DIGITAL TRANSFORMATION FOR THE SUSTAINABLE DEVELOPMENT GOALS

FRAMEWORK AND ROAD MAPS TO DRIVE PROSPERITY, INCLUSION, RESILIENCE, AND SUSTAINABILITY

DECEMBER 2024

ASIAN DEVELOPMENT BANK

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In this publication, "$" refers to United States dollars.
ADB recognizes "China" as the People's Republic of China and "Korea" as the Republic of Korea.

Cover photo: **System administrator of a network company in Dhaka, Bangladesh.** Sharmin Islam is responsible for the maintenance of servers, computers, enterprise software, and the security system.

Photo credit: All photos are ADB except case studies 3, 5, and 6 which were taken from the websites of the respective organizations of the case studies.

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Acknowledgments

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Abbreviations

4IR	Fourth Industrial Revolution
ADB	Asian Development Bank
AI	artificial intelligence
COVID-19	coronavirus disease
DAT	digital agricultural technology
DGRA	Digital Government Readiness Assessment
DHIS2	District Health Information Software 2
DMC	developing member country
DPG	digital public good
DPI	digital public infrastructure
fintech	financial technology
ICT	information and communication technology
ID	identification
IoT	Internet of Things
IT	information technology
JETP	Just Energy Transition Program
LGA	Local Government Authority
M&E	monitoring and evaluation
MIS	management information system
MSME	micro, small, and medium-sized enterprise
NIRS	National Information Resources Service
OECD	Organisation for Economic Co-operation and Development
P2P	peer-to-peer
PIA	privacy impact assessment
PISA	Programme for International Student Assessment
PPP	public–private partnership
PRC	People's Republic of China
QR	quick response [code]
R&D	research and development
RENIEC	Registro Nacional de Identificación y Estado Civil (National Registry of Identification and Civil Status)
SCADA	supervisory control and data acquisition
SDDC	software-defined data center
SDG	Sustainable Development Goal
SIRI	smart industry readiness index
SME	small and medium-sized enterprise
SSOT	single sources of truth
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
US	United States

Executive Summary

On the current trajectory, Asia and the Pacific will not achieve the United Nations (UN) Sustainable Development Goals (SDGs) before 2062. Fast-tracking progress toward the SDGs is becoming ever more urgent, considering the compounding and interconnected crises of the coronavirus disease (COVID-19), conflict, inflation, and climate change that are causing progress to go off track.

Spearheaded by the work of the UN SDG Solutions Network, a consensus has emerged over the last few years around six major transformations that can serve as systemic building blocks for advancing the SDGs, with each transformation contributing to multiple SDGs and aligning with government institutions, policies, and programs in many countries. Digital technologies and data are recognized as powerful tools for realizing the SDGs. A recent UN analysis found that digital technologies can directly help the achievement of 70% of the SDG targets.

During the COVID-19 crisis, government institutions and private companies that had invested in digitalization were able to make rapid adjustments and recover faster. They relied on cloud-based data systems, modern security protocols, and an agile organizational culture. They used a wide range of digitally enabled processes to support the sudden switch to work-from-home and the new reality of virtual transactions and interactions with partners, vendors, citizens, and businesses.

By contrast, those lagging in their digital initiatives struggled to adjust to rapid economic and social changes. The cost to economies not digitalizing fast enough includes productivity losses and deteriorating regional and global competitiveness. These countries fail to attract digital foreign direct investment and participate in global value chains and are often hampered by lackluster innovation ecosystems and outmigration, especially of skilled labor.

Global spending on digital transformation of government services, business practices, products, and organizations is projected to more than double over 2020 levels to reach $2.8 trillion in 2025, with Asia and the Pacific set to become the new hotspot for digital transformation.

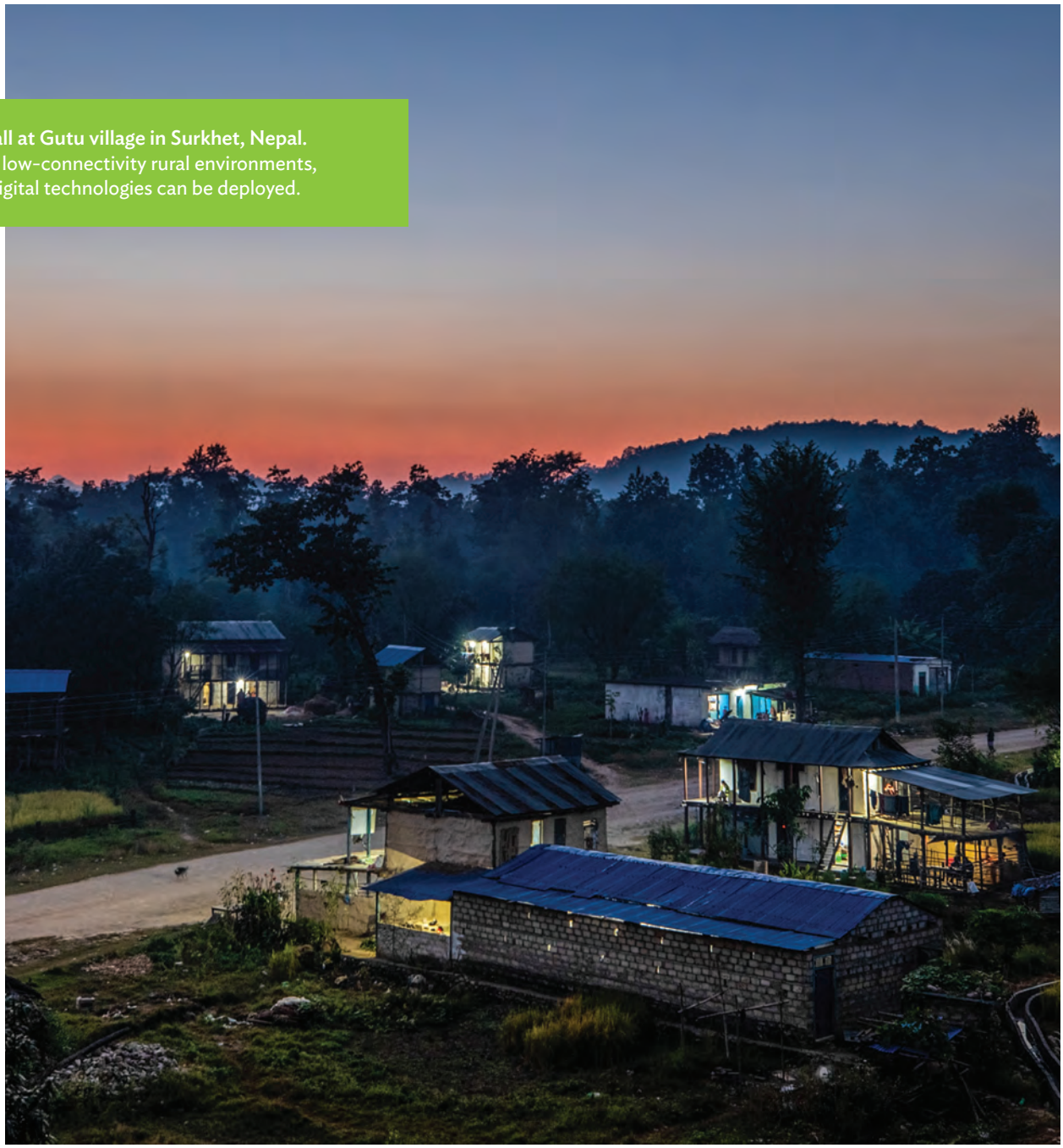
India is championing digital public infrastructure (DPI) and digital public goods (DPGs), as part of the digital transformation to achieve the SDGs. DPIs and DPGs are high-impact, people-centered initiatives consisting of interoperable digital building blocks (e.g., digital identification, digital payment services, and data exchange) that provide a platform for digital innovators to offer new services for people and businesses.

Strategically channeling investments to overcome barriers and challenges in SDG transformations in Asia and the Pacific is critical. To harness the opportunities of digital transformation for SDG attainment, a comprehensive, multisector, multistakeholder approach is needed, bringing together public, private, and civil society stakeholders to build infrastructure

and capacity, and boost policies and investments toward achieving the SDGs.

Digital transformation for the SDGs needs to be equitable, inclusive, trustworthy, and resilient to climate change and cyber risks and threats. The Asian Development Bank (ADB) is poised to support developing member countries (DMCs) in their digital transformation, accelerate progress toward digital maturity, and help facilitate collaborations to fully use digital technologies and data for SDG transformations, in line with the recently adopted UN Global Digital Compact.

To support DMCs in their digital transformation, this report outlines a set of digital road maps for six SDG transformations that are aligned with the operational priorities of ADB under its 2030 Strategic Plan.



Nightfall at Gutu village in Surkhet, Nepal. Even in low-connectivity rural environments, many digital technologies can be deployed.

The Six Sustainable Development Goals Transformation Areas

1. Enhancing human capital, creating quality jobs, and addressing equality

With about half of the region still digitally excluded, an inclusion-focused digital transformation process will need to ensure that marginalized and vulnerable groups are not left behind. There are three overarching strategies for SDG transformation in these areas: building and protecting human capital; deploying and utilizing skills and knowledge; and devising empowering policies and institutions. This involves accelerating equitable access to digital infrastructures and technologies, resolving barriers to access, improving digital literacy, addressing skill gaps, and promoting the innovative use of digital technologies.

The integration of technologies such as artificial intelligence, data analytics, and virtualization technologies in education can transform traditional teacher-centric content delivery into learner-centered approaches. Teachers become facilitators, coaches, and mentors, who empower personalized adaptive learning, improve student engagement, offer individualized content and feedback, and prioritize student needs.

With health-care systems underfunded, ill-equipped, and understaffed, the promise of digital technologies in medicine and health care includes new applications for disease surveillance, drug discovery, clinical diagnostics, patient consultation and care through telemedicine, and health-system management.

Changes in labor markets, including gig work, underemployment, demographic shifts, outmigration, and the impact of digital technologies on nearly all job categories, are diminishing the prospect of permanent employment. While e-commerce and the gig economy can boost job creation and generate flexible work opportunities, these arrangements have also come under scrutiny for low wages, unfair labor conditions, and lack of social protection. These trends are magnified in Asia and the Pacific, which has a large informal sector where workers, the majority of whom are women, face poor working conditions, unstable incomes, and vulnerabilities to shocks.

2. Decarbonizing economies and expediting energy transition

Digital technologies can enable the shift from a centralized energy system with large power plants, to a decentralized, renewable energy-based one. There are four strategic areas to accelerate decarbonization and energy transition. The first is enhancing user participation in energy systems on digital platforms, positioning them as active agents in energy markets. Secondly, digital technologies can be leveraged to transition toward more sustainable and flexible energy generation models that integrate renewable energy technologies. Thirdly, energy systems can be strengthened to become more resilient to the growing incidence of extreme climate events and cyber risks. Finally, there is establishing a robust value chain that supports the growth of local industries, industrial hubs, and clusters specialized in low-carbon digital technologies.

3. Scaling smart cities

The transformation into smart cities requires a comprehensive approach that promotes integrated urban planning and design, embeds digital innovation in urban service delivery, and builds a tech-startup ecosystem to attract digital talent. Digital technologies can assist in this endeavor by improving urban planning, enhancing public services, and opening new avenues for citizen feedback and participation.

Innovative solutions in land use, vertical food production, or densification typically require the integration of technology systems across multiple domains to connect citizens seamlessly with infrastructure and services. Virtual models of physical systems and processes (known as digital twins) can simulate the impacts of different scenarios, helping planners to optimize land use and minimize adverse environmental effects.

Traffic data and booming e-commerce are propelling smart logistics solutions, such as drones, rapid public transit, and alternative job locations to reduce commuters' carbon footprint. Digital platforms can also motivate circular economy approaches by facilitating coordination, transparency, and traceability along supply chains and product life cycles. Selecting the right technology is crucial, requiring considerations such as user-friendliness, security, costs, interoperability, and flexibility. Open-source solutions and agile regulatory mechanisms are important for successful smart cities' transformation.

4. Enhancing food security through sustainable and resilient agriculture

Digital agricultural technologies can play a critical role in enhancing the resilience and productivity of food systems, including through precision agriculture, strengthening agricultural extension services, reducing food loss and waste, and connecting smallholder farmers to markets.

Governments can support digital agricultural technologies by investing in a national digital platform for agriculture to enable the development of innovative products and services for smallholder farmers, and developing an e-agriculture strategy. Improving e-governance systems and providing an enabling policy and legal environment for digital connectivity and payment systems in rural areas are also key. Governments can also support agri-technology start-up programs.

5. Accelerating digital transformation of governments

Digital technologies have the ability to transform the way the public sector operates, delivers services, improves accountability and openness, and increases citizen participation in decision-making processes. Yet, challenges such as the digital divide, vertical silos, legacy systems, a lack of implementation capacity to re-engineer end-to-end services, and eroding public trust in government institutions hinder progress. Strategies for government leaders to accelerate public sector digital transformation need to be focused on infrastructure and business continuity; capabilities and skills; leadership; legislation and regulation; and the development of an integrated platform for government services.

6. Improving connectivity and competitiveness

Strategic areas for transformation include fostering regional cooperation and integration, enhancing digital connectivity, and enabling competitiveness and innovation. DPI and DPGs, such as digital payment systems and data exchange platforms, enable seamless cross-border trade and investment and can, in turn, be shared as regional public goods to collaboratively accelerate achievement of the SDGs. Regional cooperation in building digital infrastructure, harmonizing regulations, enhancing cybersecurity measures, and strengthening digital capacities can address digital transformation challenges head-on, ensuring a secure and inclusive digital future in Asia and the Pacific.

Digital connectivity, including broadband connectivity, is a prerequisite for adopting digital technologies and implementing foundational systems such as digital ID, digital payment, e-commerce platforms, intelligent multimodal transport systems, smart electricity grids, and smart cities. Government support is needed to correct market failures, direct resources to underserved locations to close the digital divide, and enable seamless cross-border trade. Public–private partnerships play an important role in improving digital access and accelerating digital technology adoption. Removing legislative and regulatory barriers can boost national competitiveness, including through innovation sandboxes and support for local technology start-ups.

While the six SDG transformations cover most of the key SDG interventions, trade-offs may exist in implementing various policy interventions. In addition, some sectors, such as the digitalization of the finance sector, are critical enablers for digital transformation and can contribute to all six SDG transformation areas. To achieve impact, the six transformations need to be considered holistically for execution, while being tailored and adapted based on the maturity of the specific country and environment in which they are being implemented.

Enhancing Digital Maturity: Bridging the Technological Gap in Asia and the Pacific

This report proposes a novel digital maturity model to help assess the digital readiness of organizational entities (e.g., government agency, city, company, farm, or development program) in ADB DMCs, outlining both enabling conditions and core digital components.

Digital maturity model

The digital maturity model comprises five levels, with the first level characterizing a nascent state and the fifth level serving as an illustration for an optimized state. ADB has opportunities to expand its support to DMCs to advance along the digital maturity continuum and promote a design thinking approach. This framework can help guide ADB sector groups in fine-tuning their sector-based strategic road maps to support SDG achievement in DMCs.

As countries' and organizations' digital programs progress along these maturity levels, they tend to acquire new capabilities to pilot and adopt more complex frontier technologies, such as AI, digital twins, virtual reality applications, or distributed ledger technologies. This progression requires leadership commitment, the necessary fiscal space, and a willingness to take calculated risks as these frontier technologies are not yet proven and often prone to technology hype. When a digital solution is successfully piloted (even within a limited or contained system), it may gradually be scaled and adopted nationally, ideally as part of interoperable and integrated systems and platforms. Other avenues for technology adoption that can save time and resources may be pursued through the adaptation of open-source software solutions or DPI blocks that have already been tested successfully elsewhere. The digital maturity model does not prescribe a linear pathway and does not advocate a particular technology. Rather, the digital maturity model can help map out linkages between the different analog and digital dimensions, pinpointing areas where organizations may require targeted support and providing entry points for digital transformation.

Digital transformation as regional public goods

Achieving the SDGs requires the generation and application of creative ideas and innovative design approaches. Innovation is increasingly based on digital technologies, which can enhance the efficiency and

Nasima Akhter, 35 years old, and her son Parvez, at the pump house at Chittagong, Bangaldesh. A prepaid card for irrigaton allows her to control the usage of pump for her rice field.

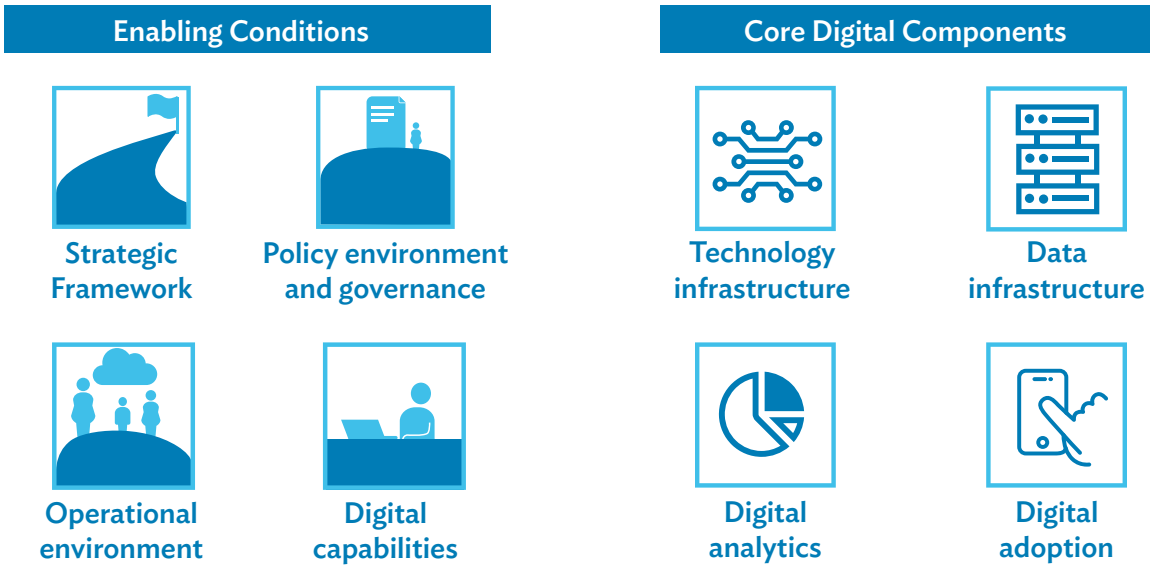
effectiveness of activities undertaken to achieve the SDGs. Government support is needed to correct market failures and direct resources to underserved communities to bridge the digital divide and create an enabling environment for the private sector.

Public–private partnerships can play an important role in increasing the adoption of digital technologies by designing and implementing citizen-centric applications. Beyond government intervention, private companies can partner with technology companies instead of developing in-house technologies to accelerate their transformation initiatives. These third-party partnerships can be structured in different ways, including as commercial contracts or venture capital investments.

DPI and DPGs are regional public goods that can help accelerate achievement of the SDGs collaboratively. Regional public goods have the potential to foster inclusive economic growth, enhance connectivity, and address common development challenges, and encourage country-specific and joint actions that generate positive spillovers to neighboring countries. As regional public goods, DPI such as broadband networks, digital payment systems, and e-governance platforms can facilitate cross-border trade, investment, and collaboration, benefiting multiple countries simultaneously. They enable efficient resource sharing, reduce transaction costs, and promote regional integration by harmonizing standards and protocols. By viewing DPI as a regional public good, DMCs in Asia and the Pacific can pool resources, share best practices, and coordinate policies, leading to more robust, resilient, and equitable digital ecosystems that drive sustainable development across the region.

Regulatory harmonization in line with regional and global standards is key to enabling regional integration and seamless cross-border trade. For example, regional payment gateways can enable frictionless, convenient, and affordable cross-border payments that can drive economic growth, support micro, small, and medium-sized enterprises, and lay the groundwork for economic cooperation. Another example is to connect the development of national single windows with digital customs clearance systems on a regional basis. By digitalizing customs processes, DMCs can speed up the cross-border movement of goods and services and introduce risk-based customs inspection regime. This not only streamlines trade by reducing paperwork and wait times but also strengthens economic ties and mutual reliance among DMCs, paving the way for a more connected and efficient regional market.

Figure: Digital Maturity Framework Enabling Conditions and Core Digital Components



Source: Asian Development Bank.

CHAPTER 1

Nepal Electricity Authority staff fixing electricity lines in Parbat, Nepal. Although overall progress in attaining the Sustainable Development Goals (SDGs) has been slow, there are some notable achievements in affordable and clean energy (SDG7) and industry, innovation, and infrastructure (SDG9), especially in increasing access to electricity and mobile network coverage.

Chapter 1

INTRODUCTION

Asia and the Pacific has made progress in achieving the Sustainable Development Goals (SDGs). However, this progress is far behind schedule. Digital transformations can accelerate progress toward the SDGs. This section examines the linkages between six digital transformations and the seven operational priorities of the Asian Development Bank's (ADB's) Strategy 2030, followed by an introduction to digital transformation and the role of digital technologies and data in attaining SDG targets.

Progress of Sustainable Development Goals in Asia and the Pacific

Asia and the Pacific is at least 32 years behind schedule in meeting the aspirations of the 2030 Agenda for Sustainable Development.[1] Data show a continuous increase in the expected time required to achieve the SDGs since their adoption in 2015. Multiple factors are contributing to this sluggish progress, including slow recovery from the impacts of the coronavirus disease (COVID-19) pandemic, ongoing crises and conflicts that are disrupting global supply chains, increases in the frequency and severity of climate events and disasters, and widening inequalities between countries in Asia and the Pacific and urban and rural areas. Fast-tracking progress toward the SDGs is urgent, considering the compounding challenges the region faces across multiple social, economic, and environmental dimensions of development (Figure 1).

Although overall progress in attaining the SDGs has been slow, there are some notable achievements in affordable and clean energy (SDG7) and industry, innovation, and infrastructure (SDG9), especially in increasing access to electricity and mobile network coverage (foonote 1). Today, 96% of the population in Asia and the Pacific is covered by mobile broadband.[2] This extensive coverage has propelled the adoption of digital technologies and contributed to growth in many sectors. It represents an opportunity to leverage digital technologies to accelerate progress in achieving the SDGs. A global United Nations (UN) analysis found that digital technologies can directly help the achievement of 70% of the SDG targets.[3]

Lack of access

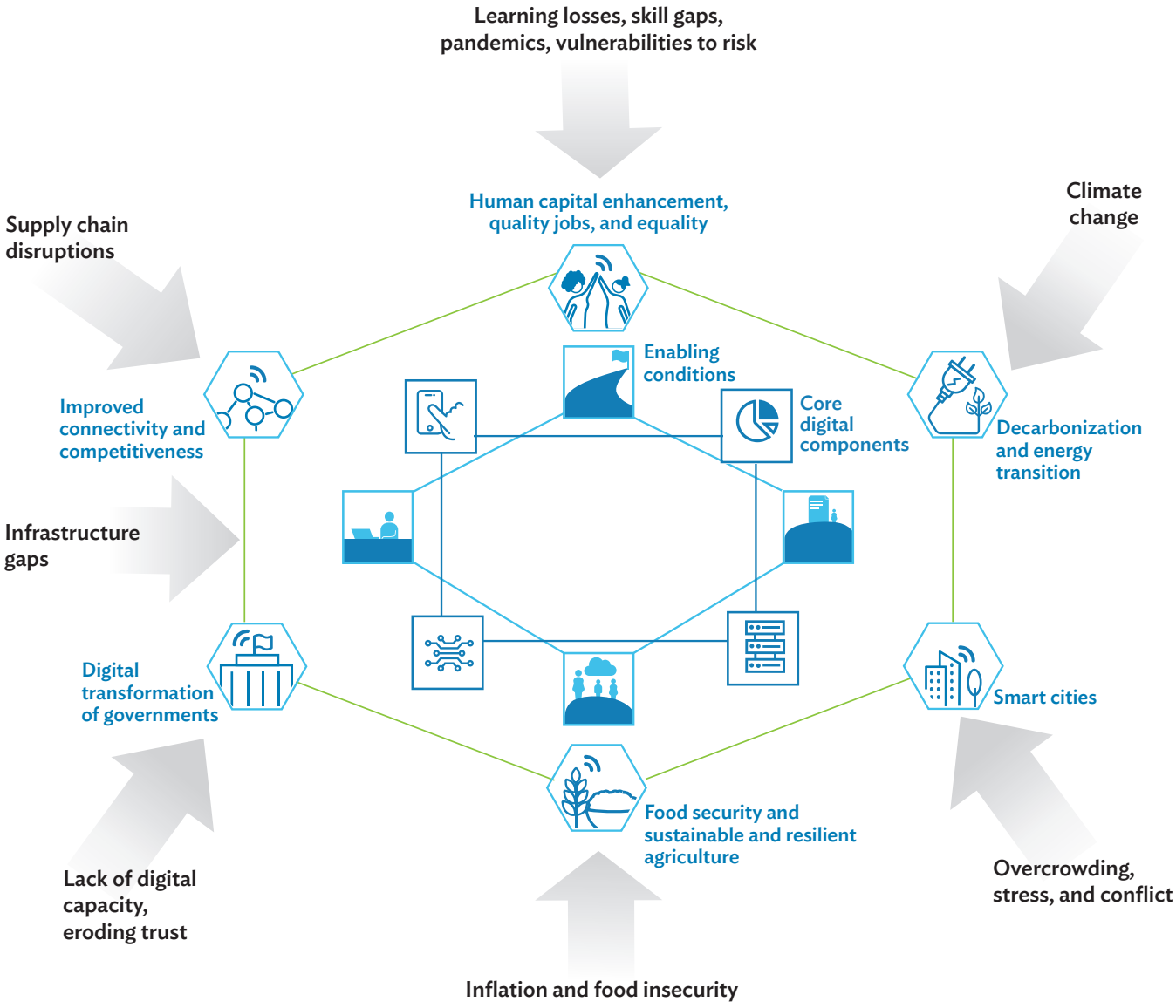
Despite almost universal coverage of mobile broadband, approximately half of the region's population is unable to access and use the technology for reasons related to affordability, skills, and relevance to their lives

1 Economic and Social Commission for Asia and the Pacific (ESCAP). 2024. *Asia and the Pacific SDG Progress Report: Showcasing Transformative Actions 2024.*

2 International Telecommunication Union (ITU). 2023. *Measuring Digital Development: Facts and Figures 2023.*

3 ITU and United Nations Developmemt Programme (UNDP). SDG Digital Acceleration Agenda. https://www.sdg-digital.org/accelerationagenda.

Figure 1: Fast-Tracking the Sustainable Development Goals with Digital Transformation



Source: Asian Development Bank.

and livelihoods. Digital technology adoption and transformation to meet SDG targets requires considerable investment in connectivity infrastructure, building up digital skills, and fostering innovative solutions. Across ADB's developing member countries (DMCs), there are widely differing levels of socioeconomic development and digital maturity.[4]

While all the subregions of ADB have experienced improvements in digital connectivity over recent years, Southeast Asia and East Asia have made faster progress compared with other subregions. South Asia and Central

[4] The International Telecommunication Union's Information and Communication Technology (ICT) Development Index shows a 69-point gap between the best-performing (98.4) and worst-performing (28.9) economies in Asia and the Pacific. (ITU. 2023. *Measuring Digital Development: Facts and Figures 2023.* Geneva.)

and West Asia lag in broadband Internet access, and the Pacific small island developing states are among the least connected countries.[5] Even when digital connectivity is available, many do not have the skills necessary to use digital technology. According to available data, only 40% of the region's population has basic digital skills (footnote 4). This prevents many from using digital technologies in innovative ways for even the most basic digital services. Moreover, the lack of data has been an impediment to SDG progress, as well as to the assessment of SDG progress.[6]

Cost to economies

The cost to economies not digitalizing fast enough includes loss of productivity, leading to deteriorating regional and global competitiveness. It makes countries unattractive for digital foreign direct investment and participation in global value chains. It leads to lackluster innovation ecosystems and outmigration, especially of skilled labor. Other drawbacks include the inability to harness the value of big data and data exchange for improved and agile decision-making.[7] It affects the ability of governments to provide end-to-end e-services to citizens and perpetuates siloed approaches and legacy systems in government agencies. It leads to lack of transparency and accountability in key government functions (e.g., revenue collection, procurement decisions, results management), and erosion of trust in government functions.

Students are learning with computers at Kalika Model School in Pokhara, Nepal. Even when digital connectivity is available, many do not have the skills necessary to use digital technology.

5 ESCAP. 2024b. Summary of the theme study on leveraging digital innovation for sustainable development in Asia and the Pacific (ESCAP/80/2).

6 ESCAP. 2024a. *Asia and the Pacific SDG Progress Report: Showcasing Transformative Actions 2024*. Bangkok.

7 J. R. Albert et al. 2019. Readiness of National Statistical Systems in Asia and the Pacific for Leveraging Big Data to Monitor the SDGs. *ADB Briefs.* No. 106. March. ADB.

Asia and the Pacific has certain advantages over other regions, including a portfolio of mature digital transformation experiences, such as in India, Japan, Malaysia, the People's Republic of China (PRC), the Republic of Korea, and Singapore. Other advantages include a favorable demographic transition, engagement in the Fourth Industrial Revolution (4IR); willingness by governments and the private sector to engage and invest in digital transformation; and the presence of regional policy circles and think tanks.

Linkages Between the Sustainable Development Goals Transformation Areas and Asian Development Bank Operational Priorities

Progress toward achieving the 17 SDGs requires a well-thought-out implementation plan organized around modular building blocks. SDG outcomes are interdependent and involve positive as well as negative trade-offs. There are repercussions that reflect complex interactions between human, technical, and natural systems.[8] Operationalizing the implementation of the SDGs requires governments, businesses, and civil society to engage in purpose-driven problem-solving informed by these interlinkages.

The SDGs are embedded in ADB's operations. In line with ADB's Strategy 2030 operational priorities, ADB has been supporting DMCs in delivering SDG-aligned results. The midterm review of Strategy 2030 emphasized a need for more digital transformation work, calling for ADB to "incentivize further mainstreaming of innovative technology."[9] This report offers a structured approach to support DMCs in fast-tracking SDG progress by providing road maps[10] for digital transformation that are based on countries' digital maturity and aligned with ADB Strategy 2030 operational priorities.

Transformations

Over the last few years, a consensus has emerged, spearheaded by the UN SDG Solutions Network, around six SDG transformations that can serve as systemic building blocks, with each contributing to multiple SDGs and aligning with government institutions, policies, and programs in many countries.[11]

The SDG transformations proposed in this report build on the conceptual framework advanced by the "The World in 2050" global research initiative under the direction of the Institute for Applied Systems Analysis (IIASA).[12] They also draw on the work of a team of scholars led by Jeffrey D. Sachs.[13] This report has adapted this work to ensure alignment with ADB Strategy 2030 and its operational priorities.

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8 International Science Council. 2017. *A Guide to SDG Interactions: From Science to Implementation.* 12 May. https://council.science/publications/a-guide-to-sdg-interactions-from-science-to-implementation/.

9 ADB. 2024. *Midterm Evaluation of Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.* Independent Evaluation: CS-24.

10 The terms "road map" and "strategic approach" are often used interchangeably. This report uses "road map."

11 UN Department of Economic and Social Affairs, Department of Economic and Social Affairs. 2019. Global Sustainable Development Report (GSDR) 2019 The Future is Now: Science for Achieving Sustainable Development. https://sdgs.un.org/gsdr/gsdr2019.

12 C. Maddox. 2018. The World in 2050 Report: Transformations to Achieve the Sustainable Development Goals. Sustainable Development Solutions Network. 13 July. https://www.unsdsn.org/news/2018/07/13/twi2050-report-transformations-to-achieve-the-sustainable-development-goals.

13 J. D. Sachs et al. 2019. Six Transformations to Achieve the Sustainable Development Goals. *Nature Sustainability.* 2, no. 9. 805–14. https://doi.org/10.1038/s41893-019-0352-9.

The six Sustainable Development Goals transformation areas proposed in this report are:

- human capital enhancement, quality jobs, and equality
- decarbonization and energy transition
- smart cities
- food security and sustainable and resilient agriculture
- digital transformation of governments
- improved connectivity and competitiveness

There are direct and indirect linkages between the 17 SDGs, 6 SDG transformations, and 7 ADB Strategy 2030 operational priorities (Figure 2).

Simpa Networks solar set demo in Uttar Pradesh, India. Digital technologies can directly help the achievement of 70% of the Sustainable Development Goals targets.

Figure 2: Linkages Between the Sustainable Development Goal Transformation Areas and ADB Operational Priorities

ADB = Asian Development Bank, OP = operational priority, SDG = Sustainable Development Goal.

Note: This is a provisional mapping of the SDG transformation areas and ADB operational priorities and can be refined further.

Source: Asian Development Bank.

Driving Digital Transformation Toward Achieving the Sustainable Development Goals

The 2030 Agenda for Sustainable Development recognizes that "the spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies."[14] Achieving the SDGs requires multistakeholder participation and collaboration, which can be effectively facilitated using different digital technologies. Achieving the SDGs also requires the generation and application of creative ideas, innovative design and techniques, and disruptive technologies. Innovation is increasingly based on digital technologies, which can enhance the efficiency and effectiveness of the activities undertaken to achieve the SDGs.

The theme of digital technology for development cuts across all of ADB's operational priorities. Strategy 2030 has identified "promoting innovative technology" as one of the guiding principles for ADB's operations. Digital technologies can serve as a driving force for change in economies and societies toward meeting SDG targets, with the understanding that these digital pathways need to be shaped responsibly and governed appropriately. ADB has been supporting DMCs in their digital transformation and in navigating both the opportunities and risks of digital development. The Digital Technology for Development Directional Guide provides a framework for ADB's digital transformation support, and this report aims to support its operationalization by offering a framework and a series of road maps.[15]

Beyond technology

Digital transformation is a process that goes beyond the introduction of digital technologies or the digitalization of products and services. It implies a profound change in how organizations operate, and services are delivered. Some sectors contribute to several SDG transformations. For instance, digitalization of the finance sector is recognized as a critical enabler for digital transformation and achievement of the SDGs. This is reflected in the report by including different forms of digital finance in all six SDG transformation areas.[16]

The deprivations triggered by the coronavirus disease (COVID-19) crisis underscored the importance of digital transformation. Government institutions and private companies that invested in digitalization in previous years could make rapid adjustments. They were able to rely on cloud-based data systems, modern security protocols, and an agile organizational culture. They could deploy a wide range of digitally enabled processes to support the sudden switch to work-from-home and the new reality of virtual transactions and interactions with partners, vendors, citizens, and businesses. By contrast, those lagging in their digital initiatives struggled to adjust to the rapid economic and social changes.

High-impact initiatives

Global spending on the digital transformation of government services, business practices, products, and organizations is projected to reach $2.8 trillion in 2025—more than double the amount allocated in 2020.[17] Asia and the Pacific is set to become the new hotspot for digital transformation. India is championing digital public

[14] United Nations General Assembly. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development, seventieth session, agenda items 15 and 116 (A/RES/70/1).

[15] ADB. *Strategy 2030 Digital Technology for Development Directional Guide*.

[16] Stand-alone coverage of digital financial services or the digitalization of the financial sector are not a central feature of this report and will require a separate publication.

[17] *Business Wire.* 2021. New IDC Spending Guide Shows Continued Growth for Digital Transformation as Organizations Focus on Strategic Priorities. 9 November.

infrastructure (DPI) and digital public goods (DPGs).[18] These are high-impact initiatives that are people-centered and interoperable digital building blocks, allowing local players to innovate on top of these blocks, fostering new services for people and businesses (Box 1).[19]

Box 1: Digital Public Infrastructure

Digital public infrastructure (DPI) is defined as a set of shared digital systems, secure and interoperable, built on open standards and specifications to deliver and provide equitable access to public and private services. DPIs are governed by enabling rules to drive development, inclusion, innovation, trust, and competition, and respect human rights.[a]

DPIs, such as digital identification systems, digital payment gateways, and interoperable data exchange platforms, represent a central feature of the connected government of the future, and are intended to enable the rollout of integrated and inclusive citizen-centric services. Designed and implemented well, DPIs can support countries in achieving digital inclusion, accelerating the achievement of their Sustainable Development Goal targets, and reducing the risks that digital technologies bring.

Md. Yakub Ali holds a card for the prepaid meter for water irrigation in Bangladesh

[a] United Nations Development Programme. 2023. The DPI Approach: A Playbook. Based on G20 New Delhi Leaders' Declaration 2023.

Source: Asian Development Bank.

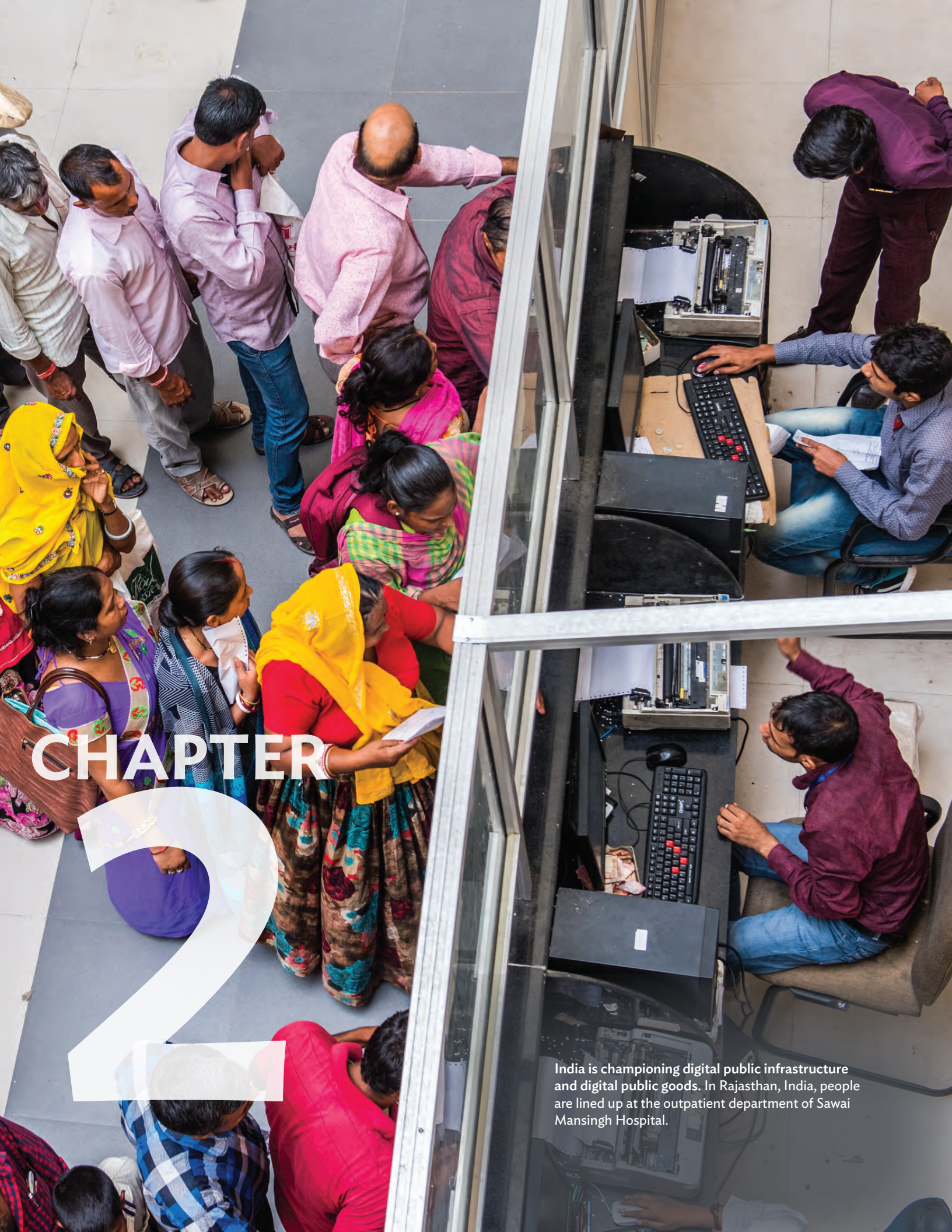
Strategically channeling investments in digital transformation to overcome barriers and challenges in SDG transformations is critical. Some common barriers and challenges faced by DMCs include creating an enabling legal and regulatory environment for digital transformation and innovative SDG solutions while addressing digital risks and threats. Other challenges include human and institutional capacity constraints to adopt and use digital technologies and data safely and responsibly, and inadequate foundational digital and data infrastructure to support advanced digital applications. Digital transformation for the SDGs needs to be equitable, inclusive, trustworthy, and resilient to climate change and cyber risks and threats (Appendix 2).

Strategically channeling investments in digital transformation to overcome barriers and challenges in SDG transformations is critical.

[18] Global Digital Public Infrastructure Repository. https://www.dpi.global/.

[19] UN. 2023. Digital Public Infrastructure: Scaling Inclusive and Open Digital Ecosystems for the SDGs. https://hlpf.un.org/sites/default/files/2023-09/Digital%20Public%20Infrastructure%20Brochure.pdf.

CHAPTER 2



India is championing digital public infrastructure and digital public goods. In Rajasthan, India, people are lined up at the outpatient department of Sawai Mansingh Hospital.

Chapter 2

DIGITAL READINESS AND MATURITY FRAMEWORKS

Numerous digital readiness and maturity frameworks exist (see the World Bank's Digital Government Readiness Assessment, the United States Agency for International Development's (USAID) Digital Ecosystem Country Assessments, and the United Nations' E-Government Framework in Appendix 1). Building on these frameworks, this report presents a new framework tailored to the ADB Strategy 2030 and its seven operational priorities, taking into consideration the varying digital readiness and maturity level of DMCs. The new framework comprises (i) the six SDG transformations mapped to ADB Strategy 2030 operational priorities, (ii) eight analog and digital readiness domains, and (iii) a five-level digital maturity model.

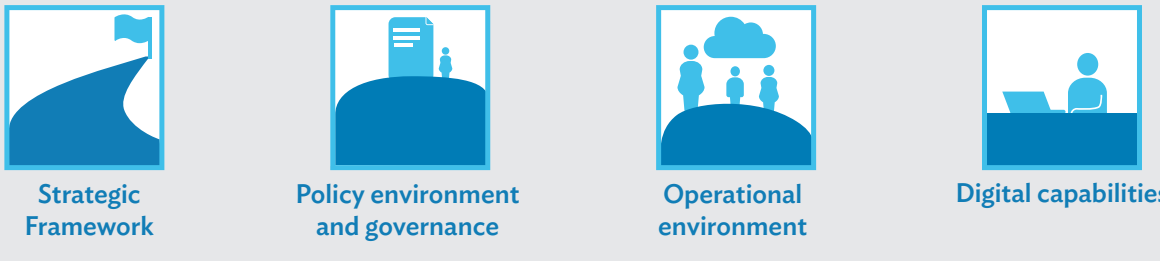
A digital readiness assessment can be instrumental for identifying and evaluating enabling conditions and core digital components for meeting SDG targets.

A digital maturity model (elaborated in Section 2.3) can be used to assess the digital readiness of an organization (e.g., government agency, city, company, farm, or development program) based on the eight domains of digital readiness. The digital maturity model does not offer a linear pathway or prescriptive advice and does not focus on a particular technology. Rather, the digital maturity model can be used to discern and map out linkages between the different dimensions, pinpointing areas where organizations require more support across the eight domains of the digital readiness assessment and provide entry points for digital transformation.

Enabling Conditions

Four key enabling conditions are shaping the trajectory of technological progress, which is best understood as a continuous process, interspersed with occasional opportunities for leapfrogging (Figure 3). Some examples of leapfrogging include providing telehealth diagnostic to remote areas, end-to-end delivery of government services, ability for real-time decision-making based on data availability, application of artificial intelligence (AI) for fraud detection in procurement and tax collections, and customized learning material in local languages and digital formats.

Figure 3: Four Key Enabling Conditions

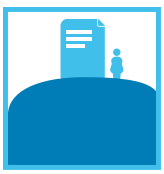


Source: Asian Development Bank.

Strategic framework. Digital transformation to enable the achievement of the SDGs requires collaboration across multiple sectors, agencies, and stakeholders. The process of strategy setting and forward planning to create a strategic framework that provides a common vision and understanding among stakeholders can help bring them together to coordinate, streamline, and accelerate impactful SDG actions. The strategic framework can draw on:

- national digital strategies and plans;
- national development plans and industry policies;
- national science, technology, and innovation policies and plans; and
- national SDG plans.

These serve to transform systems, business models, and processes to seize opportunities and help deliver strategic outcomes. A strategic framework should have key performance indicators to support monitoring and evaluation of progress toward digital transformation to achieve the SDGs. The Guidebook for the Preparation of Science, Technology and Innovation (STI) for SDGs Roadmaps—which was developed by a broad consortium of international agencies and benefited from consultations with many UN Member States—serves as a detailed policy tool.[20] Appendix 1 details the application of a conceptual framework and methodology for successful digital transformation and sound criteria for selecting technologies and vendors appropriate to a given context.



Policy environment and governance. Favorable policy, regulatory, and governance arrangements need to be in place for digital transformation to enable the achievement of the SDGs in an equitable and inclusive manner, while ensuring safeguards on personal data privacy, safety, and security. These include policies, laws, and regulations relating to critical areas such as data, cybersecurity and digital taxation, the establishment of institutions and standards, as well as key business processes that enable decision-making and accountability.

[20] European Commission and United Nations Interagency Task Team. 2021. JRC Publications Repository - Guidebook for the Preparation of Science, Technology and Innovation for SDGs Roadmaps. https://publications.jrc.ec.europa.eu/repository/handle/JRC124108.

A recent study found that trust underpins the deployment and use of technologies.[21] People need to trust that technology can solve a problem, that it will not fail and cause harm, and that it can deliver outcomes reliably. COVID-19 has shown that although digital technologies—such as contact tracing apps—can support public health strategies, a lack of concrete safeguards for data collection, and poor communication and accountability about their intended use, have raised suspicion and undercut their effectiveness in many countries. Trust is being undermined through pervasive surveillance, disinformation that may incite violence, and the exclusion of "data invisible" groups without a digital footprint or digital ID. The collection of large amounts of personal data and the frequent use of AI analytics in support of delegated decision-making have raised concerns about data misuse and misappropriation, and decision bias and discrimination. Data and technology governance frameworks need to be strengthened through trust-building provisions. Digital safeguards are imperative to support the management of privacy and security risks associated with digital technologies and platforms and promote responsible use of technologies and data (Appendix 2). ADB's Primer on Managing Digital Risks serves as an essential reference to comprehensively assess digital risks, including for cyberattacks, human rights violations, and vulnerable groups.[22] Equitable and inclusive digital transformation needs to address the needs of the poorest and most vulnerable people, including those who are not connected; empower them to take part in decision-making in a meaningful way; and ensure that digital transformation do not worsen existing inequalities.

Operational environment. This requires strategic leadership by government and the private sector, backed by an organizational culture and risk appetite that demonstrates and follows through with a credible commitment to transparency, user engagement, and adequate consumer protection (data rights). Champions are needed to set ambitious targets to operationalize digital solutions at scale, mobilize supportive coalitions, and enable action and investment in the use of data and technologies to make progress against a country's development goals. Partnerships for collective action and multistakeholder collaborations are essential to drive impact and systemic change at scale. Regular and effective communication among stakeholders is needed to facilitate collaboration and encourage digital adoption. This includes raising awareness about a government's digital support programs, such as financing, technical assistance, and incentives for digital adoption. It demands transparently reporting the results of digital programs and any outstanding challenges. It also calls for strengthening the flow of information from technology producers and knowledge providers to micro, small, and medium-sized enterprises (MSMEs) and start-ups.

Digital capabilities. Individuals and institutions must acquire the digital capabilities and skills needed to adopt and use more sophisticated technologies and participate in the design and production of scalable products and services that contribute to SDG achievement. Moreover, individuals in leadership positions need to acquire the capabilities and model the behavior needed for leading change initiatives and supporting the adoption of technologies and use of data for decision-making. The lack of digital skills is well recognized as a major barrier to digital transformation.[23] A significant amount of knowledge is needed to not just use frontier technologies, but also to identify which technologies provide added value and learn how to adapt them to different conditions. Hence, awareness and technical knowledge is a prerequisite to identify needs, define specifications, and critically assess the appropriate products and services for procurement, production, and delivery.

In the public sector, it is important to develop digital capabilities to re-engineer end-to-end business processes, design user-centric platforms, or enter into partnerships with the private sector in operating, maintaining, and upgrading these systems. Contract management and the enforcement of safeguards on market power, data use, and stakeholder involvement are crucial capabilities that need attention from the very beginning. For the private

21 Ada Lovelace Institute. 2020. No Green Lights, No Red Lines. November. https://www.adalovelaceinstitute.org/report/covid-19-no-green-lights-no-red-lines/.

22 ADB. 2023c. *Managing Digital Risks: A Primer.* Manila.

23 A. Aagaard et al. The Role of Digital Maturity Assessment in Technology Interventions with Industrial Internet Playground. Electronics. No. 10. January: 1134. https://doi.org/10.3390/electronics10101134.

sector, key digital capabilities include leveraging external expertise such as business advisory services, technology extension services, and technology centers that assist with digital transformation. Business advisory services typically target MSMEs and support the digital upgrading of general business functions, such as digitalization of accounting and marketing, human resource services, supply chain coordination, and quality management. Technology extension services provide on-site help to companies through extension staff and field offices to foster technological and knowledge-based modernization to improve competitiveness.[24] This approach is well-suited for specialized digital applications, for example, supporting production technologies and innovation capability in agriculture and manufacturing.

Government-supported technology centers and hubs tend to offer a range of technological and innovation services to companies, support sector-specific research and development (R&D) programs and demonstration pilots and adapt existing market technologies to local needs. Ideally, these centers work closely with industry and research institutions, and operate at the heart of regional innovation systems. Technology centers can anchor support measures such as pilot factories or fabrication labs with modern manufacturing equipment and offer training in new production techniques and processes, as well as product design, testing, commercialization, or legal services. They can be hosted at (or be collocated with) research institutions or technology parks, and, depending on context, seed or support the emergence of trade and industry clusters. One of the best-known applied research networks globally is the Fraunhofer Institutes in Germany, which works closely with industry and the research sector. Its 4IR competence centers aim to advance innovative technologies and bring digitalization and networking technologies to German manufacturing companies.[25] Similarly, the aim of India's Technology Centers Network is to provide access to advanced manufacturing technologies and upgrade technical skills among the youth. A key strength of this instrument is to open markets for services and training that are not yet offered by private providers.

A significant amount of knowledge is needed to not just use frontier technologies, but also to identify which technologies provide added value and learn how to adapt them to different conditions.

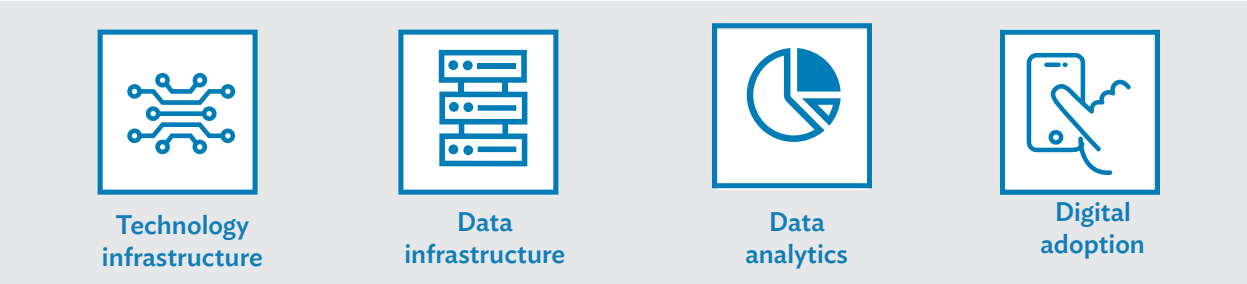
[24] The National Institute of Standards and Technology operates the Manufacturing Extension Program (MEP) as a public–private partnership with centers in all 50 states in the United States (US) and Puerto Rico to serve small and medium-sized manufacturers. MEP centers report interactions with over 27,000 manufacturers, leading to $13 billion in sales, $2.7 billion in cost savings, $4.9 billion in new client investments, and the creation and retention of more than 100,000 jobs.

[25] Competence Centers - Fraunhofer ISI. Fraunhofer Institute for Systems and Innovation Research ISI. https://www.isi.fraunhofer.de/en/competence-center.html.

Core Digital Components

The digital readiness assessment framework encompasses four core digital components. These hold the potential for significant cost reductions, measurable service improvements, and improved coordination, including across whole-of-government (Figure 4).

Figure 4: Core Digital Components



Source: Asian Development Bank.

Technology infrastructure. This is the physical and software-based infrastructure necessary to deliver digital products and services. It includes the fiber infrastructure, server hardware and software, information technology (IT) virtualizations, and operating systems. High-speed broadband connectivity and network-connected computers, devices, and sensors are needed to build digital applications and leverage frontier technologies, including generative AI (Box 2), the Internet of Things (IoT), big data analytics,[26] distributed ledger technologies, and robotics.

Data infrastructure. This component comprises the hardware, software, and networking technologies used to support the generation, storage, processing, management, sharing, and integration of datasets with increasing levels of sophistication. It includes databases, data warehouses, data centers, and cloud computing platforms. Data infrastructure enables the consolidation and integration of data from multiple sources, and the efficient retrieval, indexing, and organization of data, making it easier for users to find and access the data they need. The IoT enables the collection and exchange of data such as biometric data, behavioral information, and unstructured information, through network-connected sensors and devices that operate mostly without human intervention. Broadband technologies enable data transmission to data storage locations in the cloud. Cloud technologies provide the computing power to run AI systems. AI systems can then use the collected data to build up their intelligence capabilities. The data infrastructure also provides security features and protocols to protect sensitive data from unauthorized access, theft, or misuse.

Data analytics. This dimension involves the analysis of large volumes of data from various sources (e.g., sensors, mobile devices, social media platforms), including in real-time, and performing complex data analysis and modeling. This allows the extraction of useful insights for reporting, prediction, and decision support. Descriptive analytics can tell us what has already happened, predictive analytics shows us what could happen, and prescriptive analytics indicates what should happen in the future. Findings can be visualized in the form of charts, graphs, and dashboards; shared with key stakeholders; and used to make informed, data-driven strategic decisions, or undertake predictive maintenance on infrastructure assets.

[26] ADB. 2022a. *Harnessing the Potential of Big Data in Post-Pandemic Southeast Asia.*

Box 2: Generative Artificial Intelligence for the Sustainable Development Goals

Generative artificial intelligence (AI) creates new and original content, such as text, images, and videos, based on patterns learned from large datasets. This capability can contribute to innovative solutions for achieving the SDGs. For example, generative AI models can analyze large and complex datasets on population density, transportation patterns, energy consumption, environmental factors, or consumer preferences. Based on these datasets, optimized urban plans can be generated to maximize resource efficiencies and minimize carbon emissions. AI models can also analyze user data to tailor services and guidance to users' needs, such as through chatbots and virtual assistants. However, the effectiveness of generative AI depends on the availability of extensive and diverse datasets for training and evaluating its models. Such data may be scarce or of inferior quality in DMCs due to data fragmentation, gaps, inconsistencies, inaccuracies, and lack of standardization, which may lead to biased and discriminatory outcomes. Privacy and security concerns also need to be addressed.[a]

[a] L. Schou-Zibell and B. Kong. 2023. Your Questions Answered: Generative AI and Financial Inclusion. Asian Development Blog. 11 December. https://blogs.adb.org/blog/your-questions-answered-generative-ai-and-financial-inclusion.

Source: Asian Development Bank.

Digital adoption. Digital technologies can be adopted at individual, household, organizational, community, or nationwide level. Digital applications comprise any software or program that runs on devices, such as computers, mobile phones, and tablets, among others. Examples of digital applications for individuals include digital wallets for making and receiving payments, and education applications for e-learning. An example of a household-level digital application is the pay-as-you-go solar home rooftop system. Business productivity applications can help MSMEs improve operations, sales, marketing, and communication. Social media platforms can support community building. Large-scale applications involve investments in smart cities, smart grids, and intelligent transport systems to optimize operations as part of SDG transformation. The digitalization of the finance sector enables digital transformation for sustainable development, promoting financial inclusion, enhancing efficiency and transparency in transactions, and fostering innovation.

Digital risks associated with the technology infrastructure, data infrastructure, data analytics, and digital adoption include security, privacy, ethical risks, third-parties, business continuity, and legal and regulatory compliance. Digital risks create uncertainties, may cause financial and reputational losses, and can derail digital transformation initiatives. For public sector agencies, digital risks may involve the inability to deliver services and the accompanying erosion of social cohesion and trust in institutions, a decline in competitiveness, and/or a loss in revenues. Assessing both the opportunities and risks associated with digital technologies is imperative for digital transformation. ADB has developed a digital risk scan and a country digital risk diagnostic to support DMCs in their digital transformation (footnote 19).

Digital Maturity Model

The digital maturity model is made up of five levels of maturity, with the first level being a nascent state and the fifth level being an optimized state (Figure 5).

As countries or programs progress along their digital maturity, they gain additional capabilities to adopt and integrate more complex, frontier technologies, such as AI and distributed ledger technologies (infrastructure and protocols that allow simultaneous access, validation, and record updating across networked databases), to meet the SDGs. The nature and scale of digital transformation interventions also moves from local pilot or stand-alone systems to integrated, scalable applications that may lead to nationwide adoption. These are ideally interoperable and integrated systems and platforms of greater complexity. Refer also to Appendix 1 for a benchmarking of countries' frontier technology readiness.

At the first level of maturity, technology used to help meet the SDGs is ad hoc and disjointed. Organizations are not yet digitally enabled. Infrastructure, data, and skills are lacking, and policies and regulations are not defined.

At the second level, digital interventions are largely reactive and developed in silos. Organizations may have acquired basic digital capacity for data processing, storage, and descriptive analytics and are developing policies and regulations. The emerging digital and data infrastructure is allowing the development of these digital functionalities.

At the third level, digital services and products are being adopted, including experimentation with AI and data analytics. Resources for digital transformation are available but not sufficient for optimal operations. Full integration of systems is lacking, limiting SDG outcomes. Digital literacy and skillsets among the workforce are at an intermediate level; common policies, regulations, and standards are adopted across sectors, such as a national digital transformation strategy and plan.

Solar street lamps in Nepal. Digital connectivity is key to intelligent multimodal transport systems.

Figure 5: Digital Maturity Model

MATURITY LEVELS: Basic → Advanced

ENABLING CONDITIONS	1	2	3	4	5
STRATEGIC FRAMEWORK	Absent	Nascent	Foundational	Intermediate	Integrated
POLICY ENVIRONMENT AND GOVERNANCE	Nascent	Developing	Defined	Managed (fully aligned)	Optimizing and effective
OPERATIONAL ENVIRONMENT	Unaware	Reactive	Proactive	Managed	Continuous learning
DIGITAL CAPABILITIES	Nascent	Basic	Intermediate	Advanced	Applied and innovative
CORE DIGITAL COMPONENTS					
TECHNOLOGY INFRASTRUCTURE	Nascent, disjointed (hardware connectivity)	Emerging, standardized, coordinated (software infrastructure)	Consolidated, virtualized (network connectivity)	Pooled, service-based (operating system)	Value-based (service-based delivery models)
DATA INFRASTRUCTURE	Data capturing (apps and individual data sets)	Data processing and storage	Information exchange and common standards	Interoperability	Integration
DATA ANALYTICS	Ad hoc summary reporting	Descriptive analytics, periodic reporting	Diagnostic analytics, strategic reporting	Predictive analytics, data visualization	Prescriptive modeling, augmented decision-making
DIGITAL ADOPTION	Nascent	Developing (individual user)	Defined (point-of-service)	Managed (system level)	Optimizing and effective (population level)

Source: Asian Development Bank.

At the fourth level, a pool of talent with advanced digital skills and sufficient resources earmarked for digital transformation enables widespread development and adoption of digital services by citizens and businesses, in line with digital transformation strategies and plans. Digital processes and systems are increasingly interoperable across government agencies and sectors, and a data governance framework is in place for data exchange and predictive analytics to support decision-making.

At the fifth level, full digital transformation is realized to accelerate SDG progress. The focus is on continually improving performance and application of new innovations. Digital processes and systems are fully automated and integrated across government agencies and sectors. A highly skilled labor force works collaboratively to develop world-class digital products and services, which are user-centric, and designed with highly engaging user experience and inclusivity, as part of a design thinking process. Policies and regulations are forward-looking and support continual digital innovation and increased agility.

One of the key bottlenecks that needs to be addressed when transitioning from one level of maturity to the next is the need for continued leadership engagement in pursuing a digital road map adapted to country circumstances. Foundations for successful digital transformation include:

- the upgrading of the technology and data infrastructure through public–private partnerships (PPPs);
- addressing key policy gaps (e.g., data privacy, interoperability, cybersecurity, common data standards); and
- continuously upgrading digital capabilities, skills, and literacy, especially among vulnerable groups.

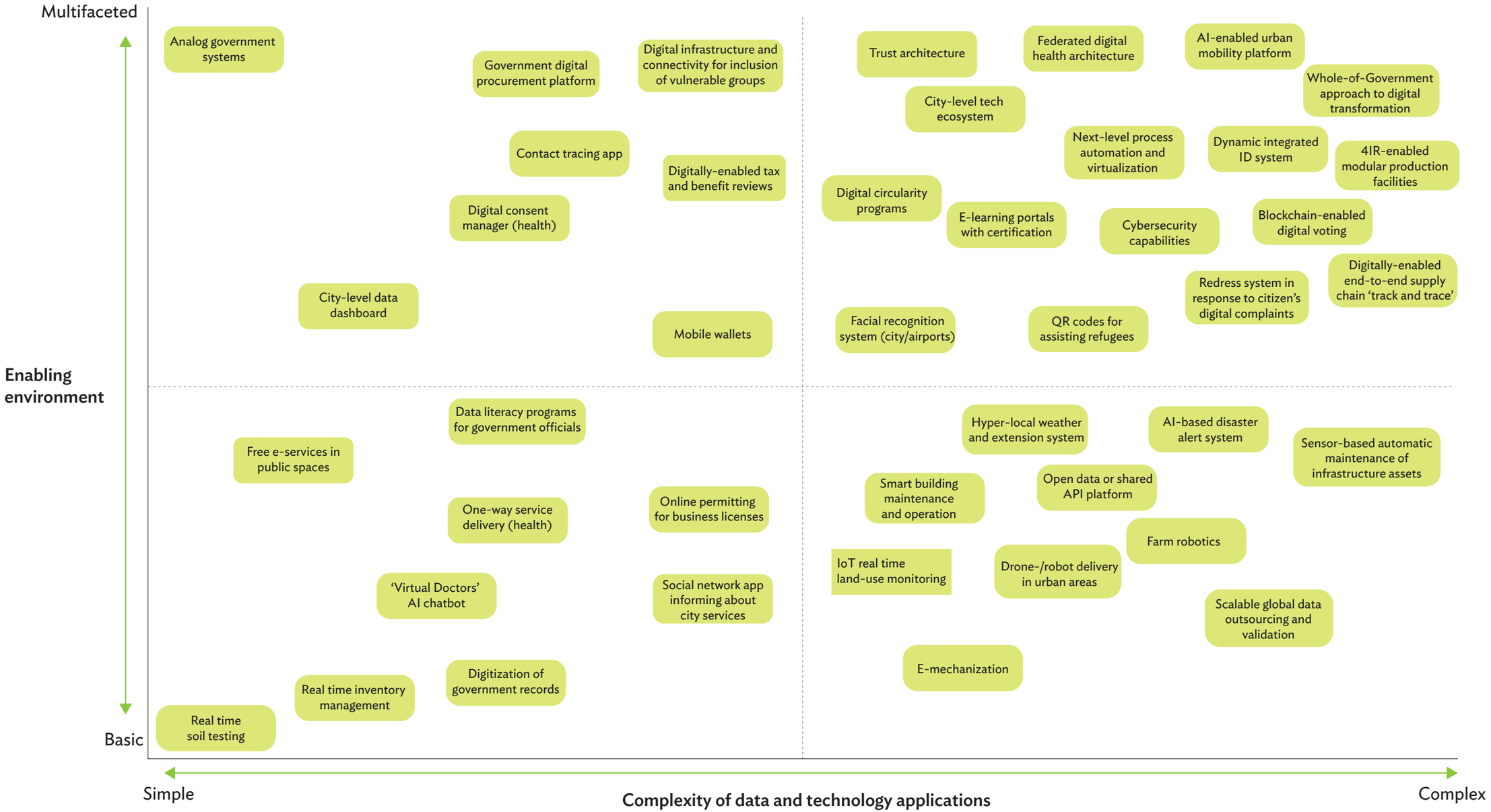
It is important to recognize digital transformation as a journey that is fundamentally preoccupied with changing business processes, mindsets, and achieving outcomes in different ways than before. This includes opening opportunities for private sector participation (e.g., data services, digital innovation) in a competitive landscape, and putting in place mechanisms to ensure that consumer and citizen-facing applications are designed, tested, and rolled out with the end-users in mind and with an understanding of culturally-appropriate behavioral change to encourage adoption.

Conducting a digital gap assessment is a strategic intervention in the preparation of road maps, which includes (i) the identification and stocktaking of operations and services that are digitalized, yet to be digitalized, and can and should be digitalized; (ii) determination of resource needs—finance, technology, and people; (iii) skills and knowledge gaps; and (iv) the availability of digital training and skill development programs.

ADB is progressively expanding its support to DMCs to advance along the digital maturity continuum and promote a design thinking approach. This framework can guide ADB sector groups in fine-tuning their sector-based strategic road maps. Figure 6 maps out examples of digital application complexity and enabling environments. The next section offers potential entry points for digital transformation to enable the achievement of the SDGs in line with ADB's operational priorities.

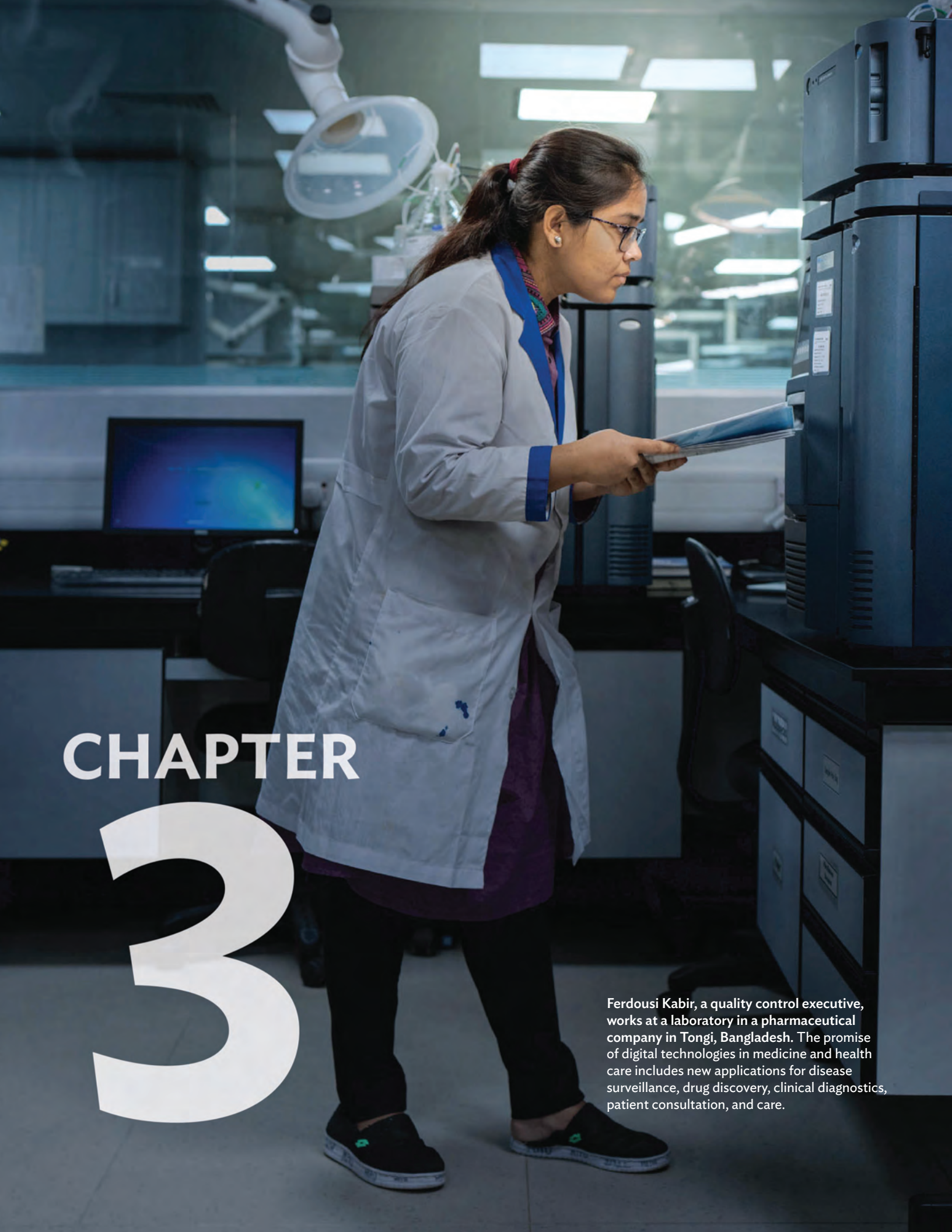
As countries or programs progress along their digital maturity, they gain additional capabilities to adopt and integrate more complex, frontier technologies, such as AI and distributed ledger technologies.

Figure 6: Examples of Digital Application Complexity and Enabling Environments



4IR = fourth Industrial Revolution, AI = artificial intelligence, API = application programming interface, IoT = Internet of Things.

Source: ADB.

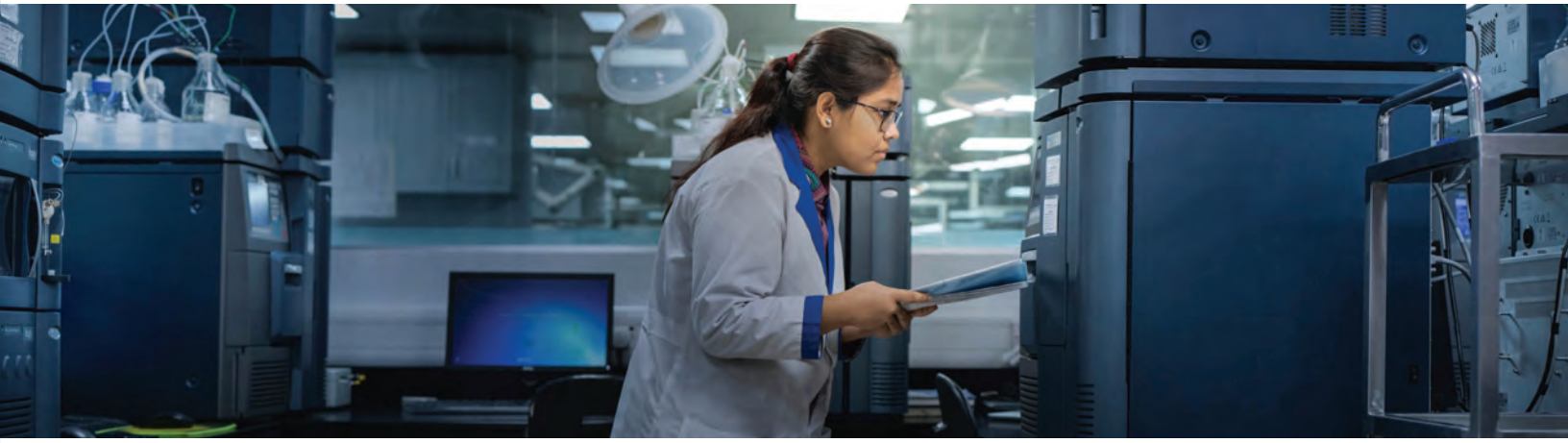


CHAPTER 3

Ferdousi Kabir, a quality control executive, works at a laboratory in a pharmaceutical company in Tongi, Bangladesh. The promise of digital technologies in medicine and health care includes new applications for disease surveillance, drug discovery, clinical diagnostics, patient consultation, and care.

Chapter 3

DIGITAL TRANSFORMATION ROAD MAPS FOR THE SUSTAINABLE DEVELOPMENT GOALS



Digital transformation strategies that require systemic reforms are rarely linear and typically involve multiple iterations to achieve their intended outcomes, requiring adaptive learning mechanisms throughout. This section highlights the key challenges faced in the six SDG transformation areas and illustrates digital strategies and interventions to address challenges and accelerate the achievement of the SDGs (footnote 10). Digital transformation case studies and good practices from Asia and the Pacific and other regions are presented in each of the six SDG transformation areas and in Appendix 3.

Sustainable Development Goal Transformation #1

Human Capital Enhancement, Quality Jobs, and Equality

This section focuses on peoples' capacity to fully realize their human potential, which crucially depends on health, education, meaningful job opportunities, and social protection against adverse shocks in line with ADB's Strategy 2030 Operational Priorities 1 and 2. With about half of the region's population still digitally excluded, an inclusion-focused strategy for SDG transformation needs to focus on (i) building and protecting human capital (through health, education, and social protection programs); (ii) acquiring and utilizing skills and knowledge; and (iii) devising empowering policies and supportive institutions. The integration of technologies such as AI, data analytics, and virtualization, can transform traditional delivery and service models in education and health care to enable personalized adaptive learning based on a student's needs and introduce new applications for disease surveillance, drug discovery, and patient diagnostics and care with the help of telemedicine. Changes in labor markets brought about by the impact of digital technologies on jobs can boost new flexible jobs but are also exposing workers, especially women in the informal economy, to insecure working conditions—creating new urgency for lifelong skill development and social protection schemes.

Overview

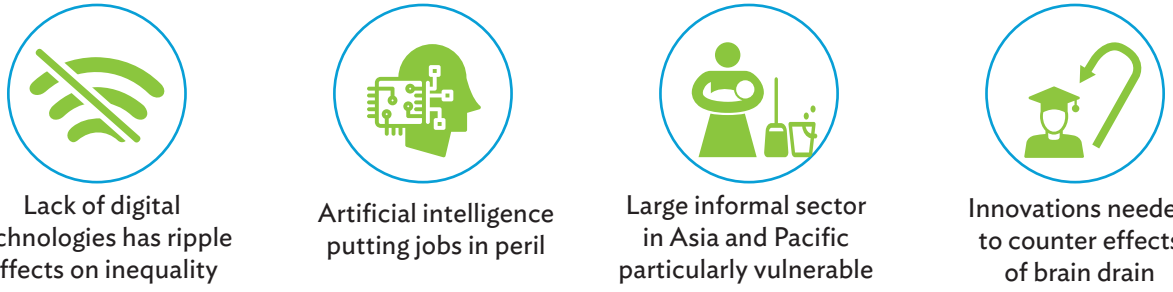
Asia and the Pacific has made great strides in poverty reduction through rapid economic growth. Extreme poverty is expected to continue to fall from 3.9% in 2022 to 1% by 2030 in the region.[27] However, over a third of the region will experience moderate poverty and economic vulnerability. Moreover, poverty reduction has not translated into an equitable distribution of income and opportunities. Many people are still excluded from access to quality education, health, and social protection services, especially women and girls. Although the gap between the number of years boys and girls attending school has narrowed, and there are more women than ever in the labor market, large inequalities remain. Women are generally paid less than men, take on a larger proportion of unpaid care and domestic work, and are more likely to experience discrimination, violence, and exploitation. Women are also less likely than men to have access to digital technologies and the skills to use them.

As DMCs recover from the COVID-19 crisis, multiple threats brought on by climate change, conflict, and food insecurity mean even more effort is needed to bring people out of poverty and ensure equality. Empowering vulnerable groups with digital technologies and skills can help boost their resilience to shocks and provide pathways out of poverty.

[27] ADB. 2023. *Key Indicators for Asia and the Pacific 2023*, 54th Edition.

Challenges

Figure 7: Challenges to Digital Transformation to Enhance Human Capital, Create Quality Jobs, and Reduce Inequalities



Source: Asian Development Bank.

With rapid digitalization catalyzed by the COVID-19 pandemic, and economies embracing digital transformation, the lack of access to digital technologies has ripple effects on inequality of opportunities in education, employment, knowledge, networks, market information, and public services.

The COVID-19 pandemic, which led to a shift to remote and hybrid learning, exposed the disparities in access, quality, and integration of digital technologies in education systems. This has accelerated demands to transform the education sector to address the global learning crisis and the learning losses caused by the pandemic. In the health sector, the pandemic has intensified demands and opportunities, particularly in the innovative use of digital technologies and data for health system strengthening, disease surveillance, and remote consultations through telemedicine. The pandemic also highlighted the urgent need for well-functioning social protection systems, evidenced by the fact that half of the region's population has no protection coverage.[28]

View of the housing complex in Colombo, Sri Lanka in March 2020, under COVID-19 island-wide curfew. To have or not have access to digital technologies has ripple effects on inequality.

[28] ILO News. 2020. Critical Gaps in Social Protection Hampering Asia-Pacific Region's Resilience to COVID-19. 15 October. https://www.ilo.org/resource/news/critical-gaps-social-protection-hampering-asia-pacific-regions-resilience.

Labor markets are becoming increasingly complex due to a range of issues such as gig work, underemployment, demographic shifts, outmigration, and the impacts of digital and technological evolution. AI and robotics threaten jobs that require routine skills. According to estimates, applied AI and next-level automation will eliminate 14% of existing jobs (out of a global workforce of 3.3 billion) over the next 15–20 years, while another 32% of jobs will change because of automation.[29]

As permanent employment may gradually decline, we may see the emergence of new types of arrangements, such as pop-up enterprises, where algorithms will locate and assemble teams of skilled workers to take on a particular project, only to be disengaged upon completion and reconfigured for the next task. Consequently, skills development and lifelong learning are becoming more important, and new forms of social protection are needed to address new vulnerabilities resulting from the informality, temporality, and mobility of work.

The region has a large informal sector where workers face poor working conditions, unstable incomes, and vulnerability to shocks such as natural hazards or illnesses because they lack job-related benefits. Seven out of 10 informal workers in developing Asia and the Pacific are women.[30] While e-commerce and the gig economy can boost job creation and generate new flexible work opportunities, they have also come under scrutiny for low wages, unfair labor conditions, and lack of social protection.

Many DMCs are confronted by the brain drain challenges that affect human capital and the capacity to innovate. Incentives and interventions are needed to retain talent and encourage "brain circulation," which can include introducing incentives for migrants to permanently return to their home countries, connecting with the diaspora network for knowledge and technology transfers, and financing business ventures.

Students attend their computer class at Shree Rastriya secondary school in Solta village, Kailali, Nepal. Access to digital technologies increases opportunities in education.

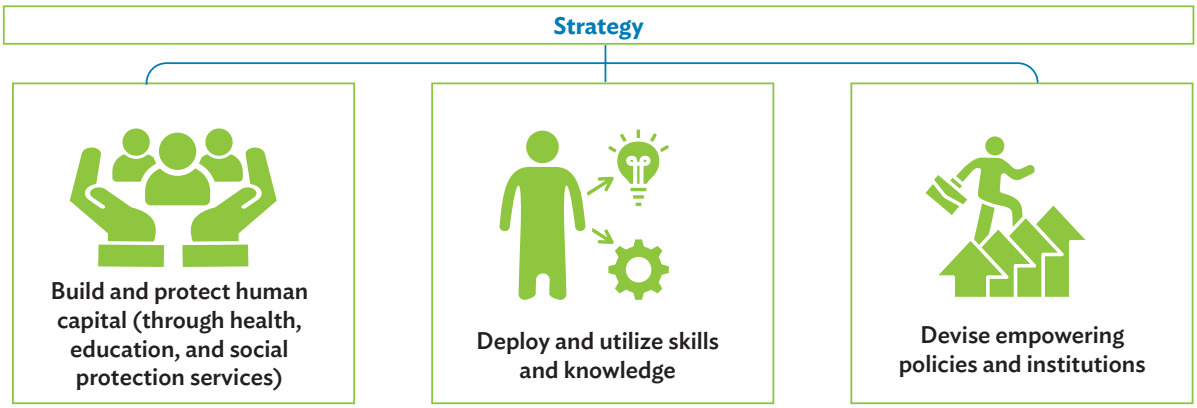
[29] Organisation for Economic Co-operation and Development (OECD). 2019. *OECD Employment Outlook 2019: The Future of Work.* https://www.oecd-ilibrary.org/employment/oecd-employment-outlook-2019_9ee00155-en

[30] ADB. 2021. Investing in Gender Equality will Build Resilience to Future Shocks. Article. 7 October. https://www.adb.org/news/features/investing-gender-equality-will-build-resilience-future-shocks#:~:text=to%20Future%20Shocks-,Investing%20in%20Gender%20Equality%20Will%20Build%20Resilience%20to%20Future%20Shocks,in%20the%20worsening%20climate%20crisis.

Digital Transformation Strategies to Enhance Human Capital, Generate Quality Jobs, and Reduce Inequalities

Digital technologies can help address poverty and reduce inequalities through three strategic means: (i) building and protecting human capital, (ii) deploying and using human capital, and (iii) enabling digital transformation through policies and institutional strengthening (Figure 8).[31]

Figure 8: Digital Transformation Strategies to Enhance Human Capital, Create Quality Jobs, and Reduce Inequalities



Leverage digital technology contributions to accelerate the buildup and protection of human capital throughout people's lives (preventive health care, diagnosis, treatment, telehealth; tele-education, computer-assisted learning, augmented/virtual reality, games.)

Improve data-driven targeting and enrollment of social protection programs aimed at poor, vulnerable, and unemployed groups

Deploy technologies to transform delivery systems (digital IDs, data platforms, digital payment) and empower users in availing services

Adapt workers' education, training, and skills to thrive in a data- and technology-driven world in manufacturing and services

Incentivize specialized human capital (e.g., scientists, engineers) to develop and produce new technologies in a well-functioning innovation ecosystem that contribute to human capital (e.g., drug discoveries, advances in agricultural productivity)

Seize technological advances to improve the performance of other sectors contributing directly or indirectly to human capital (e.g., nutrition, clean water, digital infrastructure, clean air technologies)

Engage stakeholders to set up technology governance systems, policies, norms, and social contracts for agency and human security

Promote the use of science and technology for economic growth, inclusion, and resilience across sectors (e.g., crisis preparedness and response mechanisms)

Source: Adapted from S. Bashir et al. 2021. The Converging Technology Revolution and Human Capital. In *The Converging Technology Revolution and Human Capital: Potential and Implications for South Asia.* World Bank. https://doi.org/10.1596/978-1-4648-1719-9_ch2.

[31] S. Bashir et al. 2021. The Converging Technology Revolution and Human Capital. In *The Converging Technology Revolution and Human Capital: Potential and Implications for South Asia.* The World Bank. https://doi.org/10.1596/978-1-4648-1719-9_ch2.

Build and protect human capital. With about half of the region still digitally excluded, an inclusion-focused digital transformation process can build a society's human capital, ensure equitable access for marginalized and vulnerable groups, and protect people against adversities. This involves accelerating equitable access to digital infrastructures and technologies for education and digital literacy, resolving access barriers to health care (e.g., telemedicine), and expanding the eligibility and coverage of social protection programs through the innovative use of digital technologies to meet the needs of all segments of society, particularly underserved groups. Digital transformation offers the opportunity to reimagine the delivery of education, health, and social protection services, aiming for greater access, effectiveness (targeting, customization, personalization), and efficiency. Good practices include the PRC's digital transformation in education (Case Study 1), Sri Lanka's leverage of the District Health Information Software 2 (DHIS2), a globally recognized open-source health information management system and also a DPG for COVID-19 surveillance and vaccine delivery (Appendix 3), and Maldives' development of an integrated and dynamic social registry to increase social protection coverage and reach those most vulnerable (Appendix 3). With greater digitalization of the economy and society, access to digital technologies and digital skills will be essential to overcoming the challenges ahead, and creating a more equitable, inclusive, and resilient society that is prepared for future shocks. Therefore, it is important to fast-track access to digital technologies and connectivity, alongside training teachers on how to use the technology, and educational reforms to enhance the quality and relevance of education.

The integration of technologies such as AI, data analytics, and virtualization technologies in education can transform traditional teacher-centric content delivery models into learner-centered approaches. In this modality, teachers become facilitators, coaches, and mentors who empower personalized adaptive learning, improve student engagement, offer individualized content and feedback, and prioritize student needs. They promote lifelong learning and increase global access to educational opportunities.[32] With rapid advancements in digital technology, the types of digital skills and competencies needed are changing fast, and learning content needs to be continuously reviewed and updated to remain relevant. AI applications can offer highly personalized and relevant content cost effectively and at a high quality. Agile approaches are needed to keep pace in tailoring

Khuruthang Vocational Training Institute trains youth, one-third of them women, to become electrical and mechanical engineers.

[32] ADB. 2023. *Reimagine Tech-Inclusive Education: Evidence, Practices, and Road Map*.

Case Study 1

Digital Transformation in Education in the People's Republic of China

Through the 5- and 10-Year Education Plans of the People's Republic of China (PRC), the government has made considerable progress in digital transformation in education over the past decades, focused on enabling core infrastructure and allocating funding for hardware and software, especially in rural and remote areas. According to the 2018 Programme for International Student Assessment data, more than 90% of Chinese students were enrolled in schools that had an effective online learning support platform, significantly higher than the average for Organisation for Economic Co-operation and Development economies.[a] In addition to infrastructure, the government has invested heavily in teacher training to build their digital skills and competencies, and in the creation of digital learning resources. More recently, the government's emphasis has been on improving educational management, regulations, and standards.[b] Overall, a clear vision and strategy for digital transformation in education from the highest level of the education system has served as a collective road map.

The PRC's advancement in artificial intelligence and other high-tech fields is driving schools to introduce digital literacy and coding earlier, which in turn requires teachers to upgrade their knowledge and integrate the subjects into the curriculum. The China Education Technology Standards (CETS) were introduced in 2004 and completion of the CETS course is now a mandatory prerequisite to obtaining the national teaching certificate. In-service training under the CETS initiative has helped teachers establish core technology-related competencies.[c] Government policies also incentivize innovation, research, and knowledge sharing in digital technologies for education. Advances in technology coupled with the evolving needs and capacities of digital-native students and their parents have also influenced education technology companies to continually improve product design. This improvement includes making use of AI, machine learning, and big data to improve instructional quality and deliver personalized learning experiences. The PRC is the world's largest investor in machine-based personalized learning (footnote a).

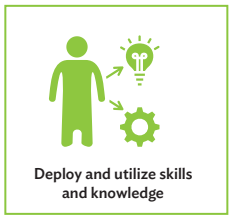
[a] J. Hallgarten and R. Fitzpatrick. 2020. EdTechHub Report: What Can be Learnt from China's Recent Experiences with Covid-19 and School Closures that Can Inform Other Countries' Education Technology-enabled Responses? Education Development Trust. https://edtechhub.org/wp-content/uploads/2020/09/EdTech-Hub-China-Report.pdf.
[b] W. Zeng. 2022. An Empirical Research on China's Policy for ICT Integration in Basic Education from 1988 to 2021. *Educational Technology Research and Development. 70* (3). pp. 1059–1082. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8856877/.
[c] Omidyar Network. 2019. Scaling Access and Impact: Realizing the Power of EdTech – China Country Report.

Source: Authors.

learning content and providing micro-certifications. Adaptable, flexible, and self-guided learning environments are likely to challenge current institutional setups (e.g., universities). ADB's digital education readiness framework can support DMCs to assess their preparedness to deliver education using digital technology.[33]

With health-care systems underfunded, ill-equipped, and understaffed, the promise of digital technologies in medicine and health care includes new applications for disease surveillance, drug discovery, clinical diagnostics, patient consultation and care through telemedicine, and health-system management.[34] These solutions have the potential to improve the speed, reach, and cost effectiveness of many health-care measures. Capacity building of government agencies and skill development of health care workers are needed to incorporate digital solutions in the health sector, and organize, manage, and integrate siloed data systems, while ensuring safeguards on personal data privacy, safety, and security. DMCs can refer to the Global Digital Health Monitor, which is aligned with the World Health Organization's Global Digital Health Strategy.[35] There is also the World Bank's Digital Health Assessment Toolkit to assess, monitor, and improve the environment for effective use of digital health technology.[36]

In transforming social protection, digital technologies can support citizens' registration for social protection programs and expand coverage. They can improve beneficiaries' experience (delivering prompt and efficient payments through mobile and online channels), manage grievance redressal, and reduce opportunities for fraud. In an effort to develop inclusive and shock-responsive social protection systems, some countries are experimenting with the use of nontraditional data sources. These include mobile phone records, phone-based location data, social media data, satellite imagery, and financial transactions, and the application of digital tools such as AI and big data analytics. They can help better identify vulnerable groups in need of social protection. The World Bank's Sourcebook on the Foundations of Social Protection Delivery Systems is a key reference framework for this. [37]



Deploy and utilize skills and knowledge. Digital transformation will require the strategic deployment and utilization of human capital in the labor market. Although the scale of the impact of technology adoption and automation on employment is difficult to gauge, job losses and displacement are likely to be significant, raising the need for massive upskilling and reskilling as well as adaptive social protection and insurance programs, including for informal sector workers.[38] Following the rapid, large-scale adoption of AI applications and large language models, and robotics, the latest estimates for global job losses in the 5 years to 2028 range from 83 million to 300 million.[39] Skills development policies and strategies need to integrate the building of digital literacy, job-market-relevant competencies, and hard-to-automate skills. Support to enhance women's employability and entrepreneurship, improve access to higher-paying jobs, and increase the number of women in leadership and management positions in the ICT sector would contribute to the attainment of gender equality. A useful reference for DMCs is the Institute of Electrical and Electronics Engineers 3527.1 Standard for Digital Intelligence, a global framework for digital literacy, skills, and readiness.[40]

33 ADB. 2023. *Toward Mature Digital Education Ecosystems: The Digital Education Readiness Framework*.

34 K. Tilmes. 2021. Emerging Lessons on AI-Enabled Health Care. *African Center for Economic Transformation.* 24 May. https://acetforafrica.org/research-and-analysis/insights-ideas/commentary/emerging-lessons-on-ai-enabled-health-care/.

35 Global Digital Health Monitor. https://digitalhealthmonitor.org/.

36 World Bank. 2021. Digital Health Assessment Toolkit Guide.

37 K. Lindert et al. 2020. *Sourcebook on the Foundations of Social Protection Delivery Systems.*

38 ADB. 2018. *Asian Development Outlook 2018: How Technology Affects Jobs.*

39 J. Kelly. 2023. Goldman Sachs Predicts 300 Million Jobs Will Be Lost Or Degraded By Artificial Intelligence. Forbes. March. https://www.forbes.com/sites/jackkelly/2023/03/31/goldman-sachs-predicts-300-million-jobs-will-be-lost-or-degraded-by-artificial-intelligence/.

40 DQ Institute. What is the DQ Framework? Global Standards for Digital Literacy, Skills, and Readiness (IEEE 3527.1 Standard for Digital Intelligence (DQ)). https://live.dqinstitute.org/global-standards/.

Another important relationship is between human capital and the creation and adaptation of technology. Specialized human expertise (e.g., scientists, engineers) operating in a well-functioning innovation ecosystem is a critical input in the development of new technologies, both for the sectors that directly contribute to producing human capital as well as for those indirectly contributing to it. It will also enable countries to adapt and diffuse technologies for their local needs and develop scalable business models to accelerate their deployment. For example, advances in agricultural productivity and improved, low-cost water and sanitation facilities may have big impacts on reducing child malnutrition; technologies that help improve the environment can reduce air and water pollution and enable livable cities.

Devise empowering policies and institutions. Concerns about inequality and empowerment are central to the analysis of human capital. The diffusion and adoption of new technologies tend to favor, particularly in the initial stages, the more educated, who enjoy greater access to financial and other complementary assets. Thus, policies and institutional systems need to be in place to offset the tendency toward a deepening of inequalities and support inclusive, sustainable, and resilient digital transformation that is based on transparency and trust. A second set of concerns relates to the risks to human beings posed by the dual-use nature of many technologies, the attendant loss of empowerment and agency, as well as the often unaddressed ethical, moral and social issues the arise. Policymakers should consider the governance of technology and how to make its use and future deployment transparent and accountable.

A national digital transformation policy and sector-wide digital transformation strategies can provide a common vision and promote coordinated actions across existing silos and engage stakeholders across government, the private sector, and civil society to accelerate impactful SDG actions. Start-up entrepreneurs, MSMEs, and industry all benefit from policy measures that promote digital skills development. But these will also require access to finance, credit, incentives, and social protection, and clear guidance on integrating proper safeguards to manage risk within the design, deployment, and use of digital technologies.

Figure 9 provides an overview of digital transformation interventions to enhance human capital, generate quality jobs, and reduce inequalities by digital maturity level.

Ananya Rahman Shatabdy is a microbiologist in Tongi, Bangladesh. With rapid advancements in digital technology, the types of digital skills and competencies needed are changing fast.

Figure 9: Digital Transformation Interventions to Enhance Human Capital, Generate Quality Jobs, and Reduce Inequalities by Digital Maturity Levels

Domain	Maturity Levels: Basic → Advanced				
	1	2	3	4	5
ENABLING CONDITIONS					
STRATEGIC FRAMEWORK	**Absent**	**Nascent** Digital literacy for all targets	**Foundational** National e-health and e-education strategic frameworks	**Intermediate** Collaborative partner ecosystem; health ecosystem operating based on open source and open science	**Integrated** Moonshots (universal health care); integration of human capital strategy into national development plans
POLICY ENVIRONMENT AND GOVERNANCE	**Nascent**	**Developing** Awareness raising through public consultations	**Defined** Standards and safeguards for data ownership, privacy, sharing, access, audit, and accountability; cross-government coordination; insurance and benefit programs	**Aligned** Laws, regulations, and institutions governing the collection, storage, use and protection of personal data; cross-government collaboration	**Optimized** Compliance with ethical AI policies to prevent bias and inequality; integrated health service delivery chain
OPERATIONAL ENVIRONMENT	**Unaware**	**Reactive** Hardware-focused	**Proactive** Political and digital leadership; chronic disease management; local language content and advice	**Managed** User-centric design and innovation; empowered front line providers	**Continuous learning and forward looking** Diffusion and adaptation of health and education applications
DIGITAL CAPABILITIES	**Nascent**	**Basic** Literacy programs	**Intermediate** Improved teaching quality; data literacy programs; teaching at the right level	**Advanced** Digital reskillng/upskilling programs for out-of-school youth and workers; advanced healthcare learning (AR/VR) for doctors, nurses	**Applied and innovative** Mixed reality/immersive learning; game-based learning
CORE DIGITAL COMPONENTS					
TECHNOLOGY INFRASTRUCTURE	**Nascent** Hardware only Education programs by radio; outdated ICT equipment	**Emerging** Software-enabled Audio-visual equipment in classrooms; wearable fitness devices; ICT-enabled telemedicine	**Virtualized** Network connectivity E-learning portal; National Research and Education Networks	**Pooled service-based system** Drone platform for remote medicine delivery; digital education platform; AI-enabled remote work platform; X-sector data-sharing platform; one-stop grievance redressal system	**Value/service-based delivery model** Smart robotics, AR/VR applications for in-hospital and remote surgeries; 3D printing of medicines and organs; cloud-based education management platform; integrated social protection delivery system
DATA INFRASTRUCTURE	**Individual datasets** Recording of individual health and education scores	**Data processing and storage** Secure blockchain-based patient data storage; basic education and health MIS; static social and beneficiary registries	**Information exchange and standards** Smart hospital management for communication, collaboration; smart tools for school resource management; dynamic integrated social and beneficiary registries; poverty maps for poverty targeting and resource allocation	**Interoperability** Digital identity and payment systems; anonymization of health data; APIs to connect diverse applications, platforms and systems and share data	**Integration** National health and education stacks; blockchain-based credentialing (education); interactive human–machine protocols; cross-disciplinary medical research
DATA ANALYTICS	**Ad hoc reporting** Raw test scores	**Descriptive analytics** Standard reporting of routine tasks and diagnostics; PISA test scores	**Causal inference, strategic reports** Learning and behavioral analytics; AI-enabled clinical trials for large-scale, high-speed drug discovery	**Predictive reporting and visualization** AI/remote sensing prediction models of pandemic spread; algorithms to assess learning gaps; emotional recognition for diagnostics and treatment; AI and big data analytics to identify vulnerable groups	**Prescriptive decision-support** Individualized personal care; AI-/ML-enabled clinical diagnosis and prognosis; genomics; affective learning programs
DIGITAL ADOPTION	**Nascent**	**Individual use** Pre-recorded educational programs (TV, YouTube)	**Point-of-service** Fee-based tutoring programs; smart homecare, virtual healthcare assistants; AI-enabled chatbot for personalized education, health, and social protection services	**System-wide** Remote monitoring and diagnostics for hard-to-reach communities; 4IR-educational platforms for girls/women; affordable, accessible educational resources	**Nationwide** Rollout of AI-driven individual health advice and medicine (bio-synthetics); pooled procurement of critical medicine; personalized, adaptive learning; skills matching, access and contracting across global markets

4IR = Fourth industrial revolution, AI = artificial intelligence, API = application programming interface, AR/VR = augmented reality/virtual reality, ICT = information and communication technology, MIS = management information system, ML = machine learning, PISA = Programme for International Student Assessment.

Source: Compiled by study authors based on Digital Maturity Model (Table 3).

Sustainable Development Goal Transformation #2

Decarbonization and Energy Transition

This section discusses strategies for the decarbonization of energy systems, in line with ADB's Strategy 2030 Operational Priority 3 to tackle climate change. The rising energy demands, coupled with high levels of greenhouse gas emissions in the region, require an accelerated shift from fossil fuels to zero-carbon sources. Digital technologies can enable the shift from a centralized energy system with large power plants, to a decentralized, renewable energy-based one with increased interconnectivity between distributed energy resource devices, energy storage systems, and markets that can accommodate variable electricity supply and flexible demand.

Four strategic areas can accelerate decarbonization and energy transition: (i) enhancement of user participation in energy systems, positioning them as active agents in energy markets; (ii) a transition toward more sustainable and flexible energy generation models that integrate renewable energy technologies; (iii) strengthening of energy system resilience to the growing incidence of extreme climate events and cyberattacks; and (iv) a robust value chain that supports the growth of local industries, industrial hubs, and clusters specialized in low-carbon technologies. Digital technologies can facilitate and enable these measures, adding user-friendly interfaces, augmenting efficiency through automation, and enabling data-driven decision-making.

Overview

Decarbonization and energy transition are well aligned with ADB Strategy 2030 that identifies tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability as an operational priority. Asia and the Pacific is uniquely placed to lead global climate action since half of the envisaged global expansion of electric power capacity in the next decade will be in the region.[41]

There has been rapid progress in energy access across Asia and the Pacific with an overall electrification rate of 95%, although there are wide variations in reliability and affordability (footnote 37). Yet, the region has regressed on decarbonizing energy use and reducing greenhouse gas emissions.[42] Although installed renewable energy capacity is growing rapidly, energy generation from fossil fuels is increasing even more quickly.[43] The energy sector is a main contributor to greenhouse gas emissions in the region and a driver of increased climate-induced risks, disproportionately affecting poor and vulnerable groups.[44]

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41 P. Wijayatunga. 2023. Q&A: Meeting Asia and the Pacific's Growing Electricity Needs. *ADB*. 9 June. https://www.adb.org/news/features/qa-meeting-asia-and-pacifics-growing-electricity-needs.

42 ESCAP, ADB, and UNDP. 2020. *Fast-Tracking the SDGs: Driving Asia-Pacific Transformations*. Bangkok. https://www.adb.org/publications/sdgs-driving-asia-pacific-transformations.

43 Although fossil fuels are still dominant at a combined 75% in 2019, they have fallen from a share of 87% in 2009, while the share of renewable energy has doubled from 10% in the same period (ADB. 2021. *Energy Policy: Supporting Low-Carbon Transition in Asia and the Pacific*. Manila).

44 Asia and the Pacific accounts for more than 50% of global carbon emissions where more than half comes from electricity and heat (ADB. Energy. https://www.adb.org/what-we-do/topics/energy).

Accelerating the pace of climate action will depend, among other things, on technological innovation, much of which will be powered by digital solutions. DMCs recognize the power of digital technologies for climate action. Two-thirds of developing countries include technology as part of their nationally determined contributions to help adapt or mitigate the impacts of climate change.[45] This underscores the urgent need to respond by developing, enabling, and scaling digital solutions and ensure they reach the most climate-vulnerable populations. At the same time, the digital sector needs to be decarbonized.

Figure 10: Challenges to Digital Transformation to Decarbonization and Energy Transition

Source: Asian Development Bank.

Challenges

Greenhouse gas emissions are set to increase with population and economic growth, urbanization, expanded land use, changing consumption patterns, unabated fossil fuel-based energy generation, and expanded transport demand.

The main challenges for DMCs are:

- achieving universal access to a reliable, efficient, and affordable energy supply across the region;
- ensuring energy security to support continued economic expansion and meet demand from population growth and urbanization;
- accelerating energy efficiency gains; and
- deploying renewable energy and low-carbon technologies.

Digital and smart technologies are transforming the energy sector, enabling and facilitating decarbonization, helping integrate variable renewable energy sources, stabilizing the grid, reducing technical and commercial losses, and enhancing energy efficiency.

The surge in digitalization, however, increases the energy sector's exposure to operational risks, particularly cybersecurity and information technology supply chain risks. Moreover, the digital sector is contributing to greenhouse gas emissions. Power consumption needed for digital technologies will continue to increase as data traffic increases exponentially. For example, AI and distributed ledger technologies use more energy than other forms of computing; training an AI model can use more electricity than 100 homes in the United States (US) consume in a year.[46]

[45] World Bank. 2023. *Green Digital Transformation: How to Sustainably Close the Digital Divide and Harness Digital Tools for Climate Action.*

[46] J Saul and D Bass. 2023. Artificial Intelligence Is Booming—So Is Its Carbon Footprint. Bloomberg. 9 March. https://www.bloomberg.com/news/articles/2023-03-09/how-much-energy-do-ai-and-chatgpt-use-no-one-knows-for-sure.

These challenges threaten sustainability and worsen the existing vulnerabilities of poor and marginalized people, who often have greater exposure to the effects of climate change. Increasing energy efficiency and transitioning to renewable energy across all sectors, including connectivity, equipment, and data processing will be important.

Digital Transformation Strategies to Accelerate Decarbonization and Energy Transition

The energy sector is in flux from several transformative influences. Power generation is decentralizing, and power flow is becoming multidirectional (involving distributed generators, the grid, and users) and more unpredictable, with a rising number of grid-connected devices, from electric vehicle charging stations to residential solar photovoltaic installations. Digital technologies have become instrumental in managing decentralized power generation, balancing supply and demand, and mitigating unpredictability. DMCs can consider adopting just transition[47] (Case Study 2) and circular economy approaches.[48] Good practices include India's use of innovative business models to achieve smart meter rollout and the strategy of the United Kingdom (UK) to digitalize the energy sector toward net zero emissions (Appendix 3). ADB is supporting Uzbekistan to modernize and digitalize its power distribution system to improve energy efficiency, make electricity services more reliable, and integrate renewable energy into the grid.[49]

Four strategic areas can accelerate decarbonization and energy transition. The first is the enhancement of user participation in energy systems, positioning users as active agents in energy markets. The second is a transition toward more sustainable and flexible energy generation models that integrate renewable energy technologies.

Kamal GC, secretary of an electricity consumers group, in front of solar mini-grid project in Gutu, Surkhet, Nepal. Digital technologies can enable the shift to a decentralized, renewable energy-based system.

47 United Nations Committee for Development Policy. 2023. Just Transition. https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/CDP-excerpt-2023-1.pdf.

48 United Nations Economist Network. N.d. New Economics for Sustainable Development: Circular Economy. https://www.un.org/sites/un2.un.org/files/circular_economy_14_march.pdf.

49 ADB. ADB to Help Digitalize Uzbekistan's Power Distribution System. News from Country Offices. 20 September. https://www.adb.org/news/adb-help-digitalize-uzbekistans-power-distribution-system.

Case Study 2

Supporting Energy Transitions in Indonesia and Viet Nam

Just Energy Transition Programs (JETPs) aim to accelerate the energy transition in Indonesia and Viet Nam by promoting a partner country-led model that aims to phase out or phase down unabated coal-fired power generation capacity. The official goal is to mobilize $20 billion for Indonesia and $15.5 billion for Viet Nam over the next 3–5 years, with ADB actively involved in the analytical and implementation aspects. JETPs aim to ensure just, equitable, and inclusive outcomes for consumers, workers, and vulnerable communities in coal-dependent regions as well as companies by diversifying the local economy through the creation of quality jobs and regional value chains; support of social protection schemes for affected groups; and mitigation of vulnerabilities of carbon-intensive industries. A second aspect concerns energy justice to ensure affordable electricity for low-income groups. The final aspect is to attract large-scale domestic and international private investments to increase the capacity to deliver these programs.

A successful JETP implementation requires a significant increase in the deployment of low-carbon technologies in addition to introducing or upgrading energy storage systems (such as batteries or pumped hydro storage), demand response programs to manage peak demand, innovative technologies to modernize the transmission and distribution grids, and measures to advance energy affordability.

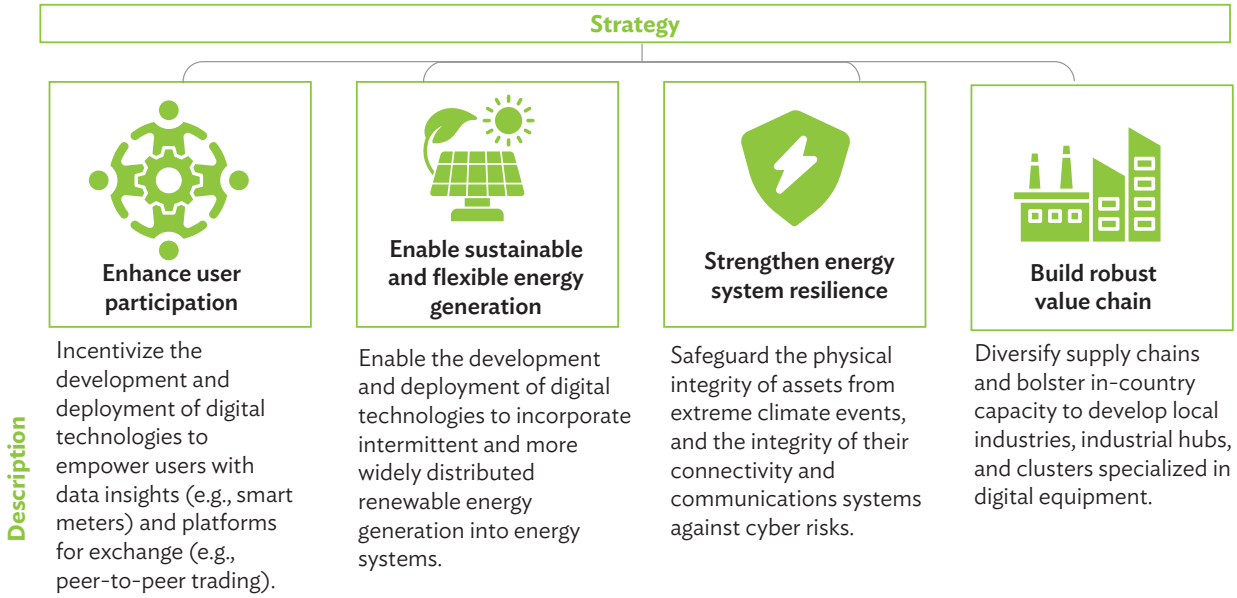
The digitalization components in Indonesia and Viet Nam's JETPs include smart grids, data-driven decision-making to inform rollouts, pricing strategies, and investment decisions, supply chain optimization, remote monitoring and predictive maintenance, and increased transparency and competition via online platforms.

A government's political will to net zero emissions, coupled with fast-track finance from industrialized countries, can potentially accelerate the energy transition and deliver positive socioeconomic outcomes. Digitalization is a critical component of the JETPs in these countries to achieve their energy transition goals efficiently and inclusively.

Source: ADB.

The third is strengthening energy system resilience to the growing incidence of extreme climate events and cyber risks. Finally, there is a need to develop a robust value chain that supports the growth of local industries, industrial hubs, and clusters specialized in low-carbon technologies (Figure 11).

Figure 11: Digital Transformation Strategies to Accelerate Decarbonization and Energy Transition



Source: O. A. Alonso et al. 2023. Roadmap for the Digital Transformation of the Energy Sector in Latin America and the Caribbean. *IDB Technical Note.* IDB-TN-02833. Inter-American Development Bank.

Enhance user participation. User-centered digitalization is a key area in the digital transformation process as consumers become prosumers and participate in energy generation and trading. This results in demand for new services such as smart meters, applications for consumption control, demand-driven energy distribution, peer-to-peer energy trading, and electric vehicle charging facilities and management. Smart meters, for example, can trigger the behavioral response of consumers and commercial energy users to regulate their energy consumption.

Enable sustainable and flexible energy generation. There is a rising demand for flexibility in energy systems to integrate renewable energy generation that is decentralized and intermittent (although grid-connected renewable energy plants also exist). Digital transformation will help reduce barriers to this integration, particularly in the capture of data and its integration into the system. Once relevant data is captured, digital technologies can facilitate the exchange of data in real time. AI-enabled visualizations and digital twins can facilitate remote operations, identify issues in real time, and enable predictive maintenance, enabling the optimization of the generation, distribution, and consumption of energy. Smart grid applications can advance renewable energy integration, improve network stability, and reduce system losses, directly contributing to decarbonization.

Strengthen energy system resilience. The resilience of energy systems is an increasingly critical area because of the rising frequency and severity of climate events that affect the energy infrastructure. But even the digital transformation process itself creates new vulnerabilities that can threaten the integrity of energy systems. Once systems have been digitalized, the underlying digital infrastructure itself becomes critical infrastructure. Breaches or cyberattacks that cause power outages or downtime, or loss of connectivity and access to linked data and information and communication systems can result in significant economic and social damage and threaten national security. It is important to strengthen energy system resilience by developing and implementing plans and guidelines to improve resilience to both physical threats such as disasters triggered by natural hazards, as well as online threats such as cyberattacks. Digitalization can play a crucial role in curtailing physical threats and enhancing resilience against disasters through early warning systems that enable real-time monitoring, communication networks, and geospatial data and digital mapping that help identify vulnerable areas, plan evacuation routes, and allocate resources effectively during disasters. Remote sensing using satellites and drones provides valuable data for disaster response and recovery efforts. Moreover, digitalization can enhance cybersecurity, as follows:

- Improved situational awareness: Digital sensors and monitoring systems provide real-time data on energy infrastructure, allowing operators to detect anomalies, identify potential threats, and respond quickly to cyber incidents.
- Advanced threat detection: Machine learning algorithms and AI can analyze large volumes of data to identify patterns associated with cyberattacks.
- Segmentation and isolation: Digitalization allows for network segmentation, isolating critical components from less critical ones.
- Redundancy and backup systems: Digital infrastructure enables redundancy and backup mechanisms.
- Security-by-design: Integrating security measures during the design phase of digital systems ensures that security is a fundamental consideration.
- Industry collaboration and information sharing help create a collective defense against threats.

Key elements and criteria for a robust and resilient digital infrastructure include (i) a cybersecurity strategy, (ii) data integrity to maintain accurate and reliable data through regular data backups and validation processes, (iii) fail-safe protocols to help prevent catastrophic failures, (iv) regular updates to address vulnerabilities and enhance security, (v) risk assessments to identify potential threats and vulnerabilities and help organization prioritize their mitigation efforts, (vi) responsive recovery plans to ensure quick response and restoration after incidents, and (vii) a security culture in which employees are educated about security best practices.

Build robust value chain. Digital transformation for decarbonization and energy transition depends on a robust value chain for the manufacture of digital and technological components, equipment, and devices. However, in recent years the COVID-19 crisis and global geopolitical instability have strained global supply chains. DMCs that are heavily dependent on foreign markets for the supply of energy-related digital components, equipment, and devices may experience delays and shortages. Mitigation strategies include the diversification of supply chains and bolstering of in-country capacity to develop local industries, industrial hubs, and clusters specialized in manufacturing relevant digital and technological components, equipment, and devices, to guarantee greater security of supply.

In addition, digital components and digitalization play a significant role in reducing costs and improving efficiency in the renewable energy sector. For instance, smart grid technologies and distributed energy resources enable the seamless integration of renewable energy into the grid. Real-time data collection and analysis allow stakeholders to make informed decisions, and predictive analytics can help anticipate market trends, demand fluctuations, and price variations. Predictive maintenance and remote monitoring can enhance operational efficiency and cost reductions in operations and maintenance. Digital supply chain management streamlines the sourcing of raw materials. Life cycle analysis and total cost of ownership analysis help in calculating these costs accurately. Digital platforms provide transparent information about prices, suppliers, and product specifications.

Figure 12 details digital transformation interventions for decarbonization and energy transition by digital maturity level.

Figure 12: Digital Transformation Interventions for Decarbonization and Energy Transition by Digital Maturity Level

Domain

Maturity Levels: Basic → Advanced

ENABLING CONDITIONS

STRATEGIC FRAMEWORK

1	2	3	4	5
Absent	**Nascent** Intention to leverage digital technologies for decarbonization	**Foundational** Organizational policy and strategy in place for digital transformation and decarbonization	**Intermediate** Sector-wide policy and strategy in place for digital transformation and decarbonization	**Integrated** National policy and strategy in place for digital transformation and decarbonization

POLICY ENVIRONMENT AND GOVERNANCE

1	2	3	4	5
Nascent Management unfamiliar with latest trends and technologies	**Developing** Siloed systems, situation analysis of digital infrastructure and services, exploratory workshops	**Defined** Regulatory framework to enable digitalization; coordination mechanism in place for decentralized system	**Aligned** Cross-sector collaboration for climate action; laws, regulations, and institutions governing ethical data use, cybersecurity, and privacy	**Optimized** Multi-agency, multi-jurisdiction, cross-border collaboration; public–private partnerships data; sandbox innovations; local value chains

OPERATIONAL ENVIRONMENT

1	2	3	4	5
Unaware Centralized grid system owned by utility	**Reactive** Centralized grid system and local renewable systems in parallel	**Proactive** Decentralized system	**Managed** Distributed renewable energy integration in power systems with real-time monitoring and active demand response	**Continuous learning and forward looking** Decentralized system with prescriptive decision-support capabilities to optimize operations

DIGITAL CAPABILITIES

1	2	3	4	5
Nascent Ad-hoc workforce training	**Basic** Training to run systems	**Intermediate** Leadership skills for systemic transformation; attract and retain digital talent for continuous systems improvement	**Advanced** Technically trained specialists in AI, data analytics, cybersecurity, data protection and privacy, and ethics	**Applied and innovative** Pool of talent to transform and co-design policies, programs, products, and services; mixed reality and immersive learning

CORE DIGITAL COMPONENTS

TECHNOLOGY INFRASTRUCTURE

1	2	3	4	5
Nascent Hardware only Power system digitalization; solar-powered devices	**Emerging** Software-enabled Information systems to manage utility organizations (enterprise resource planning); electricity transmission and distribution control; utility asset and network management	**Virtualized** Network connectivity IoT-enabled real-time monitoring of operations and asset performance; remote sensing and drones for monitoring, inspection, and maintenance; information systems for distributed solar PV management	**Pooled service-based system** Smart metering and billing; smart building and homes; smart electric vehicle charging and management; demand-response system; on-grid electricity storage; smart inverters	**Value/service-based delivery model** Smart grid control system; distributed energy resource management system; customer energy management system; interoperable cross-border energy marketplace; low-carbon, climate-resilient digital infrastructure

DATA INFRASTRUCTURE

1	2	3	4	5
Individual datasets Computer-based databases	**Data processing and storage** Online registries of distributed solar PV systems and other assets	**Information exchange and standards** Platforms and dashboards to analyze and share asset performance; power production, transmission, and distribution; customer production and consumption patterns	**Interoperability** Interoperable platforms and dashboards to analyze and share energy supply and demand; platform for intersectoral climate action 4IR-enabled building management	**Integration** End-to-end real-time cross-border supply and value chain visibility platform

DATA ANALYTICS

1	2	3	4	5
Ad hoc reporting Computer-based systems	**Descriptive analytics** Connected systems to monitor asset performance and consumer behavior	**Causal inference, strategic reports** AI and IoT-enabled data analytics for asset performance and consumer behavior	**Predictive reporting and visualization** AI and IoT-enabled predictive management, maintenance and resilience of grid; energy demand forecasting; renewable energy output forecasting	**Prescriptive decision-support** Digital twin for advanced simulations; AI system to match energy demand and supply; forecasting electricity prices and dynamic pricing; scheduling and controlling response loads

DIGITAL ADOPTION

1	2	3	4	5
Nascent Dial-up communication support for customer service	**Individual use** Remote meter reading; online and mobile payment; pay-as-you-go systems	**Point-of-service** Chatbot and customer engagement solutions for personalized service; robotics for equipment repair	**System-wide** Peer-to-peer energy trading and marketplaces; energy monitoring and analysis for prosumers	**Nationwide** Dynamic line rating; AI-enabled supply chain process optimization and automation

AI = artificial intelligence, IoT = Internet of Things, PV = photovoltaic, SCADA = supervisory control and data acquisition.

Source: Compiled by study authors based on Digital Maturity Model (Table 3).

Sustainable Development Goal Transformation #3

Smart Cities

This section highlights the increasing urbanization trend globally, particularly in Asia and the Pacific, and the associated challenges of economic productivity, social inclusion, and environmental sustainability. ADB Strategy 2030 Operational Priority 4, to make cities more livable, gives digital smart solutions a key role to play. However, challenges such as resource scarcity, climate change impacts, and poor urban planning hinder smart cities' transformation in many DMCs. To accelerate this transformation, a comprehensive approach that (i) promotes integrated urban planning and design, (ii) integrates digital innovation in urban service delivery, and (iii) builds a tech-startup ecosystem, is necessary. Digital technologies offer numerous benefits, from improving urban planning to enhancing public services and disaster management. However, selecting the right technology and ensuring agility are crucial, requiring considerations such as user-friendliness, security, costs, interoperability, and flexibility. Flexible technology approaches, such as open-source solutions and agile regulatory mechanisms, are essential for successful smart cities' transformation.

Overview

Cities are home to about 55% of the world's population, producing 70% of global economic output. By 2050, these proportions are projected to increase to 70% of the world's population and 85% of global economic output.[50] Asian cities are economic powerhouses and dynamic hubs of innovation. Yet, they face multiple challenges in meeting the triple aims of being economically productive, socially inclusive, and environmentally sustainable.

The smart cities concept has gained significant traction among DMCs. Smart cities aim to overcome the limitations of traditional urban development and address urbanization challenges by leveraging digital technologies and data to connect more directly to citizens, capitalizing on the competitive aspects of growing urban density.

Digital smart solutions that support more efficient and effective use of infrastructure, technologies, available resources, and captured data can help cities become more livable, which is one of ADB's Strategy 2030 operational priorities. The strategic use of digital technologies and data can improve access, quality, inclusiveness, and reliability of services in urban areas; strengthen the urban planning and financial sustainability of cities; and improve urban environment, climate resilience, and disaster management.

[50] UN Habitat. 2022. *World Cities Report 2022: Envisaging the Future of Cities*. https://unhabitat.org/wcr/.

Challenges

Figure 13: Challenges to Digital Transformation to Smart Cities

Source: Asian Development Bank.

Although rapid urbanization is often linked to increases in economic opportunities, it also contributes to resource scarcity, climate change impacts, overstressed infrastructure, insufficient public services, and growth of informal settlements. The rate of rapid, unmanaged urbanization compounds disaster risks, environmental degradation, and social inequality. Urban sprawl is a major issue in many countries, challenging the delivery of urban services and affecting the livability of cities (Figure 13).

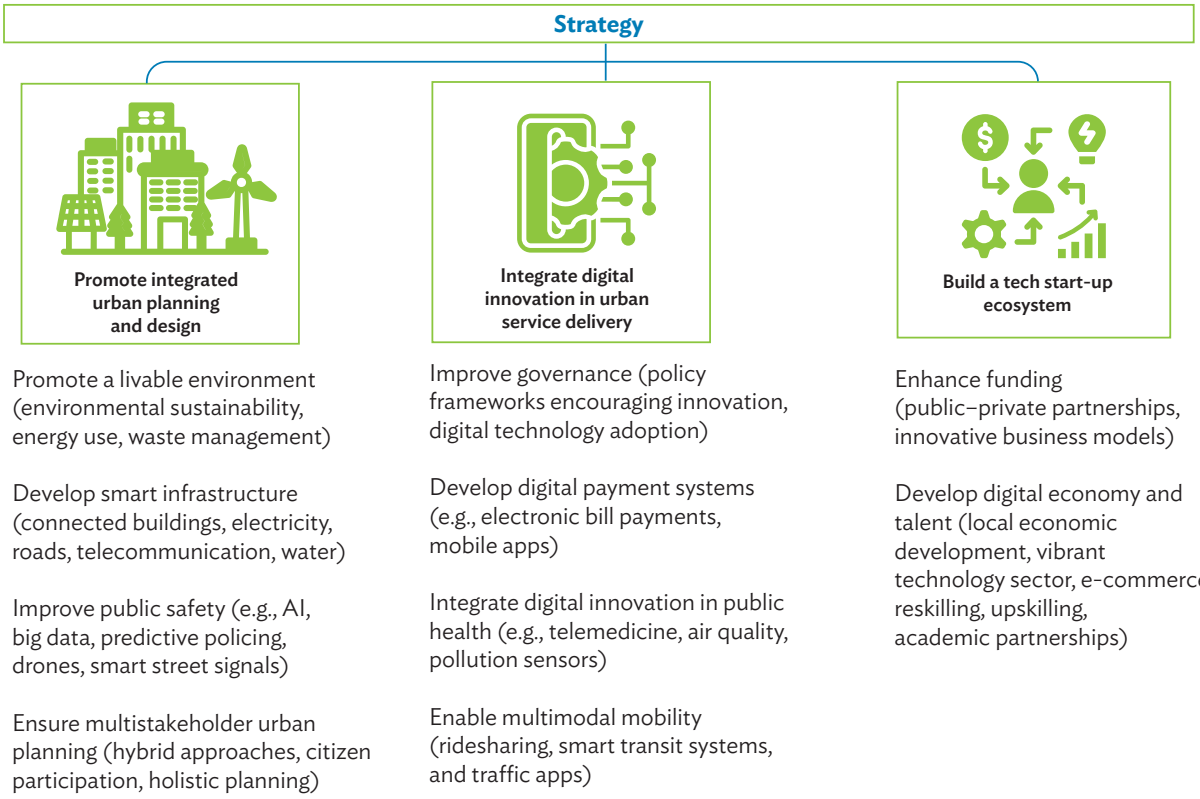
Many cities in DMCs are not fully equipped to address these challenges due to poor urban planning and governance systems. Often, innovative solutions in land use reforms, vertical development, and densification deploy technology systems across sectors such as transport, energy, water, and sanitation to enable seamless connection of infrastructure and services to people. However, cities are at various levels of digital maturity, and often lack the capacity to assess, select, and deploy the appropriate technologies for smart cities transformation.

A group of people queues for buses as they travel to their villages in Dhaka, Bangladesh. Many cities in DMCs are not fully equipped to address challenges due to poor urban planning and governance systems.

Digital Transformation Strategies to Accelerate Smart Cities Transformation

Smart cities transformation requires a comprehensive approach that (i) promotes integrated urban planning and design, (ii) integrates digital innovation in urban service delivery, and (iii) builds a tech-startup ecosystem (Figure 14).

Figure 14: Digital Transformation Strategies to Accelerate Smart Cities Transition



AI = artificial intelligence.

Source: ESI Thoughtlab. November 2018. *Smarter Cities 2025: Building a Sustainable Business and Financing Plan; A thought leadership white paper.*

Promote integrated urban planning and design. Digital technologies can support integrated urban planning and design, and the delivery of gender-responsive, inclusive, resilient, and green urban infrastructure and services. New categories of data sources and digital technologies, such as remote sensing, location-based services, tracked daily activities (such as wearables, the internet), and IoT sensors, can help gain a more granular and faster understanding of urban issues, such as those involving substandard housing, congestion, pollution, and health emergencies. For example, municipal-level integrated data analytics platforms include interfaces where municipalities can see their revenues and contributions to the state/province and national gross domestic product.

Transit-related analytics, such as data on ridership, traffic density, and road safety, have been used in efforts to increase public transit, enhance job access, and reduce carbon emissions. Digital twins that create virtual models of physical systems and processes can simulate and analyze the impacts of different land use scenarios, helping planners and designers optimize land use and minimize adverse environmental effects (Case Study 3). Another

Case Study 3

Digital Twin for Urban Planning, Management, and Collaboration in Singapore

A digital twin is a virtual representation of a physical object or system across its lifecycle. It collects data via sensors, drones, and Internet of Things (IoT) tools, and applies advanced analytics, machine learning, and artificial intelligence to the real-time data, to enable learning, reasoning, and recalibration for improved decision-making.[a] In the context of a smart city, a digital twin is a virtual replica of a city. It is constructed based on real-time data collected via sensors and other IoT devices from buildings, public infrastructure, utilities, and movement of people and vehicles. It can illustrate the overall functioning and performance of the city, offering valuable insights on issues of public health, transportation, safety, energy, and natural hazards. Using a digital twin, changes to cities can be tested and simulated in the virtual model before implementation, lowering the costs and chances of failing. It is also an engagement tool for all participants to leverage technology to promote more resilient city development.[b]

Virtual Singapore was started by the National Research Foundation to produce a digital twin of Singapore, comprising a dynamic 3D city model and a collaborative data platform.[c] It integrates various data sources from government agencies, 3D models, information from the internet, and real-time dynamic data from IoT devices, to help Singapore solve intricate challenges smartly. Virtual Singapore offers four key capabilities: virtual experimentation, virtual test-bedding, planning and decision-making, and research and development, which can be used for a range of functions including community collaboration and decision-making, communication, urban planning, and asset management.

[a] IBM. 2019. What Are Digital Twins? IBM Developer (blog). 14 November. https://developer.ibm.com/technologies/iot/articles/what-are-digital-twins/.
[b] A. Porteiro.2019. Digital Twins and Urban Planning: How to Use Replicas to Building the Cities of Tomorrow. Tomorrow.Mag (blog). 29 November. https://www.smartcitylab.com/blog/digital-transformation/digital-twins-made-with-minecraft-and-open-street-map/.
[c] Virtual Singapore. 2020. https://www.nrf.gov.sg/programmes/virtual-singapore.

Source: Authors.

example is the use of LinkedIn data to identify patterns of talent demand and migration, giving officials an almost real-time dataset to assess the health of their jurisdiction's talent pipeline for informed policymaking.[51]

Integrate digital innovation in urban service delivery. Digital technologies have been widely adopted by local governments to improve the efficiency and coverage of urban service delivery. Cities are using big data, cloud computing, and AI to improve the efficiency and safety of public transit. Multimodal public transit corridors and depots require digital systems to manage and synchronize the seamless interconnections between transport modes in real time. During COVID-19, telehealth apps reduced the burden on medical staff, contact tracing allowed public health systems to alert citizens about their infection risk, while 3D printing helped ease supply shortages of spare parts and serve as a production facility for highly specialized medical and mechanical devices (e.g., hearing aids). With the booming of e-commerce, smart logistics initiatives are piloting the use of drones and self-driving trucks for last-mile deliveries. Digital technologies have been deployed to provide real-time air quality reports and initiate remedial action. IoT devices enable the restructuring of every aspect of building management and security, including through real-time data collection of air quality and electricity consumption.[52] Digital platforms can facilitate the emergence of a circular economy, including the visualization of all material inputs and emissions along a product supply chain, or the recovery, refurbishing, and recycling of electronic waste, by enabling coordination, transparency, and traceability across supply chains.

Build a tech start-up ecosystem. Cities can catalyze local social and economic development and improve livability and competitiveness by enabling and building a tech start-up ecosystem. A tech start-up ecosystem not only provides employment, but also drives and influences the transformation of MSMEs and traditional industries. This often encompasses open innovation approaches to address social and economic challenges. In this way, ideas and solutions are co-developed, leveraging digital platforms that help form interdisciplinary teams and facilitate their innovation process.[53]

Selecting the right technology and avoiding technological obsolescence can be difficult. There are many criteria in evaluating the right technology option, including user-friendly design, security, costs, interoperability, and system flexibility. While all these dimensions are important, the key is selecting a solution that allows for agility. Smart city solutions need to be forward-looking and be able to respond to change while maintaining system reliability and efficiency. One key part of agility is avoiding vendor lock-in, where overreliance on a single vendor-based technology highly constrains flexibility and interoperability because of the high transaction cost for system upgrades. Agile solutions are not necessarily the most expensive and innovative. Rather, these are designed to work with the ecosystem of users, developers, and other partners.

The Technology Hub, also known as the T-Hub, in the Indian city of Hyderabad is an example of a premier innovation ecosystem that actively engages startups, facilitates corporate partnerships, hosts events, and attracts investors. It operates based on a triple helix model of collaboration between the government, academic institutions, and the private sector, making it a global role model for accelerating growth, providing mentorships, and catalyzing resources for entrepreneurial ventures in various digital domains. Flexible technology approaches include open-source solutions and application programming interfaces that lower the barriers of entry for

51 T. J. Zhu, A. Fritzler, and J. A. Kazimierz Orlowski. 2018. World Bank Group-LinkedIn Data Insights: Jobs, Skills and Migration Trends Methodology and Validation Results. 13 November. https://policycommons.net/artifacts/1523930/world-bank-group-linkedin-data-insights/2209400/.

52 L. D. Prasanna et al. 2018. Internet of Things: The New Government to Business Platform –Aa Review of Opportunities, Practices, and Challenges. World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/610081509689089303/Internet-of-things-the-new-government-to-business-platform-a-review-of-opportunities-practices-and-challenges.

53 Fab Lab Barcelona. 2021. Our Social Impact in 2020. Our Social Impact in 2020. FabLab BCN Blog. 5 March. https://fablabbcn.org/blog/lab-life/our-social-impact-in-2020.

new apps and devices in development. Moreover, these accelerate the replicability and scalability of a solution to other cities because these nondomain-specific applications make them highly interoperable. Also, agile regulatory approaches such as sandboxes, and co-creation mechanisms such as urban labs, can help select appropriate solutions in a flexible manner.

Figure 15 details digital transformation interventions for smart cities transformation by digital maturity level.

Malé North Harbor, the central hub for the domestic distribution of goods in Maldives. Digital connectivity can simplify logistics.

Figure 15: Digital Transformation Interventions for Smart Cities Transformation by Digital Maturity Levels

Domain

Maturity Levels: Basic → Advanced

Domain	1	2	3	4	5
ENABLING CONDITIONS					
STRATEGIC FRAMEWORK	**Absent**	**Nascent** Ad hoc initiatives for digitizing individual government services and releasing local government data on a selective basis	**Foundational** Development of a shared vision and strategy for local e-government, drawing on increased citizen inputs and stakeholder consultations	**Intermediate** Continuous update of smart city / smart service action plans based on technological innovations, big data analytics, behavioral science, and stakeholder feedback	**Integrated** Urban plans based on digital twin models of the city; holistic, integrated delivery of end-to-end urban services informed by data, evolving citizen needs, competitive position, and local climate conditions
POLICY ENVIRONMENT AND GOVERNANCE	**Nascent** Defense of the status quo behind outdated policies and regulations; no involvement by local stakeholder groups	**Developing** Stocktaking of digital infrastructure and local services; elected officials blaming budget cuts and shortcomings at provincial and federal levels	**Defined** Major reform initiatives launched (procurement tenders published, licensing portal); regular dialogue between city agencies, citizen groups, private sector; data privacy / right to information rules updated in response to complaints	**Aligned** Urban planning scenarios conducted with stakeholder participation; real-time government response systems in place; collaborative decision-making involving delegated responsibilities to community groups; local cybersecurity initiatives to protect critical infrastructure facilities	**Optimized** Adaptive, responsive governance framework; trust building through data transparency, performance KPIs, and accountability mechanisms; improved digital business environment benefiting SMEs and attracting new private ventures (recreation services, vertical farming; housing programs; etc.)
OPERATIONAL ENVIRONMENT	**Unaware**	**Reactive** Government committees tasked with addressing major pain points in public services and burdensome procedures; social media announcements of local government decisions; supply-driven city services remain dominant	**Proactive** Chief Digital Officer appointed; first local tech hub launched; protocols for citizen inquiries and service standards in place; periodic consultation with stakeholders	**Managed** Local tech scene offering digital solutions; co-design workshops between local agencies and stakeholder groups; citizen participation in government decision-making (e.g., budget allocation, land use planning, traffic and waste management)	**Continuous learning and forward looking** Participation by SMEs, CSOs in e-government problem-solving and innovations; mature local eco-system and private sector engaged in PPP and outsourcing arrangements; smart city partnership events attracting digital skills and entrepreneurs; whole city monitoring initiatives set up
DIGITAL CAPABILITIES	**Nascent** Analog	**Basic** Digital awareness programs for local government officials	**Intermediate** Key agencies with dedicated digital solution teams; joint workshops and learning events on smart city applications; digital communication initiatives to raise awareness and build trust	**Advanced** Academia–industry partnerships; local innovation labs	**Applied and innovative** Vibrant tech startup ecosystem; open innovation approaches leverage cross-sector, multidisciplinary knowledge, and skills
CORE DIGITAL COMPONENTS					
TECHNOLOGY INFRASTRUCTURE	**Nascent** Hardware only LED lights; back-up generators	**Emerging** Software-enabled Installation of assorted digital devices by different local agencies throughout the city (e.g., CCTV; sensors; traffic signals; IoT devices)	**Virtualized** Network connectivity Upgraded ICT infrastructure and digital devices in line with the smart city strategy (e.g., digital payments for city services; traffic control center; SME licensing portal; emergency service dispatch)	**Pooled service-based system** Cloud computing service platform; digital tracking system for service requests; collaboration with tech-hub to pilot urban farming, city traffic and logistic optimization, alternative housing schemes to address densification	**Value/service-based delivery model** 4IR-enabled coordinated energy-grid; AI-enabled urban mobility management, including connected EVs, traffic lights, route mapping; AR/VR experiences for local tourism efforts
DATA INFRASTRUCTURE	**Individual datasets** Partial inventory of local infrastructure assets	**Data processing and storage** Data collection from government agencies and IoT devices (health care, transportation, emergencies, road management, air pollution, etc.)	**Information exchange and standards** Easy-to-navigate portals collating data on city services, job opportunities, public tenders, etc.; pilot testing of 'single-source-of-truth' to eliminate duplicative data entries	**Interoperability** Open government data initiatives; automation of manual processes through intelligent case management; 4IR-enabled building management	**Integration** Community-distributed marketplaces for goods and services, including P2P trading; integrated delivery of city services
DATA ANALYTICS	**Ad hoc reporting** Opinion surveys	**Descriptive analytics** City statistics (health, education, environment)	**Causal inference, strategic reports** Satellite, drone, IoT land-use detection and management; big data analytics	**Predictive reporting and visualization** Predictive maintenance reports for city infrastructure assets; sensor- and AI-based urban network management (pollution, waste, water, energy); AI-led disaster prediction models (w/ automatic evacuation triggers)	**Prescriptive decision-support** Digital twinning models to inform budget allocations; AI-enabled decision-making by government agencies based on comprehensive real-time data analysis; data-driven alerts to identify cyber vulnerabilities
DIGITAL ADOPTION	**Nascent**	**Individual use** Ride-sharing initiatives; traffic apps; safety apps supporting women and girls against harassment	**Point-of-service** Social networking app to access government services (including authentication of personal data, permit applications, tender information, fee payments); citizen chatbot	**System-wide** Smart and connected city planning and mobility systems; smart pay-as-you-go utilities and shared services; smart monitoring of infrastructure facilities for operational efficiency and efficient maintenance; free e-service access in public spaces	**Nationwide** 4IR, blockchain-enabled, decentralized P2P community energy and water grids; digitally enabled circularity programs (waste management, recycling) and sharing business models; urban greening infrastructure (e.g., living building, pollution sequestration)

4IR = Fourth Industrial Revolution, AI=artificial intelligence, AR/VR = augmented reality/virtual reality, CCTV= closed circuit television, CSO = chief security officer, EV= electric vehicle, G2C = government-to-citizen, ICT= information and communication technology, IoT= Internet of Things, KPI = key performance indicator, LED= light-emitting diode, P2P=peer to peer, PPP = public–private partnership, SME = small and medium-sized enterprise.

Source: Asian Development Bank.

Sustainable Development Goal Transformation #4

Food Security and Sustainable and Resilient Agriculture

ADB's Strategy 2030 Operational Priority 5 on promoting rural development and food security addresses the urgent need to tackle rising food insecurity by transforming agricultural supply chains, agribusinesses, and food systems. Digital agricultural technologies (DATs) can play a critical role in enhancing the resilience and productivity of food systems, including by introducing the use of precision agriculture, strengthening agricultural extension services, reducing food loss and waste, and connecting smallholder farmers to markets. Governments can support DATs by (i) investing in a national digital platform to enable the development of innovative products and services for smallholder farmers, (ii) developing a digital agriculture strategy, (iii) improving e-governance systems, (iv) providing an enabling policy and legal environment for connectivity infrastructure and payment systems in rural areas, and (v) supporting agri-technology start-ups.

Overview

Promoting rural development and food security is one of ADB's Strategy 2030 operational priorities. The strategic use of digital technologies and data can modernize the agri-food supply chain from farm-to-fork, build a resilient agribusiness sector to improve food security and nutrition, and promote rural development. Digital technologies and data, including big data and geospatial data systems, can be used in the agri-food value chain to optimize productivity and ensure sustainable management of land and water resources. Other benefits of digital transformation include predicting and mitigating potential damage and losses due to climate change and other crises; enhancing the traceability and monitoring of food quality and safety in real time; improving trade, logistics, and payments to ensure an adequate supply of safe, affordable, and nutritious food; and reducing post-harvest losses and food wastage (footnote 13). Digital transformation is also creating new jobs in rural areas, attracting young talent to rural areas, and revitalizing the local agricultural industry, thus reducing the pressure for urbanization.[54]

Digital technologies and data can be used in the agri-food value chain to optimize productivity and ensure sustainable management of land and water resources.

[54] J. Kim et al. 2020. *Scaling Up Disruptive Agricultural Technologies in Africa.* World Bank. https://doi.org/10.1596/978-1-4648-1522-5.

Challenges

Figure 16: Challenges to Digital Transformation to Food Security and Sustainable and Resilient Agriculture

Asia and the Pacific has the world's highest number of food-insecure people

Agriculture and food systems are major contributors to greenhouse gas emissions

Rising incomes are increasing pressure on food systems

Smallholders' limited access to information affects food security

Source: Asian Development Bank.

Asia and the Pacific has the highest number of people facing acute food insecurity worldwide due to soaring rice prices, climate-induced disasters, and ecosystem degradation.[55] The SDG transformation in agriculture includes one of the largest potentials for trade-offs. Today's land use and food systems contribute to persistent malnutrition and obesity, and account for a third of greenhouse gas emissions, over 90% of scarcity-weighted water use, and most losses of biodiversity, while being highly vulnerable to climate change and land degradation. Given the increasing global population, increases in agricultural production may further worsen biodiversity loss and water scarcity, while rising incomes will increase pressure on food systems.

Agri-food systems are complex and involve many actors and activities from production of inputs such as seeds and fertilizers, the production and processing of food products in various forms, to their transportation and logistics to reach consumers. Agri-food systems also include supporting activities and services such as research and development, technical education and training, marketing, and financing. Shocks or stresses at any point along the supply chain can spread rapidly throughout the agri-food system and threaten livelihoods and the food security and nutrition of consumers.

Smallholder farmers generally lack access to technologies, information, and markets. Agri-food systems are often dominated by intermediaries who create high transaction costs for smallholder farmers. Food production is risky due to limited access to information about weather patterns, soil characteristics, future market demand, and other variables. With limited information on production possibilities, farmers' decisions tend to draw on experience and intuition, and thus, are often less efficient and risk averse (footnote 49). Moreover, agri-entrepreneurs and agri-technology start-ups often lack access to financing and training to expand their market and boost the adoption of innovative solutions.

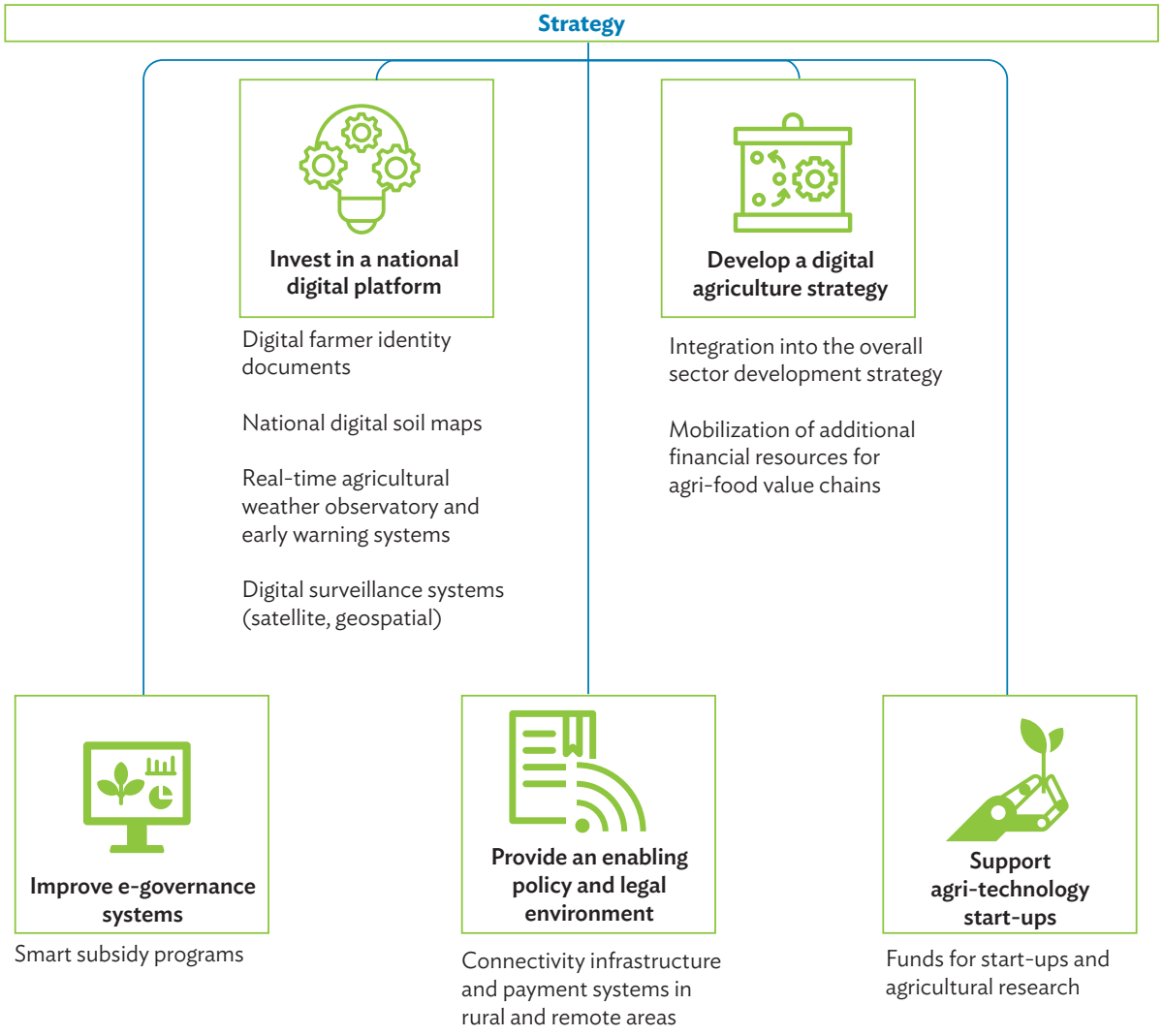
Smallholder farmers generally lack access to technologies, information, and markets.

[55] Q. Zhang. 2024. Five Pathways to Transform Food Systems in Asia and the Pacific. Asian Development Blog. 10 April. https://blogs.adb.org/blog/five-pathways-transform-food-systems-asia-and-pacific.

Digital Transformation Strategies to Accelerate Transformation in Food and Agriculture Systems

Digital agricultural technologies (DATs), including innovative business models and/or technologies, can help address many of the challenges, and enable farmers and agro-entrepreneurs to leapfrog current methods to increase their productivity, efficiency, and competitiveness (Figure 17). This will enable new market access, improved nutritional outcomes, and enhanced resilience to climate change. DATs differ from other agri-machinery innovations as they empower farmers to use easy-to-access digital tools that challenge the status quo of asset ownership and address system-wide challenges.

Figure 17: Digital Transformation Strategies for Food Security and Sustainable and Resilient Agriculture



Source: Adapted from J. Kim et al. 2020. *Scaling Up Disruptive Agricultural Technologies in Africa.* World Bank.

Invest in a national digital platform to enable the development of innovative products and services for smallholder farmers

Invest in a national digital platform to enable the development of innovative products and services for smallholder farmers. Investments in policies and platforms for data collection, management, quality assurance, and tiered access by the public and businesses will enable the development of innovative products and services. It will also develop a foundation of data for evidence-based policymaking. Digitizing farming data, for instance, would enable the development of data-based and digitally enabled products and services, and streamline benefit transfers. An example is India's AgriStack, a national digital platform that is currently under development (Case Study 4).[56] AgriStack aims to improve farmers' access to credit, inputs, markets, and services; empower agri-technology start-ups through better access to data; foster better governance through more transparent and efficient implementation of government schemes for farmers; and enable the use of big data analytics in agriculture.

Develop a digital agriculture strategy

Develop a digital agriculture strategy as part of the overall agriculture sector development strategy. This could include extension and service delivery models to enable digital innovations to be tested and tried for smallholders. DATs can help smallholder farmers by linking various actors in the agri-food system, and providing, processing, and analyzing an increasing amount of data faster and more cost effectively. DATs can help smallholder farmers make more precise decisions about resource management through accurate, prompt, and location-specific price, weather, and agronomic data and information. DATs can also make smallholders more competitive by leveling the playing field. Even in poorly connected communities, sophisticated offline DATs can provide opportunities to help poor and even illiterate farmers. Most of these solutions require partnerships between input suppliers, service providers, and digital innovators. Therefore, the digital agriculture strategy must be developed with relevant stakeholders to ensure their commitment in the implementation of the strategy.

Automatic weather station in Bangladesh. Farmers can rely on weather information provided through their mobile phones.

[56] AgriStack. https://agristack.gov.in/#/.

Case Study 4

AgriStack of India

India's AgriStack initiative represents a paradigm shift in how food is produced and distributed.[a] Originally conceived as a digital infrastructure program aimed at digital record-keeping, remote sensing technologies, and basic data analytics, AgriStack has evolved into a comprehensive ecosystem. AgriStack aims to create a seamless, integrated platform that enables stakeholders—farmers, agronomists, traders, and policymakers—to make informed decisions based on real-time data and analytics. It serves as a digital backbone supporting numerous services, including farm management software, precision agriculture, supply chain traceability, and financial services tailored for farmers. Over time, AgriStack has incorporated more sophisticated technologies. Artificial intelligence (AI) algorithms now analyze data from satellites, drones, and ground sensors to provide actionable insights on crop health, soil moisture levels, and pest infestations. Blockchain technology ensures traceability and transparency in the supply chain, enhancing food safety and quality control. Relying on Internet of Things and data analytics, smart irrigation systems can adjust water usage based on soil moisture data and weather forecasts. By analyzing climate data and modeling crop responses to various weather scenarios, AgriStack platforms help farmers adapt their practices to changing environmental conditions. AI-driven advisory services offer personalized guidance to farmers on everything from crop selection and pest management to market trends. The integration of digital financial services within AgriStack platforms allows famers to connect to digital marketplaces, access credit, and mitigate risks.

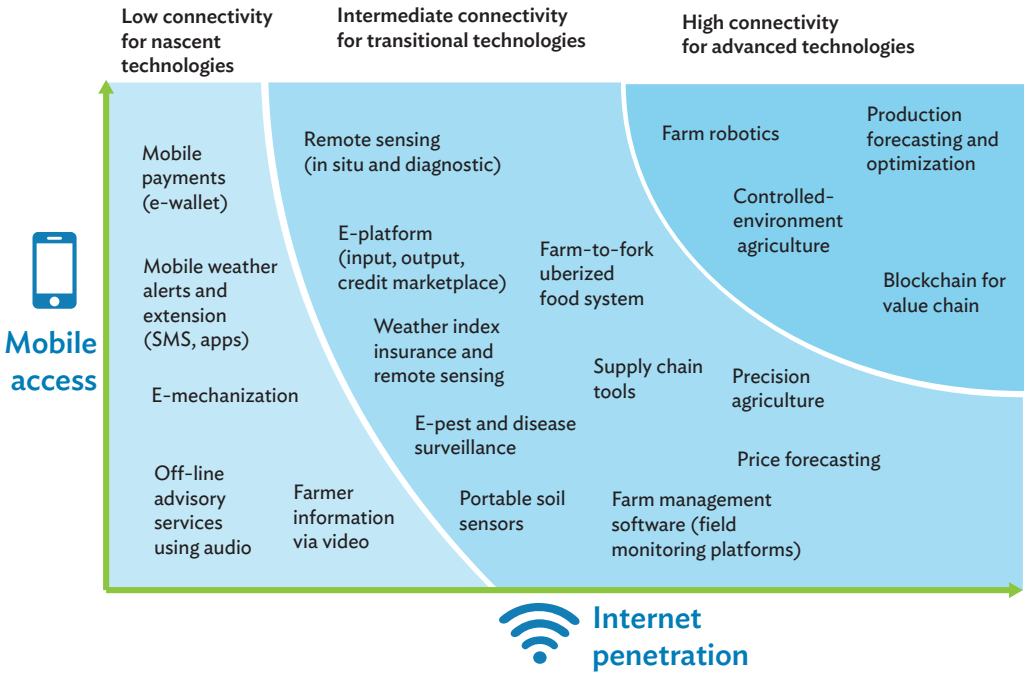
As AgriStack continues to evolve, lessons learned in India could be crucial in neighboring countries as well. The future challenges that AgriStack can address include integrating genomic data to develop crop varieties that are more resilient to pests and climate change and supporting urban and vertical farming initiatives.

[a] AgriStack. https://agristack.gov.in/#/.

Source: ADB.

Improve e-governance systems. This improvement is to allow input subsidies and other incentives to be channeled through digital services. In Sub-Saharan Africa, for instance, an inventory of nearly 200 DATs revealed that more than 70% were developed in the last decade (footnote 49). The key drivers behind this acceleration are (i) low-cost connectivity, (ii) adaptable and more affordable tools, (iii) advances in data analytics and exchange, and (iv) increasing demand for context-specific agricultural solutions. Indeed, more than 75% of scalable DATs are digital, with the rest either focused on energy, production of bio products, aquaponics, or hydroponics. Nonetheless, the agriculture sector is still one of the slowest sectors to digitalize. These technologies exist along a continuum (Figure 18). Even in low-connectivity rural environments, many DATs can be deployed, such as portable soil tests, SMS-based farmer education tools, and offline functioning edge platforms to upload or receive data as connections become available. More than 80% of DATs run as e-marketplace or basic precision agriculture tools that do not require high connectivity, while 15% are focused on financial inclusion.

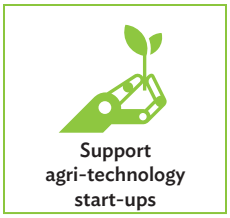
Figure 18: Digital Agriculture Continuum



Source: J. Kim et al. 2020. *Scaling Up Disruptive Agricultural Technologies in Africa.* World Bank. https://doi.org/10.1596/978-1-4648-1522-5.

Most of digital agriculture solutions require partnerships between input suppliers, service providers, and digital innovators.

Provide an enabling policy and legal environment for connectivity infrastructure and payment systems in rural areas. Continued investments in improving the speed, quality, and affordability of digital connectivity as well as promoting the use of digital payment systems in rural and remote areas is critical to enable nationwide adoption of increasingly advanced technologies such as AI, distributed ledger technologies, and IoT by smallholder farmers to improve their livelihood and resilience. During the COVID-19 pandemic, many governments and private operators fast-tracked the deployment of e-commerce and digital payment platforms that directly connected farm producers and buyers constrained by lockdowns. By reducing the need for intermediaries, smallholder farmers have been able to earn higher profits and incomes, which in turn has strengthened their resilience.[57] Technologies such as early warning systems for extreme climate-related events, or web-based weather advisory and forecasting services, can also help farmers manage their crops better.



Support agri-technology start-ups. This support can help farmers expand their market and boost the adoption of innovative practices and digital technologies in the agriculture sector, which tends to be more conservative and slower to adopt new practices and solutions. Given that most DAT applications are currently limited to offering point-based solutions, there is significant scope for improvement. Bundled services, such as digital platforms that combine input supply with extension services, or linking farmers to buyers complemented by credit, may help increase adoption and accelerate systemic changes. In parallel, investments in the enabling ecosystem should pick up momentum to allow expansion at regional and international levels.

Figure 19 details digital transformation interventions for food security and sustainable and resilient agriculture by digital maturity level.

Continued investments in improving the speed, quality, and affordability of digital connectivity as well as promoting the use of digital payment systems in rural and remote areas is critical to enable nationwide adoption of increasingly advanced technologies such as AI, distributed ledger technologies, and IoT by smallholder farmers to improve their livelihood and resilience.

[57] K. Schroeder, J. Lampietti, and G. Elabed. 2021. *What's Cooking: Digital Transformation of the Agrifood System.* World Bank.

Sadia Afrin Shupta, a scientific officer in the greenhouse at Bangladesh Rice Research Institute in Gazipur, Bangladesh. Digital agricultural technologies can play a critical role in enhancing the resilience and productivity of food systems.

Figure 19: Digital Transformation Interventions for Food Security and Sustainable and Resilient Agriculture by Digital Maturity Level

Domain	Maturity Levels: Basic → Advanced				
	1	2	3	4	5
ENABLING CONDITIONS					
STRATEGIC FRAMEWORK	**Absent**	**Nascent** Stand-alone, departmental action plans	**Foundational** Long-term investment plan and PPPs to expand rural infrastructure and market links	**Intermediate** Comprehensive road map for digital agriculture	**Integrated** Converging technology program to minimize environmental impacts, preserve biodiversity, and improve nutrition
POLICY ENVIRONMENT AND GOVERNANCE	**Nascent**	**Developing** Engagement with rural farming communities	**Defined** Regulatory framework for digital agriculture (central government – local government roles; digital value chain pilots, logistics reforms)	**Aligned** Policies for data protection, investor protection, digital taxation, and e-commerce	**Optimized** Reform programs to enable the business of agriculture for farmers; food safety, security, and behavioral nudges to influence food preferences
OPERATIONAL ENVIRONMENT	**Unaware** Traditional agricultural practices (pre-ICT)	**Reactive** Digital pilots to extend rural connectivity	**Proactive** Agri-technology hubs; VC-funding for agri-technology start-ups	**Managed** Positive attitudes and incentives toward entrepreneurial risk taking; availability of risk insurance	**Continuous learning and forward looking** Agricultural observatory; personalized skill-based training for farmers to reach best practices; lifelong-learning programs
DIGITAL CAPABILITIES	**Nascent** Community video	**Basic** Digital advisory to improve farmers' crop management and financial literacy	**Intermediate** Digital capacity building for rural youth	**Advanced** Support for agro-entrepreneurs and scale-up of pilots; building advanced digital skills along the entire food value chain	**Applied and innovative** Funding for university and industry research collaboration; advanced cross-disciplinary graduate-level skills
CORE DIGITAL COMPONENTS					
TECHNOLOGY INFRASTRUCTURE	**Nascent** Hardware only Solar-powered irrigation pump	**Emerging** Software-enabled Portable pH sensor; agricultural drone	**Virtualized** Network connectivity Digitally enabled tractor hiring; 4IR-enabled internet connectivity (through drones, satellites)	**Pooled service-based system** Farm robotics deployed for harvest and process automation	**Value/service-based delivery model** IoT system to enable precision agriculture; low-emission, minimum-waste farming (hydroponics, vertical/urban farming)
DATA INFRASTRUCTURE	**Individual datasets** Storage inventory; farmer's crop yield; purchase orders	**Data processing and storage** Web-based agriculture value chain MIS	**Information exchange and standards** Farm management software (field monitoring platform)	**Interoperability** Digitalization of value chain data; big data for e-market platforms	**Integration** Blockchain-based traceability of food supply chains; trustworthy land-registry platforms; smallholder farmer digital identity systems
DATA ANALYTICS	**Ad hoc reporting** Loan status; crop for sale	**Descriptive analytics** Real-time land-use mapping and monitoring	**Causal inference, strategic reports** Hyper-local real-time weather alerts and extension services; aerial pest and disease surveillance	**Predictive reporting and visualization** Sensor-enabled predictions of food supply and demand; AI-based famine prediction application; satellite and drone-enabled disaster risk insurance products	**Prescriptive decision-support** Production forecasting and optimization; precision analytics for agricultural management
DIGITAL ADOPTION	**Nascent** Farmer info (via radio)	**Individual use** Digital payment system, digital extension service; real-time soil-testing service	**Point-of-service** AI-enabled extension services for smallholder farmers to increase productivity; e-purchase platform for farmers (inputs, e-wallets, insurance products)	**System-wide** Farm-to-table Uberized food system; digital platforms to match buyers and sellers; food traceability; digital food safety clearance	**Nationwide** Sustainable, controlled environment agriculture programs; use of farming techniques based on advanced soil carbon sequestration; crop biotech solutions to improve resilience and nutritional content; single window for agrifood trade

4IR= fourth industrial revolution, AI = artificial intelligence, ICT= information and communication technology, IoT = Internet of Things, MIS= management information system, pH= potential of hydrogen, PPP = public–private partnership, VC = venture capital.

Source: ADB.

Sustainable Development Goal Transformation #5

Digital Transformation of Governments

This section examines the ability of digital technologies to transform the way the public sector operates, delivers services, improves accountability and openness, and increases citizen participation in decision-making processes. Challenges, such as the digital divide, and the lack of capacity and trust, are hindering progress. ADB's Strategy 2030 Operational Priority 6 on strengthening governance and institutional capacity recognizes digital transformation in government as a crucial part of public sector reform and strengthening of governance and institutional capacity. Strategies for government leaders to accelerate public sector transformation need to be focused around (i) digital infrastructure and business continuity, (ii) digital capabilities and skills, (iii) digital leadership, (iv) digital legislation and regulation, and (v) an interoperable, user-focused platform for government services.

Overview

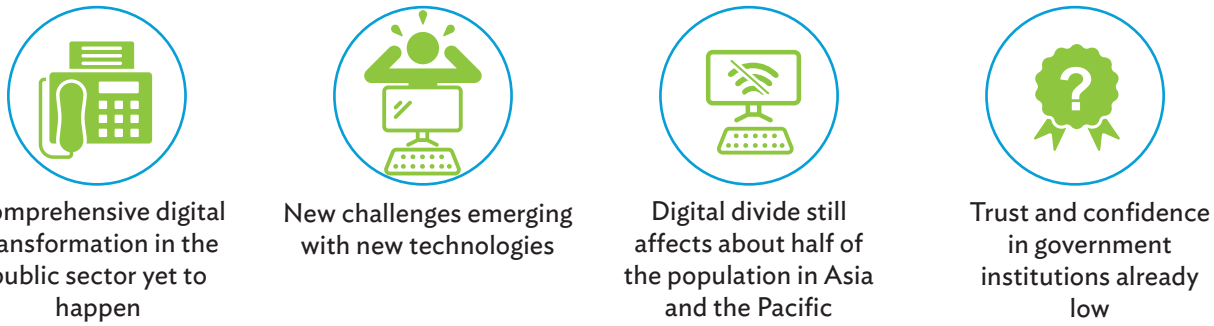
The strategic use of digital technologies and data can facilitate the fast and efficient delivery of public services, improve government accountability and openness, and increase citizen participation in decision-making processes. A growing number of countries have strengthened their institutional and legal frameworks for e-government development, according to the UN E-Government Development Index 2022.[58] Most countries have adopted a national electronic or digital government strategy, as well as legislation on cybersecurity, personal data protection, national data policy, open government data, and e-participation. Digital platforms have improved efficiency and helped implement whole-of-government approaches for citizen-centric public service delivery. Platforms for geospatial data sharing and geographic information systems to analyze, visualize, and map geospatial data have also emerged to support and improve policy and planning across sectors, including for pandemic and disaster response, and to enhance climate and disaster resilience. Individuals and businesses can interact with public institutions through online platforms and access public content and data.

Digital transformation in government is embedded in ADB's operational priority for strengthening governance and institutional capacity. The benefits of digital transformation in government include increased efficiency and productivity, easier collaboration across the whole of government and with private partners and civil society, better decision-making through data-driven insights, improved understanding of citizens' needs, and more dynamic and responsive public services.

[58] UN DESA. 2022. *UN E-Government Survey 2022*. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2022.

Challenges

Figure 20: Challenges to Digital Transformation of Governments



Source: Asian Development Bank.

While important advances have been made in e-government over the past decades, comprehensive digital transformation in the public sector has not yet materialized. Governments across Asia and the Pacific are at various stages of their digital transformation journey and have varying priorities on their national agendas toward digital development (Figure 20).

The main challenges in advancing e-government are:

- lack of consistent leadership;
- lack of user involvement at design and pilot stage;
- lack of business process engineering as precursor and necessary change management;
- vendor lock-in into legacy systems;
- insufficient sustained financing to ensure ongoing operations and maintenance;
- siloed approaches as opposed to whole-of-government approaches; and
- lack of digital capabilities[59]

Moreover, digital development has introduced new challenges related to consumer and labor protection, competition, taxation, and data protection.

Inclusive design has not received sufficient attention. The digital divide still affects about half of the population in Asia and the Pacific with significant variations in the coverage, usage, and quality of connectivity and public service delivery. The groups that are easiest to reach have generally benefited most from the notable progress in e-government, while many of the poorest and most vulnerable groups have been left behind. Moreover, few countries have engaged in online consultations, and even fewer countries have incorporated user input in policy decisions relating to vulnerable groups (footnote 52).

Trust and confidence in government institutions will remain low without increased transparency and inclusiveness. Data privacy and security concerns have taken center stage amid rising cyberthreats and growing dependence on digital technologies. Addressing these risks requires dedicated institutions and regulations to increase public trust and adoption of public sector platforms, digital services, and citizen feedback mechanisms.

To govern and shape digital innovations, it is necessary to strengthen public institutions and human capacities. These are also needed to tackle implementation challenges across the other SDG transformation areas.

[59] UNDP. 2023. *The DPI Approach: A Playbook.*

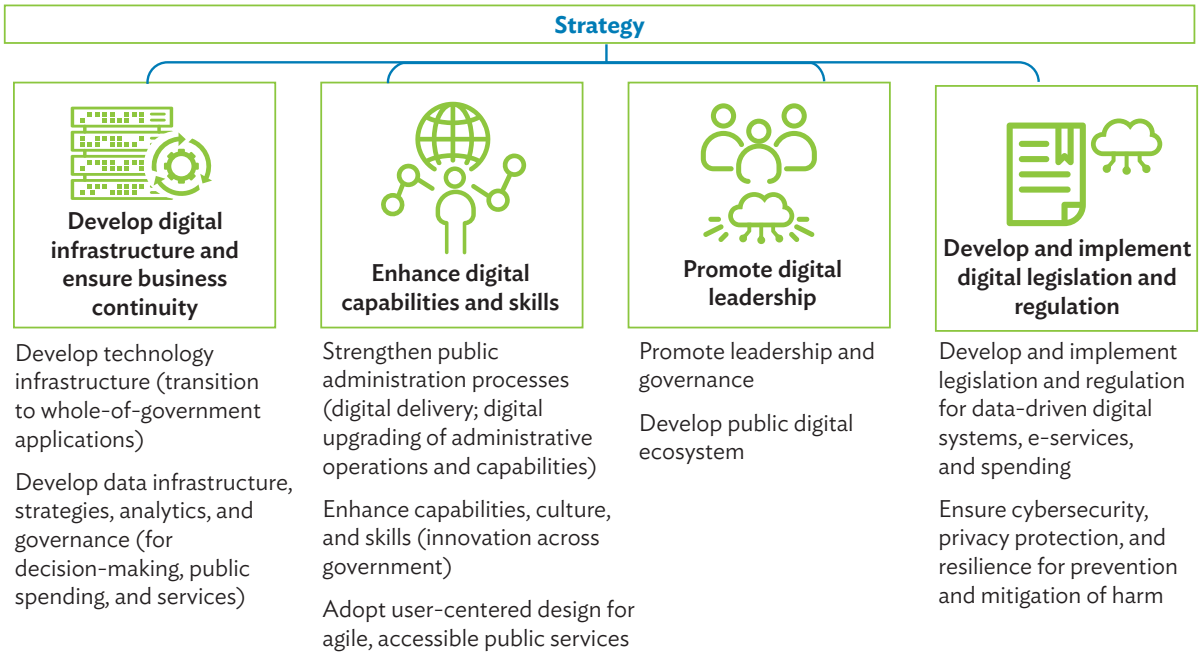
Implementing whole-of-government digital strategies and comprehensive public sector reforms takes a concerted effort. The transition to integrated digital solutions and shared platforms requires substantial investment in hardware, data systems, change management, and digital skills development. Digital transformation in government needs to be based on policy coherence across government (horizontal) and between levels of government (vertical). Digital transformation in government also requires engagement with the business community and civil society through a predictable set of policies, incentives, and regulations.

Digital Transformation Strategies to Accelerate Public Sector Reform

A growing number of countries are moving toward seamless public service delivery systems in which fully automated and personalized services are made accessible to anyone, anytime, and from anywhere. More governments are deploying innovative technologies such as cloud computing, AI, and distributed ledger technologies, to assess and address the needs of constituents. Some have developed new methods to exploit data-driven modeling tools for policy development and have created pilot initiatives and sandboxes to design, validate, and scale up innovative solutions. These approaches allow governments to strengthen their analytical and anticipatory capabilities, and proactively shape future development scenarios. With the increased focus on agile and adaptive government and the development of predictive capabilities, governments are setting themselves up to better predict and respond to the needs of all members of society. Good practices include the Republic of Korea's Government Cloud-First Initiative (Case Study 5), Singapore's Digital Government Blueprint (Appendix 3), and Australia's Data and Digital Government Strategy (Appendix 3).

Digital transformation of the public sector involves a comprehensive set of regulatory standards, infrastructure, and digital systems. This includes (i) digital infrastructure and business continuity, (ii) digital capabilities and skills, (iii) digital leadership, and (iv) digital legislation and regulation (Figure 21).

Figure 21: Digital Transformation Strategies to Accelerate Public Sector Reform



Source: World Bank. 2020. *Digital Government Readiness Assessment Toolkit: Guidelines for Task Teams.* April. https://doi.org/10.1596/33674.

Case Study 5

"Cloud First" Initiative of the Republic of Korea

The National Information Resources Service (NIRS) is the world's first pan-governmental data center, responsible for integrating and managing the data and information of central government institutions.[a] Consolidating information resources—once separately managed by individual government departments—in one centralized place, NIRS was set up to change the operation of isolated information systems, including the inefficient use of information resources, duplication in digital investments, the lack of digital expertise, and wide exposure to security risks. To achieve its vision of becoming an Intelligent Cloud Computing Center, NIRS is building a software-defined data center (SDDC) for its government cloud. The SDDC will accelerate cloud migration for government and public organizations to support the government's "cloud first" initiative.[b] The four main functions of this government-wide data center are to: (i) integrate, operate, and manage 1,460 digital government services linked to 45 central government institutions and oversee about 45,000 government information resources, including servers and storage; (ii) consolidate and retrieve information through the government-exclusive G-Cloud to facilitate interdepartmental information sharing and optimize resource utilization; (iii) operate Hye-An, the pan-governmental big data portal, for all government officers to support science- and data-driven government policymaking; and (iv) protect national information resources against cyber threats through an integrated security management system using AI technologies.

[a] National Information Resources Service. Achievements. https://www.nirs.go.kr/eng/achieve/achieve_01.jsp (accessed 24 April 2024).
[b] Red Hat. 2020. National Information Resources Service Daegu Center and Orange Life Named Winners of the Red Hat APAC Innovation Awards 2020 for Korea. Press release. 21 October. https://www.redhat.com/en/about/press-releases/national-information-resources-service-daegu-center-and-orange-life-named-winners-red-hat-apac-innovation-awards-2020-korea.

Source: Authors.

Develop digital infrastructure and ensure business continuity

Develop digital infrastructure and ensure business continuity. Public sector transformation can be accelerated by the development of shared digital infrastructure with strong cybersecurity and government business continuity management across public administration and operations. This includes the building of foundational digital infrastructure and DPIs, such as national ID systems, digital payment systems, and national procurement or data management portals (footnote 53). It also requires the development of integrated risk management action plans across key sectors to include consumer protection (e.g., privacy and data protection), mitigation of risks and threats (e.g., disasters, pandemics, cybersecurity, and job loss from automation), and the development of temporary safety nets.

A common pitfall in developing shared digital infrastructure, data systems, and platforms is the building of government-first or government-only digital platforms. It is important that DMCs build digital platforms and solutions that the private sector can use, to avoid duplicated efforts and enable greater impact. A recent but by now well-documented digital transformation initiative is the development of DPGs and DPIs, which has been recognized as a promising approach by the G20 during India's presidency.[60] For example, the India Stack is a set of DPI components that has been used to accelerate India's digital development and rapid growth of its digital economy. It has helped secure the efficient delivery of both public and private services to its citizens.[61] Components in the India Stack include the Aadhaar unique identification and authentication system to enable remote and real-time identification and verification of individuals, and the Unified Payments Interface that allows for real-time and interoperable payments across bank accounts and mobile wallets, among other components. The India Stack has enabled financial inclusion, reduced gender disparities in financial access and usage, and promoted growth in e-commerce and the digital economy by allowing private companies and start-ups to create a wide range of services around the India Stack.

Shared digital infrastructure, data systems, and platforms require innovative approaches in governance, funding, and interoperability, to avoid siloed planning and investment. Most governments already have developed core systems, such as back-office and front-office solutions, online service portals, and open data platforms, but these systems are often fragmented, disconnected, and not designed with user preferences in mind. Alongside centralized procurement practices, this calls for the deployment of enterprise architecture frameworks for interoperable systems, harmonization of operating systems, development of frameworks for data governance and exchange, and introduction of cost-efficient measures for digital resource management across government.

Enhance digital capabilities and skills

Enhance digital capabilities and skills. Digital skills development across the public administration is critical to using digital technologies for SDG transformation while at the same time addressing rising data privacy and cybersecurity risks and threats. Many governments now consider core digital skills for civil servants to be an essential workforce skill and have started developing competency frameworks and training programs structured around them. The UN Global Digital Literacy Framework and the EU DigComp frameworks provide general competency frameworks for generalist skills. Beyond these, more specific skills for digital professionals (digital leaders as well as experts), as well as organizational level competences should be developed that support the government's digital transformation agenda. Such competency frameworks allow for the design of appropriate training programs (which can be delivered by private providers) as well as the assessment of the digital skills of public servants. The government can play an important role in setting out digital competency standards and frameworks for students, teachers, professionals, and technicians in the IT fields; general workforce; and citizens, which can be incorporated into curricula of educational institutions and training providers.

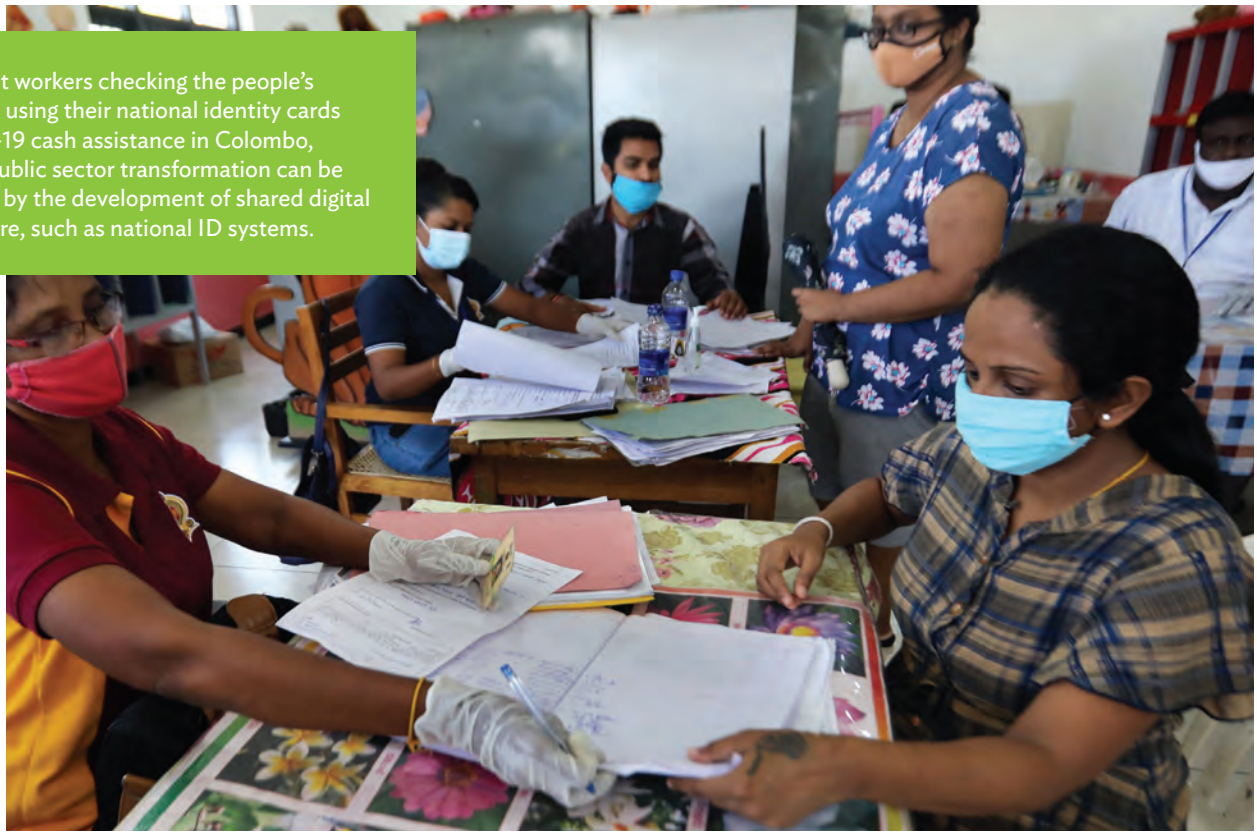
[60] Group of 20. 2023. G20 Framework for Systems of Digital Public Infrastructure (Annexure 1). https://g7g20-documents.org/fileadmin/G7G20_documents/2023/G20/India/Sherpa-Track/Digital%20Economy%20Ministers/2%20Ministers%27%20Annex/G20_Digital%20Economy%20Ministers%20Meeting_Annex1_19082023.pdf.

[61] Digital India Corporation. India Stack Global. https://dic.gov.in/india-stack-global/.

Key agencies where digital capabilities need to be built up include revenue and customs departments, land registration, as well as citizen-facing agencies which deliver the bulk of services. Another key function involves the procurement of complex IT systems and software and human resource management. For instance, serious problems in IT procurement and subsequent deployment arise from the lack of knowledge on formulating requests for proposals, avoiding vendor lock-in, applying government standards to allow systems to be connected, developing KPIs to monitor system performance and adoption, and assessing costs of regular maintenance and upgrading.

Digital entrepreneurship and innovation are two other dimensions for building broad digital capabilities that fuel the growth of the digital economy. Broad-based economic and societal transformation requires a critical mass of digital skills, ranging from basic digital literacy to advanced technical skills among workers in the public and private sectors, small enterprises, farmers, and the public. There is a growing sector with firms engaged in IT and IT-enabled services, as well as freelancers working on global digital platforms, where advanced digital skills are employed. Governments can tap into this emerging talent pool by supporting and partnering with innovation hubs that offer opportunities for startup ventures, networking, digital sandboxing, and solution design adapted to local conditions. A concrete example is to develop, test, and roll out cybersecurity applications for use by government agencies as well as the private sector to shore up defenses against digital vulnerabilities in critical infrastructure facilities, banking systems, data centers, education, and health institutions.

Promote digital leadership. Clear prioritization of digital transformation initiatives by both political and administrative leadership is critical. The vision and goals of digital government transformation should be articulated in a national policy and endorsed by stakeholders across the public administration. This will enable whole-of-government digital transformation, promote ministerial-level coordination, and enhance engagement with relevant agencies.



Government workers checking the people's information using their national identity cards for COVID-19 cash assistance in Colombo, Sri Lanka. Public sector transformation can be accelerated by the development of shared digital infrastructure, such as national ID systems.

Develop and implement digital legislation and regulation. Digital government transformation needs a sound legal and regulatory environment for digital signatures, digital identification, data governance and management, transition to cloud computing, personal data protection, consumer protection, privacy, and cybersecurity.[62] Legislative and regulatory tools can help address risks and ethical concerns related to digital technologies, build trust in the digital environment, and support digital transformation.

Creating a functional digital ecosystem that encompasses the four aspects described above is critical, particularly for the adoption of a whole-of-government approach that requires engagement with different sectors, agencies, and levels of government, as well as partnerships among government, private sector, and civil society organizations. Interlinking relevant operations and services, e.g., land registration (under land reform department) with property tax (under local governments), is important to capture relevant data and activities across agencies and promote collaboration.

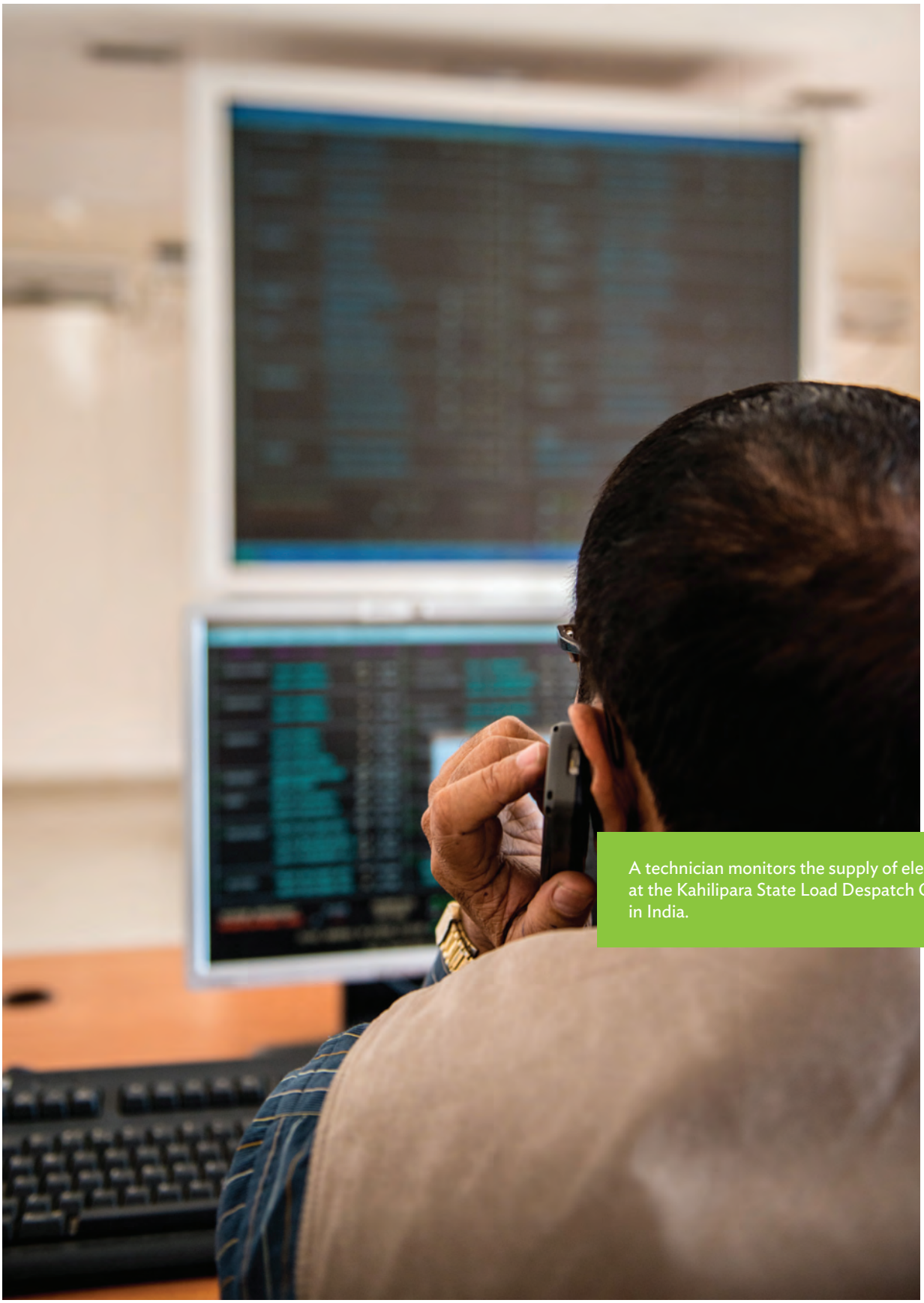
Another area of concern is to adjust the tax differential between online and offline services. In low-income countries, a lower tax rate on connection charges and data packages can spur the adoption of e-commerce applications, which, in turn, may increase the take-up of digital financial transactions as well as online health and education services. For middle-income countries, a primary consideration on setting tax rates for online transactions should be to make digital services more affordable, especially for vulnerable population groups.

An important prerequisite for digital transformation is to develop and institutionalize clear change management procedures and policies to ensure political will and coordinated implementation of digital transformation plans, as well as the further development of digital government. There is growing awareness (and experience) of the need to update the institutional frameworks, governance models, and operational processes underpinning public service delivery. In many countries, an institutional anchoring at the highest levels of government, such as the president or prime minister's office, can help build momentum for policy reforms, procedural change, and financial allocations to important digital transformation pillars, such as digital infrastructure investments and skill development initiatives.

Figure 22 details digital transformation for government transformation by digital maturity level.

Legislative and regulatory tools can help address risks and ethical concerns related to digital technologies, build trust in the digital environment, and support digital transformation.

[62] ADB and Amazon Web Services Institute. 2022. *Data Management Policies and Practices in Government.*



A technician monitors the supply of electricity at the Kahilipara State Load Despatch Centre in India.

Figure 22: Digital Transformation Interventions of Government Transformation by Digital Maturity Levels

Domain

Maturity Levels: Basic → Advanced

ENABLING CONDITIONS

STRATEGIC FRAMEWORK

1	2	3	4	5
Absent	**Nascent** Visioning exercise of a country's future development goals and needs	**Foundational** Multiyear implementation plans/road map	**Intermediate** Alignment of national digital strategy with local level strategies	**Integrated** SDG goals and targets incorporated into inclusive national development strategy

POLICY ENVIRONMENT AND GOVERNANCE

1	2	3	4	5
Nascent Isolated technology 'islands' in government agencies; traditional functions of national statistical offices	**Developing** Exploratory workshops; baseline assessment of the role of digital technologies; digital toolkits	**Defined** Comprehensive legal and regulatory framework for digital government (digital identity, online information, personal data, M&E systems, data sharing, cybersecurity)	**Aligned** Whole-of-government approach to integrate organizational processes and public service delivery; regulatory sandboxes; organizational culture change initiatives	**Optimized** Multiagency, multijurisdictional collaboration; public–private partnerships data; digital ecosystems; collaboration with international counterparts; anticipatory and resilient

OPERATIONAL ENVIRONMENT

1	2	3	4	5
Unaware	**Reactive** Procurement of stand-alone e-government solutions (hardware, proprietary software); siloed/niche-based approach	**Proactive** Executive leadership, with central agency/CIO for digital agenda; institutional ecosystem to adopt digital tech and deploy digital government services; user-centric approach	**Managed** Increased citizen expectations for accessible, connected, and readily available public services; citizen centric e-portal (e-participation, open government, public procurement)	**Continuous learning and forward looking** Data-enabled experimental policy design; agile tech deployment to reinforce transparency, accountability, trust; open government data 'hackathons;' targeted improvements triggered by user feedback, evaluation, foresight

DIGITAL CAPABILITIES

1	2	3	4	5
Nascent Outsourced; isolated expertise	**Basic** Public officials trained in data-informed decision making; society-wide engagement in technological change; user-relevant content	**Intermediate** Leadership skills in technical and policy areas for data oversight, policy, and technical frameworks; policymakers with expertise to lead systemic transformations; attract and retain top digital talents	**Advanced** Technically trained specialists in analytics and data science; specialized AI skills; adopting digital mindset across government agencies and society	**Applied and innovative** Ability of government and society to transform policies, programs, and services by using innovation, digital technology; co-design of digital applications in partnership with private tech companies, universities, communities

CORE DIGITAL COMPONENTS

TECHNOLOGY INFRASTRUCTURE

1	2	3	4	5
Nascent Hardware only Desktop PCs, scanners, copiers, etc.	**Emerging** Software-enabled IoT devices for emergency response	**Virtualized** Network connectivity Device-to-device communication; national e-government portal	**Pooled service-based system** AI-based tools for administrative automation; cyber defense	**Value/service-based delivery model** Customized electronic portfolios; AI-enabled digital passport and visas

DATA INFRASTRUCTURE

1	2	3	4	5
Individual datasets Household surveys	**Data processing and storage** Digitization of analog records into machine-readable text; fragmented data storage and processing capabilities	**Information exchange and standards** AI-enabled information platform to access public services, business permits, rules; open government data; mesh-up of administrative data with alternative data sources	**Interoperability** Crowd-sourcing information from social media, sensor networks; open-source code and APIs for public data	**Integration** Combining individual citizen data across multiple systems; AI-enabled cybersecurity systems; integrated digital identity solutions to establish access to services, economic identities

DATA ANALYTICS

1	2	3	4	5
Ad hoc reporting Opinion polls	**Descriptive analytics** Public expenditure review	**Causal inference, strategic reports** Advanced demographic data analytics; satellite and AI-enabled geospatial mapping; digital publication of government expenditure; real-time public sentiment analysis to inform public policy	**Predictive reporting and visualization** AI, big data, economic analytics for economic and fiscal forecasting; AR/VR visualization to plan infrastructure investments; big data for disaster preparation; pattern detection of tax fraud and corruption	**Prescriptive decision-support** AI-enabled early-warning system involving financial markets; augmented tax and benefit reviews and job placement schemes

DIGITAL ADOPTION

1	2	3	4	5
Nascent Opportunistic hardware acquisitions by public agencies	**Individual use** Multilingual capabilities to assist citizens; services targeting vulnerable groups	**Point-of-service** Low-cost biometric identification; conversational AI for G2P service interactions; use of social networking and chatbot tools	**System-wide** AI-enabled unbiased selection for and delivery of public services; AI-enabled digital footprint for mobile money	**Nationwide** One-stop shop delivery platform for public services; voice-enabled delivery of citizen services; blockchain-enabled digital voting

AI = artificial intelligence, API = artificial programming interface, AR/VR = augmented reality/virtual reality, CIO = chief information officer, G2P= government-to-person, IoT = Internet of Things, M&E=monitoring and evaluation, PC=personal computer, SDG = Sustainable Development Goal.

Source: Asian Development Bank.

Sustainable Development Goal Transformation #6

Improved Connectivity and Competitiveness

Enhancing connectivity and competitiveness is embedded in ADB's Strategy 2030 Operational Priority 7 on fostering regional cooperation and integration. Digital connectivity is a prerequisite to adopting digital technologies and implementing systems such as digital ID, digital payment, e-commerce platforms, intelligent multimodal transport systems, smart electricity grids, and smart cities. This section explores ways to address the persistent digital divide and barriers to digital technology adoption that are affecting national competitiveness, hindering productivity gains of businesses, and preventing the advancement of the Fourth Industrial Revolution that uses AI, robotics, and innovative manufacturing technologies. These strategies comprise (i) regional cooperation and integration, (ii) digital connectivity, and (iii) competitiveness and innovation. Government support is needed to correct market failures and direct resources to underserved or unserved locations to bridge the digital divide and enable seamless cross-border trade. Regional cooperation and PPPs can play a key role in accelerating digital technology adoption and addressing digital transformation challenges such as inadequate internet connectivity, low digital literacy rates, and concerns over cybersecurity.

Overview

Improving connectivity and competitiveness is embedded in ADB's operational priority on fostering regional cooperation and integration. This includes enhancing regional digital connectivity and using digital technologies to promote regional cooperation and seamless cross-border trading and investment and the development and sharing of regional public goods toward achievement of the SDGs.

To enable the frictionless flow of data, products, and services across the region, a harmonized regulatory framework and robust regional cooperation arrangements need to be in place to bridge digital divides and address threats to cybersecurity. Regional cooperation in building the digital infrastructure, harmonizing regulations, enhancing cybersecurity measures, and strengthening digital capacities can address digital transformation challenges head-on, ensuring a secure and inclusive digital future in Asia and the Pacific.

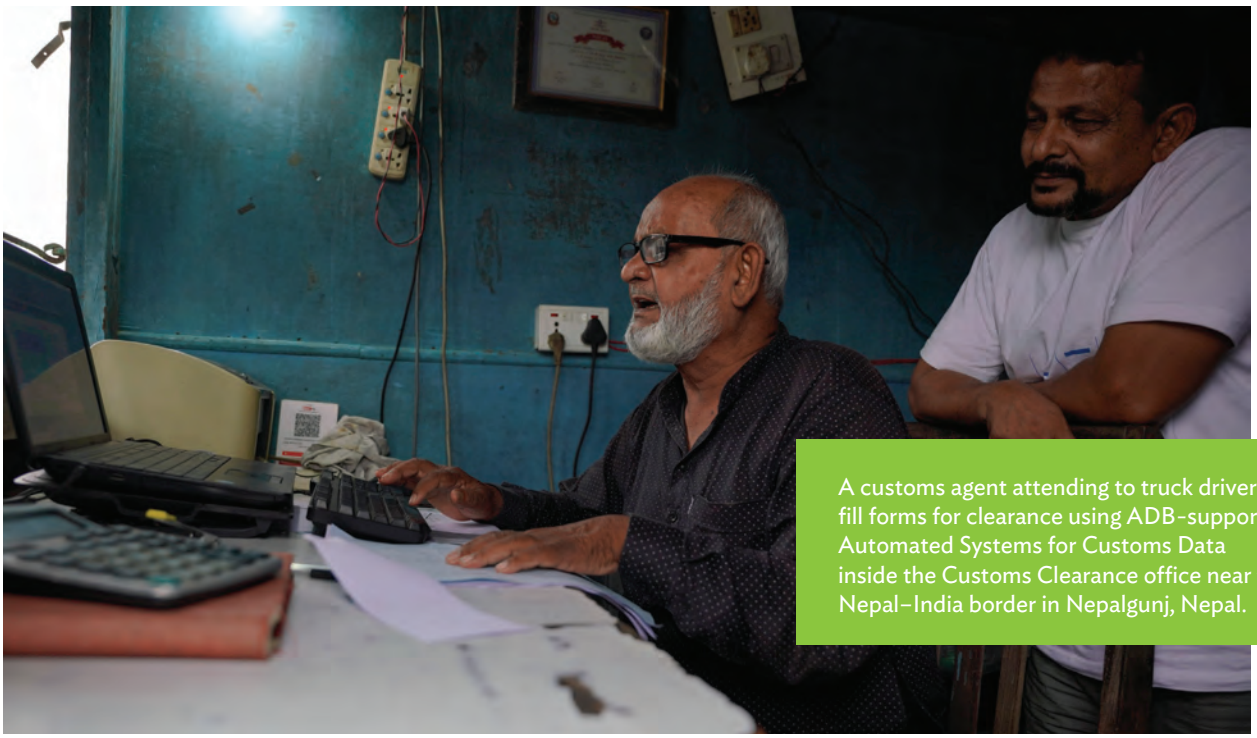
Digital connectivity is an enabler of growth and change, from traditional economies to digital economies. Digital connectivity is a prerequisite to adopting digital technologies and implementing systems such as digital ID, digital payment, intelligent multimodal transport systems, smart electricity grids, and smart cities. As the world's collective reliance on digital technology grows, ensuring widespread and affordable yet robust and high-quality digital connectivity is crucial to enhancing national competitiveness and the diffusion of innovation.

Challenges

Figure 23: Challenges to Digital Transformation to Improve Connectivity and Competitiveness

Source: Asian Development Bank.

Regional cooperation and integration play a vital role in improving cross-border connectivity, increasing regional trade and investment, and reducing vulnerability to shocks. A united approach is needed to address common digital transformation challenges such as inadequate internet connectivity, low digital literacy rates, and concerns over cybersecurity (Figure 23). Further harmonization and standardization of digital technologies can enhance the efficiency of cross-border payment and settlement systems. Joint initiatives to advance regional integration include interoperable digital payment systems, interoperable blockchain-based smart contracts for a secure exchange of information and assets, and the development of a robust national data infrastructure. As technology becomes increasingly integrated into daily life and critical infrastructure, the importance of safeguarding digital assets and information against cyberthreats becomes paramount, elevating the regional importance of cybersecurity.



A customs agent attending to truck drivers to fill forms for clearance using ADB-supported Automated Systems for Customs Data inside the Customs Clearance office near the Nepal–India border in Nepalgunj, Nepal.

Across and within DMCs, there are large variations in technology adoption, with most companies operating far from the technology frontier.[63] Many companies in developing countries are held back by the incomplete adoption of so-called Industry 2.0 (intermittent electricity), enjoy wider access to mobile phones but incomplete adoption of Industry 3.0 (use of computer or internet), and are still far from using 4IR technologies. A country's average technological sophistication is closely related to its productivity level. Comparisons across sectors show that manufacturing and service-oriented companies tend to work at more advanced technological levels than farms. Larger companies tend to use more sophisticated technologies than smaller ones, a gap which further increases with a country's income level. Importantly, the variations in technological sophistication between companies within a given country tend to be larger than their differences across countries. This suggests that the pathways for upgrading technologies differ across business functions. For instance, low-cost digital technologies such as standard software, and social media, are readily available to perform general business functions, while sector-specific functions usually require more specialized digital applications (e.g., Global Positioning System in tractors).

Understanding what drives the speed of technology adoption in DMCs is critical for policies that aim to incentivize technology adoption and upgrading. Several factors may be at play. First, capabilities are a key driver of technology adoption. Any type of technology adoption support program cannot solely focus on the hardware or software component. It also needs to provide services to strengthen these capabilities. Second, decision-makers in both public and private organizations often do not see the value of technology upgrading. This may be because they lack the necessary information, are caught by status-quo bias, or judge the returns to be uncertain. Third, policies are needed to adjust existing regulatory frameworks and governance arrangements to enable the adoption of digital technologies, without throttling the drive for innovation.

More broadly, the persistent and growing digital divide is still a challenge. The greatest acceleration in technology and digital solutions is concentrated in countries with well-developed digital ecosystems (e.g., the PRC, India, the Republic of Korea, or Singapore). Any new technology funding will likely be directed to markets with existing infrastructure and ecosystems, thereby risking leaving others behind. Another growing divide may involve urban and rural areas. New technology solutions, especially those focusing on last-mile delivery, e-commerce, and e-payment, play to the advantage of the digital urban consumer. Although digital solutions in health care and education have the potential for universal reach, affordability and connectivity barriers in rural areas may make the adoption of digital services harder.[64]

An operator works inside the control room of the automated Khurkot substation in Parbat, Nepal.

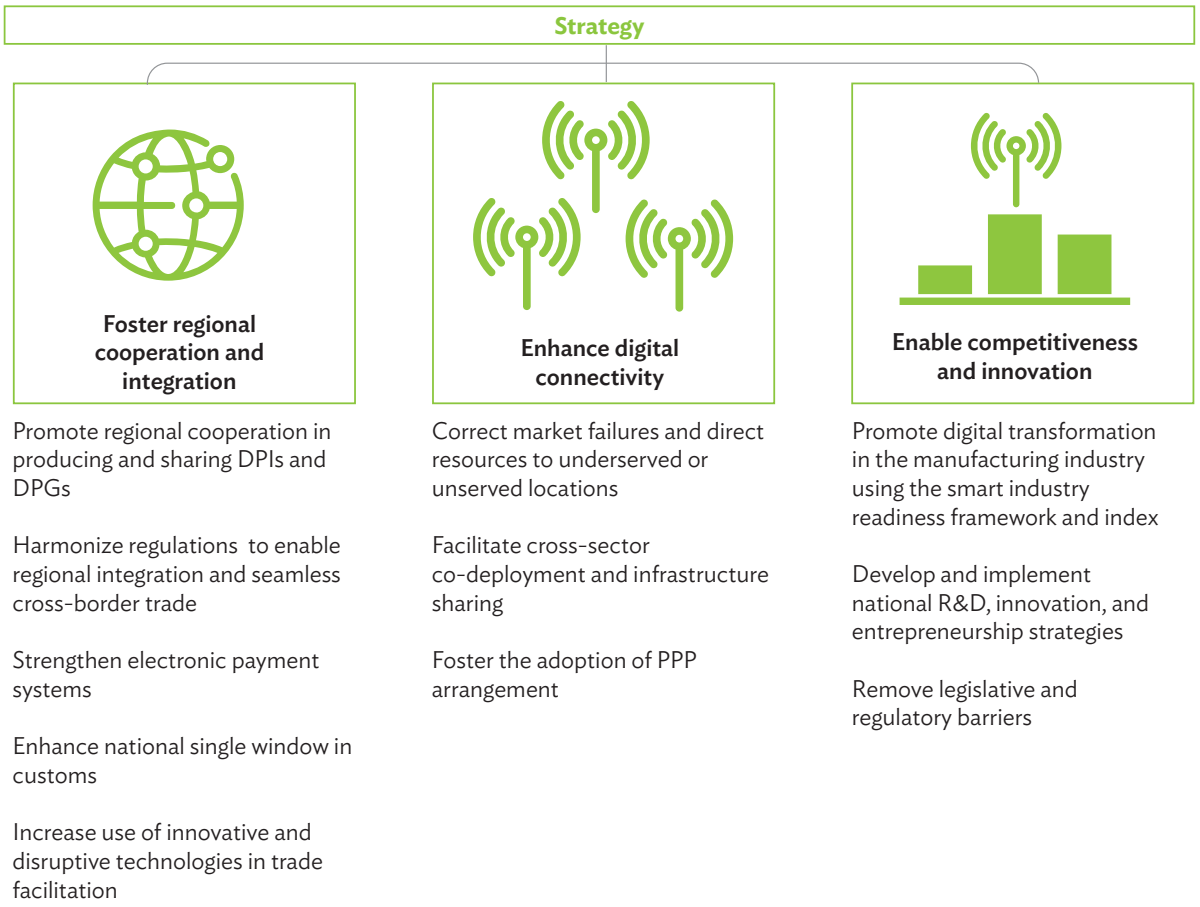
[63] D. Comin and M. Mestieri. 2014. Technology Diffusion: Measurement, Causes, and Consequences. *Handbook of Economic Growth*. 2: 565–622.

[64] J. Brewer, Y. Jeong, and A. Husar. 2022. Last Mile Connectivity: Addressing the Affordability Frontier. *ADB Sustainable Development Working Paper Series.* No. 83. ADB.

Digital Transformation Strategies to Improve Connectivity and Competitiveness

Strategies to encourage the adoption of digital technologies in the pursuit of improved connectivity, competitiveness, and expanded trade and investment need to foster regional cooperation, trade integration, and innovation (Figure 24).[65] Good practice examples include Bangladesh's ekShop digital commerce model and platform (Case Study 6) and cross-sector infrastructure co-deployment in India (Appendix 3).

Figure 24: Digital Transformation Strategies to Improve Connectivity and Competitiveness



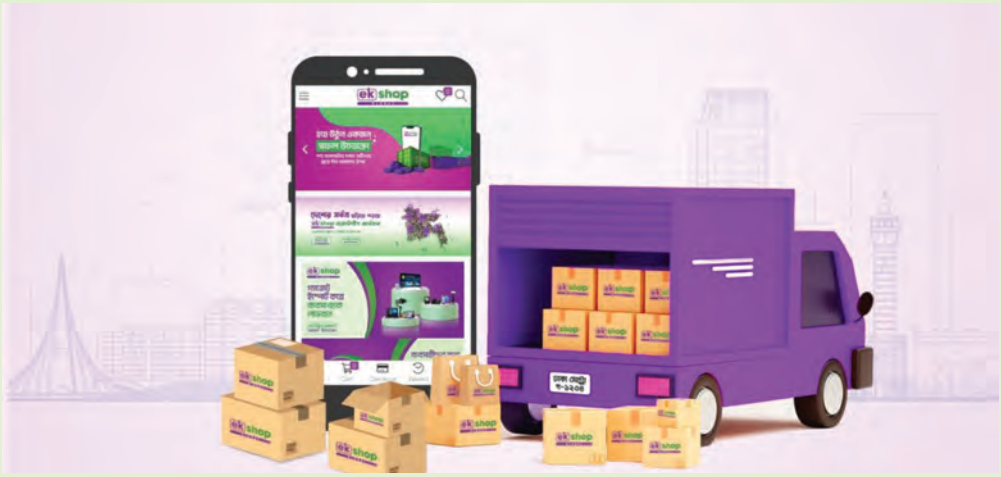
DPG = digital public good, DPI = digital public infrastructure, PPP = public–private partnership, R&D = research and development.

Source: ADB.

[65] Smart Industry Readiness Index. The Smart Industry Readiness Index: Catalysing the Transformation of Manufacturing. https://www.edb.gov.sg/content/ dam/edb-en/about-edb/media-releases/news/the-smart-industry-readiness-index/the-sg-smart-industry-readiness- index-whitepaper%20(1).pdf.

Case Study 6

ekShop Digital Commerce Model and Platform in Bangladesh



EkShop is an integrated rural digital commerce model and platform that was launched in 2019 by the Aspire to Innovate (a2i) program of the Information and Communication Technology Division of the Government of Bangladesh and the United Nations Development Programme.[a] It connects digital commerce and logistics companies with a nationwide network of over 4,000 digital centers and 9,000 ekShop points that are easily accessible to rural communities, enabling rural youth, women entrepreneurs, artisans, and farmers to participate in digital commerce.[b] More than 4,600 farmers, 16 digital commerce companies, and 4,900 wholesalers are registered on the platform, and about 77% of the rural products marketed through ekShop are produced by women.[c] EkShop has since expanded to many other countries including Egypt, Gambia, Ghana, Malaysia, Nepal, Singapore, South Sudan, Sri Lanka, Türkiye, Uganda, and Yemen, with plans to expand to countries in Europe, the Middle East, and North America. By relying on this e-commerce model, the a2i program came to be known as the ekShop Shoron platform which played a crucial role in supporting the livelihood of Rohingya refugees in Cox's Bazar. After receiving training, Rohingya women started a fashion line which was sold internationally, including in the United Kingdom and Thailand. With Rohingya refugees not being allowed to receive cash payments in Bangladesh, the a2i program partnered with the World Food Programme to convert the sales receipts into e-vouchers that refugees could use to buy food and other necessities.

[a] ekShop. https://www.ekshop.gov.bd/.
[b] a2i. 2022. ekShop the Largest e-Commerce Aggregator in Bangladesh. YouTube. 22 August. https://www.youtube.com/watch?v=Bsi3JkzwVKo.
[c] Digital Public Goods Alliance. 2022. Government of Bangladesh Joins as a New DPGA Member. 8 September. https://digitalpublicgoods.net/blog/government-of-bangladesh-joins-as-a-new-dpga-member/.

Source: Authors.

Foster regional cooperation and integration. DPIs and DPGs can be produced and shared as regional public goods to accelerate achievement of the SDGs collaboratively. Regional public goods have the potential to influence the impact of national and global public goods by encouraging country-specific and joint actions that increase positive spillovers to neighboring countries. Regulatory harmonization in line with regional and global standards is key to enabling regional integration and seamless cross-border trade. For example, regional payment connectivity can make inter-country payments more seamless, convenient, and affordable. By facilitating seamless, cross-border digital transactions, regional payment systems can drive economic growth, support MSMEs, and reduce transaction costs, laying the groundwork for a unified economic space. Another example is to connect the development of national single windows with digital customs clearance systems on a regional basis. By digitalizing customs processes, DMCs can achieve smoother and faster cross-border movement of goods and services. This not only streamlines trade by reducing paperwork and wait times but also strengthens economic ties and mutual reliance among DMCs, paving the way for a more deeply connected and efficient regional market.

Bridge digital divides. Government support is needed to correct market failures and direct resources to underserved or unserved locations to bridge the digital divide. The tools and approaches that are available to governments include: (i) policy change and regulatory reforms; (ii) initiatives that foster PPPs; (iii) cross-sector co-deployment and infrastructure sharing between the telecommunications network and other linear infrastructure from transport, water, and energy sectors; (iv) support for technology innovation through R&D programs, startup incubators, tax rebates, preferential spectrum assignment, or licensing arrangements; and (v) financial incentives, including through funding allocations from universal access funds. Public and development banks can provide credit lines or guarantees to finance the purchase of technologies.

Mobile phone shop in Bangladesh. Affordable access to mobile phones can help bridge the digital divide.

PPPs can play an important role in increasing the adoption of digital technologies. Routine government operations can be outsourced to private enterprises, including the provision of public services such as health care, education, transportation, waste collection services or the collection of fees and taxes. Governments can facilitate these opportunities by creating an enabling environment that may entail the assignment of digital IDs to every citizen or provide internet connectivity to educational institutions and hospitals. Partnerships with private businesses could focus on designing and implementing appropriate education or health care applications.

Beyond government intervention, private companies can partner with technology companies instead of developing in-house technologies to accelerate their digitalization. These third-party partnerships can be structured in a number of ways including as commercial contracts or venture capital investments aimed at developing these services. A commercial enterprise can, for instance, team up with an e-commerce platform or e-logistics platform to market products online instead of relying on their own platform.

Digital connectivity enables the growth of digital platforms for e-commerce, social media, and the "sharing economy" (e.g., ride-sharing applications). The ability of digital platforms to aggregate, integrate, and scale has brought new efficiencies and growth opportunities, particularly for MSMEs and start-ups. Many such platforms simplify logistics and integrate supply chains and value chains across borders, enabling the participation of small businesses in international trade.[66]

Enable competitiveness and innovation. ADB has been working with the International Centre for Industrial Transformation in promoting digital transformation in the manufacturing industry using the smart industry readiness framework and index (SIRI) and embedding sustainability in their operations (COSIRI).[67] Singapore has been a pioneer in developing and adopting SIRI, led by the Singapore Economic Development Board (footnote 60). There have been many success stories from a number of industries, including SEW-EURODRIVE and Rockwell Automation.[68]

To remain relevant in the face of increasing competition, companies must adapt their organizational structures, processes, and talent pool to retain and upgrade their workforce. National R&D, innovation, and entrepreneurship programs can channel public and private innovation finance, attract and foster talents, and set up collaboration platforms to address priority SDG challenges. An innovation ecosystem strategy that can draw on this combination of initiatives can motivate cross-sector collaboration to create new businesses and boost the competitiveness of existing ones.

Removing legislative and regulatory barriers can further boost digital adoption through innovative sandboxes (Box 3) and support for local technology start-ups. Governments can support local venture capital funds, accelerators, and incubators by matching funds from private investors and development finance institutions.

Figure 25 details digital transformation interventions for improving connectivity and competitiveness by digital maturity levels.

66 ADB. 2023. *E-commerce Evolution in Asia and the Pacific: Opportunities and Challenges.* http://dx.doi.org/10.22617/TCS230473-2.

67 International Centre for Industrial Transformation. Smart Industry Readiness Index. https://incit.org/en/services/siri/; International Centre for Industrial Transformation. Consumer Sustainability Industry Readiness Index. https://incit.org/en/services/cosiri/.

68 International Centre for Industrial Transformation. 2022. SEW-EURODRIVE's SIRI Success Story. 16 June. https://incit.org/en_ca/case-studies/sew-eurodrive-improves-flexibility-and-raises-productivity-with-siri/; International Centre for Industrial Transformation. 2022. Rockwell Automation's SIRI Success Story. 27 May. https://incit.org/en_ca/case-studies/rockwell-automation-drives-sectorial-transformation-with-siri/.

Box 3: Regulatory Sandboxes: What Have We Learned?

The risks, speed, and complexity characterizing technological development often contribute to policy and regulatory challenges. Governments may have insufficient resources, expertise, and capacity to fully access and use government data and understand, assess, and keep up with rapidly evolving technology-enabled innovations, especially those derived from artificial intelligence, distributed ledger technologies, and other frontier technologies. Very often there are scenarios where under-regulation translates into missed opportunities or where regulatory overreaction stifles innovation and worsens digital exclusion. In 2016, the first regulatory sandboxes were set up by regulators allowing financial technology (fintech) start-ups to conduct live experiments in a controlled environment under a regulator's supervision. A review of the lessons learned from the implementation of 73 sandboxes in 57 countries concluded that these mechanisms could help shape a country's fintech environment by serving as an evidence base for regulation where requirements were unclear or missing.[a] They could also help market the entry of companies (with the caveat that far more fintech companies have been supported by innovation hubs); foster partnerships between financial companies and fintechs; enable fintech market development; and build capacity within regulatory institutions. While approximately 60% of sandboxes are focused on general fintech innovations, others have encouraged particular technologies or products to come to market, such as distributed ledger technologies, innovations in insurance or payment systems, or digital authentication technologies. Sandboxes can bring substantial benefits in terms of setting up a fintech market, but they must be adapted to each country's context, with their direct and indirect benefits subjected to meaningful progress indicators. This innovative and catalytic approach can help accelerate progress toward achieving SDGs.

[a] S. Appaya and M. Haji. 2020. Four Years and Counting: What We've Learned from Regulatory Sandboxes. 18 November. World Bank Blogs. https://blogs.worldbank.org/psd/four-years-and-counting-what-weve-learned-regulatory-sandboxes.

Source: Asian Development Bank.

An innovation ecosystem strategy that can draw on this combination of initiatives can motivate cross-sector collaboration to create new businesses and boost the competitiveness of existing ones.

Figure 25: Digital Transformation Interventions for Improving Connectivity and Competitiveness by Digital Maturity Levels

Domain	Maturity Levels: Basic 1	2	3	4	Advanced 5
ENABLING CONDITIONS					
STRATEGIC FRAMEWORK	**Absent**	**Nascent** Pursuit of narrow sector strategies	**Foundational** National competitiveness agenda approved by government / parliament	**Intermediate** Regional cooperation agreements signed; develop and implement national R&D, innovation, and entrepreneurship strategies	**Integrated** Expand regional integration agenda to other areas / sectors / stakeholders; promote digital transformation in manufacturing using the Smart Industry Readiness Framework;
POLICY ENVIRONMENT AND GOVERNANCE	**Nascent**	**Developing** Gap analysis of regional barriers to trade, digital connectivity, finance, migration, climate, etc.	**Defined** Develop regional cooperation agenda, action plan, and scorecard.	**Aligned** Align regional regulatory frameworks and governance arrangements to ease adoption; Incentivize digital foreign investments;	**Optimized** Create shared understanding and approach to address common digital transformation challenges (e.g., digital divide, digital literacy)
OPERATIONAL ENVIRONMENT	**Unaware**	**Reactive** Commission think tanks to analyze gains from closer cooperation;	**Proactive** Creation of new institutional convening mechanisms, such as: National Foreign Trade Council created; digital ecosystems; regional networks of champions; etc. MDB financing for strategic regional corridor programs	**Managed** Collaborate on digital transition challenges outsource routine government operations to private enterprises (e.g., education, health, waste collection); Incentivize job creation, esp. among women, along regional road corridors	**Continuous learning and forward looking** Strengthen systems and processes to reduce regional vulnerabilities and build resilience
DIGITAL CAPABILITIES	**Nascent**	**Basic** Growing awareness of shared threats / digital needs	**Intermediate** Digital capacity building programs for key agencies (e.g., customs and trade officials; cybersecurity personnel)	**Advanced** Active support for regional convening platforms (e.g., reform champions, scientists, women entrepreneurs, technologists, editors)	**Applied and innovative** Joint regional capacity building programs; mutual recognition of academic credentials;
CORE DIGITAL COMPONENTS					
TECHNOLOGY INFRASTRUCTURE	**Nascent** Hardware only Incentivize program to close the digital divide	**Emerging** Software-enabled E-commerce infrastructure in place; low-cost digital software packages / social media	**Virtualized** Network connectivity National single window facilitates digital trading; central banks agree on cross-border digital payment settlement	**Pooled service-based system** Multi-modal transport system operational energy trading platform ilaunched; deploy digital platforms to streamline logistics, integrate supply chain operations across borders, and expand SME participation	**Value/service-based delivery model** Produce and share DPI/DPGs as regional public goods
DATA INFRASTRUCTURE	**Individual datasets**	**Data processing and storage** Digitalization of trade processes	**Information exchange and standards** Automated system for customs data (ASYCUDA) in place; regional cybersecurity alert system in place	**Interoperability** Interoperable blockchain-based smart contracts for secure exchange of data / assets	**Integration** Facilitate cross-sector co-deployment and infrastructure sharing
DATA ANALYTICS	**Ad hoc reporting**	**Descriptive analytics** Statistics on foreign trade, FDI, migration, etc.	**Causal inference, strategic reports** Regional industrial development clusters identified; mapping of digital ecosystems across the regions	**Predictive reporting and visualization** Advanced mapping of knowledge networks, regional risk exposure (cyber, climate, competitiveness)	**Prescriptive decision-support** Strategies in place to improve regional competitiveness relative to other regional blocks; Identify measures to reduce vulnerability to shocks;
DIGITAL ADOPTION	**Nascent**	**Individual use** Traders and digital entrepreneurs finding niche digital solutions	**Point-of-service** Tourists use interoperable digital payments	**Managed (system level)** Public–private partnerships and industry associations incentivize digital adoption	**Optimizing / Population level** Convene regional science policy dialogue to improve air quality

DPI = digital public infrastructure, DPG =digital public goods, FDI = foreign direct investment, MDB = multilateral development bank, SME = small and medium-sized enterprise.

Source: Asian Development Bank.

CHAPTER 4

A woman walking a street amid COVID-19 lockdown in Nepal. COVID-19 pushed SDG progress off track, but it also provided governments and the private sector opportunities to innovate digital solutions for the public good.

Chapter 4

Conclusion

Today's interconnected crises of COVID-19, conflict, and climate are pushing SDG progress off track. At the current pace, Asia and the Pacific are set to achieve only one-third of SDG progress by 2030. In this sobering setting, digital technologies and data have emerged as a transformative force for meeting SDG targets.

There is an opportunity to include digital transformation as one of the core operational priorities under future ADB strategies and monitor the development impact of ADB support for digital solutions. Promoting innovative technology is one of three guiding principles of ADB's Strategy 2030, whereby ADB will proactively seek ways to promote the use of advanced technology across its operations and provide capacity-building support.[69] While an increasing number of ADB staff are working on technology and the number of projects that incorporate digital solutions is also increasing, Strategy 2030 has not set formal targets for operations supporting digital solutions (footnote 8). The midterm review of Strategy 2030 indicated that clear targets in ADB's corporate results framework could incentivize further mainstreaming of innovative technology in the bank's operations. It is worth noting that the World Bank Group recently released its new scorecard framework with 2 of the 15 indicators specifically referring to digital outcome areas (footnote 64).

The analysis in the report illuminates that trade and competitiveness, including diffusion of innovation and technology adoption, as well as sustainable consumption and production are important factors in driving economic growth, fostering job creation, and enhancing overall prosperity in Asia and the Pacific. To achieve the SDGs, countries must change patterns of consumption and production by adopting circular economy models that promote reuse and recycling. The digital revolution offers tremendous potential to make many services accessible in a much more resource efficient manner, be it by substituting resource intensive physical products and services with virtual services or by using digital platforms to match supply and demand in real time.

New initiatives for transitioning toward a more service- and circular-oriented economy are being piloted with respect to mobility, housing, energy, and food systems. How will 4IR technologies affect the future of work through automation, optimization of supply chains, increased adherence to environmental sustainability practices, and new organizational and skill requirements? How can changes in behavior and mindset accelerate this transition on a societal basis?

Future ADB strategies would benefit from a clearly articulated focus on trade and competitiveness, support for innovation ecosystems, technology adoption, and entrepreneurship for driving economic growth and resilience in the region. Identifying digital transformation and trade and competitiveness as core verticals would involve enhancing ADB's internal capacity in these areas.

While many digital transformation frameworks exist, this report stands out by presenting a set of digital transformation road maps to guide the six SDG transformation areas that are linked to ADB's strategy and operational priorities. This report offers a structured approach along core digital components and enabling conditions for digital transformation to achieve the SDGs. Due to wide variations in the development priorities and needs of DMCs, and their digital readiness, differentiated approaches are necessary, based on digital maturity. This report suggests concrete entry points to tailor ADB's support.

ADB is poised to support DMCs in their digital transformation, accelerate progress toward digital maturity, and help facilitate collaborations to fully leverage digital technologies and data for SDG transformation areas.

[69] ADB. 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.*

Kalika Model School, Ram Bazar in Pokhara, Nepal. Digital transformation is changing the future direction of education in low- and middle-income countries.

APPENDIX 1

Global Frameworks and Success Factors for Digital Transformation

This section outlines key factors contributing to successful digital transformation. This is followed by an examination of reference frameworks being used by the World Bank and the United Nations (UN) to inform and guide digital transformation toward achieving the Sustainable Development Goals (SDGs), and a discussion of criteria for technology selection. The section concludes with benchmarking countries' frontier technology readiness.

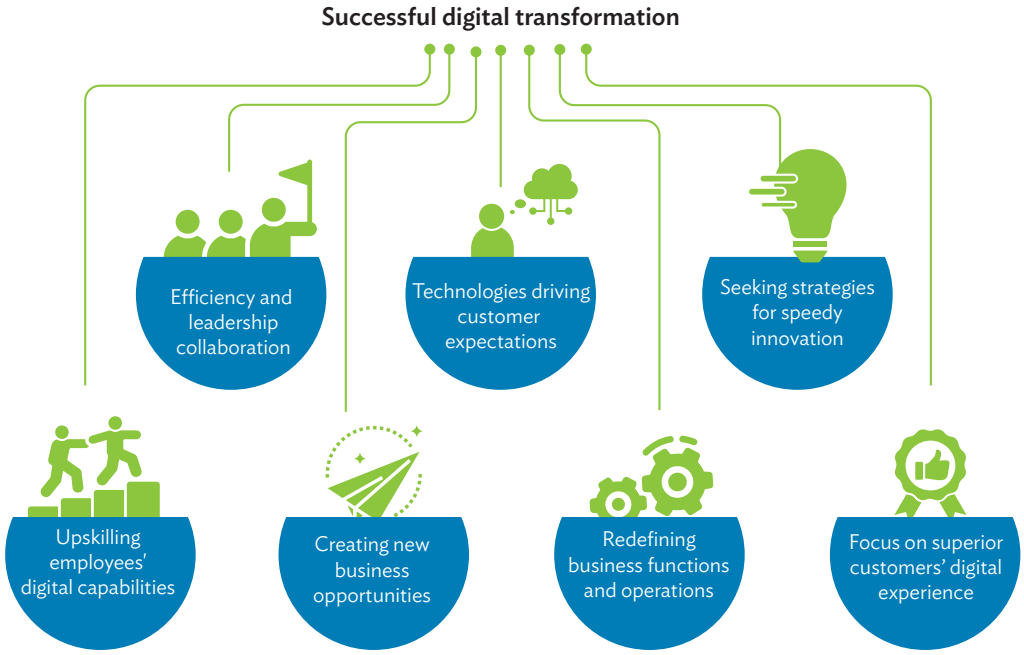
Factors for Successful Digital Transformation

As the push for digital transformation continues to accelerate globally, applying a systematic process that effectively assesses the readiness of countries, institutions, and enterprises, and establishes sound criteria for selecting technologies and vendors appropriate for a given context will be important for success. The complex interplay between government institutions, the private sector, and the public will play a key role in the pace and success of digital transformation.

To succeed, organizations need to understand and address the challenges and avoid common pitfalls, such as resistance to change, challenges in recruiting or retaining the right talent, and compliance concerns, while selecting the best-fit solution. Research points to the importance of a holistic, integrated, cross-sectoral approach that recognizes that digital transformation goes beyond the introduction of stand-alone digital components and requires more than just offering more digital services. Digital transformation drives change at the level of organizations and technological innovations, but it also catalyzes broader institutional, societal, and environmental change across the entire ecosystem.

Crucially, organizations that laid the groundwork for a successful digital transformation (Figure A1.1) tended to be more than twice as successful as those that did not. Rather than treating digital transformation as a sprint with a fixed end point, it is better understood as an evolutionary process geared toward continuous learning and improvements over time. Strong leadership matters for setting priorities, communicating progress toward the goals, engaging potential users to encourage uptake, and adapting implementation efforts in response to feedback and opportunities for scale-up.

Figure A1.1: How Do Organizations Lay the Groundwork for a Successful Digital Transformation?



Source: Global Lancers. 2022. Top 7 Reasons Why Digital Transformations Fail. *Global Lancers.* June. https://lancersglobal.com/insights/digital-transformation/the-reasons-why-organizations-fail-digital-transformation.

Digital Transformation Frameworks

Multiple digital transformation frameworks exist, such as the World Bank Digital Government Readiness Assessment (DGRA) and the UN E-Government Framework. However, the value of the framework proposed in this report is that it is tailored to the ADB Strategy 2030's seven operational priorities and takes into consideration the wide range of digital readiness conditions and maturity levels among DMCs, which require differentiated approaches.

Governments can use the World Bank's Digital Government Readiness Assessment (Version 3.0)[1] to assess their readiness to provide leadership and governance for digital transformation; apply digital technologies to improve administrative operations and services; invest in a shared digital infrastructure with stepped-up cybersecurity measures; and establish laws and regulations for data privacy, consumer protection, digital identification, and cybersecurity.

The DGRA toolkit identifies strengths and weaknesses of current digital government efforts and proposes action steps to develop a comprehensive national digital strategy. The assessment considers the rising use of data by government and citizens; the increasing availability of big data; and the prevalence of networks, artificial intelligence, and analytic tools for governments to become data driven.

The DGRA toolkit comprises nine foundational areas for building open and agile digital infrastructure and operations (Figure A1.2): (i) leadership and governance; (ii) user-centered design; (iii) public administration and change management; (iv) capabilities, culture, and skills; (v) technology infrastructure; (vi) data infrastructure,

[1] World Bank. 2020. *Digital Government Readiness Assessment Toolkit: Guidelines for Task Teams.* World Bank. April. https://doi.org/10.1596/33674.

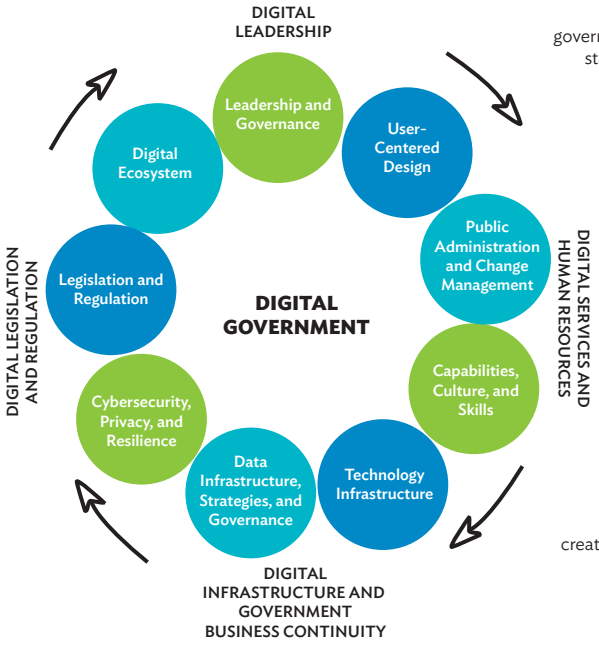
strategies, and governance; (vii) cybersecurity, privacy, and resilience; (viii) legislation and regulation; and (ix) digital ecosystem.

The toolkit nudges users to identify emerging good practices for digital government and adapt them to their local context, for instance by illustrating how to:

- adopt a whole-of-government approach;
- apply a user-centric design philosophy to service design and implementation;
- develop an integrated multichannel delivery approach;
- design services for scale and sustainability;
- promote collaboration and shared infrastructures, platforms, and processes;
- build capabilities, skills, and cultures for innovation and continuous improvement;
- address cybersecurity, privacy, and resilience; and
- adopt legislation and regulation for addressing digital risks.

The United Nations E-Government Framework (Figure A1.3) comprises four building blocks in an iterative cycle: (i) undertake a situation analysis to assess digital transformation capacity gaps and opportunities; (ii) articulate a shared vision of digital transformation; (iii) devise a strategy and road map; and (iv) put monitoring and evaluation mechanisms in place to collect data and feedback to inform subsequent rounds of situation analysis, strategy development, and implementation.[2]

Figure A1.2: Digital Government Readiness Components



Digital Ecosystem
Public digital ecosystem not only boosts innovation, education, and entrepreneurship, but also contributes to the modern digital economy.

Legislation and Regulation
Legislation and regulation brings transparency to many decision-makings on public spending or any e-services that is driven by data.

Cybersecurity, Privacy, and Resilience
A specific protocol, scenarios should be prepared to ensure security and recovery, and minimize risks from any undefined cyber threats, disaster, etc.

Data Infrastructure, Strategies, and Governance
For better decision-making, public spending, and services, digital governments are improving their ability to collect, analyze, and share data using new technologies.

Leadership and Governance
A clear vision, leadership, governance of digital strategy encourages the stakeholders to link the government-wide digital transformation.

User-Centered Design
Basing high-quality of agile and accessible public services around the users needs - *the public* - increase engagements and open participation of the citizens.

Public Administration and Change Management
Public administration process has to be optimized for digital delivery. Digital technologies can rapidly improve administration operations and capabilities.

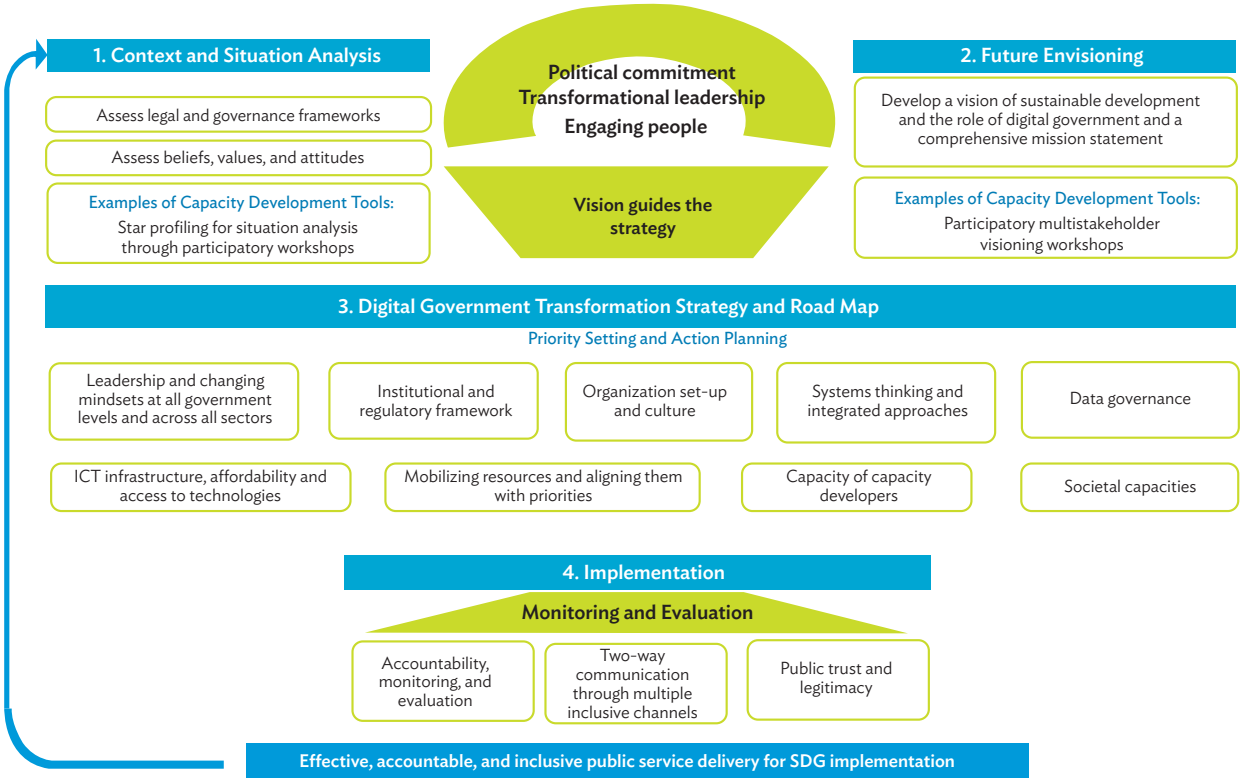
Capabilities, Culture, and Skills
Technology cannot substitute all the government's operations. Hiring and training individuals for digital skills by creating a culture of innovation and creativity across the administration is crucial.

Technology Inftrastructure
Rather than investing specific applications, leaders in today's digital government increasingly look to use whole-of-government standardized technology infrastructure.

Source: World Bank's Digital Government Readiness Assessment (Version 3.0).

[2] UN DESA. 2020. *2020 United Nations E-Government Survey*. United Nations. https://www.un.org/en/desa/2020-united-nations-e-government-survey.

Figure A1.3: A Holistic Approach to Digital Government Transformation and Capacity Development



ICT= information and communication technology, SDG = Sustainable Development Goal.

Source: https://www.un.org/en/desa/2020-united-nations-e-government-survey.

Criteria for Technology Selection

Digital transformation is becoming increasingly important to an organization's lifecycle. With so many software applications and hardware solutions available for digital transformation,[3] choosing the wrong ones can be costly in both time and money.[4]

Many digital transformation initiatives are faced with similar questions:

- What strategic considerations should guide the selection and acquisition of technologies that are expected to be at the core of new business processes, services, and business models?

[3] The most common tech solutions for digital transformation include cloud computing; AI/ML/natural language processing; robotic process automation; API integrations; big data; and real-time analytics.

[4] CNBC reported that companies like GE, Ford, and Procter & Gamble wasted $900 billion on failed digital transformation initiatives in 2018 alone. The biggest reason for their failure was the inability to effectively communicate their goals, strategy, purpose, and outlook with their employees. Keith Kitani GuideSpark. 2019. The US$900 Billion Reason GE, Ford and P&G Failed at Digital Transformation. CNBC. 30 October. https://www.cnbc.com/2019/10/30/heres-why-ge-fords-digital-transformation-programs-failed-last-year.html.

- What criteria can help guide the selection of and engagement with technology vendors?
- Given the rapid diffusion of new technologies in both public and private sector domains, can technology forecasting and foresight offer insights to decision-makers to assess the likely impacts of technologies and help frame plausible scenarios for alternative pathways?

Given the vast scope of possibilities, the selection of technologies should follow a strategic plan and methodical process that focuses on intended outcomes, digital maturity, implementation readiness, trade-offs, and life-cycle aspects (Figure A1.4).[5]

Figure A1.4: Ten Criteria for Technology Selection

Source: Vera Solutions. 2019. *10 Criteria to Evaluate When Choosing a New Technology.* 17 October. https://verasolutions.org/10-criteria-to-evaluate-when-choosing-a-new-technology/.

[5] R. Hamzeh et al. 2018. A Technology Selection Framework for Manufacturing Companies in the Context of Industry 4.0. In 2018 World Symposium on Digital Intelligence for Systems and Machines (DISA). 267–76. https://doi.org/10.1109/DISA.2018.8490606.; Vera Solutions. 2019. 10 Criteria to Evaluate When Choosing a New Technology. Vera Solutions (blog). 17 October. https://www.verasolutions.org/10-criteria-to-evaluate-when-choosing-a-new-technology/?locale=en.; Cathy McKnight. 2022. Guide to Successful Technology Selection and Partner Selection. http://www.digitalclaritygroup.com/step-step-best-approach-successful-technology-selection/.

Governments may weigh multiple criteria in their decision to select technologies that provide critical digital infrastructure. Public investments in digital public goods, such as digital ID systems, payment platforms, affordable connectivity solutions for remote areas and underserved communities, or data and computing environments for education and health facilities, are often indispensable to achieve public policy objectives such as equitable access, inclusion, and innovation.

Benchmarking Economies' Frontier Technology Readiness

Economies, sectors, and organizations vary in their readiness to adopt digital solutions. High-income economies at the core of the technology revolution have seen simultaneous technological changes in productive processes, consumer behavior, infrastructure, and institutions. In contrast, developing economies tend to experience technology waves: technology changes first occur in the infrastructure (internet, mobile communication) and consumer spheres (e-commerce, e-government, health, and education services) and only later through changes in productive sectors (foreign direct investment, followed by domestic production).

Which economies have the momentum to advance further? The Digital Evolution Scorecard 2020,[6] co-developed by teams at the Tufts University Fletcher School and Mastercard, tries to answer this question for 90 economies by focusing on four key drivers:

- Supply conditions – how developed is the digital and physical infrastructure to support a digital ecosystem?
- Demand conditions – are consumers able and willing to engage in the digital economy?
- Institutional environment – do the economy's laws, regulations, and governance arrangements help advance digitalization?
- Innovation and change – does the economy's innovation ecosystem benefit from the talent and collaboration to produce new, scalable products and services?

Four categories of economies can be identified (Figure A1.5):

- Stand-out economies include consistently top-ranked performers such as Singapore; the United States; Hong Kong, China; the Republic of Korea; Estonia; or Malaysia, which offer both high levels of digitalization and strong forward momentum.
- Break-out economies exhibit limited existing digital infrastructure, but are rapidly digitalizing, as is the case with the People's Republic of China, Indonesia, India, followed by Kenya, Viet Nam, Bangladesh, Rwanda, and Argentina.
- Stall-out economies show high levels of digital maturity but less growth going forward, in part to give space for inclusion and regulation to catch up, as is the case in the Euro zone.
- Watch-out economies—concentrated in Africa, Asia, Latin America, and Southern Europe—lack in both existing digital capabilities and momentum for future development.

Although only a few economies currently create frontier technologies, all economies need to prepare to be ready for their adoption and use. To assess an economy's capability to equitably use, adopt, and adapt these technologies, UNCTAD has developed a frontier technologies readiness index, which comprises information and communication technology deployment, skills, research and development (R&D) activity, industry activity, and access to finance. These technologies include artificial intelligence, the Internet of Things, big data, distributed ledger technologies, 5G, 3D printing, robotics, drone technologies, gene editing, nanotechnology, solar

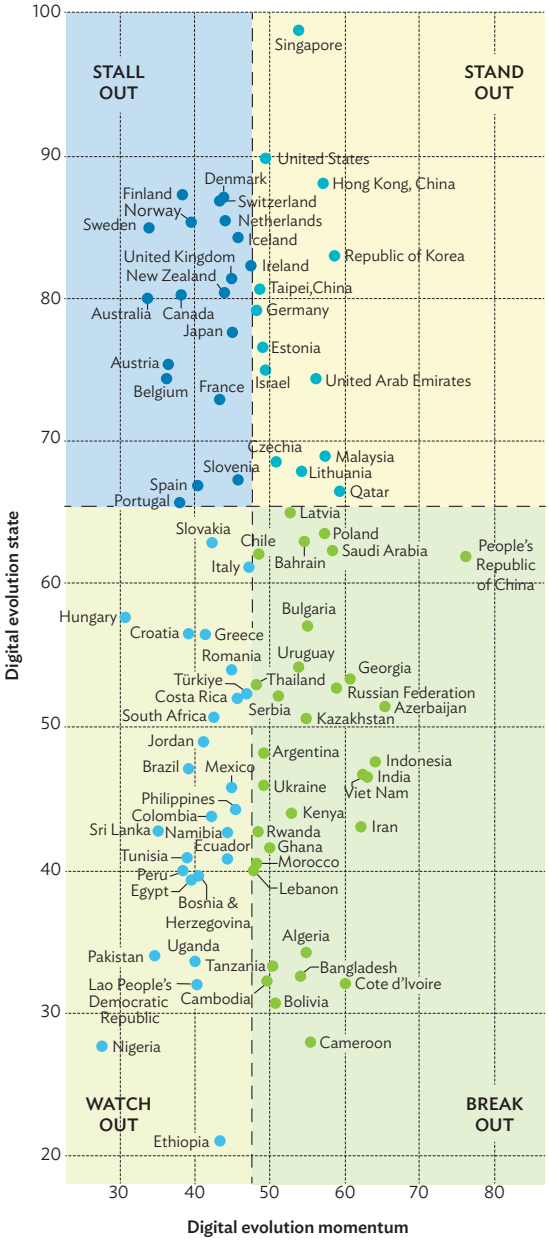
[6] B. Chakravorti, A. Bhalla, and R. S. Chaturvedi. 2020. Which Economies Showed the Most Digital Progress in 2020? Harvard Business Review. 18 December. https://hbr.org/2020/12/which-economies-showed-the-most-digital-progress-in-2020.

photovoltaic, concentrated solar power, biofuels, biogas and biomass, wind energy, green hydrogen, and electric vehicles.[7]

According to UNCTAD's frontier technology readiness index of 166 economies for 2022, the US; Sweden; Singapore; Switzerland; Liechtenstein; the Netherlands; the Republic of Korea; Germany; Finland; and Hong Kong, China are ranked in the top 10 positions. DMCs in South Asia are positioned as follows (2020 rank in parenthesis): India #46 (#43); Sri Lanka #89 (#86); Maldives #103 (#114); Nepal #106 (#109); Bhutan #116 (N.A.); and Bangladesh #126 (#112).

Economies readiness index scores tend to be strongly correlated with the use of frontier technologies (e.g., broadband, solar photovoltaic, robots) and per capita income. Outliers that perform better than their per capita gross domestic products would suggest, include India (due to high R&D and abundant highly skilled workers) and the Philippines (reflecting strong foreign direct investment in high-tech manufacturing and a well-educated workforce). Viet Nam and Jordan also outperform, reflecting supportive government policies for financial inclusion and digital literacy, respectively.

Figure A1.5: Digital Evolution: State and Momentum



Digital Evolution: State and Momentum

An analysis of the current level of digital development and peace of digital growth of 90 global economies divides those economies into four distinct zones: Stall Out, Stand Out, Break Out, and Watch Out.

Source: B. Chakravorti, A. Bhalla, and R. S. Chaturvedi, 2020. Which Economies Showed the Most Digital Progress in 2020?. Harvard Business Review. 18 December. https://hbr.org/2020/12/which-economies-showed-the-most-digital-progress-in-2020.

[7] United Nations Conference on Trade and Development (UNCTAD). 2021. Technology and Innovation Report 2021. https://unctad.org/page/technology-and-innovation-report-2021.

APPENDIX 2:
Good Practices on Managing Digital Risks

Content in this appendix is extracted from ADB. 2023. *Managing Digital Risks: A Primer*. The publication outlines ADB's digital risk assessment tools, looks at the role of development partners, and considers issues including cybersecurity, third-party digital risk management, and the ethical risks of artificial intelligence. Explaining why many digital transformations fall short, it shows why digital risk management is an evolutionary process that involves anticipating risk, safeguarding operations, and bridging gaps to better integrate digital technology into development programs.

Cybersecurity

The United States Agency for International Development (USAID) published a cybersecurity primer that offers guidance on how to incorporate a risk-based approach into country strategies, program, and project design and implementation.[1]

At the country level, a baseline assessment can offer valuable insights into the current cybersecurity landscape and maturity level, identify key actors in the cybersecurity space, and gauge the perceptions of different stakeholder groups about the adequacy of the policy, regulatory, and legal environment for cybersecurity (Table A2.1).

To lay the groundwork for a system-level approach to cybersecurity, a people, process, and technology lens can be applied (Table A2.2). The "people" dimension examines the capacity, behavior, and resources that an individual within an organization is expected to keep remaining secure in any digital activity. The "process" dimension is focused on procuring appropriate technology, response protocols for cyberattacks, and approaches for knowledge sharing. The "technology" lens focuses on sector-specific risk assessments and organizational maturity to determine appropriate and cost-effective technology solutions to secure an organization's digital ecosystem.

[1] USAID. 2021. Cybersecurity Primer. https://www.usaid.gov/sites/default/files/2022-05/10-26-21_EXTERNAL_CyberPrimer-CLEARED-accessible.pdf.

Table A2.1: Assessing the Cybersecurity Landscape, Risks, and Opportunities

Current State and Impact

- What information is publicly available on the state of cyber threats and trends, particularly through government and private sector analysis and reporting? How might these threats and trends affect the programming?
- Are the programs involved in any activities that might be perceived as politically sensitive (e.g., advocacy for democratic norms, human rights, or anticorruption) that may increase the likelihood of attacks and data breaches?
- Do the programs utilize and depend on any hardware or software that is vulnerable to attacks? Have these technologies been designed from the start with security as a priority? Is the software used by partners and/or beneficiaries licensed and current?
- What cybersecurity policies, regulations, and legislations exist in the country? To what extent are they implemented?
- What, if any, organizations exist that raise awareness of cybersecurity risks? How do they raise awareness? What impact do they have on increasing cybersecurity practices?
- What cybersecurity measures are in place to protect critical internet infrastructure?
- What is the extent of different actors' (user, business, government) capability to understand and use cybersecurity products and standard practices?
- Do higher education institution offer curricula on cybersecurity? Are these programs adequate to prepare current and future demand for information security workforce skills?
- What does the competitive landscape look like in terms of cybersecurity providers (e.g., many vs. few; local vs. international companies)?
- Have there been any recent high-profile data breaches or cybersecurity incidents (private or public sector)? At what scale? How were they handled? Was there any communication issued by the government? By the private sectors?
- Do institutions or organizations undergo information audits (such as penetration testing) to ensure the validity of the cybersecurity strategies and policies in place?
- Do cybersecurity standards limit the growth of tech startups and small and medium-sized enterprises?

Cybersecurity Actors

- Who are the key cyberthreat actors related to your environment and programs (e.g., criminal entities, domestic actors, foreign nation states, businesses, political parties, hacktivists, etc.)?
- What stakeholders are engaged in policymaking, advocacy, or programming on cybersecurity (e.g., civil society organizations, tech companies, government ministries, donors)?
- What stakeholders are responsible for monitoring and enforcing cybersecurity threats?
- Is there a national cyber/critical incident response team, computer emergency response team, or a computer security incident response team? Which individuals or organizations are members? What is its mandate?

Perceptions

- How do different stakeholders (civil society, private sector, government, individuals) perceive the importance of cybersecurity?
- How is the policy, regulatory, and legal environment for cybersecurity perceived by different stakeholders (individuals, private sector, business associations, civil society organizations)?
- What is the perception by different stakeholders of government's capacity to monitor, detect and react to cybersecurity breaches?
- How do people's concerns around cybersecurity threats affect their online activities?
- To what degree do cybersecurity concerns deter investment in new technologies?

Source: USAID. 2021. *Cybersecurity Primer.*

Table A2.2: Applying System-Level Approaches to Cybersecurity Interventions

People	Processes	Technology
• Build in-house capacity of team members to understand why cybersecurity and its societal implications are relevant for programs across sectors. • Institute digital literacy and cyber hygiene training across all levels. • Build a robust pipeline of cybersecurity and technology professionals in the country, by working closely with appropriate institutions and/or with other donors. • Leverage programs to support the local technology ecosystems that can then provide local talent to solve local cybersecurity challnges. • Support the development of a cyber-resilient civil society that monitors digital trends in a country, advocates for open, secure, and interoperable digital systems, and educates the population on cyberthreats and security.	• Conduct a digital ecosystem country assessment to understand the digital context of the partner country, including legislation related to cybersecurity. • Build trust initiatives that encourage local processes or frameworks for NGOs to share information on observed cybersecurity attacks. • Encourage partners to adopt risk-based approaches to cybersecurity, including clear processes to identify, protect, detect, respond to, and recover from cyber attacks. Such processes tend to be resource intensive. • When designing programs, incorporate lessons learned from existing cybersecurity programs. • Establish a cybersecurity donor coordination group in-country to discuss cyber challenges and opportunities. • Across programming, encourage information sharing related to cyberattacks or cybersecurity vulnerabilities.	• Consider conducting an assessment of potential risks associated with proposed digital solutions for your sector by an implementing partner or outside experts for a second opinion. • Encourage partners to understand the VPN marketplace, including whether their use is permitted or whether they may be monitored, before using them. • Encourage the transparent procurement of software and hardware technology assets in-country to prevent or limit the use of pirated digital assets that may be compromised.

NGO = nongovernment organization, VPN = virtual private network.

Source: USAID. 2021. *Cybersecurity Primer.*

Third-Party Digital Risk Management

Over three-quarters of organizations are increasing the number of third parties they work with to carry out their priorities through collaboration with or outsourcing to third parties. These arrangements often deliver superior deployment in terms of speed, efficiency, and adaptability by shortening production or delivery cycles and providing access to innovative ideas. It is often better to outsource expertise for highly specialized tasks related to digital technologies, particularly when there is no in-house capacity or if it is considered insufficient.

A vendor's software development life cycle is a cornerstone of the selection process, including how it will be developed, and which models and frameworks the team will use to meet project requirements (e.g., continuous integration, code review, high-end coding review, refactoring, version control). Criteria for quality assurance, bug fixing, user acceptance testing, and protection of user data are best negotiated upfront as part of the vendor selection process. Vendor experience, including past successes and failures with digital transformation projects, should rank high among the selection criteria.

Good relationships and open communication are central to high-performing outsourcing engagements. Successful vendor relationships rely on contracting frameworks that are customized to specific digital transformation. Vendors involved often define the project scope and implementation plan, with clients shifting their contractual focus from outputs to outcomes. Vendors must also adapt to agile ways of working, which require more frequent interactions and multiple iterations rather than a single final deliverable. Here, continued involvement by the vendor's pre-sale team in the digital transformation process is crucial in keeping teams working together effectively.

An important vendor selection criterion is to understand how the vendor will identify and mitigate potential risks connected with project implementation. Possible risks include aspects like third-party service and integration; unforeseen technological challenges (e.g., dependency on tech stack and versioning, changes in user interface design); organizational factors (e.g., change in direction due to client feedback); or added functionality that influences the system's overall performance.

Most successful companies reported that staying on budget and delivering by the agreed-upon launch date were key success factors, suggesting a strong link between good planning, competitive selection, and positive outcomes. When a project experiences scope creep or slippage, leaders must be prepared to invoke either contractual obligations for nondelivery or vendor incentives

Organizations can improve the results of digital transformation initiatives and manage unexpected digital risks with a well-thought-out vendor selection and engagement strategy. A survey conducted by the Boston Consulting Group found that most companies with digital transformation success used advisory firms and a combination of insourcing and outsourcing to execute their programs. This blend of expertise is best when the vendor strategy is developed at the start of the initiative.

Ethical Artificial Intelligence

An example of a data-driven risk assessment methodology for ethical artificial intelligence (AI) by organizations has been developed and field tested in approximately 200 use cases by a team from Sweden's Lund University (Figure A2.1).[2]

The team identified four recurring pitfalls:

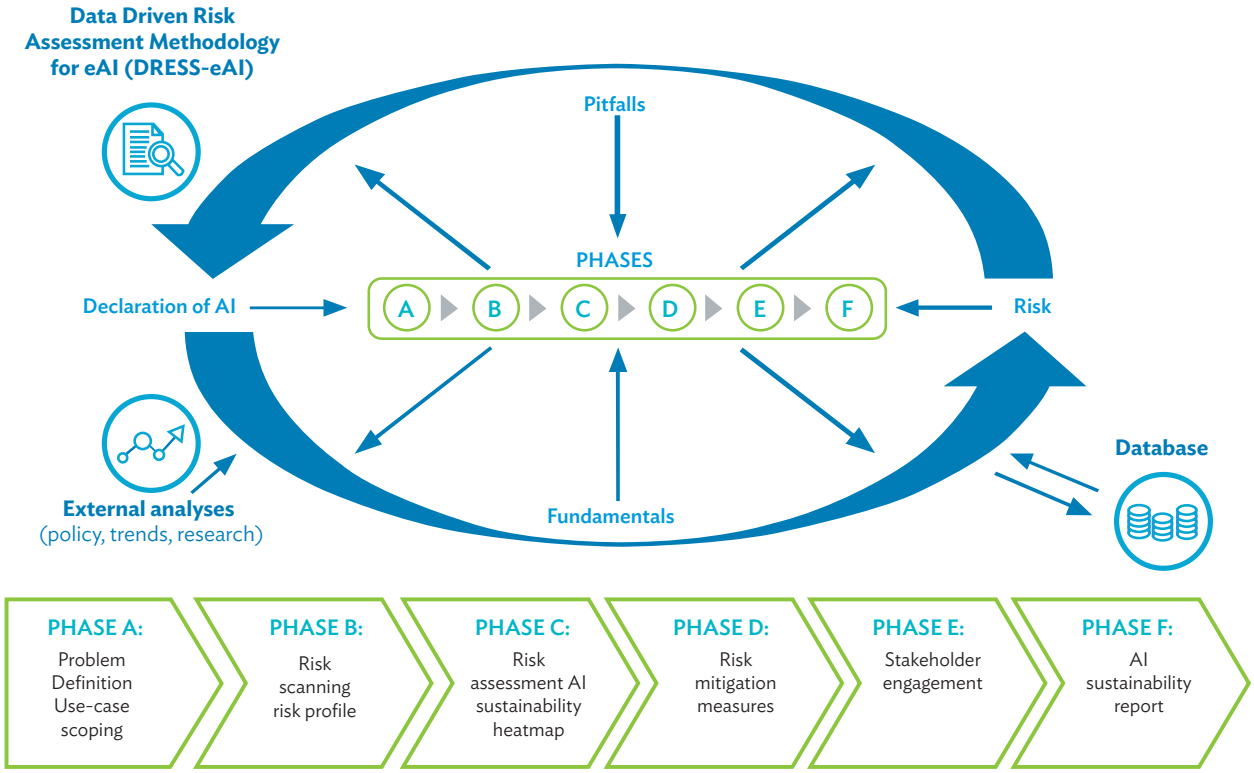
1. Misuse or overuse of data, whereby the AI application could be overly intrusive, use private data, or be used for unintended purposes by others.
2. Bias of the creator whereby values and biases are intentionally or unintentionally programmed by the developer, who may also lack knowledge and/or skills of how the solution could scale.
3. Immature data and AI, where insufficient training of algorithms on data sets and lack of representative data could lead to incorrect and unethical recommendations.
4. Data bias, whereby the data available is not an accurate reflection of reality or the preferred reality and may lead to incorrect and unethical recommendations.

To address these pitfalls, any organization aiming to achieve ethical AI needs to put certain fundamentals in place as a minimum requirement. These include the following:

1. The need to establish accountability and justify one's decisions and actions to partners, users, and others with whom the AI system interacts.
2. The adoption of governance principles, policies, and/or protocols, and continuous monitoring of their proper implementation.
3. The ability to explain algorithmic or data-driven decisions such that they can be understood by end users and other stakeholders using nontechnical terms to establish trust.
4. The requirement for transparency to discover, trace, and detect how and why an AI system made a specific decision or acted in a certain way, and, if a system causes harm, to discover the root cause.

[2] A. Felländer et al. 2022. Achieving a Data-Driven Risk Assessment Methodology for Ethical AI. *Digital Society*. 1 (13). 1–27. https://doi.org/10.1007/s44206-022-00016-0.

Figure A2.1: Overview of Data-Driven Risk Assessment for Ethical Artificial Intelligence



AI = artificial intelligence, eAI = ethical AI.

Source: A. Felländer et al. 2022. Achieving a Data-Driven Risk Assessment Methodology for Ethical AI. *Digital Society*. 1 (13). 1–27. https://doi.org/10.1007/s44206-022-00016-0.

A structured process to ensure that human values and rights are sustained for data-driven AI applications involve the following phases:

A. Workshops are organized to produce a detailed description of the ethical AI use case, including a summary of challenges; guiding policies, codes, and values; key stakeholders; technical specifications; and the project team. This phase also includes a survey to assess the organization's preparedness for ethically high-risk AI systems.
B. Using an in-depth questionnaire, risk scanning and profiling helps generate structured data related to the organization's current state of achieving fundamentals and identifying vulnerabilities associated with pitfalls.
C. The risk assessment phase identifies and prioritizes ethical risk scenarios and stakeholders that could be affected by their exposure to pitfalls and fundamentals.
D. In this phase, technical and/or nontechnical risk mitigation measures are decided at both organizational and use-case levels to address the root causes of a risk scenario or its effects. The implementation of risk-mitigating measures (e.g., updated legal documents, synthetic data for avoiding bias or preserving privacy, tailored explainability models, training, and establishment of an AI ethics board) is assigned to risk owners within the organization, together with plans for the implementation and continued monitoring of follow-up actions.
E. A critical validation step is to capture stakeholder feedback on the risk mitigation measures and what should be done to manage actual and potential impacts.
F. A subsequent review, including an updated risk scan of the use case, is conducted to track the effectiveness of risk mitigation activities and provide recommendations on how internal frameworks can be strengthened.

Data Privacy

A privacy impact assessment (PIA)—is used to identify and evaluate specific privacy risks. Regulatory authorities, such as the Office of the Australian Information Commissioner, Singapore's Personal Data Protection Commission, and the UK Information Commissioner's Office, have published detailed guides, process maps, and use cases for undertaking PIAs.

PIAs can help assess (i) the collection of new personal information, (ii) opportunities for data minimization, (iii) anticipated retention periods, (iv) criteria requiring consumer consent, and (v) the use of technical and security safeguards. The methods for safeguarding these values may vary from case to case.[3] PIA practitioners offer the following suggestions to ensure their effective deployment:

- **Do more than a legal compliance check.** Many PIAs are conducted as if they are simply a compliance check against statutory privacy principles without ever asking what impact the activity will have on individuals. For example, the public's visceral reaction against the invasion of their privacy through full-body scanners led to their reconfiguration at airports to show screening officers a generic outline of a human body.
- **Consider context.** PIAs that focus on one element of a project or program in isolation, rather than the whole ecosystem, will often miss the point. How well users understand the legal protection, transparency, and messaging of a system or project affects their level of trust and their ability to take more informed decisions. During the rollout of COVID-19 tracking apps, for instance, many PIAs did not examine the compliance or risks posed by health departments, which were accessing and using the personally identifiable information collected by the app yet were operating under a patchwork of privacy laws.
- **Test for necessity, legitimacy, and proportionality.** A PIA should not only be about assessing one potential vector for privacy harm, such as compromising personal information, but also whether any negative impacts on individuals are proportionate to the benefits or achievement of the objective. For instance, the Office of the Australian Information Commissioner found that while 7-Eleven had a legitimate interest in understanding customers' in-store experience, the covert collection of biometrics to achieve that objective was neither necessary nor proportionate to the benefits.
- **Test the tech.** A PIA needs to verify the functionality of a digital device or application in order to validate actual or likely benefits. Should this prove to be impossible, no judgment can be rendered as to the trade-offs between privacy risks and benefits.
- **Consider customer expectations in gaining trust.** Rather than simply asking "Do you trust this organization/brand?" probing public trust requires a more in-depth set of questions on a case-by-case basis: "Do you understand and trust the way your personal data will be stored, shared, or processed? Are you in a position to assess whether the use of your personal date will be stored, shared, or processed? Are you in a position to assess whether the use of your personal data will deliver benefits to you and third parties?"
- **Rely on multiple mitigation levers and compare their effectiveness to address privacy risks,** such as technology design and configuration (i.e., choosing which settings to use when implementing off-the-shelf tech); legislation; governance; public communications; user guidance, and staff training.
- **Put the recommendations into practice.** Unless findings and recommendations to mitigate privacy risks are taken on board, a PIA will be a pointless exercise in creating a veneer of respectability. Project teams may need time and space to significantly alter the course of a project or abandon it altogether if necessary.

[3] A. Johnston. 2022. The Seven Habits of Effective Privacy Impact Assessments. *Salinger Privacy*. 2 August. https://www.salingerprivacy.com.au/2022/08/02/how-to-make-pias-great-again/.

APPENDIX 3:
Case Studies

This section presents selected case studies that highlight best practices and lessons learned from digital transformation for achieving the Sustainable Development Goals (SDGs). They are organized by the SDG transformation areas discussed in Section 3.

Sustainable Development Goal Transformation #1

Human Capital Enhancement, Quality Jobs, and Equality

Sri Lanka Leverages District Health Information Software 2 for Coronavirus Disease Vaccine Management

During the coronavirus disease (COVID-19) pandemic, Sri Lanka used District Health Information Software 2 (DHIS2), a globally recognized open-source health information management system and a digital public good for COVID-19 surveillance and vaccine delivery.[a] The Ministry of Health was already using DHIS2 as its primary health information system to track and manage health data and, in January 2020, a COVID-19 surveillance module was integrated into the system with support from the global Health Information Systems Program that manages the existing DHIS2 infrastructure and new developments. Subsequently, in January 2021, the vaccine management module was also integrated into Sri Lanka's DHIS2 system.[b] The COVID-19 immunization tracker of DHIS2 collects case-based and aggregated data on vaccine distribution and stocks at all vaccination centers. The system also manages vaccine appointments and the issuance of digital COVID-19 vaccination certificates. Building on the existing DHIS2 platform has enabled Sri Lanka to leverage the underlying data infrastructure, local digital expertise, and healthcare workers' familiarity to rapidly train for the new COVID-19 modules and deploy them. Moreover, the interoperability of DHIS2 with the immigration system, location data from mobile phones, and local health apps such as the Supariksha app that manages COVID-19 testing data from labs around the country, has helped track and manage critical health system components such as intensive care unit bed availability.[c] Since the DHIS2 health information system platform is widely used globally, the new COVID-19 modules developed in Sri Lanka were quickly adopted by more than 50 other countries.

[a] DHIS2. DHIS2 News: DHIS2 featured by the Digital Public Goods Alliance. https://dhis2.org/dpga-digital-public-good/.
[b] DHIS2. Innovative management of COVID-19 vaccine delivery in Sri Lanka. https://dhis2.org/sri-lanka-covid-vaccine/.
[c] Exemplars in Global Health. Scaling DHIS2 in Sri Lanka: Early Action to Track and Prevent COVID-19. https://www.exemplars.health/emerging-topics/epidemic-preparedness-and-response/digital-health-tools/sri-lanka.
Source: Asian Development Bank.

Integrated and Dynamic Social Registry of Maldives

In Maldives, the Asian Development Bank is providing technical assistance to the Local Government Authority (LGA) in the development and rollout of the Madhadhu app that will serve as a social registry of people in need of special care and protection. The app is linked to other systems such as the national ID system for the verification of application. Madhadhu is also linked to the Social Protection Information System of the National Social Protection Agency and the Social Services Information System of the Ministry of the Gender, Family and Social Services, enabling them to increase social protection coverage and reach those most vulnerable. The Madhadhu app is incorporated as one of the apps on the LGA's e-council platform. The app enables local councils, women's development committees, and relevant citizens' groups to register individuals. The app also has a citizen interface that allows vulnerable individuals to register themselves. To ensure that those without digital connectivity can register, the establishment of Madhadhu Citizen Kiosks are being piloted. This includes the development of clear guidelines and training for relevant local council officers on the establishment, use, and maintenance of the kiosks. To maximize the use of the kiosks, the government recognizes that they should not only be for Madhadhu but incorporate other services of the councils and national institutions. The kiosk design thus incorporates the option to add other services of the e-council platform and host selected services, such as the application for birth certificates and household registrations, adopting a whole-of-government approach.

Source: This case study is extracted from an ADB forthcoming report. *Digital Technology for Social Protection: Case Studies from Asia and the Pacific*.

Digital Labor Platforms

Digital labor platforms increased globally from 142 in 2010 to 777 in 2020, with the United States accounting for 29%, followed by India with 8%.[a] While demand for online work originates largely from the Organisation for Economic Co-operation and Development economies, the labor supply comes from low- and middle-income countries, with India accounting for an estimated 20% of online work. Companies use digital labor platforms to outsource tasks to a global pool of workers. Cloud-based platforms allow work to be broken up into smaller chunks and distributed globally over the internet to large numbers of workers and then reassembled for faster delivery. The cost of hiring workers is typically lower, as workers with similar skills can be sourced at lower price points, especially from developing countries. The platforms also allow the hiring of highly specialized skills without being limited by geography. A web application may be developed in India, while its user interface is sourced from the United Kingdom and the analytics from Ukraine, allowing for faster delivery as work can continue around the clock.

Digital labor platforms have opened new opportunities for workers, especially in developing countries. Businesses, especially small and medium-sized enterprises, can benefit by reducing the time and cost of hiring. A recent study by the Boston Consulting Group and the Michael and Susan Dell Foundation estimated that the gig economy has the potential to service up to 90 million jobs in India's nonfarm economy, transacting over $250 billion in the volume of work, and contribute 1.25% to its gross domestic product over the long term.[b] There are several downsides, however. Given the ability of these platforms to tap larger labor pools, the supply of workers in most cases far exceeds demand, triggering a race to the bottom. The algorithms that assign work to workers are opaque and the rating given to workers can be highly judgmental and biased. Income from platforms can fluctuate widely, and social security and safety nets are largely absent, leaving workers without basic labor protections.

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Continuation

Digital labor platform companies face significant challenges, ranging from significant upfront investments to gain market share with consumers to regulatory compliance when operating in multiple geographies. Upwork, which claims to be the world's largest marketplace, with over 18 million registered freelancers with access to 10,000 skills across 90+ categories and 5 million clients in 180 countries, has posted successive operating losses over the last few years.[c] In markets where Upwork operates, it is subject to laws and regulations involving worker classification, health and safety standards, labor and employment, data protection, data residency, online payment services, money transmitter regulations, anticorruption and money laundering, escrow, content regulation, website accessibility, intellectual property, taxation, consumer protection, background checks, security, and privacy classifications, etc. Platform labor will continue to grow and become more valuable for companies. Policymakers need to take a long-term view in addressing the emerging future of work as far as it relates to platform workers.

[a] International Labour Organization. 2021. *World Employment and Social Outlook: The Role of Digital Labour Platforms in Transforming the World of Work*. 23 February. http://www.ilo.org/global/research/global-reports/weso/2021/WCMS_771749/lang--en/index.htm.
[b] R. Augustinraj, V. Jain, and S. Bansal. 2021. Unlocking the Potential of the Gig Economy in India. Boston Consulting Group. 26 March. https://www.bcg.com/en-in/unlocking-gig-economy-in-india.
[c] Upwork. The World's Work Marketplace for Freelancing. https://www.upwork.com/.
Source: Asian Development Bank.

Sustainable Development Goal Transformation #2

Decarbonization and Energy Transition

India Uses Innovative Business Models to Achieve Smart Meter Rollout

Energy Efficiency Services Limited (EESL) is an energy service company promoted by the Ministry of Power as a joint venture of four reputed public sector undertakings: NTPC Limited, Power Finance Corporation Limited, REC Limited and POWERGRID Corporation of India. It was selected to implement a smart metering program at the national level. In turn, EESL entered into a joint venture with the National Investment and Infrastructure Fund and established IntelliSmart Infrastructure Private Limited, taking on the role of demand aggregator and making the entire upfront investment for smart meters. As is often the case, bulk procurement of smart meters through competitive bidding created economies of scale and reduced the overall costs of the smart meter rollout. Projects are now being developed in various Indian states, amounting to 7.8 million smart meters. The bulk-procured meters by EESL are then leased out to state electricity distribution companies (DISCOMs) at rental rates equal to or lower than the calculated increase in revenue generated from increased billing efficiency and avoided meter reading costs. At the end of the lease period, the entire smart metering system is transferred to the DISCOM. This means, the deployment of smart meters under this program required no upfront capital expenditure from DISCOMs or state governments. In the future, smart meter data are expected to allow DISCOMs to analyze household energy usage patterns and benefit from demand-side management, outage prevention, and distribution optimization.

Source: International Energy Agency. 2023. *Unlocking Smart Grid Opportunities in Emerging Markets and Developing Economies.* https://iea.blob.core.windows.net/assets/5d97b28a-ca5f-46a5-a194-2c13fd6e4aad/UnlockingSmartGridOpportunitiesinEmerging-MarketsandDevelopingEconomies.pdf.

United Kingdom's Strategy to Digitalize the Energy Sector Toward Net Zero Emissions

To achieve its goal of net zero carbon emissions by 2050, the United Kingdom (UK) developed a strategy and action plan to digitalize the energy sector in 2021.[a] The UK is one of the first countries in the world to provide the energy sector with a clear vision, direction, and shared approach to accelerate decarbonization. The strategy focuses on leveraging energy system data. It aims to put in place standards and regulatory frameworks that ensure energy data collection, governance, and application meet best practices. It also strives to ensure that data assets are treated as open and accessible by default, while privacy and security are protected. According to the strategy: "By 2030 and beyond, system operators will have visibility of all energy assets, making planning, forecasting, and operations quicker, more accurate, and cheaper. Greater data access in the marketplace will support new business models and services, and new market entrants participating in the energy sector. These new entrants will be able to tailor energy services to consumers using sophisticated digital platforms, address system needs via software rather than hardware, and create predictive models that prevent issues before they happen. A digital energy system will provide a modern platform for entrepreneurs and innovators to revolutionize how we interact with and conceive of the energy system, and how it integrates with our wider national infrastructure and services. These capabilities will underpin a secure decarbonized energy system."

[a] UK Government Department for Business, Energy, and Industrial Strategy. 2021. *Digitalising Our Energy System for Net Zero: Strategy and Action Plan 2021*. https://assets.publishing.service.gov.uk/media/60f5d393d3bf7f568dc8a58b/energy-digitalisation-strategy.pdf.
Source: Asian Development Bank.

Sustainable Development Goal Transformation #3

Smart Cities

Buenos Aires Deploys Digital Technologies to Improve City Services

Buenos Aires used to rely on an inefficient telephone hotline system to receive citizens' complaints or requests for public services. It took an average of 600 days to resolve issues. The city has since switched to a mobile app where citizens can snap a photo of the issue, from a large pothole in the road that needs filling to vandalized public property that needs repairing. The app, using an integrated geographic information system, instantly sends the location and information of the complaint to the ministry, and work is assigned to the closest vendor that can resolve the problem. Once the issue has been solved, a city street inspector confirms the completed work and uploads a picture of the resolved issue to the mobile app, allowing citizens to see that the problem has been fixed. Citizens can even give the public services a rating based on how satisfied they are with the quality of work, so the government can see where it can improve. The average time needed to solve a complaint in Buenos Aires has since fallen by 93% with no increase in budget.[a]

Another public service innovation involves Buenos Aires' cloud-based lighting management system. To reduce energy use, local authorities installed a high-quality light-emitting diode street lighting system supported by cloud-based lighting management software. The new system is more energy efficient, cheaper to use, more sustainable, and has made the city safer and smarter.

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Continuation

The system allows the remote monitoring, switching, and dimming of each light point in the network, optimizing energy consumption and creating safe conditions for vehicles and pedestrians. The system upgrade has affected 91,000 light points or 75% of the city lighting in Buenos Aires, saving 50% in operational costs and significantly reducing annual carbon dioxide emissions.[b]

[a] *CB Insights Research.* 2020. What Is a Smart City? 15 December. https://www.cbinsights.com/research/what-are-smart-cities/.
[b] *Interact*. 2020. Buenos Aires: An Innovative Platform that Supports Adaptive and Smart City Applications. https://www.interact-lighting.com/en-us/customer-stories/buenos-aires.
Source: Asian Development Bank.

São Paulo Tracks Trash with Technology

São Paulo is one of the largest metropolises in the world—with 12.5 million inhabitants and more than 300,000 registered companies—generating 20,000 tons of waste daily, and accounting for 8% of all waste in Brazil. In 2019, the city enacted a law to direct its waste management policies using data on public and private waste management.[a] All companies headquartered in São Paulo must now register with the Electronic Waste Transport Control (CTR-E), the city's technology-driven garbage collection system. CTR-E was created to monitor and track all private stakeholders that are part of the urban cleaning system—those disposing of, transporting, handling, or recycling solid waste.

Companies must complete an electronic form to declare how much waste they generate and who they use to transport and dispose of it. Private service providers (even microentrepreneurs) must register with the system. The city uses technology (smart phone apps, specialized software, and Quick Response codes on containers, dumpsters, and trucks) to identify and track the sources, volume, movement, and destination of solid waste. Using detailed monitoring data, municipal authorities can streamline operations and optimize waste treatment solutions.

Private waste transporters benefit from the system, which helps efficient customer management through effective control of the geolocation of their equipment and of all waste transportation vehicles authorized to travel on public roads. Since large waste generators are now required to make their own arrangements for waste transport, treatment, and disposal, the number of private waste management entities applying for official licensure has skyrocketed. Prior to the system's implementation, only 16,000 companies had informed the municipality of how they were disposing of their waste, and only 80 transporters were officially authorized to collect waste in the city. With the introduction of CTR-E, the number of business registrations has increased to more than 438,000 registrations, including companies, equipment, and carriers. More than 25,000 waste containers in the municipality are registered and are now geolocatable so that actions can be taken when and where needed. These measures are keeping exposed garbage bags off the streets and are thus helping to prevent flooding and rodent infestation.[b]

[a] R. Greice de Souza et al. 2017. Municipal Solid Waste in Brazil: A Review. *Waste Management & Research*. Volume 35, No. 12. 1 December. 1195–1209. https://doi.org/10.1177/0734242X17735375.
[b] C. Sousa. 2019. Track Your Trash: How São Paulo is Reducing Waste with Technology. *World Economic Forum*. 30 September. https://www.weforum.org/agenda/2019/09/the-benefits-of-digitizing-waste-management/.
Source: Asian Development Bank.
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Sustainable Development Goal Transformation #5

Digital Transformation of Governments

Singapore's Digital Government Blueprint

Singapore's digital vision:"Digital to the Core" recognizes data as the heart of digital government.[a] The strategy revolves around the public sector reorganizing itself around a new data management framework. The strategy also "identifies the horizontal enablers needed to manage data across its life cycle." Trusted centers aggregate data across the single sources of truth (SSOTs) "and provide a one-stop-shop for users to access core government datasets. Users who need cross-sectoral datasets will not need to go individually to each SSOT to ask for data." Three trusted centers, located in the Department of Statistics (individuals and businesses), Singapore Land Authority (geospatial), and Smart Nation and Digital Government Group (sensors), are tasked with implementing this strategy.[b] This focus on data is what defines the government's transformation drive, which will put in place the policies, processes, systems, and people that will enable the public sector to systematically acquire, manage, and exploit data on an industrial scale. Using a whole-of-government approach, the Singapore Public Service has made significant changes to organizational structures, placing data at the center of agency digital transformation efforts at the highest level of leadership.

The Government Data Office is guiding agencies to develop and implement data strategies as part of their digitalization efforts. It is also developing a new competency framework for chief data officers, providing them with a mandate to drive data transformation in their agencies. A data science competency framework supports structured training to improve the data capabilities of public officers. Further digitalization will generate more data from sensors and Internet of Things devices that could be triangulated with municipal feedback to develop predictive maintenance models for infrastructure such as lifts. This will enable agencies to go upstream to address the root causes of municipal feedback, and for government and residents to co-create more livable neighborhoods.

[a] Governmentech Singapore. 2020. Digital Government Blueprint. https://www.tech.gov.sg/digital-government-blueprint/.
[b] Civil Service College. 2019. *Bringing Data into the Heart of Digital Government.* CSC. 8 August. https://knowledge.csc.gov.sg/ethos-issue-21/bring-data-in-the-heart-of-digital-government/.
Source: Asian Development Bank.

Data and Digital Government Strategy of Australia

Australia's Data and Digital Government Strategy, led by the Digital Transformation Agency (DTA), was released in 2023.[a] The strategy is a unified blueprint for how it will maximize the value of its data holdings and digital capabilities. The strategy outlines five missions to accelerate transformation across the Australian Public Service, focusing on delivering simple and seamless services "for all people and business," embedding solid foundations for trusted and secure digital and data, and calibrating government so that it is fit for the future. It is accompanied by an implementation plan, which includes "whole-of-government scorecards for unprecedented accountability." DTA is creating multidisciplinary teams and communities of practice to foster better information sharing. The agency is providing free training to government teams and working on a digital capability program with the Australian Public Service Commission to attract digital talent, create clear career pathways, help managers create digital teams, and inspire leaders to take a visionary approach to creating digital services. The agency is also organizing communities of practice that bring together people working in government to share ideas, solve problems, and explore best practice.

[a] Digital Transformation Agency, Australian Government. 2023. A Unifying Strategy to Revitalise Data and Digital Transformation. 15 December. https://www.dta.gov.au/blogs/unifying-strategy-revitalise-data-and-digital-transformation.
Source: Asian Development Bank.

Sustainable Development Goal Transformation #6

Improved Connectivity and Competitiveness

India's Cross-Sector Infrastructure Co-deployment

Infrastructure co-deployment and sharing between sectors is an effective and proven strategy to expand service coverage and reduce the aggregate costs of deployment. Co-deployment of fiber optic cables or mobile towers alongside linear infrastructure such as railways, roads, water, sewage systems, and power transmission lines is a good practice to improve connectivity and future-proof the infrastructure assets. An Asian Development Bank project in Bengaluru, India, supports the Bangalore Electricity Supply Company Limited (BESCOM) in converting 7,200 kilometers (km) of overhead distribution lines to underground cables while installing 2,800 km of fiber-optic cable for communication, smart metering, distributed automation systems, and other communication network uses. Moving above-the-ground electrical transmission lines underground to protect the transmission from environmental conditions and other interferences is estimated to reduce technical and commercial losses by about 30%. Further, in designing the project, BESCOM recognized an opportunity to increase potential revenue by installing fiber-optic cable alongside its electrical transmission system specifically for lease.

Source: A. Husar, Y. Jeong, and J. Garrity. 2023. Cross-Sector Infrastructure Co-deployment: Closing Digital Connectivity Gaps Through Collaboration and Sharing. *ADB Sustainable Development Working Paper.* No. 86.

APPENDIX 4

Glossary of Terms

AgriStack. A government initiative to build an ecosystem that facilitates the delivery of digital agriculture services, including advisory services and access to quality inputs. AgriStack consists of various databases, registries, data standards, artificial programming interfaces, policies and a regulator.[1]

Artificial intelligence. The theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.[2]

Augmented reality. An enhanced, interactive version of a real-world environment achieved through digital visual elements, sounds, and other sensory stimuli via holographic technology.[3]

Blockchain. A decentralized, distributed, and public digital ledger that is used to record transactions across many computers so that the record cannot be altered retroactively without the alteration of all subsequent blocks and the consensus of the network.[4]

Digital public goods. Software, data sets, AI models, standards or content that are generally free cultural works and have an intention to contribute to sustainable national and international digital development.[5] Digital public goods (DPG) can be open-source software, open data, open artificial intelligence models, open standards and open content. In principle, these DPGs are non-rival and nonexclusive.[6]

Digital public infrastructure. Solutions and systems that enable the effective provision of essential society-wide functions and services in the public and private sectors. This includes digital forms of ID and identity verification; civil registries; payments, including digital transactions and money transfers; data exchange; and Information systems.[7]

Distributed ledger technology. The technological infrastructure and protocols that allow simultaneous access, validation, and record updating across a networked database.[8]

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1 World Economic Forum. 2023. India's Farmers Are on the Cusp of an Agritech Revolution: AgriStack. 14 November. https://www.weforum.org/agenda/2023/11/indias-farmers-are-on-the-cusp-of-a-technological-revolution-agristack/.

2 Oxford Languages. https://languages.oup.com/google-dictionary-en/.

3 Microsoft Corp. What is Augmented Reality or AR? https://dynamics.microsoft.com/en-ca/mixed-reality/guides/what-is-augmented-reality-ar/#:~:text=Augmented%20reality%20is%20an%20enhanced,sensory%20stimuli%20via%20holographic%20technology.

4 Synopsys. Blockchain. https://www.synopsys.com/glossary/what-is-blockchain.html#:~:text=Definition,a%20timestamp%2C%20and%20transaction%20data.

5 Wikipedia. Digital Public Goods. https://en.wikipedia.org/wiki/Digital_public_goods#:~:text=Digital%20public%20goods%20are%20public,national%20and%20international%20digital%20development.

6 GIZ. Digital Public Goods. https://www.giz.de/expertise/html/60115.html.

7 New America. Financing Digital Public Infrastructure. https://www.newamerica.org/digital-impact-governance-initiative/reports/financing-digital-public-infrastructure/introduction/

8 S. Nevil. Distributed Ledger Technology (DLT): Definition and How It Works. Investopedia. 2023. https://www.investopedia.com/terms/d/distributed-ledger-technology-dlt.asp#:~:text=Distributed%20ledger%20technology%20(DLT)%20is,updating%20across%20a%20networked%20database.

India Stack. A set of DPI components that has been used to accelerate India's digital development and rapid growth of its digital economy.[9]

Internet of Things. A network of physical devices, vehicles, appliances, and other physical objects that are embedded with sensors, software, and network connectivity, allowing them to collect and share data.[10]

Quick response (or QR) code. A type of two-dimensional matrix barcode consisting of black squares arranged in a square grid on a white background, which can be read by an imaging device, and the required data extracted.[11]

Virtual reality. The use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional visual or other sensory environment.[12]

9 Digital India Corporation. India Stack Global. https://dic.gov.in/india-stack-global/ (accessed on 5 April 2024).

10 IBM Corp. What is the Internet of Things (IoT)? https://www.ibm.com/topics/internet-of-things.

11 Wikipedia. QR code. https://en.wikipedia.org/wiki/QR_code.

12 H. E. Lowood. (2024). virtual reality. Encyclopedia Britannica. https://www.britannica.com/technology/virtual-reality

Digital Transformation for the Sustainable Development Goals

Framework and Road Maps to Drive Prosperity, Inclusion, Resilience, and Sustainability

This publication outlines how digital solutions can fast-track progress toward meeting the Sustainable Development Goals (SDGs) by 2030 and shows how the Asian Development Bank can assist in inclusive and resilient digital transformations. Noting the need for substantial investment in digital infrastructure, it looks at investments and public–private partnerships and outlines road maps for digital transformation in six areas, including food security, decarbonization, and human capital enhancement. The publication also proposes a set of enabling conditions, core digital components, and levels of digital maturity, which are key ingredients to SDG attainment.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 69 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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