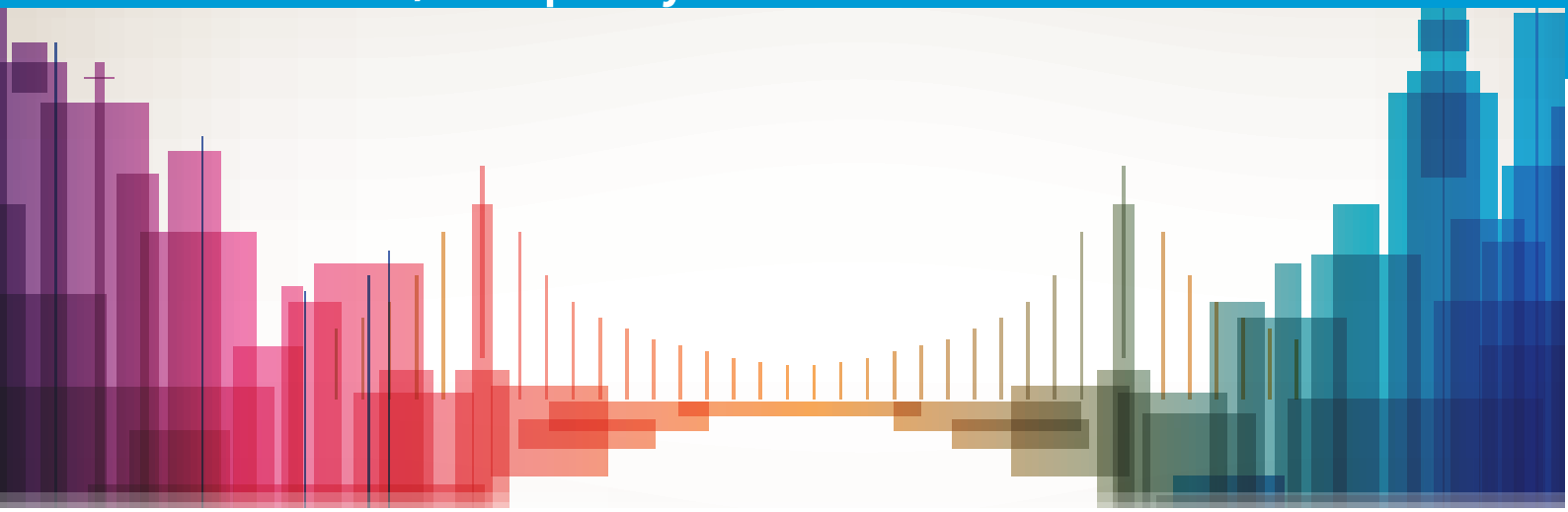
Building digital public infrastructure for cities and communities

A strategic framework for city leaders, officials, ministers, and policymakers



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

UNIDO

ITU

UNDP

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment programme

UNEP FINANCE INITIATIVE

United Nations Framework Convention on Climate Change

unitar United Nations Institute for Training and Research

UN HABITAT FOR A BETTER URBAN FUTURE

United Nations Department of Economic and Social Affairs

UN 4 PARTNERSHIPS

UNU EGOV

UN Tourism

UN WOMEN

WORLD METEOROLOGICAL ORGANIZATION

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Foreword

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of any specific digital transformation technology. It advocates for policies encouraging responsible use of information and communications technologies (ICTs) that contribute to the economic, environmental and social sustainability as well as the advancement of the 2030 Agenda for Sustainable Development and the Pact for the Future and its Global Digital Compact.

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Contents

List of abbreviations

Abbreviation	Full Form
ADB	Asian Development Bank
ADEx	Agriculture Data Exchange
AI	Artificial Intelligence
APIs	Application Programming Interfaces
AR	Augmented Reality
CAR	Cadastro Ambiental Rural
CCC	Command and Control Centre
CCTV	Closed-Circuit Television
COBOL	Common Business-Oriented Language
COC	City Operational Centre
CPMI-IOSCO	Committee on Payments and Market Infrastructures and the International Organization of Securities Commissions
CSOs	Civil Society Organisations
DFFT	Data Free Flow with Trust
DFG	Declaration on Future Generations
DMA	Digital Markets Act
DPGs	Digital Public Goods
DPI	Digital Public Infrastructure
DPIAs	Data Protection Impact Assessments
FAO	The Food and Agriculture Organization of the United Nations
FOSS	Free and Open-Source Software
G2Px	Digitalizing Government-to-Person Payments
GDC	Global Digital Compact
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information Systems
GPA	Agreement on Government Procurement
GVB	Gemeente Vervoerbedrijf
ICT	Information and Communications Technology
ID	Identity
ID4D	Identification for Development
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IKD	Identitas Kependudukan Digital
ILO	International Labour Organization

Abbreviation	Full Form
IoT	Internet of Things
IRS	Internal Revenue Service
ISO	International Organization for Standardization
ITU	International Telecommunication Union
KISIP II	Kenya Informal Settlement Improvement Project
KPIs	Key Performance Indicators
LMICs	Low- and Middle-Income Countries
NCDs	Non-Communicable Diseases
NDCs	Nationally Determined Contributions
NR	New Radio
OASC	Open and Agile Smart Cities
OECD	Organisation for Economic Co-operation and Development
OSPOs	Open-Source Programme Offices
PbD	Privacy by Design
PFI	Private Finance Initiative
PhilSys	Philippine Identification System
PPPs	Public–Private Partnerships
QR	Quick Response
SAML	Security Assertion Markup Language
SDGs	Sustainable Development Goals
TG-DPI4Cities	Thematic Group on Digital Public Infrastructure for Cities
U4SSC	United for Smart Sustainable Cities initiative
UN	United Nations
UNCDF	United Nations Capital Development Fund
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNECLAC	The United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
UNOPS	The United Nations Office for Partnerships
UNSG	UN Secretary-General
UNU	United Nations University
UNWTO	UN Tourism
UPI	Unified Payments Interface

Abbreviation	Full Form
USSD	Unstructured Supplementary Service Data
VR	Virtual Reality
W3C	The World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines
WEF	World Economic Forum
WGA	Whole-of-Government Approach
WHO	World Health Organization
WMO	World Meteorological Organization

Executive Summary

Cities and communities around the world are undergoing a profound transformation. As urban populations grow and the demands on public services intensify, Digital Public Infrastructure (DPI) has emerged as a foundational enabler of inclusive, efficient and sustainable urban development. DPI for Cities refers to a suite of trustworthy, secured, and interoperable people-centric digital systems – including digital identity, payments, data exchanges, and service platforms – that serve as public goods and enable the delivery of essential services in the digital age as well as the inclusive, open, sustainable, fair, safe and secure engagement between people, and the city's processes, and its underlying technologies.

This framework document provides a strategic roadmap for city leaders, ministers and policymakers to understand, design, and implement DPI that delivers real impact for people and communities. Grounded in global experiences and aligned with key international frameworks – the Sustainable Development Goals (SDGs), the Pact for the Future, and the Global Digital Compact (GDC) – the document positions DPI for Cities as a critical tool for shaping the cities of tomorrow.

Key insights include:

- **DPI is not just technology infrastructure – it is a policy and governance imperative**: When designed as public goods, DPI systems promote transparency, inclusion, accountability, and innovation in city services and governance.
- **Benefits are wide-ranging**: From improving access to health, education, and financial services, to enabling real-time urban management through Internet of Things (IoT) and data analytics, to boosting civic participation through digital engagement platforms.
- **Challenges remain**: Fragmented legacy systems, lack of interoperability, digital inequality, weak data governance, and capacity constraints – particularly in low-resource environments. These must be addressed proactively to ensure DPI benefits all.
- **Case studies** offer practical examples of DPI for Cities delivering measurable outcomes – such as streamlining subsidy delivery, enabling smart mobility, expanding financial inclusion, and enhancing service integration.
- **Inclusive governance, legal frameworks, and standards** are essential to ensure DPI is trusted, rights-based, and future-proof. International standards (from International Telecommunication Union, and others) provide a solid foundation for cities to build scalable, interoperable systems.
- **Global alignment is more urgent than ever**: DPI supports many of the SDGs directly, while also offering a tangible mechanism for cities and nations to localize the principles of the Pact for the Future and Global Digital Compact – including digital inclusion, responsible innovation, and the recognition of Digital Public Goods (DPGs).

The framework document concludes with clear policy recommendations tailored to local and national authorities: invest in holistic and inclusive DPI strategies; adopt Whole-of-Government approaches (WGA); align with global standards; promote local digital ecosystems; and prioritize privacy, ethics, and human rights by design. Now is the moment for visionary leadership. Cities and governments that invest in robust, inclusive DPI are not only modernizing service delivery – they are laying the digital foundation for equitable and resilient societies. This framework equips policymakers with the insights and tools needed to lead that transformation.

1 The rise of digital public infrastructure

In an era characterized by two significant transitions, namely vast urbanization and technological progress, our cities are facing complex urban challenges related to inclusivity, sustainability and the responsible use of technologies (UN-Habitat, 2024). Digital technologies are transforming urban life globally, offering great opportunities to enhance how cities and human settlements are designed, planned, managed and governed. Through improved urban planning, and the provisioning of data-centric systems and services for a data-driven policy rule-making (ITU, 2025), digital technologies do, indeed, have a profound influence in the way our cities are governed (UN-Habitat, 2025).

Urbanization has been one of the most significant trends shaping the built environment in the twentieth and twenty-first centuries. The shift towards an increasingly urbanized world is a transformative force that can and should be harnessed to ensure sustainable development. In urban settings, addressing development challenges with effective interventions can have wide-ranging cumulative impacts (United Nations, 2018). However, if unplanned and poorly managed, urbanization has the potential to exacerbate many of the problems it claims to solve, leading to economic instability, congestion and environmental degradation. Furthermore, inefficient sprawl due to inadequate land-use planning and management remains a major concern, pushing residential areas away from resources and public services (UN-Habitat, 2024).

Housing remains inadequate and unaffordable for many, with unchecked development encroaching on arterials and right of ways, posing problems for the development of public services. Rapid expansion often degrades natural features, necessitating integrated environmental planning processes to better manage urbanization and its effects on the natural environment. Poorly planned urbanization can result in congestion, inconsistent densities and social exclusion, particularly affecting poor households. Congestion and inadequate investment in infrastructure further exacerbate these challenges, calling for better planning and investment to ensure sustainable and inclusive urban growth.

It is evident that cities are increasingly leveraging innovation and management processes, information and communications technology (ICT), and data-centric solutions to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental and cultural aspects. By adopting ICT, digital systems and data-centric solutions, cities are able to deliver better services for residents and address critical global urban challenges, including climate change, poverty, social and economic inequality, unemployment, environmental degradation, food scarcity and sustainable economic resilience. However, given the scale of these global urban-related challenges – for example, 2.8 billion people lacking access to adequate housing (UN-Habitat, 2022), 2.6 billion people still lacking affordable access to the Internet (ITU, 2024), and 39 per cent of the global population still not using the Internet, despite having access to it – with adoption gaps especially pronounced in rural areas, low-income countries, and among women (UN-Habitat, 2024), it is evident that a holistic, sustainable and people-centred ICT-based smart city design approach that adopts digital transformation at scale, is needed. In such an approach, digital technologies

should be assembled to meet local development needs and their development process should be grounded using collective intelligence, bottom-up actions, participatory governance, open and user-driven innovation, and community-led urban development (Mora & Deakin, 2019).

The "bottom-up" approach of sustainable smart city design and implementation appears to offer a more equitable model for urban development that recognises a diverse range of users, in addition to being advocated to ensure the widespread adoption by the local residents. Smart city technologies are constructed in a particular socio-historical context and thus are shaped by politics, budgets and local culture as much as by the technical specifications and capabilities of the technology itself (e.g., processing power, bandwidth) (Angelakis *et al.*, 2017). Cities can thus play a crucial role in sustainable development by connecting various elements like economy, energy, environment, science, technology, society, culture and investment. These links help create the integrated policies necessary for achieving sustainability.

Our goal is to have an inclusive, open, sustainable, fair, safe and secure digital future for all (United Nations General Assembly, 2024a). At the city level, one way to achieve this is to adopt a digital transformation strategy and implementation for a holistic people-centred city operation and management. By utilizing the full potential of digital transformation to support urban operations, services' provisioning and the engagement and participation of residents, smart sustainable cities can be key enablers for achieving the main objectives envisioned in the New Urban Agenda and the attainment of the UN Sustainable Development Goals (SDGs) addressed in the 2030 Agenda for Sustainable Development.

However, as optimistic as this may sound, empirical evidence indicates that the effective digital transformation necessary to achieve the SDGs needs much more than supply-side and demand-side initiatives. According to the UN Secretary-General (UNSG) in his Policy Brief 5, "Our Common Agenda, A Global Digital Compact (GDC) – an Open, Free and Secure Digital Future for All" ("the Policy Brief") (United Nations, 2023), a concerted effort is still needed to: connect the remaining 2.7 billion people, more than one billion of whom are children and most of whom live in least developed countries; introduce policy and financial investments to make broadband and mobile devices affordable and reliable; and make a global effort to strengthen digital learning and skills, with targeted efforts for women, girls and young people, so that everyone can take full advantage of the opportunities of connectivity and employers and workers can adapt to digital transformation (United Nations, 2023).

Supply-side initiatives are not enough for a successful human-centred digital transformation at scale. A demand pull is also needed through the provision of Digital Public Goods (DPGs) and services that are meaningful for people and communities. Despite the rapid growth in demand for ICT infrastructure and the rapid development of digital applications and services, and their inclusion in almost any digital transformation strategy at a national scale, some notable challenges still remain.

So far, the more-affluent and better-educated populations have generally had earlier and better access to ICTs than the less-affluent and less-educated populations. Additionally, the global supply market is showing some signs of dominance in certain parts of the supply chain, leading to potential vendor lock-in, and other regulatory challenges associated with end-user privacy protection, data ownership, data sovereignty and data protection.

For over a decade, governments were asked to employ a wide range of strategies and policies to support the development of ICT infrastructure such as through market liberalization (for example, opening international gateways to competition) and the allocation and award of new spectrum for wireless broadband (for example, releasing the "digital dividend" spectrum for commercial wireless use once the country's digital television transition is completed) (Kelly & Rossotto, 2011).

While this has proved to be a sound policy, backed-up by plenty of scientific socio-economic empirical evidence, it has long been recognized that to realize the full benefits of ICT infrastructure, various sectors of the economy and society must have the capacity to acquire, assimilate, transform and exploit the capabilities enabled by this platform.

This "absorptive capacity" is the mechanism by which the benefits obtained from ICT (e.g., broadband) feed into the greater economy, allowing this technology to unleash its potential and achieve all promised gains. This requires:

"(a) the creation and availability of broadband-enabled services…", (or more generally ICT infrastructure), *"…and applications that increase efficiency and productivity and (b) the capacity of businesses, government, and citizens to use broadband-enabled services and applications in a productive and efficient way."*

(Kelly & Rossotto, 2011)

Hence, one enduring question remains:

"What policies, strategies, regulatory actions, norms, and industry best practices, are needed to be embraced by city leaders, government officials, and the whole industry, to ensure an accelerated and sustainable digital transformation process at the city level, to achieve the 2030 Agenda for Sustainable Development? If it is not only, supply-side interventions, or demand-side stimulus, what else could be missing to achieve a successful human-centred digital transformation at scale, at the city and/or the community level?"

1.1 Understanding digital public infrastructure for cities

There have been numerous treatments of Digital Public Infrastructure (DPI) in the industry. At its simplest, DPI can be understood as an intermediate layer in the digital ecosystem. International approaches to DPI vary from being totally decentralised and open source on one side, to centralised and proprietary on the other side. Hybrid approaches have been also reported.

DPI sits atop the physical layer. It enables applications across various sectors (for example, information systems and solutions to different verticals, e-commerce, social protection, remote education and telehealth) to exchange data securely, and to scale and interoperate/interwork in an open and inclusive manner. The focus on reusable and horizontal foundational digital elements is a paradigm shift from conventional approaches to digitalization that have, in many cases, led to fragmentation and siloes (World Bank, 2023).

In 2024, Organisation for Economic Co-operation and Development (OECD) defined DPI as a set of shared, secure and interoperable digital systems designed to support broad access to public and private services. Examples include digital identity, data sharing systems, digital payments, and digital post and notifications. These DPI systems act as common digital building blocks that underpin government processes and services and enable digital government transformation at scale. Key benefits identified include offering socio-economic advantages, generation savings and efficiency gains for the public sector and the private sector. Alongside economic gains, DPI can promote inclusivity, service resilience, security and user satisfaction, providing essential infrastructure for efficient, scalable and innovative services. The main benefits identified include

efficiency, interoperability, user experience and inclusion, scalability, resilience and innovation (OECD, 2024). OECD's approach is oriented towards digital government.

These perspectives were not tailored though at the peculiarities of cities and their associated urban challenges, which might deem the identified digital components, uneconomical or difficult to implement, unless if specific measures and/or policies have been implemented at an early stage both at the national/federal and city/local community levels alike. DPI for cities must adopt a carefully crafted architecture framework which is capable of reflecting multiple stakeholders' needs, concerns and viewpoints at the city/local community level.

In 2023, United Nations Development Programme (UNDP) identified DPI as having four characteristics: it (1) is interoperable (forms the underlying infrastructure for a variety of use cases alongside a range of tools, technologies and service providers); (2) can be built on open standards (is available to anyone to build on to and integrate services for people); (3) operates at a societal scale (is not restricted by geography or demographic); and (4) has robust enabling rules and regulations (has unified and coherent governance frameworks to safeguard people and prevent misuse). UNDP suggested twelve key technology, governance and community principles, building upon the advancements in this domain such as the Principles on Identification for Sustainable Development, the Committee on Payments and Market Infrastructures and the International Organization of Securities Commissions (CPMI-IOSCO) Principles for Financial Market Infrastructures, UN Principles for Responsible Digital Payments and the Principles for Digital Development:

1. **Inclusivity**: Eliminate or reduce economic, technical, or social barriers to enable inclusion, empowerment of end-users, last-mile access and avoid erroneous algorithmic bias.
2. **Interoperability**: Enable interoperability by using and building on open standards and specifications with a technology neutral approach, wherever possible, while accounting for appropriate safeguards and keeping in view the legal considerations and technical constraints.
3. **Modularity and extensibility**: Extensible approach implies a building block or modular architecture to accommodate changes/modifications without undue disruption.
4. **Scalability**: Use flexible design to easily accommodate any unexpected increase in demand and/or to meet expansion requirements without changing existing systems.
5. **Security and privacy**: Adopt an approach that embeds key privacy enhancing technologies and security features within the core design to ensure individual privacy, data protection and resilience based on standards offering appropriate levels of protection.
6. **Collaboration**: Encourage the participation of community actors at different stages of planning, designing, building and operating to facilitate and promote a culture of openness and collaboration. Enable the development of user-centric solutions and facilitate widespread and sustained adoption and allow innovators to develop new services.
7. **Governance for public benefit, trust and transparency**: Maximise public benefit, trust and transparency while respecting applicable legal frameworks. This means that laws, regulations, policies and capabilities should seek to ensure that these systems are safe, secure, trusted and

transparently governed, and also promote competition and inclusion, and adhere to principles of data protection and privacy.

8. **Grievance redress**: Define accessible and transparent mechanisms for grievance redress, i.e., user touchpoints, processes, responsible entities, with a strong focus on actions for resolution.
9. **Sustainability**: Ensure sustainability through adequate financing and technological support and enhancements to facilitate uninterrupted operations and seamless user-focused service delivery.
10. **Human rights**: Adopt an approach that respects human rights at every stage of planning, designing, building and operating.
11. **Intellectual property protection**: Provide adequate and effective protection and enforcement of intellectual property rights for the rights-holders of technologies and other materials used based on existing legal frameworks.
12. **Sustainable development**: Seek to develop and deploy these systems that contribute to the implementation of the 2030 Agenda for Sustainable Development and achievement of SDGs.

The above principles, being generic enough, can be applied seamlessly at the city/local community level and ensures coherence with national/federal level implementations.

In contrast to digital private infrastructure, DPI are the foundational components that allow societies to connect the remaining 2.7 billion people living on our planet, reach the bottom of the pyramid, and cover for the market gaps. These remaining chronic developmental challenges usually arise from the lack of the private sector appetite to invest in costly and economically unfeasible ICT services and/or infrastructure provisioning projects, regardless of any incentives provided by the policy makers. Obviously, the public funding or States' sole interventions might not be enough to cover the high cost of implementing a nationwide ICT infrastructure that can match local communities' demand.

The key question, though, is how to balance the private sector's interests (e.g., revenue-driven, customer's data-centric acquisition focused) with the need to have an inclusive, open, sustainable, fair, safe and secure digital future for the consumers (e.g., ensure privacy-by-design, privacy-by-defaults, security-by-design, security-by-default, inclusivity)? And, to what extent does the current state of play of DPI implementations suit city-level implementations? DPI has been advocated, from its onset, as a national/federal level intervention, with little/limited focus on local-level, city-led interventions. Are any complementary components needed to address the highly complex urban environment of a smart city (i.e., the local context), given its ever-evolving ecosystem?

It is the purpose of this document to explore how DPI can be tailored to address the urban challenges with grassroots stakeholders' views, taking into consideration the wide and inclusive view of all relevant smart sustainable cities' stakeholders' groups. In particular, the following framing questions

are used to direct qualitative analytical approach adopted by this report, to analyse global case studies of DPI for cities implementations:

- What are the key components of DPI deemed necessary and sufficient to achieve an effective and efficient sustainable digital transformation at the city level, to achieve the SDGs?
- What are the necessary tools, frameworks and requirements to guide stakeholders (e.g., city leaders) in deploying an effective DPI for cities to achieve cities' sustainability agenda (e.g., to enhance their socio-economic and environmental metrics, supporting their journey towards a sustainable deployment and fostering public trust)?

1.2 DPI and its core analytical viewpoints for cities

Given the above context, the United for Smart Sustainable Cities (U4SSC) initiative, as a global UN collaboration, supported by 20 United Nations (UN) agencies,[1] along with an international network of cities embracing and adopting the U4SSC key deliverables, provides a unique value proposition in tackling DPI for cities.

The U4SSC approach merges bottom-up with top-down viewpoints to develop policies, frameworks, guidelines and recommendations deemed necessary for the sustainable and inclusive development of digital transformation of smart sustainable cities. To this end, the "Thematic Group on Digital Public Infrastructure for Cities (TG-DPI4Cities)" was established to develop policies, frameworks and requirements of DPI and services for smart sustainable cities to enable human-centred digital transformation at scale.

TG-DPI4Cities defines **Digital public infrastructure (DPI)** *for cities* as:

> *"Necessary and sufficient digital ICT systems that improves quality of life, efficiency of urban operation and services, and competitiveness, by supporting city level sustainable digital transformation at scale through trustworthy, secured, and interoperable engagement between people, and the city's processes, and its underlying technologies. DPI for cities provides a foundational, holistic, and inclusive digital layer for societies to engage effectively and efficiently with smart cities' systems and services. DPI for cities includes critical systems such as digital identity, digital payments, data exchange, artificial intelligence (AI), and other foundational infrastructure, needed to support the interworking, interoperability, scalability and adaption of systems and processes, to wide range of varying city conditions, challenges, and risks, to achieve an inclusive, open, sustainable, fair, safe and secure digital adoption for all."*

[1] As of the date (July 2025) of developing this document, United for Smart Sustainable Cities (U4SSC) initiative is a global UN collaboration, coordinated by ITU, UNEP and UNECE, and supported by a network of key partners, including UN-Habitat, CBD, ECLAC, FAO, UNDESA, UNDP, UNECA, UNESCO, UNEP, UNEP-FI, UNFCCC, UNIDO, UNITAR, UNOPS, UNU-EGOV, UN-Women, UNWTO, and WMO.

TG-DPI4Cities adopts core analytical viewpoints for analysis, deemed necessary to ensure the sustainability and quality of life of city residents current and future generations. In this context, DPI for cities integrates the following viewpoints in the design fabric of the shared digital systems ensuring trustworthiness, safety, inclusiveness, sustainability and resilience:

1. **Secured, resilient infrastructure and climate adaptation**: Delivering sustainable, safe and secured, resilient urban infrastructure; integrating meteorological services and early warning systems; foster industrial decarbonization and urban disaster resilience.
2. **Urban environmental sustainability and biodiversity**: Embedding biodiversity conservation, nature-based solutions, air quality management and urban ecosystem services into city planning and governance.
3. **Urban economic transformation and industrial innovation**: Enabling inclusive economic development through sustainable industry, innovation, and the promotion of green and circular economy models within urban environments.
4. **Gender equality, social inclusion and human rights in urbanization**: Prioritizing women's empowerment, human rights, gender-sensitive urban design, inclusive governance, and the equitable distribution of urban benefits and services.
5. **Smart digital governance and data-driven urban management**: Developing smart city platforms, responsible AI systems, applications and services for cities, ICT infrastructure, and interoperable urban data governance systems.
6. **Sustainable urban mobility, tourism and cultural preservation**: Promoting sustainable urban tourism, cultural heritage management, sustainable transport and smart mobility integration.
7. **Sustainable urban food systems and rural-urban linkages**: Strengthening urban food security, rural-urban supply chains and sustainable food ecosystems as part of city resilience strategies.
8. **Multilateral cooperation and regional urban strategies**: Integrating cities into broader regional and global cooperation frameworks for innovation, economic resilience and SDG localization.

Unlike siloed e-government projects of the past, DPI for cities provides an open and a neutral stack-agnostic foundational digital layer for systems and processes, to operate in an efficient and effective manner.

By digitizing city services and automating urban operations, and by integrating therein all relevant sustainability and people-centred aspects, DPI for cities can accelerate economic development, financial inclusion, and can deliver an effective service delivery in cities. However, these opportunities come with key governance imperatives. Cities must ensure that DPI systems are inclusive (leaving no one behind), secure, privacy-protective, and accountable in their design and operation.

The importance of sustainability and people-centricity for city development is underscored by international agendas like the United Nations Sustainable Development Goal 11, which calls for making cities inclusive, safe, resilient and sustainable. A people-centric approach to digital

transformation – grounded in human rights and transparency – is essential to build residents' trust in smart city initiatives.

The premise is that Digital Public Goods (DPGs) harness huge amounts of data that, if governed safely and used effectively, can help cities to accelerate their development and advance the achievement of the 2030 Agenda for Sustainable Development. To enable public and private institutions to pool resources and draw upon public data, DPI for cities must be open, inclusive, secure and interoperable. Most importantly, DPI for cities must pool-in resources from national/federal level implementations and integrate – wherever possible – national/federal level implementations at the city/local level. This is important to optimize resources, remove silos and ensure coherence from a security and efficiency points of views.

Consequently, the capacities of public administrations (at the national/federal and city/local community levels) to manage and provide an interoperable, open, secured and scalable digital ICT infrastructure, must be built as a matter of urgency.

2 The global digital compact: an international compass

On 22 September 2024, world leaders adopted at the Summit of the Future, the Pact for the Future and its annexes: the Global Digital Compact (GDC) and Declaration on Future Generations (DFG). The Summit of the Future produced an inter-governmentally negotiated, action-oriented Pact for the Future (United Nations General Assembly, 2024a).

This Pact covers a broad agenda including peace, climate, sustainable development and, crucially, digital cooperation. A key element of the Pact is an annex known as the GDC, envisioned as a roadmap toward a "responsible and sustainable digital future". The GDC represents the first comprehensive global framework for digital governance and cooperation, outlining shared principles for an "open, free, secure, and human-centred digital future". This global compact seeks to guide national and local policies in harnessing technology for good while safeguarding rights, enshrined in the UN Charter and the doctrine of international law. DPI for cities provides a roadmap for effectively integrating the GDC's principles and the Pact's vision into smart city frameworks, ensuring that future cities are not only "smart" but also inclusive, accountable and aligned with global standards.

2.1 Leveraging the SDGs for urban DPI

Entangled in a web of intricate interconnections, urbanization underscores the complex nature and profound links between the SDGs and the DPI in urban settings. These frameworks converge on a shared vision: creating an equitable, inclusive and fair world for current and future generations; and ensuring that no individual or place is overlooked. The "urban" DPI, with its commitment to integrating the principles of the GDC, serves as a crucial tool in advancing the SDGs' transformative agenda, particularly in the context of smart cities. By fostering collaboration and interoperability across various domains, DPI for cities enhances the effectiveness of urban planning and development, aligning with the broader goals of sustainable cities and communities.

Some of the linkages between the two global agendas are evident and are most clearly seen in the inclusion of the historically first stand-alone goal on sustainable cities, SDG 11, to "Make cities and human settlements inclusive, safe, resilient and sustainable". SDG 11 on sustainable cities and human settlements is intrinsically linked to other SDGs (Fronza *et al*., 2023)

The synergies between the SDGs and the DPI underscore that efforts to achieve the SDGs must work in tandem with the implementation of DPI at the local city/community scale. For example, reducing unauthorized construction in high-risk areas to prevent natural disaster-related deaths (SDG target 13.1) can be achieved through urban DPI implementations that provides real-time monitoring and data analysis at the city level. Urbanized DPI implementations add additional dimensions on the infrastructure requirements, reflecting city stakeholders' views (e.g., the need to mitigate flooding risks, integrating DPI with blue-green infrastructure elements, etc.). Similarly, improving productivity and access to decent jobs (SDG target 8.3) can be supported by investments

in reliable, accessible and affordable public transportation systems enabled by urbanized stack-agnostic DPI implementations.

Evidence shows that integrated urban planning, access to basic services, slum upgrading, and the provision of decent and affordable housing play a critical role in reducing Non-Communicable Diseases (NCDs) and limiting environmental impacts. These interventions support global goals on health and well-being (SDG 3), energy (SDG 7) and climate action (SDG 13) by improving living conditions, promoting active mobility and reducing exposure to harmful pollutants (WHO, 2019; Corburn & Sverdlik, 2020). Slum upgrading efforts, in particular, contribute to health equity and resilience by ensuring access to clean water, sanitation and safer housing structures (Corburn & Sverdlik, 2020).

Meanwhile, the development of regional and urban infrastructure, aligned with SDG 9, enhances market connectivity and strengthens value chains, thereby supporting decent work and economic growth (SDG 8), and sustainable consumption and production (SDG 12) (United Nations, n.d. a; United Nations, n.d. b). Improved infrastructure also helps bridge rural-urban divides, facilitating food distribution networks and reducing post-harvest losses – key to achieving food security (SDG 2), better nutrition and sustainable agriculture (FAO, 2018; Nizami & Kolokotsa, 2024). These interlinked strategies reflect the transformative potential of inclusive urban planning and infrastructure in achieving multiple SDGs. Emphasis should, however, be placed on the requirement for DPI implementations at the local level to take the local city/community context into consideration, as well as the intricate nature of smart city operational system requirements emanating from contextual and operational constraints.

Moreover, UN-Habitat's 2016 report, *Sustainable Urbanization in the Paris Agreement*, highlights that 113 out of 164 submitted Nationally Determined Contributions (NDCs) include urban references, establishing clear linkages between sustainable urbanization and climate action (UN-Habitat, 2016). This underscores the pivotal role of DPI in advancing these goals, particularly within the context of smart cities, by fostering collaboration and interoperability across various domains.

By integrating the principles of the GDC, DPI for cities enhances the effectiveness of urban planning and development, aligning with the broader goals of sustainable cities and communities. The GDC proposes principles, objectives and actions for advancing an open, free, secure and human-centred digital future, which supports the attainment of the SDGs (United Nations, 2023). These synergies between the SDGs and DPI reflects a holistic approach to development, where technological advancements and policy initiatives work hand in hand to build resilient and thriving urban environments

2.2 Operationalizing the Pact for the Future

The Pact for the Future, adopted by the UN General Assembly in 2024, emphasizes strengthening the multilateral system to be effective, capable and prepared for the future. Digital governance is a crucial theme in this pact, recognizing that emerging technologies are rapidly reshaping societies

and affect humanity on multiple scales. The Pact's drafters recognized that emerging technologies are reshaping societies rapidly, and that international cooperation must "keep pace with a changing world" and guard against technology outpacing governance (UNGA, 2024a). The GDC establishes a common baseline of principles for the digital space, promoting an open, free, secure and human-centred digital future.

The GDC brings together issues that were often treated separately. As noted, it spans connectivity & digital inclusion, DPGs/infrastructure, human rights online, Internet governance, trust and safety (including misinformation and cybercrime), data governance (privacy, security, cross-border flows), standards and interoperability and artificial intelligence. Historically, each of these might be handled by different institutions or techno-policy communities – such as the International Telecommunication Union (ITU) for connectivity, the human rights council for online rights, and standardization bodies like the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and ITU for telecommunications standards. The GDC does not replace those specialized efforts, but by covering all in one compact, it encourages a more "networked multilateralism" that links these domains.

Urban DPI can be seen as the operational arm of the Pact for the Future and the GDC by translating the high-level principles they promote into concrete strategic plans, institutional reforms, city level strategies, implementation frameworks, and technical standards, that enshrines an inclusive, open, sustainable, fair, safe and secure human-centred digital adoption for all.

2.3 Implementing the global digital compact locally

While the GDC is a global framework, its relevance cascades down to local governance of digital infrastructure, particularly in smart cities where digital technology meets day-to-day governance. Smart cities are at the frontlines of the implementation of many of the technologies and policies addressed by the GDC. The GDC's emphasis on universal connectivity and closing digital divides translates, at the city level, into ensuring that all urban residents have affordable Internet access. In many cities, connectivity is uneven; wealthier or central districts enjoy high-speed networks while low-income neighbourhoods or peri-urban areas remain underserved. The GDC effectively provides political backing for treating digital access as a public necessity. Additionally, digital inclusion in cities must consider groups like the elderly, migrants, or persons with disabilities, echoing the GDC's human-centred approach. Urban policy makers, guided by the Compact, may implement digital literacy programmes, free device lending, or multilanguage e-services so that all city residents can benefit from smart city services.

The Compact advocates for "open, free, secure" DPGs – these could include open-source software, open data and interoperable platforms. For smart cities, this is highly pertinent. Cities face choices between proprietary "smart city platforms" provided by vendors/technology providers versus open, interoperable systems. DPI in cities act as a key instrument to implement this framework by developing the key interoperable components that would not only enable local city services from interoperating and interworking, but also, allow the interoperability and interworking of

city systems and services with national/federal governmental systems and services (e.g., national federated identity systems).

2.4 Tools and support from the U4SSC and UN agencies

The U4SSC initiative and its network of key partners contribute to the smart sustainable cities' global agenda and dialogue, through converging several viewpoints including infrastructure resilience, environmental stewardship, inclusive governance and innovation. Across UN agencies, there is a clear demand for integrated approaches that leverage data, partnerships and cross-sector synergies to maximize cities' contribution to the 2030 Agenda and the New Urban Agenda.

The overarching insight is that a truly smart sustainable city is defined not merely by its digital infrastructure, but also by its ability to harmonize resilience, equity, environmental health, innovation and inclusive prosperity. Agencies' strategic plans and flagship programmes together create a global architecture where urban governance must be anticipatory (climate-smart), participatory (inclusive and rights-based), productive (innovation-driven) and regenerative (nature-based). Cities must thus develop integrated strategies that cut across infrastructure, digitalization, environment, gender, culture, and economic transformation to meet the multiple and interconnected demands laid out by the UN agencies and global frameworks. In essence, achieving smart sustainability is about systemic transformation rather than sectoral excellence.

3 Implementation challenges: developing inclusive and sustainable DPI policies

Establishing inclusive and sustainable DPI governance is essential for long-term success. Since DPI increasingly serves as a key enabler of inclusive development, efficient public service delivery and economic resilience, governments worldwide face growing challenges in ensuring its effective implementation. Developing sustainable DPI goes beyond technical solutions; it requires navigating complex political, financial, institutional and ethical landscapes. Although there is a broad recognition of DPI's potential as a digital public good, implementation often stalls because of fragmented governance, limited funding, outdated legacy systems and overreliance on proprietary technologies. This chapter identifies and unpacks the key challenges that hinder the inclusive and sustainable deployment of DPI and discusses how cities can ensure all residents benefit from digital services, how governance models can promote SDGs, and which funding and partnership models can support DPI deployment.

3.1 Accessibility and digital inclusion

Despite the transformative promise of DPI, certain communities continue to face challenges that prevent them from fully benefiting from these systems. One significant issue is the digital divide, particularly in terms of access to devices and reliable connectivity. For example, in parts of

sub-Saharan Africa and South Asia, Internet penetration rates are still below the global average and smartphone or data plan costs remain a major barrier for many low-income households. In Malawi, recent figures indicate that approximately 43 per cent of the population owns a mobile phone and around 15 per cent uses the Internet, dropping to about 9 per cent in rural areas compared with roughly 41 per cent in urban centres (Kajoloweka, 2021).

Socio-cultural factors can also play a role in limiting inclusion. In countries like Pakistan, disparities in digital literacy, social norms and safety concerns contribute to a gender gap in accessing online governance services (Pakistan Telecommunication Authority, 2024). Similarly, language and literacy challenges arise when digital platforms are only available in a dominant language or require advanced reading skills.

Persons with disabilities are another segment that often encounters barriers to DPI access. Although international standards like the Web Content Accessibility Guidelines (WCAG) exist, actual implementation remains uneven. Many government websites and apps have yet to fully accommodate users with visual or cognitive impairments (UK Government, 2024).

Accessing digital Identity (ID) systems can also be problematic for individuals who lack official documentation. For instance, some Rohingya refugees and stateless people in Bangladesh have faced difficulties obtaining services tied to national ID schemes owing to the lack of recognized identity documents (Hussain, 2024). In addition, certain indigenous or rural communities in Australia have historically received less representation in national broadband development plans, despite efforts to bridge the connectivity gap (Park, 2024).

3.2 Governance models promoting sustainable development

One of the key challenges in advancing sustainable DPI governance lies in the complexity and fragmentation of institutional roles. Many countries face difficulties in coordinating efforts across multiple agencies, sectors and levels of government. For instance, India's Digital India initiative has made substantial strides but continues to grapple with infrastructure gaps. While demand for digital services grows rapidly, the availability of public Internet hotspots remains far below the estimated levels needed to ensure widespread access (Parsheera, 2019).

Ensuring inclusive and participatory design processes is equally critical. Lessons from various contexts show the importance of engaging diverse stakeholders from the outset. In Kenya, for example, the rollout of the Huduma Namba digital ID system encountered legal and societal pushback, partly due to limited involvement of civil society and marginalized communities during early planning stages (Kennedy, 2025).

A number of countries have introduced foundational DPI elements such as national ID systems, ahead of establishing comprehensive legal and regulatory safeguards. Nigeria illustrates a broader concern seen in multiple regions, namely, the need for strong data protection frameworks to build public trust and prevent misuse (Benjamin, 2025). Robust accountability mechanisms remain essential but are often underdeveloped. Additionally, aligning DPI development with broader sustainability goals is increasingly urgent. Across various national contexts, data centres – central to digital infrastructure – are expanding rapidly, sometimes without integration into national climate strategies, raising concerns about energy consumption and environmental impact (UNEP, 2024).

3.3 Funding models and public-private partnerships

Public-private partnerships (PPPs) have emerged as a strategic funding model to bridge fiscal constraints while leveraging private-sector resources and innovation, critical for DPI. In high-income countries, governments often rely on direct public funding, particularly during initial phases of DPI deployment. By contrast, Low- and Middle-Income Countries (LMICs) intensively deploy blended finance frameworks, combining public financing with private investment, concessional loans and grant support to scale DPI initiatives aligned with UN SDGs (Bandura *et al*., 2024).

Empirical studies reveal a mixed record from PPPs. OECD (2018) reports that PPP investments account for just 0–5 per cent of infrastructure spending in advanced economies and less than 25 per cent in emerging economies, partly due to the complexity and risks inherent in PPP arrangements. A 2016 World Bank survey underscores that preparation and transaction costs, excluding capital, are often significantly higher for PPP contracts versus traditional procurement, with governments and donors commonly bearing much of this burden (Leigland, 2018).

Nevertheless, when structured effectively, PPPs can deliver better value for money. When compared to conventional public procurement, PPPs meet cost and time targets more reliably; this is mainly due to stronger risk allocation to parties best equipped to mitigate them (Tiwari & Dugal, 2024).

PPP proponents highlight their capacity to mobilize technical expertise, align long-term incentives and transfer execution risk from the public sector (Schomaker, 2020).

Case studies provide tangible insights into DPI-focused PPPs. São Paulo's telecentres partnership, supported by civil society and private actors, established 128 community ICT hubs using open-source platforms to promote digital inclusion (Selaimen, n.d.). However, PPP also carries inherent risks. Canadian reviews such as those from Ontario and PPP Canada, report average cost overruns of up to 16 per cent compared to traditional models, with challenges in transparency, accountability and higher borrowing costs. The United Kingdom's National Audit Office had initially cast doubt on the claimed value for money from PPPs, with some Private Finance Initiative (PFI)-funded services later returned to public administration after cost escalations and performance shortfalls (Teo, 2024).

3.4 Legacy systems

Legacy systems, often decades old, highly specialized and deeply embedded in public institutions, pose significant challenges for DPI. These systems are characterized by steep maintenance costs, operational fragility, security vulnerabilities and rigid architectures incompatible with contemporary technologies (Sasidhar, 2025).

Legacy systems impose substantial financial burdens. For instance, a U.S. Government Accountability Office report revealed that ten critical federal systems, some dating back 51 years, consumed approximately USD 337 million annually in maintenance alone (Burney, 2023). Similarly, McKinsey estimates that consolidating data centres or migrating them to the cloud can yield cost reductions of up to 50 per cent, while also improving oversight and operational efficiencies (Das *et al.*, 2019).

Ageing technologies restrict government agencies from delivering timely services or adapting to emerging needs. McKinsey finds that modernization supports more agile, user-centred delivery and enhances productivity via automation and data accessibility (Das *et al.*, 2019). Additionally, legacy systems generate considerable security risk. They frequently rely on obsolete languages, such as Common Business-Oriented Language (COBOL), and unpatched vulnerabilities. U.S. agencies have acknowledged that systems, including those maintained by the Internal Revenue Service (IRS), represent serious cybersecurity threats due to outdated codebases and scarce maintenance expertise from retiring personnel (Burney, 2023; US Government, 2023).

Modernization unlocks qualitative gains in service delivery and citizen experience. Academic studies across European administrations show that modernization efforts yield 15-30 per cent operational cost reductions, 40-60 per cent faster system responsiveness, up to 50 per cent shorter service times and 70 per cent higher user satisfaction (Sasidhar, 2025). By moving away from monolithic systems toward microservices, public agencies also diminish technical debt and create more scalable service architectures (Lenarduzzi *et al.*, 2020).

As such, modernizing legacy systems is a crucial step toward more inclusive, resilient and responsive DPI. Transitioning from ageing, monolithic architectures to agile, cloud-based and microservices-oriented platforms not only eases maintenance burdens and fortifies cybersecurity but also empowers public agencies to adapt swiftly to emerging needs.

3.5 Vendor Lock-in

Vendor lock-in remains a significant obstacle to building sustainable DPI. When public authorities become overly dependent on proprietary platforms, switching to alternative solutions or integrating new systems often entails substantial financial, technical and operational challenges. The dominance of digital private infrastructure and the ongoing trend of platformization further intensify this risk by limiting openness, interoperability and long-term flexibility.

A notable example is Denmark's growing reliance on one key technology provider's products, has sparked national debate over the sustainability of such procurement models. Concerns have been raised about the implications of dominant vendor/technology provider's pricing strategies, limited market competition and the erosion of digital sovereignty (Cleura, 2025). This case highlights how market concentration can drive up public expenditure without delivering proportional improvements in service quality, adaptability, or control. Across the Nordic region, similar concerns have emerged. In Sweden, one-third of public agencies reported that vendor lock-in impeded cost-effective IT operations.

Challenges extended beyond pricing and included complex licensing arrangements, restricted legal usage rights and insufficient exit strategies (Lundell *et al*., 2021). These findings suggest that technical and legal constraints often limit the ability of public institutions to pivot toward more adaptive digital solutions.

Moreover, lock-in is not limited to proprietary systems. A case study on municipal e-service platforms identified instances of "soft lock-in," where even open-source solutions became difficult to replace. This was due to limited technical documentation, exclusive dependencies, procurement constraints and a general organizational preference for maintaining the status quo (Persson & Linåker, 2024). Such cases highlight that overcoming lock-in requires addressing broader institutional capabilities, including skills development, process redesign and cultural change rather than focusing solely on licensing terms.

Addressing vendor lock-in is therefore a crucial part of tackling the broader implementation challenges that affect DPI development. Fragmented systems, inequitable access to funding, outdated technologies and dependence on dominant vendors collectively limit the potential of DPI to promote digital inclusion, economic opportunity and sustainable public governance. Policy responses must be context-specific yet globally informed, grounded in open standards, collaborative governance models and resilient, future-proof design principles.

4 DPI in action: Case studies of successful implementations

To ground the discussion in real-world context, we examine several leading cities (case studies) that have pioneered effective governance and regulatory frameworks for their digital infrastructure, with key sustainability and people-centricity at their core processes. The core analytical viewpoints for cities, outlined in earlier sections, have been used to frame the analysis of the case studies. These case studies – including Singapore, Estonia, Barcelona, Egypt's New Administrative Capital, New York City – highlight diverse approaches shaped by different legal systems and priorities. Each offers insight into how cities can leverage policy and regulation to foster innovation while safeguarding public interest in the digital age.

4.1 Secured, resilient infrastructure and climate adaptation

Building secured and climate-resilient cities relies on DPI, which enables data-driven, integrated solutions for urban resilience and climate adaption strategies. For instance, in Aveiro, a dense network of fibre infrastructure, reconfigurable radio units, 5G-New Radio (NR) radio and 5G network services, Wi-Fi, LoRaWAN, vehicular and passive radars, edge computing units, aggregating and interconnecting sensors embedded in smart lampposts and municipal vehicles; monitors environmental and traffic conditions securely in real time (Rito *et al*., 2023). These infrastructure components record mobility and environmental data, making a complete live map of these parameters in the city, and providing the required data for traffic monitoring and safe driving systems. The system uses open-source data platform as one DPI component (e.g., Helix, a microservice platform based on FIWARE) that is integrated seamlessly with sensory nodes to achieve resilient and climate adaptation objectives. Furthermore, the project enables third-party access to the infrastructure, allowing for extending functionality, innovation and higher users' engagement (i.e. the engagement element of the DPI definition – see DPI definition above). This is an example of how DPI for cities can support adaptive urban management to improve mobility, safety and city resources allocation.

Another example is Copenhagen's Cloudburst Management System that combines hydrological models with real-time sensor data from streets and drainage networks to predict flooding, guide green infrastructure investments and issue early warnings in case of flooding events (Brears, 2023; Ziersen *et al*., 2017). This case shows how DPI for cities (e.g., Cloudburst Management System) uses Geographic Information Systems (GIS) based modelling for water catchment modelling and flood scenario planning (one form of an AI-enabled, scenario-based planning) as a foundation for planning and prediction, whereby data are exchanged and stored using GIS-based technologies. Hydrological models are considered a foundational model that is re-used across several water catchment modelling applications (e.g., streams classification, catchment area capacity calculation, flow directions estimation) enables cities to become agile and climate-adaptive, pre-empting risks and optimizing deployed infrastructure through continuous data feedback.

Egypt's Command and Control Centre (CCC) in Egypt's New Administrative Capital fuses a wide range of IoT sensors, systems and processes to ensure safety and security and to provide emergency response. It plays a significant role in detecting accidents and unusual activities, by integrating city-wide video broadcasting with advanced analytics, AI and scenario planning capabilities. This allows improved incident response and enables unified dispatching for relevant agencies in real-time, in cases of crises or emergencies (Egypt New Administrative Capital, n.d.).

4.2 Urban environmental sustainability and biodiversity

DPI for cities could drive urban environmental sustainability and biodiversity by integrating data systems, smart technologies and nature-based solutions to enable evidence-based decision-making and ecological resilience. An example to demonstrate the use of digital identity to provide significant value in sustainability and biodiversity use cases like biodiversity monitoring, enabling

nature-positive climate finance and value chain traceability, is the use of Nature ID, which links diverse environmental datasets (including remote sensing and Indigenous knowledge) to verify ecosystem services and facilitate conservation financing in initiatives like Brazil's Cadastro Ambiental Rural (CAR).

This data exchange system synthesizes and authenticates environmental, administrative and financial datasets. By linking diverse sources, including remote sensing data and indigenous knowledge, Nature ID aims to improve the visibility of complex DPI ecosystems (e.g., sharing multidimensional data) and helps quantify their environmental value in decision-making. It empowers countries and local communities to pursue environmental justice and access green finance, strengthens traceability in agro-industrial value chains, and protects the rights of farmers and indigenous people. In addition, it has the potential of supporting the verification of ecosystem services and facilitates conservation financing, as seen in initiatives like Brazil's CAR (UNDP, 2025).

Another example is the Urban Oasis, which integrates modular green infrastructure with IoT sensors for real-time climate adaptation. It demonstrates how DPI elements such as sensors, data connectivity and data systems can be embedded directly into urban infrastructure and public furniture to support smart sustainable cities. By equipping smart urban furniture with DPI components (e.g., real time data exchange of environmental sensors and embedded motion detectors), Urban Oasis enables the continuous collection of valuable environmental and climate data, enhancing urban sustainability, resilience, and informed decision-making in connected cities (Sádaba *et al.*, 2025). Additionally, green infrastructure mapping, which quantifies biodiversity value through geospatial analysis to guide urban planning (Vander Meer, 2022); and Germany's smart grids demonstrate the application of DPI functions within ICT-based energy systems by enabling real-data exchange and system updates. These capabilities support AI-driven demand management, optimize energy flows and contribute to emission reductions (Dena & GIZ, 2022). This illustrates how DPI for cities

establishes interoperability and data exchange frameworks for environmental data governance while embedding ecological intelligence into physical infrastructure via sensor networks.

4.3 Urban economic transformation and industrial innovation

DPI acts as a transformative catalyst for urban economic development and industrial innovation across diverse contexts, as illustrated by four paradigmatic cases. In Brazil, Porto Digital has revitalized Recife's economy through a tripartite partnership among government, academia and the private sector. It has established a thriving tech hub that hosts more than 350 companies and has created more than 17 000 high-value jobs, while promoting walkable urban design and a knowledge-based economy (Mari, 2023).

In Rwanda, the Irembo platform demonstrates how DPI can significantly enhance governance efficiency and financial inclusion. Offering more than 100 public services, via a Web/ Unstructured Supplementary Service Data (USSD) interface, it has reduced service access time by 80 per cent, while a network of 4 000+ agents ensure accessibility for digitally excluded populations. This platform provides many DPI functions like a digital payment component (e.g., Irembopay) and a digital marketplace (e.g., IremboPlus).[2]

Thailand's *Traffy Fondue* highlights DPI's potential to improve urban management through AI-driven civic engagement. Designed to address a broad spectrum of civic issues, the digital platform uses AI to categorize and route complaints efficiently to the appropriate government agencies. To date, it has handled more than 1.37 million infrastructure-related reports with a 77 per cent resolution rate, intelligently routing citizen complaints to the appropriate authorities and enhancing transparency and responsiveness (Hansen & Dahiya, 2025).

Finally, Brazil's Pix instant payment system represents a leap in financial infrastructure. It enables real-time transfers between bank accounts, within seconds, at any time of day, while maintaining high standards of speed, security and accessibility. By making quick response (QR) code-based wallets interoperable, Pix simplifies digital transactions across platforms and promotes widespread financial inclusion (Pix, n.d.). This example highlights DPI's capacity to support real-time, low-cost digital payments at scale.

Together, these cases demonstrate DPI's role in driving innovation, streamlining governance, enhancing civic engagement and building inclusive financial systems.

4.4 Gender equality, social inclusion and human rights in urbanization

DPI has also shown its capacities in advancing gender equality, social inclusion and human rights in urbanization by creating inclusive digital ecosystems that empower marginalized groups through participatory governance and accessible identification systems. This impact is evident in Barcelona's

[2] https://irembo8.wpcomstaging.com/

Decidim, an open-source platform built on Free and Open-Source Software (FOSS) and is guided by transparent, inclusive and ethical principles. Decidim enhances citizen engagement in policymaking and participatory budgeting by providing a flexible, modular system that can be tailored to various governance scales (Cardullo *et al.*, 2023). Nigeria's digital ID system provides the foundational identification layer, maintaining a central identity database such that authorized entities can securely access their specific functional needs. The system has enrolled more than 48 million women (2024), so playing a critical role in narrowing gender gaps in access to public services and financial inclusion (Women's World Banking, 2025).

Nairobi's Braiding App, is another example linking informal women workers to digital markets to counteract post-pandemic exclusion (Women's World Bank, 2025; World Bank, 2020); while Indonesia's digital ID: Identitas Kependudukan Digital (IKD), integrates 13 million users with health care, education and financial services while upholding data protection laws.[3]

These initiatives illustrate how DPI democratizes urban governance through transparent participation, dismantles systemic barriers for women and vulnerable groups with secure identity solutions, opens economic pathways for informal workers via purpose-built platforms, and safeguards rights through inclusive design and legal frameworks.

4.5 Smart digital governance and data-driven urban management

By unifying real-time information from across city operations, DPI enables more responsive and sustainable management. Lisbon and Bristol's Cloud City Operation Centre (COC) demonstrates this potential, combining transportation, energy and public safety data into a single dashboard for coordinated emergency response and operational efficiency.[4]

Amsterdam's Smart City initiative goes further, by using IoT sensors and open data to dynamically optimize traffic flows and energy use. The system's adaptive traffic signals reduce congestion while lowering emissions (Smith, 2022).

[3] https://govinsider.asia/intl-en/article/indonesias-new-digital-id-aims-to-make-it-easier-for-citizens-to-access-public-services

[4] https://www.nec.com/en/global/techrep/journal/g18/n01/180105.html

Egypt's New Administrative Capital smart digital governance processes and platforms collect and integrate all operational tasks related to facilities and public services in the city in its COC. This is achieved through companies specialized in the execution, operation and management of each facility or public service, and by interacting directly with residents at the individual and institutional levels, while applying the principle of complete separation between the service provider and the recipient. The collaborative environment for providing shared services requires the provision of each specific public service or facility by a specialized company through an efficient management platform that ensures the efficient delivery of services while simultaneously achieving cost reduction in operations (Egypt New Administrative Capital, n.d.).

Beyond this, Sydney's Digital Twin represents the next frontier, merging DPI components (e.g., urban data exchange with predictive modelling capabilities) with urban governance. This digital replica helps planners simulate climate impacts and design flood-resilient infrastructure before risks materialize (Sohail *et al*., 2025).

These cases illustrate the evolving role of DPI in integrating foundational data with predictive governance, enabling cities to function more effectively today while better preparing for the challenges of tomorrow.

4.6 Sustainable urban mobility, tourism and cultural preservation

In sustainable urban mobility, DPI enables real-time, multimodal coordination, as demonstrated by Amsterdam's smart city initiatives. Through a real-time data exchange system, the city's IoT-

enabled bike-sharing programmes (e.g., OV-fiets) and the Gemeente Vervoerbedrijf (GVB) transit app integrate cycling with public transport, reducing congestion and emissions while empowering users with seamless, car-free travel, directly supporting SDG 11 (Vujko *et al*., 2025).

DPI fosters the sustainable planning and management of tourism and enhances accessibility. Turkey's deployment of Virtual Reality (VR)/ Augmented Reality (AR) for heritage marketing illustrates this: digital platforms democratize access to cultural sites, curating immersive experiences that divert physical foot traffic, alleviate environmental strain and preserve fragile heritage (Karaman & Deniz, 2025). This virtual layer also enriches cultural preservation, transforming static monuments into dynamically engaging educational resources.

As such, DPI's synergistic capacity to optimize resource use, decentralize visitor flows and safeguard cultural assets prove that technology, when woven into public infrastructure, becomes a catalyst for ecological resilience and inclusive socio-cultural vitality.

4.7 Sustainable urban food systems and rural-urban linkages

DPI seamlessly connects rural producers with urban markets while advancing sustainability, enhancing hence rural-urban linkages and contributing to economic flows (e.g., agricultural produce, services, labour and capital), enhanced mobility, sustainable food security and agriculture.

Urban markets depend on rural producers for food and raw material in many cases, while rural farmers reply on urban demand and access to logistics and processing hubs. Open data ecosystems exemplified by Telangana's Agriculture Data Exchange (ADEx), an open-source interoperable platform, enables discoverability and accessibility of important datasets (e.g., agriculture produce) through appropriate consent management mechanisms. It dismantles information asymmetries, empowering farmers with insights to optimize yields and reduce waste (Goel, 2023).

Similarly, Estonia's integrated registries and X-Road Application Programming Interfaces (APIs) unify land, ownership and soil data, enabling precision agriculture tools (e.g., eAgronom) that automate compliance and enhance productivity, freeing farmers from administrative burdens while ensuring resource-efficient practices (Kärner, 2017). Such data liquidity strengthens rural-urban supply chains by synchronizing production with urban demand.

Additionally, protocol-based networks like Open Belém's Beckn-driven platform create open and ethical digital marketplaces. It positions Bélem as a digital hub through open digital networks with sustainability, to establish a city-wide multisector open network across diverse sectors such as education, employment, mobility, healthcare, commerce, energy and others. Belém's Open Network enable access to learning, employability and livelihood opportunities for all, thereby linking Amazonian bioeconomy producers directly to global consumers and incentivizing sustainable livelihoods (Bélem, n.d.; Mukherjee *et al*., 2023). Beckn is an open protocol that enables location-aware local commerce across industries. The protocol is a set of recommendations and rules that outline specific technical standards that be adopted for an industry, in a region or a market among its participants to enable open interoperable connections between them. Beckn acts as a transaction protocol that allows discovery, ordering, fulfilment and payment between buyers and sellers (consumers and providers in the digital marketplace).

4.8 Multilateral cooperation and regional urban strategies

By harmonizing standards, pooling resources and synchronizing governance across borders, DPI functions as a catalytic framework for multilateral cooperation, ultimately advancing integrated regional urban strategies.

For example, Kazakhstan's public-private model exemplifies this domestically: its Digital Kazakhstan Programme fused government digital ID with private fintech APIs, digitizing 89 per cent of transactions (2014-2024) and transforming cities into interconnected economic hubs. This national success catalyses regional integration, as standardized payment and identity systems (e.g., eGov) reduces friction in cross-border commerce (Suominen, 2024). Further reinforcing this, Brazil's unified registries, CadÚnico (social welfare), CAR (environmental land use) and Gov.br (digital ID), demonstrate how interoperable DPI (i.e. in this case, national registries) enables vertical cooperation. By linking federal, municipal and community data, these systems align urban planning with rural sustainability goals (e.g., regulating Amazon deforestation) while ensuring equitable service delivery (UNDP, 2023; ILO, 2022).

At the regional level, the SOURCE platform, a secure cloud-based platform that provides governments and public agencies with a standardized infrastructure project governance framework, including access to global benchmarks, and a collaborative environment for coordination across government agencies and financing institutions. SOURCE exemplifies institutional multilateralism, developed by multilateral development banks, it standardizes infrastructure project design across nations, allowing governments to co-develop urban transit, energy, or water systems using shared digital templates (ADB, 2023). This accelerates SDG-aligned investments while mitigating risks through pooled expertise.

Collectively, these DPIs transform fragmented governance into networked action, where open APIs, federated data and digital trust mechanisms synchronize policy implementation across geographies, proving that interoperable infrastructure is indispensable for resilient, regionally coherent urban futures.

5 Strategic benefits of DPI for urban governance

5.1 Service access and equity

Expanding access to essential services

DPI has demonstrated significant potential in promoting social equity, accessibility and digital inclusion in urban settings (OECD, 2024). By enabling access to essential services such as identity verification, healthcare registration, financial inclusion, social protection and utility management, DPI helps bridge the digital divide and support inclusive economic growth. As cities become increasingly digitized, equitable access to these digital services is vital to ensuring no resident, regardless of income, age or social status, is left behind (ITU, 2025). However, the transformative potential of DPI depends on scalable design, inclusive governance and sustainable investment in underserved communities.

National identity platforms in countries like the Philippines and Morocco have expanded access to financial and welfare services for millions of people previously excluded from formal systems (World Bank, 2024; Philippine Statistics Authority, 2023). Similarly, Pakistan's digital payment system has connected unbanked women in rural areas to the financial ecosystem, thereby promoting gender equity and reducing poverty (Kemal, 2018; Data2X, 2019). Egypt's use of digital payment systems and e-wallets to administer cash-based social aid programmes, including large scale social protection programmes (e.g., the "Takaful and Karama Programme", the Arabic interpretation of "Social Solidarity and Dignity"), has had a significant impact on its economy. Entitled beneficiaries benefitted immensely as they tended to rely on case aid programmes; however, they often lacked access to formal financial sector services (Central Bank of Egypt, 2023; Egypt, 2025). These examples highlight how DPI can foster social inclusion by building accessible and interoperable systems that target historically marginalized populations.

Country	DPI Initiative	People reached / Impact	Source
Philippines	PhilSys National ID	80+ million registered; integrated with government cash transfers	Philippine Statistics Authority
Kenya	M-Pesa (Mobile Payments)	Achieving an 85% Internet penetration rate by 2023	Chisika and Yeom, 2025
Morocco	National Digital ID	Millions gained access to welfare and financial services	World Bank, 2024
Egypt	InstaPay (Instant Payment Network)	National network linking all operating banks within Egypt, 90+ million financial and non-financial transaction within Q1 of 2024	Egyptian Central Bank, 2023

Empowering communities through participatory and open infrastructure

Beyond access, DPI can act as a catalyst for citizen empowerment through participatory technology design and community-driven innovation. A compelling example is the Community-Empowered Air Quality Monitoring System, where residents of a pollution-affected area collaborated with developers to create a monitoring platform combining animated smoke visuals, air quality metrics, wind data and smell reports. Although these residents had limited technical expertise, their co-creation of a robust monitoring system provided scientific evidence to challenge regulatory decisions, helping to rebalance power dynamics and enable policy advocacy (Hsu *et al*., 2017). This case illustrates the potential of DPI to foster digital citizenship and empower local actors in governance processes.

Advancing digital inclusion through community and urban strategies

Cities across the globe are advancing digital inclusion by adopting community-centred DPI strategies. In Detroit, a bottom-up digital equity strategy is being implemented through stakeholder engagement and community partnerships aimed at expanding broadband, digital skills training and affordable device access (Wiley *et al*., 2020). Baltimore City's Digital Inclusion Strategy similarly outlines a roadmap for addressing systemic barriers through investments in infrastructure, education and public Wi-Fi access (City of Baltimore, 2023). On a national scale, municipal broadband projects – such as the initiative New York – demonstrate how targeted public investment in digital infrastructure can close access gaps and ensure digital equity (Connect ALL Office, 2024).

Kenya's Tatu City integrates DPI principles into urban development, providing affordable housing alongside digital services for low-income populations (Blomfield, 2025). These global initiatives reinforce the idea that DPI, when embedded within broader governance and planning strategies, can serve as a powerful tool to dismantle digital inequities and promote inclusive development.

5.2 Efficient and responsive governance

Traditional city administrations often struggle with fragmented information systems, siloed departments and manual processes that create bottlenecks in public service delivery. DPI

addresses these limitations by providing an integrated foundation that streamlines operations across government functions. Through the unification of digital identity systems, interoperable data exchanges and e-payment platforms, DPI enables cities to reduce bureaucratic redundancies, automate administrative tasks and deliver services more efficiently and reliably (OECD, 2024).

The benefits of DPI-driven efficiency are increasingly evident across diverse city contexts. For example, the implementation of the Philippine Identification System (PhilSys) has rapidly transformed how services are accessed and coordinated. With more than 91 million citizens enrolled by late 2024, PhilSys has become the backbone for integrated service delivery across financial aid, health care and local governance systems. This large-scale enrolment has enabled cross-agency data verification and significantly shortened service processing times (Philippine Statistics Authority, 2023).

A comparable transformation is taking place in Rwanda through the Irembo platform, which digitizes more than 50 per cent of government services and centralizes access through a single online portal. From civil registration to insurance renewals and land applications, services that once required time-consuming visits to multiple offices are now completed online, leading to a 42 per cent increase in processed applications between 2022 and 2023 (Umutoni, 2024).

Furthermore, Digital Egypt, a forward-looking people-centred digital transformation strategy that reinvents how government, businesses and citizens interact with technology, unlocking unprecedented opportunities for progress. At its core, Digital Egypt is about integration – bringing together infrastructure, policy and innovation to forge a cohesive, intelligent ecosystem. It turned complex bureaucratic processes into intuitive digital experiences, transforming raw data into actionable insights and ensured that no citizen, regardless of geography or background, is left behind in this rapid evolution (Egypt, 2024).

What PhilSys, Digital Egypt and Irembo reveal is how DPI facilitates not just faster transactions but also more reliable service tracking, transparency and data-driven management within government.

Local-level impacts and citizen perceptions

This pattern of reform extends into local contexts such as Makassar City, Indonesia, where digitalization has had a direct and measurable impact on citizen experience. Here, the shift to digital-based public services led to a 40 per cent reduction in processing times for documents like business licenses and civil records. Crucially, 75 per cent of surveyed residents reported improvements in government responsiveness – a testament to how DPI not only optimizes operations internally but is also perceived positively by the public (Mannayong, 2024).

Moreover, DPI enables real-time data flows that strengthen urban infrastructure and governance resilience (Digital Cooperation Organization, 2024; UNDP, 2023). The Golden Mile Project in Vijayawada, India exemplifies this, transforming a 2.9 km corridor into a digitally integrated urban zone. Features such as smart lighting, Wi-Fi, traffic systems and public surveillance are coordinated through a City Digital Platform, allowing for rapid, evidence-based responses to emergencies

and daily operations alike (GW, 2017). This integration shows how DPI can be embedded into the physical fabric of cities to enable smarter, safer and more sustainable urban environments.

Similarly, Estonia's renowned e-governance ecosystem illustrates this point most vividly. Anchored by a secure digital identity and an interoperable data exchange layer (X-Road), Estonia has made 100 per cent of public services available online, while connecting more than 52 000 organizations and supporting more than 2.2 billion transactions annually (e-Estonia, n.d.). Services that used to take days now occur in minutes, saving the state an estimated 2 per cent of Gross Domestic Product (GDP) per year in administrative costs (e-Estonia, 2025; European Commission, 2018).

5.3 Resilience, transparency and trust

In an era marked by increasingly frequent climate events, health crises and cyberthreats, cities must build governance systems that are not only efficient, but also resilient, transparent and trustworthy. DPI plays a pivotal role in strengthening these capacities, ensuring that governments can withstand disruptions, engage citizens openly and foster long-term legitimacy.

Building urban resilience through DPI

The resilience of urban systems hinges on their ability to continue functioning during emergencies. DPI provides a critical foundation for this by enabling uninterrupted communication, secured digital data delivery, rapid service delivery and informed decision-making during crises. In Nairobi, for example, informal settlements, highly vulnerable to natural hazards, have benefited from digitally enabled community planning through the Kenya Informal Settlement Improvement Project (KISIP II). This initiative leverages the Global Facility for Disaster Reduction and Recovery (GFDRR)'s Digital Public Works Model, an innovative approach to urban data collection, generation and validation that aligns closely with the functions of DPI. Since 2022, more than 300 young people have been trained to map infrastructure and collect urban data, helping local authorities' direct resources to the most at-risk areas. This localized, data-driven approach (although not highly sophisticated in terms of digitization) has improved planning and reinforced urban resilience by aligning investments with real needs (World Bank, 2023).

Similarly, countries and cities such as Singapore and Bengaluru are using digital powered flood alert systems to manage urban flooding risks. In Bengaluru, the Megha Sandesha mobile app offers real-time rainfall forecasts and flood warnings using more than 100 rain gauges and sensors, while Singapore's system integrates IoT-based sensors and closed-circuit television (CCTV) networks to monitor water levels. These systems enable real-time alerts and automated responses, reducing the impact of climate-related disasters and protecting infrastructure and residents (Banerjee *et al.*, 2022).

Resilience also includes public health readiness. In Rio de Janeiro, a predictive model for dengue fever – powered by integrated climate and health data – has allowed the city to anticipate outbreaks and allocate resources proactively. This kind of early-warning system reduces the burden on health

infrastructure and strengthens community preparedness in the face of climate-induced health threats (Booth & Lautarup, 2024). In addition, maintaining communication during emergencies is vital. Smart infrastructure such as digitally enabled streetlights or mobile citizen apps can be adapted into mesh networks or public Wi-Fi hotspots when conventional systems fail. These networks support the continuity of services, facilitate emergency coordination and enable timely evacuations – crucial aspects of resilience (Baumgärtner *et al.*, 2019). DPI thus provides cities with flexible, robust systems that adapt in real time to emerging threats.

Fostering transparency and public trust

While resilience secures continuity, transparency and trust ensure legitimacy. DPI opens new channels for citizen engagement by enabling transparent, inclusive and participatory governance. Traditional mechanisms – like in-person consultations or paper-based feedback – often limit public involvement. In contrast, digital platforms powered by DPI allow real-time consultations, crowd-sourced policymaking and performance monitoring.

In Hong Kong, research shows that when citizens are actively engaged in digital governance platforms, their trust in public institutions and satisfaction with services increase (Hartley, 2023). Similarly, Estonia's secure digital identity and data systems allow residents to interact directly with government agencies, track decisions and access public records – enhancing accountability and administrative responsiveness (European Union, 2023). Cities across Europe are institutionalizing participatory budgeting through open-source tools such as Decidim. In Zurich and Lucerne, residents have submitted proposals, voted on priorities and influenced how public funds are allocated. In Zurich's Wipkingen district, for example, eight citizen-driven initiatives were selected for funding out of nearly 100 proposals. These experiences show how DPI enables co-governance, making government more responsive to the needs and ideas of its residents (Barandiaran *et al.*, 2024; Suter *et al.*, 2024).

Together, these cases illustrate that DPI is not only a vehicle for delivering services, but also a tool for building cities that are adaptive in crises, transparent in decision-making and trusted by their citizens. By enabling real-time information sharing, participatory platforms and inclusive access to services, DPI reinforces the social contract between governments and communities. In doing so, it transforms urban governance into a more resilient, accountable and citizen-driven system, one capable of withstanding tomorrow's risks while deepening public trust today.

5.4 Digital innovation and sustainable economic empowerment

Economic competitiveness increasingly depends on how well cities and countries leverage DPI to foster innovation, lower barriers to entrepreneurship and enable inclusive growth. DPI acts as a foundational layer – connecting people, businesses and governments in real time – while reducing transaction costs and creating a trusted environment for data and financial flows. As UNDP (2023) notes, DPI is a key catalyst for sustainable digital transformation and a driver of equitable economic development.

Unlocking growth through foundational infrastructure

A robust DPI framework facilitates innovation ecosystems by providing open, interoperable platforms that public and private actors can build upon. India's Aadhaar system exemplifies this transformation (UNDP, 2023; Aadhaar Annual report, 2024). Launched in 2014, Aadhaar has provided more than one billion people with biometric-linked digital identities, streamlining access to public services and eliminating systemic inefficiencies.

The Indian government estimates that it has saved approximately 41 billion US dollars by preventing fraud in welfare schemes. Beyond efficiency, Aadhaar underpins India's fast-growing digital payment system – particularly the Unified Payments Interface (UPI), which processed 8 billion transactions in a single month in 2023 (Aadil, 2025). These layers of interoperable infrastructure have stimulated an explosion of fintech innovation and broadened access to formal financial systems (International Monetary Fund, 2024).

Fostering inclusive innovation and entrepreneurship

DPI also plays a critical role in democratizing entrepreneurship, particularly in underserved and rural communities. In Kenya, the success of M-Pesa – a mobile money platform built on basic DPI infrastructure – has been transformative. M-Pesa enabled millions of unbanked individuals to access financial services and transact digitally, contributing to a 20 per cent rise in mobile money transactions during the COVID-19 pandemic. As a result, Kenya's economy rebounded by 7.5 per cent in 2021, highlighting how inclusive digital infrastructure can serve as a powerful economic stabilizer during crises (Ndung'u, 2021; Islam *et al*., 2025).

This pattern of DPI driving inclusive growth and economic resilience is further exemplified by India's large-scale DPI initiatives. India's DPI initiatives, including Aadhaar, UPI and FASTag, generated an estimated 31.8 billion US dollars in economic value in 2022, contributing approximately 0.9 per cent to the nation's GDP. Projections indicate that by 2030, DPI could contribute between 2.9 per cent and 4.2 per cent to India's GDP, potentially aiding the country in achieving an 8 trillion US dollars economy (IBEF, 2024).

Driving sustainable and green innovation

Beyond economic growth, DPI also supports environmental sustainability by enabling smarter resource allocation and enhancing green innovation. Research on China's Yangtze River Economic Belt found that regions with advanced digital infrastructure experienced more significant green innovation outcomes. Improved connectivity not only accelerated market coordination but also raised environmental awareness and stimulated investment in sustainable technologies (Zhou *et al*., 2024). This suggests that DPI can serve dual roles – spurring economic development while reinforcing climate resilience.

Bridging the digital divide for local economic development

In developed contexts, DPI is increasingly used to close access gaps that inhibit inclusive growth. In New York State, where more than 20 per cent of residents lack home Internet access, municipal broadband initiatives have emerged as a solution to affordability and coverage challenges. These programmes view broadband as a public good and have spurred local economic development by attracting small businesses, improving educational access and increasing digital literacy. The Municipal Infrastructure Program is now a cornerstone of New York's broader competitiveness strategy (Tifft, 2025).

Moreover, cities that invest in DPI become more attractive to investors and innovators. As the World Economic Forum (2023) notes, digital infrastructure is now a key determinant of a city's global competitiveness. DPI attracts research, development and talent, further accelerating economic dynamism and positioning cities as hubs for innovation in the global economy.

DPI is not just a facilitator of digital transactions, it is a strategic enabler of inclusive, sustainable and innovation-led economic development. Whether in Nairobi or New York, Bangalore or Dhaka, DPI creates the conditions for entrepreneurship supports financial inclusion and accelerates local and national growth. Cities and nations that prioritize robust, interoperable DPI systems lay the groundwork for long-term prosperity in the digital age.

6 Enabling policies and institutional foundations

International legal norms and policy imperatives shape how cities deploy and regulate their DPIs. For example, the European Union's General Data Protection Regulation (GDPR) has set a global benchmark for data privacy, requiring consent, data minimization and "privacy by design (PbD) and default" in all digital services – principles that city platforms handling personal data must follow.

Similarly, the United Nations' Urban Agenda and the U4SSC initiative provide guidelines linking smart city projects to sustainable development and good and effective governance. International standards development organizations like ITU have developed standards (called ITU-T Recommendations) and frameworks for smart city Key Performance Indicators (KPIs) and ICT interoperability, encouraging cities to align with best practices.

Cities are also increasingly joining networks (e.g., the Open and Agile Smart Cities, OASC)[5] to commit to shared principles on privacy, security, transparency and interoperability. To govern DPI effectively in cities, it is crucial to establish a strong policy and institutional foundations based on international legal frameworks and universal governance principles.

[5] https://oascities.org/

This section discusses enabling policies and institutional foundations necessary for the successful implementation of DPI at city level, offering guidance for policy makers and relevant practitioners, and addressing the interplay between national and municipal regulations in the digital domain, and the necessary links between cities and national/federal policies to ensure maximum synergies, ensure coherence and avoid duplication of efforts.

6.1 Whole-of-government approach

To ensure coherence, efficiency and long-term sustainability of DPI, a Whole-of-Government approach (WGA) is essential. This approach promotes coordinated policy design, implementation and oversight across all levels and sectors of government, moving beyond fragmented or siloed efforts (Christensen & Lægreid, 2007; Aoki *et al*., 2024). Rather than managing DPI as a standalone project, it must be embedded into broader governance strategies, aligned with national digital transformation agendas, local service delivery mandates and overarching policy goals such as climate resilience, health, education and inclusive economic growth.

Policymakers should establish institutional coordination mechanisms such as inter-ministerial digital task forces, cross-sectoral digital governance boards and digital leadership units. These structures should include representatives from national, regional and municipal levels to ensure alignment across jurisdictions. Such mechanisms are critical for harmonizing digital standards, avoiding duplication and enabling interoperable data systems and services that reinforce one another (UNDP, 2023).

A whole-of-government model also enables shared investments in foundational infrastructure such as cloud services, digital identity systems and open data repositories, lowering costs, reducing redundancies and enhancing scalability (World Bank, 2025). Most importantly, it fosters cross-sectoral digital capacity, shared accountability and alignment between technical innovation and public value delivery – ensuring that DPI serves as a resilient and inclusive enabler of sustainable development.

6.2 Governance models for sustainable DPI

As cities rapidly adopt digital technologies to modernize governance and public services, DPI has become a vital enabler of inclusive, efficient and trusted service delivery (OECD, 2024). Yet the mere existence of digital tools is not enough. Without effective governance, DPI risks becoming fragmented, under-utilized, or even harmful, hence potentially undermining public trust and long-term sustainability (Eaves *et al*., 2025). For policymakers, this subsection serves as a guide to understanding and designing sustainable DPI governance models, ones that are institutionally embedded, legally robust, transparent and aligned with the long-term interests of citizens.

Institutionalizing DPI governance

Many DPI initiatives start as pilot projects or sector-specific programmes. While these can foster short-term innovation, they often remain isolated, lack interoperability and are susceptible to disruptions due to political changes. To achieve lasting impact and scale, DPI must be institutionalized, i.e., fully integrated into the government's core administrative functions, policy frameworks and budget processes.

Key implementation considerations include:

1. Establishing Dedicated DPI Bodies
2. Integrating DPI Across Government Levels
3. Securing Sustainable Funding
4. Policy Safeguards

Governance models and international examples

There is no one-size-fits-all model for DPI governance. The structure depends on each country's administrative capacity, legal framework, political system and development priorities. They facilitate collaboration and create a shared vision for design, management and promotion of DPI (OECD, 2024, p20). Effective DPI governance should balance central oversight with local adaptability, ensure technological interoperability and enable collaborative delivery of services (World Bank, 2025).

Policymakers can consider the following governance models:

Model type	Description
Centralized national platforms	A single national body oversees and operates DPI systems to ensure standardization.
City-led or decentralized models	Local governments manage DPI to tailor services to urban needs, within a national framework.
Federated or networked models	Multiple jurisdictions share governance and standards, allowing flexibility and interoperability.
Public-private partnerships (PPPs)	DPI is co-developed or operated by private partners under clear regulatory oversight.

Enabling mechanisms and tools

Even the best-designed governance models will falter without the necessary operational tools and institutional mechanisms to support decision-making, risk management and performance monitoring. Policymakers must invest in the core infrastructure of governance such as legal frameworks, technical standards, accountability systems and capacity building. These enabling mechanisms are crucial to turning policy into effective action, so ensuring that governance models remain practical, resilient and adaptable over time.

Key implementation tools for policymakers to consider include:

Mechanism	Function
Legal and regulatory instruments	Laws that define data rights, accountability structures and standards.
Oversight and audit bodies	Independent agencies or ombudspersons to review DPI decisions and address grievances.
Capacity building	Training programmes and institutional support for civil servants managing DPI.
Stakeholder participation platforms	Regular dialogue with citizens, civil society and the private sector.
Monitoring and evaluation systems	Ongoing assessment of DPI performance, inclusion and service outcomes.

6.3 Legal and regulatory frameworks

As governments invest in DPI to enable digital identity, payment systems, data exchanges and service delivery platforms, the legal and regulatory foundations that govern these systems become critical. Legal frameworks do not merely enable DPI, they define its boundaries, safeguard fundamental rights and determine whether these infrastructures can be trusted, scaled and sustained across public and private domains. Without sound regulation, DPI risks violating data privacy, enabling exclusion, stifling innovation, or entrenching monopolies (World Bank, 2025, p.22). This section helps policymakers understand how to craft legal and regulatory environments that ensure DPI is trusted, inclusive and accountable.

Foundation laws for DPI: What needs to be regulated

DPI typically comprises core systems such as digital ID, digital payments, data exchanges and interoperability layers. Each of these components operates at the intersection of multiple domains, technology, civil rights, commerce and public administration, and thus requires legal clarity. Data serves as a central role of DPI. In this case, core data protection must ensure lawfulness, fairness and transparency in data processing (World Bank, 2025, p.23).

Key legal domains relevant to DPI include:

1. Data Protection and Privacy.
2. Digital Identity Laws.
3. Cybersecurity and Resilience Regulations.
4. Public Procurement and Standards.
5. Digital Inclusion Mandates.
6. Responsible Use of DPI Resources and Cost Recovery Policies.

Harmonizing laws across levels of government

In many countries, digital governance operates across multiple layers of government, national, regional and municipal. However, when laws at these different levels are misaligned, this can lead to regulatory gaps, overlaps, or contradictions that undermine the effective implementation of DPI. To address this, national legislation should provide overarching principles and frameworks, while granting sufficient flexibility for local adaptation and innovation. One practical mechanism for this

is the use of regulatory sandboxes, controlled environments where cities or regions can pilot DPI innovations under relaxed regulatory conditions before broader deployment.

Additionally, multilevel data governance frameworks are essential to clarify the respective roles and responsibilities of federal and municipal actors in areas such as data collection, stewardship and interoperability. This is particularly important in smart city contexts, where local authorities play a key role in the delivery and management of digital services that depend on data sharing across jurisdictions.

DPI Regulation through standards and industry/community led instruments

While formal legislation remains a cornerstone of DPI governance, many governments increasingly complement it with soft regulatory instruments such as guidelines, voluntary codes of conduct and technical recommendations, and the adoption of international standards. These non-binding tools allow policy makers to respond more quickly to technological change, offering flexibility without the delays of legislative reform.

Key considerations for policymakers include aligning national DPI initiatives with internationally recognized standards – such as those developed by ITU, ISO and the World Wide Web Consortium (W3C) – to ensure consistency in areas such as data governance, cybersecurity and interoperability. In parallel, regulatory bodies should be empowered to develop sector-specific guidelines that can adapt over time to evolving technological trends and market needs. Additionally, encouraging the adoption of open standards and DPGs not only strengthens interoperability across systems but also helps avoid vendor lock-in, lowers long-term costs and enhances the resilience and inclusiveness of digital infrastructure.

6.4 Stakeholders' engagement and public trust

For DPI to be truly effective and sustainable it must be more than a technological system, it must be trusted by the public and co-owned by society. Trust is not automatic; it is built through continuous, inclusive engagement with a broad ecosystem of stakeholders, including citizens, civil society, industry, academia and government institutions. Transparent participatory processes ensure that DPI responds to real needs, protects fundamental rights and delivers tangible public value (Ehwi, 2019; Eaves & Rao, 2025). This section guides policymakers on how to design stakeholder engagement processes that foster legitimacy, accountability and trustworthiness in DPI ecosystems.

DPI is not only a government initiative, it is also a shared societal asset. Stakeholder collaboration influences DPI design, use and governance, ensuring innovation, scalability, security and accessibility (OECD, 2024, p.21). Policymakers must identify and engage all relevant actors early in the DPI lifecycle in order to avoid blind spots, capture diverse needs and ensure alignment across sectors. Key stakeholder groups include:

1. Citizens & Communities.

2. Civil Society Organizations (CSOs).
3. Private Sector & Start-ups.
4. Academia & Experts.
5. Public Sector Agencies.
6. International Partners.

Designing inclusive engagement mechanisms

Meaningful stakeholder engagement is essential to the legitimacy, usability and long-term sustainability of DPI. To support this, policymakers can adopt a variety of participatory tools and mechanisms. Digital assemblies and public town halls offer structured spaces to gather community feedback on DPI priorities and service design. Citizen panels and co-creation labs bring end-users into the process of testing and refining DPI components such as digital identity systems or consent dashboards, ensuring solutions reflect real-world needs. Open consultations, where draft policies, technical standards, or architectural frameworks are published for public input, promote transparency and inclusive governance.

Equally important are continuous feedback loops such as helpdesks, user satisfaction surveys and digital feedback forms, which provide mechanisms for ongoing input, redress and iterative improvement. These approaches not only foster trust and responsiveness but also help build shared ownership of DPI as a public good.

Building institutional mechanisms for trust

Trust in DPI is not only earned through transparency but also institutionalized through governance practices. For policymakers, building trust in DPI means going beyond aspirational statements about transparency or ethics. Trust must be operationalized through concrete institutional mechanisms that are transparent, responsive and accountable by design. This involves establishing clear rules,

roles and remedies to ensure that DPI protects rights, provides recourse when problems arise and remains subject to meaningful oversight. The following mechanisms offer practical entry points for institutionalizing trust in DPI and ensuring it delivers long-term public value.

Institutional trust enablers include:

Mechanism	Purpose
Digital ombudspersons	Independent redress body to investigate user complaints.
Data stewardship councils	Multistakeholder bodies that oversee ethical data use.
Algorithmic transparency laws	Require disclosure of automated decision-making logic.
Independent audits	Verify DPI performance, equity and rights compliance.
Codes of digital conduct	Ethical charters signed by DPI operators and vendors.

7 The role of international standards and cooperation

As cities expand their digital infrastructure, they must proactively address the ethical implications and security risks associated with emerging technologies. This section delves into frameworks for PbD, ethics in AI and blockchain deployment, and building trust through security measures and safeguards against misuse, by adopting international standards and engaging in partnership initiatives and sustainable people-centred cooperation models. Ensuring ethical use of technology is not a mere add-on but a core component of responsible DPI governance, directly impacting public trust and safety.

7.1 Interoperability and open standards

Interoperability constitutes a foundational pillar of DPI, enabling seamless integration across diverse systems, platforms and jurisdictions. By adopting open standards such as those developed by the W3C, APIs, ITU and ISO/IEC data exchange protocols, ITU IoT and digital twins and smart sustainable cities Recommendations, cities can avoid the pitfalls of technical silos and vendor lock-in. This ensures that core DPI components, including digital identity systems, payment platforms and data registries, can interact without proprietary constraints (Chakraborty, 2024).

One example is India's UPI, which demonstrates the transformative potential of open API standards in fostering financial inclusion and cross-border interoperability. By leveraging QR-based protocols and eliminating transaction fees for merchants and consumers, UPI facilitates frictionless digital payments at scale (Bandura *et al.*, 2024). Such open architectures not only enhance user accessibility but also catalyse a dynamic and competitive ecosystem in which third-party developers can build value-added services on top of shared APIs and standardized data schemas.

The adoption of open standards significantly reduces integration costs and development timelines, making DPI more adaptable and sustainable (UNDP, 2023). Policymakers must, therefore, prioritize

open interoperability frameworks in order to avoid vendor dependency and ensure long-term scalability – this is especially important in Global South contexts, where fragmented systems and limited institutional capacity often undermine efficiency.

7.2 Privacy-by-design and data protection

The rapid proliferation of DPI necessitates the establishment of robust privacy frameworks to mitigate the risks of surveillance, data misuse and erosion of individual rights. PbD, a foundational principle embedded in the European Union's GDPR mandates that data protection measures be integrated into the architecture of systems from the outset, rather than retrofitted as an afterthought. Standards like Recommendations ITU-T X.1054, ITU-T Y.4810, ISO/IEC 27014 and ISO/IEC 27701 are all examples of relevant standards that can be used to enhance security and privacy postures of organizations and systems in smart cities.

An illustrative example is Brazil's CAR; a DPI platform designed for environmental governance. By leveraging open-source technologies and incorporating PbD principles, the system manages sensitive geospatial and personal data in a manner consistent with national privacy regulations (Data Privacy Brasil, 2024). Key features such as data minimization, purpose limitation and consent management are embedded across the system's lifecycle, ensuring alignment with personal data protections laws and regulations as well as globally recognized security standards. These measures institutionalize trust and foster accountability in citizen–government data interactions (UNEP, 2024).

Nonetheless, significant challenges remain in harmonizing privacy standards across jurisdictions. Variations in legal definitions, enforcement capacities and regulatory maturity create inconsistencies, particularly for developing economies with limited domestic data protection frameworks. In this context, the recent resolution of ITU on DPI[6], underscores the urgent need for global consensus on data sovereignty, interoperability and the ethical governance of cross-border data flows.

However, privacy cannot stand alone without strong *security*. Security safeguards are essential to protect personal data from breaches, unauthorized access and malicious actors. Without robust cybersecurity, even well-intentioned privacy protocols can be rendered ineffective. For DPI, which operates at scale and often supports vulnerable populations, this integration is not optional, it is critical to maintaining public trust, preventing harm and ensuring the long-term resilience of public digital systems. Positioning PbD alongside *security by design*, ensures the rights and the safety of individuals are protected in digital public life.

7.3 Ethics in AI, blockchain and emerging tech

Emerging technologies, particularly AI and blockchain, offer transformative potential for enhancing public service delivery. However, they also raise significant ethical challenges, including algorithmic

[6] https://www.itu.int/pub/T-RES

bias, issues of interpretability and unequal access. To address these concerns, international frameworks such as the United Nations Educational, Scientific and Cultural Organization (UNESCO)'s Recommendation on the Ethics of Artificial Intelligence (UNESCO, 2024) and the Institute of Electrical and Electronics Engineers (IEEE)'s P7000 series provide structured methodologies for risk assessment and ethical governance (IEEE, 2021). Complementary initiatives like the IEEE's Ethically Aligned Design and OECD's AI Principles further outline requirements for transparency, accountability and human oversight. Despite this progress, approximately 85 per cent of ITU member states currently lack dedicated AI governance policies, underscoring the urgency of institutional capacity-building in this domain (ITU, 2024; Chakraborty, 2024; Hamin & Hanson, 2024).

Cities should mandate ethics impact assessments for all algorithmic systems, particularly those deployed in high-stakes areas such as predictive policing or social welfare eligibility. These assessments should be accompanied by legally codified requirements for transparency such as public model documentation, audit trails and provisions for human-in-the-loop decision-making. In the case of blockchain applications used for public registries or financial services, policymakers must consider not only technical performance but also inclusivity, governance mechanisms and the socio-economic implications of decentralization, ensuring that no group is inadvertently marginalized.

Moreover, blockchain-based DPI systems should adhere to internationally recognized standards (e.g., W3C's decentralized identifiers, and blockchain requirements and functional architectures in relevant ITU-T Recommendations on IoT, digital twins and smart sustainable cities and communities) to support verifiable credentials and self-controlled identity, protecting ownership, control and usage of their sensitive data online, while avoiding single points of failure. To ensure global alignment and context-sensitive governance, policymakers must advance multilateral cooperation and embed ethical principles within culturally responsive frameworks, an approach increasingly emphasized in multilateral forums such as the G20's Digital Public Infrastructure agenda.

7.4 Accessibility and inclusion standards

The digital divide is characterized by unequal access and fragmented solutions. DPI offers accessible learning opportunities for all and the digital transformation of the education space by providing a strong yet flexible foundation, an infrastructure that enables a plug-and-play approach for educational applications, fostering innovation and driving real impact (UNDP, n.d. b).

Inclusive DPI requires strict adherence to accessibility standards that address the needs of marginalized populations, particularly persons with disabilities. Standards like ITU-T Y.4204, ITU-T Y.4211 and ITU-T Y.4219 are increasingly recognized as best practices in different smart cities and communities use cases for accessibility and inclusion. Frameworks such as the WCAG and ISO 30071-1 provide comprehensive technical and organizational guidance for designing barrier-free digital interfaces. These include specifications for screen reader compatibility, logically

structured navigation and simplified user interfaces. However, implementation remains uneven, especially in low-resource settings where capacity and institutional support are limited.

The United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2006) obligates signatory governments to align public services with universal design principles. Nonetheless, enforcement mechanisms remain weak, particularly in the absence of binding international compliance instruments. Embedding accessibility standards into public procurement processes can help bridge this gap, transforming accessibility from a discretionary feature into a non-negotiable contractual obligation, enforced through usability testing and verification by diverse user groups.

Inclusive DPI design must go beyond technical compliance to embrace participatory co-creation with marginalized communities (UNDP, 2023). By grounding design processes in lived experience rather than abstract assumptions, cities can ensure that digital services evolve in ways that are genuinely responsive to the needs of all users.

7.5 Trust and security mechanisms to prevent misuse

Public trust in DPI hinges on robust security architecture and transparent institutional stewardship. International standards for information security management and for business continuity (e.g., ITU-T Y.4810, ITU-T Y.4806, ITU-T Y.4500.3, ITU-T X.2050, ISO/IEC 27001, ISO 22301) provide foundational frameworks for structured risk management. These include provisions for regular penetration testing, incident response planning and continuity protocols essential for maintaining the reliability of critical public services.

Beyond conventional threats, policymakers must also address the risks associated with adversarial interoperability, where external systems are forcibly integrated without authorization or consent. To mitigate such vulnerabilities, it is essential to mandate strong encryption standards alongside audit protocols that regulate and monitor third-party system access.

Identity federation mechanisms, including protocols like Security Assertion Markup Language (SAML), OpenID Connect and regional frameworks such as Europe's eIDAS, play a crucial role in enhancing security and usability. These systems enable secure, cross-platform authentication, facilitating seamless access to digital services across institutions and jurisdictions. Moreover, public procurement contracts must embed explicit security requirements. These should include mandatory independent security audits, continuous compliance monitoring and enforceable breach notification protocols. Such measures not only fortify technical resilience but also enhance transparency and public accountability, both of which are essential for sustaining citizen trust in the digital transformation of public services.

7.6 Public procurement for scalable DPI

Strategic procurement practices are essential for the deployment of DPI that upholds open standards and mitigates the risk of monopolistic capture. International instruments such as the World Trade Organization's Agreement on Government Procurement (GPA) and the European Union's Digital Markets Act (DMA) emphasize principles of competitive bidding, transparency and vendor neutrality – laying the groundwork for inclusive and innovation-friendly procurement ecosystems.

The procurement process serves as a pivotal mechanism for operationalizing digital standards, translating policy ambitions into enforceable contractual requirements. By embedding criteria related to open standards compliance, cybersecurity certifications, accessibility and interoperability into tenders, public authorities can foster a diverse and agile supplier base. This not only stimulates local innovation but also reduces long-term risks associated with vendor lock-in.

Adopting modular procurement strategies, where DPI is structured as interoperable components such as identity, payment and data-sharing layers, enables flexible, "plug-and-play" architectures that can be adapted to evolving policy needs. Procurement tools such as multivendor catalogues, reference architectures and framework agreements help expedite implementation by drawing on validated design blueprints.

International standards, spearheaded by bodies such as ITU and UNESCO, serve as foundational pillars for DPI. They ensure that interoperability, privacy, ethics, accessibility, security and procurement become not just ideals, but operational realities. Through embedding these standards within governance frameworks and cross-border cooperation, cities can construct DPI that are scalable, trustworthy and responsive to the complex needs of diverse communities.

8 Policy recommendations for city leadership and ministers

8.1 Development of an integrated national and a municipal DPI strategy

An explicit DPI strategy is essential for articulating a coherent vision and establishing a robust governance framework that ensures interoperability, scalability and public accountability. According to (OECD, 2024), effective DPI should encompass shared digital systems, underpinned by strong public governance mechanisms to support inclusive and equitable service delivery. Empirical evidence demonstrates that the creation of centralized DPI authorities significantly enhances governance coherence and accelerates the adoption of digital technologies. Building on this model, national and municipal governments should establish dedicated DPI agencies in a coordinated manner, equipped with regulatory authority, stakeholder convening power, and independent budgetary capacity.

To be effective, a DPI strategy must operate at the intersection of national policy objectives and local implementation needs. It should reflect context-specific priorities while maintaining alignment with broader governmental goals. Early-stage stakeholder engagement, comprehensive privacy assessments and transparent institutional design are critical to cultivating public trust and democratic legitimacy (Van der Hoogen *et al*., 2024).

Governments should begin by conducting a DPI readiness assessment to map existing digital assets, institutional capacities and stakeholder needs. They should then develop a multistakeholder roadmap through inclusive collaboration with public agencies, civil society, technical experts and the private sector. They should also: adopt open standards and modular design principles to ensure scalability, interoperability and adaptability; institutionalize capacity-building by investing in the digital skills of public servants and communities; and align the overall strategy with the SDGs and broader national or municipal development priorities.

8.2 Invest in inclusive, scalable and interoperable infrastructure

Essential components of DPI must be designed as interoperable "building blocks" that function across sectors and administrative levels. Open-source DPGs offer a strategic avenue to achieve scalability, cost-efficiency and digital sovereignty, while also mitigating the risks of vendor lock-in (UNDP, 2022). These foundational elements not only enable flexible integration but also serve as critical enablers of innovation in public service delivery.

Research by the World Bank highlights DPI's role in enhancing systemic resilience, particularly during crises (World Bank, 2025). As such, investment strategies should prioritize the development of core digital infrastructures built upon *open standards and modular architectures*. These components not only ensure technical flexibility and future-proofing but also facilitate the replication and localization of digital solutions in diverse governance contexts.

Effective DPI must embody the principles of openness, modularity and architectural resilience. Publicly backed digital payment systems can rapidly achieve mass adoption when deployed within coherent, standards-based frameworks. However, these successes also underscore the importance of long-term financial and institutional sustainability. A forward-looking DPI investment strategy must explicitly account for inclusion, accessibility and resilience. This entails developing multilingual interfaces and offline capabilities to accommodate diverse user environments and connectivity levels. It also requires sustained funding for ongoing system maintenance, cybersecurity audits and iterative service upgrades.

To ensure universal and equitable access, policymakers should direct investments toward affordable connectivity solutions and widespread device availability. Adopting open standards and APIs can help prevent vendor lock-in and promote seamless interoperability across key sectors, including health, education and social protection.

Fundamentally, DPI should be developed using open protocols and modular services, rather than monolithic applications that constrain adaptability. Inclusive co-design practices – such as engaging marginalized communities through user interface workshops, pilot programmes and participatory service design – have proven effective in increasing system legitimacy and usability. Moreover, DPI investments must extend beyond initial infrastructure build-out to include regular cybersecurity testing, system upgrades and preparedness for offline-dominant environments. These measures are vital to ensure that DPI systems remain secure, adaptive and equitable as they evolve over time.

8.3 Promote human rights and digital trust

DPI can only be as robust and legitimate as the trust it inspires among its users. Trust must be cultivated deliberately through technical safeguards and institutional accountability. The principle of PbD, central to the GDC, ensures that user autonomy and control over personal data are embedded at every stage of system development. Advanced technical approaches such as zero-knowledge proofs – which allow users to verify credentials without disclosing underlying information – have gained traction in international forums, including the G20. These innovations are complemented by legal instruments like mandatory Data Protection Impact Assessments (DPIAs), which enable governments to proactively identify and mitigate privacy risks before large-scale DPI deployment.

Institutional trust, meanwhile, depends on transparency and procedural fairness. Establishing independent oversight bodies – such as data protection authorities or digital ombudspersons – ensures that DPI systems are subject to public accountability. These bodies should be complemented by real-time transparency tools, including open APIs, public dashboards and audit logs that are accessible to citizens and watchdog organizations.

Trust and human rights must be treated not as downstream outcomes of DPI, but as design principles from the outset. The World Economic Forum (WEF, 2023) underscores that DPI systems grounded in trust frameworks enhance digital sovereignty and enable equitable participation in the digital economy. As the UN-led DPI Safeguards Working Group released its multisectoral governance framework. The imperative is clear: address risks associated with safety, inclusion, structural vulnerabilities through around 300 recommendations and practices to be followed in DPI design (Digital Public Infrastructure Safeguards, n.d.).

A rights-based approach to DPI further ensures that citizens maintain meaningful agency over their data, particularly in cross-border data ecosystems characterized by emerging frameworks such as "Data Free Flow with Trust" (DFFT) (WEF, 2023). To this end, governments must embed ethics codes, privacy laws and procedural safeguards into DPI architectures.

Key governance mechanisms that anchor digital trust include embedding privacy-by-design protocols in alignment with global frameworks like the GDPR or the African Union's Data Policy Framework. Additionally, ensuring algorithmic transparency – particularly in AI-powered DPI applications – is essential to guard against systemic bias and discrimination (Cobbe *et al.*, 2021). Crucially, accessible and enforceable redress mechanisms must be provided so that individuals can challenge automated decisions or report data misuse. City leaders must actively address digital exclusion by closing digital literacy gaps and ensuring accessibility for marginalized and underserved groups. Without such attention, DPI risks replicating existing inequalities rather than transforming them.

While DPI offers a wide range of benefits, it also presents challenges and potential risks that need to be addressed to ensure the development of effective and trusted systems that contribute to better digital societies and leave no one behind. Exclusion arises when DPI is not designed to address the needs of minorities or groups with specific requirements, including but not limited to the elderly, migrants, individuals with disabilities, or those with limited digital literacy (OECD, 2024).

8.4 Strengthen public-private partnerships and innovation ecosystem

A vibrant DPI ecosystem is built on dynamic partnerships that span government agencies, private firms, civil society organizations and academic institutions. Multistakeholder collaboration plays a crucial role not only in strengthening technical capacity but also in ensuring inclusive design processes. As highlighted by the World Economic Forum in 2023, participatory engagement fosters locally appropriate solutions and accelerates the development of human capital essential

for DPI sustainability. Governments should prioritize the creation of institutional support structures, including national Open-Source Programme Offices (OSPOs), innovation accelerators and civic hack labs that localize global DPGs for national and municipal use.

DPI flourishes in environments in which innovation is actively encouraged but carefully governed. Governments must act as enablers, opening space for experimentation (e.g., open-source implementation), while maintaining regulatory oversight to ensure that public interest remains paramount. Several mechanisms have proven effective in this regard. These include establishing regulatory sandboxes and dedicated funding streams to test experimental solutions such as *GovTech challenges or innovation sprints*. Infrastructure development can be enhanced through *strategic partnerships with private-sector actors*, provided these arrangements incorporate safeguards to prevent monopolistic control and ensure long-term public ownership.

The true strength of DPI lies not only in its technical architecture but also in its capacity to act as a platform for continuous innovation. International experiences affirm this logic. In Sweden, collaboration between banks and technologists led to the rapid scaling of Swish, a real-time payments platform. In China, municipal governments integrated Alipay into public service delivery systems, streamlining access to transit and health benefits. These examples demonstrate that when *public and private sectors align through shared DPI strategies*, service delivery becomes faster, more responsive and more inclusive.

To institutionalize innovation within DPI ecosystems, ministries should establish permanent public-sector testbeds, regulatory sandboxes and innovation labs that leverage open data. The European Union's *Interoperable Europe* framework (European Commission, 2017) provides a strong precedent, encouraging governments to publish datasets and APIs for use by researchers, start-ups and civic technologists. At the same time, public procurement policies must be updated to reward contributions to open-source technologies and reusable digital building blocks.

Ultimately, DPI's value lies not only in connecting systems, but in connecting people, ideas and institutions through collaborative innovation. Governments that embed these principles into their digital strategies will be better equipped to deliver responsive, rights-based and future-proof public services.

8.5 Development of an enabling regulatory and a business-friendly environment

Regulatory environments often determine whether DPI can scale and sustain impact. Forward-leaning legal frameworks have consistently enabled DPI innovation by providing certainty and clarity for public and private actors. A supportive regulatory framework is thus not merely beneficial but foundational to DPI's long-term viability. Such a framework must be underpinned by open standards, legally protected data portability, non-discriminatory access to core infrastructure and "light-touch" yet enforceable oversight. These elements collectively promote competition, reduce vendor lock-in and foster innovation. European programmes like *Digital Europe* illustrate how

regulation, when anchored in clarity and interoperability principles, enables cross-border digital services to flourish.

Balancing innovation with accountability requires adaptive regulatory approaches – those flexible enough to accommodate technological change while safeguarding public interest. Governments should streamline licensing and compliance for DPI providers, for instance through unified digital business permits or simplified accreditation for civic-tech initiatives. "Test-and-learn" regulatory models – such as those piloted for blockchain and AI governance – can enable experimentation within defined guardrails, ensuring that innovation proceeds responsibly. In parallel, clarifying data ownership, consent and sharing protocols is essential to protecting rights while encouraging productive data use.

To replicate the success of frontrunner countries, national and municipal leaders must legislate for openness, interoperability and accessibility, and to nurture a business-friendly environment. Laws that mandate API standards, enforce the use of open-source platforms for government services, and embed accessibility principles into procurement processes not only enhance efficiency but signal a long-term commitment to inclusive digital development. However, legal reform alone is insufficient. Research on adaptive governance shows that regulatory agility must be paired with institutional capacity.

A future-ready DPI ecosystem depends on legal architectures that are not only enabling but evolvable. By combining streamlined regulation with robust institutional capacity building, policymakers can transform DPI from a compliance burden into a catalyst for inclusive digital transformation.

8.6 Measure impact and share best practices

A scientifically rigorous approach to DPI demands continuous measurement, best practice sharing and structured learning. Systematic monitoring is critical to assess operational performance and broader societal outcomes. KPIs should encompass system adoption rates, demographic inclusion, service uptime, incident and tampering reports, cost-efficiency assessments and socio-economic impacts such as reductions in service wait times or increased public access to essential services.

Transparent sharing of successes and failure practices is essential to building trust, securing political support and accelerating global learning. Governments should actively contribute to international knowledge ecosystems such as the World Economic Forum, the World Bank's Identification for Development (ID4D), Digitalizing Government-to-Person Payments (G2Px) initiatives and UNDP's digital inclusion programmes and the U4SSC initiative. To ensure DPI systems remain responsive to evolving needs, governments must embed feedback loops that are quantitative and adaptive. This includes regularly evaluating systems against user satisfaction, accessibility metrics and technology evolution – particularly with regard to emerging tools such as AI. Rigorous monitoring must be matched by structured evaluation frameworks that link DPI performance to SDGs targets and crisis resilience indicators. Institutions such as UNDP and the World Bank have repeatedly

underscored the need for such outcome-based monitoring to demonstrate DPI's contribution to inclusive development (WEF, 2022).

At the local level, municipalities should operationalize these principles by establishing standardized, public-facing dashboards that track inclusion, usage frequency, resilience and public trust. Governments should formalize these exchanges through peer networks, testbed collaborations and shared repositories of design and implementation case studies.

Robust monitoring and knowledge exchange are not auxiliary tasks; they are central pillars of sustainable DPI. Governments must define KPIs aligned with strategic objectives, institutionalize learning through multilateral platforms and foster a culture of iterative improvement. Through transparent evaluation and global cooperation, DPI systems can evolve from infrastructure projects into adaptive, resilient and inclusive public institutions.

9 Conclusion: Future-proofing urban development with stack-agnostic DPI for cities (DPI+)

9.1 The urgency of now

Cities stand at a critical juncture in human history. Rapid urbanization, climate change and technological disruption are reshaping the urban landscape at an unprecedented pace. The challenges are immense; rising inequality, environmental degradation and the digital divide

threaten to undermine the sustainability and inclusivity of our cities. And yet, these challenges also present a unique opportunity to reimagine urban governance and service delivery through DPI.

The urgency to act is clear. As highlighted throughout this framework, cities that fail to invest in robust, inclusive DPI risk falling behind in the global race for resilience, innovation and equitable growth. Fragmented legacy systems, vendor lock-in and inadequate digital inclusion measures are not just inefficiencies, they are barriers to achieving the SDGs and fulfilling the promises of the GDC. The time for incremental change has passed; cities must embrace transformative DPI solutions that are scalable, interoperable and designed for the public good.

The COVID-19 pandemic underscored the vital role of digital infrastructure in crisis response, from enabling remote education and health care to facilitating cash transfers for vulnerable populations. Similarly, climate-related disasters demand real-time data sharing and adaptive governance – capabilities that DPI can provide. The window to future-proof our cities is narrowing and the cost of inaction will be borne by the most marginalized communities.

Urban environments worldwide are undergoing rapid transformation. Accelerating population growth, climate volatility, infrastructure strain and shifting economic landscapes are imposing unprecedented stress on city systems. These compounding forces demand that municipal decision-makers act with agility – and this is where Stack-Agnostic DPI+ comes in. By enabling seamless integration across data ecosystems – regardless of platform, vendor, or legacy constraints – it empowers cities to respond in real time to system failures, service disparities, public health emergencies and environmental threats.

Time is not a luxury we can afford. With infrastructure lifespans ticking toward critical thresholds and digital inequality widening all around, everyday counts. DPI provides the framework cities need today to make tomorrow manageable, whether this is stress-testing transportation flows in a heatwave, rerouting utilities during a flood, or scaling vaccination campaigns in a public health crisis. This is not just about solving problems; it is also about equipping cities to foresee them. And the closer we march toward climate tipping points and infrastructure collapse, the more immediate this urgency becomes.

9.2 The opportunity for global leadership

The rise of DPI offers a generational opportunity for cities to lead the way in shaping a digital future that prioritizes people over profit, inclusion over exclusion and sustainability over short-term gains. By adopting stack-agnostic DPI, systems that are interoperable across technologies and jurisdictions, cities can avoid the pitfalls of proprietary silos and ensure long-term adaptability.

Pioneer cities have demonstrated the transformative potential of DPI, from seamless digital identity systems to participatory governance platforms. These examples prove that DPI is not just a technical solution but also a governance imperative, one that aligns with global frameworks like the SDGs, the Pact for the Future and the New Urban Agenda.

The opportunity for global leadership lies in:

1. **Collaboration**: Cities must work together, sharing best practices and standards to create a cohesive digital ecosystem. Initiatives like the U4SSC and Open and OASC provide platforms for this exchange.
2. **Innovation**: By fostering public-private partnerships and local digital ecosystems, cities can drive innovation while retaining control over critical infrastructure.
3. **Equity**: DPI must be designed with inclusivity at its core, ensuring that no resident is left behind, whether due to disability, income, or lack of connectivity.
4. **Resilience**: Integrating DPI with climate adaptation strategies such as smart grids and early-warning systems can safeguard cities against future shocks.

The vision of DPI+, a next-generation digital infrastructure that is adaptive, ethical and universally accessible, is within reach. City leaders, ministers and policymakers must seize this moment to champion DPI as the foundation of sustainable urban development. The choices made today will determine whether our cities become engines of inequality or beacons of progress. The time to act is now.

By embracing DPI+, cities can unlock a future where technology serves humanity, where governance is transparent and participatory and urban spaces are resilient, inclusive and thriving for generations to come. The path forward is clear; the tools are at hand. The question is whether we have the collective will to build the cities of tomorrow – today. Embracing DPI is not just about mitigation; it is about ambition. Cities that pioneer stack-agnostic, interoperable DPI can leapfrog ahead in the race to becoming global exemplars in sustainable, inclusive, resilient urban governance. They can design service ecosystems that scale across jurisdictions, incubate home-grown civic-tech ecosystems and attract investment attracted to predictable, data-driven governance.

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