HARNESSING DIGITAL TRANSFORMATION FOR GOOD

ASIAN DEVELOPMENT POLICY REPORT

MAY 2025

ASIAN DEVELOPMENT BANK

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Foreword

Digital transformation is fundamentally reshaping economies and societies. While promoting growth, innovation, and productivity, it also presents new opportunities to reduce inequality and poverty, and enhance resilience to extreme weather events. However, if not properly managed, digital transformation can widen inequalities, undermine sustainability, and create risks related to cybersecurity, data privacy, and the spread of misinformation. Thus, digital transformation must be carefully managed to serve people, transform lives, and build a resilient future for the next generation.

The 2025 Asian Development Policy Report, ***Harnessing Digital Transformation for Good***, explores how policymakers can leverage digital transformation to accelerate progress toward inclusive and sustainable development. To achieve this goal, economies in developing Asia can benefit from national digital strategies that ensure effective policy coordination. Digital policies should be tailored to each economy's unique context. Promoting shared prosperity will also require proactive engagement and collaboration with all stakeholders—including the private sector, civil society, and both local and international communities.

By addressing market and equity failures, digital policies can harness digital transformation as a powerful catalyst for good. The Asian Development Bank stands ready to support its developing member countries on this journey. By investing in high-quality digital infrastructure, promoting universal connectivity, enhancing digital literacy, and fostering digital innovation, the region can achieve sustainable growth while ensuring that no one is left behind.

I am confident that this report will offer valuable insights to policymakers and stakeholders across developing Asia on how to harness digital transformation to accelerate the journey toward a prosperous, inclusive, resilient, and sustainable future.

Masato Kanda

Masato Kanda
President
Asian Development Bank

Acknowledgments

I am pleased to present the Asian Development Policy Report (ADPR) 2025, *Harnessing Digital Transformation for Good*. ADPR 2025 examines how developing economies in Asia and the Pacific can take advantage of the opportunities from digital transformation to promote inclusive and sustainable development. This report provides new analysis and insights that will inform and support regional policymakers to better manage digital transformation to maximize its positive impact.

ADPR 2025 was prepared by staff of the Economic Research and Development Impact Department (ERDI) and the Digital Sector Group, Sector Department 2 of the Asian Development Bank (ADB). The Climate Change and Sustainable Development Department, Sector Departments (SD), and regional departments provided useful background materials and suggestions to help strengthen the policy relevance of the report.

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ADPR is ADB's annual flagship publication that addresses the salient development challenges confronting Asia and the Pacific. It provides high-quality data and analysis to support evidence-based policy making that contributes to a prosperous, inclusive, resilient, and sustainable region.

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Abbreviations

ADB	Asian Development Bank
AI	artificial intelligence
ASEAN	Association of Southeast Asian Nations
CIS	Commonwealth of Independent States
COVID-19	coronavirus disease
CSC	common service centers
DBT	direct benefit transfer
DIKSHA	Digital Infrastructure for Knowledge Sharing
DLT	distributed ledger technology
EPI	Environmental Performance Index
ESG	Environmental, Social, and Governance
EU	European Union
EVI	Enhanced Vegetation Index
fintech	financial technology
GB	gigabyte
GDP	gross domestic product
GenAI	generative artificial intelligence
GHG	greenhouse gas
GIS	geographic information system
GNI	gross national income
GPS	global positioning system
GSTN	Goods and Services Tax Network
GXR	global x-ray
HH	High-Digitalization, High-Inclusion and Sustainability
HL	High-Digitalization, Low-Inclusion and Sustainability
ICT	information and communication technology

IGI	Inclusive Growth Index
IoT	internet of things
IT	information technology
IPS	Instant Payment System
ITU	International Telecommunication Union
KOMN	Kochi Open Mobility Network
Lao PDR	Lao People's Democratic Republic
LD	Low-Digitalization
Mbps	megabits per second
$MtCO_2$	megatonnes of carbon dioxide
NRI	Network Readiness Index
OECD	Organisation for Economic Co-operation and Development
ONDC	Open Network for Digital Commerce
ONEST	Open Network for Education and Skilling Transactions
PPP	public-private partnership or purchasing power parity
PRC	People's Republic of China
RWI	Relative Wealth Index
SME	small and medium-sized enterprise
SNSI	Sino-Securities Index
SRN	shared rural network
STEM	science, technology, engineering and mathematics
TWh	terawatt-hour
UI	user interface
UHI	Universal Health Interface
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UPI	Unified Payment Interface
USF	Universal Service Fund
WEF	World Economic Forum
WHO	World Health Organization

Definitions and Assumptions

The economies discussed in the Asian Development Policy Report 2025 are classified by major analytic or geographic group. For the purposes of this report, the following apply:

- **Association of Southeast Asian Nations (ASEAN)** comprises Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam.
- Developing economies in Asia and the Pacific (**Developing Asia**) comprises 46 regional members of the Asian Development Bank listed below by geographic group.
- **Caucasus and Central Asia** comprises Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Tajikistan, Türkiye, Turkmenistan, and Uzbekistan.
- **East Asia** comprises the People's Republic of China; Hong Kong, China; the Republic of Korea; Mongolia; and Taipei,China.
- **South Asia** comprises Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.
- **Southeast Asia** comprises Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam.
- **The Pacific** comprises the Cook Islands, Fiji, Kiribati, the Marshall Islands, the Federated States of Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.
- **Asia and the Pacific** comprises the 49 regional members of the Asian Development Bank.

Unless otherwise specified, the symbol "$" and the word "dollar" refer to US dollars.

Highlights

Digital Technologies as Tools to Promote Inclusion and Sustainability

Inequality and vulnerability to extreme weather events remain key challenges for developing economies in Asia and the Pacific (developing Asia). Despite progress in poverty reduction and human development, inclusive development is still a work in progress. The population-weighted average national Gini coefficient across developing Asia increased 21.9% from 1990 to 2010 and was still about 6% higher in 2022 than in 1990. In 2024, 18.9% of the region's population was classified as poor, defined as living on less than the $3.65 per day poverty line for lower middle-income economies. Additionally, the region is highly vulnerable to extreme weather events due to its geographic and socioeconomic conditions, resulting in significant economic losses. Estimates indicate that, under a high-end emissions scenario, by 2070 riverine flooding could affect over 110 million people and result in losses of $1.3 trillion annually. Furthermore, the region could experience accumulated losses of around 16.9% of gross domestic product due to the impacts of disasters.

Advances in digital technologies have the potential to promote inclusion and environmental sustainability in the region through five key channels. First, by reducing geographic and informational barriers, digital technologies can enhance access to information and services such as finance and education, creating new economic opportunities, particularly for disadvantaged groups. Second, digital technologies improve disaster monitoring and response, especially in areas vulnerable to extreme weather events, by generating granular data and information needed for effective responses. Third, digital technologies facilitate entrepreneurship and business creation by removing constraints and fostering innovative and scaled solutions. They also lower barriers and costs, enabling small firms to engage in trade and expand internationally. Fourth, digital technologies improve productivity and efficiency, which in turn fosters economic growth, innovation, and business expansion. For example, automation and artificial intelligence (AI) enhance factor allocation and improve productivity. Last, digital technologies can be used to encourage responsible behavior. For example, providing information on sustainability and setting sustainability-friendly default options can nudge consumers toward environmentally friendly decisions.

However, if not managed well, digital transformation could exacerbate inequality and compromise environmental sustainability. The realization of benefits from digital technologies depends on how effectively digital transformation is managed and governed. Digital transformation involves structural changes enabled by the application of digital technologies to various economic and social activities. Digital divides are a major deterrent to digital transformation. They originate from disparities in access, use, and outcomes of digital technologies, which in turn lead to further inequalities. The impacts of digital transformation on employment are complex. Labor substitution due to automation may be offset by increased employment resulting from expanded production and the creation of new job tasks. Evidence from Southeast Asia indicates that digitalization creates new complementary jobs for high-skilled workers while substituting for low-skilled, routine-task workers. Where governance is weak, issues such as cybersecurity, data privacy, competition, and the spread of misinformation can disproportionately affect vulnerable groups, eroding confidence and trust in technologies and hindering digital transformation. Additionally, digital transformation can undermine sustainability; for example, efficiency gains from digital technologies could be offset by increased energy use stemming from expanded production and behavioral responses.

Digital Transformation and Policy Challenges in Asia and the Pacific

Developing Asia has witnessed rapid progress in digital connectivity, yet the region continues to experience gaps in connection quality, affordability, and digital skills. Between 2019 and 2023, the proportion of regional population covered by fixed broadband rose by 17.7% to 2.20 billion people, while mobile broadband coverage increased by 5.0% to 2.25 billion. During the same period, download speeds for fixed and mobile internet surged by 156% and 396%. Nevertheless, as of March 2024, large regional economies such as the People's Republic of China (PRC), India, and Indonesia still had fewer data centers per million people compared to major advanced economies and non-regional developing economies such as Brazil and Mexico. According to the International Telecommunication Union, in Asia and the Pacific, the share of the population covered by faster 5G networks was 41.5%, lower than in Europe and the Americas in 2023. For 4G mobile networks, the coverage of rural populations in developing Asia was 7.4% lower than the coverage for urban populations. In some regional economies, limited affordability poses a barrier to universal connectivity. When factoring in income levels and rising data requirements, mobile data costs in the Kyrgyz Republic, Mongolia, the Philippines, and Sri Lanka were unaffordable for the three to four poorest income deciles. Moreover, digital literacy remains low across the region, even in upper middle-income economies.

Developing Asia has advanced faster in digital transformation than the rest of the world, but the region's progress, in terms of inclusion and sustainability, has not kept pace. Between 2020 and 2024, developing Asian economies across all income levels mostly improved their rankings in digital transformation, as measured by the Network Readiness Index. However, the region showed mixed progress in inclusive growth, as indicated by the Inclusive Growth Index (IGI), and showed slower progress than the rest of the world in environmental sustainability, whether indicated by the Environmental Performance Index or the environment subindex of the IGI. Market and equity failures hinder digital transformation from promoting inclusion and sustainability. For example, market failure occurs when high fixed costs cause underinvestment in digital infrastructure in remote areas. Market failure also results in underinvestment in sustainability-aligned digital solutions because externalities are underpriced by the market. Equity failure happens when factors such as skills and affordability prevent disadvantaged groups like poorer and older people from benefiting equally from digital transformation. Public policies are essential to address these failures and enable innovation that promotes inclusive and sustainable development.

The Impacts of Digital Transformation on Inclusion

Digitalization can reduce income inequality by expanding economic opportunities for disadvantaged groups. A one-unit increase in a city's digitalization level in the PRC significantly reduces income inequality for an average household by 1.94%. This narrowing of income inequality is driven by higher income gains among households with lower income and education levels, as well as those in less developed areas. The main channels for this effect are increased employment, business, and investment opportunities. In Viet Nam, a one-unit increase in the provincial level of household internet access is significantly associated with a 16.6% higher chance for the average female household head to engage in service sector jobs, significantly higher than the 12.4% more chance for the average male household head. Additionally, economy-level evidence from developing Asia shows that a 1% increase in access to the internet is associated with a 0.32% decrease in poverty, on average. These reductions are linked to improved employment opportunities and better access to basic services such as finance and education.

Digital technologies empower small and medium-sized enterprises (SMEs). They do so by improving the delivery of key services such as finance, overcoming conventional barriers, and increasing resilience. For instance, financial technology and platforms improve SMEs' access to finance and business networking. Digital payments, in particular, have gained significant penetration among underbanked groups. Around 66% of digital lending customers in Southeast Asia are unbanked or underbanked. Moreover, digital technologies expand SMEs' access to both domestic and foreign markets, reduce transaction costs, and improve process efficiency. In India, a one-unit increase in digital technology adoption by a micro firm is associated with a 4% higher probability of exporting. These digital technologies also help enhance the economic resilience of SMEs during major disruptions by supporting the continuity of economic activities. In Indonesia, during the early months of the COVID-19 pandemic (March–April 2020), 5.7 percentage points more non-digitally operated SMEs suffered revenue losses exceeding 30.0% compared to their digitally operated counterparts that utilized the internet for business, partly due to sustained business activities via internet connectivity.

However, digital transformation may exacerbate inequality if market and equity failures are not properly addressed. Digital divides are prevalent across developing Asia. Of the 22 regional economies with available data, 19 have a higher share of internet use among men than women. The percentage of residents using the internet is 13 percentage points higher in urban areas compared to rural areas. Mobile internet download speeds are also 38% faster in urban areas than in rural areas. In Thailand, a nationwide survey conducted in 2022 revealed gender and regional disparities in participation in online activities. In the Republic of Korea, educational attainment and literacy are significant drivers of the divide in digital technology use among older adults. Such disparities can contribute to broader inequality by disadvantaging certain groups from accessing economic opportunities.

Inclusion-aligned digital policies can help developing Asia leverage digital transformation for inclusive development. Subsidies, such as the Universal Service Fund (USF), incentives, and regulatory tools like coverage obligations in licensing or spectrum allocation, can boost universal connectivity. For example, Thailand's latest USF program collaborated with the Ministry of Social Development and Human Security to better identify slum areas and vulnerable populations, thereby improving targeting efficacy and digital inclusion. Fiji and Pakistan, among other economies, have deployed subsidies and fiscal incentives to increase connectivity in underserved areas. Market mechanisms such as spectrum allocation auctions, adopted by India and Indonesia among other economies, can contribute to digital inclusion via efficient spectrum allocation. Regulations can also promote market competition to protect small businesses. India's Digital Competition Law of 2024 aims to curb unfair practices by large technology companies, thereby supporting SMEs. Many regional governments have rolled out capacity-building and skill-upgrading schemes to build digital literacy, helping to narrow digital divides and mitigate potentially adverse employment impacts. For example, Malaysia has introduced a program that incentivizes companies to hire workers for digital jobs while encouraging employees to complete digital training.

The Impacts of Digital Transformation on Sustainability

Digital technologies can improve sustainability by facilitating monitoring and responses and improving access to information. Firm-level evidence from the PRC indicates that a 1% increase in an average firm's digitalization level can raise the environmental score of the company by 0.62 units, or around 1% of the sample average. This impact is driven by enhanced green innovation, increased information transparency, and strengthened monitoring. Advanced technologies also offer new solutions to promote sustainability. For example, in 2024, the city of Bengaluru in India launched an AI-driven traffic control system that reduced travel time by 33%, thereby decreasing fuel consumption and pollution. By enabling effective information tracking and monitoring, digital technologies help mobilize green finance via reduced information asymmetry and reputational risks, while also fostering the sustainability reporting of SMEs. Additionally, household surveys in India, Nepal, and Bangladesh reveal that digital technologies can improve access to information regarding disaster-resistant crop varieties and appropriate cropping shifts, such as transitioning from rice–wheat to maize–wheat in flood-prone areas.

Digital technologies can strengthen resilience to extreme weather events and enable effective disaster risk management. Digital technologies support resilient agricultural strategies. For example, agricultural technologies, such as plant and soil health monitoring and modeling, enable informed decisions on irrigation, machinery, and fertilization to cushion the adverse effects of extreme weather events. Digital technologies also improve disaster monitoring and analytics, fostering timely responses to disasters and thereby strengthening resilience. In Thailand, GPS data combined with demographic information can accurately track evacuation distances and the duration of human displacement in flood-affected areas, providing effective relocation support for temporarily displaced people. This is particularly beneficial for poor households, as 10% more of low-wealth households tend to remain at home during flooding due to limited resources compared to high-wealth households. In Fiji, digital technologies enable timely disaster risk impact assessments, including evaluations of agricultural damage. Such assessments inform decisions even before satellite imagery becomes available, thus accelerating the delivery of social assistance and other recovery measures.

Digital transformation can also compromise sustainable development if not properly managed. The main sources of energy consumption during digital transformation are digital devices, data centers, and network infrastructure. The International Energy Agency projects that the world's aggregate electricity consumption by data centers, cryptocurrencies, and AI will increase by 35% to 128% by 2026, rising from 460 terawatt-hours in 2022. Increased electricity consumption would have emission implications if digital technologies were powered by fossil fuels. To achieve universal connectivity, middle-income economies in developing Asia will require higher energy consumption per device than their high-income counterparts. This is partly attributed to the need to build new digital infrastructure and the lack of energy-efficient solutions.

Sustainability-aligned digital policies can address market failures and enable digital transformation to promote sustainability and resilience. There is a growing consensus that future growth in computing capabilities should come from green digital infrastructure. The PRC, the Republic of Korea, Malaysia, and Singapore have issued regulations and standards to develop green data centers. The PRC, the Republic of Korea, and Singapore also use carbon pricing, a market mechanism, to improve energy efficiency and encourage the use of renewable energy. Fiscal incentives can promote the innovation and adoption of sustainability-friendly digital technologies, such as smart technologies, big data analytics, and AI, which offer energy-efficient solutions and improve disaster risk management. Furthermore, governments can collaborate with the private sector to promote spectrum sharing and infrastructure sharing to lower deployment costs and enhance sustainability. For example, in hard-to-connect rural areas, the Shared Rural Network strategy for 4G with wireless backhaul technology can reduce annual energy consumption by 16% in South Asia compared to scenarios without sharing.

Policies to Harness Digital Transformation for Inclusive and Sustainable Development

Developing Asia can adopt integrated policies—comprising three pillars—to harness digital transformation for promoting inclusion and sustainability:

- The first pillar is an **overarching national digital strategy** that integrates objectives for inclusion and sustainability. Currently, most regional economies view digital transformation and inclusive and sustainable development as separate priorities. A high-level national digital strategy can align and coordinate policy actions across ministries and agencies. For example, the Korean New Deal, launched in 2020, aimed to accelerate digital transformation and sustainability while promoting better digital access, particularly for SMEs, older people, and vulnerable groups. In some economies, cross-ministerial entities support overall government alignment. For example, Malaysia established a National Digital Economy and Fourth Industrial Revolution Council, chaired by the Prime Minister and supported by various ministries.

- The second pillar involves **policy interventions aligned with inclusion and sustainability.** These policy tools address market and equity failures while incentivizing innovation to promote inclusion- and sustainability-friendly digital solutions, such as platforms, smart technology, and disaster risk management tools. They also ensure that digital transformation itself is inclusive and sustainable by reducing digital divides and adopting renewable energy, alongside energy-efficient technologies like liquid cooling systems.

- The third pillar focuses on engagement with a **broad range of stakeholders,** including the private sector, households, civil society, and local and international communities. For example, India's digital public infrastructure offers a new approach to digitalization that facilitates the deployment of scaled solutions and services through private sector innovation. Collaborating with civil society and local communities can leverage their local knowledge and trust, which is needed to successfully roll out educational and training initiatives in targeted communities. Additionally, governments can engage in cross-border collaboration to harmonize international digital standards, encourage data flows, and support trade. They can also leverage financial and knowledge resources from international organizations.

Regional economies need to consider economy-specific circumstances when prioritizing policy implementation. Policy choices can be guided by their relative levels of digitalization, inclusion, and sustainability. Compared to the global median, "Low-Digitalization" economies such as Cambodia, Bangladesh, Mongolia, Pakistan, and Uzbekistan must accelerate digital transformation by investing in digital infrastructure, digital skills, and literacy, while also improving affordability. Given resource constraints, these governments can consider cost-efficient solutions, such as spectrum sharing, infrastructure sharing, cloud-based solutions, and adopting emerging technologies like low-earth orbit satellites and 5G Fixed Wireless Access for last-mile communications. For "High-Digitalization, Low-Inclusion and Sustainability" economies such as the PRC, India, Indonesia, Malaysia, Thailand, and Viet Nam, the priority should be to leverage existing digital infrastructure and skills to close digital divides and decarbonize digital infrastructure. For example, Viet Nam's National Digital Transformation Program, launched in 2020, aims to train 1 million people in digital skills by 2025, focusing on areas like coding, data analytics, and digital marketing. In addition, the PRC has required that publicly owned data centers be entirely powered by renewable energy by 2032. Finally, "High-Digitalization, High-Inclusion and Sustainability" economies like the Republic of Korea and Singapore should lead in promoting inclusion- and sustainability-friendly digital innovations, serving as models of best practice for others. For example, Singapore deploys fiscal incentives such as the Green Computing Funding Initiative to encourage research and trials in green software.

In conclusion, advances in digital technologies offer significant opportunities to promote inclusion, resilience, and sustainability. However, addressing market and equity failures is crucial to harness digital transformation for good. Regional economies can implement digital policies tailored to their specific circumstances, leveraging digital transformation for a prosperous, inclusive, resilient, and sustainable future.

1 Digital Technologies as Tools to Promote Inclusion and Sustainability

Rapid advancements in digital technologies hold great potential for the region to create synergies between economic growth and the transition to an inclusive and sustainable development path. This chapter discusses how digital technologies can promote inclusion and environmental sustainability, as well as the challenges they pose.

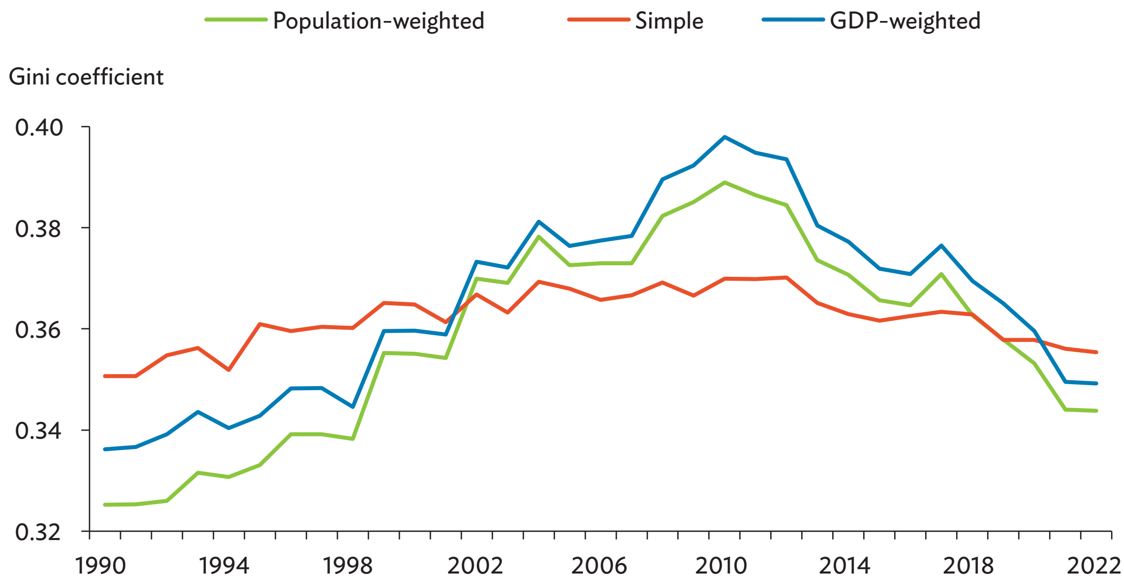
1.1 | Asia and the Pacific Faces Challenges to Combat Inequality and Vulnerability to Natural Hazards

Poverty and inequality remain key development challenges in developing economies in Asia and the Pacific (developing Asia). Developing Asia has made remarkable progress in reducing poverty and promoting human development in recent decades. This is the result of rapid economic growth and government policies such as concerted investments in education and health care. Furthermore, this rapid growth has benefited a broad segment of the population in many parts of the region. However, the fight to eradicate poverty is far from over. In 2024, an estimated 106 million people in developing Asia, or 2.6% of the region's population, lived in extreme poverty, which is defined as living on less than $2.15 a day.[1] Using the poverty line of $3.65 a day, which is appropriate for developing Asia as most of its economies are now middle income, 767.6 million people, or 18.9% of the region's population, were considered poor. South Asia, home to several populous economies, had the second-highest regional prosperity gap in the world in 2024 at 6.2, compared to the global average of 4.9. This means that the income of an average person in South Asia needs to increase by 6.2 times to reach the global prosperity standard of $25.00 a day (World Bank 2024a). Moreover, South Asia (31%) and East Asia and the Pacific (15%) account for around 45% of the global prosperity gap, trailing only to sub-Saharan Africa (39%).

Developing Asia's inclusive development remains a work in progress. Within-economy, inequality in the region narrowed in the 1970s and 1980s but has remained stagnant since the 1990s (ADB 2020). While many economies in the region have achieved a relatively low level of inequality, income inequality in Asia rose significantly from 1990 to 2010 (Figure 1.1). Between 1990 and 2010, the population-weighted average Gini coefficient in the economies of developing Asia increased by 22% before declining. In 2022, it remained 6% higher than the 1990 level, showing no progress in reducing inequality. Between 1990 and 2018, Asia witnessed the largest increase in income inequality among all regions of the world (Jurzyk et al. 2020). Addressing unequal access to various development opportunities is critical for improving livelihoods and enabling all citizens to lead meaningful lives (UNESCAP 2015). Thus, there is much scope for regional economies to promote more inclusive development by expanding opportunities for disadvantaged groups with new solutions that address the key sources of inequality, particularly the differences in education, employment, and finance (Huang, Morgan, and Yoshino 2019).

1 Asian Development Bank (ADB). Key Indicators Database (accessed 4 February 2025).

Figure 1.1: Weighted Average Gini Coefficient—Developing Asia



GDP = gross domestic product.

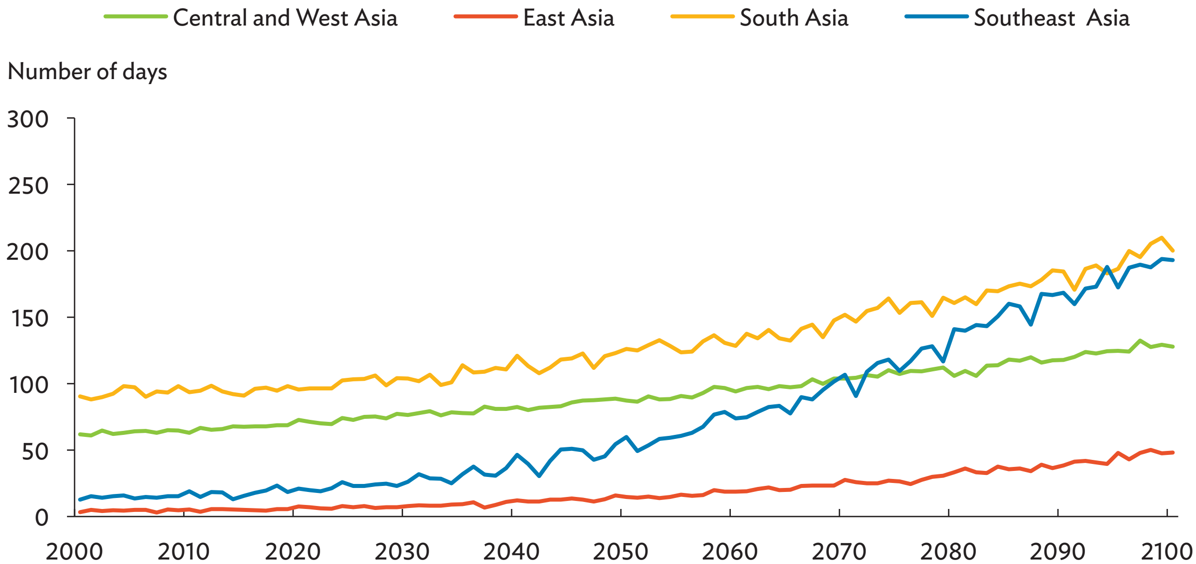
Notes: Data for developing Asia represent the aggregate of the 10 economies: Bangladesh, the People's Republic of China, Indonesia, India, the Lao People's Democratic Republic, Malaysia, Pakistan, Sri Lanka, Thailand, and Viet Nam. The data for the nearest available year were used in place of the Gini coefficient data for years when it was unavailable.

Source: Authors' calculations using data from World Bank. World Development Indicators (accessed 1 March 2025).

Continued warming and related frequent extreme weather events will cause profound changes in living conditions for people in developing Asia. According to the Asian Development Bank (ADB 2024a), despite strong actions taken to promote sustainability, the planet will continue to warm, locking in many biophysical impacts over the coming decades. Developing Asia experienced unprecedented heat waves in 2024. Under a "high end emissions" scenario of global warming of 4.7°C by 2100, ADB (2024a) finds that developing Asia will become hotter and wetter. Utilizing data from the Copernicus Interactive Climate Atlas, ADB (2024a) assesses that by 2100, the number of days with temperatures exceeding 35°C is projected to increase significantly in all subregions across developing Asia (Figure 1.2), with South Asia experiencing the largest increase from 90 days to more than half a year. The destructive power of cyclones is expected to double by 2100, and rainfall will become more extreme and concentrated, with maximum daily precipitation projected to rise by about 50% in the Pacific, 40% in South Asia, and 30% in East Asia and Southeast Asia (ADB 2024a). Continued warming will exacerbate the devastation from extreme weather events such as heat waves, floods, tropical storms, and droughts in the region. According to World Bank (2024a), South Asia has the world's largest total population at high risk from extreme weather events, with 32% of the population exposed to such risks. South Asia also has the highest global share of the population exposed to heat waves (83%), followed by East Asia and Pacific (53%). In South Asia and East Asia and Pacific, 12%–14% of the population is exposed to floods.

Developing Asia is highly vulnerable to extreme weather events due to its geographic and socioeconomic conditions. Warming-related extreme weather events threaten livelihoods, food security, and health, posing a significant risk of economic losses. According to ADB (2024a), under a "high end emissions" scenario, a total loss of 16.9% in gross domestic product (GDP) across developing Asia is projected by 2070, with a large proportion of

Figure 1.2: Projected Median Number of Days Above 35°C Annually, 2000–2100—Developing Asia by Subregion



Note: Subregions are as defined by the Intergovernmental Panel on Climate Change.

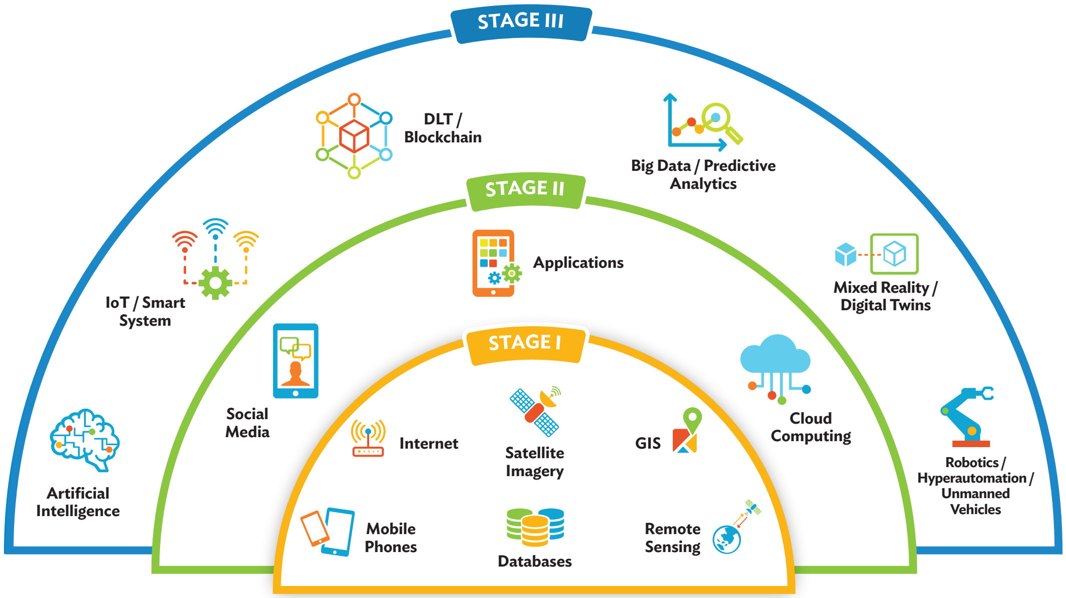
Source: ADB (2024a).

the region facing output losses greater than 20%. This includes highly populous regional economies such as Bangladesh (–30.5%), Viet Nam (–30.2%), Indonesia (–26.8%), India (–24.7%), and Pakistan (–21.1%). ADB (2024a) further estimates that sea-level rise and storm surges under this "high end emissions" scenario will lead to a GDP loss of 6.3% in developing Asia by 2070. ADB (2024a) also predicts trillions of dollars in capital damage each year due to sea-level rise, storm surges, wave formation, and coastal flooding by 2070. These long-term damages are expected to concentrate in large and densely populated regional economies—including Bangladesh, the People's Republic of China (PRC), India, and Viet Nam—with annual affected populations exceeding 50 million and annual damage amounting to $3 trillion by 2070. Moreover, riverine flooding is expected to cause annual damages of $1.3 trillion by 2070, affecting over 110 million people across the region each year.

The rapid advance of digital technologies is increasingly transforming economies and societies, offering new solutions to drive fundamental changes. There are synergies between reducing inequality and poverty, increasing resilience, and improving environmental sustainability, as disadvantaged groups suffer more from a deteriorating environment and extreme weather shocks. Promoting faster and more inclusive growth while protecting people from shocks will require fundamental changes in how economies approach their national development strategies (World Bank 2024a). Since the beginning of the 21st century, the miniaturization of computing power and the rise of internet-enabled mobile digital devices have spurred the rapid evolution of transformative digital technologies such as cloud computing, big data analytics, artificial intelligence (AI), 5G, and the Internet of Things (IoT) (Figure 1.3).[2] Stringent mobility restrictions during the coronavirus disease

[2] ADB (2021) demonstrates three stages of digital technologies: Stage 1 technologies provide basic information and communication capabilities. Stage 2 technologies further cover instant communication, information sharing, and storage. Finally, stage 3 technologies are critical in transforming economies and societies.

Figure 1.3: Ecosystem of Digital Technologies



DLT = distributed ledger technology, GIS = geographic information system, IoT = internet of things.
Source: ADB (2021).

(COVID-19) pandemic further accelerated digital transformation, with solutions such as remote work, e-commerce, information tracking, and online services (e.g., education and fintech) sustaining economic and social activities. Digitalization helped mitigate the impacts of negative shocks on disadvantaged groups during the pandemic, as economies with higher levels of digital adoption were able to deliver essential support, such as cash transfers, to affected populations (Jurzyk et al. 2020).

This report will discuss how developing Asia can ride the wave of digital transformation to promote inclusion and sustainability. Digital technologies can enable synergy between growth and inclusive and sustainable development. However, if not managed well, the benefits of digital transformation could be offset by adverse effects on equity and sustainability caused by digital divides, complex job market impacts, cybersecurity and data privacy risks, and increased energy consumption demand. This report aims to help policymakers in developing Asia to develop digital transformation strategies that benefit all citizens and address the challenges posed by extreme weather events. This report refers to digital technologies, digitalization, and digital transformation, following ADB's operations approach (Box 1.1).

Box 1.1: Digital Technology, Digitization, Digitalization, and Digital Transformation

Digital technology can be used as an umbrella term to cover different aspects of technologies at various stages. Digital technology encompasses electronic devices (e.g., computers, tablets, and mobile phones); telecommunication networks and systems (e.g., internet, mobile networks, and satellite communications); hardware (e.g., servers and networking equipment); and software (e.g., programs and applications that run on computers and mobile devices) (ADB 2021). Following ADB practice, digital technology in this report covers five interrelated components: (i) digital infrastructure, (ii) digital industries, (iii) digital-enabled services and applications, (iv) digital strategy and policy, and (v) digital capacity (e.g., skills, awareness, and literacy).

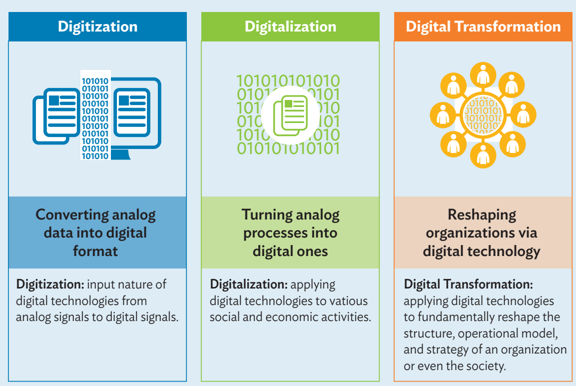
Digitization, digitalization, and digital transformation describe changes in social and economic activities driven by digital technologies, but they differ from one another in scope. Digitization refers to the conversion of analog signals into digital signals, producing information and data that are more accessible, storable, and maintainable (Chafferdine and Umlai 2023, Gobble 2018). Digitalization typically refers to the application of digital technologies to various social and economic activities, indicating the process through which digital technologies are deeply integrated with changing business processes and social life (Autio et al. 2018, Björkdahl and Holmén 2019). Digital transformation refers to the comprehensive application of digital technologies to optimize and fundamentally reshape the structure, operational model, and strategy of an organization or even all of society (Chanias, Myers, and Hess 2019; Correani et al. 2020; Huang 2024; Vial 2019).

ADB's forthcoming Operational Approach for Digital Transformation outlines six building blocks, following the Organisation for Economic Co-operation and Development's integrated digital transformation framework:

1. **Access.** Ubiquitous access to high-quality and affordable next-generation networks and technologies is fundamental to sustainable and inclusive digital development.
2. **Use.** Relevant, affordable, and accessible solutions are required to ensure the mainstream adoption and use of digital services by different user groups.
3. **Innovation.** Digital transformation is essential for the productivity, innovation capacity, and growth of businesses in the region—especially micro, small, and medium-sized enterprises—and the related value chains.
4. **Skills.** Developing the right digital skills and fostering a digital mindset and talent are key to the adoption and meaningful use of digital technologies.
5. **Society.** Digitally empowered communities will drive economic development and improve quality of life through renewed efforts to redesign social policies, environmental strategies, health care, climate resilience, trade and commerce, and public service delivery across all sectors.
6. **Trust.** Building digital trust and ensuring security and safety must be a priority as societies become increasingly reliant on digital tools and data.

The different scopes of digitization, digitalization, and digital transformation are summarized in the box figure (Smith and Achong 2024). This report refers to all three concepts and uses related terms throughout the report where contexts fit.

Scopes of Digitization, Digitalization, and Digital Transformation



Source: Smith and Achong (2024).

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Box *continued*

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Source: Jeong and Apikul (2025).

1.2 | Digital Technologies Can Help Propel Inclusive and Sustainable Development

Digital technologies are promising tools to achieve inclusive and sustainable development. They can deliver inclusion and environmental benefits through five interconnected channels (Figure 1.4), including (i) enhancing access to information and services, (ii) strengthening monitoring and response, (iii) fostering innovative and scaled solutions, (iv) improving productivity and efficiency, and (v) nudging behavioral changes. Each of these channels is discussed in more detail below.

Enhancing Access to Information and Services

Digital technologies expand access to information and services, providing new economic and resilience opportunities, especially for underserved groups. The development of digital infrastructure and the availability of digital devices enhance connectivity and promote information transmission by breaking geographic and information fragmentation between users and service providers (Luo, Tian, and Wu 2025). This is particularly beneficial for underserved people living in remote, often underdeveloped areas, as it connects them to better services such as finance, health care, and education, as well as new job and business opportunities. For example, financial technologies—such as online banking, digital payment and investment, and online credit services—

Figure 1.4: Digital Technologies Promote Inclusive and Sustainable Development Through Five Channels

AI = artificial intelligence, fintech = financial technology, IoT = Internet of Things, SMEs = small and medium-sized enterprises.

Source: Authors.

enable financial service provision in hard-to-reach areas that previously lacked commercial viability, reducing information asymmetry between borrowers and financial institutions and effectively promoting financial inclusion (Figuet and Kere 2022; Klapper and Singer 2017; Ye, Xu, and Chen 2023). Health technology and remote diagnostics allow health-care providers to reach patients in rural and underserved areas, reducing geographic and financial barriers to health care. In Fiji, e-health services in remote communities significantly improve health-care access and quality. Telemedicine platforms enable patients to consult with doctors remotely, reducing the need for long and costly travel. Digital health records streamline patient management, ensuring timely and accurate treatment (Rahman et al. 2025). Online education can benefit students in underdeveloped areas by making learning resources more accessible (Hosen et al. 2021; Hwang, Wang, and Lai 2021). One education technology intervention that connected top teachers to over 100 million rural students in the PRC had lasting positive effects on academic achievement, helping to close the rural–urban education gap (Bianchi, Lu, and Song 2022). The establishment of internet kiosks in rural areas of central India helped farmers acquire market information, leading to improvements in their production and income (Goyal 2010).

Improving Monitoring and Response

Digital technologies facilitate effective monitoring and granular data collection, enabling timely responses that enhance resilience and inclusion. Digital technologies—such as satellites, drones, sensors, and surveillance cameras—can monitor real-time conditions and enable big data analytics, building resilience to extreme weather events and disaster risks. For example, smart water-conservancy technologies and soil sensors can improve fertilization usage and irrigation schemes (Muangprathub et al. 2019). Drones and satellites provide real-time information about weather and crop health (Goel et al. 2021), while AI-enabled analytics can provide advisory about strategies for resistant crop varieties. Digital technologies also support disaster risk management by monitoring, forecasting, facilitating evacuation planning, assessing damage, and ensuring the timely delivery of social assistance and other recovery efforts (Bakhtiari et al. 2023; Tim, Cui, and Sheng 2021; Fujimi and Fujimura 2020; Girotto et al. 2023). Mobile phones and social media platforms can effectively gather and disseminate information about disaster-affected areas, disruptions in evacuation routes, and infrastructure damage from a wide array of sources (Roy, Hasan, and Mozumder 2020). Timely communication and responses help affected populations, especially disadvantaged groups, obtain needed resources to reduce potential losses and strengthen resilience.

Fostering Innovative and Scaled Solutions

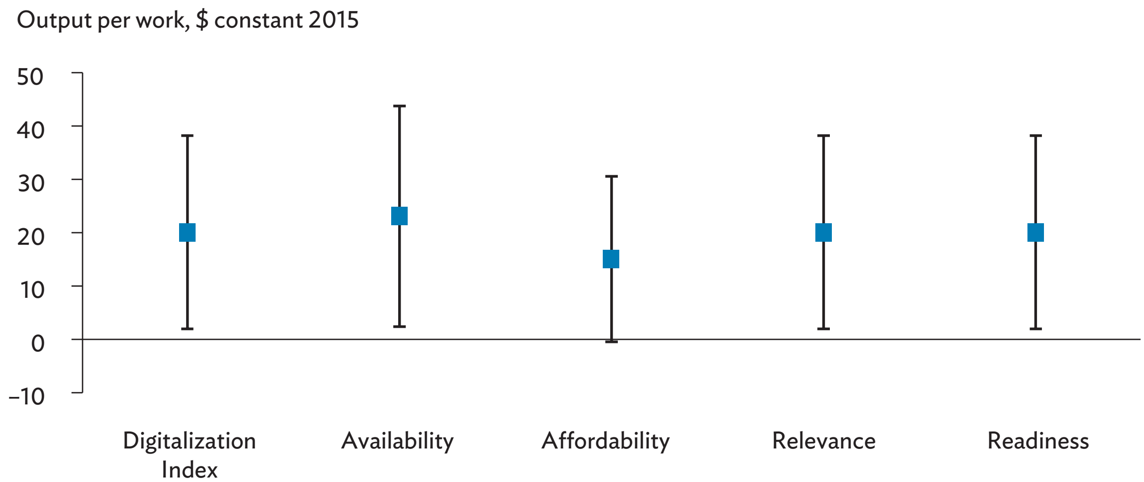
Digital technologies create development opportunities through innovative job and business opportunities, as well as scaled solutions, especially benefiting disadvantaged groups. By enhancing connectivity, digital technologies open new pathways for novel business models and work modes, creating more opportunities for disadvantaged groups, such as small and medium-sized enterprises (SMEs), less-educated individuals, and those living in remote areas. Such groups often face conventional barriers to success, including a lack of business connections and high transaction costs. E-commerce platforms, such as eBay, Amazon, Facebook, and Alibaba, can effectively scale the scope of business operations, by providing SMEs and other disadvantaged groups with a broader customer and supplier base, direct marketing tools, and more transaction links (Manyika et al. 2016). Additionally, digital technologies enable SMEs to engage in international trade by addressing traditional business barriers, such as limited access to trade finance, high transaction costs, and limited business networks (Kim, Ardaniel, and Endriga 2022). Furthermore, digital technologies facilitate innovative, flexible working modes—such as remote work and live streaming businesses—creating new job and business opportunities for disadvantaged groups with limited resources and those who require flexible working hours (Churchill and Craig 2019).

Boosting Productivity and Efficiency

Digital technologies can boost productivity and growth, as well as enable business expansion and creation. Advances in digital technologies contribute to economic growth by enhancing factor allocation efficiency and increasing total factor productivity through technological progress and spillovers (Acemoglu 2025; Beirne and Fernandez 2022; Cette, Nevoux, and Py 2022; Karlilar, Balcilar, and Emir 2023; Mollins and Taskin 2023; Venturini 2022). Fernando (2025) examines the association between digitalization and labor productivity using panel data from developing Asian economies during 2017–2022. She finds that a 1% increase in digitalization—capturing information about availability, affordability, relevance, and readiness—is significantly associated with a $20 increase in output per worker in developing Asia (Figure 1.5). Moreover, digital technologies enable business expansion by innovating operations and production, reducing operating costs, scaling customer bases, forecasting orders, and promoting innovation and service quality (Chen et al. 2023; Edquist, Goodridge, and Haskel 2021; Lyver and Lu 2018; Rehman and Nunziante 2023).

Digital technologies improve efficiency by enabling more precise use of inputs and reducing costs (Borowski 2021; Mawson and Hughes 2019). They can optimize internal production and management, promoting the efficient use of materials and resources. They can also help raise marketing efficiency and lower management costs (Acemoglu, Antràs, and Helpman 2007). Digitalization improves service capability and quality by improving information processing (Ardolino et al. 2018, Opresnik and Taisch 2015). Digital technologies, such as smart grids, smart parking meters, and adaptive traffic control, can improve energy efficiency and optimize logistics in production processes and service delivery, thereby reducing emissions from major emitting sectors such as energy, transport, and agriculture (Choi and Siqin 2022; Plageras et al. 2018; Zekić-Sušac, Has, and Knežević 2021).

Figure 1.5: Digitalization and Labor Productivity in Developing Asia



Notes:

(i) Error bars pertain to the 99% confidence interval.

(ii) Labor productivity is measured as output per hour worked. Estimated association is for 1% higher digitalization.

(iii) Developing Asia sample includes Bangladesh, Bhutan, Cambodia, the People's Republic of China, India, Indonesia, Kazakhstan, the Republic of Korea, Malaysia, Mongolia, Myanmar, Pakistan, the Philippines, Singapore, Sri Lanka, Thailand, Uzbekistan, and Viet Nam.

Source: Fernando (2025).

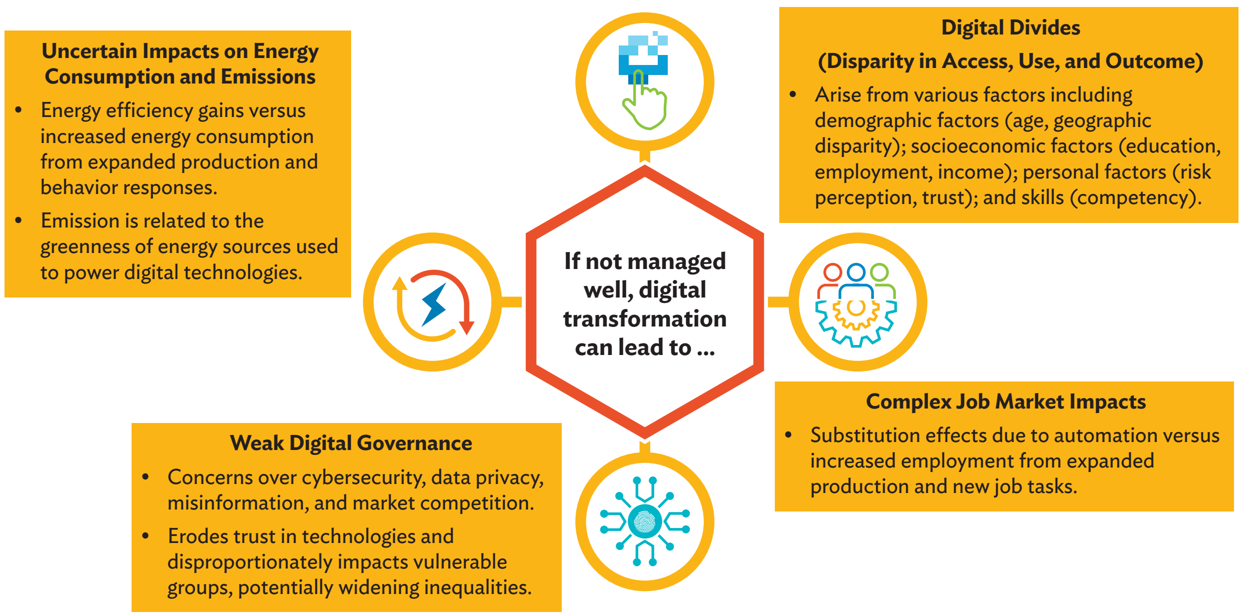
Driving Behavior Changes

Digital technologies can help drive behavioral changes toward sustainable patterns. They can encourage sustainability-friendly decisions by providing information and feedback about the environmental impacts of actions and by setting sustainability-friendly options as default choices for various transactions. For example, digital technologies can inform consumers about the carbon footprints of their purchases and decisions, encouraging them to consider the environmental consequences of their actions (Henkel et al. 2019, Taube and Vetter 2019). Such nudging schemes have been found to promote the sale of renewable energy (Ebeling and Lotz 2015) and induce energy savings (Loock, Staake, and Thiesse 2013). Changing the default setting to "no cutlery" and rewarding consumers with "Ant Forest Green Points" on Alibaba's food delivery platform can significantly and persistently increase the share of no-cutlery orders, thereby reducing plastic consumption (He et al. 2023). Meanwhile, social media, online platforms, and digital education applications can play a crucial role in disseminating knowledge and facilitating discussions about sustainability and equity. They can also present new perspectives and counternarratives that challenge existing views on issues such as the environment and discrimination (Verwiebe et al. 2023).

1.3 | Interventions Are Needed to Manage the Challenges of Digital Transformation

Realizing the benefits of digital technologies depends on the extent to which digital transformation is aligned with inclusion and sustainability objectives. If not managed carefully, digital transformation can pose risks that widen inequality and compromise environmental sustainability (Figure 1.6). For example, it could exacerbate inequalities stemming from various digital

Figure 1.6: Possible Challenges of an Unmanaged Digital Transformation



Source: Authors.

divides, complex impacts on employment, and weak digital governance such as concerns over cyberattacks, data privacy, misinformation, and unfair competition would disproportionately affect disadvantaged groups. Additionally, digital transformation may have uncertain impacts on overall energy consumption, as efficiency gains could be offset by increased energy use resulting from improved productivity, expanded production, and behavioral responses. Without appropriate efforts to promote energy efficiency and the use of clean energy sources, digital transformation might lead to higher emissions. Developing Asia must manage these risks with effective policies. If not managed well, misaligned decisions can become "locked in" for the medium to long term, particularly regarding digital infrastructure, as the associated assets can be highly durable, lasting for decades.

Digital Divides

Digital divides arise when there is a disparity in access, use, and outcomes during digital transformation (Fisk et al. 2023; Lythreatis, Singh, and El-Kassar 2022). The first type of digital divide (Level 1) is associated with unequal access to quality digital infrastructure, devices, and services across different groups. This gap stems from both supply-side constraints, such as the government's or private sector's ability and willingness to provide digital infrastructure and services, and demand-side challenges, including affordability, access to information, income, education level, and digital literacy among various groups (Cirera, Comin, and Cruz 2022; Korupp and Szydlik 2005; van Dijk 2006). For example, Oughton (2023) suggests that market failure, where the costs of supplying connectivity exceed the potential revenues from available demand—particularly in remote and sparsely populated areas—could lead to underinvestment in digital infrastructure and give rise to digital divides. The second type of digital divide (Level 2) pertains to unequal use of digital technologies, which can arise from social, psychological, and cultural factors such as skills, motivation, preferences, and demographic attributes like age, gender, education level, and social class (Hsieh, Rai, and Keil 2008; van Deursen and van Dijk 2014). The third type of digital divide (Level 3) relates to differences in socioeconomic outcomes or empowerment, such as unequal economic benefits, welfare levels, and overall well-being, partly due to varying digital practices among firms and individuals (Ragnedda 2017; Scheerder, van Deursen, and van Dijk 2017).

Digital divides are driven by a wide range of factors that need to be considered in policy interventions. Lythreatis, Singh, and El-Kassar (2022) summarized nine categories of factors associated with the three types of digital divides: (i) sociodemographic (such as age, gender, geographic disparity, and urban–rural dimensions); (ii) socioeconomic (such as education, employment, and income); (iii) personal elements (such as trust, motivations, risk perceptions, and religion); (iv) social support (such as access to support and social interaction); (v) technology (such as devices); (vi) training (such as competency and learning); (vii) rights (such as political rights); (viii) infrastructure (such as electrical access and submarine cables); and (ix) large-scale events (such as the COVID-19 pandemic). In the context of digital divides, some groups may benefit less or even suffer losses during digital transformation, which can widen inequality. Governments need to intervene and engage disadvantaged groups to ensure full participation in digital transformation, fostering inclusive growth (Lopez-Claros 2015). Policies aimed at addressing digital divides can consider these factors to close related disparities. For example, economies in developing Asia, including the PRC, Fiji, India, the Republic of Korea, Pakistan, Singapore, and Thailand, are widely adopting various policy instruments to incentivize universal connectivity among rural and low-income households and rolling out capacity-building schemes to enhance the skills of groups such as older people, low-income groups, and less-educated individuals.

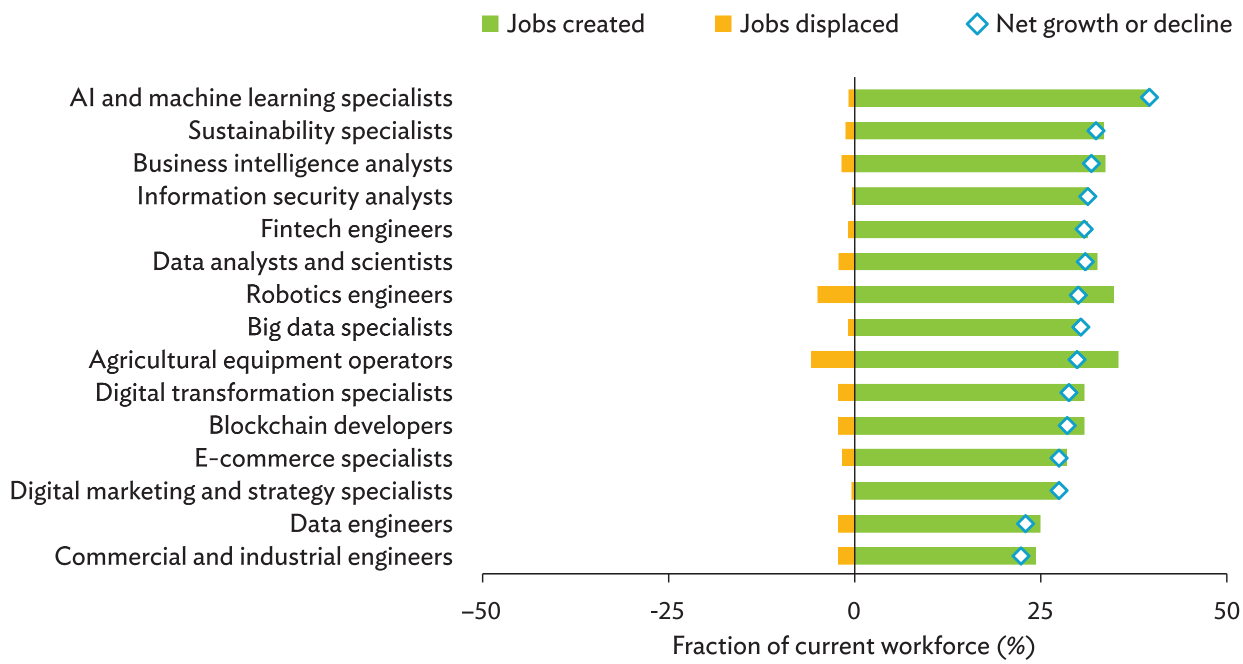
Complex Job Market Impacts

Digital technologies—especially automation and AI—have complex impacts on jobs. The net impact of digital technologies on labor demand is jointly determined by a negative “displacement effect” and a positive “reinstatement effect” (Acemoglu and Restrepo 2018, Acemoglu 2025). The displacement effect occurs when new technologies enable capital to substitute for labor, replacing some tasks previously performed by workers, such as assembly line workers and ticket sellers, thereby reducing the demand for labor (Acemoglu and Restrepo 2018). In contrast, the reinstatement effect arises when new technologies introduce a productivity boost and allow the flexible allocation of tasks to factors, driving demand for new nonautomated tasks where labor has a comparative advantage (Acemoglu and Restrepo 2019). In Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam, enhanced productivity from automation has created jobs for skilled workers engaged in nonroutine manual and cognitive tasks, while formal workers employed in routine manual work have simultaneously been displaced (World Bank 2024b). Although a stable, balanced path between the two effects is possible, inequality may increase if the displacement effect outpaces the reinstatement effect (Acemoglu and Restrepo 2018). Therefore, interventions are needed to build new skills to accelerate the reinstatement effects.

Digital technologies create job opportunities with new tasks and working modes. Job opportunities can emerge where there is complementarity between labor and certain automated tasks, particularly when digital technology cannot fully substitute for humans. For example, the jobs with the fastest net growth during 2023–2027 are expected to be directly related to digital technologies, with AI and machine learning specialists ranking as the fastest-growing jobs, followed by business intelligence analysts and information security analysts (Figure 1.7) (WEF 2023). Some aspects of digital transformation can also create employment. For example, the building of digital infrastructure, the rise of the platform economy, and the emergence of new business models contribute to job creation. For example, the construction of digital infrastructure can drive employment in related industries, such as hardware, software, and communication equipment (Nuray 2011). Digital technologies also offer job opportunities by enabling new working modes, such as flexible employment and remote working (Rani and Furrer 2021). The rise of the sharing economy and the platform economy can break down spatial and temporal constraints on employment, leading to more flexible and diverse forms of work (Spreitzer, Cameron, and Garrett 2017).

Digital technologies also have complex impacts on the structure of employment skills, with implications for inequality. Technologies such as AI replace rule-based tasks in both low-skill and high-skill sectors,

Figure 1.7: Projected Net Growth of Occupations, 2023–2027



AI = artificial intelligence, fintech = financial technology.

Note: Projected net growth of each occupation as a fraction of current employment between 2023 and 2027 for the global employee dataset.

Source: WEF (2023).

while driving an increased demand for complex cognitive and social skills (Acemoglu et al. 2022). For example, the development of generative AI and other technologies may lead to the automation of 60%–70% of current jobs, affecting both low-skill and high-skill jobs, including customer operations, marketing and sales, software engineering, and research and development (Chui et al. 2023). However, generative AI may benefit some lower-skilled workers by narrowing their skill gaps through human-computer collaboration (Brynjolfsson, Li, and Raymond 2023; Noy and Zhang 2023; Tolan et al. 2021). For example, developers with less programming experience benefit more from using GitHub Copilot (Peng et al. 2023). Nonetheless, such benefits may be limited to workers with complementary knowledge and experience that allow them to adequately evaluate AI-generated solutions (Dell'Acqua et al. 2023; Otis et al. 2024). Overall, AI may not widen inequality as much as previous automation technologies due to its universal impact across demographic groups (Acemoglu 2025).

Weak Digital Governance

Cybersecurity risks can impose sizable economic costs, particularly for disadvantaged groups. A cybersecurity incident (or a cyberattack) describes an event in which unauthorized use of an information system or network results in actual or potentially adverse effects on information systems, networks, and/or data (Harry and Gallagher 2018). Cyberattacks can lead to sizable economic costs. For example, based on official reports and industry surveys, the direct economic cost of cybersecurity incidents ranged between 0.21% and 9.1% of global GDP from 2017 to 2023 (Vergara Cobos and Cakir 2024). Cybersecurity threats can severely impact developing economies (Centre for Cybersecurity Belgium 2024). For example, a 2022 ransomware attack on nearly 30 government ministries in Costa Rica resulted in prolonged service outages, a national emergency declaration, and an estimated 2.4% loss of GDP (Vergara Cobos 2024). From 2014 to 2023, cyberattack incidents worldwide grew at an average annual rate of 21%, with upper middle-income countries experiencing the highest surge at 37% (World Bank 2024a). At the firm level, cybersecurity has material implications for operational, financial, legal, and reputational risks. It has emerged as a key business risk for firms and is consistently ranked as the greatest near-term concern for business leaders and risk managers in global surveys (Allianz 2024, PWC 2023, and WEF 2024b). There is a significant lack of cybersecurity awareness and resources among SMEs, making them particularly vulnerable to cyber threats (Chaudhary, Gkioulos, and Katsikas 2023; ENISA 2021; Wilson et al. 2022). Compared to larger organizations, SMEs often lack the financial buffers and operational resilience needed to recover from ransomware attacks, leading to cybersecurity-related bankruptcies and financial stress (Fernandez de Arroyabe and Fernandez de Arroyabe 2021).

Concerns over cybersecurity, data privacy, and misinformation may erode trust and confidence in technologies, widening digital divides and hindering digital transformation. Data privacy involves the protection and control of personal information regarding how data are collected, stored, transmitted, and used (Digital Frontiers Institute 2024). Limited digital skills and resources, along with inadequate protection against cyberattacks, can expose low-capacity groups to higher cybersecurity risks as they become more connected. This exposure can lead to skepticism and distrust of digital technologies, counteracting efforts to narrow digital divides (Mokhtar and Rohaizat 2024). Aside from cybersecurity, data privacy concerns also affect market integrity, as well as the confidence and adoption of digital technologies among businesses and individuals (OECD 2019). Another challenge to trust and integrity is misinformation, which indicates misleading or inaccurate information content (Caled and Silva 2022). Misinformation can be intentional but it can also be unintentional due to the dissemination of incorrect narratives, for example, when there is a lack of information or understanding of the messages. Concerns over cyberattacks, privacy, and misinformation, combined with limited digital literacy and skills, can discourage disadvantaged groups from participating in digital transformation. If these concerns are not addressed properly, they can widen digital divides and hinder digital transformation (Heeks 2022, Keck et al. 2022).

Another challenge that digital transformation poses to inclusive development is the potential hindrance of market competition. The dominant market positions of big tech companies in many sectors of the digital economy can potentially enable those companies to exploit their positions and gain an unfair advantage over smaller players, such as SMEs. Network effects, which increase the value of a product or service as the number of users grows, and can result in a winner-takes-all outcome, further exacerbate competitive concerns. Economies of scope also affect market power in digital markets, since favorable access to data and consumers in one market can be a substantial source of competitive advantage. For example, the European Commission found that new tech players would be unable to challenge Google's position in online search advertising, because developing a rival search engine with similar reach and performance would be difficult. Further, large technology firms can use product bundling to protect their market power, making it hard for SMEs to compete. Data control is another factor that can diminish competition, since data accumulation along with restrictions on data sharing serves as a barrier to entry (OECD 2022). Ensuring market competition in the digital sector is critical to protecting disadvantaged groups and reducing inequality.

Uncertain Impacts on Energy Consumption and Emissions

There is no consensus on the relationship between energy consumption and digital transformation. While digital technologies can improve energy efficiency, they may also lead to increased energy consumption due to a rebound effect (Greening, Greene, and Difiglio 2000; Thiesen et al. 2008). Such rebound effects occur when improvements in energy efficiency incentivize increased consumption through expanded production and behavioral responses by firms and households. For example, digital technology has been shown to be significantly related to increased electricity consumption in 19 emerging economies (Sadorksky 2012) as well as among members of the Organisation for Economic Co-operation and Development (OECD) (Salahuddin and Alam 2016). The relationship between digitalization and environmental performance can be nonlinear, specifically resembling an inverted U-shaped environmental Kuznets curve (Wang, Hu, and Li 2024; Wu et al. 2021; Zhang and Wei 2022). Mixed evidence has been documented on the link between digital connectivity and energy consumption in developing Asian economies (Husaini et al. 2025).

The rapid rise of generative AI also casts uncertainty on energy consumption. Training AI tools requires processing large amounts of data, and using these tools entails a significant amount of computing power when generating responses to requests. Both processes are energy-intensive (de Vries 2023). For instance, a typical query for OpenAI's ChatGPT can result in a tenfold increase in electricity usage (2.9 watt-hours) compared to the average electricity demand per request of a typical Google search (0.3 watt-hours) (de Vries 2023). Considering 9 billion daily searches, this would require almost 29.2 terawatt-hours of additional electricity per year, which is equivalent to the entire annual electricity consumption of Ireland (Hubert and Le Texier 2025). By 2026, the AI industry is expected to grow exponentially, consuming at least 10 times its demand in 2023 (IEA 2024). Meanwhile, novel energy-efficient solutions enabled by AI, emerging lightweight models like DeepSeek, and new technologies such as liquid cooling systems can significantly reduce energy consumption. The uncertain net impacts of generative AI on energy use highlight the need for targeted interventions to maximize its sustainability benefits. Moreover, the digital sector accounted for 2%–3% of global emissions in 2021, which could rise significantly if the scaling up of digitalization does not entail tapping clean energy sources (UNEP 2021). The net impact of digital transformation on emissions will ultimately depend on the implementation of effective policies that promote energy efficiency and the use of renewable energy sources to support low-carbon development.

2 Digital Transformation and Policy Challenges in Asia and the Pacific

Developing Asia has made rapid progress in digitalization, which can be a powerful tool for inclusion and environmental sustainability. However, digital transformation can pose a challenge to the two development goals if not carefully managed. Policy intervention is thus essential to leverage digital transformation and accelerate the shift toward inclusive and sustainable development in developing Asia.

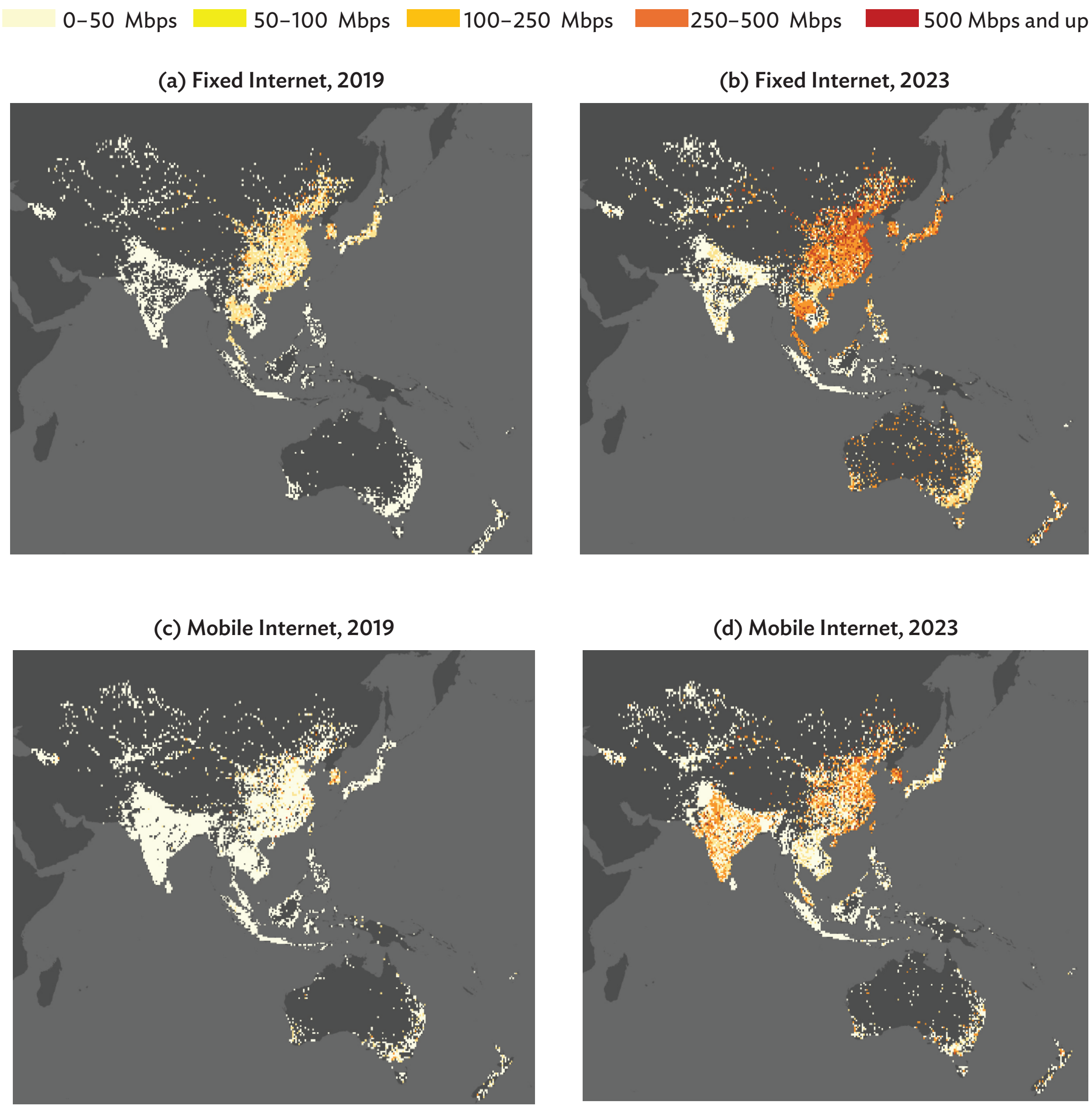
2.1 | Digital Transformation in Developing Asia

Developing Asia has witnessed rapid development in digital connectivity in recent years. Between 2019 and 2023, the region experienced significant progress in internet coverage and connection speeds (Lee, Wei, and Iddawela 2025). Figure 2.1 presents a spatial distribution of fixed and mobile broadband coverage and download speeds during this period. The figure shows that the population covered by fixed and mobile internet in developing Asia increased from 1.87 billion and 2.14 billion in 2019 to 2.20 billion and 2.25 billion in 2023, respectively, representing increases of 17.7% and 5.0%.[3] Download speeds for fixed and mobile internet rose from 49.34 megabits per second (Mbps) and 23.91 Mbps, respectively, in 2019 to 126.07 Mbps (with growth of 156%) and 118.56 Mbps (with growth of 396%) in 2023.

Online platforms, social media, and financial technologies have supported inclusive and sustainable development in developing Asia. The increasing penetration of mobile phones and broadband networks has led to the rise of e-commerce platforms in developing Asia, including Shopee, Tokopedia, Lazada, Tiki, Kaspi, Daraz, Taobao, and Flipkart, which foster scaled solutions and innovative business models. These platforms create job and entrepreneurship opportunities for disadvantaged groups facing conventional barriers. For example, women entrepreneurs encounter long-standing challenges such as limited business networking and the need to balance family and work obligations. The expansion of e-commerce, captured by transactions on the JD.com platform in the People's Republic of China (PRC), has a causal impact on women's entrepreneurship and employment (Cong et al. 2024). Figure 2.2 shows that a 1% increase in sales on the JD.com e-commerce platform resulted in a 0.68% increase in the number of women entrepreneurs and a 0.43% increase in the number of women executives among new enterprises between 2015 and 2019. This impact is economically significant, as the 0.68 elasticity translates into 56.3% of the increase in women entrepreneurs in the PRC during the same period. Social media often serves as people's first experience with the internet, particularly in low-income economies (Internet Society Asia-Pacific 2017). It not only facilitates public engagement but also provides businesses with opportunities for marketing, sales, and customer service. In developing Asia, social media platforms such as Facebook, TikTok Shop, and WeChat have evolved from communication tools into online marketplaces. Digital financial services, including mobile payments and digital wallets, like Alipay, GCash, and GrabPay, have enabled users to pay bills, purchase goods and services, make

[3] The population covered refers to the population within any Ookla download speed tiles. The download statistics are derived from crowdsourced Ookla data, based on the packages that users have subscribed to. There may be limitations and biases in capturing the actual capacity and speed of the available networks.

Figure 2.1: Spatial Distribution of Fixed and Mobile Internet Download Speeds, 2019 and 2023



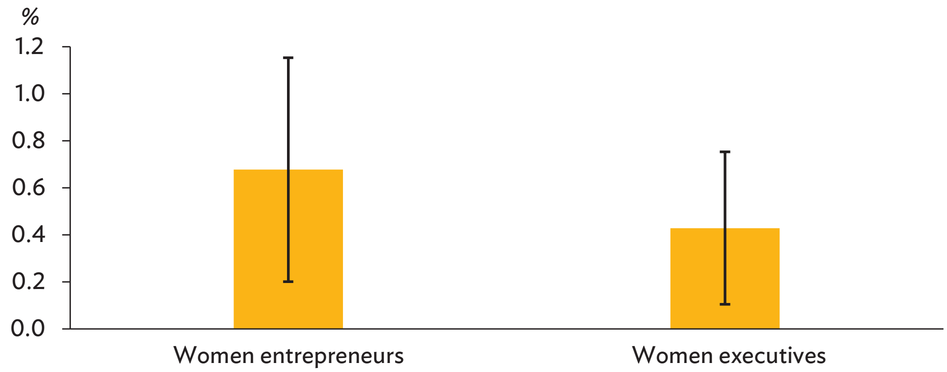
Mbps = megabits per second.

Note: The download speeds for mobile internet are calculated using the weighted mean speed from the crowdsourced Ookla download speed tiles.

Source: Authors based on Lee, Wei, and Iddawela (2025).

investments, and transfer money, thus sustaining social and economic activities during the coronavirus disease (COVID-19) pandemic. Box 2.1 highlights how financial technologies contributed to financial inclusion and economic resilience during the pandemic in Azerbaijan. Platforms like Alipay are also effective in implementing nudging programs to encourage low-carbon behavioral changes.

Figure 2.2: Impact of E-Commerce on Women in New Enterprises



Note: Error bars pertain to the 99% confidence interval. The bars represent the average impact of a 1% increase in sales on the JD.com platform on the increase in the number of women entrepreneurs and executives in new enterprises between 2015 and 2019. "Entrepreneur" refers to the one-to-one legal representative for each registered firm in the PRC. "Executive" includes all major positions (such as supervisor, director, chair, chief executive officer, general manager) within a firm but excludes the legal representative.

Source: Cong et al. (2024).

Box 2.1: Financial Technology Advances Open a Path Toward Financial Inclusion in Azerbaijan

Financial inclusion in Azerbaijan has improved in recent years through several key financial technology initiatives. It is estimated that, by 2025, 3.85 million people—approximately one-third of the population—will be using digital payments.

The Instant Payment System (IPS) developed under the central bank's digital payment strategy, allows for the remote registration of customers and their bank accounts. It also enables users to retrieve balance information, maintain accounts, and close them. These operations are based on open banking principles for a secure system where vendors and banks can share account details to facilitate payments. In addition to 19 banks, the IPS platform connects to the Finance Ministry's State Treasury Agency and the national postal service, Azerpost. Ongoing efforts are aimed at extending IPS coverage and expanding the range of digital solutions available to users.

Further innovations include the introduction of "tap to/on phone" technology and the establishment of an Electronic Knowledge Management System, which improves access to information and ensures remote identification. These initiatives are supported by efforts to develop the legal basis and standards for open finance.

From 2017 to 2021, the value of mobile banking increased by 14.1 times and the volume by 7.4 times. For internet banking, the value rose by 5.1 times and the volume by 2.1 times. In addition, banks have expanded the use of tokenization technology and the issuance of virtual payment cards among innovative payment solutions, while four banks launched an Apple Pay project in 2021.

Access to bank accounts has been addressed through a "basic banking services" project implemented in 2021. Bank reforms to develop electronic banking services—including mobile and internet banking, as well as the introduction of innovative payment solutions—have directly influenced financial inclusion. The "basic banking services" project offers bank services free of charge, including opening a current account, issuing a payment card, providing access to electronic banking services, and cashless payment operations. This initiative has brought about 1.5 million previously excluded individuals into the financial system.

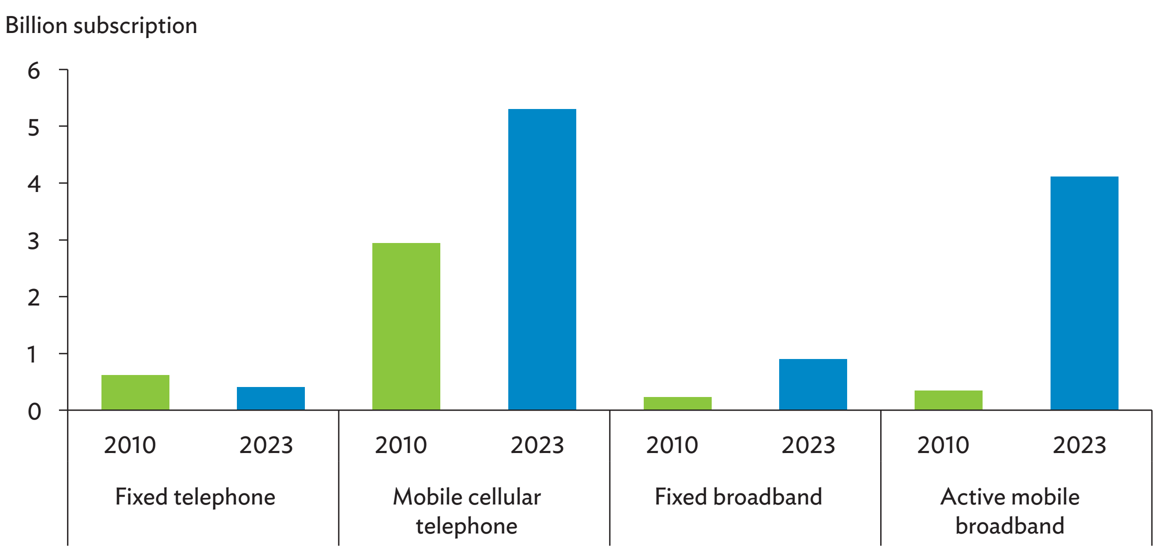
To increase financial literacy, the central bank and the Azerbaijan Banking Association, in collaboration with international financial institutions, produced several educational videos during the COVID-19 pandemic. These videos were broadcast on local television, websites, and social media, providing guidance on protection against infection while shopping and using banking services, as well as on how to use payment cards effectively during quarantine. During the pandemic, the country's banks distributed lump sum payments to 600,000 individuals as part of a government countercyclical pandemic response package totaling AZN3.5 billion (about $2.0 billion), which helped maintain economic activities and improve the living standards of the most vulnerable citizens.

Source: ADB (forthcoming).

Increased internet access in developing Asia has been driven by mobile internet; however, there are still gaps in connectivity quality and usage. According to data from the International Telecommunication Union (ITU), fixed broadband subscriptions in the ITU-defined regions of Asia and the Pacific and the Commonwealth of Independent States (CIS)— which encompass all ADB developing members—grew by 288% from 2010 to 2023. In contrast, mobile broadband subscriptions increased by 1,090% during the same period (Figure 2.3).[4] As of 2023, the share of the population in Asia and the Pacific covered by 3G and 4G networks was comparable to the shares in the Americas and Europe. However, the proportion of the population covered by faster 5G mobile networks was 41.5% in Asia and the Pacific lower than in Europe and the Americas (Figure 2.4). In addition, while approximately 96% of Asia and the Pacific population had connectivity via 3G or 4G technology in 2023, there was a coverage gap of 7.4 percentage points between the urban population (99.3%) and the rural population (91.9%). Despite the significant expansion in mobile internet coverage, substantial barriers still prevent full adoption. The usage gap, defined by Global System for Mobile Communications Associations, as the "population that live within the footprint of a mobile broadband network but do not use mobile internet", remains considerable in the region. While more than half of the population in Asia and the Pacific subscribed to mobile internet services—totaling more than 1.4 billion subscribers—significant gaps remain in economies like Bangladesh, India, and Pakistan, where 50% or more of the population is covered by mobile networks but has not subscribed to services due to various barriers (Shanahan and Bahia 2024).

Moreover, developing Asia still lags behind major developing economies in terms of data centers. Data centers are a crucial component of digital infrastructure, essential for enabling access and ensuring quality connectivity. As of March 2024, large regional economies such as the PRC, India, and Indonesia had fewer data centers per 1 million people compared to major advanced economies and other major developing economies like Brazil and Mexico (Figure 2.5). This has implications for inclusion in terms of access to and the

Figure 2.3: Phone and Internet Services in Asia and the Pacific

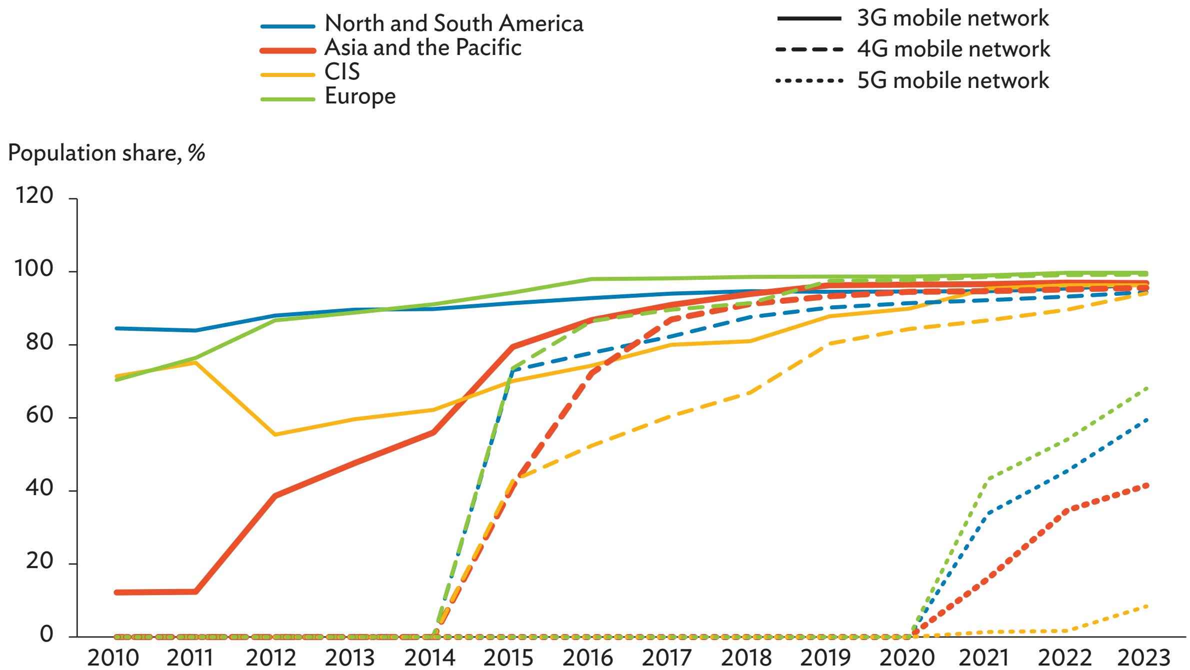


Note: The Asia and Pacific region is based on the economy classifications of International Telecommunication Union (ITU).

Source: Authors based on ITU. Global and Regional ICT Data (accessed 1 February 2025).

[4] ITU. Economy Classifications.

Figure 2.4: Shares of Regional Populations Covered by Mobile Network



3G = third generation, 4G = fourth generation, 5G = fifth generation, CIS = Commonwealth of Independent States.

Note: All regions as defined by the International Telecommunication Union (ITU).

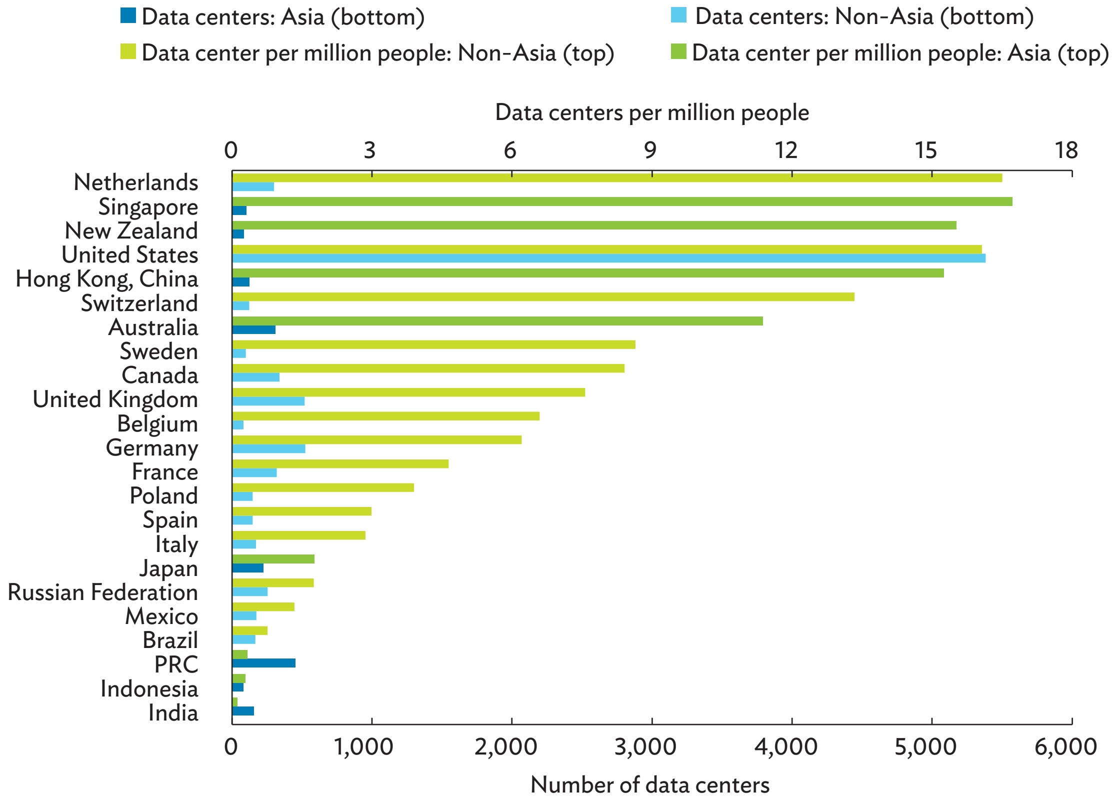
Source: Authors based on ITU. Global and Regional ICT data (accessed 1 February 2025).

quality of digital connectivity in the region. The relative paucity of data centers suggests that developing Asia will require substantial construction of new digital infrastructure. This, in turn, could have important implications for environmental sustainability.

Some economies in developing Asia still lack the affordability necessary to achieve universal connectivity. Notwithstanding the rapid increase in broadband coverage in recent years, many disadvantaged individuals in areas with broadband access remain unconnected due to affordability issues. In the ITU-defined Asia and Pacific region, the basket price of the data-only for 2-gigabyte mobile broadband was 1.2% of gross national income (GNI) per capita in 2023, indicating better affordability that exceeds the Broadband Commission for Sustainable Development's affordability target of 2.0%. However, the 3.0% basket price for fixed broadband (5 GB) in the Asia and Pacific region is less affordable than the global target of 2.0%.[5] Moreover, the international broadband commission's affordability target of 2.0% has limitations when considering different income levels within economy, pricing differences across broadband products, and the increasing data requirements of digital services and applications (Brewer and Jeong 2023). For example, 5 GB for the 2.0% of GNI per capita, which represents the global target for entry-level fixed broadband basket, is only a fraction of the 32 GB per month consumed by the average smartphone user in Bhutan, India, and Nepal in 2024, and around one-fourth of the 19 GB per month consumed by users in Southeast Asia and Oceania in the same year (19 GB per month) (Ericsson 2024). When accounting for income levels and rising data requirements, mobile data in economies such as

[5] Affordability is defined as the cost of an allocation of mobile data relative to a percentage of GNI per capita. The globally agreed targets established by the Broadband Commission for Sustainable Development, led by the ITU, are "1 for 2," or 1 GB of mobile data for 2% or less of GNI per capita, and "5 for 2," or 5 GB of fixed broadband data for 2% of GNI per capita.

Figure 2.5: Number of Data Centers in Selected Economies, Q1 2024



PRC = People's Republic of China, Q = quarter.

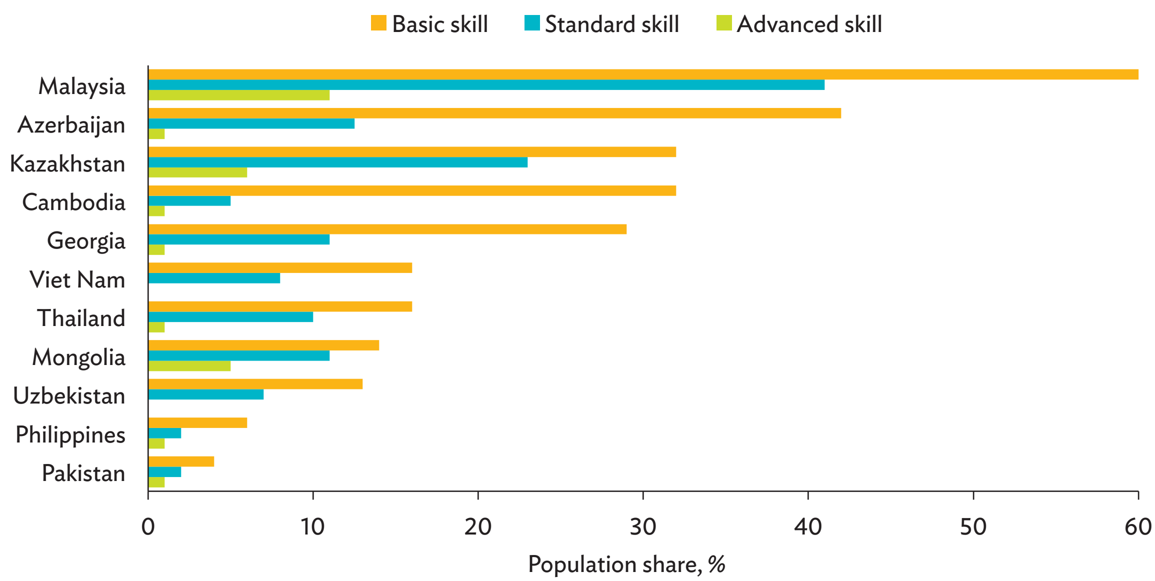
Source: Hubert and Le Texier (2025).

the Kyrgyz Republic, Mongolia, the Philippines, and Sri Lanka were unaffordable for the lowest 3–4 income deciles (Brewer and Jeong 2023). This lack of affordability, combined with other barriers such as poor digital literacy, prevents individuals from connecting to the internet, even in areas with internet coverage.

The digital skills needed to foster digital transformation in developing Asia remain generally low. For individuals to fully benefit from digital transformation, the ability to adopt digital technologies is critical. However, digital skills in developing Asian economies remain low. According to UNESCAP (2023), digital skills can be categorized into basic, standard, and advanced levels. A basic digital skill level indicates that users can perform computer-based activities, such as using basic functions like text, copy, and paste. A standard skill level means that users are able to operate various digital applications and download, install, and configure software. An advanced skill level indicates that users can write computer programs or employ specialized programming languages to achieve specific goals. As shown in Figure 2.6, even in upper middle-income economies like Malaysia, approximately 40% of the population still lacks basic digital skills. In most regional economies where data are available, less than 15% of the population has standard digital skills. Therefore, developing Asian economies must invest more in building various digital skills to ensure that all groups can participate in digital transformation and equip the workforce with the skills needed for future jobs.

The digital sector's contribution to developing Asia's output is significant; however, the growth of its shares in output and employment has remained stagnant. Developing Asia has become the world's largest supplier of digital products and services. By

Figure 2.6: Digital Skills—Developing Asia, Selected Economies

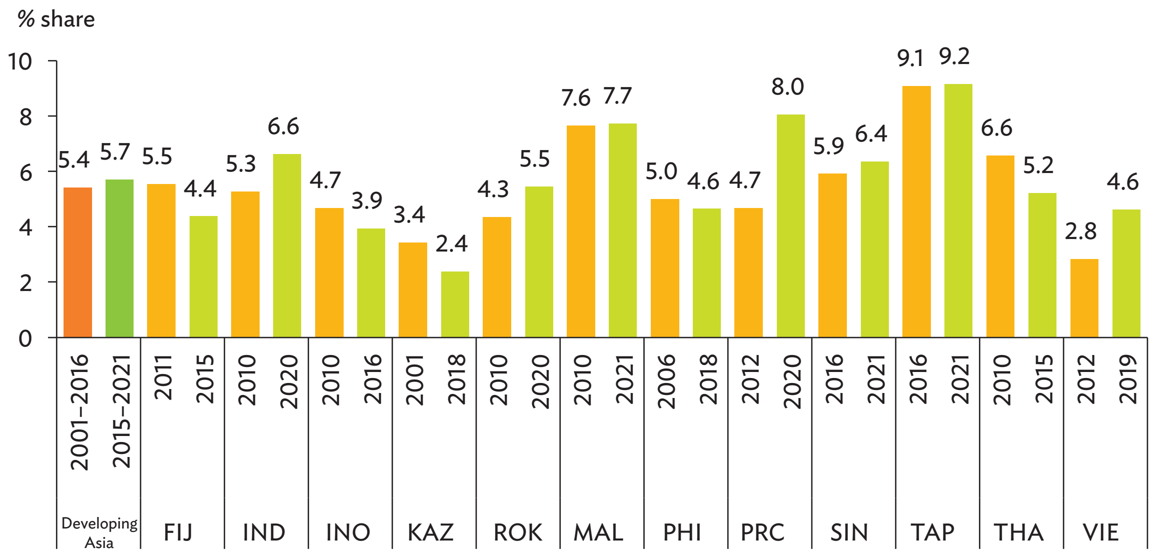


Source: UNESCAP (2023).

the 2010s, the region accounted for about half of global exports of these products and services (Sedik et al. 2019). The gross domestic product (GDP) contribution of digital sectors (i.e., "digital GDP") in developing Asian economies, measured as both direct and indirect value-added, ranged from 2.4% to 9.2% in the latest year for which data are available (Figure 2.7). However, the digital sector's share of GDP has been relatively stagnant across developing Asia in recent decades. In fact, in many regional economies, the growth of the digital sector has not kept pace with the growth of non-digital sectors. For example, sectors such as transportation in Fiji, agriculture in Kazakhstan, and tourism in Thailand all expanded faster than their respective digital sectors during the review period, which reduced the relative GDP contribution of the digital sector in each economy. Meanwhile, between 2008 and 2019, digital sector employment as a share of total employment in the region remained flat (Figure 2.8). The employment share of the digital sector is particularly low in large regional economies. For example, the digital sector in India has accounted for only 0.9%–1.4% of total employment since 2008, while in the PRC, this share has remained below 1.0%.[6] In contrast, the digital GDP shares in these economies grew during the review period, rising from 5.3% to 6.6% in India and from 4.7% to 8.0% in the PRC, as shown in Figure 2.7.

[6] The PREDICT database has collected information and communication technology, research and development, and other macroeconomic variables from 40 advanced and emerging economies since 2006. European Commission. EU Science Hub. PREDICT Database 2023 (accessed 25 October 2024).

Figure 2.7: Contribution of the Digital Sector to Gross Domestic Product—Developing Asia, Selected Economies

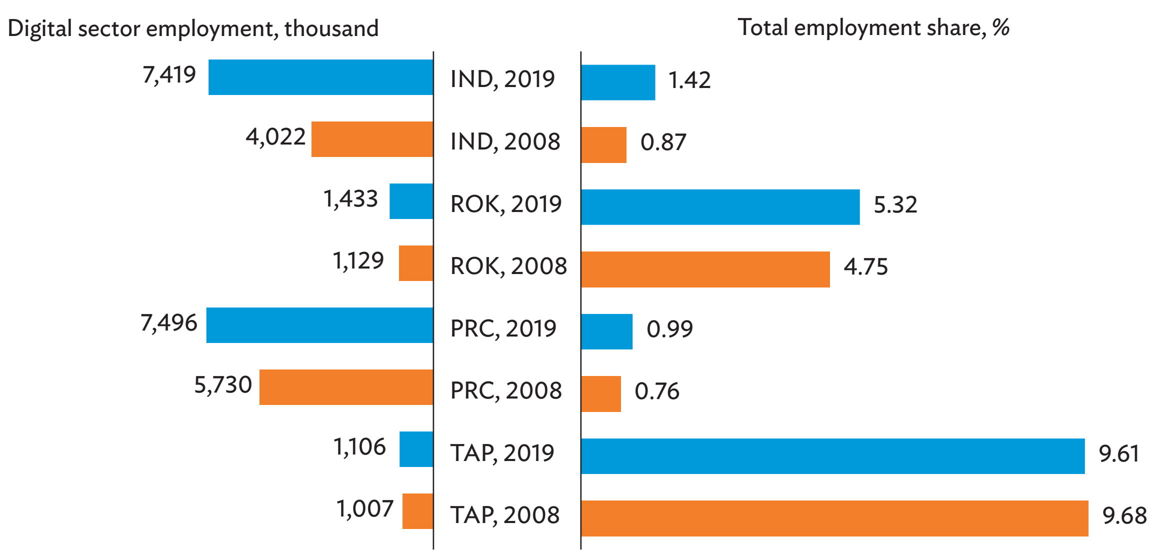


PRC = People's Republic of China; FIJ = Fiji; GDP = gross domestic product; IND = India; INO = Indonesia; KAZ = Kazakhstan; ROK = Republic of Korea; MAL = Malaysia; PHI = Philippines; SIN = Singapore; TAP = Taipei,China; THA = Thailand; VIE = Viet Nam.

Note: Data for developing Asia represent the aggregate of the 12 economies.

Source: Author's calculations using data from local sources and ORBIS.

Figure 2.8: Digital Sector Employment and Share in Total Employment—Developing Asia, Selected Economies



PRC = People's Republic of China; IND = India; ROK = Republic of Korea; TAP=Taipei,China.

Source: Authors based on European Commission. EU Science Hub. PREDICT Database 2023 (accessed 25 October 2024).

2.2 | Policy Interventions Are Needed to Drive Digital Transformation for Good

Developing Asia's digital strategies and policies have shifted from focusing on digital infrastructure and connectivity to enabling digital transformation. Initially, these strategies and policies in developing Asia focused on supply-side issues to improve the accessibility and affordability of digital technologies, such as broadband and mobile devices, by deploying digital infrastructure, expanding network coverage, and boosting universal connectivity. For example, India's BharatNet Project aimed to provide high-speed internet to rural areas through optical fiber, while Bangladesh's Connected Bangladesh Project sought to establish optical fiber network connectivity in remote and underserved areas. More recently, economies in developing Asia have shifted their digital strategies and policies toward digital transformation. This involves integrating digital technologies into social and economic activities, improving services and building digital skills, all while promoting productivity, innovation, competitiveness, and growth. Examples of this shift can be seen in country strategies such as Mongolia's Digital Nation Policy, 2022–2027; Indonesia's Making Indonesia 4.0; the Digital Nation Pakistan Act; Digital Kazakhstan; Viet Nam's National Digital Transformation Program; Papua New Guinea's Digital Transformation Policy; and Fiji's planned inaugural National Digital Strategy (Government of the US, Department of Commerce, ITA 2024a).

Digitalization has advanced in developing Asia more rapidly than in the rest of the world, yet similar progress has not been observed in inclusion and environmental sustainability. Following Kedia (2025), this report assesses the digitalization progress of developing Asia using changes in the ranking of the Network Readiness Index (NRI).[7] As shown in Table 2.1, from 2020 to 2024, 14 out of the 21 regional economies with NRI data improved their ranking, indicating that the region has largely progressed faster than the rest of the world in terms of digitalization. In terms of inclusion, the UN Conference on Trade and Development (UNCTAD) introduced an Inclusive Growth Index (IGI), which serves as a broad measure of inclusion and economic well-being. The IGI is a comprehensive proxy for both inclusion and environmental sustainability, encompassing information about the economy, living conditions, equality, and the environment. However, the region shows mixed progress on inclusion. Among the 19 regional economies with both IGI and NRI data, 9 showed improvement during the review period, while 10 have experienced no change or deteriorated. A closer examination of environmental sustainability was conducted using the Environmental Performance Index (EPI), a composite index that measures environmental health and ecosystem vitality, as well as the environmental component of the IGI. As shown in the last two columns in Table 2.1, regional economies are progressing slower than the rest of the world in terms of environmental sustainability, with most regional economies falling back in their environment performance rankings.

Market failure and equity failure must be addressed to align digital transformation with inclusive and sustainable development. Market and equity failures hinder private actions that promote inclusion and sustainability (Kedia 2025). For example, market failure can occur when significant upfront investments and lower returns in broadband or mobile networks in remote or sparsely populated areas discourage private investment. The high fixed costs and low returns create natural monopolies, resulting in the under-provision of digital infrastructure. Additionally, while digital technologies have the potential to improve energy efficiency and lower carbon footprints, if the market underprices these externalities, it may lead to underinvestment in sustainability-aligned digital

[7] The NRI consists of four pillars: technology, which captures the availability and quality of ICT infrastructure; people, which captures the skills and capabilities of the workforce to effectively engage with and contribute to the digital economy; governance, which addresses the regulatory environment, policies, and institutions that support the development and adoption of ICT; and impact, which measures the effects of ICT on economic growth, social development, and quality of life.

Table 2.1: Progress of Digitalization, Inclusive Growth, and Sustainability—Developing Asia, Selected Economies

Income Category	Economies	Change in Rank			
		NRI (2024 vs 2020)	Overall IGI (2023 vs 2021)	EPI (2024 vs 2020)	IGI Environment (2023 vs 2021)
High Income	Singapore	↑	↓	↓	→
	Republic of Korea	↑	→	↓	↓
Upper Middle Income	PRC	↑	↑	↓	↑
	Malaysia	↓	↓	↓	↓
	Thailand	↑	↓	↓	↑
	Indonesia	↑	→	↓	→
	Kazakhstan	↓	↑	↑	→
	Armenia	↓	↑	↓	↓
	Georgia	↑	↑	↑	↑
	Azerbaijan	↓	↑	↓	↓
	Mongolia	↑	↓	↑	↓
Lower Middle Income	Viet Nam	↑		↓	
	India	↑	↑	↓	→
	Philippines	↑	↓	↓	↓
	Kyrgyz Republic	↑	↑	→	→
	Bangladesh	↑	↓	↓	↑
	Sri Lanka	↓	↓	↓	↑
	Pakistan	↑	↑	↓	↓
	Lao PDR	↓	→	↓	↓
	Nepal	↑	↑	↓	↓
	Cambodia	↓		↓	

PRC = People's Republic of China, EPI = Environmental Performance Index, IGI = Inclusive Growth Index, Lao PDR = Lao People's Democratic Republic, NRI = Network Readiness Index, vs = versus.

Note: Cells highlighted in green (↑), yellow (→), or red (↓) imply improvement, unchanged, or deterioration in rankings, respectively.

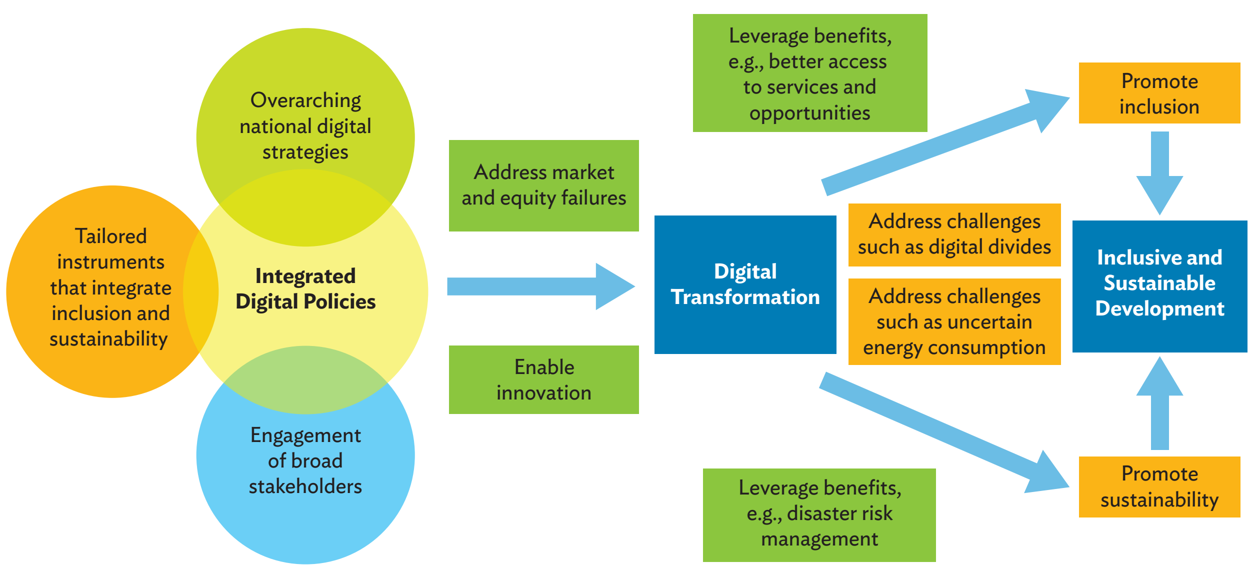
Sources: Authors' calculations based on Block et al. 2024; Portulans Institute (2020, 2024a); UNCTAD. IGI database (accessed 18 March 2025); Wendling et al. 2020; Kedia (2025).

technologies. Equity failure arises when certain groups are excluded from effectively participating in digital transformation due to factors such as affordability, access, skills, knowledge, and trust, ultimately diminishing their overall social well-being. For example, even when services like satellite broadband are available, individuals in underserved areas may lack the ability to pay for them, resulting in equity failure that leaves disadvantaged groups behind and thus, contributes to digital divides. Beyond addressing these failures, governments must also create an enabling environment for the private sector to continue innovating digital technologies that deliver inclusion and environmental sustainability benefits, such as energy-efficient hardware and software.

Digital policies that address market and equity failures can catalyze digital transformation for inclusive and sustainable development. As discussed in Chapter 1, recent advancements in digital technologies hold significant potential for good. However, neoclassical frameworks have shown that market economics cannot capture issues related to equity and environmental sustainability. Existing market and equity failures hinder different parties—such as businesses, communities, and individuals—from taking positive actions toward inclusion and sustainability (Kedia 2025). For example, while digital technologies improve economic opportunities and delivery of services, some groups may struggle to participate fully in digital transformation due to various sociodemographic, socioeconomic, and personal conditions, as well as factors related to skills and technology. These factors will contribute to digital divides and widen inequality unless related failures are addressed. Therefore, government interventions are essential to correct these failures and enable positive private actions. Digital policies that integrate the economy, society (including social equity), and the environment will help leverage digital transformation to accelerate inclusive and sustainable development.

Integrating inclusion and sustainability with digital transformation can harness digital transformation for good. Current digital policies in developing Asia normally focus on transformation toward a digital economy, enhancing economic growth, service delivery, competition, and innovation. However, developing Asia has the opportunity to leverage digital transformation to accelerate inclusive and sustainable development by making inclusion and sustainability integral objectives of this process. So far, existing digital policies in developing Asia have considered universal connectivity in terms of both coverage and quality, as well as the development of digital skills. However, more comprehensive strategies to ensure inclusion during digital transformation merit consideration. For example, promoting inclusive digital services and applications that cater to all groups, including older people, SMEs, and less educated groups, is crucial. Furthermore, only a few regional economies have aligned digital transformation with environmental sustainability objectives. For example, the Republic of Korea's Green and Digital New Deal, introduced in 2020, aims to elevate both green and digital transformations, fostering a green transition through the use of digital technologies. Similarly, the PRC's Guidelines for Coordinated Digital and Green Transformation, launched in August 2024, seeks to accelerate green transformation through digital technology while promoting the green development of digital industries. Figure 2.9 illustrates that integrated digital policies, which include considerations for inclusion and sustainability, will enable digital transformation to act as a catalyst for inclusive and sustainable development.

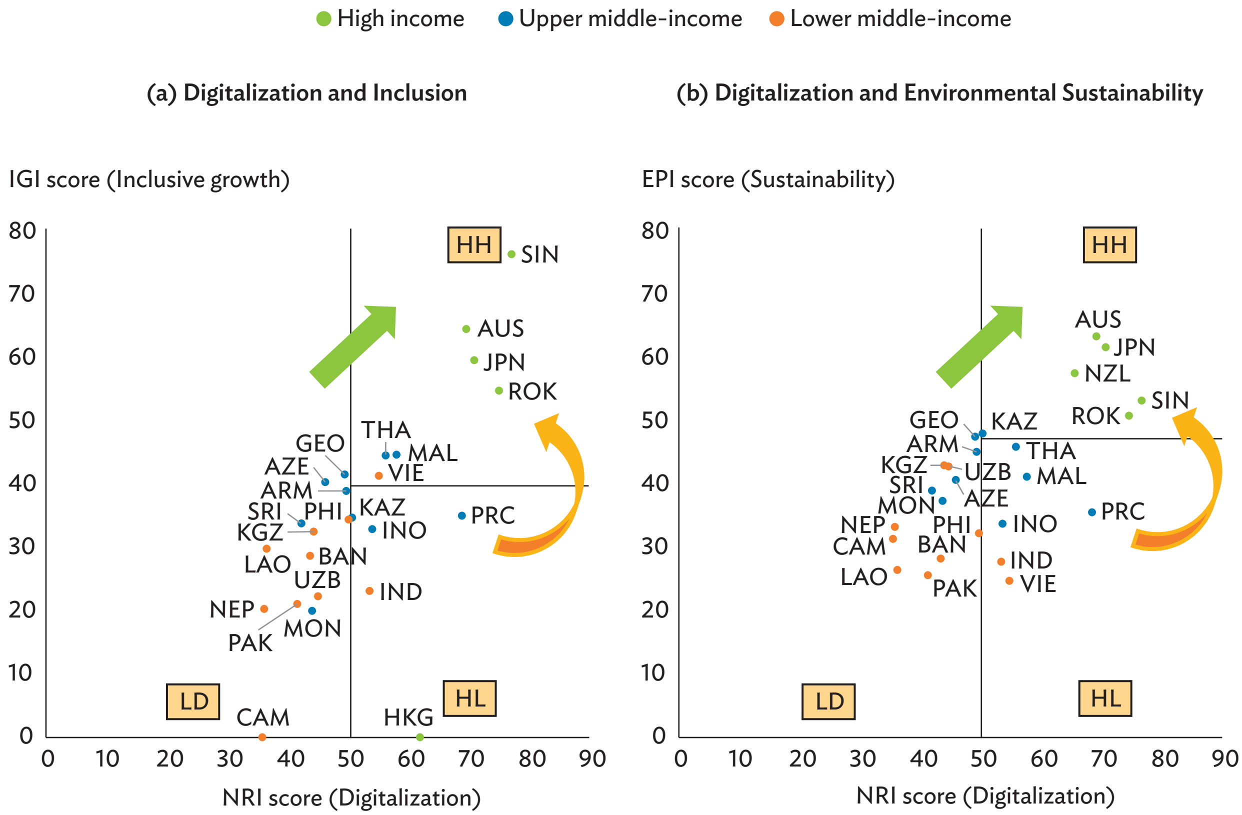
Figure 2.9: Harnessing Digital Transformation for Inclusive and Sustainable Development



Source: Authors.

Regional economies have different digital-inclusion and sustainability profiles that can affect how their digitalization can be aligned with inclusion and sustainability. Following Kedia (2025), Figure 2.10 shows a demonstration of the digitalization-inclusion and sustainability profiles of the regional economies, using the latest NRI index to capture digitalization, the IGI index to assess inclusive growth, and the EPI to capture environmental sustainability. The data show that digitalization inclusion, and sustainability largely progress alongside economic development. In this report, we describe the profile of an economy's digital-inclusion and sustainability by grouping regional economies according to where an economy stands in terms of digitalization, inclusion, and sustainability. To capture an economy's digitalization progress, one way is to compare its NRI score with the median NRI level of the global middle-income and high-income economies (global median). Economies with an NRI score above the global median are classified as high-digitalization, while economies with an NRI score below the global median are classified as Low-Digitalization (LD), as shown in the left two quadrants in Figure 2.10. The report then captures the inclusion and sustainability profiles of an economy by comparing their IGI scores with the IGI global median and their EPI scores with the EPI global median, respectively. Economies that score above the EPI and IGI global median are grouped as High-Inclusion and Sustainability, while economies with one or two indexes below the EPI and IGI global median are grouped as Low-Inclusion and Sustainability. As shown, most LD economies tend to be in the Low-Inclusion and Sustainability group, the report thus categorizes regional economies into three broad groups: (i) LD, (ii) High-Digitalization, Low-Inclusion and Sustainability (HL), and (iii) High-Digitalization, High-Inclusion and Sustainabiity (HH), based on common elements in different plots to discuss various policy implications. As shown, LD economies have a unique opportunity to accelerate digital transformation while promoting inclusion and sustainability by directly adopting inclusion and environment friendly technologies such as platforms and disaster risk management technologies, to shift toward the HH group (as shown by the green arrow). This approach differs from the economies in the HL group—such as the PRC, India, and Indonesia—because they need to expedite the decarbonization of their existing digital infrastructure and the adoption of energy-efficient technologies to achieve HH status (as shown by the orange arrow).

Figure 2.10: The Digitalization-Inclusion and Sustainability Profile—Developing Asia, Selected Economies



ARM = Armenia; AUS = Australia; AZE = Azerbaijan; CAM = Cambodia; PRC = People's Republic of China; EPI = Environmental Performance Index; GEO = Georgia; HH = High-Digitalization, High-Inclusion and Sustainability; HKG = Hong Kong, China; HL = High-Digitalization, Low-Inclusion and Sustainability; IGI = Inclusive Growth Index; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KGZ= Kyrgyz Republic; ROK = Republic of Korea; Lao PDR = Lao People's Democratic Republic; LD = Low-Digitalization; MAL = Malaysia; MON = Mongolia; NEP = Nepal; NRI = Network Readiness Index; NZL = New Zealand; PAK = Pakistan; PHI = Philippines; SIN = Singapore; SRI= Sri Lanka; THA = Thailand; UZB = Uzbekistan; VIE = Viet Nam.

Note: The lines denote the median level of indexes of global high-income and middle-income economies. The latest scores of NRI and EPI are as of 2024, while the latest IGI scores are as of 2023.

Sources: Authors' calculations based on Block et al. (2024); Portulans Institute (2020, 2024a); UNCTAD. IGI database (accessed 18 March 2025); Wendling et al. (2020); Kedia (2025).

3 Impacts of Digital Transformation on Inclusion

With appropriate strategies and policies, digital transformation can promote inclusive development that benefits the wider population. This chapter presents new evidence and case studies illustrating how digital technologies contribute to inclusive development by closing income gaps; empowering small and medium-sized enterprises (SMEs) and women; increasing productivity and resilience; and improving access to basic services such as finance and education. Additionally, it lays out the challenges of digital transformation for inclusive development, including digital divides, potential disruptions in the job market, and governance issues related to cybersecurity, data privacy, misinformation, and competition. This chapter also outlines inclusion-aligned policy instruments that facilitate digital transformation for inclusive development.

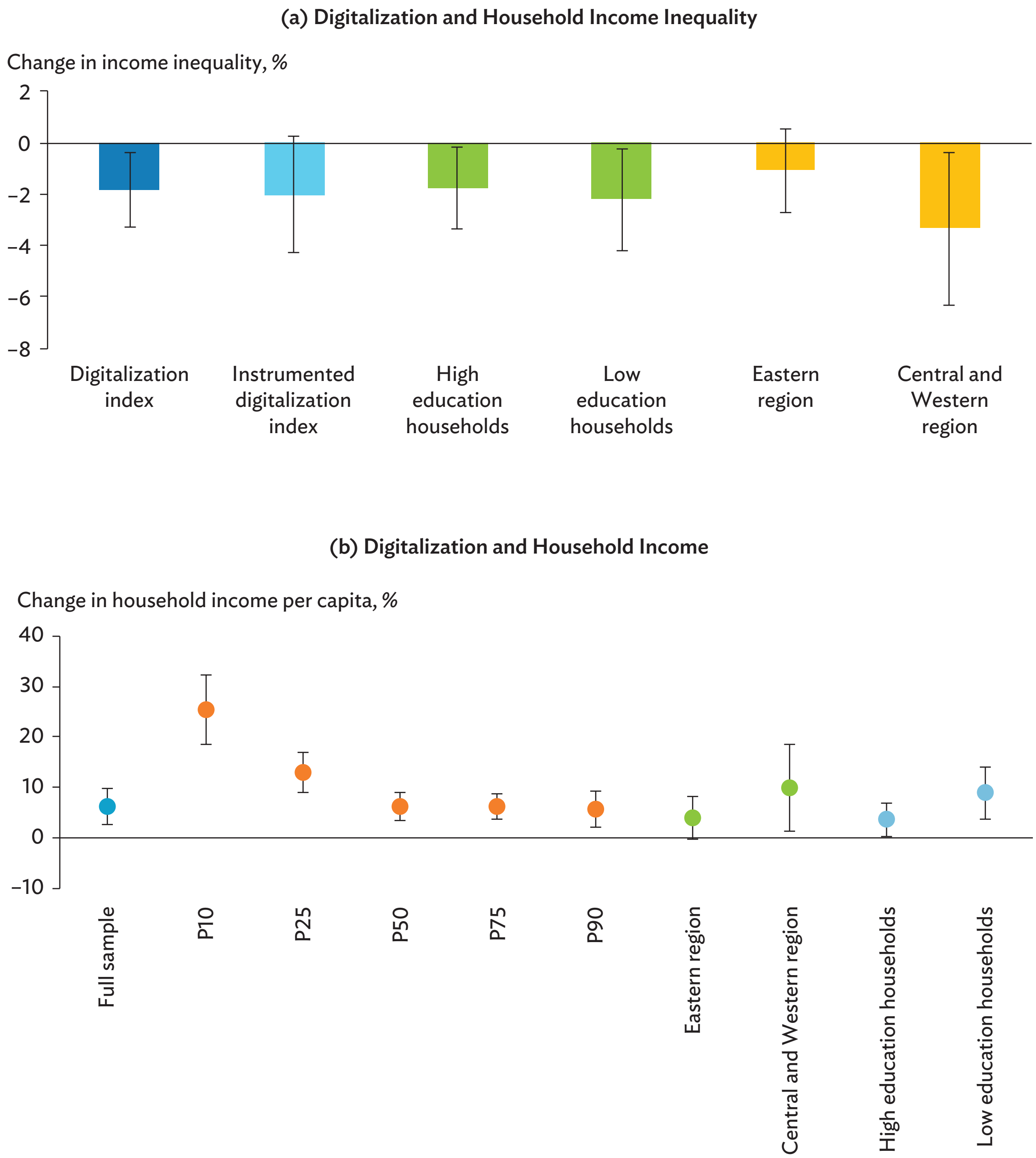
3.1 | Opportunities to Promote Inclusion

Narrowing Income Gaps and Reducing Poverty

Digital technologies can help narrow income gaps by broadening access to economic opportunities. Geographic and information segmentation pose barriers to economic opportunities. By breaking down this segmentation, digital technologies enhance connectivity and generate more business and job opportunities for disadvantaged groups (Ahmed and Al-Roubaie 2013; Demir et al. 2022; Li and Qin 2022). New evidence from the People's Republic of China (PRC) indicates that at the city level, a one-unit increase in digitalization of a city leads to a reduction in household income inequality by 0.0183 for an average household, which is around 1.94% of the mean level of household income inequality in the sample (Tian, Wu, and Zhou 2025) (Figure 3.1a). The effects of this inequality reduction are statistically significant and are particularly pronounced among households in less developed central and western regions, as well as those with lower education levels. This reduction in income inequality is primarily driven by the greater income-boosting impact of digitalization on low-income and less educated households, along with those living in less developed areas (Figure 3.1b). On average, a one-unit increase in a city's digitalization corresponds to a 6.2% increase in household per capita income for the average household; however, this impact increases to 25.5% for households in the bottom income decile. The income impacts are also more significant for households with lower education levels (9.0%) and those from less developed central and western regions (9.9%). Further evidence shows that digitalization promotes income by creating employment, business, and investment opportunities (Box 3.1).

By creating more economic opportunities for disadvantaged groups, digital technologies have the potential to reduce poverty. The positive spillover effects of digitalization on economic opportunities, productivity, and economic growth increase the income of disadvantaged groups, thus reducing poverty. Research using household-level data indicates that digital technologies contribute to poverty reduction in both rural and urban areas of India (Das and Chatterjee 2023). Financial inclusion has been identified as a key channel through which digital technologies reduce inequality and poverty in 62 developing economies between 2001 and 2012 (Mushtaq and Bruneau 2019). In developing Asia,

Figure 3.1: Digitalization, Household Income, and Household Income Inequality: Evidence from the People's Republic of China



P = percentile.

Note: Error bars pertain to the 99% confidence interval.

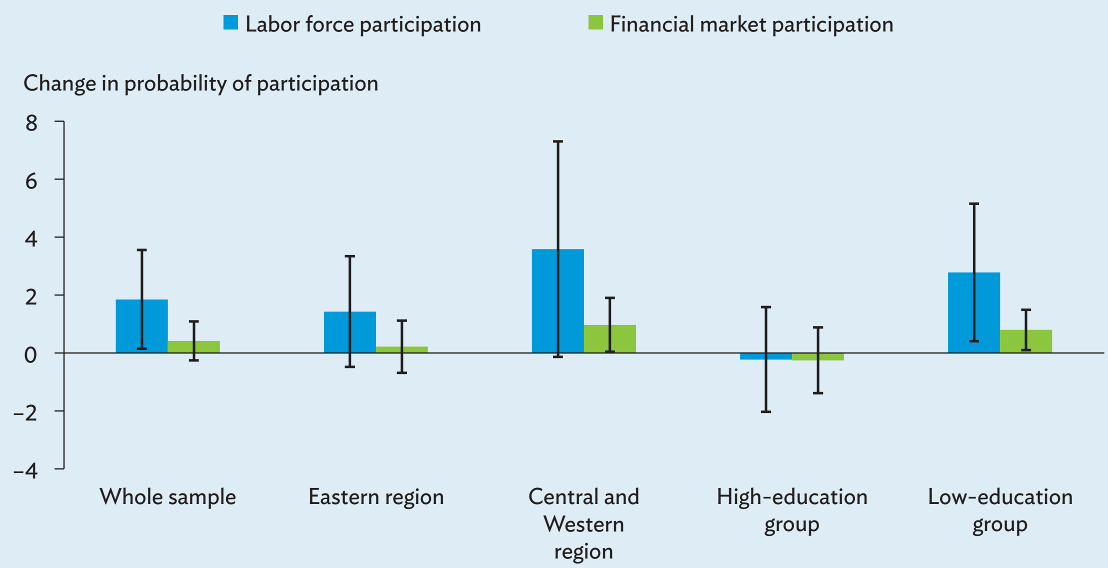
Source: Tian, Wu, and Zhou (2025).

Box 3.1: Digitalization and Income Inequality: Household-Level Evidence

Using household-level data from the China Household Finance Survey conducted in 2013, 2015, 2017, and 2019, Tian, Wu, and Zhou (2025) empirically examine the relationship between a city's level of digitalization and income inequality of its households. Following the approach in Bossert and D'Ambrosio (2006), the study measures household-level income inequality using the Kakwani Index, defined as the average distance between a household and all households with higher per capita income levels in the same community. To measure the digitalization level of the city where a household resides, the study constructs a comprehensive index that gauges digital industry development and digital technology adoption. This index includes factors such as mobile phone subscriptions, digital payment coverage, telecommunication service revenue, 5G patent licenses, the number of digital industry enterprises, and employment in those enterprises.

Analyzing a sample of 107,671 households from 544 cities, the estimated results presented in Figure 3.1 suggest that a city's digitalization is significantly negatively related to household income inequality. The reduction in income inequality is driven by higher income increases among households with lower income and education levels, as well as those living in less developed regions. Further evidence indicates that these increases in income levels can be associated with improved opportunities for participation in both the job market and financial markets. As shown in the box figure, a one-unit increase in digitalization is significantly linked to a 1.8% higher likelihood of job participation, with greater chances estimated for less educated households (2.8%) and households in less developed regions (3.6%). Additionally, a one-unit increase in digitalization is also significantly related to a 1% higher likelihood of financial market participation for households with lower education levels and those from less developed regions. Moreover, the evidence suggests that higher digitalization also enhances households' business income.

Digitalization and Job Market and Financial Market Participation



Note: Error bars pertain to the 99% confidence interval.

Source: Tian, Wu, and Zhou (2025).

Reference

Bossert, W. and C. D'Ambrosio. 2006. Reference Groups and Individual Deprivation. *Economics Letters*. 90. p. 421–426;

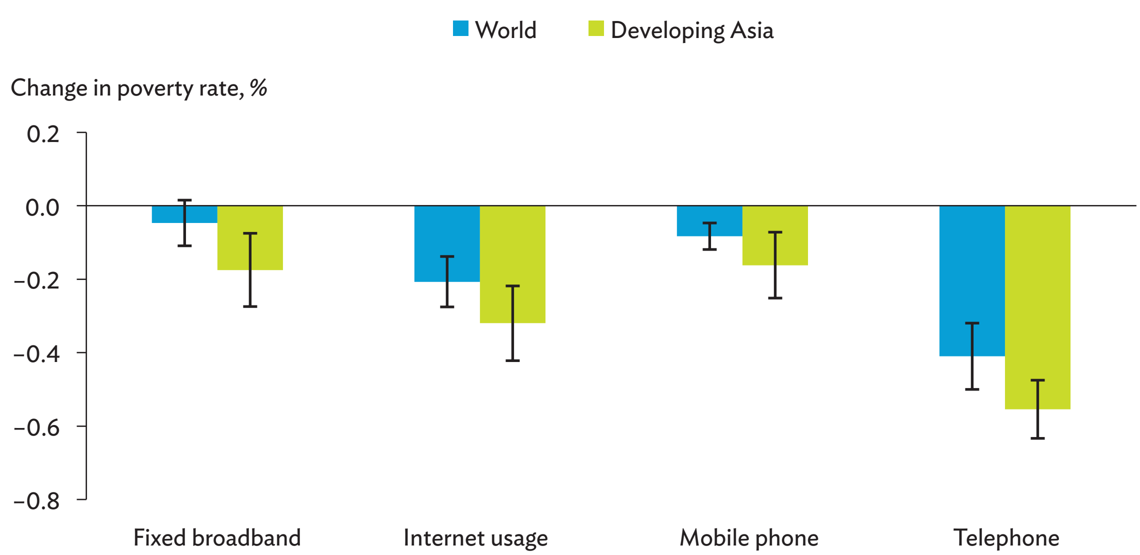
Source: Tian, Wu, and Zhou (2025).

a significant negative cross-economy correlation between various measures of digital connectivity and poverty rates was documented by Acheampong, Park, and Tian (2025). After controlling for income and levels of economic development, a 1% increase in access to internet is significantly associated with average decreases of 0.32% in poverty in developing Asia (Figure 3.2). Further analysis shows that the negative association between digital connectivity and poverty rates is related to reduced income inequality, better access to basic services such as finance and education, and increased employment opportunities (Acheampong, Park, and Tian 2025).

Enabling SMEs

Digitalization can boost SMEs' performance by transforming their operational processes and business functions. As shown in Figure 3.3, digital technologies can reduce transaction and operational costs while facilitating access to finance, public services, and training and recruitment resources. For example, online business and remote working lower office and warehouse costs while connecting SMEs to a broader base of customers, suppliers, and talent. Digital technologies also contribute to productivity by automating repetitive tasks and streamlining operations such as inventory tracking and smart business processes. They improve customer services and facilitate interaction and communication among internal and external stakeholders (ADB 2024b; Roman and Rusu 2022; Rossato and Castellani 2020). Platforms, social media, and e-commerce, for instance, help SMEs with effective marketing and customer service. SMEs particularly benefit from digital platforms via enhanced visibility, improved productivity and profits, and an expanded customer base (ILO 2021). Small business marketing managers in business-to-business industries report that social media significantly enhances marketing efforts and influences customer decision-making, thereby strengthening brand awareness and relationship building (Hayes and Kelliher 2025). Social media and email marketing can help SMEs reach global clients cost-effectively. Evidence from a microenterprise survey in India shows that the use of the internet and social media is significantly related to

Figure 3.2: Digital Connectivity and Poverty



Note: Error bars pertain to the 99% confidence interval.

Source: Acheampong, Park, and Tian (2025).

Figure 3.3: Digitalization Benefits for SMEs

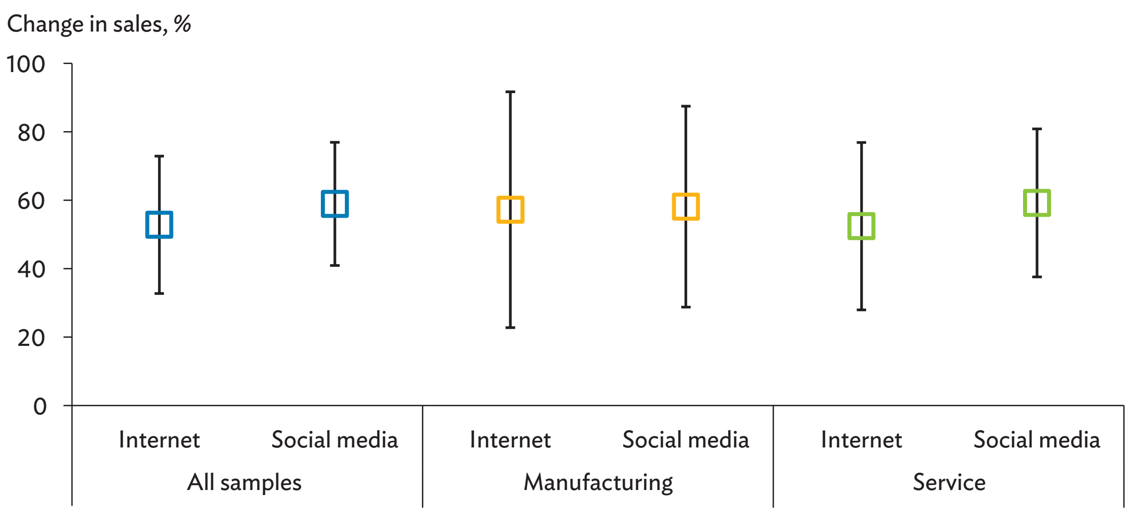
SMEs = small and medium-sized enterprises.

Source: Authors based on ADB (2024b).

sales increases of 53% and 59% for the average micro firm in India (Reddy and Sasidharan 2025) (Figure 3.4).

Digital technologies help SMEs access global markets by reducing entry barriers and transaction costs. Digital technologies facilitate effective information dissemination and business connections, lifting networking barriers for SMEs and enabling them to adapt to and capitalize on opportunities in foreign markets (Hervé, Schmitt, and Baldegger 2020). Evidence from a sample of 14,513 SMEs across 34 global economies indicates that SMEs that use the internet to provide information and facilitate transactions have a higher degree of internationalization and a greater ratio of foreign sales to total sales (Eduardsen 2018). In Eastern Europe and Central Asia, SMEs that use the internet are more likely to export than similar businesses that do not use the internet (Clarke 2008). In India, a one-unit increase in the first two principal components of 12 digital technology adoption measures is significantly associated with a 4% higher probability of exporting for an average micro firm (Reddy and Sasidharan 2025). E-commerce platforms like Amazon, eBay, Shopify, and Alibaba enable SMEs to scale their businesses in global

Figure 3.4: Adoption of Digital Technologies and Microenterprises' Performance in India



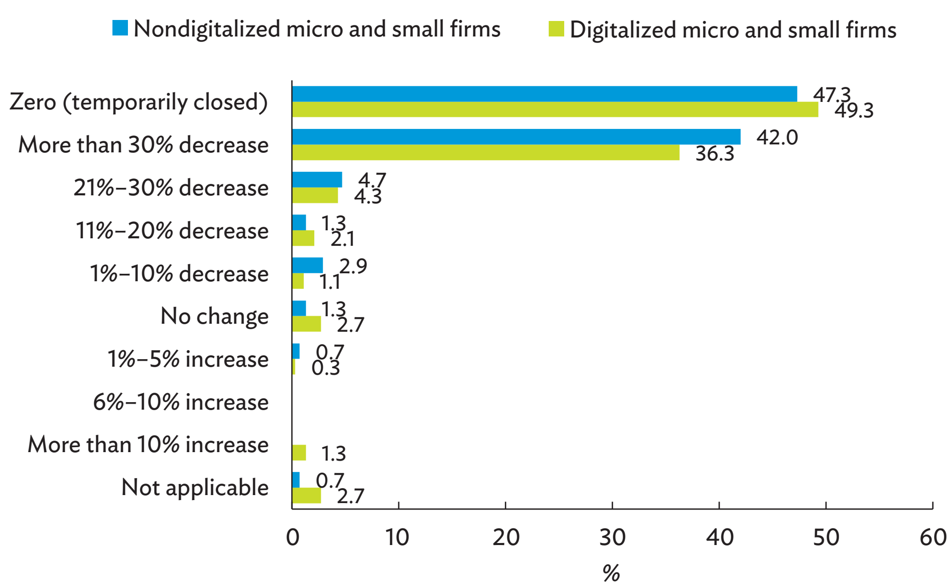
Note: Error bars pertain to the 99% confidence interval. The bars denote the percentage change in sales of an average micro firm associated with the use of internet or social media.

Source: Reddy and Sasidharan (2025).

markets, transforming them into "micro-multinationals" by connecting with international clients and suppliers while reducing entry barriers. Digital platforms facilitate the entry of New Zealand SMEs into the PRC market by overcoming resource constraints and easing access to networks (Jin and Hurd 2018). Digitalization offers a transformative solution for SMEs to enhance process efficiency and reduce costs in trade transactions (Kim, Ardaniel, and Endriga 2022). Traditional trade transactions rely heavily on paper-based documentation, such as letters of credit, which are time-consuming, prone to human error, and costly, accounting for 50%–60% of the fees charged to clients. Digitalization improves efficiency by automating trade documentation, enabling real-time verification, and reducing transaction costs. For example, adopting electronic bills and cloud-based invoices allows trade transactions to be completed more quickly while minimizing paperwork and human errors.

Digital technologies enhance the economic resilience of SMEs during major disruptions by supporting the continuity of economic activities. In the face of significant economic shocks, such as the pandemic, firms with greater digital readiness and capabilities demonstrate increased resilience. A global firm-level analysis indicates that companies in more digitalized industries experienced less revenue loss during recessions (Copestake, Estefania-Flores, and Furceri 2024). Firms' pre-pandemic technological sophistication is positively associated with their sales during the pandemic in Brazil, Senegal, and Viet Nam (Comin et al. 2022). Digitally enabled firms in the Middle East and Central Asia recorded a smaller decline in sales during the pandemic compared to digitally constrained firms (Abidi et al. 2023). Digital connectivity and technologies were particularly beneficial for SMEs during the pandemic. For example, peer-to-peer lending and crowdfunding emerged as important sources of finance for SMEs during this time (Gama et al. 2023; Najaf, Subramaniam, and Atayah 2022). In Indonesia, during the early pandemic period (March–April 2020), SMEs using the internet for business experienced a less negative impact on their revenues compared to their nondigital peers (Shinozaki 2022). Specifically, 36.3% of digitally operated SMEs suffered revenue losses of more than 30.0%, compared to 42.0% for nondigital SMEs (Figure 3.5). This difference was partly driven by sustained demand and business activity via internet connection. Up to 70% of small firms increased their use of digital technology during the COVID-19 pandemic (OECD 2021).

Figure 3.5: Revenue Changes of SMEs in Indonesia, March–April 2020



SMEs = small and medium-sized enterprises.

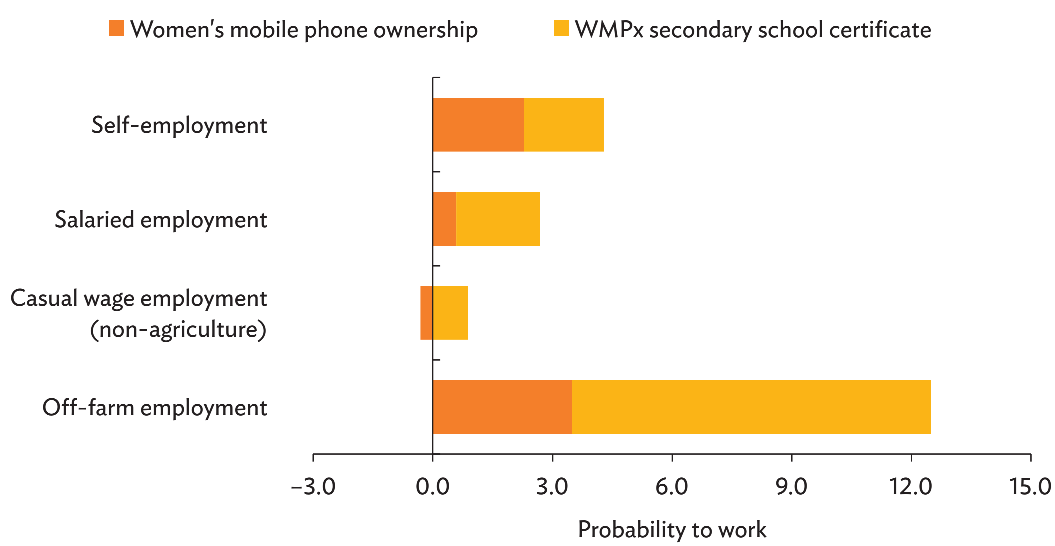
Source: Shinozaki (2022).

Empowering Women

Digital technologies can provide innovative solutions that empower women with new job and income opportunities. Digital technologies can reduce barriers in communication and social networks, creating opportunities for women who face connection constraints (Matsuura-Kannari, Islam, and Tauseef 2024; Zheng, Zhou, and Rahut 2023). Digital technologies also offer more flexible "gig" opportunities in terms of working hours and locations, generating new job opportunities for women with family care responsibilities, who may be less physically mobile (Hunt and Samman 2019). In Viet Nam, a one-unit increase in provincial household internet access is significantly associated with a 16.6% higher likelihood of average female household heads holding service sector jobs, compared to 12.4% for average male household heads (Liang, Tian, and Zhang 2025). This difference is statistically significant and has income implications. Furthermore, survey data from rural households in Bangladesh reveal that mobile phone ownership of women is significantly associated with higher off-farm income for average rural household wives. This relationship is partly driven by increased off-farm employment and self-employment opportunities, especially for women who have completed secondary education (Matsuura-Kannari et al. 2025) (Figure 3.6).

Digital technologies also facilitate women entrepreneurship by circumventing conventional constraints. Globally, there are about 8 female entrepreneurs for every 10 male entrepreneurs, and 1 in 6 women plans to start a business (Komlósi et al 2025a) Various impediments have been identified as contributing to a gender gap in entrepreneurship. These include inadequate access to external financing for women (Ewens and Townsend 2020, Guzman and Kacperczyk 2019); a relative lack of social networks and unfavorable social institutions (Field, Jayachandran, and Pande 2010; Howell and Nanda 2019); and more family care obligations (Bertrand, Goldin, and Katz 2010; Core 2020). The adoption of digital finance significantly improves women's bargaining power within households in the PRC (Han, Zhang, and Zhu 2023). In addition to improving access to finance, digital technologies can also reduce other barriers. For example, e-commerce disproportionately benefits women entrepreneurs, as it relies less on traditional business networks (Ma and Hu 2022) and allows for a better balance between work and family obligations (Yunus, Rahman, and Islam 2022).

Figure 3.6: Mobile Phone Ownership and Off-Farm Employment of Rural Women in Bangladesh



WMP = women's mobile phone ownership.

Notes: WMPx secondary school certificate is the interaction term between women's mobile phone ownership and secondary school certificate variable. It captures whether the benefits of owning a mobile phone on the outcome differs depending on whether a woman has completed secondary school.

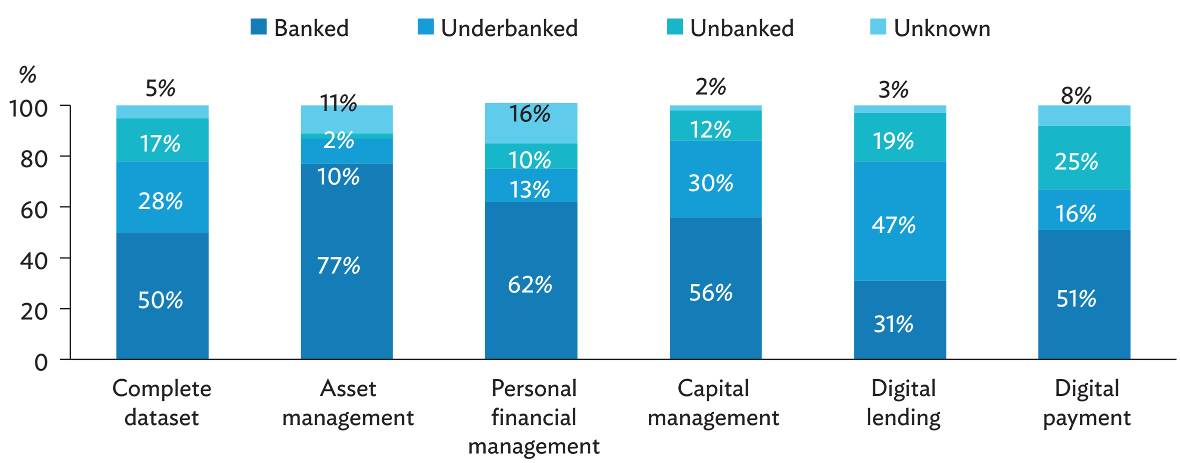
Source: Matsuura-Kannari et al. (2025).

Using online and offline enterprise survey data in the PRC, a 1% increase in sales on the JD.com e-commerce platform is associated with a 0.68% increase in the number of women entrepreneurs, contributing to nearly 56.3% of the increase in the share of women entrepreneurs (Cong et al. 2024). Digital transformation is positively and significantly associated with female entrepreneurship based on data from 78 global economies: A one-unit increase in the digital transformation index corresponds to a 0.45 higher score in the Female Entrepreneurship Index, which is 118% of the sample mean of 0.38 (Komlósi et al. 2025b). In Vanuatu, e-commerce has enabled local businesses, particularly female entrepreneurs, to reach broader markets and access more business opportunities (Rahman et al. 2025).

Enhancing Financial Inclusion

Digital technologies can improve financial inclusion by expanding access to financial services for underserved groups. Digital financial services such as mobile banking, online transfers, mobile money, peer-to-peer platforms, and digital payment platforms can improve the coverage and accessibility of financial services. They provide scalable, cost-effective solutions for delivering formal financial services such as credit, insurance, savings, and investment options to underserved groups, including SMEs and unbanked populations, thereby promoting financial inclusion (Agarwal and Assenova 2024; Carè et al. 2025; Kouladoum, Wirajing, and Nchofoung 2022). The rapid spread of mobile phones and internet access facilitates the adoption of digital financial services among these groups (Elhajiar and Ouaida 2019; Senyo and Osabutey 2020). Digitalization of financial services also provides a solution to the shortage of bank branches in rural areas, thereby enhancing the capacity of remote rural areas to access financial services (Benami and Carter 2021). For example, mobile phone and internet services are crucial drivers of financial inclusion in the South Asian Association for Regional Cooperation economies (Lenka and Barik 2018). In Southeast Asian economies, digital payments have significant penetration among underbanked groups, with around 66% of digital lending customers being unbanked or underbanked (Morgan 2022) (Figure 3.7).

Figure 3.7: Users' Status of Digital Financial Technologies in Southeast Asian Economies



Source: Morgan (2022).

Digital technologies enable conventional financial institutions to extend financial services to underserved groups by improving information transparency and monitoring. Financial institutions typically face challenges when extending credit to groups such as SMEs and farmers, who typically have difficulty providing acceptable collateral and reliable operational information. Digital technologies enable financial institutions to collect detailed and reliable information on operational activities and analyze customer data, making it possible for them to extend credit to creditworthy customers (Chu et al. 2023). In this way, digital technologies improve the efficiency and capacity of conventional financial institutions in serving underserved groups.

Promoting Education Equality

Digital technologies can reduce educational inequality by promoting the sharing of educational resources and enriching learning approaches. Digital technologies have been transforming teaching and learning processes. Online education can promote educational equity by breaking down geographic and economic constraints, broadening access to educational systems and resources, enabling the online sharing of knowledge and opinions, creating personalized learning opportunities, and boosting collaboration and interaction among students. The biggest beneficiaries are students and teachers in underdeveloped economies and regions (Gottschalk and Weise 2023; Zhang and Zhou 2023). For example, an analysis of 3,603 anonymous students from an online learning platform in the PRC shows that participating in online education narrows the performance gap in mathematics between socioeconomically privileged and less privileged students (Gao et al. 2024). This impact is partly driven by equal access to and quality of online education resources for both rural and urban students. A large-scale intervention that employed technology-aided teaching to replace one-third of traditional teaching in 1,823 rural government schools in India showed a positive impact on student learning outcomes in English, mathematics, and science (Naik et al. 2020). In Papua New Guinea, the introduction of e-learning platforms in rural areas allows students to access quality educational resources online, bridging the gap between urban and rural education standards (Rahman et al. 2025). More recent developments in generative AI, in particular, have considerable potential to contribute to educational equality via data-driven decision-making processes that help identify and address learning gaps, thereby enabling a more personalized and adaptive learning environment (Roshanaei, Olivares, and Lopez 2023). Figure 3.8 outlines several ways in which generative AI can strengthen more inclusive education.

Digital technologies enable the continuation of educational activities during major shocks, promoting inclusion. During the pandemic, economies in developing Asia quickly adopted online learning programs to support educational continuity amid mobility restrictions and school closures. These remote learning modes have been shown to be inclusive across various income, gender, and geographic groups. In Malaysia, a nationwide online teaching scheme launched during the pandemic, the Pengajaran dan Pembelajaran di Rumah, created various online learning platforms to provide continued education for 3 million students affected by school closures. Under this program, almost universal mobile phone ownership contributed to no systematic differences among students from different income groups in terms of access to the main learning tools such as Google Classroom and Zoom (Asadullah 2023, UNICEF 2020). Evidence from household survey data from 7,100 households across seven Southeast Asian economies indicates that almost all surveyed students used some form of remote learning during the pandemic, with a slightly lower share in the Lao People's Democratic Republic and Cambodia (Figure 3.9). Furthermore, engaging in internet-based learning was significantly correlated with a 16% higher chance of achieving the same progress as in-person schooling, compared to those who did not use such learning modes (Maddawin et al. 2024). The impact was consistent for both male and female students.

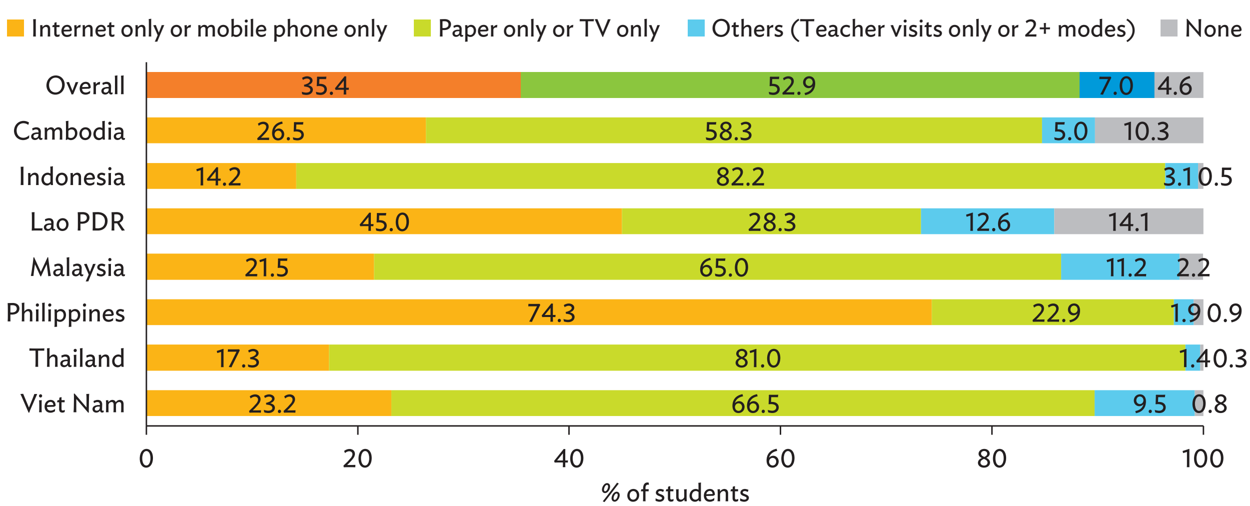
Figure 3.8: How Generative Artificial Intelligence Contributes to Inclusive Education

Enable Tailored Learning	Address Language Barriers	Support Disadvantaged Groups
• GenAI enables teachers to tailor learning content for specific groups. • Personalized learning assistance is more beneficial to students in developing economies where education quality and resources are more limited.	• The high-quality translation and content generation of large language models can integrate teachers and other global resources due to students excluded from language barriers. • Non-native English speakers can benefit from GenAI-enabled personalized language tutoring and translation to access more educational resources.	• GenAI can assist learning among disadvantaged groups, such as students with disabilities. • Note-taking may be facilitated by converting audio lecture into texts, which can be studies along with course slides using large language models.

GenAI = generative artificial intelligence.

Source: Child (2025).

Figure 3.9: Use of Remote Learning in Southeast Asian Economies During the COVID-19 Pandemic



COVID-19 = coronavirus disease, Lao PDR = Lao People's Democratic Republic, TV = television.

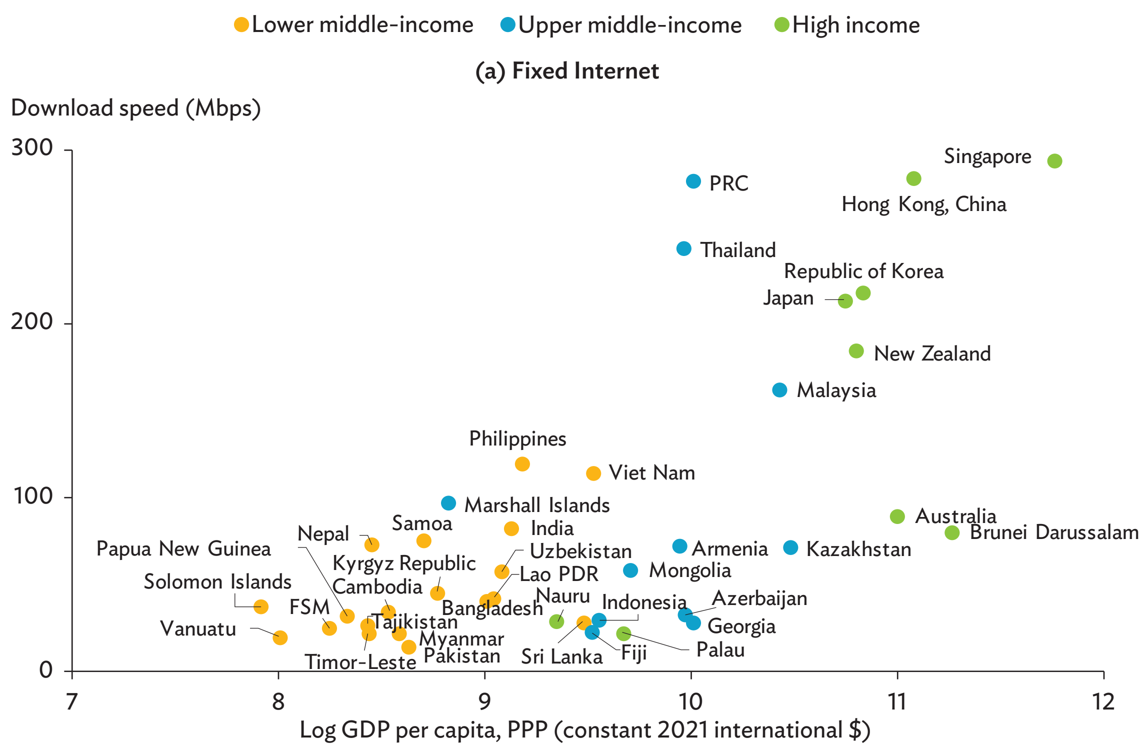
Source: Maddawin et al. (2024).

3.2 | Challenges to Inclusion

Prevalence of Digital Divides in Developing Asia

Digital divides—which refer to disparities in access, use, and outcomes of digital technologies—are still prevalent across developing Asia. For example, there is a large variation in internet connection speeds across different income levels in developing Asia (Figure 3.10). Digital divides related to sociodemographic factors such as gender and remoteness are also prevalent within developing Asian economies, particularly between rural and urban areas and between women and men. Rural areas consistently lag behind urban areas in internet speed across developing Asian economies (Figure 3.11). On average, mobile phone internet download speeds in rural areas are 55 Mbps, compared to 76 Mbps in urban areas, while fixed internet download speeds average 72 Mbps in rural areas versus 88 Mbps in urban areas. Internet penetration is generally higher among men and urban populations than among women and rural populations (Figure 3.12). In 22 regional economies with available data, 19 economies show a higher share of individuals using the internet among men than among women. On average, 84% of urban populations in these economies use the internet, compared to 71% of rural populations. Overall, significant variations in digital inclusion exist across developing Asia, including in availability, affordability, relevance, and readiness, with the largest difference seen in affordability (Figure 3.13).

Figure 3.10: Internet Download Speed Across Income Levels



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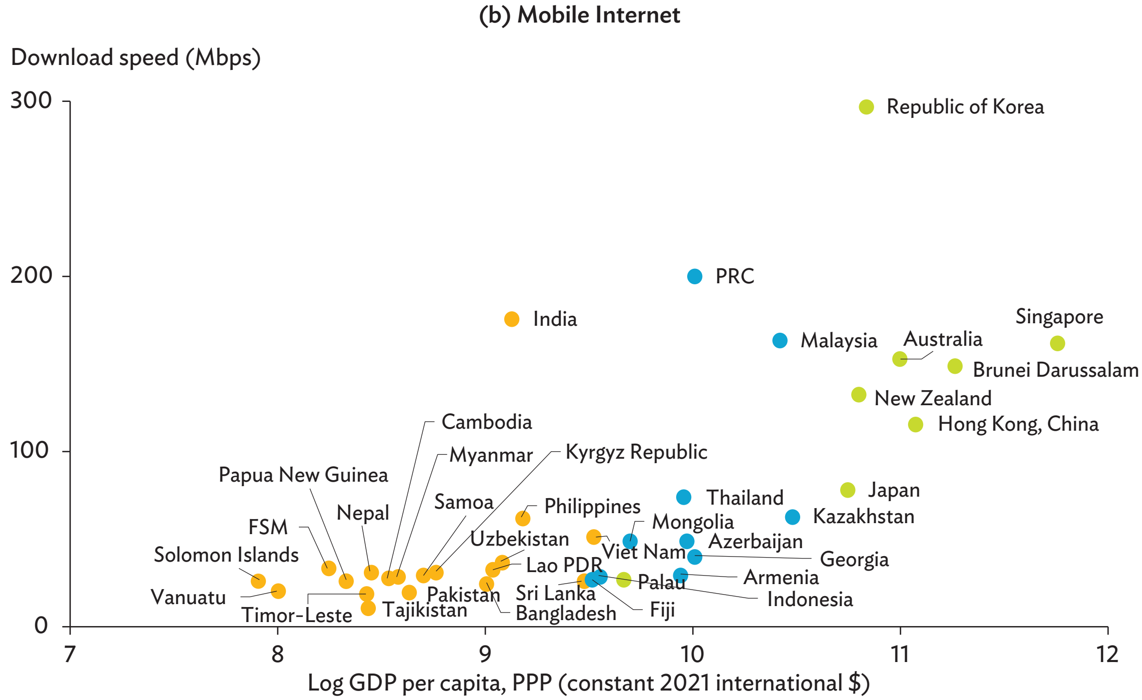
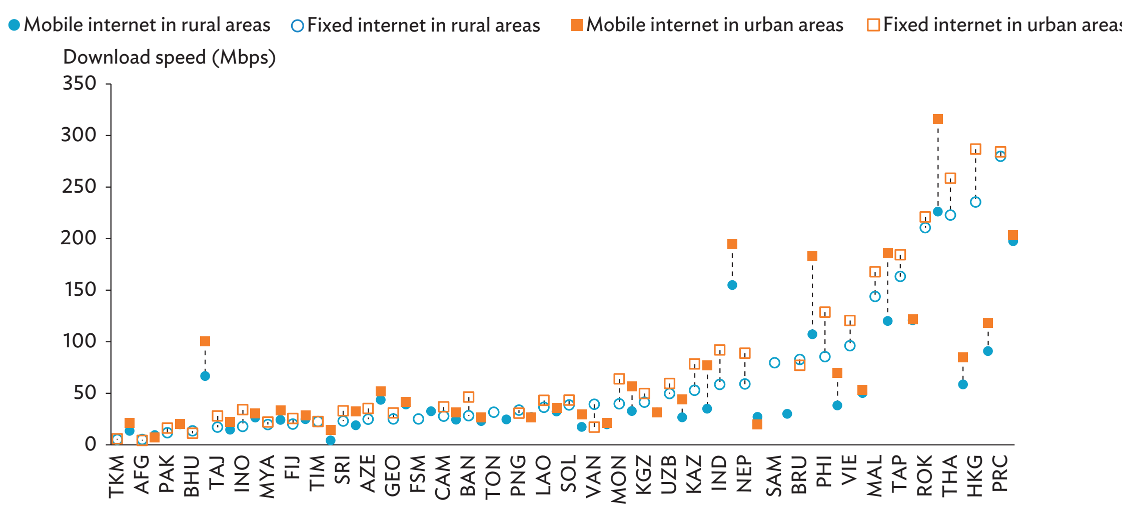


PRC = People's Republic of China, FSM = Federated States of Micronesia, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, Mbps = megabits per second, PPP = purchasing power parity.

Source: Lee, Wei, and Iddawela (2025).

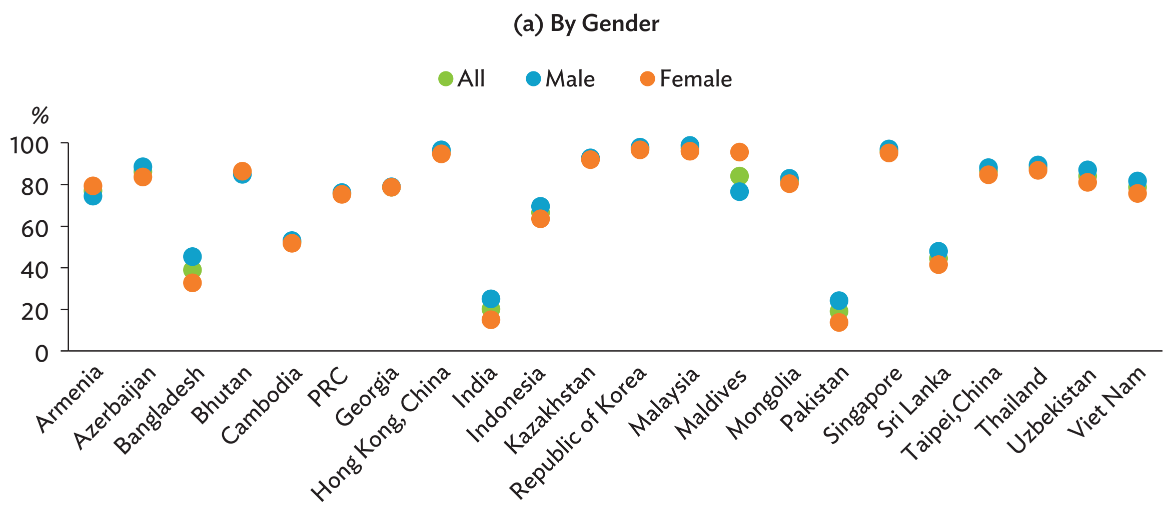
Figure 3.11: Internet Download Speeds in Rural and Urban Areas Across Developing Asia

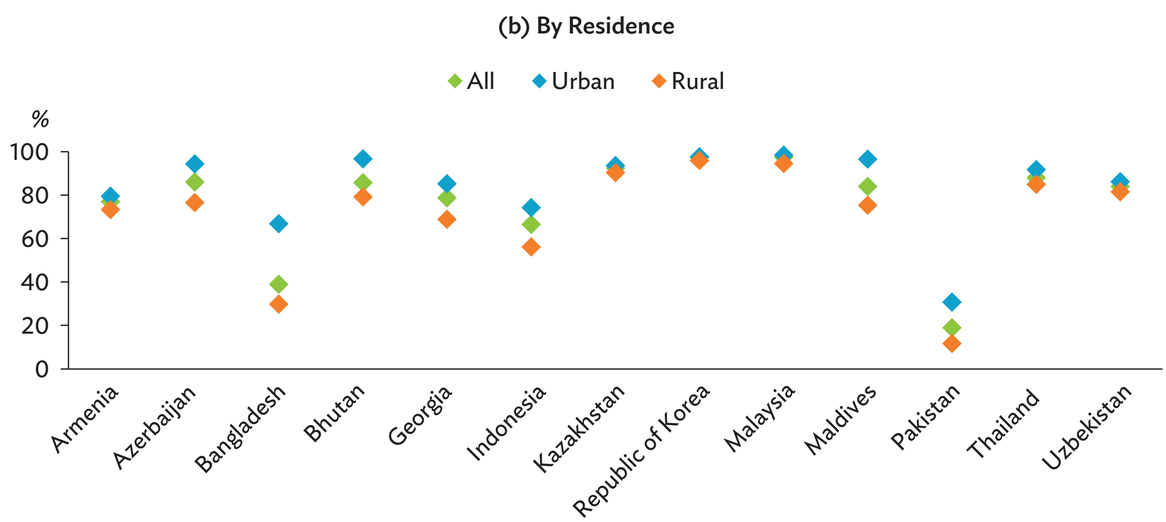


AFG = Afghanistan; AZE = Azerbaijan; BAN = Bangladesh; BHU = Bhutan; BRU = Brunei Darussalam; CAM = Cambodia; PRC = People's Republic of China; FIJ = Fiji; FSM = Federated States of Micronesia; GEO = Georgia; HKG = Hong Kong, China; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KGZ = Kyrgyz Republic; ROK= Republic of Korea; LAO = Lao People's Democratic Republic; MAL = Malaysia; Mbps = megabits per second; MON = Mongolia; MYA = Myanmar; NEP = Nepal; NZL = New Zealand; PAK = Pakistan; PHI = Philippines; PNG = Papua New Guinea; SAM = Samoa; SOL = Solomon Islands; SRI = Sri Lanka; TAJ = Tajikistan; TAP = Taipei,China; THA = Thailand; TIM = Timor-Leste; TKM = Turkmenistan, TON = Tonga; UZB = Uzbekistan; VAN = Vanuatu; VIE = Viet Nam.

Source: Lee, Wei, and Iddawela (2025).

Figure 3.12: Individuals Using the Internet by Gender and by Residence, 2022—Developing Asia, Selected Economies



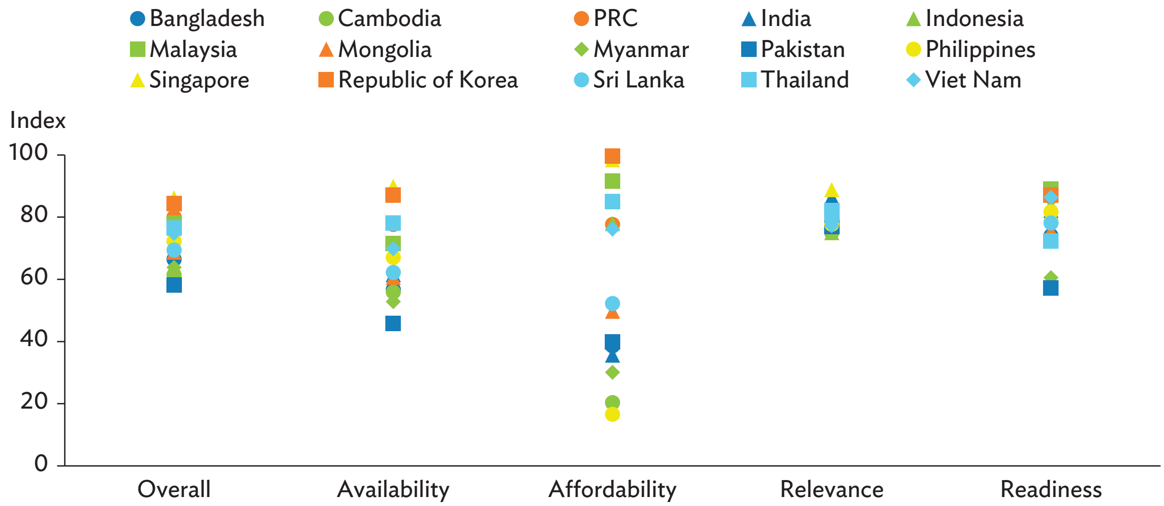


PRC = People's Republic of China.

Note: The data presented in the figures above are from 2022, except for Azerbaijan, Bangladesh, Bhutan, Mongolia, and Sri Lanka, which are based on 2021 data. Cambodia's data are from 2019, India's data are from 2018, and Pakistan's data are from 2020.

Source: International Telecommunication Union. Global and Regional ICT Data (accessed 3 March 2025).

Figure 3.13: Digital Inclusion Index—Developing Asia, Selected Economies



PRC = People's Republic of China.

Source: The Economist. The Inclusive Internet Index 2024 (accessed 3 March 2025).

Understanding the factors contributing to digital divides in developing Asia is essential for addressing these in local contexts.[8] Lack of access to and affordability of digital connectivity and devices, insufficient digital skills and literacy, negative attitudes toward digital technologies, as well as social, cultural, and economic barriers, including gender biases, are key drivers of the digital divide in developing Asian economies (Singh 2025). In South Asia, social, demographic, and economic factors—such as urban versus rural residence, gender, income and educational inequality, as well as personal factors like religion and culture—have collectively contributed to digital divides (Jamil 2021). In Bangladesh, after controlling for age, educational attainment, and other socioeconomic factors, male students in Bangladesh's public universities demonstrated greater digital competency than their female counterparts (Hossain et al. 2023). In Indonesia, disparities in internet access by age, gender, income, and education widened between urban and rural areas, as well as between remote islands and main islands, from 2010 to 2012 (Sujarwoto and Tampubolon 2016). A 2022 nationwide survey of 43,465 respondents in Thailand reveals gender and regional disparities in online participation, with younger adults and those from the northeastern region showing higher participation, underscoring the importance of education and confidence in the internet as key drivers of the digital divide (Pukdeewut and Setthasuravich 2024). In the Republic of Korea, educational attainment and literacy (as measured by basic skills) are significant factors influencing the digital divide in the use of digital technologies, such as email, among older adults (Yamashita et al. 2020). Economic, social, cultural, and personal factors contribute to differences in internet and digital device usage among older adults in the Republic of Korea's two largest cities: Seoul and Busan (Park and Chun 2024). In the PRC, the age-related digital divide widened during the COVID-19 pandemic, influenced partly by personal attitudes and motivations, as well as education, income, and lack of social support (Song, Qian, and Pickard 2021). Lack of digital competency and readiness also contributes to digital divides between large and small companies in developing Asia (Cirera, Comin, and Cruz 2022).

8 According to Lythreatis, Singh, and El-Kassar (2022), nine broad categories of factors influence digital divides: (i) sociodemographic (e.g., age, gender, and urban–rural dimension); (ii) socioeconomic (e.g., education, employment, and income); (iii) personal (e.g., trust, motivations, and risk perceptions); (iv) social support (e.g., access to support, social interaction, and social connections); (v) type of technology (e.g., device dimensions); (vi) digital training (e.g., competency, learning, and training); (vii) rights (e.g., political rights, civil liberties); (viii) infrastructure (e.g., access to electricity and submarine cables); and (ix) large-scale events (e.g., the COVID-19 pandemic).

Digital divides can exacerbate economic and social exclusion and inequality and need to be addressed during the digital transformation process. Insufficient access to digital infrastructure and digital devices, along with limited digital skills and capabilities, may lead to the exclusion of disadvantaged groups, intensifying social dissatisfaction and community fragmentation (Maji and Laha 2022). For example, in aging economies like the PRC and the Republic of Korea, the age-related digital divide can exclude older adults from many social and economic activities. This divide could negatively affect the well-being of older people and weaken the effectiveness of aging-related policies. Despite efforts by governments, households, and the private sector, inequality in access to and use of remote learning tools exacerbated divergence in the learning outcomes of students during pandemic-related school closures in East Asia and the Pacific (Yarrow, Shen, and Alyono 2023). The digital divides may also contribute to income inequality and the loss of economic opportunities for less developed regions. A one-unit increase in the digital divide is associated with a 0.13 unit increase in the income gap between urban and rural areas in the PRC (Qiu et al. 2023). The digital divides limit the ability of certain groups to benefit from digital technologies, potentially triggering new governance challenges. Therefore, addressing the digital divides remains a high priority for the digital transformation of developing Asia.

Complex Job Market Impacts

Digital technologies, especially automation and robots, can replace labor-intensive and routine tasks. An analysis of the automation potential of more than 2,000 work activities across 46 global economies indicates that about 60% of all job activities could be at least 30% technically automated. This suggests that workers will work more closely with digital technologies in the future (Manyika 2017). The share of tasks performed primarily by humans may decline from 47% in 2024 to 33% by 2030, with 81.5% of this reduction attributable to automation and the remainder due to human–machine collaboration (WEF 2025). A 1% increase in sectoral exposure to foreign robots or the use of robots by main trade partners per worker is significantly associated with a 0.103% decrease in average sectoral employment from 2008 to 2014 in 10 emerging economies, including the PRC, India, Indonesia, and Thailand (Díaz Pavez and Martínez-Zarzoso 2024). By 2049, 278 million workers, representing 35.8% of current employment, could be replaced by artificial intelligence (AI) in the PRC (Zhou et al. 2020). Such substitution impacts may be stronger for women, older people, and low-education and low-income groups. For instance, many workers at risk of disruption from AI in the Asia and the Pacific region are engaged in service and sales roles, which are typically occupied by women (Henning and Kahn 2025, IMF 2024).

Conversely, digital technologies can promote employment by creating new tasks and jobs. Digital transformation creates new professions and positions in which labor complements digital technologies. These roles include digital technology workers, maintenance personnel, media professionals, digital marketing and online sales personnel, and data analysts, as well as ride-hailing drivers and food delivery riders (Acemoglu and Restrepo 2018; Bessen et al. 2018; Manyika 2017). Digital platforms such as Uber, Etsy, and Didi and their workforce will continue to expand rapidly, driven by scale, efficiency, and ease of use. In India, Google is implementing the Internet Saathi (Friends of the Internet) program, which trains rural women to use the internet, enabling them to become local service providers in their villages (Manyika 2017). Digital platforms enhance employment by providing workers with access to more work opportunities and offering flexible working hours and arrangements (ILO 2021). Due to increasing internet penetration and rapid e-commerce adoption in India, the internet generates 2.6 new jobs for every job it replaces (Chaudhuri and Kumar 2015). Smartphones and internet access also improve farmers' participation in nonagricultural employment (Ma et al. 2020; Rajkhowa and Qaim 2022). For example, in Central Asia, the application of digital technologies in agriculture enhances production efficiency, reduces dependence on traditional labor, and facilitates the transition of labor from agricultural to non-agricultural employment (Rasch 2022). Targeted investments in digital technologies can further promote employment, with universal broadband coverage projected to create a net increase of 24 million jobs worldwide by 2030 (ILO 2022).

Digital technologies also increase employment by enhancing firm productivity, scaling production, and fostering economic growth. In Western Asian economies, the application of digital technologies and the development of high-tech digital industries have significantly contributed to economic growth and created numerous local employment opportunities (Zerkot 2023). Digitalization is found to be positively related to employment in developing Asian economies (Sinha et al. 2025). The use of automation and robotics in Southeast Asia has improved production efficiency, reduced production costs, and promoted the growth of the service industry, resulting in substantial employment opportunities in the service sector (Calì and Presidente 2021). Box 3.2 presents new evidence on the relationship between the adoption of robots and employment in Korean firms. Findings indicate that the adoption of robots in the Republic of Korea is associated with a 137% increase in permanent employment during the third year following the initial adoption in 2017, and a 12% increase in the subsequent year after adoption in 2018 (Park and Shin 2025).

The rapid advancement of digital technologies will drive a shift in the skills required for future jobs. This shift calls for timely skill upgrading to mitigate the potential negative employment impacts of digital transformation. Digital technologies not only alter business operations but also change the nature of work (WEF 2025). Estimates from McKinsey indicate that Europe and the United States will experience growing demand for workers with higher skills, such as those in science, technology, engineering, and mathematics fields, health professions, and social and emotional skills, with projected growth rates of 17%–30% and 11%-14% in the two economies, respectively, between 2022 and 2030 (Hazan et al. 2024). Furthermore, WEF (2025) pictures the changing demands for different tasks, showing that AI, robots, and autonomous systems are driving the creation of some of the fastest-growing new jobs, while roles defined by routine tasks, such as cashiers and ticket clerks, are declining (Figure 3.14). WEF (2025) suggests that from 2025 to 2030, many industries can expect a balance between the displacement effects of task automation and the reinstatement effects due to workforce augmentation (Figure 3.15). For industries anticipating greater displacement than reinstatement, early interventions such as skill upgrading could be beneficial. Governments and businesses must assist workers in acquiring new skills to meet the evolving skill demands of the digital economy. For example, in Uzbekistan, 52% of employers expect to implement strategies to reskill their workers to enable collaboration with AI (WEF 2025).

Box 3.2: Impact of Robots on Employment and Labor Productivity: Firm-Level Evidence from the Republic of Korea

Park and Shin (2025) examine the implications of robots on employment and productivity using a firm-level database from the Republic of Korea. They employ propensity score matching to control for firm characteristics, allowing for a causal interpretation of the impacts of robots. Unlike AI, which affects both highly skilled and less skilled workers, robots primarily impact the latter group. For instance, many robots are deployed to perform repetitive manual tasks on the factory floor.

Box figures show the impact of robots on employment for Korean firms. Box figure 1 shows that firms adopting robots in 2017 experienced a 137% increase in permanent employment by the third year (i.e., 2020). Similarly, firms that adopted robots in 2018 saw a 12% increase in permanent employment in 2019, 1 year after adoption. In terms of temporary employment impacts, box figure 2 indicates that firms adopting robots in 2019 experienced a statistically significant 10% increase in temporary employment within the initial year of adoption. Overall, the analysis provides evidence that the adoption of robots could lead to increased employment.

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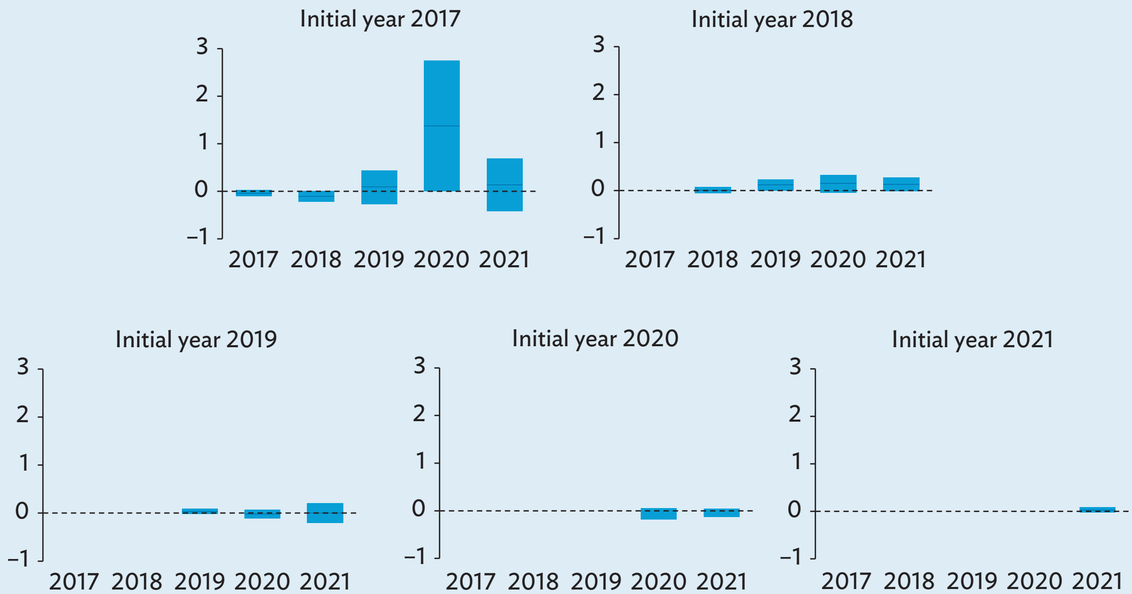
Box *continued*

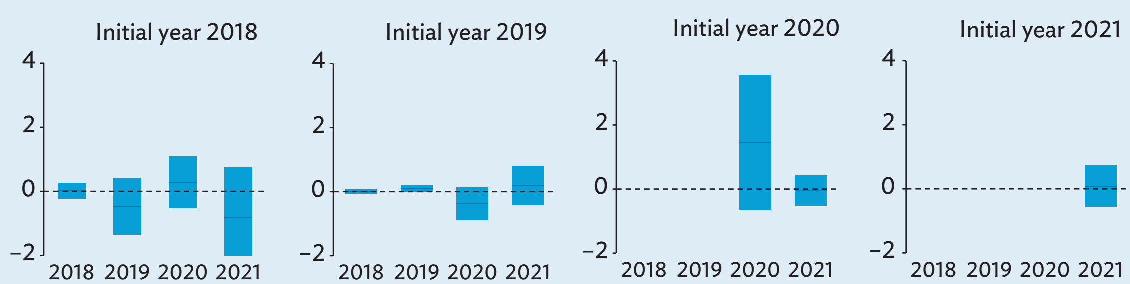
1: The Impact of Robot Adoption on Permanent Employment



Notes: This first panel presents the effects of robot adoption in 2017 on permanent employment in the subsequent years. The central line represents the estimated average treatment effect on the treated group, while the bars indicate the 90% confidence intervals. Similarly, the second panel depicts the impact of robot adoption in 2018 on permanent employment over the following years, with subsequent panels applying the same analytical approach to later years of robot adoption.

Source: Park and Shin (2025).

2: The Impact of Robot Adoption on Temporary Employment

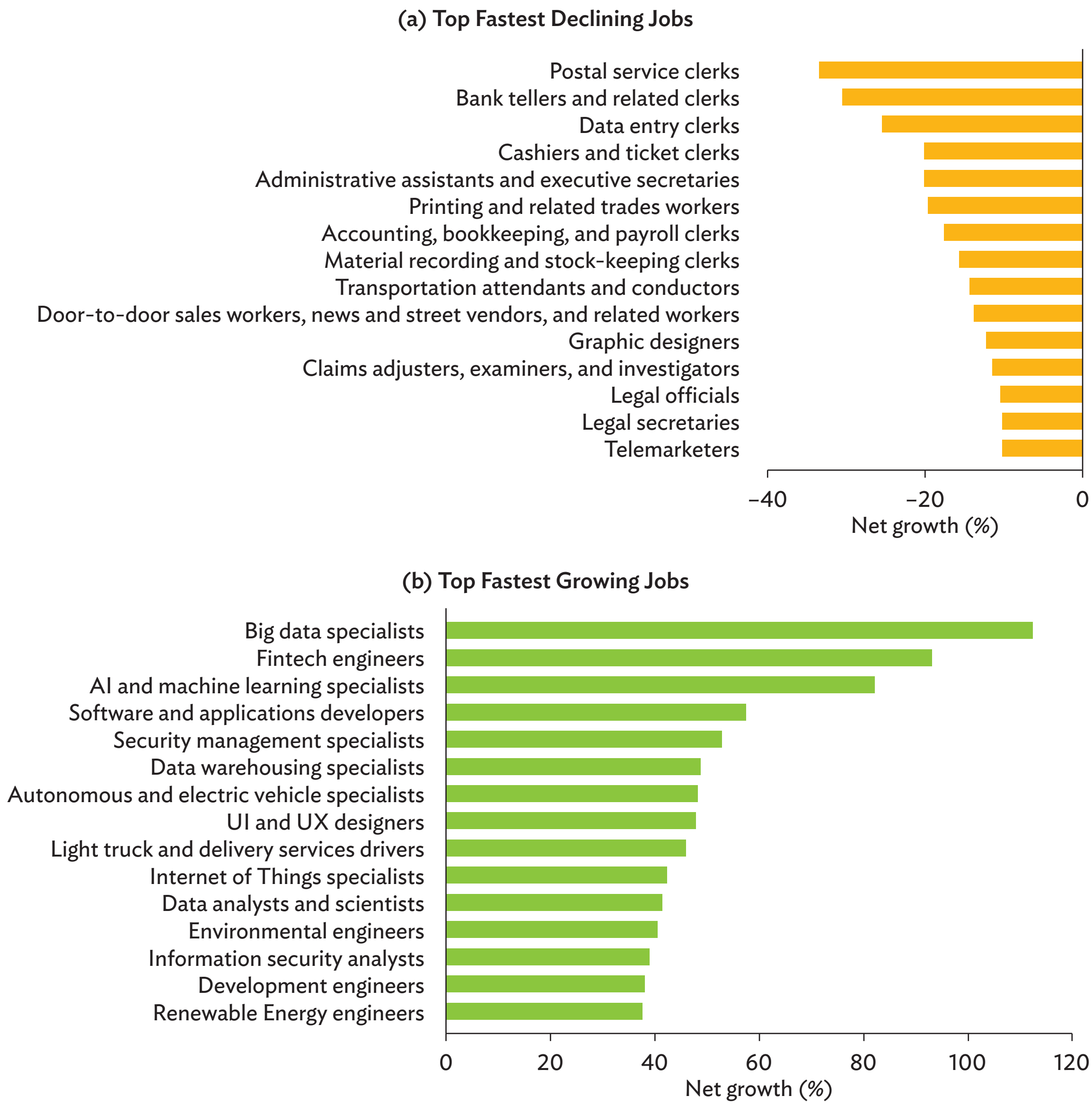


Notes: This first panel presents the effects of robot adoption in 2018 on temporary employment in the subsequent years. The central line represents the estimated average treatment effect on the treated group, while the bars indicate the 90% confidence intervals. Similarly, the second panel depicts the impact of robot adoption in 2019 on temporary employment, with subsequent panels applying the same analytical approach to later years of robot adoption.

Source: Park and Shin (2025).

Source: Park and Shin (2025).

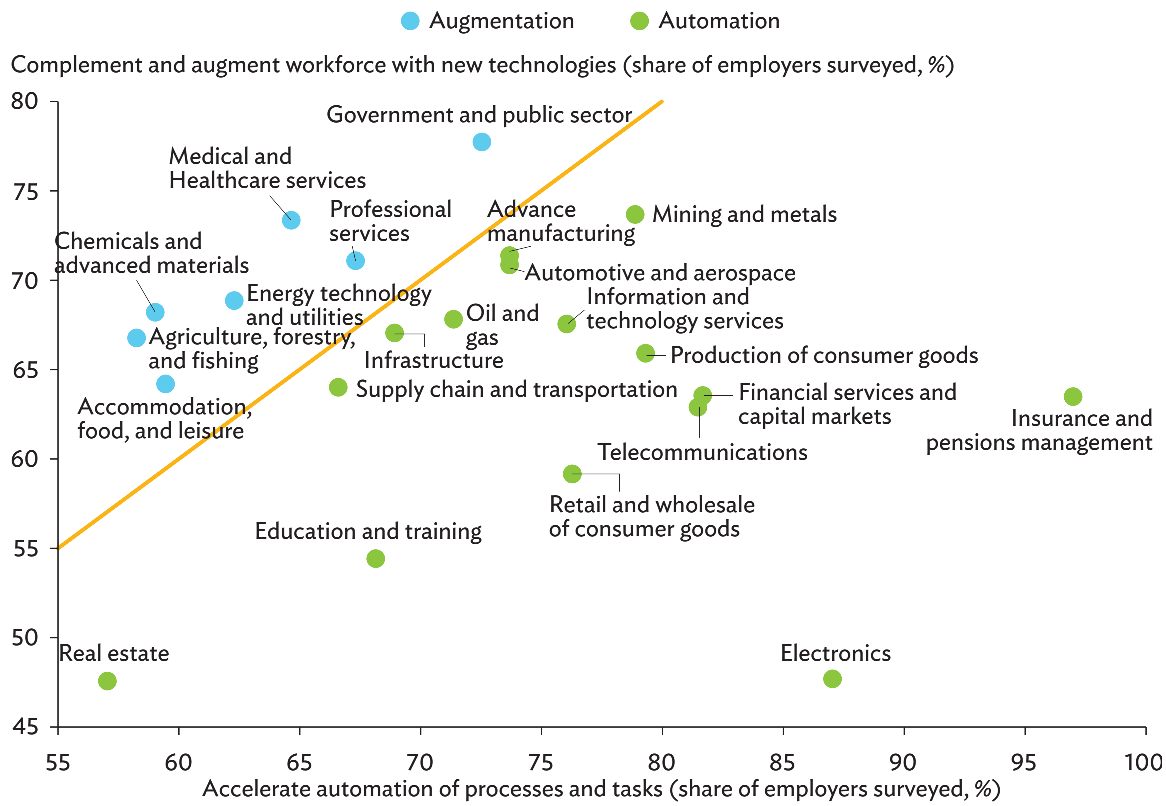
Figure 3.14: Projected Net Growth of Various Jobs, 2025–2030



AI = artificial intelligence, UI = user interface, UX = user experience.

Source: WEF (2025).

Figure 3.15: Workforce Automation and Augmentation Effects by Industry



Source: WEF (2025).

Weak Digital Governance

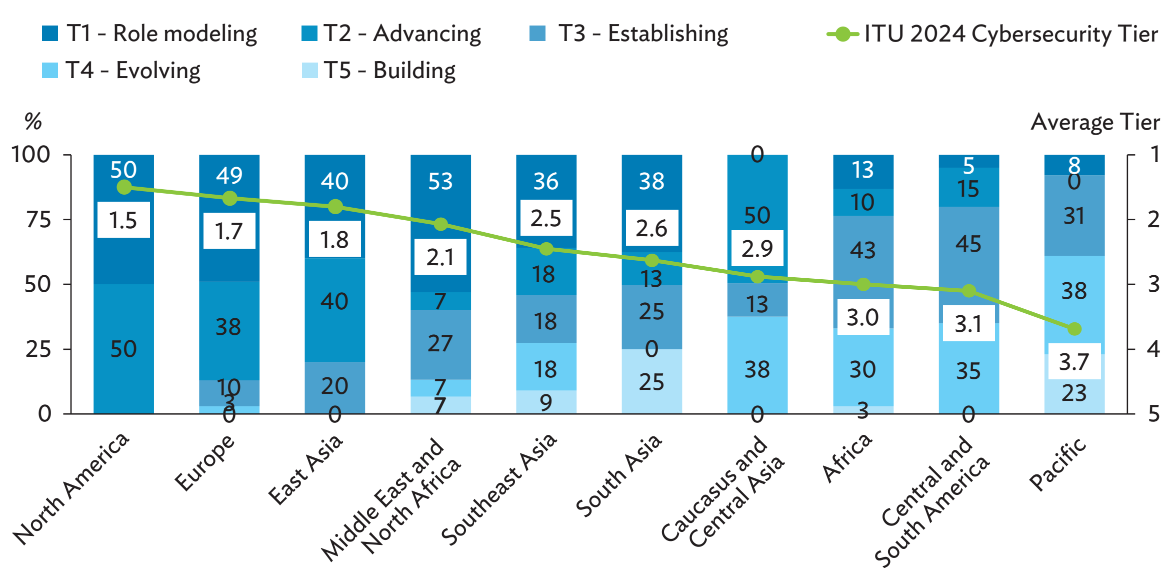
Cybersecurity poses a significant downside risk that can inflict significant economic costs if not managed effectively. Cybersecurity can be broadly defined as the policies, practices, and technologies that protect and maintain the availability, integrity and privacy of systems data, and connected assets across public and private networks (CoE et al. 2021). Cybersecurity risks thus refer to unauthorized access, data breaches, and damage to an organization's systems and data.[9] These risks not only lead to financial losses, operational disruptions, and reputational damage for the targeted institution, but they also inflict losses on the broader economy through impacts on supply chain partners and financial stakeholders (Kamiya et al. 2021), ultimately hindering economic growth, particularly in developing economies (Anderson et al. 2013; Vergara Cobos et al. 2024). IBM (2024) reported that the average corporate cost of a data breach in the Association of Southeast Asian Nations and India reached record highs of $3.23 million and $2.35 million, respectively, in 2024, marking an increase of 6%–7% from 2023. The rise in cyberattacks in the Asia and the Pacific region is attributed to factors such as the rapid adoption of technology during the pandemic without adequate security measures, a lack of awareness about engineering attacks and phishing among the new generation of users, the rise of the hybrid working model and collaboration platforms, and the growing economic significance of Asia, making it a more

9 Sentinel One. Cybersecurity 101—Security Risk. What Is Security Risk? Types and Examples.

attractive target region (Gullapalli 2023). Therefore, effective cybersecurity practices are essential for supporting digital transformation.

Cybersecurity risks can be particularly costly for disadvantaged groups that lack the resources and capacity to implement cybersecurity measures. At the organizational level, the proportion of organizations maintaining even minimal viable cyber resilience declined by 31% in 2023 compared to 2022, with poorly resourced organizations such as SMEs falling even further behind (WEF 2024). Smaller organizations like SMEs also have limited financial and operational buffers to recover from cyberattacks. Specifically, small organizations are more than twice as likely as large organizations to lack essential cyber resilience and three times as likely to lack the requisite cyber skills to meet minimum critical operational requirements, resulting in disproportionately high financial losses (WEF 2024). For example, 85% of organizations with more than 100,000 employees carry cyber insurance, compared to only 21% of organizations with 250 or fewer employees. At the economy level, as illustrated in Figure 3.16, developed regions such as North America and Europe generally exhibit stronger cybersecurity capacity levels than developing Asia (Mortimer 2025). Figure 3.17 shows that lower-income economies tend to have weaker commitment to cybersecurity, partly due to a relative lack of legal frameworks and regulation for cybersecurity, institutional capacity including training and education, and national strategies for implementing cybersecurity. Some developing economies—such as Bangladesh, India, Sri Lanka, Kazakhstan, Pakistan, the Philippines, and Viet Nam—perform better than expected relative to their peers in the same regional group and income level based on top-down measures. This could be the result of active policy efforts to strengthen cybersecurity (Figure 3.18).

Figure 3.16: ITU Global Cybersecurity Index 2024—Regional Aggregate Performance by Tier

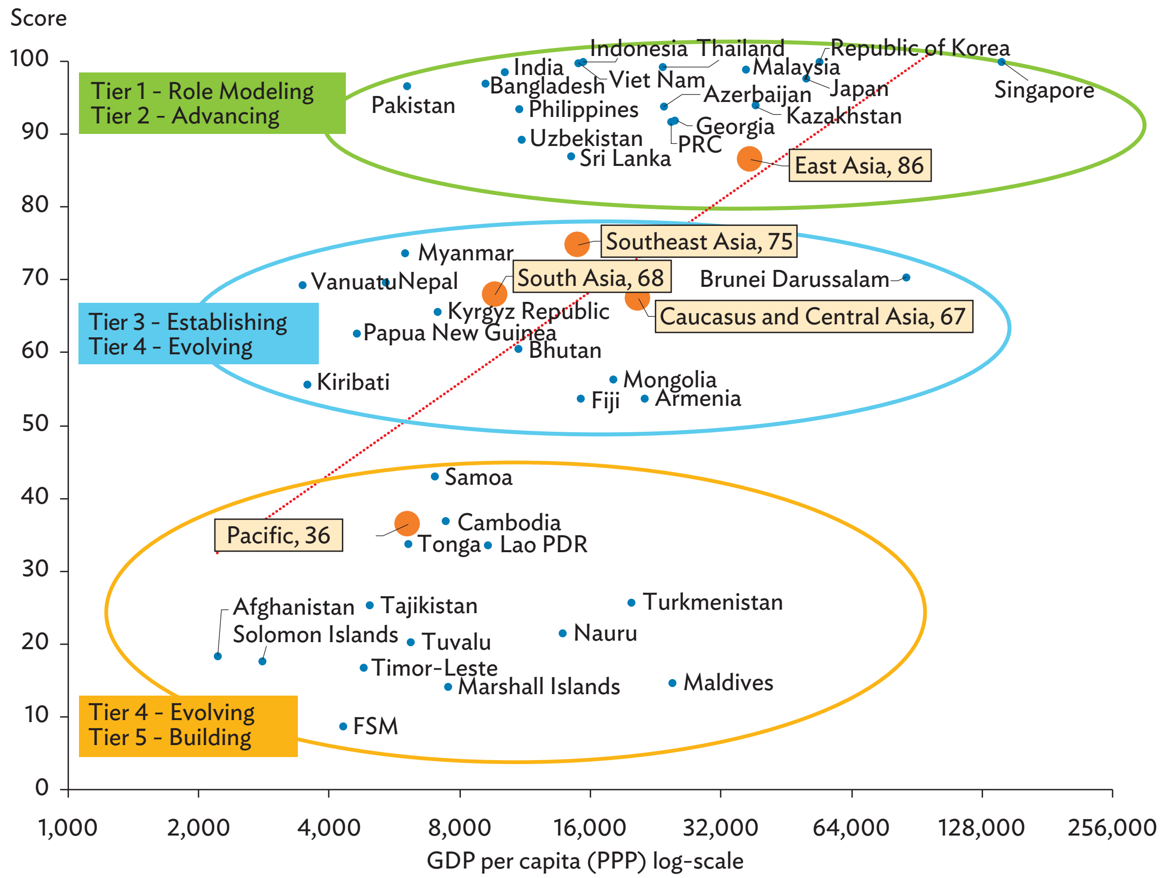


ITU = International Telecommunication Union, T = tier.

Note: Tier 1 is most advanced.

Source: Mortimer (2025).

Figure 3.17: ITU Global Cybersecurity Index 2024 of Economies in Developing Asia



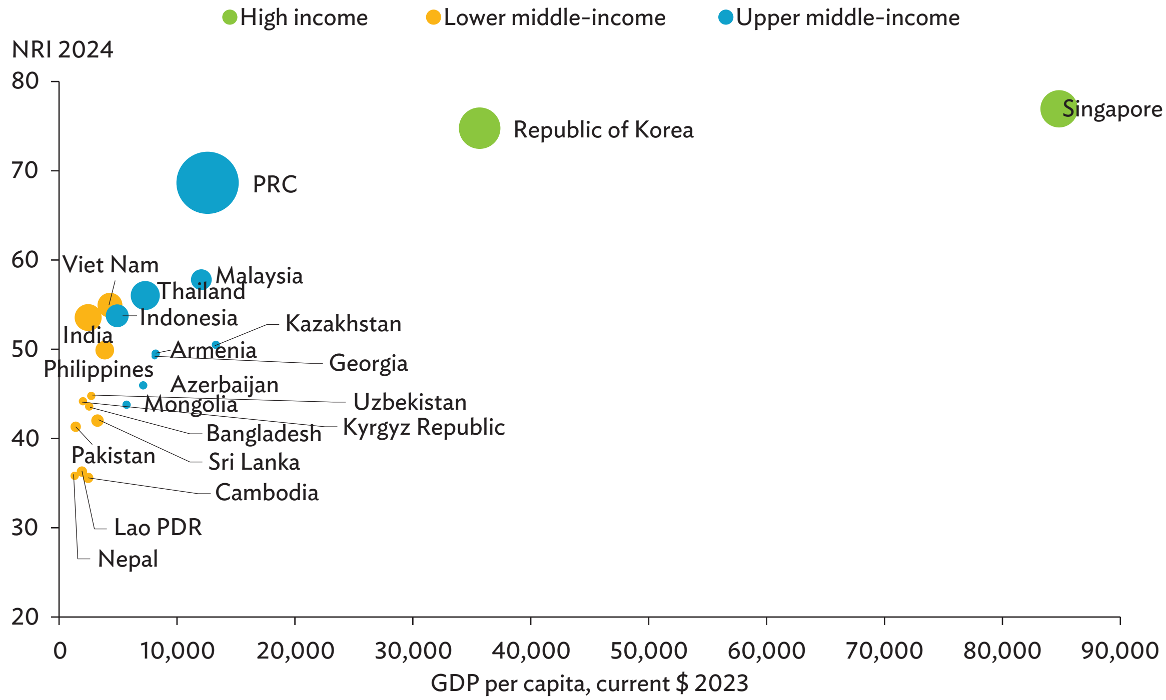
Note: Higher scores are more advanced.

PRC = People's Republic of China, GDP = gross domestic product, ITU = International Telecommunication Union, Lao PDR = Lao People's Democratic Republic, FSM = Federated States of Micronesia, PPP = purchasing power parity.

Source: Mortimer (2025).

Concerns over cybersecurity, data privacy, and misinformation can erode trust and confidence in adopting digital technologies, particularly among disadvantaged groups. While digital transformation has significantly improved access to information, services, and markets, it has also accelerated the spread of misinformation, undermining democratic institutions and social cohesion. Social media platforms—widely adopted across the region—can easily become channels for disseminating fake news and disinformation. For example, during the COVID-19 pandemic, WHO and UNICEF issued warnings that digital disinformation was fueling vaccine hesitancy and prolonging public health risks. UNICEF (2023) documents that the perception of the importance of vaccines for children declined by more than a third in the Ghana, Japan, the Republic of Korea, Papua New Guinea, and Senegal after the start of the pandemic due to factors such as growing exposure to misinformation, declining trust in expertise, and political polarization. The rise of AI-powered deepfakes has added a new layer of complexity to information disorder. The Asia and the Pacific region saw a 1,530% increase in detected deepfakes between 2022 and 2023, with Viet Nam experiencing the highest increase in deepfake fraud in the region (25.3%) (Surasit 2024). Concerns about cybersecurity, data privacy, and misinformation can lead to mistrust and delay in the adoption of digital technologies, excluding disadvantaged groups from

Figure 3.18: Policies and Laws to Strengthen Cybersecurity in Developing Asia



PRC = People's Republic of China, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, NRI = Network Readiness Index.

Note: The size of the bubble denotes the number of policies and laws aimed at strengthening cybersecurity practices. The GDP per capita for Sri Lanka is based on 2022 data.

Source: Authors' calculations based on International Monetary Fund. World Economic Outlook 2024 database; TradeLab Digital Development Strategies across Asia and the Pacific. HBKU-GU-Q TradeLab clinic (both accessed 4 April 2025); and Portulans Institute (2024a).

digital participation, particularly those with limited digital literacy and skills. This exclusion prevents vulnerable groups from benefiting from digitalization, especially in education, health care, and financial services. Addressing these governance issues is critical to ensuring that digital transformation benefits all.

The dominance of large technology companies in the digital economy can pose risks to market competition and challenge inclusive development. Large technology companies enjoy advantages in terms of digital infrastructure, user bases, and data, which can expand their market power, eroding competition and harming small businesses. For example, in Indonesia, the antitrust agency fined Google around Rp202 billion ($12.4 million) in January 2025 for unfair business practices related to the Google Play Store payment system. Investigations uncovered that Google mandated Indonesian app developers to use Google Play Billing, which charged fees of up to 30%, violating Indonesia's monopoly laws (Reuters 2025). In 2021, the PRC's State Administration for Market Regulation fined Alibaba CNY18.23 billion (approximately $2.8 billion) for abusing its dominant position in the e-commerce platform services market by forcing merchants to sell exclusively on Alibaba's platforms and restricting their presence on competing platforms (Svetlicinii 2021).

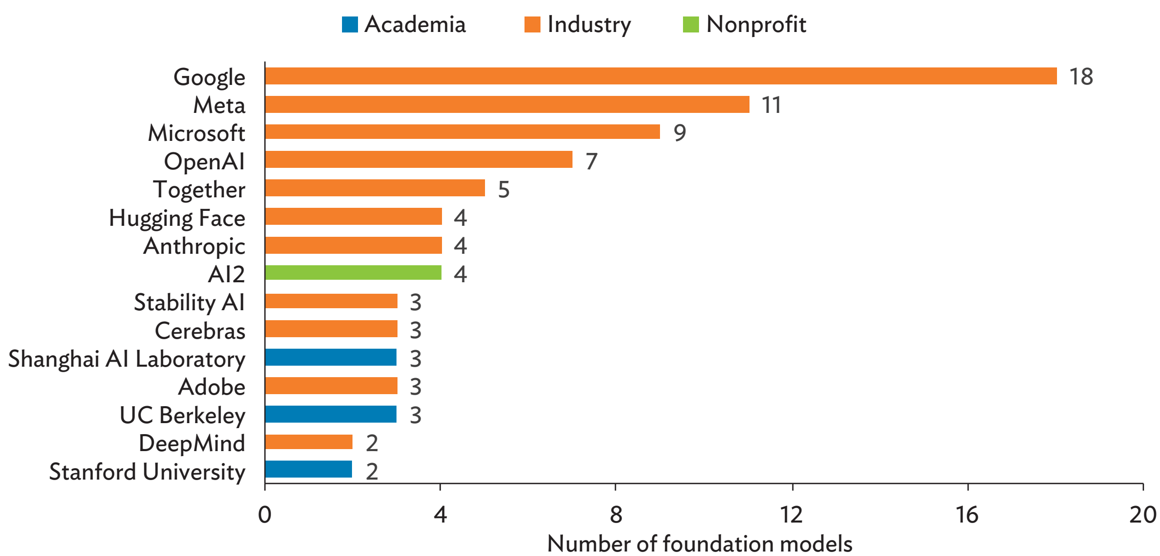
The dominance of large technology companies can lead to biased algorithms and exclusionary practices, disproportionately affecting disadvantaged groups and hindering inclusive digital ecosystems. The large language models used in AI are data-driven and require vast amounts of data for training to identify patterns that generate model outputs. Output bias may arise from biased training datasets used during the learning and training processes of these models (Ferrara 2023). For example, training data may inherently reflect various biases and inequalities prevalent in the societies that generate the data. When models learn from biased data, they internalize these biases by adopting stereotypes, favoring certain groups, or making assumptions that do not equitably represent all groups, thus affecting the equity of model outputs. Data-intensive generative AI training faces a major challenge in addressing such biases and ensuring inclusion. The concentration of AI capabilities in a few institutions can further deepen these biases (Figure 3.19). Addressing these antitrust concerns is essential to ensure that digital transformation provides opportunities for all.

3.3 | Inclusion-Aligned Digital Policies

Digital policies that ensure access to and usage of digital technologies for all groups are essential for building a digitally inclusive society. Many economies have incorporated inclusive access and use into their digital policies to address challenges such as the gaps between urban and rural areas and among different income groups (Arfeen and Saranti 2021). Inclusion-aligned policy tools can overcome equity failures and market failures during the digital transformation process. These policies contribute to an inclusive society by reinforcing institutional commitments to address a wide range of digital divides—supporting disadvantaged groups such as people with disabilities, older people, and SMEs. These policies also foster digital technologies that deliver growth and inclusion benefits, such as platforms, fintech, and education tech, while ensuring that the digital transformation itself is inclusive and fair. This includes addressing challenges like lack of digital access, various types of digital divides, potential disruptions in the job market, and governance issues related to cybersecurity, data privacy, misinformation, and market competition.

Many developing Asian economies have enhanced the design of their digital policies to promote inclusive access to and use of digital technologies. For example, the Republic of Korea's Digital Strategy 2022 aims to create an inclusive digital society where all citizens can enjoy digital benefits and develop valuable digital skills. India's National Digital Communications Policy 2018 seeks to improve the coverage and affordability of telecommunications services across the economy. India's new National Broadband Mission 2.0 further tackles the challenges of establishing stable and faster broadband connectivity in underserved rural and remote areas via satellite broadband, improved energy supplies, and faster internet and mobile services (e.g., 4G and 5G networks) (Government of India, Ministry of Communications

Figure 3.19: Number of Foundation Models by Organization, 2023



AI = artificial intelligence.

Source: Maslej et al. (2024).

2024a, 2025). Mongolia's Digital National Policy 2022–2027 includes nationwide projects to roll out high-speed internet access in remote areas and to develop a workforce equipped with digital skills (DigWatch 2022). These digital policies offer comprehensive institutional support to promote internet access, enhance digital skills, and strengthen competition, cybersecurity, and data protection. This section outlines various digital policy options by different instrument types.

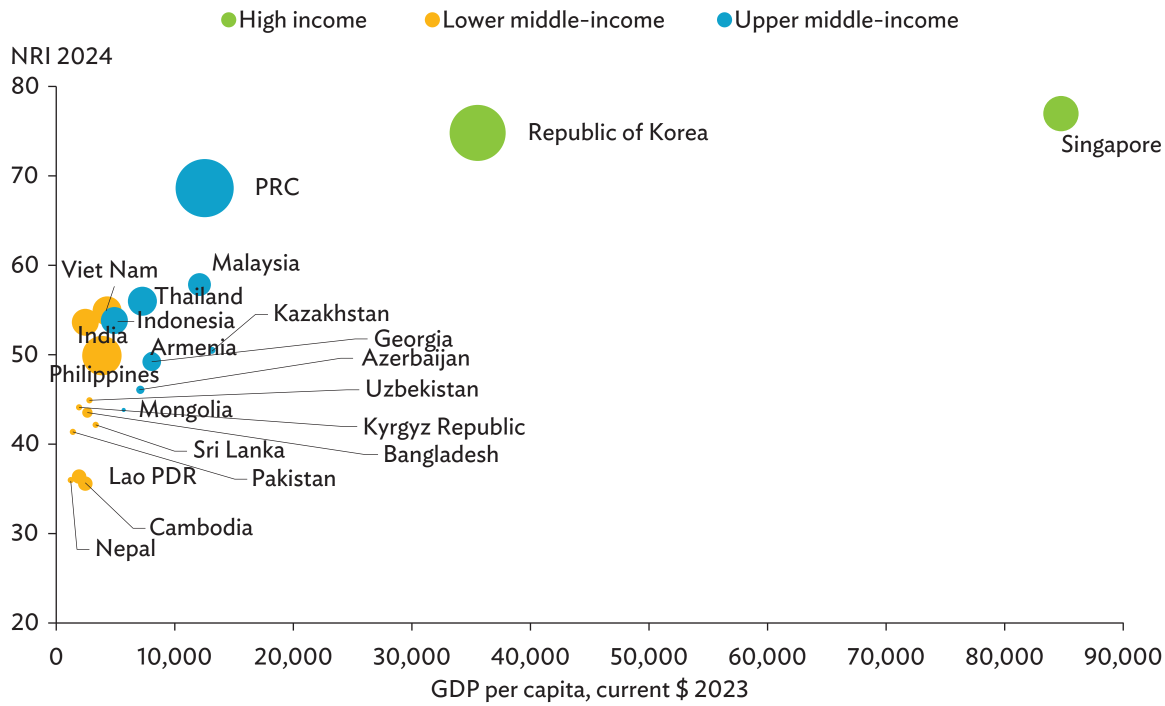
Strategies, Regulations, and Legislation

Governments can use regulations to promote universal access to digital technology. Digital divides in access to the internet and digital devices are on the rise in developing economies (UN 2023). To address unequal access to digital technologies (i.e., Level 1 digital divide), governments can foster universal connectivity by rolling out quicker and more reliable internet connections to populations in all areas. However, the lack of commercial viability often deters the private sector from providing internet services in rural, isolated, and sparsely populated areas. One potential solution is supply-side policy intervention, such as requirements that specify minimum coverage levels or obligations tied to new spectrum band licenses (Oughton 2025). For example, Thailand's National Broadcasting and Telecommunications Commission auctioned 2.1 gigahertz (GHz) spectrum licenses with specific deployment obligations. Licensees were required to provide network coverage in every province, reaching at least 50% of the population within 2 years and 80% within 4 years of the license award date. Similarly, Hong Kong, China mandated that each successful bidder in the 6/7 GHz band cover at least 50% of the population within the first 5 years of the spectrum assignment (Government of the Hong Kong Special Administrative Region of the People's Republic of China, Communications Authority 2024). Licensees are also required to lodge a performance bond to guarantee compliance with network and service rollout obligations. These obligations aim to ensure the rapid and widespread domestic deployment of mobile network services (Malisuwan, Tiamnara, and Suriyakrai 2015). A well-resourced digital technology regulatory authority is essential to ensure that coverage obligations are effectively met, with enforcement actions taken in cases of noncompliance.

Governments can use laws and regulations to safeguard cybersecurity and data privacy. Many developing Asian economies have adopted laws and regulations to strengthen cybersecurity, protecting vulnerable users such as SMEs and low-income households that lack the resources to recover from losses. In response to a rise in cyberattacks in 2023 that disrupted online public and private sector services—including public health, financial, and government services—Singapore amended its Cybersecurity Act in 2024 to enhance the cybersecurity of critical digital infrastructure (Government of Singapore, Cybersecurity Agency 2025). The amendment requires owners of critical information infrastructure to report a wider range of incidents, including those occurring in their supply chains, and imposes penalties for noncompliance. In Thailand, the Cybersecurity Act of 2019 mandates that public and private critical information infrastructure entities conduct cybersecurity risk assessments, implement security controls, and report incidents (Formichella 2021). Establishing ratings or standards for cybersecurity levels can provide clear guidance for the private sector to strengthen cybersecurity measures. For example, Singapore offers cybersecurity certification to help the private sector assess cybersecurity risks and improve preparedness: the Cyber Essentials mark for SMEs and the Cyber Trust mark for larger, more digitalized organizations. Many regional economies have actively utilized policies to strengthen data protection (Figure 3.20). For example, Indonesia introduced the Personal Data Protection in Electronic Systems Regulation in 2016, mandating electronic system operators to (i) obtain explicit consent before collecting and processing personal data, (ii) implement security measures to protect personal data from unauthorized access and disclosure, and (iii) report cases of personal data breaches (Government of Indonesia, Ministry of Communication and Informatics 2016).

Governments can use regulations to foster market competition, contributing to inclusive digital transformation. With the rising demand for submarine cables, governments have engaged the private sector to develop additional submarine cable systems. Big technology companies like Amazon, Google, Meta, and Microsoft have been building submarine cables since the 2010s. Private sector technology companies now play a crucial role in submarine cable investment, accounting for an estimated 70% of cable projects (Pinaud 2023). Public

Figure 3.20: Policies and Laws that Strengthen Data Protection in Developing Asia



PRC = People's Republic of China, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, NRI = Network Readiness Index.

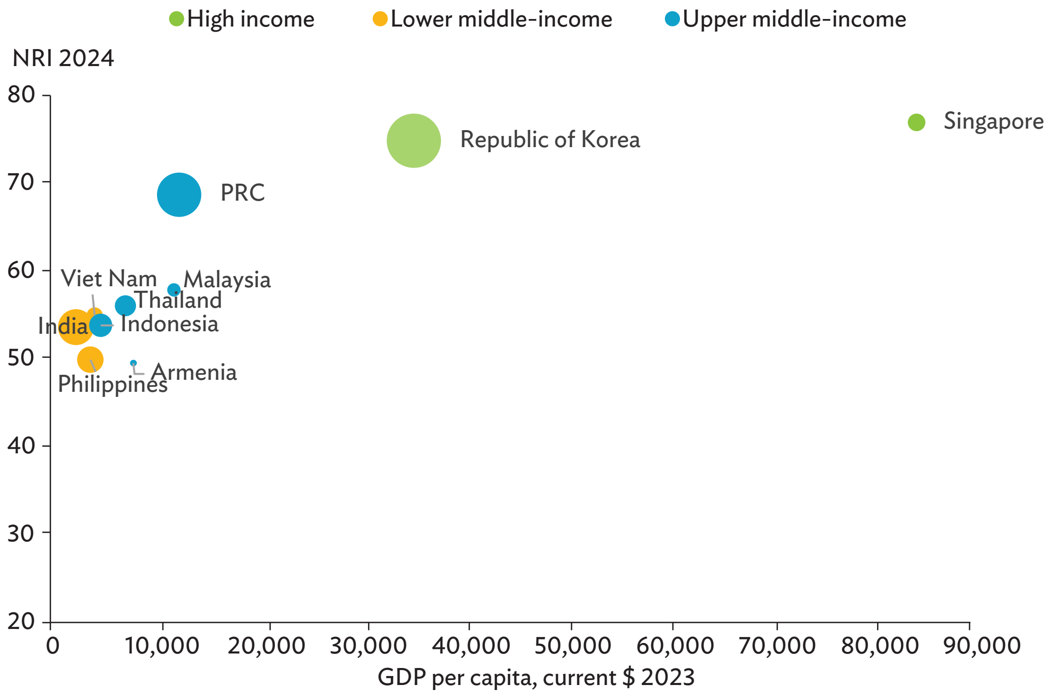
Note: The size of the bubble denotes the number of policies and laws that strengthen data protection practices. The GDP per capita for Sri Lanka is based on 2022 data.

Source: Authors' calculations based on International Monetary Fund. World Economic Outlook 2024 database; Digital Development Strategies across Asia and the Pacific. HBKU-GU-Q TradeLab clinic (both accessed 4 April 2025); and Portulans Institute (2024a).

concerns have grown regarding the potential monopoly power of large social media platforms such as Amazon, Facebook, and Alibaba. Regulating these dominant market players can foster fair pricing and competition, providing opportunities for small businesses. For example, India launched the Digital Competition Law in 2024 to curb the dominance of large tech companies—including self-preferencing, data monopolization, and exclusive agreements—in an effort to help SMEs compete during the digital transformation (Singh 2024). Based on Digital Policy Alert, developing Asian economies adopting digital policies tools to ensure competition are mostly economies with a high-digitalization (HD) status as categorized in Chapter 2 (Figure 3.21).

Regional governments can use regulation or legislation to ensure fairness in digital technologies. Without proper oversight, AI systems and machine learning algorithms may perpetuate existing biases or introduce new ones, leading to discriminatory practices (Lee, Resnick, and Barton 2019). It is therefore important to use intervention to mitigate biases in AI systems and algorithms by improving algorithmic design, accountability, and fairness. The European Union (EU) has been exploring related regulations. For example, the EU's AI Ethics Guidelines 2019 emphasize ethical principles such as fairness, transparency, accountability, and human agency (European Commission 2019). The AI Principles 2019 (revised in 2024) of the Organisation for Economic Co-operation and Development further contribute to this evolving regulatory landscape (Reisman et al. 2018). Moreover, there are particular concerns regarding algorithmic management, especially concerning digital platform workers such as delivery drivers. In March 2024, the EU approved a provisional agreement aimed at improving working conditions for platform workers. This agreement specifically seeks to improve understanding of how algorithms function, including allocating tasks and setting prices (Litardi, Adăscăliței, and Widera 2024). As of April 2024, EU

Figure 3.21: Digital Policies on Competition in Developing Asia



PRC = People's Republic of China, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, NRI = Network Readiness Index.

Note: The size of the bubble denotes the number of digital policies on competition. Digital competition policies include unilateral conduct regulation, merger control regulation, competition authority governance, anti-competitive agreements regulation, state aid control, data protection regulation, and other competition not elsewhere classified.

Source: Digital Policy Alert. Digital Policy Alert Activity Tracker (accessed 10 April 2025).

member states such as Belgium, Croatia, Greece, Malta, Portugal, and Spain have embedded such provisions in their national legislation. Developing Asian economies can learn from global good practices to enhance fairness in digital technologies to promote a more inclusive digital transformation.

Fiscal Incentives

Governments can offer both supply-side and demand-side fiscal incentives to expand access to and use of digital technologies among disadvantaged groups. On the supply side, these fiscal incentives can improve the commercial viability of extending connectivity to remote areas for the private sector, thereby supporting universal connectivity and boosting inclusion. Typical fiscal instruments to improve the quality and coverage of network services in marginalized areas include tax exemptions, subsidies, and public–private partnerships (Oughton 2025). On the demand side, governments can also create targeted fiscal incentives for disadvantaged groups to make digital devices and connections more affordable. Specific preferential measures, such as subsidies tailored to low-income families and socially marginalized groups, help them access digital services. Table 3.1 lists some regional examples of fiscal incentives that promote an inclusive digital transformation.

Market Mechanisms

Market mechanisms lower the cost of deploying digital infrastructure and enhancing cybersecurity, thereby boosting inclusion. Market mechanisms like auctions and reverse auctions can efficiently allocate spectrum band licenses to operators, reducing the long-term costs of digital infrastructure

Table 3.1: Examples of Incentives to Promote Inclusion in Developing Asia

Fiji	The government provided a 10-year tax exemption to ICT operators within the Kalabu Tax Free Zone between 2007 and 2016, as well as a 13-year tax exemption to new operators starting in 2009 (ITU 2019).
India	The BharatNet project provides tax reductions of up to 75% for operators purchasing optical fiber, aiming to provide broadband connectivity access to all telecom providers so that applications such as e-health, e-education, and e-governance can reach rural and remote areas.[a]
Malaysia	The government is providing direct subsidies through its National Fiberisation and Connectivity Plan to enable affordable digital connectivity by working with telecommunications service companies to install towers and build and operate network services for public cellular services (Government of Malaysia, Malaysian Communications and Multimedia Commission. 2020). Malaysia has also offered substantial tax incentives through a new national strategic initiative called Malaysia Digital, aimed at encouraging investment in digital infrastructure. A wide range of fiscal incentives include income tax reductions, grants, and other facilitative measures (Government of Malaysia, Malaysian Investment Development Authority 2022).
Philippines	The government provides a free Wi-Fi access program for all, with a focus on geographically isolated and disadvantaged households.[b]
Malaysia	Launched in 2020, the SME Digitalisation Grant provides grants of up to RM5,000 to help SMEs in adopting digital solutions like e-commerce platforms, digital marketing tools, cybersecurity, electronic point of sale system, smart systems, and accounting software.[c]

ICT = information and communication technology, RM = ringgit, SMEs = small and medium-sized enterprises.

[a] Government of India, Ministry of Communications, Department of Telecommunications. BharatNet Project.
[b] ADB. Regional: Expanding Connectivity and Affordability to Address the Digital Divide.
[c] Government of Malaysia, National Savings Bank (BSN). Micro, Small, and Medium Enterprise Digital Grant Madani. Evolve Your Business to the Digital Forefront.

Source: Authors' compilation.

coverage. For example, India has undergone changes in spectrum policy over the past decade, moving from an administrative regime to a more market-oriented regime. India has adopted auctions in the primary spectrum market and trading in the secondary spectrum market, liberalizing the spectrum (Jain and Dara 2017). Reverse auctions have also emerged as another mechanism to identify the lowest cost points within a market of broadband operators, including in India and Nepal (Wallsten 2009). Furthermore, market mechanisms can promote cybersecurity by making cybersecurity data publicly available, allowing investors to monitor companies' cybersecurity practices and pressuring them to strengthen cybersecurity (Mortimer 2025).

Building Capacity and Skills

Governments can implement training and capacity-building programs to improve the digital skills of disadvantaged groups. Such programs assist individuals with limited digital skills in effectively using digital technologies, thereby narrowing digital divides related to access, usage, and outcomes. For example, the Government of India launched the Pradhan Mantri Gramin Digital Saksharta Abhiyan program in 2017, offering free training on basic digital skills, including smartphone usage, online access to government services, and digital payments, targeting disadvantaged groups in rural areas such as women, minorities, and low-income individuals. As of July 2024, this program has helped approximately 50 million people improve their digital literacy, enabling them to access online services, participate in e-commerce, and improve their livelihoods (Government of India, Ministry of Electronics and IT 2024). In Thailand, the Village

Broadband Internet project (or Net Pracharat) is a flagship digital infrastructure development project aimed at expanding high-speed internet to all villages. To raise awareness and promote the use of Net Pracharat, the Government of Thailand developed a curriculum on basic internet skills, social media, and internet applications in health care, agriculture, and government services. By September 2018, the program had reached more than 1.2 million villagers (APT 2019). Additionally, Thailand launched a New-Normal Market Transformation program in 2022, with the goal of empowering SMEs with digital skills and knowledge. By February 2023, the program had helped 1.2 million SMEs, generating over B300 million in economic value (Bangkok Post 2023). The Government of the Republic of Korea introduced the Smart Education Initiative in 2011, which integrates digital tools and e-learning platforms into the public education system, significantly benefiting students in remote areas by bridging the gap in educational resources between urban and rural schools.

To mitigate the disruptive impacts on the job market, governments can roll out skill upgrading and education programs. Such programs can help equip the workforce with the necessary skills for the digital era. For example, Malaysia launched the MyDigitalWorkforce Work in Tech program with RM100 million in 2021 (Digital News Asia 2021). This program includes the Digital Business Services and Digital Tech Apprenticeship initiatives, which provide incentives for companies that hire unemployed Malaysians for digital business services and high-demand tech jobs in areas such as data science, software development, and cybersecurity. Employees will receive salary and training incentives to complete a minimum of 40 hours of in-house training or “Work and Learn” courses listed in the Malaysia Digital Economy Corporation’s Digital Skills Training Directory. This program expects to create about 6,000 job opportunities and at least 1,000 high-tech talents. Governments are advised to conduct comprehensive assessments of the impact of digital technology on the job market to ensure their programs are appropriately targeted to the most affected groups. Moreover, governments can incorporate digital technologies into their formal education systems, thereby helping the future workforce learn the digital skills they will need in the workplace.

Collaborating with the Private Sector

Governments can collaborate with the private sector to achieve universal connectivity. For example, public–private collaboration can take the form of digital infrastructure and public goods sharing. Infrastructure sharing has proven effective in reducing mobile broadband deployment costs by 10%–50% in rural and remote areas (Kumar and Oughton 2023a, 2023b). Prudent regulatory and fiscal policy choices, combined with infrastructure sharing, can encourage network operators to deploy more infrastructure and significantly lower costs (Oughton et al. 2022). In developing Asia, for example, tower companies in Thailand are required by infrastructure-sharing regulations to share infrastructure assets on fair commercial terms.[10] Governments can also utilize existing public assets—such as schools, hospitals, and libraries—to lower the private sector’s digital infrastructure deployment costs. In hard-to-reach rural and remote areas, governments may already have assets that can be used to mount antennas and house nearby radio equipment. For example, an electricity power supply may also be available onsite, further lowering deployment costs. Therefore, governments that are committed to achieving universal broadband are advised to explore these potential synergies. Where feasible, they may consider offering assets at minimal rent or even for free in areas where private infrastructure investments are unlikely to be economically viable. Furthermore, economies such as the PRC, India, and the Republic of Korea are actively exploring the use of library resources to provide convenient internet access and digital training services to the public (Lo and Stark 2021; Noh 2019).

10 World Bank. Telecom Infrastructure Sharing, Thailand.

Governments can help the private sector in identifying and supporting digitally marginalized groups. Governments can promote inclusive digital transformation by helping the private sector identify business opportunities and offering incentives to develop digital products and services for disadvantaged groups. Examples include digital applications that serve minority language speakers or those designed with gender and age considerations. While the private sector is largely profit-oriented, governments can collaborate with the private sector to ensure the accurate identification of needs that promote inclusive digital technology innovations for all groups. Governments can work with the private sector to carry out digital skills training—such as basic computer operations, network applications, and programming—to create new jobs and economic opportunities for disadvantaged groups. For instance, Amazon is promoting the adoption of e-commerce technology in South Asia through skills training in the e-commerce sector (Varma and Ray 2023). India's digital public infrastructure serves as a good example of collaboration between the public and private sectors to enable digital transformation for inclusive development (Box 3.3).

Box 3.3: India's Digital Public Infrastructure: Public–Private Collaboration for Inclusive Development

A key function of government is to build and maintain infrastructure that raises the productivity of the entire economy. This function is particularly crucial in developing economies, where inadequate infrastructure often hinders growth and development. Amid the rapidly unfolding digital transformation, digital infrastructure has become an essential component of infrastructure. Without strong digital infrastructure, an economy risks falling behind in the digital age.

In this context, India has developed a world-class digital public infrastructure (DPI) to support its sustainable development goals. DPI refers to a set of shared digital building blocks—including applications, systems, and platforms—powered by interoperable open standards or specifications. "India Stack" is the collective name for a set of commonly used DPIs in India, consisting of three layers: unique identity (Aadhaar); complimentary payment systems (Unified Payments Interface, Aadhaar Payments Bridge, and Aadhaar Enabled Payment Service); and data exchange (DigiLocker and Account Aggregator). Together, these components enable online, paperless, cashless, and privacy-respecting digital access to various public and private services.

India's DPI, which can serve as a model for other developing economies, is based on a close partnership between the public and private sectors. Specifically, DPI is built on open technologies to deliver equitable access to both public and private services for all members of society. As such, the name DPI can be somewhat misleading, even though the government played a leading role in its development. India's experience suggests that a successful DPI requires a symbiotic and mutually reinforcing relationship between the public and private sectors concerning public policy, digital assets, and market innovation (box figure). DPI has been a powerful engine of inclusive growth in India by facilitating financial inclusion, expanding access to essential services, and empowering citizens of all income levels. The poor and vulnerable, in particular, have benefited the most. For instance, during the early months of the pandemic, the digital infrastructure enabled an impressive 87% of poor households to receive at least one benefit. Digital platforms also facilitated the efficient distribution of COVID-19 vaccines to the broader population. However, perhaps their most significant impact on inclusive growth has been in financial inclusion. The creation of the Unified Payments Interface (UPI) has made digital payments ubiquitous, with UPI now accounting for 68% of all payment transactions by volume. DPI has greatly expanded access for the poor to digital payments and financial services, creating new economic opportunities.

What are the salient lessons for other developing countries from India's DPI? One important takeaway is the need for an enabling information and communication technology environment. India boasts one of the lowest costs of mobile access and data transmission globally, averaging $0.16, largely due to low telecommunications tariffs for mobile internet access and widespread 4G coverage. Another key insight is the unique feature of India's DPI: the implicit public–private partnership. While the government clearly leads DPI, its open access to private firms and services has made the infrastructure much more useful to users. Access to both public and private services has greatly contributed to DPI's success. DPI, as a mix of the state-led and market-led models, offers a fresh approach for other developing economies to scale up inclusive digital solutions.

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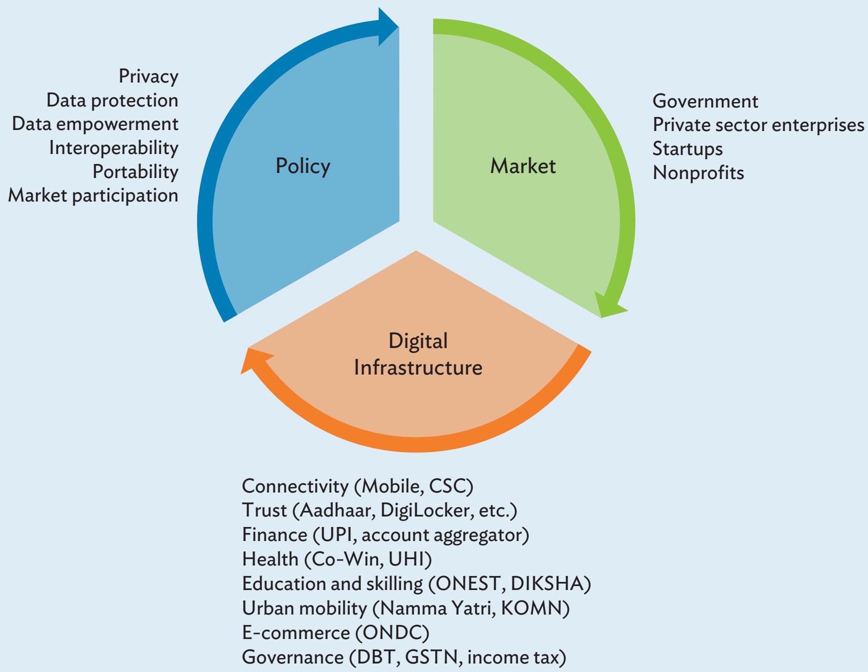
Box *continued*

India's Digital Public Infrastructure Framework



CSC = common service centers, DBT = direct benefit transfer, DIKSHA = digital infrastructure for knowledge sharing, GSTN = goods and services tax network, KOMN = kochi open mobility network, ONDC = open network for digital commerce, ONEST = open network for education and skilling transactions, UHI = universal health interface, UPI = unified payment interface.

Source: Hadda and Mukherjee (2024).

Reference

Hadda, K. and A. Mukherjee. 2024. How Digital Public Infrastructure Can Support Financial Inclusion. *Issue Brief.* Atlantic Council Policy. 21 October.

Source: Alonso et al. (2023).

4 Impacts of Digital Transformation on Sustainability

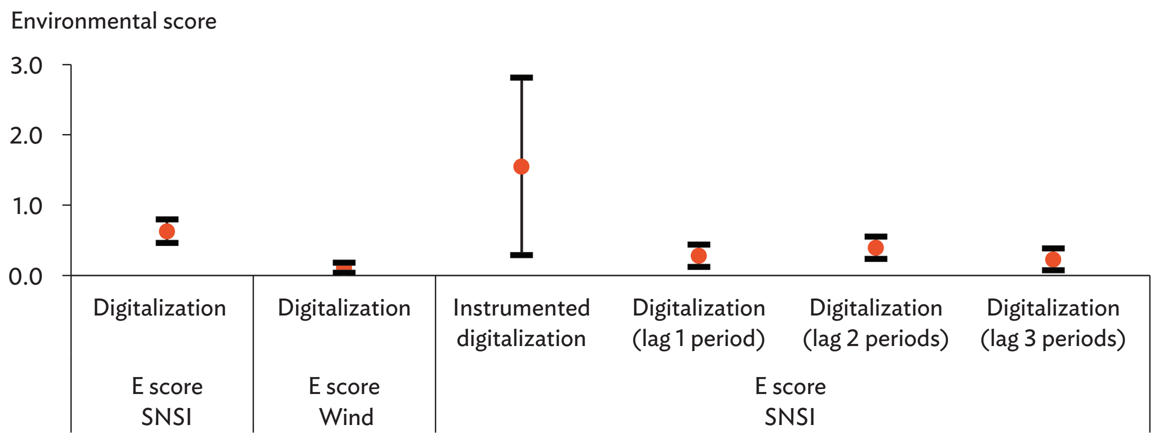
This chapter presents new evidence and case studies demonstrating that digital technologies can promote environmental sustainability and build climate resilience in developing Asia. It also explores the uncertain impacts of digital transformation on energy consumption and emissions. The chapter discusses sustainability-aligned strategies and policies that leverage digital transformation to advance sustainable development.

4.1 | Opportunities to Promote Environmental Sustainability

Digital technologies contribute to sustainability by enhancing monitoring and optimizing resource utilization during manufacturing and production. Digital technologies such as artificial intelligence (AI) and the Internet of Things have bolstered automation, connectivity, and flexibility within production, manufacturing, and consumption processes, leading to greater efficiency (Borowski 2021; Mawson and Hughes 2019). Sensors and remote sensing technologies can monitor soil moisture, nutrient levels, and crop health, enabling farmers to apply inputs more efficiently and reducing emissions associated with excessive irrigation and fertilizer use (Kwakwa, Adjei-Mantey, and Adusah-Poku 2023; Yuan et al. 2021). For example, an ADB pilot and demonstration case of mobile application IrriWatch supported irrigation scheduling in select fields in Kazakhstan, helping farmers improve their irrigation management. IrriWatch was found to reduce farmers' irrigation needs and associated energy consumption by one-third, thereby decreasing demand for fossil fuel energy and lowering costs (Bastiaanssen and Abuov 2020). Through information digitization, innovative designs, and production models such as additive manufacturing and virtual reality, digital technologies also reduce the use of paper and physical prototypes, contributing to environmental sustainability (Ford and Despeisse 2016; Mehrpouya et al. 2019).

Digitalization can help companies improve their environmental performance through various channels. Digital technologies can reduce unnecessary energy consumption and enhance energy efficiency by increasing the frequency of information exchange in both production and operations (Reisch et al. 2021). Digitalization also contributes to improved environmental performance of companies via enhanced resource utilization efficiency, operational capability, and information transparency (Chen and Hao 2022; Lu et al. 2024). Luo, Tian, and Wu (2025) empirically examine how corporate digitalization affects their environmental performance, using environmental scores from externally rated environmental, social, and governance ratings as a proxy. Analyzing a sample of publicly listed firms from the People's Republic of China (PRC) between 2009 and 2022, the evidence indicates that a 1% increase in an average firm's digitalization level can raise the environmental score of the company by 0.62 units, or around 1% of the sample average (Figure 4.1). This impact can be attributed to enhanced green innovation, improved monitoring and response mechanisms, increased information transparency, and greater external attention.

Figure 4.1: Digitalization and Corporate Environmental Performance



E = environmental, SNSI = Sino-securities index.

Notes: Error bars pertain to the 99% confidence interval. Estimation controls for various firm characteristics, and firm- and time-fixed effects. The first two bars used different environmental scores from the Sino-Securities Index and the Wind environmental, social, and governance (ESG) Rating systems as alternative environmental performances. The third bar shows estimated results using instrumented firm-level digitalization, and the last three bars considered digitalization index from a different time period for robustness.

Source: Luo, Tian, and Wu (2025).

Advanced digital technologies like AI, cloud computing, and big data analytics offer opportunities to reduce emissions through enhanced analytics and forecasts. Advanced technologies such as generative AI and cloud computing provide new solutions to decrease emissions in conventional emitting sectors like aviation, agriculture, and shipping. For example, Google's "Project Greenlight" leverages AI to optimize traffic flows, cutting emissions at intersections by 10% and potentially eliminating 30 million car rides each month. Google's "Transforming Aviation" uses AI to analyze data from satellite imagery, weather, and flight paths, creating forecast maps for contrails, which contribute to about 35% of aviation's global warming impact (IPCC 2022). American Airlines conducted 70 demonstration flights using Google's AI predictions to select routes that avoid contrails, resulting in a 54% reduction in contrails. In Bengaluru, India, an AI-powered traffic control system launched in 2024 reduced travel time by 33%, improved hourly vehicle throughput by up to 30%, and reduced fuel consumption and pollution by minimizing idling times at signals.

Digital technologies can drive green consumption and investment behaviors via nudging schemes. Online platforms can facilitate environmentally friendly shifts in consumption and investment patterns. Digital technology-enabled nudging schemes effectively reduce emissions by informing consumers about the environmental impacts of their behaviors. The nudging scheme with the "no cutlery" sustainability-aligned default option on Alibaba's food delivery platform led to a 648% increase in the share of "no cutlery" orders, reducing the demand for single-use cutlery by 21.75 billion sets annually, which saves 5.44 million trees each year (He et al. 2023). Individual investors who receive higher sustainability-aligned feedback in the form of "Ant Forest Green Points" via Alibaba's fintech platform Alipay tend to allocate more funds to environmentally friendly mutual funds (Gao et al. 2024).

Digital technologies can help mobilize sustainable finance and promote sustainability reporting via enhanced transparency and traceability. The lack of reliable information is a major barrier to mobilizing private finance for sustainability-aligned investments (ADB 2024a). Insufficient reliable information can lead to potential overstatement of an investment's environmental performance, a phenomenon known as "greenwashing," which undermines investor confidence and poses reputational risks. Digital technologies can provide real-time tracking and verification of transactions, thereby enhancing the transparency and integrity of green investments. For example, blockchain technology can facilitate the issuance of green bonds and improve their transparency and accountability by ensuring that funds are used as intended, thus preventing greenwashing (Christodoulou et al. 2023). Box 4.1 discusses how the Japan Exchange Group employs digital technologies to track operational activities and provide reliable information to mobilize green finance by enhancing transparency and boosting investor confidence. Additionally, digital technologies can offer carbon footprint analysis and product labeling that help businesses measure, monitor, and reduce their carbon footprints. For example, Alibaba's "Energy Expert" platform uses AI and analytics computing technologies to help businesses within its ecosystem measure emissions and product carbon footprints and develop energy-saving and carbon-reducing schemes.[11]

Digital technologies can strengthen climate resilience through enhanced monitoring, analytics, and improved access to information about advanced technologies. Digital technologies such as satellites, drones, sensors, and surveillance cameras can monitor real-time conditions and produce granular data. Real-time data, including soil quality, moisture levels, and overall crop health, can provide the basis for predictions and analyses (Sani, Mashi, and Chup 2023). As a result, farmers can make informed decisions regarding irrigation, machinery, and fertilization based on analytics and information to mitigate the negative impacts of extreme weather events. For example, a project by Google's Moonshot Factory utilizes AI and advanced sensing technologies to analyze over 800 million plant images to better understand plant health and contribute to the climate resilience of the agriculture sector via advanced analytical capacity. Additionally, digital technologies like smartphones and the internet provide farmers with climate-smart business advice, helping them adapt to extreme weather events. These technologies include climate-resilient crop varieties, drought-tolerant maize, flood-resistant rice, and shifting cropping patterns such as from rice-wheat to maize-wheat in flood-prone areas. A household survey conducted in Bangladesh, India, and Nepal, reveals that information about weather trends and climate-smart practices aids farmers in building climate resilience (Bhatta et al. 2017). For example, in flood-prone areas like Madhepura, India, farmers' shifting from rice-wheat to maize-wheat has reduced crop losses by 30%. In Vanuatu, digital platforms have been used to disseminate weather-related information and early warnings, thereby enhancing community resilience to weather-related shocks (Rahman et al. 2025).

Digital technologies promote disaster risk management via effective monitoring, analytics, and timely responses. Digital technologies such as the global positioning system (GPS) and remote sensing can gather real-time information to facilitate predictions and risk management measures for extreme weather events. For example, a case study by Ang Ngo Ching et al. (2025) utilized the spatial and temporal granularity of GPS location data to monitor temporary disaster-related evacuation and relocation, along with duration patterns, during a flood in Thailand in 2019. As shown in Figure 4.2, approximately 60%–65% of temporarily displaced individuals were affected for only 1–2 nights, highlighting the quick responses to the flood in Mueang Lop Buri. Those who evacuated for just an overnight stay typically relocated within 30 kilometers, often within the same district, indicating a strong preference for local surroundings due to familiarity, local resources, and social support from family and friends. However, up to 35% of individuals left their homes for longer periods (3 days or more) and moved farther away, indicating a significant level of displacement. By integrating socioeconomic status information, such as income levels and age, digital tools like GPS data and AI can enhance disaster risk management responses. These tools help vulnerable groups reduce the negative impacts of extreme events by facilitating evacuation planning and delivering recovery measures. As shown in Figure 4.3, when

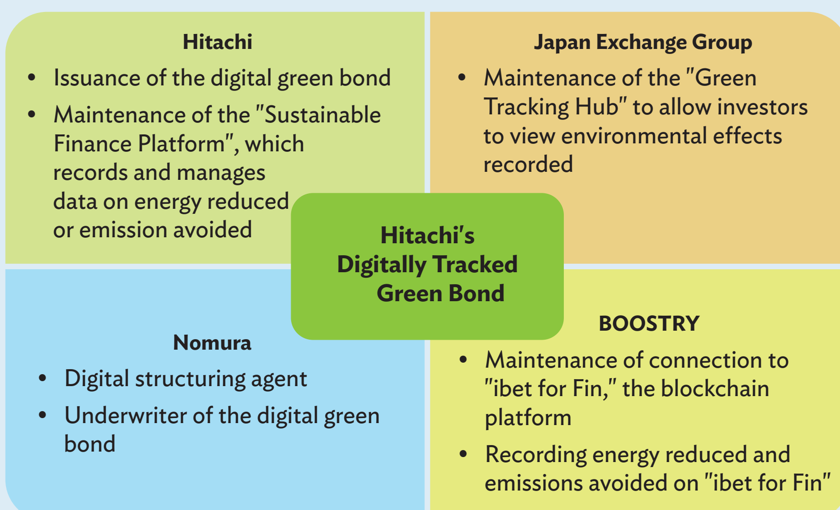
[11] Alibaba Cloud. Energy Expert.

Box 4.1: Digitally Tracked Green Bond Scheme by the Japan Exchange Group

Japan Exchange Group (JPX) has initiated a scheme to issue digitally tracked green bonds to enhance transparency in raising funds for environmentally sustainable projects. This initiative launched an Internet of Things and blockchain platform called "the Green Tracking Hub," which provides investors with timely information on the environmental performance of green bonds, such as the amount of electricity generated by green power projects funded through these bonds. The decentralized nature of blockchain ensures that all transactions are securely recorded and verifiable, preventing tampering and minimizing the risk of fraud. The immutable ledger provided by blockchain helps maintain a clear and tamper-proof record of how bond proceeds are used, ensuring that funds are allocated to genuine environmental projects (Chen and Volz 2022; Shankar 2022).

The box figure illustrates how Hitachi's Digital Green Bond issuance utilized blockchain technology to track and report the environmental impacts of JPX's digital tracked green bond scheme. As shown in the figure, the issuer (Hitachi) sold a digital green bond to finance the construction and refurbishment of an energy-saving building (Kyōsō-to). Nomura Securities served as the digital structuring agent and underwrote the digital green bonds to investors. After Hitachi invested the bond proceeds in the energy-saving building, it maintained the records and managed data on energy reduced or emissions avoided. BOOSTRY Co., Ltd. developed the blockchain network "ibet for Fin" and maintained the connection to enable the recording of energy savings and emissions reductions from Hitachi's green bonds on the platform. JPX maintained the Green Tracking Hub to allow investors purchasing Hitachi's green bonds to view in real-time the energy reduced and emissions avoided recorded on the "ibet for Fin" blockchain platform.

Different Parties in Hitachi's Digital Green Bond Issuance



Source: Nomura (2023).

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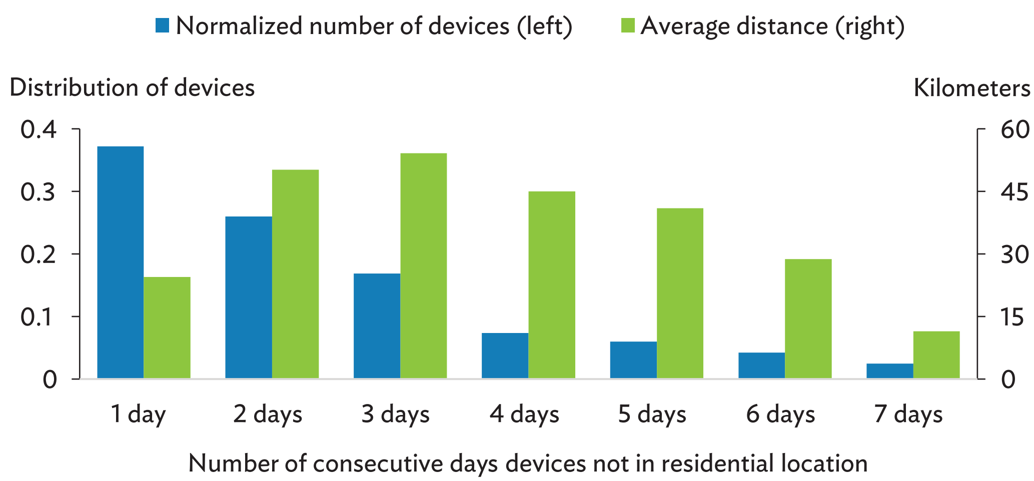
Source: ADB (2024c).

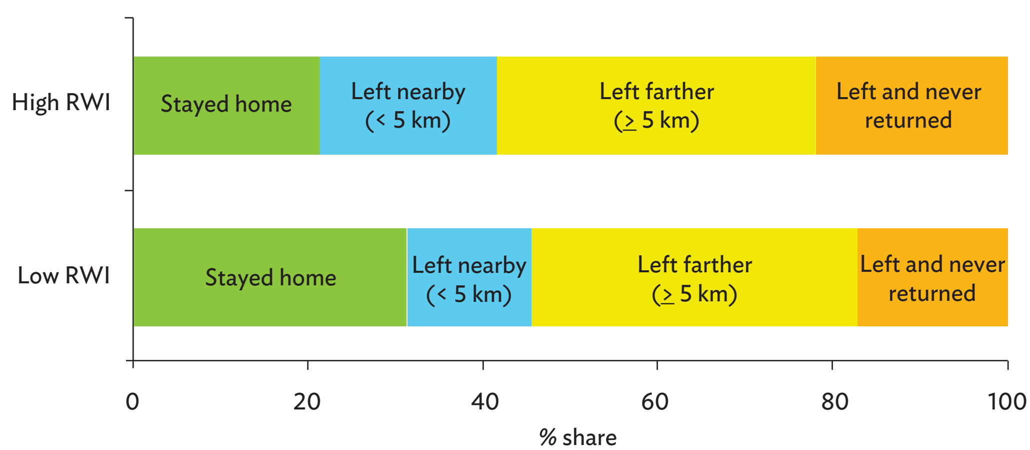
considering Relative Wealth Index (RWI) values of mobile device holders, digital technologies can reveal mobility patterns of low-RWI (i.e., low wealth) and high-RWI individuals for informed recovery support strategies (Ang Ngo Ching et al. 2025). In this case, around 31.4% of low-RWI individuals did not relocate, compared to 21.4% of high-RWI individuals, partly due to limited mobility options or fewer available resources. Such a system enables timely disaster responses by identifying affected residents, monitoring and tracking evacuation locations and duration of displacement, thereby enhancing climate resilience, especially for vulnerable groups.

Figure 4.2: Evacuation Distance and Duration of Mueang Lop Buri Residents, Thailand



Source: Ang Ngo Ching et al. (2025).

Figure 4.3: Mobility Trends of High- and Low-Wealth Groups During the 2019 Flooding in Mueang Lop Buri, Thailand



km = kilometer, RWI = relative wealth index.
Source: Ang Ngo Ching et al. (2025).

Box 4.2: Disaster Impacts Assessment Using Remote Sensing and Socioeconomic Data in Fiji

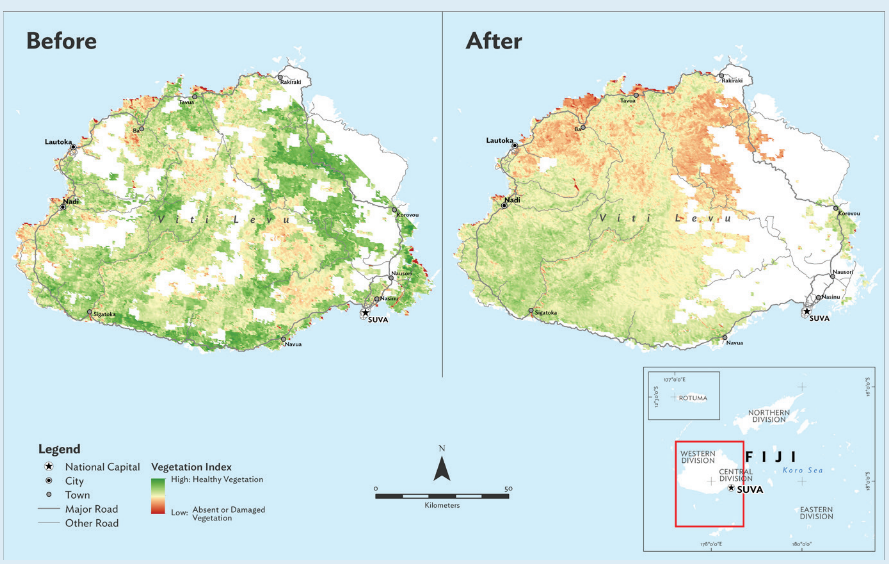
Government agencies need reliable and readily available information on the impacts of disasters to make informed decisions regarding target responses, early recovery measures, and resource mobilization. Conventional methods for assessing disaster impacts, such as ground surveys and informant interviews, are time-consuming, resource-intensive, and challenging to conduct during widespread disasters. Common models for disaster impact assessment may overlook local vulnerabilities, be too complex for quick interpretation, and fail to capture cascading effects—where one disaster triggers others—making them less reliable for decision-making. Recognizing these limitations, the United Nations International Strategy for Disaster Reduction's Sendai Framework for Disaster Risk Reduction 2015–2030 emphasizes the need to enhance disaster risk management by improving disaster risk assessment and monitoring to better address these challenges (UNISDR 2015).

Advancements in digital technologies now enable researchers to harness innovative big data for more effective disaster risk management. Remote sensing data, primarily derived from satellites, is increasingly used for post-disaster needs assessments to evaluate the impact of natural hazards such as tropical cyclones, floods, landslides, and tsunamis. These data can complement existing assessments by expediting the identification of damages, losses, and needs. It provides rapid, relevant, and detailed socioeconomic impact data at low cost, in near real-time (through nowcasting and post-disaster assessments), or even before a disaster (through impact-based forecasting), facilitating a timely and informed response.

Noy et al. (2023a) extracted remote sensing data from Sentinel-2 and MODIS to construct the Enhanced Vegetation Index (EVI) pre- and post-cyclone at the grid cell level in Fiji. These data were then combined with hazard variables, such as distance from the cyclone track (from the International Best Track Archive for Climate Stewardship), and socioeconomic features of the region, including crop types, household characteristics, and economic conditions, obtained from the 2013–2014 Household Income and Expenditure Survey and the 2020 Fiji Agriculture Census.

Box figure 1 shows the EVI before (left) and after (right) Tropical Cyclone Winston passed through Viti Levu in 2016, the largest island in Fiji. Healthy vegetation, indicated by high EVI values, appears as green areas on the map, while non-vegetated surfaces or damaged vegetation, indicated by low EVI values, are shown in yellow to reddish areas. A comparison of the two images reveals a clear shift from green to yellow and red across Viti Levu Island following the cyclone's passage.

1: Enhanced Vegetation Index Values in Fiji's Viti Levu Island, Before and After Tropical Cyclone Winston



Note: Left panel shows the enhanced vegetation index (EVI) before Tropical Cyclone Winston (2016) and the right panel shows the EVI after the cyclone.

Source: Noy et al. (2023b).

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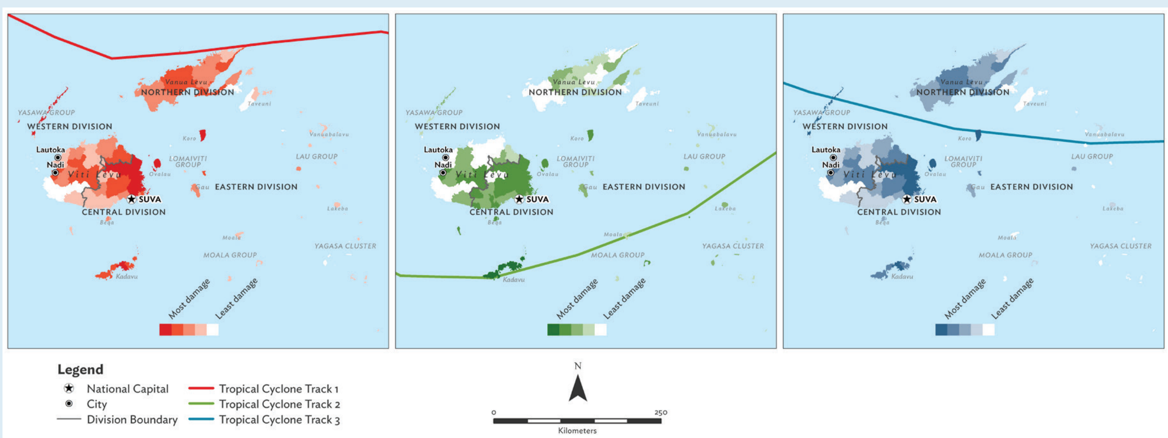
Box *continued*

Further analysis yields interesting results. Greater distance from the cyclone path is linked to less vegetation damage, which is expected. In addition to hazard variables, socioeconomic characteristics also influence the impact. For example, areas with a higher proportion of banana and dalo crops in exposed regions experience more damage, while land dedicated to cassava incurs less damage. Districts with higher incomes and, in some cases, larger households tend to experience less cyclone-induced vegetation damage, whereas areas with higher government transfers and remittances from abroad often suffer more vegetation damage.

This approach requires ground-level data with high spatial and temporal resolutions and further validation before it can be fully integrated into disaster risk assessment and management systems. Nonetheless, the preliminary analysis presents a promising method for rapidly estimating impacts. For instance, by using hazard information about an ongoing cyclone alongside estimates from retrospective analysis, potential agricultural damage at a granular geographic level can be estimated even before satellite imagery becomes available, as shown in box figure 2 (Noy 2023b). Such information can feed into and accelerate post-disaster assessments.

2: Extent of Damages for the Three Tropical Cyclone Simulations



Note: Districts with highest possible damage for each simulated track are shown in darker colors.

Source: Noy et al. (2023b).

References

Noy, I., E. Blanc, M. Pundit, and T. Uher. 2023a. Nowcasting from Space: Tropical Cyclones' Impacts on Fiji's Agriculture. *Natural Hazards.* 118. pp. 1707–1738.

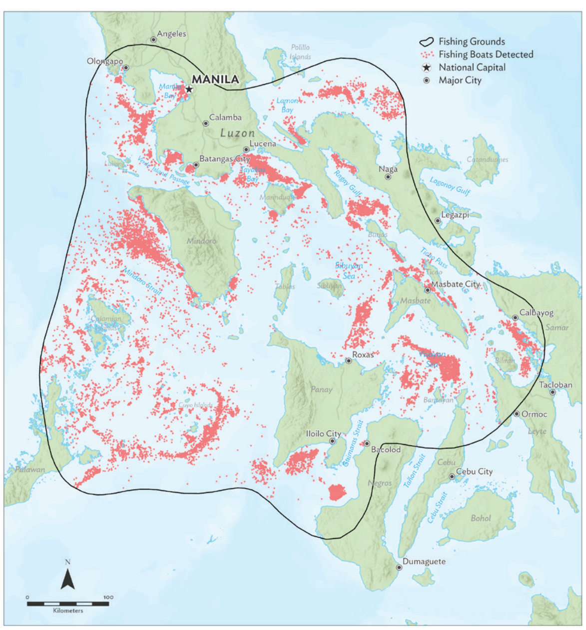
Noy, I., M. Pundit, H. Pagkalinawan, and P. Villanueva. 2023b. Appraising New Damage Assessment Techniques in Disaster-prone Fiji. *ADB Briefs.* No. 240. ADB.

United Nations Office for Disaster Risk Reduction (UNISDR). 2015. *Sendai Framework for Disaster Risk Reduction 2015–2030.*

Source: Noy et al. (2023b).

Digital technologies can expedite disaster risk impact assessments to support informed decisions and early recovery measures. A study conducted in Fiji demonstrated that integrating remote sensing data with socioeconomic information can help nowcast the impact of cyclones on agriculture (Noy et al. 2023a). As shown in Box 4.2, areas with a higher proportion of banana and dalo crops in cyclone-exposed regions experience more damage compared to those growing cassava. Districts with lower income levels suffer more cyclone-induced vegetation damage. This damage assessment can be conducted even before satellite imagery becomes available, accelerating recovery support measures and alleviating the impact of potential disaster risks, particularly for low-income groups. In the Philippines, remote sensing data were used to assess the impact of tropical cyclones on fishing activities (Noy, Pundit, and Lacheheb 2025). Fishing is crucial for the livelihoods of coastal communities but faces persistent challenges due to its vulnerability to tropical cyclones, which frequently disrupt fishing operations and damage boats. Satellite and digital technologies facilitate data collection, storage and advanced analysis, such as monitoring fishing activity in real time, categorizing main fishing areas based on daily fishing boat data when no typhoons are detected, and conducting post-typhoon analysis. Figure 4.4 shows the main fishing grounds identified in 2012 for the Southern Luzon and Visayas regions of the Philippines. By combining this real-time information with socioeconomic data, digital-based analysis can assess how changes in translation, wind speed, and distance from the typhoon track disrupt fishing activities in various grounds (Noy, Pundit, and Lacheheb 2025). Such analysis can enhance resilience and mitigate disruptions caused by natural hazards.

Figure 4.4: Estimated Fishing Grounds in the Southern Luzon and Visayas Regions of the Philippines



Source: Noy, Pundit, and Lacheheb (2025).

4.2 | Challenges to Sustainability

The impacts of digital transformation on energy consumption and emissions remain inconclusive and depend on a variety of social and economic factors. While digital technologies contribute to energy efficiency, these gains may be offset by increases in production capacity and economic growth through labor and energy productivity improvements, scaled-up solutions, and innovations (Ren et al. 2021). Additionally, overall consumption may rise due to behavioral responses from firms and households (Greening, Greene, and Difiglio 2000; Thiesen et al. 2008). For example, digital development in cities in the PRC has led to increased electricity consumption, particularly in high-income regions (Peng et al. 2023). Higher energy consumption could also result in increased emissions, especially when the energy to fuel digital technologies is derived mainly from nonrenewable energy generation technologies. Furthermore, the energy efficiency benefits of digital technologies, such as smart technologies, may be reduced by limited adoption capacity (Danish et al. 2018; Nizam et al. 2020). Overall, the net benefit of digital technology on energy consumption is influenced by various social and economic factors, while its effect on emissions is further determined by whether these digital technologies are powered by fossil fuels.

The production and use of digital devices and digital infrastructure, such as data centers and networking equipment, are significant contributors to energy consumption during digital transformation. Estimates suggest that the total global energy demand of digital technologies is approximately 805 terawatt-hours (TWh) annually. This includes electricity consumption from end-user devices (304 TWh), network infrastructure (220 TWh), and data centers (245 TWh), which together account for around 3.6% of the global total electricity consumption of 21,000 TWh (Malmodin and Lundén 2018). The production of digital devices—such as smartphones, laptops, and tablets—has a substantial carbon footprint, as do their usage patterns, including screen brightness, processing demands, and network activities (Cordella, Alfieri, and Sanfelix 2021; Subramanian and Yung, 2017; and

Suckling and Lee, 2015). According to International Energy Agency (IEA) estimates, global data center workloads increased by more than 260% from 2015 to 2021, with electricity consumption for data centers in 2022 estimated to reach 240–340 TWh, or around 1.0%–1.3% of the global final electricity demand.[12] This consumption is similar to the annual electricity consumption of economies like Indonesia (312 TWh) or Viet Nam (252 TWh). In 2020, data centers and data transmission networks were responsible for approximately 330 megatonnes of carbon dioxide ($MtCO_2$) equivalent, accounting for 0.9% of energy-related greenhouse gas (GHG) emissions and 0.6% of total GHG emissions.[13]

Demand for data center services is likely to increase substantially in the future. With the evolution of cloud computing and the expansion of data-intensive applications such as video streaming and generative AI, the number and capacity of data centers have grown exponentially (Madlener, Sheykhha, and Briglauer 2022). Data centers consume electricity to run servers, network equipment, air distribution fans, and cooling systems. Servers account for 40% of a data center's electricity demand, cooling requirements for stable processing efficiency account for another 40%, and the remaining 20% comes from other associated IT equipment such as storage devices and communication equipment (ABB 2022). The IEA (2024) expects global electricity consumption for data centers, cryptocurrencies, and AI to range between 620 TWh and 1,050 TWh in 2026, with the base case for demand at just over 800 TWh, up from 460 TWh in 2022.

However, uncertainty remains regarding energy consumption and emission patterns amid the rising demand for data center services. Increases in data center services may not necessarily lead to a corresponding increase in energy consumption. Despite a sixfold growth in global workloads, the electricity consumption of data centers remained stable at around 205 TWh per year in 2020 (Masamet et al. 2020). The traffic of mobile telecom network operators increased by threefold from 2015 to 2018, while electricity consumption remained nearly constant (Lundén et al. 2022). This is partly due to improved efficiencies in software, hardware, and cooling, as well as a shift from traditional data centers to cloud and green data centers. For example, liquid cooling systems can drastically reduce power consumption in data centers by up to 90% through enhanced heat dissipation (Gillin 2023). AI-driven optimization contributes to energy conservation by optimizing server use and managing workloads. Hyperscale data centers, by tailoring their architecture for optimal efficiency and scalability, can significantly reduce energy usage per unit of computing power (Parsons et al. 2024). Moreover, associated emissions are also uncertain due to the potential for greater production and use of renewable energy. The integration of renewable energy sources, including solar and wind power, into data center operations offers a viable path to reducing carbon footprints (Chew 2025). Data centers in developing Asia are beginning to tap renewable energy. For example, the PRC has pledged to increase the share of renewable energy in data centers' total energy consumption by 10% annually (Government of the PRC 2024b).

The rise of AI could lead to increased energy consumption unless energy efficiency improves. Generative AI, which can produce text, images, and other data according to specific instructions, has experienced rapid growth since 2022. While it can enhance energy efficiency in various activities, generative AI is energy-intensive in nature. It requires significant computing power for both training and inference—every time it generates text or an image (de Vries 2023). For example, Hugging Face, an AI development company, reported that its text-generating AI tool consumed approximately 433 megawatt-hours during training, enough to power 40 average homes in the United States for a year. In addition to inference and training, AI contributes to energy consumption via hardware production and the construction of digital infrastructure. Developing Asia

[12] This excludes energy used for cryptocurrency mining, which was estimated at around 110 TWh in 2022, accounting for 0.4% of annual global electricity demand.

[13] IEA. Data Centers and Data Transmission Networks.

Box 4.3: Sustainability-Friendly Innovation and Applications of Artificial Intelligence

Artificial intelligence (AI) has the potential to improve energy efficiency in key emitting industries. In electricity grids, AI-powered demand response systems and predictive analytics can optimize energy consumption and reduce grid inefficiencies (IEA 2024). AI-powered demand response systems utilize real-time data and machine learning to enable users to automatically shift energy usage to off-peak times when electricity is cheaper and cleaner. Predictive analytics forecast energy demand based on historical patterns, allowing utilities to optimize power generation and distribution, which reduces reliance on fossil fuel plants. Additionally, AI-driven precision farming enhances the efficiency of water and fertilizer use in agriculture, improving crop yields while lowering associated energy consumption (Martin 2024). In the transport sector, AI-driven traffic optimization in Bangkok and Singapore has led to reduced fuel consumption and congestion-related emissions (Ng 2025).

Recent advancements in AI model efficiency and hardware offer hope for reducing energy consumption. For example, DeepSeek-R1, a newly launched AI model, consumes less energy due to its smaller size, optimized training techniques, and lower-end processors, which reduce computational load. Hardware innovations also play a critical role in improving energy efficiency. Neuromorphic chips, which mimic the human brain's efficiency, and ARM-based processors, which require fewer transistors, can help reduce AI's energy footprint. Moreover, replacing air-cooling systems with liquid-immersion cooling can reduce energy consumption by up to 95% (Williams 2024).

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Source: Ciminelli (2025).

hosts some of the fastest-growing data center markets, including the PRC, Singapore, India, and the Republic of Korea, driving regional growth (CBRE 2024). Furthermore, semiconductor manufacturing, which is also extremely energy-intensive, is concentrated in Taipei,China; the Republic of Korea; and the PRC. By 2030, the semiconductor manufacturing industry is projected to consume as much electricity as Australia did in 2021, while a dedicated semiconductor foundry in Taipei,China, is on track to consume as much electricity as 5.8 million people there (Greenpeace East Asia 2023). Box 4.3 indicates that recent innovations and applications of AI in energy efficiency can help reduce overall energy consumption. Thus, the environmental impacts of rising AI depend on various factors, including model size, hardware efficiency, and the energy mix powering data centers (Ciminelli 2025). Without further improvements in energy efficiency and the adoption of renewable energy, the rapid growth of AI could lead to increased carbon emissions, compromising environmental sustainability.

Technology and energy choices in the rollout of digital infrastructure are critical in shaping energy consumption during digital transformation, particularly in less developed areas. A major challenge when deploying digital infrastructure in rural and remote locations is access to electricity. A conventional low-cost solution to address this issue has been the colocation of diesel generators to power the sites, for example, using weekly refueling via trucks (Suman and De 2020). However, this approach has substantial impacts on emissions (Farquharson, Jaramillo, and Samaras 2018). Moreover, economies with middle-income levels in developing Asia may experience higher device energy consumption and emissions than their high-income counterparts as they still need to expand their digital infrastructure (Oughton 2025). The adoption of spectrally efficient technology, such as fifth generation (5G), could help reduce energy consumption, partly because 5G is more efficient spectrally and therefore requires fewer sites. Overall, the net effect of digital transformation on energy consumption and emissions depends on sustainability-aligned solutions and the energy mix used to power digital technologies, where policy intervention can play a crucial important role in guiding these developments.

4.3 | Sustainability-Aligned Digital Policies

Digital policies that integrate sustainability considerations drive digital transformation toward sustainable development. To address related market failures, various policy instruments can serve two broad objectives: (i) to promote innovation and the adoption of sustainability-aligned digital technologies, such as smart technologies, digital green nudging, AI-driven traffic optimization, and disaster risk management tools; and (ii) to reduce carbon emissions associated with digital transformation, including the production of digital infrastructure and digital devices, by adopting renewable energy and improving energy efficiency in the digital sector. This section outlines sustainability-aligned digital policy options categorized by major instrument types to harness digital transformation for sustainability goals.

Legislation and Regulations

Where feasible, governments can use regulations and standards to promote the use of energy-efficient technologies and renewable energy to power digital infrastructure. Sustainability-aligned standards and regulations can ensure that new digital infrastructure construction and operations are energy-efficient and environmentally friendly. Box 4.4 outlines how advanced economies promote green data centers. Many developing Asia economies with relative high level of digitalization has also made efforts to green their digital infrastructure. For example, Singapore issued the Green Data Center Roadmap in 2024, which aims to achieve power usage effectiveness of 1.3 or lower over the next 10 years (Wong 2024). Singapore also developed the world's first Tropical Data Center Standards, including practical applications such as determining the optimal operating temperature for data centers to ensure reliability while reducing energy use (Government of Singapore, Ministry of Communications and Information, IMDA 2023a). In the PRC, regulations are being updated to reduce the environmental footprint of data centers. Since July 2023, regulations have required all data centers acquired by public organizations to improve their energy and water efficiencies (Liu 2023). For instance, the power usage effectiveness of a data center must be below 1.4 from June 2023 and below 1.3 from 2025 onward. The water usage effectiveness must be less than 2.5 liters per kilowatt-hour. Furthermore, data centers should be entirely powered by renewable energy by 2032, starting with a 5% share renewable energy mandate in 2023. Malaysia approved its new data center planning guidelines in 2024, which include power usage effectiveness and carbon usage effectiveness as possible conditions for applying for government incentives (Kerner 2024). Such regulations and standards comprehensively consider the environmental performance of data centers, including the energy efficiency of IT equipment and cooling systems. In many regional markets, these regulations and guidelines can also be part of the government's energy transition plan. The emissions implications of digital infrastructure largely depend on whether the associated energy supply is clean. Governments should assess and explore the emissions, costs, and benefits of switching to renewable energy and encourage network operators to adopt

Box 4.4: Examples of Regulatory Measures to Support the Greening of Data Centers

As a major component of digital infrastructure, "green" data centers are designed for maximum energy efficiency and minimal negative environmental effects (Fedoseenko 2022). They focus on energy savings and shift the energy mix toward more renewable energy, water savings, and recycling. In 2024, there were around 10,205 data centers worldwide, with about 53% located in the United States (US), and 23% in the European Union (EU). Leading data center locations, such as the US and the EU have introduced regulations to encourage low-carbon practices in their data centers.

In the US, both the federal and state governments have set targets for data centers to adopt more sustainable practices. At the federal level, the Energy Act of 2020 requires the federal government to conduct studies on the energy and water usage of data centers to develop applicable energy efficiency metrics and best practices, as well as report historical data on energy and water use. At the state level, Virginia and Oregon have proposed laws aimed at increasing scrutiny of data center energy and water consumption (Tozzi 2023).

The EU also promotes sustainable practices for data centers through various instruments, as elaborated below:

- The revised Energy Efficiency Directive includes regulations for the European data center sector, enhancing transparency and accountability to improve energy demand management.[a] Starting in 2024, owners and operators of data centers in their territory with a power demand for installed IT equipment of at least 500 kilowatts will have mandatory reporting obligations for their energy use and emissions. Large-scale data centers, with a power demand for installed IT equipment equal to or greater than 1 megawatt are required to implement waste heat recovery applications when technically and economically feasible and achieve carbon neutrality by 2030.
- A regulation from the European Commission, published in 2019 and effective since 2020, sets efficiency standards for data centers, enabling better control over their environmental impact (Office Journal of the EU 2019).
- The Climate Neutral Data Centre Pact was created by Cloud Infrastructure Services Providers in Europe and the European Data Centre Association in cooperation with the European Union. Launched in January 2021, the pact supports the European Green Deal, which aims to make Europe the world's first climate-neutral continent by 2050, and the European Data Strategy by making EU data centers climate neutral by 2030. More than 60 data center operators, including large operators like Equinix, Digital Realty, and Cyrus One, have signed the pact, with 95% of the initial cohort comprising nearly 75% of the EU's data center capacity.
- The European Union has adopted legislation requiring data center operators to report key performance indicators, including water usage. This move is expected to drive innovation in water efficiency without setting specific targets for water usage effectiveness.

[a] European Union (EU). EUR-Lex. Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). Article 12 and Annex VII.

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Source: Hubert and Le Texier (2025).

renewable energy where feasible, especially at off-grid sites in rural and remote areas (Oughton 2025).

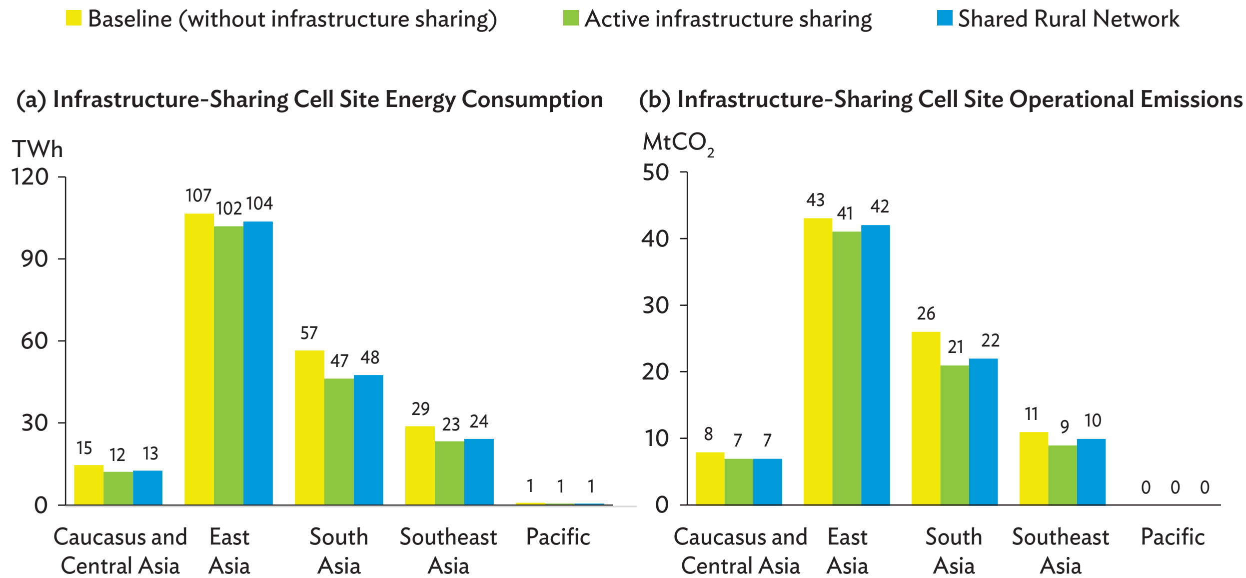
Policymakers can implement regulatory measures to enhance transparency and reporting, encouraging low-carbon practices in digital infrastructure. Many data centers lack the incentives to shift to energy- or carbon-efficient operations due to insufficient transparency regarding their operations and actual carbon footprints (Hubert and Le Texier 2025). Governments can strengthen regulations on disclosing and reporting energy efficiency and carbon footprints to motivate data center operators to improve their energy consumption and emissions performance. For example, authorities can establish regulations that gradually require operators and providers of digital technology products and services to disclose the carbon footprint of their digital products and services in their annual sustainability reports, beginning with voluntary disclosure (Chew 2025). Additionally, governments can promote voluntary carbon accounting standards and carbon offset programs—where operators and digital companies invest in reforestation, carbon capture, or renewable energy projects—to enhance transparency and offset emissions without imposing strict regulatory burdens on the private sector (Ciminelli 2025).

Governments can use incentives and regulations to promote low-carbon business practices, such as infrastructure-sharing, to reduce emissions associated with duplicating digital infrastructure. Infrastructure-sharing strategies can efficiently provide universal connectivity in underserved areas by avoiding infrastructure duplication, thus reducing emissions. Some regional economies, such as Bangladesh and the Philippines, have introduced policies to enable digital infrastructure sharing (Government of Bangladesh, BTRC 2024; Government of the Philippines, DICT 2020). Compared to a scenario where each operator builds its own network, emissions can be reduced when operators share active electronic equipment to reduce duplication (e.g., antennas, baseband units, and backhaul links). Alternatively, a Shared Rural Network (SRN) allows operators to share infrastructure and spectrum specifically in financially unviable rural areas, to lower deployment costs without affecting infrastructure competition in urban and suburban areas (Oughton 2025). Infrastructure-sharing strategies can lead to a mean reduction in carbon dioxide emissions of between 9% and 19%, depending on whether an active or SRN is implemented (Oughton 2025). As shown in Figure 4.5, for a baseline of 20 GB per month utilizing 4G with wireless backhaul technology, the most significant reductions in annual energy consumption and emissions occur in South Asia, decreasing from 57 TWh and 26 $MtCO_2$ without infrastructure sharing to 46 TWh and 21 $MtCO_2$ under active infrastructure sharing, and 48 TWh and 22 $MtCO_2$ under SRN. The benefits would be even greater with larger data plans. It is important for regulatory authorities to ensure that sharing strategies do not crowd out infrastructure investment or affect competition in commercially viable areas. For example, regulatory authorities could encourage infrastructure-sharing only in hard-to-connect areas that fall below a defined threshold (e.g., a population density of less than five persons per square kilometer or a certain distance from defined metropolitan areas) (Oughton 2025).

Fiscal Incentives

Governments can use fiscal incentives to promote low-carbon digital infrastructure and technologies by catalyzing commercial viability. In cases where deploying low-emission digital technologies or adopting renewable energy for network operations is not commercially feasible, governments can introduce incentives to improve these technologies' commercial viability. Typical examples include reducing spectrum licensing costs or offering tax exemptions or subsidies on a site-by-site basis when the power supply shifts to more energy-efficient models or renewable sources. This approach could also be part of government efforts toward low carbon transition. For example, the Government of India has introduced incentives for telecom operators to adopt renewable energy sources, such as solar and wind, to power mobile towers. Investments in renewable energy for telecom infrastructure can benefit from accelerated depreciation, potentially allowing up to 80% in the first year. This enables companies to deduct a larger percentage of the asset's cost in the early years, resulting in reduced taxable income and tax savings. Incentives can drive sustainability-aligned digital innovations by transforming them into commercial cases that support further research and development (R&D). For

Figure 4.5: Energy Consumption and Emissions for Infrastructure-Sharing Strategies in Developing Asia, by Subregions



$MtCO_2$ = megatonnes of carbon dioxide, TWh = terawatt-hour.

Note: Figures above reported for 20 gigabyte per month of 4G with wireless backhaul technology under the International Energy Agency's Announced Policy Scenario 2030.

Source: Oughton (2025).

example, Singapore's Green Data Center Roadmap in 2024 outlines the government's commitment to codevelop standards and certifications with the industry while providing incentives for adopting new standards and more energy-efficient computer and IT equipment.[14] Through this road map, Singapore aims to drive innovation through R&D initiatives such as the Sustainable Tropical Data Centre Testbed, a public–private collaboration focused on developing optimal cooling technologies for tropical weather (NUS 2023). Governments can also utilize the procurement of sustainability-aligned digital technologies, such as smart technologies, to scale up digital technologies that deliver environmental benefits. Governments can create a national sustainability standard for procurement, in particular for the procurement of digital products and services. This will help harmonize criteria across government ministries and agencies (Chew 2025).

Market Mechanisms

Carbon pricing is a cost-effective market-based instrument that helps reduce emissions and incentivizes the adoption of low-carbon digital technologies. As an important component of the low-carbon transition, carbon pricing drives the innovation, deployment, and adoption of energy-efficient and emission-friendly technologies. By putting an effective price on emissions, market failures can be corrected, motivating the shift to renewable energy and encouraging resource allocation toward energy-efficient and low-carbon economic activities. Several developing Asian economies are implementing carbon taxes or emission trading systems, although carbon prices in developing Asia remain low compared to those in developed economies (ADB 2024a). In addition to carbon pricing, removing inefficient subsidies for fossil fuels is important

[14] Government of Singapore, Ministry of Communications and Information, Infocomm Media Development Authority. About the Green Data Centre (DC) Roadmap.

to enhance the attractiveness of renewable energy and low-carbon technologies. In the absence of carbon-pricing, governments may also consider eliminating tax incentives or implementing targeted electricity taxes for high energy-consuming data centers to encourage improvements in energy efficiency.

Building Capacity

Governments need to strengthen their capacity to leverage digital monitoring and analytics for effective disaster risk management. Governments in developing Asia have begun leveraging satellite and remote sensing technologies to monitor land use and weather conditions to assist with responses to sustainability-related challenges such as illegal logging and crop health. Platforms like the Asia-Pacific Climate Change Adaptation Information Platform aggregate open online scientific data and tools, which are being used by several regional economies, including Indonesia, Mongolia, the Philippines, and Viet Nam.[15] However, having digital technologies does not automatically lead to effective disaster risk management responses. Governments must build capacity to enhance disaster preparedness based on monitoring and warning signals from digital technologies. For example, ADB provides technical assistance to its developing member economies, providing policy recommendations and technical guidance for disaster risk management tailored to the specific characteristics of disasters, local exposure, and both physical and socioeconomic vulnerabilities.[16]

Engaging broad stakeholders

Governments can strengthen collaboration with the private sector to promote sustainable digital infrastructure. The private sector has the motivation to develop green digital infrastructure, due to financing and resilience considerations. For example, in Indonesia, the Greenship Data Center certification, proposed nationally in 2023, was developed through a collaboration between the Green Building Council Indonesia, an independent, nongovernment, nonprofit organization, and the Ikatan Profesional Pusat Data Hijau Indonesia (Association of Indonesia Green Data Center Professionals). This certification can promote innovation and attract investment, positioning Indonesia as a preferred destination for sustainable infrastructure (Widyanto and Hardjoprakoso 2024). These sustainable measures enhance the resilience of Indonesia's digital infrastructure during extreme weather conditions by improving energy backup systems, increasing cooling efficiency, and implementing disaster recovery measures. Thus, governments have an opportunity to work with the private sector to better align practices with national climate goals.

15 Asia-Pacific Climate Change Adaptation Information Platform. Scientific Data and Tools Database ClimoKit.

16 ADB. China, People's Republic of: Integrated Framework for Cost-Effective Disaster Risk Management.

5 Policies to Harness Digital Transformation for Inclusive and Sustainable Development

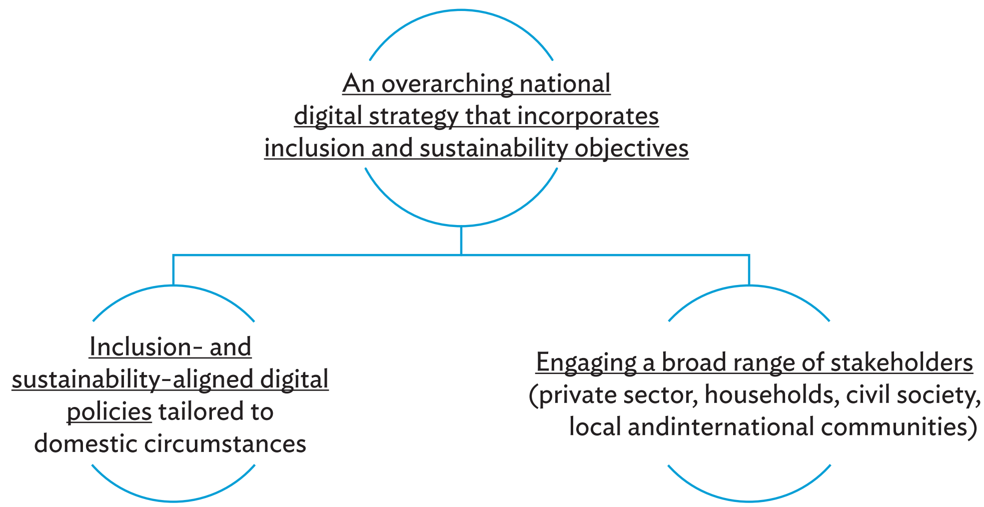
Previous chapters have shown how digital transformation can help developing Asia address the development challenges associated with inequality and sustainability. However, if not managed well, digital transformation could also exacerbate these challenges. This chapter proposes an integrated policy package designed to leverage digital transformation to accelerate inclusive and sustainable development in developing Asia.

This policy package would include three pillars (Figure 5.1). The first pillar focuses on developing an overarching national strategy that incorporates inclusion and sustainability as integral components of digital transformation goals. Such strategy would provide clear leadership and direction from the top, facilitate coordination among ministries and agencies, and engage key stakeholders. The second pillar includes a range of inclusion- and sustainability-aligned policy interventions to address market and equity failures, tailored to economy-specific circumstances. The third pillar involves engagement with a broader group of key stakeholders, including the private sector, households, civil society, and local and international communities, to strengthen efforts that enable digital transformation for good.

5.1 | National Digital Strategies for Policy Alignment

Developing Asia can accelerate inclusive and sustainable development through a national digital strategy that explicitly incorporates inclusion and sustainability goals. While digital technologies have significant potential to deliver inclusive and sustainable benefits, market and equity failures can hinder these benefits from being realized. By explicitly incorporating inclusion and sustainability objectives into national digital strategies, digital policies can facilitate digital transformation in support of inclusive and sustainable development. For example, the Republic of Korea's overarching digital strategy, the Green IT National Strategy of 2009 supports both sustainability and digital transformation (Box 5.1). The Korean New Deal, launch in 2020, not only underpinned the establishment of green industrial complexes as part of a green and digital convergence project but also aimed to accelerate digital transformation while ensuring inclusion, particularly for small and medium-sized enterprises (SMEs), older people, and vulnerable groups. As part of the Korean New Deal of 2020 there are policy initiatives to expand digital infrastructure to underserved areas, enhance digital literacy for seniors and low-income households, and assist SMEs in adopting digital technologies. In Singapore, the Infocomm Media Development Authority (IMDA) launched a national initiative, Digital for Life, to strengthen digital inclusion and ensure that the benefits of technology reach everyone. IMDA also introduced the Seniors Go Digital program and the SME Go Digital program in 2020 to include disadvantaged groups in the digital transformation. Green digital transformation is an integral part of Singapore's Green Plan 2030, a nationwide initiative aimed at advancing Singapore's sustainable development agenda. In 2022, IMDA issued its Green Data Centre Roadmap to develop sustainable data centers that support Singapore's digital economy while reducing energy consumption and carbon emissions. Key efforts include the adoption of energy-efficient technologies, use of renewable energy and innovative cooling solutions, and collaboration with industry players to set sustainability standards.

Figure 5.1: An Inclusion- and Sustainability-Aligned Digital Policy Package



Source: Authors.

A national digital strategy helps strengthen cross-ministerial coordination. Aligning digital transformation with inclusive and sustainable development is a cross-sectoral effort in nature. But ministries and other government agencies typically pursue their objectives in isolated silos, adhering to established standard operating procedures. In many developing Asian economies, digital transformation and inclusive and sustainable development are viewed as separate national objectives, lacking alignment or coordination. Managing digital policies separately can lead to competing conflicting priorities weakening overall policy effectiveness. For example, different ministries might prioritize their distinct mandates, such as economic growth, environmental protection, and innovation. Therefore, coordination is needed at both the horizontal level (across different government departments) and the vertical level (between national and local governments) to align policies. In August 2024 for example, the People's Republic of China's Office of the Central Cyberspace Affairs Commission, joined by nine central ministries, issued the Implementing Guidelines on the Coordination of Digital and Green Transition and Development (Government of the PRC, 2024a). The guidelines aim to guide national departments, local governments, social organizations, and businesses toward a well-coordinated digital transformation and green growth. In this context, a well-defined national digital transformation strategy serves as a framework for aligning national objectives and guiding resource allocation (Portulans Institute 2024b).

An overarching national digital strategy entails a whole-of-government approach, enabling high-level leadership to support policy alignment and coordination. In practice, cross-ministerial entities can coordinate the government's overall alignment of digital transformation with inclusion and sustainability goals, with representatives from relevant agencies participating in a national digital strategy board. For example, Indonesia has a coordinating ministry, while Singapore operates its coordinating body under the Prime Minister's Office. In Malaysia, to implement the Malaysia Digital Economy Blueprint of 2021, the National Digital Economy and Fourth Industrial Revolution Council, comprising members from various ministries, was established to lead policy direction, with a steering committee responsible for coordinating and monitoring effective implementation. To ensure effective implementation, it may be beneficial to introduce new budgetary rules and procedures that incentivize inclusion- and sustainability-aligned allocations within ministries and agencies, alongside fostering cross-agency collaboration.

Box 5.1: The Republic of Korea's Integrated Policy Approach to Greening the Digital Sector

The Republic of Korea was one of the first governments in the world to explicitly prioritize green information technology (IT). The country's commitment to green growth was crystallized by the government's announcement of the national policy, Low Carbon, Green Growth, in August 2008. This was followed by the introduction of the Green IT National Strategy in May 2009, which emphasized a whole-of-government approach facilitated by cross-ministerial collaboration. This policy framework ensures that digital and climate policies are not set in separate silos.

The two strategic pillars of the Green IT National Strategy are (i) greening the IT industry itself through the transformation of the entire life cycle of IT products and services, and (ii) greening the entire economy using IT to maximize energy efficiency and accelerate the transition to a sustainable society.

In greening of the IT industry, the government prioritized three key tasks:

- Green IT product development and exports, which include PCs, TV displays, and servers with high market potential;
- Green IT services, where the government aims to increase IT service energy efficiency by 40% by greening data centers, adopting cloud computing, and greening broadcasting and communication network infrastructure; and
- Giga internet deployment to support the sustainable transition, with the government building a high-speed, high-capacity network that will be up to 10 times faster than current infrastructure.

The Korean New Deal, launched in 2020, builds on this approach (Government of the Republic of Korea 2021). The program consists of three pillars: (i) the Digital New Deal, (ii) the Green New Deal, and (iii) a Stronger Safety Net. Furthermore, the Green New Deal is underpinned by three key components: (i) a green transition in cities through spatial planning and living infrastructure, (ii) the diffusion of sustainable and distributed energy, and (iii) the establishment of innovative green industry ecosystems. Establishing sustainable and green industrial complexes is one of the four green and digital convergence projects of the Korean New Deal. As such, cities and municipal governments are forming public–private partnerships to develop large-scale green data centers (box table). The Korean New Deal combines efforts to achieve carbon neutrality with the acceleration of digital transformation (e.g., the transition to 6G). After the first year of implementing the Korean New Deal, the government announced an upgrade to Korean New Deal 2.0 to adapt changes to the strategy and address concerns, such as the surging demand for labor in new industries like software and the need to respond to external trends, including movements toward carbon neutrality and accelerating digital transformation.

Green Data Center Construction Projects as Part of the Korean New Deal

Project Name	Description	Project Period, Budget
K-Cloud Park (Gangwon-do)	The eco-friendly hydrothermal energy convergence cluster project is part of the Korean New Deal. One of the main goals of the project is to build six green data centers using cold water from Soyanggang Dam in Chuncheon, the capital city of Gangwon-do.	Invest W302.7 billion by 2025
Saemangeum Data Center Industrial Park (Jeollabuk-do)	The Saemangeum area of Gunsan City signed an agreement with SK Broadband—the internet infrastructure division of SK Telecom—to build 16 large-scale, renewable energy-powered data centers. The company's goal is to make the data centers run off 100% renewable energy by 2029.	Invest W2.0 trillion by 2029
Suncheon-NHN Cloud Data Center (Jeollanam-do)	In March 2021, the city of Suncheon signed a W300.0 billion investment agreement with NHN Enterprise to build public cloud data centers and a smart IT industrial complex in the city. The city plans to transfer public data to the cloud by 2025.	Invest W300.0 billion in a 20-year period

W = won.

Source: World Bank (2022).

continued on next page

Box *continued*

The Republic of Korea's decarbonization strategy and policies for the IT sector are part of the country's broader systematic efforts to achieve carbon neutrality. As one of the world's most connected countries and an early mover in this area, the Republic of Korea's experience offers valuable lessons for other countries seeking to adopt measures that enable the IT sector to make positive climate impacts while also reducing its own carbon footprint. Key takeaways from the Republic of Korea's systematic policymaking in greening its IT sector include (i) recognizing the importance of early commitment, (ii) long-term planning and comprehensive policies, (iii) setting clear priorities, (iv) investing in research and development to drive implementation, and (v) establishing a governance structure that allows a whole-of-government approach.

Source: World Bank (2022).

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Government of the Republic of Korea. 2021. *Korean New Deal 2.0*.

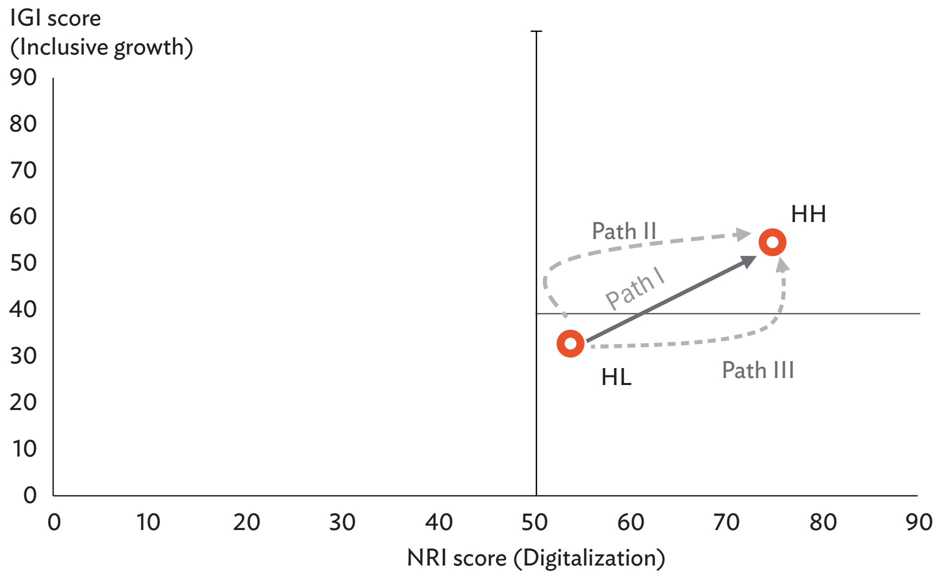
World Bank. 2022. Greening Digital in Korea: Korea Case Study for Greening the ICT Sector. *World Bank Korea Office Note Series*. Number 6.

5.2 | Tailored Inclusion- and Sustainability-Aligned Digital Policies

The implementation of inclusion- and sustainability-aligned digital policies must be tailored to local circumstances. Chapters 3 and 4 have outlined various policy tools—such as regulations and legislation, fiscal incentives, market mechanisms, and capacity-building and education programs— that can drive digital transformation to promote inclusion and sustainability. However, different economies have different priorities when addressing related market and equity failures. Following the classification in Figure 2.10, an economy's digitalization (Network Readiness Index [NRI]), inclusive growth (Inclusive Growth Index [IGI]), and environmental performance (Environmental Performance Index [EPI]) are compared to the global median. For example, economies with an NRI lower than the global median are classified as Low-Digitalization (LD) status. They must accelerate digital transformation to boost growth and income levels, which will, in turn, improve inclusion and sustainability. Each economy's policy choices will determine whether they follow Path I, II, or III to transition to the High-Digitalization, High-Inclusion and Sustainability (HH) status. For example, economies with High-Digitalization, Low-Inclusion and Sustainability (HL) status (HL) would benefit from taking Path I to achieve HH status (Figure 5.2).

The appropriate mix of policies thus relates to an economy's urgency in addressing market and equity failures during digital transformation. Table 5.1 briefly summarizes the policy priorities to address the related failures faced by three economy categories—LD, HL, and HH—according to their digitalization-inclusion and sustainability profiles, which serve as an illustrative example of an economy's local circumstances. For LD economies that need to accelerate their digital transformation, prioritizing the resolution of market failures that hinder universal connectivity and equity failures that exclude disadvantaged groups is essential. This will require building digital infrastructure, developing skills, and incentivizing the adoption of digital technologies. However, a deteriorating environment will ultimately harm growth and negatively impact disadvantaged groups. Therefore, to sustain inclusive growth, it is also important for governments to address market failures such as environmental externalities during the digital transformation process. In addition to government action, engaging a broad set of stakeholders can effectively harness digital transformation for

Figure 5.2: Transition to High Digitalization, High Inclusion and Sustainability Status



HH = High-Digitalization, High-Inclusion and Sustainability; HL = HIgh-Digitalization, Low-Inclusion and Sustainability; IGI = Inclusive Growth Index; NRI = Network Readiness Index.

Note: Path I represents a balanced transition, with equal emphasis on inclusion and sustainability as well as digitalization; Path II involves slowing down digitalization to help reduce its environment and inclusivity burden; and Path III focuses on accelerated digitalization to enhance energy efficiency and inclusion, but not necessarily sustainable digital technologies. Using the Environmental Performance Index (EPI) gives a similar chart. The chart using EPI is available upon request.

Source: Authors based on Kedia (2025).

Table 5.1: Policy Priorities Based on Digitalization-Inclusion and Sustainability Profiles

Economy Profiles	Examples of Regional Economies and Characteristics	Suggested Actions
LD	Upper and lower middle-income economies that are relatively low emitters and vulnerable to extreme weather events and disasters, including: Armenia, Azerbaijan, Bangladesh, Cambodia, Georgia, the Kyrgyz Republic, the Lao PDR, Mongolia, Nepal, Pakistan, the Philippines, Sri Lanka, and Uzbekistan	• Accelerate the building of digital infrastructure and capacity with cost-efficient solutions and help from stakeholders. • Adopt digital technologies to build climate resilience, such as disaster risk management and close digital divides.
HL	Upper and lower middle-income economies that have made rapid digitalization progress, including: the PRC, India, Indonesia, Kazakhstan, Malaysia, Thailand, and Viet Nam	• Accelerate innovation and adoption of inclusion- and sustainability-friendly digital technologies. • Decarbonize existing and new digital infrastructure.
HH	High-income economies with effective institutions, governance, and sufficient resources, including: the Republic of Korea and Singapore	• Lead the frontier of inclusion- and sustainability-friendly innovations. • Set good practices.

PRC = People's Republic of China; HH = High-Digitalization, High-Inclusion and Sustainability; HL = HIgh-Digitalization, Low-Inclusion and Sustainability; Lao PDR = Lao People's Democratic Republic; LD = Low Digitalization.

Source: Authors' compilation based on Kedia (2025).

Table 5.2: Examples of Stakeholder Actions in an Integrated Digital Policy Package

Failures to Be Addressed	Governments (Public Sector)	Businesses (Private Sector)	Households, Civil Society, and Local Communities	International Communities
Market Failure	• Incentives to enhance commercial viability of inclusion- and sustainability-friendly technologies • Regulations such as minimum coverage requirements, standards for energy efficiency, and renewable energy use • Market mechanism such as carbon pricing • Public provision of infrastructure and services	• Corporate strategies that incorporate inclusion and sustainability into profit • Sustainable technology innovation and initiatives, like supporting businesses in the ecosystem with emissions tracking • Nudging responsible behavioral changes	• Behavioral changes toward responsible practices • Educational program	• Financing and technical support • International collaboration
Equity Failure	• Regulations to ensure fairness and inclusion in the market and service delivery • Fiscal incentives to promote universal connectivity and improve affordability • Capacity building and skill upgrading	• Tax contributions • Inclusive technology innovation and initiatives such as training startup businesses on the use of digital platforms	• Community-led literacy and skilling programs	• Financial and technical support such as capacity building • International cooperation

Source: Authors' compilation based on Kedia (2025).

positive outcomes. Table 5.2 shows some illustrative entry points for policy choices, as discussed in Chapters 3 and 4, along with potential stakeholder engagement and connections to market and equity failures.

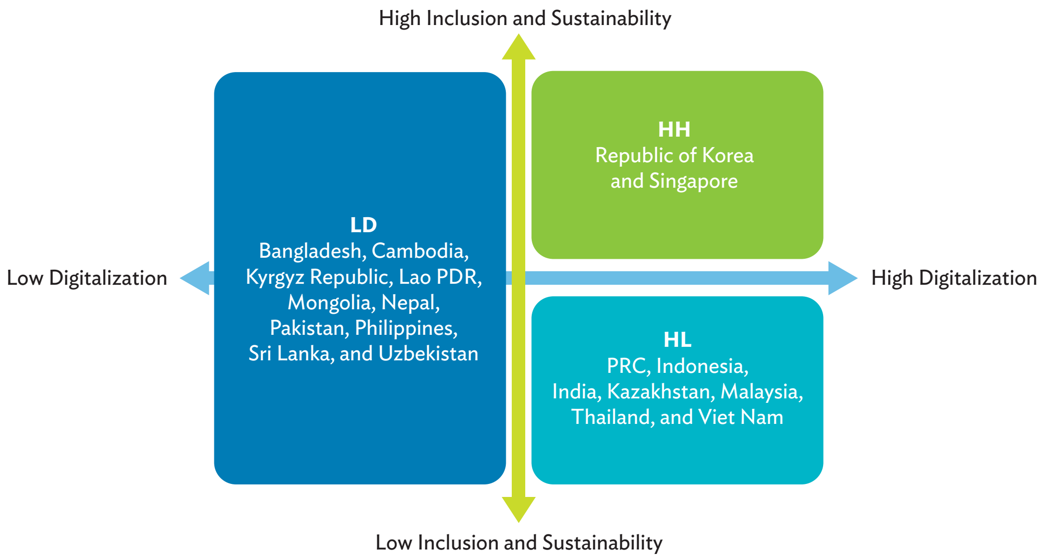
LD economies must accelerate digital transformation by investing in digital infrastructure and skills. Figure 5.3 simplified the three economy groups in Table 5.1 and shows that economies in the LD group typically consist of upper and lower middle-income economies that are minor emitters, such as Bangladesh, the Kyrgyz Republic, Mongolia, Pakistan, and Uzbekistan. These governments should prioritize investing in building digital infrastructure, improving affordability, and enhancing digital literacy and skills. By doing so, they can realize the scaling and leapfrogging benefits of digital technologies in terms of productivity, innovation, and growth opportunities. For example, in 2019, the Kyrgyz Republic adopted the Digital Kyrgyzstan 2019–2023 strategy, which aims to improve digital infrastructure and internet connectivity, enhance digital literacy, and provide IT education to promote employment opportunities (Government of the US, Department of Commerce, ITA 2024b). Governments can utilize tools such as fiscal incentives, public–private partnerships (PPP), and capacity-building programs to achieve these targets. For example, the Government of Fiji granted a 10-year tax exemption for IT operators within the Kalabu Tax Free Zone from 2007 to 2016, and a 13-year tax exemption for new operators establishing internationally accredited ICT training institutions, starting in 2015, to promote universal connectivity (Government of Fiji 2018). Bangladesh's National Broadband Policy leverages PPP to expand fiber networks in rural areas. Following the model of India's Digital Public Infrastructure system, as elaborated in

Box 3.4, these economies can also actively engage the private sector to quickly scale service deliveries such as fintech. Many of these economies are low emitters and particularly vulnerable to extreme weather events, as discussed in Chapter 1. Building digital infrastructure and enhancing digital literacy will enable them to utilize digital technologies to strengthen climate resilience and conduct effective disaster risk management. For example, AI-enabled analytics and forecasting can assist farmers with advice on drought resistant crop planting, while GPS-enabled monitoring can facilitate planning and responses during disasters. Box 4.2 illustrates how remote sensing can help Fiji conduct timely assessments of disaster impacts in the face of tropical cyclones.

LD economies can consider cost-efficient solutions and collaborate with stakeholders to accelerate digital transformation. According to the United Nations Trade and Development (UNCTAD 2023), low and lower middle-income developing economies will incur an annual average per capita cost of $416 to promote inclusive digitalization from 2023 to 2030. Given tight resource constraints, these economies should consider low-cost deployment solutions. For example, enabling spectrum sharing and secondary markets allows operators to lease, share, or trade spectrum to enhance efficiency. India has introduced intra-band spectrum-sharing policies to improve network utilization, thereby reducing costs for new entrants (Government of India, Ministry of Communications 2024a). Additionally, active and rural digital infrastructure sharing, as discussed in Chapter 4, can lower both deployment costs and emissions by reducing infrastructure duplication. The Philippines' Common Tower Policy encourages shared digital infrastructure to cut costs (Government of the Philippines, DICT 2020), while Thailand permits telecom operators to use public infrastructure to expedite fiber deployment. Emerging low-cost network solutions, such as low-earth orbit (LEO) satellites and 5G fixed wireless access for last-mile communications, can enhance connectivity in remote areas. Tapping into cloud-based solutions and virtual facilities not only decreases the deployment costs of digital infrastructure—such as upfront capital expenditures and ongoing maintenance and upgrades—but also scales up digital services cost-effectively. Furthermore, cloud-based solutions promote sustainability by avoiding the need for physical digital infrastructure. Given their relatively low-digitalization status, these economies have a unique opportunity to build the needed digital infrastructure and capabilities "from the ground up" to achieve the desired development outcomes, including the direct adoption of energy-efficient technologies, to shift toward HH status, as shown in Figure 5.3. In addition, LD economies also need to strengthen market competition to protect small businesses and consumers from unfair treatment, facilitating full participation in digital transformation. As shown in Figure 3.21, only a few LD economies have competition policies for the digital sector, while HH economies all have competition-related digital policies.

The HL group should leverage their digital infrastructure and skills to accelerate the innovation and adoption of inclusion- and sustainability-friendly digital technologies. Economies in this group—such as the PRC, India, Indonesia, Malaysia, Thailand, and Viet Nam—have made rapid progress in digital transformation. For example, many policy efforts have been devoted to boosting universal connectivity and building the digital skills needed to adopt digital technologies that improve service delivery—such as smart-tech, fintech, e-commerce, and platforms—which contribute to inclusion (Government of the US, Department of Commerce, ITA 2024b). An example is the Indonesia Digital Roadmap 2021–2024. Other initiatives from India and the PRC are listed in Box 5.2. To shift toward HH status, HL economies must continue investing in digital infrastructure, skills, and upskilling their workforce. For example, Viet Nam's National Digital Transformation Program (2020) aims to train 1 million people in digital skills by 2025, including coding, data analytics, and digital marketing. Subsidies such as the Universal Service Fund, along with incentives and regulatory tools—including coverage obligations at licensing or spectrum allocation—can boost universal connectivity. For example, Thailand's latest Universal Service Fund program collaborated with the Ministry of Social Development and Human Security to better identify slum areas and vulnerable populations to improve targeting efficacy and promote digital inclusion. India's Digital Competition Law of 2024 aims to curb unfair practices by large tech companies, thus helping SMEs thrive. Market mechanisms like spectrum allocation auctions, which are adopted by India and Indonesia, among other economies, can enhance

Figure 5.3: The Digitalization–Inclusion and Sustainability Profiles—Developing Asia, Selected Economies



PRC = People's Republic of China; HH = High-Digitalization, High-Inclusion and Sustainability; HL = HIgh-Digitalization, Low-Inclusion and Sustainability; Lao PDR = Lao People's Democratic Republic; LD = Low-Digitalization.

Note: The profiles are based on the latest versions of the Network Readiness Index (2024), the Environmental Performance Index (2024), and the Inclusive Growth Index (2023).

Source: Authors.

digital inclusion by improving efficiency of spectrum allocation. Thailand has implemented minimum coverage obligations for new spectrum allocations to promote universal connectivity. In January 2025, Indonesia launched Digital Skills Development Strategies to address the growing skill gap between job seekers and the evolving job market, aiming to equip the workforce with skills to meet current and future industrial demands. Malaysia's Digital Education Policy 2023 integrates digital technology into the learning environment, fostering digital literacy among students to prepare them for the digital economy. In Thailand, information and communication technology (ICT) and internet skills have been incorporated into the national curriculum (Smit, Autio, and Park 2025b). The Government of Thailand, in collaboration with educational institutions and nonprofit organizations, has conducted digital literacy campaigns to train citizens in effectively using digital devices and online services. Schools, community centers, and government initiatives now offer digital skills training to bridge the skill-related digital divide.

Meanwhile, HL economies should focus on decarbonizing digital infrastructure and accelerating sustainability efforts. According to Kedia (2025), some larger G20 developing Asian economies, such as India ($780 million) and Indonesia ($400 million), still lag behind the G20 average ($2.6 billion) in overall investment in green data centers. In 2024, the PRC introduced an action plan for green data centers, outlining specific green targets, including reducing the average effective power usage data centers to less than 1.5 by 2025 and increasing the use of renewable energy in data centers by 10% annually (Government of the PRC 2024b). Additionally, regulations and incentives could also be implemented to support these goals. Market mechanisms such as carbon pricing and disclosure of data centers' environmental performance can further promote the use of energy-efficient digital solutions.

Box 5.2: Examples of Inclusion- and Sustainability-Aligned Digital Policies in the People's Republic of China and India

The People's Republic of China

The People's Republic of China (PRC) launched the Guidelines for Coordinated Digital and Green Transformation in August 2024, aimed at coordinating the transformation toward digital development and green growth (Government of the PRC 2024). These guidelines outline fundamental principles to "promote the green, sustainable development of digital industries" and "accelerate the green transformation of various sectors through digital technology." They also specify the roles of key stakeholders—including government authorities, business and industry associations, and research institutes—during the digital and green transitions.

Internet Plus is an initiative launched in 2015 that seeks to integrate digital solutions—such as mobile internet, cloud computing, big data, and the Internet of Things (IoT)—with traditional industries—including agriculture, health care, and education—to enhance efficiency, strengthen competitiveness, and promote innovation. According to ADB (2018), some activities enabled by the initiative include:

- Pilot projects aimed at improving access to e-commerce platforms and information for villages and rural households. The government invested CNY8.4 billion to support 496 counties across the country in launching comprehensive demonstrations of e-commerce entry into rural areas. Key areas covered include (i) the establishment of a rural e-commerce public service system and credit cooperatives; (ii) the development of trade or the flow of goods in rural areas; and (iii) personnel training to address the talent shortage in rural e-commerce, among others.
- Promoting "intelligent agriculture" practices by allocating funds through two batches of national demonstration projects for IoT applications. Implementing intelligent agriculture practices helps reduce emissions from the agriculture sector through the optimized use of fertilizers and pesticides, thereby reducing associated soil pollution and greenhouse gas emissions.

India

The National Smart Grid Mission was established by the Government of India in March 2015 to accelerate the deployment of smart grid technologies across the country. The National Smart Grid Mission uses AI, the IoT, and blockchain to modernize India's power grid, promoting the adoption of technologies that reduce and optimize energy consumption while boosting grid reliability. For example, AI analyzes real-time energy consumption, enabling demand prediction and preventing power outages. Smart meters and IoT sensors facilitate dynamic energy distribution by providing real-time data. In addition, these technologies enable the integration of solar and wind renewable energy sources, contributing to India's transition. The government has also invested in developing smart grids in smart cities and micro grids, as well as in training and capacity building, and consumer engagement.

The Digital India Initiative was launched in 2015 to transform India into a digitally empowered society and knowledge economy. The Government of India has implemented various policies to foster inclusive development. Some examples include

- **BharatNet,** an initiative to connect rural areas with high-speed broadband, ensuring that even remote regions can access digital services;
- **Pradhan Mantri Gramin Digital Saksharta Abhiyan**, an initiative that aims to increase digital literacy among rural populations by training citizens to use digital technologies, thereby improving access to government services and digital marketplaces and promoting financial inclusion; and
- **Bharat Interface for Money**, a digital payments platform that encourages inclusive financial participation, including for marginalized groups.

The Government of India has also launched other programs to promote sustainable solutions using digital tools. For example, India's Green Credit Program, introduced in 2023, encourages individuals and entities to take climate-positive actions by rewarding participants with green credits.[a] This program uses digital tools, such as a web platform, to streamline operations like registration, verification, and monitoring of plantation-related activities.

[a] Government of India, Ministry of Environment, Forest, and Climate Change. Green Credit Programme.

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Government of the People's Republic of China (PRC). 2024. China Issues Guidelines for Coordinated Digital, Green Transformation. News release. 26 August.

Source: Authors.

HH economies can lead in frontier technologies by focusing on policies that promote innovative inclusion- and sustainability-aligned digital solutions. With relatively advanced digital infrastructure and skills, governments of HH economies—such as the Republic of Korea and Singapore—can leverage their institutions, governance, and digital capabilities to create an enabling environment for innovative digital solutions that support inclusive and sustainable development. Regulations, fiscal incentives, and market mechanisms can all be used to promote inclusion- and sustainability-friendly digital technologies in HH economies. For example, Singapore's Digital Connectivity Blueprint 2023 aims to develop green data centers and optimize the energy efficiency of existing data centers. Singapore is implementing the Green Software Trials Initiative to reduce the carbon footprint of software. The government offers grants and subsidies through programs such as the Green Computing Funding Initiative to support research and trials in green software, as well as the Seniors Go Digital Program to ensure that disadvantaged groups, such as low-income older people, have access to smartphones and mobile plans (Government of Singapore, Ministry of Communications and Information, IMDA 2023a, 2025). The Digital Strategy of Korea aims to establish the best practices in digital innovation and position the country as a leader in digital technology. This strategy directs investment toward research and development in major innovative digital technologies, including AI, AI semiconductors, 6G communication, and quantum computing (Government of the Republic of Korea, Ministry of Science and ICT 2022a). Both Singapore and the Republic of Korea have the institutional frameworks necessary to implement carbon pricing, which can drive the adoption of energy-efficient technologies and the use of renewable energy. HH economies must also invest in skill upgrading to equip their digital workforce with needed skills for future jobs.

5.3 | Engaging a Broad Range of Stakeholders

The private sector's participation can effectively align digital transformation with inclusion and sustainable objectives. Leading global digital companies such as Google, Microsoft, Alibaba, and Amazon have established corporate strategies that incorporate inclusion and sustainability alongside profit-seeking. For example, Google has been carbon-neutral since 2007 and aims to operate its data centers and campuses on 100% renewable energy sources by 2030. Amazon, through initiatives like Amazon Saheli and Amazon Karigar, supports women entrepreneurs and artisans in Bangladesh, helping them sell their products and grow their businesses on its platforms. These initiatives signal the shifting mandates and preferences of stakeholders and influence their business partners in developing Asia. Consequently, many regional digital companies have adopted sustainable practices and launched responsible initiatives. For instance, Malaysia's AirTrunk, a data center operator, has initiated renewable energy projects by installing a 1-megawatt rooftop solar system at its data center in Johor Bahru, aiming for net-zero emissions by 2030. Additionally, India's HCLTech aims to improve gender diversity in its workforce, targeting women to make up 40% of its total workforce and 30% of senior leadership positions by 2030 (HCLTech 2024). The private sector has also developed innovative solutions to promote sustainability reporting for their clients and supply chains. For example, Alibaba's Cloud Energy Expert is a digital platform that helps businesses, including SMEs, monitor and track their environmental impacts such as carbon emissions and energy consumption. It provides tools for sustainability reporting and energy management systems, facilitating the creation of green supply chains.

Governments can actively engage private sector digital champions and innovations to drive inclusive and sustainable digital transformations. A typical example of such innovation is India's Digital Public Infrastructure system, which offers a new approach to digitalization that facilitates the delivery of nationwide services by leveraging private sector innovation and entrepreneurship, as discussed in Box 3.4. Singapore's Green Data Center Roadmap of 2024 specifies that the government will codevelop standards and certifications with the private sector. Additionally, the Government of Singapore has initiated public and private sector collaborations, such as the Sustainable Tropical Data Centre Testbed, to promote innovation in optimal cooling technology for tropical climates (NUS 2023). Some illustrative areas where governments can collaborate with the private sector include the following:

- **Sharing public infrastructure.** Infrastructure sharing between operators and existing public goods and assets—such as schools, parks, hospitals, and libraries—helps the private sector expand digital infrastructure coverage in underserved areas while reducing both deployment costs and emissions by avoiding the construction of new digital infrastructure (Oughton 2025).
- **Nudging behavioral changes.** Many leading digital companies run nudging programs to influence individuals' sustainability behaviors. For example, Alipay's Ant Forest program promotes a greener lifestyle by integrating sustainable activities into daily routines. According to Liu (2022), Ant Forest developed algorithms to quantify individuals' sustainable behaviors as "green energy points." For instance, riding a shared bike earns 159 green energy points per day, equivalent to a reduction of 159 grams of carbon emissions. Although these green energy points do not provide direct financial benefits, they can be redeemed for virtual trees planted by Ant Forest, or for virtually protecting nature reserves, with Alipay implementing the actual tree planting and nature reserve protection. These programs encourage individuals to adopt sustainable lifestyles and foster preferences for green investments (Gao et al. 2024). Governments can collaborate with the private sector to develop effective nudging schemes that promote responsible lifestyles.
- **Close digital divides.** To effectively utilize public resources, governments in developing Asia are increasingly adopting whole-of-society approaches and partnering with the private sector to bridge digital divides. For example, women's representation in science, technology, engineering, and mathematics (STEM) sectors significantly declines during the transition from university to the workforce (UNDP 2024). Many young and qualified women graduates in the PRC and Malaysia choose not to enter the STEM workforce due to a lower sense of self-efficacy and perceived limitations in career advancement opportunities. Policy interventions can promote women's participation in the STEM sector. Governments can collaborate with the private sector to certify and reward women-friendly workplaces. Some governments partner with the private sector to launch women-sensitive programs that equip women with the requisite skills for tech jobs. For example, Sri Lanka's SheCodes program offers free coding classes to women.[17] Similar initiatives can help close digital divides affecting older people and low-education groups. Governments and the private sector can jointly develop inclusion-aligned practices and standards to ensure that digital applications and services reach disadvantaged groups such as older people and speakers of minority languages. For instance, smartphone producers and application developers can introduce inclusion-aligned features, including larger fonts and multiple language options to accommodate speakers of different languages.

Collaborating with various domestic stakeholders amplifies the impacts of digital policies that harness digital transformation for good. As shown in Table 5.2, governments can engage domestic stakeholders—including households, civil society, nongovernment organizations, and local communities—to address market and equity failures. Engaging various stakeholders such as investors and consumers facilitates public monitoring, which can act as a stewardship mechanism to improve inclusive and sustainable practices (Mortimer 2025). For example, the effects of government spending on environmental monitoring technology for air quality improvement are primarily driven by increased public awareness and active monitoring of air quality in the PRC (Liang, Liu, and Tian 2025). Additionally, there are significant benefits to governments collaborating with civil society, nongovernment organizations, and local communities to develop and roll out educational and capacity-building schemes in targeted areas. These local stakeholders possess the knowledge and trust necessary to effectively execute community-led literacy and skills programs. For example, in India, tech start-ups like Easy Hai and nonprofit organizations such as HelpAge India have conducted digital literacy workshops for the older people (Lim 2023). HelpAge

[17] Delac Foundation. The Delac Foundation Supports Sri Lankan Women.

India has successfully empowered seniors to become more independent and proficient in online banking and social media, allowing them to stay connected with their families and the world (Bhandari 2020).

Developing Asia can strengthen international cooperation to promote inclusion- and sustainability-aligned digital solutions. Greater international collaboration is essential for expanding the scope of digital activities across borders by addressing shared challenges such as cybersecurity, data governance, and interoperability standards. Governments should work together to support initiatives that harmonize international digital standards and prevent the creation of digital silos. Smaller or emerging economies can benefit significantly from regional cooperation frameworks like the Association of Southeast Asian Nations (ASEAN) Digital Integration Framework, which promotes shared standards and facilitates technology transfers. Currently, ASEAN economies are negotiating a digital economy framework agreement that is expected to cover several aspects of digital transformation, including talent development, regulations, and connectivity. This agreement will enable firms, both large and small, to expand internationally in a cost-effective, efficient, and seamless manner. Meanwhile, leading economies have the responsibility to drive global initiatives by setting standards for responsible digitalization, ethical AI, and sustainable technology practices (Smit, Autio, and Park 2025a). For example, Singapore has signed four digital economy agreements: the Digital Economy Partnership Agreement with Chile and New Zealand, the Singapore–Australia Digital Economy Agreement, the United Kingdom–Singapore Digital Economy Agreement, and the Republic of Korea–Singapore Digital Partnership Agreement. These agreements aim to establish international rules on various parameters, such as cross-border dataflow, data protection, data innovation, digital identity, and digital payments, thereby encouraging digital trade and facilitating interoperability through aligned standards. Furthermore, the absence of a robust legal framework for digital trade often imposes additional regulatory compliance costs on firms, particularly SMEs, discouraging their participation in international trade. Developing Asian economies can collaborate to promote trade by standardizing digital trade documentation and enhancing cross-border interoperability, such as by adopting the Model Law on Electronic Transferable Records.

Multilateral organizations can assist developing Asian governments in aligning digital transformation with inclusive and sustainable development. As shown in Table 5.2, engaging international institutions can help address market and equity failures through knowledge support, capacity building, and financial assistance. For example, Indonesia launched its Digital Transformation Multi-Stakeholders Partnership Initiative in March 2024. This initiative aims to accelerate digital transformation in alignment with the Sustainable Development Goals through multistakeholder collaboration among governments, private companies, civil society organizations, research institutions, and international organizations (UN Indonesia 2024). United Nations (UN) agencies, the Nationwide University Network of Indonesia, and the Indonesian Digital Leadership Association are leading this initiative to combine expertise and resources for developing and implementing digital solutions that benefit the broader community. Similarly, Fiji is collaborating with the UN Office for Project Services to codevelop its National Digital Strategy, to ensure that no one is left behind in the transformation process (UNOPS 2024). The development of this digital strategy involved comprehensive consultations with domestic stakeholders, including public and private sector institutions, academia, religious organizations, and civil society organizations in 2024. Box 5.3 elaborates on how multilateral development banks such as ADB work with the governments of developing member countries to promote digitalization in remote areas like the Pacific.

Box 5.3: Empowering Governments and Communities in the Pacific

The Pacific remains one of the least digitally connected regions globally, with less than 20% internet penetration due to costly and unreliable satellite-based connectivity. Recognizing the critical role of digital connectivity in economic development, the Asian Development Bank (ADB) has been instrumental in enhancing the region's digital infrastructure since 2010. For example, ADB supported the implementation of five submarine cable systems in Tonga, Samoa, Palau, Cook Islands, and Kiribati. These systems have significantly improved internet connectivity, affordability, and reliability, laying the foundation for broader digital transformation. Following the establishment of submarine cable infrastructure, ADB has focused on empowering governments to strengthen digital capacities and leverage improved connectivity for better social service delivery. Through projects like the Pacific Information and Communication Technology Investment Planning and Capacity Development Facility, ADB supports the advancement of information and communication technology (ICT) policy and regulatory frameworks, ICT application development, and the adaptation of technological innovations.

One notable example is the "Smart Islands in the Pacific" project, a collaboration between the International Telecommunication Union and ADB. This 2-year project, running from October 2022 to December 2024, targets Fiji, Papua New Guinea, and Vanuatu. The project developed the Smart Villages and Smart Islands (SVSI) Model to provide affordable connectivity and sustainable digital services to remote communities, enhancing their well-being and livelihoods through digitally enabled solutions.

The Smart Villages and Smart Islands Model

The SVSI Model adopts a whole-of-government approach, emphasizing demand-driven, user-centric, flexible, and sustainable solutions. It focuses on four key pillars:

- Improving broadband connectivity: Enhancing internet access in remote areas to bridge the digital divide.
- Making broadband affordable: Reducing the cost of internet services to ensure accessibility for all.
- Enhancing digital skills: Providing training and resources to equip communities with the necessary digital competencies.
- Providing digital services: Implementing digital solutions tailored to local priorities, such as e-health, e-education, and e-commerce.

This model ensures that digital transformation reaches the grassroots level, leaving no one behind and fostering inclusive growth.

Source: Rahman et al. (2025).

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Harnessing Digital Transformation for Good

Asian Development Policy Report

Asia and the Pacific is undergoing a rapid digital transformation, presenting opportunities to promote inclusive and sustainable development. However, if not well managed, digital transformation can exacerbate inequality and compromise environmental sustainability. This Asian Development Policy Report highlights tailored policies to harness digital transformation as a catalyst for accelerating inclusive and sustainable development throughout the region.

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