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Empowering Inclusive Growth through Digital Public Infrastructure: Bridging the Connectivity and Service Delivery Divide

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ABSTRACT

In the evolving digital landscape, Digital Public Infrastructure (DPI) has emerged as a critical enabler for inclusive growth by bridging longstanding gaps in connectivity and service delivery. This research examines the role of DPI as a foundational system composed of digital identification, digital payments, and data exchange layers, each contributing to enhanced accessibility, transparency, and efficiency. Highlighting India's pioneering efforts through initiatives like Aadhaar, Unified Payments Interface (UPI), DigiLocker, and the Open Network for Digital Commerce (ONDC), the paper demonstrates how DPI fosters citizen empowerment, promotes financial inclusion, and strengthens governance frameworks. The study finds that DPI systems were pivotal during the COVID-19 pandemic, ensuring resilience in public service delivery, education, and commerce. However, the paper also identifies persisting challenges such as the digital divide, infrastructure gaps, cybersecurity risks, and the need for robust regulatory frameworks. Through an extensive review of national initiatives and global perspectives, the research emphasizes the necessity for a multi-stakeholder, community-driven approach to maximize DPI's potential. The Indian experience offers valuable

lessons for emerging economies seeking to leverage digital infrastructure for equitable development. The paper concludes that DPI is not merely a technological advancement but a socio-political tool that redefines citizen-state relationships, driving sustainable and inclusive digital transformations. Building resilient, secure, and inclusive DPI ecosystems will be critical in realizing visions like Viksit Bharat @2047 and achieving broader Sustainable Development Goals (SDGs).

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1. Introduction:

Digital transformation has become a defining force in the rapidly changing 21st-century landscape, altering the governance structures, the economy, and social interactions. At the heart of this transformation lies Digital Public Infrastructure (DPI)- a foundational set of digital systems and platforms designed to facilitate seamless, secure, and inclusive access to public services, information, and economic opportunities. As nations, particularly emerging economies like India, strive to foster inclusive growth and equitable development, DPI offers a strategic lever to bridge long-standing gaps in connectivity and service delivery. Inclusive growth- a development model that ensures participation and benefit-sharing across all segments of society- is intricately tied to the effectiveness of public service delivery. Historically, access to essential services such as healthcare, education, financial inclusion, and welfare support has been uneven, especially across rural, marginalized, and economically weaker sections. These disparities have been compounded by fragmented governance systems, inefficient bureaucratic processes, and a lack of real-time data and accountability. In this context, DPI represents a paradigm shift- moving from siloed and manual public service mechanisms to integrated, digital-first, and citizen-centric systems. India stands at the forefront of this transformation, having developed and operationalized one of the most comprehensive DPI ecosystems globally. Key components of this ecosystem include the Aadhaar digital identity system, the Unified Payments Interface (UPI) for real-time financial transactions, DigiLocker for document storage and verification, and public data platforms such as the National Digital Health Mission (NDHM) and the Government e-Marketplace (GeM). These innovations have not only enhanced the efficiency and transparency of service delivery but have also catalyzed grassroots empowerment, particularly in regions and populations previously excluded from the

formal economy. Yet, the promise of DPI is not merely in digitization, but in democratization- ensuring that digital systems are inclusive, interoperable, and built with public purpose. When appropriately designed and implemented, DPI can dismantle structural barriers to access, reduce transaction costs, enhance trust in public institutions, and foster citizen empowerment. Moreover, DPI enables a more responsive and resilient governance framework, especially crucial in times of crisis, such as the COVID-19 pandemic, where digital systems played a central role in ensuring continuity of services, dissemination of information, and distribution of welfare benefits. The integration of broadband connectivity, digital identity systems, and open public data platforms serves as the backbone of DPI. These elements, when aligned with effective policy design and community engagement, create an enabling ecosystem for digital empowerment. For instance, the synergy between Aadhaar and the Direct Benefit Transfer (DBT) framework has not only reduced leakages in welfare distribution but also fostered financial inclusion by bringing millions into the formal banking system. Similarly, UPI has revolutionized digital payments, making transactions accessible to even the smallest street vendors and remote villagers. However, challenges remain. The digital divide- marked by disparities in internet access, digital literacy, and infrastructure availability- continues to impede the full realization of DPI's potential. Rural areas, tribal regions, and underserved urban settlements often face inconsistent connectivity, limited access to smart devices, and socio-cultural barriers that hinder adoption. Moreover, concerns around data privacy, cybersecurity, and algorithmic bias necessitate robust governance frameworks to ensure trust and accountability in digital systems. To address these challenges and harness DPI's full potential, a multi-pronged approach is essential. This includes expanding last-mile digital connectivity, investing in digital literacy and capacity building, and co-creating DPI solutions with community participation. Public-private partnerships, open-source development, and interoperability standards also play a critical role in ensuring that DPI remains scalable, sustainable, and inclusive.

The Indian government's vision of Viksit Bharat @2047, which aspires to build a developed and resilient India by the centenary of its independence, places significant emphasis on digital transformation as a cornerstone of inclusive development. DPI is a strategic enabler of this vision, not only in improving service delivery but also in catalyzing innovation, entrepreneurship, and citizen participation in governance. As India scales up its DPI efforts, the lessons and models it generates offer valuable insights for other nations navigating their own digital transitions. This research paper is structured as follows: The next section presents a theoretical overview of Digital Public Infrastructure, including its key features, principles, and frameworks. This is followed by an analysis of India's DPI

ecosystem, highlighting flagship initiatives and their impact on inclusive service delivery. A regional case study focusing on Uttarakhand illustrates the role of DPI in improving connectivity and governance in industrial clusters and remote areas. The paper then discusses critical challenges and policy recommendations to enhance the inclusiveness and effectiveness of DPI. Finally, it concludes by reflecting on the global relevance of DPI and its role in shaping a more equitable and digitally empowered society.

In essence, Digital Public Infrastructure is not just a technological solution, but a socio-political instrument that can redefine the relationship between the state and its citizens. By bridging the connectivity and service delivery divide, DPI offers a pathway to inclusive growth- where no citizen is left behind in the journey towards a digitally empowered and developed nation.

Essence of Digital Public Infrastructure-

According to the United Nations Development Programme- Though the concept of DPI is still developing, there is increasing agreement that it consists of three components:

(i) Open technology standards that are networked and built for the public interest.
(ii) Enabling governance.
(iii) A community of competitive and creative market players that work to drive innovation, particularly across public programs.

Table 1: Definitions of DPI

S. N.	Researchers, Scholars, and Organization	Definition
01	**Heeks, R. (2020)**	The term digital public infrastructure (DPI) describes the application of digital technology to better public resource management and service delivery, increase accountability and transparency in the public sector, and encourage citizen participation in governance processes.
02	**OECD (2020)**	Digital identification systems, electronic payment platforms, and e-government are just a few of the projects that fall under the umbrella of digital public infrastructure. Nations all around the world have been

		making significant investments in DPI, especially in reaction to the COVID-19 pandemic, which has brought attention to the need for effective and efficient digital solutions to assist telemedicine, e-learning, and remote work.
03	**Aaditeshwar Seth (2023)**	It is implied that important ethical ideals are ingrained in the technology itself when it is asserted that digital public infrastructures (DPIs) adhere to or facilitate concepts like open-source, open APIs, interoperability, privacy by design, inclusive design, and universal access.
04	**Henfridsson, O. and B. Bygstad (2013)**	Digital infrastructures are crucial building blocks for businesses looking to maximize the promise of emerging digital technology. Networks, procedures, and organizational and technological elements make up a digital infrastructure. It includes the social milieu of digital tool users as well as the designers and system developers associated with the infrastructure.
05	**Maheshwari, Ankit (2023)**	Platforms like identification (ID), payment, and data exchange systems that assist nations in providing essential services to their citizens are referred to as digital public infrastructure (DPI). India is hardly an exception to the way it has changed how governments function. India's recent surge of digital public infrastructure initiatives has significant implications for the social and economic advancement of the nation.
06	**Astha Kapoor and Erin Watson (2023)**	The DPI approach is based on transparent, responsible, and participatory governance frameworks for public, business, and civil society participation and innovation. It uses open and interoperable technology to generate societal outcomes. By using a DPI method, nation-states

		can establish digital sovereignty and exert agency over their digital journeys, preventing consumers from being locked in by proprietary technologies.

2. History of Digital Public Infrastructure:

Before and after independence, India's digital public infrastructure underwent many stages of development.

Pre-Independence Era: Before independence in 1947, India had a limited technological landscape. The British colonial rule did introduce some elements of modern infrastructure, such as railways and telecommunication, However, these were more focused on economic and administrative control than on public services. The telegraph, introduced in the mid-19th century, was a key communication technology. It played a vital role in administrative and commercial affairs, facilitating quicker transmission of messages across the vast subcontinent.

Post-Independence Era (1947-1990s): After gaining independence, India underwent a gradual process of modernization and development. The initial decades focused on building the fundamentals of a sovereign nation, and technological advancements were not as rapid.

- ***Communication Networks:*** The telecommunication network was established and expanded in large part by the state-owned company Bharat Sanchar Nigam Limited (BSNL). The population's access to basic communication services was prioritized at this time.
- ***Computerization and Early Digital Initiatives:*** In the 1980s and early 1990s, India began to embrace computerization. Government offices and public institutions started adopting computers for record-keeping and administrative purposes. However, the digital infrastructure was in its infancy, with limited connectivity and accessibility.
- ***Liberalization and Economic Reforms (1990s):*** India's economic liberalization in the early 1990s marked a turning point. The information technology sector gained prominence, leading to a significant boost in the digital landscape.
- ***IT Boom:*** The late 1990s witnessed the emergence of India as a global IT hub. Cities like Bangalore and Hyderabad became IT centers, attracting multinational corporations. This era saw the rise of software services, outsourcing, and a burgeoning tech-savvy workforce.

- ***Digital Public Services:*** With the advent of the internet, the late 1990s and early 2000s saw a gradual shift towards digital public services. Government websites were launched, offering information and some basic services online. However, the penetration of these services remained limited due to factors like infrastructure gaps and digital illiteracy.
- ***National e-Governance Plan (NeGP):*** In 2006, the Indian government launched the National e-Governance Plan (NeGP) to transform governance through the extensive use of IT. NeGP aimed to provide government services to citizens electronically, enhance efficiency, and promote transparency.
- ***Aadhaar - Unique Identification Authority of India (UIDAI):*** Aadhaar is a significant undertaking in India's digital infrastructure. Aadhaar is a biometric identity system that was introduced in 2009 and assigns people a distinct 12-digit number. It is essential to many public services, such as identification verification, direct benefit transfers, and subsidies.
- ***Digital India Initiative (2015):*** The Digital India campaign, launched in 2015, is a comprehensive initiative aimed at transforming India into a digitally empowered society and knowledge economy. Its main objectives are to close the digital gap, advance digital literacy, and provide a large number of public services online.
- ***Unified Payments Interface (UPI):*** The UPI, launched in 2016, revolutionized digital payments in India. It allows seamless, real-time money transfers between banks through mobile devices. Financial inclusion and a cashless economy have benefited greatly from UPI's support.
- ***Goods and Services Tax Network (GSTN):*** The implementation of the Goods and Services Tax (GST) in 2017 necessitated a robust digital infrastructure for tax administration. The GSTN was established to handle the technological aspects of GST, including registration, filing returns, and invoice matching.
- ***BharatNet Project:*** The BharatNet initiative intends to give all gram panchayats (village councils) in India high-speed broadband connectivity to address the country's digital divide. The project, which was started in 2011, is essential to increasing internet access in rural areas.
- ***Open Network Digital Commerce:*** Open Network Digital Commerce (ONDC) is a government initiative in India aimed at creating an open digital commerce ecosystem that enables small traders, artisans, and other stakeholders to engage in e-commerce activities. It was incorporated on 31 December 2021.

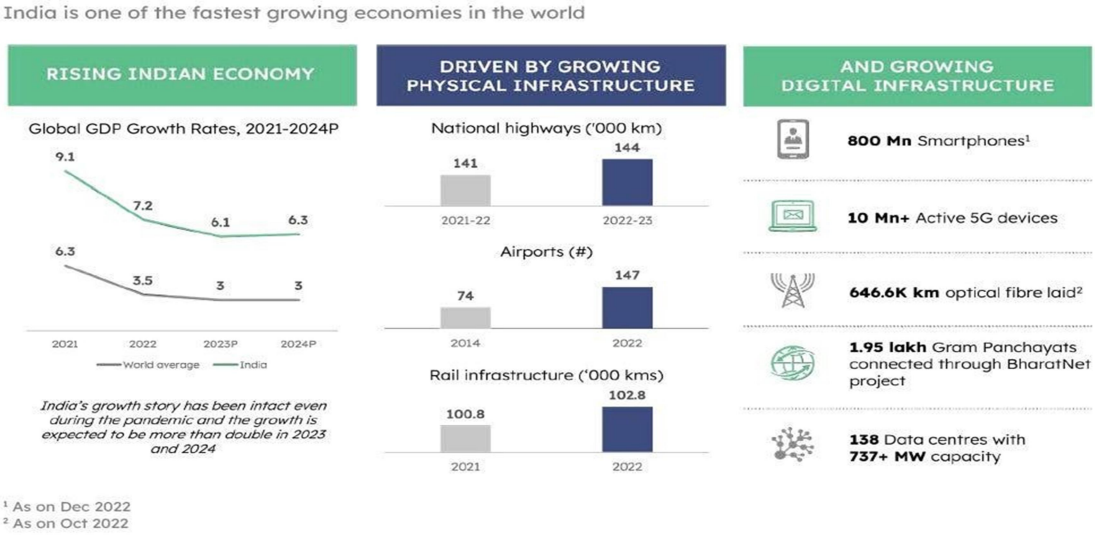

Figure 1 Source-Article 31 Summary: India's digital public infrastructure, Feb'24

3. Literature Review:

By offering the fundamental digital infrastructure that facilitate effective service delivery across sectors, the DPI plays a critical role in closing the gap between connection and service delivery. DPI serves as an intermediary layer between physical infrastructure and sectoral applications, facilitating digital identification, payments, and data sharing. The COVID-19 pandemic highlighted the resilience of countries with robust DPI, as they could maintain essential services and reach more beneficiaries with emergency cash transfers. However, significant challenges remain, such as the lack of official IDs for 850 million people and secure online access for five billion people globally (Marskell et al., 2024). Vivek Raghavan et al. (2019) India has made significant progress in digital inclusion through initiatives like the India Stack, which includes the Aadhaar program for digital identity and the Unified Payments Interface for low-cost digital payments. The open architecture of India Stack has led to the rapid growth of digital payment apps in the country. While the Aadhaar project has faced criticism for privacy and security concerns, the UIDAI has implemented design changes to address these issues. The public discourse around Aadhaar has also emphasized the need for a Data Privacy Law in India, offering valuable lessons for other countries considering similar digital infrastructure platforms. Ethan Zuckerman (2020) The systems that enable us to participate in civic and public life in digital spaces are known as digital public infrastructures. Most of the time, our digital infrastructures are only unintentionally public. For example, Facebook was created to show users advertisements rather than to promote citizenship. We should strive for a collection of tools that are purposely digital public

infrastructures, environments that function with norms and affordances organized around a set of civic principles. The summary highlights the importance of redesigning digital public infrastructure to prioritize civic values over surveillance capitalism. It emphasizes the need for tools that monitor community values, encourage civic engagement, and support journalism through new economic models. Governments should fund these infrastructures as essential social goods to address negative externalities. Alfred SIAME (2020) Digital Public Infrastructure (DPI) in enhancing public service delivery and financial management through digital technologies. It highlights the benefits of DPI in improving transparency, accountability, and efficiency in public finances, as well as supporting financial inclusion. Challenges such as the need for substantial investment and skilled personnel are identified. The research opportunities include exploring blockchain for fiscal transparency and leveraging digital solutions for tax collection and administration to advance sustainable development goals. Romina Bandura et. al. (2023) DPI serves as both the framework for digitization and the system of enablement that makes it possible to offer digital services to the public and commercial sectors. Among the first places where DPI was used were the internet and GPS. DPI is not new in that regard, but all of these current systems have mainly remained isolated from one another. Innovative approaches to DPI have the potential to spur cross-sector innovation. The digital public infrastructure is made up of three main parts: data exchange systems, electronic payment systems, and digital identity systems. Aarushi Gupta and Aman Nair (2023) The findings suggest that there is a need for more empirical evidence and research on the impact of Digital Public Identification. While DPIs like Aadhaar in India have been implemented to reduce delivery pipeline leakages, studies indicate that they have not significantly changed leakages or the value of goods received by households, but have increased transaction costs and exclusion errors. The G20 is encouraged to issue guidelines for DPI implementation, promote longitudinal studies, and engage in dialogues on data protection and security. Ankit Maheshwari (2023) India's economy and society have benefited greatly from digital public infrastructure, which has advanced e-governance, financial inclusion, business efficiency, education, and research. Digital public infrastructure does, however, also come with difficulties and debates, such as privacy issues, security threats, and implementation difficulties. All things considered, the creation and execution of digital public infrastructure projects in India are essential to fostering economic expansion and advancement as well as enhancing the quality of life for its people. For these programs to be implemented successfully, with openness, efficiency, equality, and sustainability, effective public administration is crucial. Under this paper, various infrastructures were discussed like Aadhar, Unified Payment Interface, National Knowledge Network, Digi Locker & Digi Yatra, etc. Aaditeshwar Seth et al. (2023) The paper

discusses challenges faced by digital public infrastructures (DPIs) in India, emphasizing the importance of implementing ethical values like privacy and inclusivity. Issues such as predatory lending, privacy concerns, lack of grievance resolution mechanisms, and gaps in de-duplication processes are highlighted. Recommendations to the G20 include advocating for citizen-empowering governance frameworks for DPIs. Proposed solutions focus on accountability, observability, autonomy, decentralization, and subsidiarity in technology governance to address these challenges effectively. Ajay Dutta & Novedeep Jeerh (2023) provides an overview of key initiatives in digital infrastructure and citizen empowerment in India. It mentions the Open Forge Project for collaborative e-governance app development, challenges in AI projects, and the Government e-Marketplace (GeM) for electronic procurement. Digital India initiatives focus on empowering citizens through Aadhaar, mobile banking, and e-learning platforms. The summary also touches on the growing popularity of digital currency like Bitcoin globally, indicating potential for widespread adoption in the future. Aadya Gupta & Suyash Rai (2024)" The difficulties in this process as well as the possibility for DPIs to enhance the state of the economy. Effective stakeholder engagement, trust-building, competition promotion and preservation, and striking a balance between public and private interests are all critical to the success of DPIs. Navigating the complexities of DPI deployment also requires an ongoing discussion of legislation and practicality. Furthermore, in order to fully use DPIs and guarantee fair and sustainable economic growth, governments, the private sector, and international organizations must work together. Kratika Neema & Arpit Neema (2018) The Unified Payment Interface is a digital payment system facilitating seamless fund transfers and merchant payments through Virtual Payment Addresses. Key players like Uber and SBI Pay are adopting UPI for transactions. Its advantages include instant transfers, single-click authentication, and secure transactions. Challenges include limited awareness and slow rural adoption post-demonetization. UPI presents a promising mobile payment solution with significant growth potential in India. Mahesh A, & Ganesh Bhat (2021) The research paper focuses on the Unified Payments Interface (UPI) in the Indian digital payment ecosystem. UPI accounts for a significant share of digital transactions, offering instant payments and enhanced security features. The paper analyzes UPI's strengths, weaknesses, opportunities, and threats, highlighting its user-friendly nature and growth potential. It emphasizes the importance of understanding UPI's position in digital payments and identifies areas for future research to enhance its capabilities and market presence further. Vijay Kumar & Harshitha (2023) The Open Network for Digital Commerce in India aims to democratize e-commerce by establishing mutually approved rules and regulations. The implementation strategy focuses on onboarding millions of retailers and customers to increase e-commerce penetration. ONDC benefits

MSMEs by empowering local sellers, resolving disputes, and enabling hyper-localization. India's global impact in digital commerce is set to rise due to ONDC's ambitious project, with partnerships in talks with 200 firms to accelerate e-commerce adoption, benefiting existing players like Amazon and Flipkart. Ram Girdhar (2023) The findings discuss the potential benefits of the Open Network for Digital Commerce in India, emphasizing its role in promoting competition, innovation, and consumer welfare in the digital commerce sector. Studies by organizations like the Reserve Bank of India (RBI) and the Indian Council for Research on International Economic Relations (ICRIER) highlight how open networks can improve competition, reduce costs, increase financial inclusion, and support small and medium-sized enterprises in accessing digital payment services. The ONDC is seen as a platform that could bridge the gap between large players and small retailers, offering growth potential for all participants.

4. Key Components of Digital Public Infrastructure:

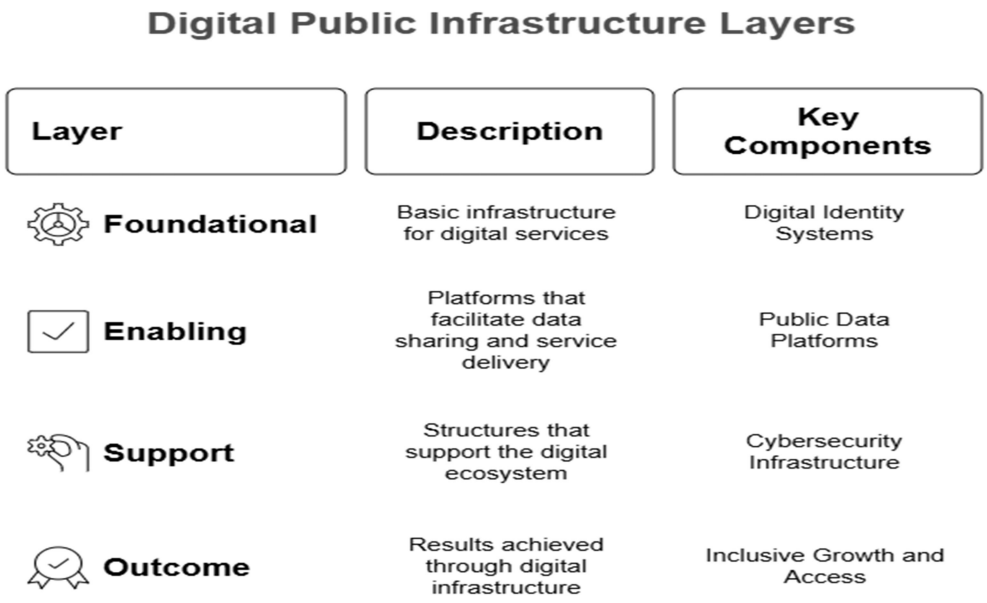

Figure 2: Digital Public Infrastructure Layers

The Digital Public Infrastructure Layers shows how digital systems are organized to enable inclusive, efficient, and sustainable services for citizens. The structure is divided into three primary layers: Identity, Payments, and Data Exchange, each fundamental to building a robust and secure digital public infrastructure (DPI). These layers are foundational, interoperable systems that allow various applications and services to interact seamlessly while ensuring trust, transparency, and accessibility.

The first layer, Identity, represents the digital systems that authenticate and verify individuals or entities within the ecosystem. It ensures that services are accessed securely and by the rightful users. Examples include Aadhaar in India or digital ID systems in other countries. This foundational layer enables seamless access to services by providing verifiable credentials, thereby empowering individuals to participate fully in economic, social, and civic activities. Digital identity systems also facilitate targeted delivery of government benefits, financial inclusion, and access to education and healthcare.

The second layer, Payments, facilitates secure and efficient digital financial transactions. Systems under this layer, such as India's UPI, allow for instantaneous and low-cost money transfers across various stakeholders. By standardizing and democratizing access to payment networks, this layer enables micro-entrepreneurs, consumers, and businesses to participate actively in the digital economy. Secure digital payments are critical not only for economic activity but also for promoting transparency in financial flows, reducing corruption, and enabling small and medium enterprises (SMEs) to expand their reach.

The third layer, Data Exchange, focuses on enabling consent-based, secure, and interoperable sharing of data among individuals, businesses, and governments. Data exchanges, often facilitated through protocols like the Data Empowerment and Protection Architecture (DEPA) in India, allow users to manage their data and grant access to third parties when needed. This layer fosters innovation, as developers can build new services and applications based on secure, accessible data streams while preserving individuals' privacy and control. Moreover, data exchange systems are essential for sectors like healthcare, education, finance, and logistics, where timely and accurate information sharing is crucial for better outcomes.

Together, these three layers form the backbone of a resilient digital public infrastructure that can drive inclusive growth, bridge digital divides, and support sustainability goals. They are complemented by governance frameworks, open standards, and regulatory oversight to ensure they remain open, secure, and citizen-centric. The interconnectedness of the layers underscores the vision of digital public infrastructure as not merely a collection of isolated systems, but as a cohesive platform enabling multiple use cases across sectors and communities.

This framework is particularly significant in the context of emerging economies, where DPI can leapfrog traditional barriers to development and create equitable opportunities. It aligns with broader global objectives such as the United Nations' Sustainable Development Goals (SDGs), specifically those related to reducing inequality, fostering innovation, and building resilient infrastructure. As nations

explore digital transformations, understanding and adopting this layered approach to digital public infrastructure becomes critical for creating a future where digital technologies serve everyone fairly, responsibly, and sustainably.

5. Findings:

The research highlights the critical role of Digital Public Infrastructure (DPI) in promoting inclusive growth and enhancing service delivery across sectors. DPI, characterized by its open standards, reusability, and cross-sectoral adaptability, acts as an essential intermediary between physical infrastructure and sector-specific applications. Key components identified include Digital Identification, Digital Payments, and Data Sharing systems, each playing a foundational role in improving service accessibility and resilience. Despite 850 million individuals worldwide lacking official identification as of 2021, digital ID systems are recognized as vital for access to healthcare, education, and financial services. Similarly, digital payment systems have proven instrumental, especially during the COVID-19 pandemic, in facilitating financial transactions, promoting financial inclusion, and ensuring emergency aid distribution to wider populations. Furthermore, efficient and secure data sharing has enabled innovation and enhanced service delivery across sectors.

The study also uncovers how DPI bolstered countries' resilience and continuity during crises, maintaining government functions, commerce, and education systems remotely. By fostering financial inclusion, DPI systems empower marginalized communities, offering them tools to participate meaningfully in the digital economy. Additionally, cross-border interoperability emerges as a future opportunity, hinting at the possibility of seamless international digital service networks. Nevertheless, the findings emphasize persistent challenges such as infrastructure deficits- where over five billion individuals still lack secure internet access- and the pressing need for robust regulatory and governance frameworks to safeguard data privacy and security. Addressing these issues is paramount to realizing the full potential of DPI and ensuring its sustainability and inclusivity.

6. Conclusion:

Digital Public Infrastructure presents a transformative opportunity to bridge existing connectivity and service delivery divides, fostering a more inclusive and resilient digital society. The research underscores that DPI's open and standards-based nature allows it to serve as a foundational layer that supports diverse applications and services. By prioritizing systems like digital identification, digital payments, and data exchange platforms, countries can unlock new avenues for inclusive growth,

ensuring that historically underserved populations gain access to essential public and financial services. However, while DPI's benefits are profound, realizing its full promise requires addressing key structural challenges. Regulatory frameworks must evolve rapidly to keep pace with technological innovation, ensuring that digital platforms remain secure, transparent, and inclusive. Without effective governance, issues such as data breaches, exclusionary practices, and trust deficits could undermine DPI's potential. Additionally, the significant infrastructure gap- with billions still lacking reliable internet access- demands urgent investments in digital connectivity, particularly in remote and marginalized regions. The future trajectory of DPI also points towards greater cross-border interoperability, offering exciting possibilities for global service delivery, financial inclusion, and digital innovation. Nonetheless, international collaboration, trust frameworks, and harmonized standards will be critical to facilitate these transitions effectively. In conclusion, DPI offers a powerful pathway toward empowering inclusive growth, but its success will hinge on a balanced approach that champion's innovation while embedding equity, security, and sustainability at its core. Bridging the connectivity and service delivery divide through robust DPI development will not only uplift individual nations but also contribute significantly to achieving global digital transformation goals.

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