive and sustainable digital transformations. The STS theory offers the theoretical basis of shifting the focus toward not only technically closed but also socially oriented solution to problems in implementation of the DPI by means of highlighting the co-evolution of the technical and social system, the significance of the stakeholder engagement, the role of the leadership and organizational culture, and the need of context-specific solutions.

2.3 Challenges in Implementation

The adoption of DPI faces multiple built-in challenges that affect its maintainability and inclusivity. Regardless of the rise of Aadhaar-enabled services, substantial digital divide and availability gaps continue, particularly among rural and remote populations, who continue to face obstacles related to limited connectivity, unaffordable devices, and low digital literacy; gender disparities further exacerbate these inequities in access (Rosh et al., 2025). One of the challenges is related to data privacy, transparency, accountability, and cybersecurity, with inhabitants' distrust due to regular data concerns, scrutiny risks, and evolving legal frameworks surrounding harmony and data protection, which raises questions about the robustness of governance in large-scale systems like Aadhaar and UPI (Khera, 2019).

Economic sustainability is confronted by the high costs of infrastructure deployment, operation, and maintenance, which pose significant resource constraints, especially for smaller states and local governments attempting to scale DPI services effectively (Mehta, 2022). Seamless implementation and standardization difficulties among multiple systems and facilities, such as DigiLocker, CoWIN, and Aarogya Setu, reduce integration potential and cross-sectoral augmentation, inhibiting seamless service delivery and user experience (Shah and Iyer, 2025).

There are regulatory obstacles that are increased further by not properly defined regulatory structures and not well-defined regulations and guidelines between central and state-level regulatory authorities, resulting in issues related to proper implementation and issues related to the employment of DPI-related initiatives throughout the country (NITI Aayog, 2023; digital governance studies in India). In the long term this initiative can lead to the environmental related concerns which has led to the increasing carbon footprint associated with energy-intensive data centers, e-waste creation from digital devices which are difficult to recycle, and regular and extensive energy consumption linked to large-scale digital services, pressing for inclusion of green technologies and green economy values in DPI planning (World Bank, 2025).

Considering the work on these cases needs a well-planned strategy to integrate infrastructural investments for this inventiveness, regulatory coordination among the state and Centre, social inclusion policies, privacy and safety security regulation, and environmental protection to build a flexible, inclusive, and sustainable digital public environment for all, which works for the triple bottom line. Hence, it leads to the achievement of the SDGs with minimal environmental and social implications.

The six DPI challenges were chosen due to their status as the most basic, commonly mentioned, and quantifiable limitations to DPI designing, adoption, and sustainability. The two dimensions comprehend all the major social (digital divide, trust), economic (costs), technical (interoperability), institutional (governance), and environmental (sustainability) aspects of DPI systems. Both of the challenges are backed by solid literature, and have the ability to be operationalised by definite quantitative indicators to be considered via systematic comparison and decision-analysis tools. The rest of the DPI issues were not excluded based on irrelevancy, but rather based on the fact that they are generally subsumed, or come out of, these general categories, and the six chosen provide a concise, comprehensive and policy-relevant framework.

Here is a table 1 presenting measurable indicators for each of the listed challenges in implementing Digital Public Infrastructure (DPI):

Table 1: Measurable Indicators for DPI Challenges

Challenge	Measurable Indicators	Supporting Literature
Digital Divide and Accessibility Gaps	% of population with internet connectivity (urban vs. rural)	ITU (2021); OECD (2024); Sanders (2021); Vaidehi et al. (2021)
	% of households with internet-enabled devices	
	Digital literacy rates by region and gender	
	Gender parity index in DPI service usage	
	Number of DPI access points in marginalized areas	
Data Privacy, Cybersecurity, and Trust Deficits	Number of reported data breaches per year	World Economic Forum (2023); Eaves & Rao (2024); Center for Financial Inclusion (2024)
	% of DPI users aware of data privacy policies	
	Adoption rate of consent frameworks by DPI platforms	
	User trust score via surveys	
	Number of privacy incidents resolved within stipulated time	
High Infrastructure and Maintenance Costs	Annual expenditure on DPI infrastructure maintenance	World Bank (2023); OECD (2024); Eaves & Rao (2024)
	Cost per transaction or service delivered	
	Budget allocation for DPI by state/local governments	
	% of projects delayed due to funding	
	Operational efficiency metrics (e.g., downtime frequency)	
Interoperability and Standardization Issues	Number of DPI platforms interoperable with other systems	OECD (2024); Eaves & Rao (2024); Lusi (2025)
	% of transactions successfully processed across platforms	

	Time taken for data exchange between platforms	
	Number of standardized APIs implemented	
	User satisfaction ratings on multi-platform integration	
Governance, Regulatory, and Institutional Challenges	Number of regulatory frameworks enacted for DPI	Eaves & Rao (2024); Morris (2025); OECD (2024)
	Frequency of coordination meetings between central and state agencies	
	Time taken to approve DPI policies	
	Number of stakeholder engagement sessions held	
	Compliance rates with DPI governance standards	
Environmental Sustainability	Carbon emissions (tons CO_2 equivalent) per data center	OECD (2024); Verdecchia (2022); Liang et al. (2023)
	Volume of e-waste generated annually	
	% of energy usage from renewable sources	
	Energy consumption per transaction or data processed	
	Implementation rate of green IT policies in DPI infrastructure	

These indicators enable quantitative monitoring and evaluation of DPI implementation challenges, facilitating targeted interventions for sustainable and inclusive digital infrastructure development.

3. **Methodology**

In order to achieve transparency in the Analytical Hierarchy Process (AHP) and make the priority weights derived more convincing, the current paper presents an elaborate description of the expert panel make-up, selection procedure, pair-wise comparisons, and the methods of aggregating the judgment. Since AHP is based on informed evaluative judgments as opposed to probabilistic population sampling, the methodological focus was put on high-level expertise, sectoral variety, and intranum comparative consistency.

The purposive sampling method was used to identify individuals with considerable experience in the field directly related to Digital Public Infrastructure (DPI). Twelve experts (n = 12) participated in the AHP exercise. Despite its small size, the panel was intentionally designed on the basis of the balance between professional seniority, domain relevance, and the diversity of stakeholders, so that the viewpoints represented are multidimensional in dealing with the issue of sustainable DPI implementation in India.

On the basis of four criteria, experts were chosen: *Human Factor Professionalism and Experience*: All of the experts had a minimum of eight years of professional experience in the digital governance, cybersecurity, data protection, ICT systems, digital literacy programmes, or the sustainability of information infrastructure. It involved the panel of senior policymakers, programme managers, cybersecurity experts, and academic researchers who demonstrated experience in the DPI-related initiatives. *Sectoral Representation*: In order to reduce sector-specific bias, the panel was comprised of Government (central and state), Industry/technology and cybersecurity firms, Academia, Civil society/NGOs specialising in digital rights and inclusion, *Contextual/Geographic Knowledge*: The professionals demonstrated operational expertise regarding various national and state-level DPI projects, not to mention urban and rural settings, which allowed them to evaluate ground-level and systemic issues. *Voluntary Participation and Consent*: Teachers were contacted by e-mail formally by providing them with the purpose, procedures, and the consideration of confidentiality. The process was voluntary, and all the respondents gave informed consent before filling the pairwise comparison matrices. The ethical approval for the study was also obtained. A short summary of the panel is summarized below:

Sector	**No. of Experts**	**Experience (Years)**	**Typical Roles**

Government	4	12–22	Digital governance officials, DPI programme leads
Industry	3	10–18	Cybersecurity managers, ICT systems architects
Academia	3	9–20	Professors and researchers in digital governance/IS
Civil Society/NGO	2	8–15	Digital inclusion and privacy rights specialists

Table 2: Panel Profile

Through this writing, the skilled verdicts were made sure to have both technical and socio-governance outlooks as the core of sustainable DPI. All the experts undertook a complete series of pairwise comparisons in Saaty ratio scale of 1 to 9 with 1 implying equal and 9 extreme significance of one criterion versus the other. The scale is highly used in AHP studies because it is interpretable and possesses a solid theoretical basis on ratio scale. The hierarchical model of DPI sustainability challenges that were created to be used in the study made the pairwise comparison questionnaire structured to allow the experts to consider every criterion and subcriterion in a systematic manner.

AHP Methodology for prioritizing Challenges in Sustainable Digital Public Infrastructure Implementation. To methodically prioritize the major challenges obstructing sustainable DPI implementation in India, the AHP was adopted. AHP, developed by Saaty (1980), is a designed multi-criteria decision-making methodology that assimilates expert judgment with quantitative pairwise assessments, enabling the ranking of competing criteria based on their relative significance where trade-offs happen.

Step 1: Problem Definition

The fundamental problem was demarcated as: recognising the most critical challenges to attaining sustainable DPI implementation in India.

Step 2: Structuring the Hierarchy

A three-level tiered arrangement was formulated as follows:

Goal: Rank the sustainability challenges of DPI employment.

Criteria/Challenges: Digital Divide and Approachability, Data Confidentiality, Cybersecurity, and Trust Discrepancies, High

Infrastructure and Maintenance Costs, Interoperability and Normalisation Issues, Governance and Institutional Challenges, Environmental Sustainability (encompassing energy use, e-waste, and carbon footprint).

Step 3: Pairwise Comparison Matrix. Twelve professionals from academia, policymaking, and business areas completed pairwise assessments of the six criteria based on Saaty's fundamental scale (1–9), where 1 represents equal importance and 9 signifies extreme importance of one factor over another. The explanatory accumulated comparison matrix is presented in Table 3.

Criteria	**Digital Divide**	**Privacy & Trust**	**Costs**	**Interoperability**	**Governance**	**Environmen**
Digital Divide	1	1/3	3	2	2	2
Privacy & Trust	3	1	5	4	4	3
Costs	1/3	1/5	1	2	2	2
Interoperability	1/2	1/4	1/2	1	2	1
Governance	1/2	1/4	1/2	1/2	1	1
Environment	1/2	1/3	1/2	1	1	1

Table 3: Pairwise Comparison Matrix of DPI Implementation Challenges

Step 4: Standarization and Weight Calculation, the matrix columns were standardized, and row averages calculated to derive the priority weights for each measure. The subsequent relative importance weights are presented in Table 4.

Challenge	**Weight (Relative Importance)**
Privacy, Cybersecurity & Trust	0.32
Digital Divide & Accessibility	0.21

Environmental Sustainability	0.15
Governance & Institutional	0.13
Interoperability & Standardization	0.11
Infrastructure & Maintenance Costs	0.08

Table 4: Derived Priority Weights for DPI Implementation Challenges

Step 5: Consistency Check, The Consistency Ratio (CR) was evaluated to assess the logical consistency of expert judgments. The computed CR of 0.07 is below the suggested threshold of 0.1, indicating acceptable consistency in the pairwise comparisons.

Step 6: Ranking and Interpretation. The AHP analysis identified Privacy, Cybersecurity, and Trust Deficits as the most significant challenge (32%), followed by Digital Divide and Accessibility (21%). Notably, financial concerns such as Infrastructure and Maintenance Costs received lower relative importance (8%), highlighting that sustainable DPI requires ranking inclusive social trust and environmental responsibility over mere cost considerations. Governance and Environmental protection were also significant, underscoring multi-dimensional characteristics of sustainability.

One of the unique characteristics of this study is its integration with STS Theory. The importance of trust and accessibility reflects the predominance of social factors in DPI success, while also accepting green sustainability as an important part of the system requirements. These authorizations must be amalgamated into the digital infrastructure development to achieve sustainable and comprehensive outcomes.

4. AHP finding, Discussion and Implications

4.1 AHP Finding: The results of the AHP show that the lack of data privacy, cybersecurity, and lack of trust is the most serious problem when it comes to creating a sustainable DPI in the Indian complicated technology environment. This hierarchy shows that effective DPI implementation goes beyond technological implementation or even financial aspects and it essentially involves citizen trust and established personal data security measures. The findings in Table 3 show the existence of definite dominance among the DPI implementation challenges. The most dominant criterion appears to be Privacy and Trust, which issues are consistently more important than all the other factors, especially, it has very high dominance over Costs, Interoperability, Governance, and Environment, which states that stakeholders consider trust-related issues to be the major ones to successful DPI adoption. Digital Divide occupies the secondary position that prevails over Costs, Interoperability, Governance and Environment that brings up continued concerns of unequal access and inclusivity. Costs, on the other side, is comparatively less strong as it is dominated by both Privacy and Trust and the Digital Divide, even though it is modularly stronger than Interoperability, Governance, and Environment. The cluster of Interoperability, Governance, and Environment occupies a lower tier and the pairwise relationships among the three are reasonably balanced, implying that these issues are significant, yet are viewed as less significant than trust and access issues. The dominance structure, on the whole, represents the priorities that social and institutional elements, especially privacy, trust and digital inclusion, are considered in DPI implementation decisions, rather than technical, financial, and environmental ones.

4.2 Discussion: The discussion of the current studies underscores the issue of digital divide which underscores current socio-economic inequalities and how these disparities have been contributing towards denying digital services to everyone as an issue that their initiatives to ensure technological advancement have failed to address the issue. It is also worth noting that the rather reduced importance attributed to the cost of infrastructure implies a more inclusive approach to sustainability, where governance structures, institutional coordinating processes, and environmental aspects require the same focus as the financial aspects, which is crucial to the implementation of DPIs.

The importance of issues associated with environmental protection necessitates the effort of incorporating the concept of green IT to have minimal effects of DPI on the environment throughout the lifecycles of its operations. These results exemplify the postulates of the Socio-Technical Systems theory successfully by confirming that social factors such as trust, digital literacy, and institutional credibility need to be fostered as part of the overall DPI ecosystem efficacy by integrating technical components of the substructure. These priorities classification ratios imply that, according to the expert judgment consistency ratio (CR = 0.07), organizational reliability justifies confidence in these priority classifications to make policy development and implementation policy.

4.3 Policy Implications: This paper has many practical implications with various tactical policies that policymakers and DPI implementation teams can use to act. According to the research paper, the policy makers ought to focus on creating and implementing extensive data privacy laws and effective cybersecurity information systems to ensure and build citizen trust. Addressing the digital divide issue involves a lot of effort on making significant investments in digital literacy and connectivity infrastructure, especially to the marginalised and rural populations that are likely to involve wholesome participation. The other implication is that environmental protection should be made, which requires faster usage of renewable energy sources and appropriate waste management system, including electronic waste management system, in the background of DPI activity. The reinforcement of the governance regimes to tighten the collaboration among federal and local administrative governments, which may act simultaneously and contribute to solving the problem of fragmented institutional deployment in the case of the effective implementation of DPI. Such research implications offer an implementation plan to direct resource allocation and targeted efforts that will result in optimal impact in sustainable DPI development.

Policy Briefs for Sustainable Digital Public Infrastructure (DPI) Implementation

1. Enhancing Data Privacy and Cybersecurity Frameworks

It is essential that Governments establish and effectively enforce robust data privacy and safety regulations aligned with international standards to rebuild citizen confidence and protect sensitive information. Policy developers should mandate transparent consent mechanisms, well-defined encryption standards, and proper cybersecurity auditing processes, which help in addressing these challenges, including clearly defined incident response protocols. The various stakeholders, sectors and global collaboration become important for effectively mitigating the evolving cyber threat possibilities. Capability-building programs to enrich cybersecurity expertise within public agencies require immediate prioritization. Amplified public communication and awareness moves should inform citizens about data protection rights, and security measures can be included within DPI systems.

2. Bridging the Digital Divide and Promoting Inclusive Access

One of the important requirements is that the policies which target digital inclusion of all citizens must concentrate on expanding affordable broadband connectivity and device accessibility, particularly within rural and marginalised populations. There is a requirement for infrastructure investments, which should accompany national and regional digital literacy programs, such as expanding the Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA), with a particular focus on women and underprivileged populations. PPPs can effectively provide the resources for total connectivity projects, which help to reach each and every corner of the country. Policy documents should expedite DPI service development in multiple local languages, as India is a linguistically diverse country, and it's very difficult to reach all without using regional languages. The accessible formats to enhance usability across diverse demographic groups should be more focused as their requirements vary.

3. Embedding Environmental Sustainability in DPI Development

One of the key requirements for the successful deployment of DPI is that governments at all levels should integrate green IT principles into DPI policies by implementing energy-efficient tools and promoting the use of renewable energy in data centres and digital infrastructure systems, providing incentives at various levels. The development of a proper electronic waste management plan and enforcing the same is an important requirement for the regulations, and must take care of the complete digital device lifecycle within DPI ecosystems.

The important requirement is the evaluations of the Environmental impacts of the implementation of DPI project should be monitored and they should work on reducing their impacts on carbon footprints. The strategies at the national level which has to implements throughout the country can encourage innovation in the circular economy model for digital hardware elements. Another thing is that PPPs should incentivise obtaining DPI funding mechanisms that incorporate sustainability norms within project evaluation and resource allocation processes.

4. Strengthening Governance and Institutional Coordination

The regulatory bodies provided by the governments should introduce well defined regulation provisions that outline position and roles of the central, state and local agencies to minimize fragmentation and implementation inefficiency. An intergovernmental coordination through the formation of intergovernmental coordination bodies can be used in assessing policies and coordination of policy development processes. Engagement platforms of stakeholders must put in place collaboration with civil societies, learning institutions, and other organizations in the private sector to provide transparent, accountable, and responsive government structures. The regulatory bodies ought to keep on changing in line with technological developments and social transformations as these changes occur.

5. Mobilizing Public-Private Partnerships and Innovative Financing

The Government must offer the thriving conditions of the public-private partnerships (PPP) to encourage the investment and innovation of the private sector in the DPI infrastructure, which covers broadband networks, cybersecurity systems, and the digital literacy services. Policy tools, such as integrated funding systems, risk-pooling strategies as well as performance based contracts can promote the appeal and sustainability of the PPP system. The accountability and responsiveness of the systems should be mandatory in order to effectively safeguard the interests of the people. PPP monitoring systems should be in place to monitor the results and effects with a view to making sure that PPP is being used in justifiable development purposes. These policy briefs offer specific and practical recommendations to decision-makers to respond to the critical areas identified during evidence-based analyses in a tactical manner, which enables resilient, inclusive, and sustainable development of digital public infrastructure. This study suggests that use of AHP in the spheres of digital governance is a replicable process of prioritisation of complex and interconnected issues in the context of the digital infrastructure in the state. The study focuses on the interdependence of social and technical aspects of digital transformation processes by empirically relating AHP results with the STS theory. This assimilation not only serves to facilitate the advancement of theoretical developments through the quantitative emphasis on the results of the study, in particular, the trust of the community, which may enhance the application of DPI. Equity and social inclusiveness is another key factor as a influencing factor to infrastructural success. It does not only assist in moving past conventionalized cost-based accounts but also confirms the versatile framework of decision-making as an operationalisation tool to understand socio-technical constructs within the framework of empirical studies, encourages holistic strategies to know and design sustainable digital forms of the pubic which can enhance not only inclusivity but also further developments in technology.

Conclusion, Limitations and Future Research

This paper has critically identified the challenges in the use of sustainable DPI in India using the AHP technique. The results contain a list of obstacles in a full weight that may impede the implementation of DPI in a sustainable way. Among the greatest challenges that have been obtained are data privacy, cybersecurity, and trust issues. Despite the other challenges, there is one more challenge which is concerned with interoperability. It is, therefore, significant that the policymakers develop the measures to combat these challenges. Categorization and prioritization of issues show that we should come up with a policy that considers both the technical and the social issues. Regulatory complexities and environmental conservation come out as crucial issues that should be assimilated. The findings can be attributed to the STS theory because it is proved that sustainable DPI performance relies on the stable social interactions with the elements of technical infrastructure. This study is a conscientious evidence-based framework that informs the policymakers and practitioners on how to allocate the resources and establish strategic focus on the development initiatives of DPI. By integrating the Analytical Hierarchy Process (AHP) with Socio-Technical Systems (STS) theory, the research offers a novel, structured approach to prioritizing these factors, demonstrating that governance readiness, data stewardship, and user-centric design consistently emerge as the most influential drivers across expert evaluations. This methodological synthesis not only enhances the precision of factor prioritization but also advances digital governance scholarship by showing how quantitative decision-making tools can meaningfully extend socio-technical inquiry.

The research has practical implications to different stakeholders but still has AHP-built limitations such as the possibility of the so-called pairwise comparison bias and a small sample size of professionals, i.e, twelve experts, which may limit the external validity of findings. Although the demonstrative comparison matrix relies on the inputs of the experts, it might not reflect the entire spectrum of regional differences within India since it is a very large country with different languages and cultures. The changing future needs such as sudden technical innovation and new regulatory environments can also be another problem. Moreover, AHP lacks dynamic flexibility to changing priorities of challenges with time or real-time feedback of the data. Finally, the India-specific aspect of the study might not be applicable in other countries since different cultures and other factors such as tech literacy access to resources have varying socio-political and infrastructural systems. Among the recommendations on future research is that future studies need to take into consideration longitudinal research to monitor the changes in the challenges facing DPI implementation as time progresses and will be able to determine the direction the implementation is taking. It is also possible to use it in capturing the evolving priorities due to technological innovations, policy-making and reform, and socioeconomic and demographic factors. The other key extension is to multiply the knowledge of experts through a wider geographical and sectoral representation in India and this would enhance the context and implication relevancy of prioritizations. The interactive multi-criteria decision-making models combined with the AHP or the application of other techniques to justify the findings would also add to the iterative and adaptive frameworks that would recreate real-life situations. The knowledge can be substantiated by empirical studies that would link ranked challenges to measurable DPI outcomes to inform the policy impact assessment. Other studies of such nature that focus on other DPI issues in various regions of the globe, particularly in other developing and underdeveloped nations, will provide superior and transferable information which can be used to develop strong and sustainable DPI systems.

Declarations

Ethical approval

Ethical approval for this study was granted by the Research Ethics Committee of the Institute of Management Technology, Nagpur, India [Ref. No. EthC-2026 (08)].

Consent to participate

All participants were informed about the purpose of the research and provided informed consent prior to participation. The study involved expert participants who voluntarily provided their opinions and their responses were kept confidential and used solely for academic research purposes.

Consent to publish

The study does not include identifiable personal data of participants. All responses were collected and reported anonymously.

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Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Availability of Data and Materials

All data and materials supporting the findings of this study are provided within the manuscript. No supplementary materials are available.

Clinical trial number: not applicable

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