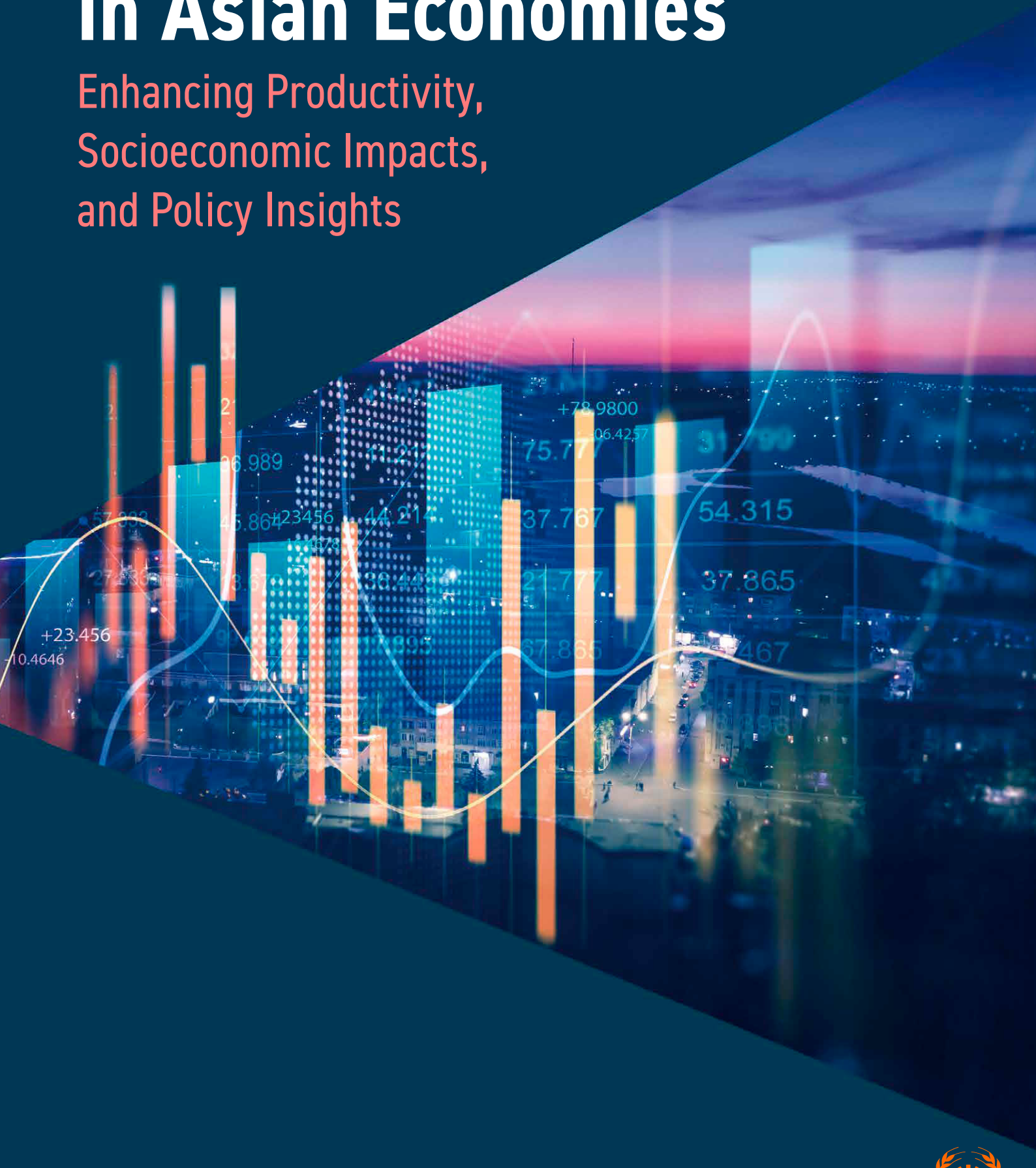
Digital Transformation in Asian Economies

Enhancing Productivity, Socioeconomic Impacts, and Policy Insights



Asian Productivity Organization

The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the National Productivity Organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 members.

APO Members

Bangladesh, Cambodia, Republic of China, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Turkiye, and Vietnam.

DIGITAL TRANSFORMATION IN ASIAN ECONOMIES

Enhancing Productivity, Socioeconomic Impacts, and Policy Insights

JULY 2024 | ASIAN PRODUCTIVITY ORGANIZATION

DIGITAL TRANSFORMATION IN ASIAN ECONOMIES:
ENHANCING PRODUCTIVITY, SOCIOECONOMIC IMPACTS, AND POLICY INSIGHTS

Dr. Nobuyuki Shirakawa served as the chief expert and volume editor.

First edition published in Japan
by the Asian Productivity Organization
1-24-1 Hongo, Bunkyo-ku
Tokyo 113-0033, Japan
www.apo-tokyo.org

Designed by Samvac LLP

CONTENTS

FOREWORD

In the ever-accelerating march of technological progress, Digital Transformation (DX) has emerged as a catalyst for profound change worldwide, across industries, economies, and societies. As we stand at the threshold of this digital revolution, the publication of research on emerging trends in DX could not be more timely or pertinent. DX is not a one-size-fits-all phenomenon; it manifests uniquely in each economy, influenced by its developmental stage, infrastructure, and strategic priorities. Understanding these nuances is paramount to developing effective DX strategies tailored to specific national needs and goals.

The twelve APO members covered in this report highlight that digitalization offers unprecedented opportunities to leapfrog traditional stages of development and accelerate integration into the global economy. However, realizing this potential demands more than simply alignment of policies, investments, and societal aspirations. It requires a holistic approach encompassing robust infrastructure development, comprehensive digital literacy programs, and innovative ecosystem support mechanisms. By fostering inclusive growth, bridging the digital divide, and nurturing local digital ecosystems, nations can not only benefit from the transformative potential of digital technologies but also empower their citizens, promote economic resilience, and drive sustainable development.

The journey toward enhanced productivity and innovation of the twelve APO member economies through DX is a multifaceted one, marked by both promises and challenges. This research not only highlights the transformative potential of DX but also offers actionable insights and strategic recommendations to help navigate the challenges posed by disparities, cybersecurity threats, and environmental sustainability concerns, thereby contributing to informed decision-making and effective policy formulation in the digital age. Furthermore, by synthesizing insights from diverse perspectives and experiences across APO member economies, the research results encourage collaboration and knowledge-sharing, facilitating a collective approach to harnessing the full benefits of DX for inclusive, sustainable development.

The efforts of the team of experts led by Dr. Nobuyuki Shirakawa, Associate Professor, Niigata University, Japan, and supported by national experts from Bangladesh, Cambodia, the ROC, India, Mongolia, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, Turkiye, and Vietnam who conducted the research and wrote this publication are greatly appreciated. It is hoped that the *Digital Transformation in Asian Economies: Enhancing Productivity, Socioeconomic Impacts, and Policy Insights* will illustrate pathways to sustainable, inclusive digital economies and help create a world where the transformative potential of digital technologies is harnessed for the benefit of all.

Dr. Indra Pradana Singawinata
Secretary-General
Asian Productivity Organization
Tokyo

INTRODUCTION

Digital Transformation and Socioeconomic Changes

Digital transformation (DX) presents a diverse landscape globally, particularly in Asian countries. This approach differs according to each nation's developmental stage, infrastructure, and strategic priorities. Understanding these nuances is crucial for formulating effective DX strategies tailored to address specific national needs and goals.

DX fundamentally reshapes business and national operations by integrating digital technology, profoundly impacting productivity, and offering numerous advantages. It enhances efficiency through automation, accelerates innovation by fostering new products and business models, and improves decision-making with better access to information and analysis. Additionally, it expands educational opportunities, which is crucial for developing a skilled workforce, and enables market expansion and flexible work practices. Moreover, it supports sustainable development by promoting resource optimization and energy efficiency.

While DX offers numerous advantages, it also poses challenges, including disparities in cybersecurity and environmental sustainability. One of the key challenges is translating productivity gains at the organizational level to national productivity. In addressing these challenges, the government plays a pivotal role. It must develop supportive infrastructure, promote education reform, and establish robust regulatory frameworks. The ICT industry, with its digital financial services, e-commerce, and digital marketplaces, is a significant growth catalyst. Education reform and cybersecurity are also critical for the success of DX, offering both challenges and opportunities for developed and emerging countries.

Digital Transformation and Policy Agenda

DX entails utilizing digital technologies to transform a business or organization's business model, operations, customer experience, and workforce to gain a competitive advantage. Research on the relationship between DX and productivity has been extensive in recent years, both domestically and internationally. In 2021, Japan's Ministry of Economy, Trade and Industry published the DX Report 2.1. The report estimates that the progress of DX could increase Japan's GDP by about JPY150 trillion and productivity by about 30% by 2030 [1–2].

In 2019, the OECD published the Productivity-Led Growth Policy Agenda, emphasizing the importance of DX in addressing labor shortages and achieving sustainable growth. DX is expected to significantly impact productivity at national and enterprise levels [3]. By leveraging digital technologies, businesses and organizations can improve efficiency, automate tasks, and create new business models, all of which can lead to productivity gains.

Digitalization has fundamentally reshaped industry and society in the last decade, highlighted by concepts such as Industry 4.0 [4–6] and Society 5.0 [7]. While distinct in focus and scope, these paradigms converge on technology's transformative potential. Industry 4.0, synonymous with the

Fourth Industrial Revolution (4IR), targets manufacturing efficiency and automation, leveraging information and communication technologies.

Society 5.0, a broader societal vision initiated by Japan, aims to merge digital and physical spaces to tackle complex societal challenges across healthcare, education, and the environment, thereby fostering an inclusive and sustainable society. Despite their distinct focuses, Industry 4.0 and Society 5.0 are committed to leveraging technology for societal advancement. Their synergy lies in using industrial advancements (from Industry 4.0) to propel societal goals (of Society 5.0), such as improving healthcare with smart devices.

Industry 4.0

This concept revolves around industrial automation, data exchange, and manufacturing technologies. It aims to increase production efficiency and customization through real-time data analysis and interconnected systems.

Society 5.0

Proposed by Japan, Society 5.0 envisions integrating advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain into everyday life. It focuses on resolving social issues and improving the quality of life, emphasizing human-centric solutions.

Exploring DX: Trends and Policy Insights Among the APO Members

The project, Research on Emerging Trends in the APO Members, is designed to delve into the evolving DX landscape within various sectors such as industry, agriculture, public services, and service industries across the APO member economies. It aims to scrutinize the adoption and impact of advanced technologies, such as IoT and AI, focusing on their influence on productivity, sustainability, and the diverse challenges and opportunities in different regions.

The study provides evidence-based policy recommendations to enhance productivity and competitiveness among the APO members, addressing the varying pace of DX and its broader implications. National experts from the APO member economies, including policy analysts and academic researchers specializing in digital technologies, contributed to a thorough and multifaceted understanding of these trends and their effects on socioeconomic progress.

This research project focuses on DX across various sectors within the APO economies and aims to explore emerging trends and innovations in the industry, agriculture, public, and service sectors. Utilizing a methodology grounded in horizon scanning and an extensive literature review, the study includes coordination meetings and scenario analysis to identify and neutralize critical drivers of disruptive change. The analytical framework involves horizon scanning, identifying pivotal drivers, setting priorities, and analyzing fundamental scenarios from a macro external environment perspective. This enables the identification of multidimensional technological trajectories by considering country-specific differences.

The goal was to provide nuanced policy recommendations and capture the diverse stages of economic development and national circumstances. This study analyzes how digital technology is adopted and its impact on productivity across national contexts. The findings are summarized in a comprehensive report highlighting commonalities and differences among countries.

Context

Digital Transformation and National Productivity

Digitalization offers the APO member countries a pathway to bypass traditional industrialization, accelerating their shift to knowledge-based economies and enhancing productivity. This involves adopting digital technologies and creating new value chains, which play a more significant role in the global economy. However, this requires tailored public policies and industry strategies to build robust digital infrastructure, ensure Internet access, and foster digital literacy.

It is also crucial to develop local digital ecosystems, support Small and Medium Enterprises (SMEs), and integrate digital technologies into sectors such as agriculture and manufacturing for efficiency and competitiveness. Inclusive digitalization ensures equitable benefits and is the key to socioeconomic development. Ultimately, embracing digitalization is a strategic move for the APO members, leveraging their unique attributes for sustainable and inclusive growth in the global economy.

In economic development, a critical observation is equalizing opportunities for productivity gains via DX. It transcends varying stages of economic development, geographic conditions, and contextual factors. This technological shift in productivity is not uniform; instead, it presents diverse trajectories deeply influenced by each nation's distinct industrial strategies and the digital transformation of their public sectors. To address these complexities systematically, this study proposes a comprehensive analytical framework. This framework discerns common drivers of change, scrutinizes the industrial focus of individual countries, pinpoints potential impediments to enhancing productivity, and offers tailored policy recommendations based on these insights.

Additionally, the report delineates the common patterns and scenarios emerging from this analysis, providing a nuanced understanding of the interplay between technological advancement and economic development in various national contexts. Going ahead, the report explores how threats, opportunities, potentials, and optimal productivity growth are interconnected and influence each other in the broader context of economic development and strategic planning.

Uneven Pace of Digital Transformation

DX is an ongoing process that dynamically integrates digital technologies into various aspects of business and governance. Staying ahead of this rapidly evolving digital landscape is crucial for the APO members. However, the pace and extent of DX vary across sectors and economies, presenting unique challenges and opportunities for industries and regions. Understanding these variations is essential for policymaking and strategic business decisions to enhance productivity and competitiveness.

Considering the varying pace and impact of DX across sectors and economies within the APO member economies, there is a pressing need for a comprehensive scenario that addresses these disparities while fostering growth and productivity. This scenario needs to consider how emerging technologies like IoT and AI affect productivity and sustainability and address the unique challenges and opportunities in different regions. By combining insights from policy analysts and academic researchers in digital technologies, it aims to provide evidence-based policy recommendations tailored to the specific needs of each sector and region. This approach aims to boost overall socio-economic progress and competitiveness among the APO members.

Developed Vs. Emerging Countries

The approaches to DX differ between developed and emerging countries. Both contexts show DX's role in boosting productivity through enhanced efficiency, innovation, and economic diversification.

Developed Countries

These nations, especially in Europe and the US, use DX to enhance service-oriented sectors, such as finance and healthcare. They focus on innovation, advanced technology integration, and sophisticated digital solutions.

Emerging Asian Countries

With the focus on manufacturing and agriculture, DX is more gradual among emerging Asian countries. These countries face a digital divide but invest in digital infrastructure and skill development to catch up.

Navigating Challenges in Emerging Economies

Innovation within emerging economies is characterized by its nonlinear nature, marked by a web of interdependencies and challenges in adoption, necessitating a nuanced understanding of sectoral evolution and adaptation. The digitization of these economies, significantly influenced by Society 5.0 and Industry 4.0, goes beyond technological adoption to signify a profound transformation in societal and industrial dynamics. In this transformation, traditional stages of development are bypassed, and the sequence of industrial focus is reversed. For example, Mongolia's pastoralists may digitize before their manufacturing sector. However, this innovative landscape is fraught with challenges, such as co-innovation risk, where an innovation's success depends on the commercialization of another (e.g., the dependency of a new electric vehicle's success is dependent on advanced battery technology), and adoption chain risk, where the failure of early adopters to recognize an innovation's value can hinder overall adoption and success. These risks are compounded by broader infrastructure issues in member economies, posing significant barriers to innovation and productivity.

Leapfrogging: Opportunities for Emerging Economies

Leapfrogging, a pivotal concept in the digitalization of emerging economies [8–13], describes the phenomenon where these countries bypass traditional stages of technological development, swiftly adopting advanced technologies. Unlike the gradual development path in more developed nations, emerging economies leverage leapfrogging to modernize and innovate rapidly. This is particularly evident in sectors such as telecommunications, where many countries have bypassed the development of extensive landline networks and directly embraced mobile technology and the Internet.

This strategic approach allows emerging economies to quickly and efficiently access cutting-edge technologies, accelerating their development and integration into the global digital economy. However, this rapid transition also brings challenges, such as ensuring sufficient infrastructure and skill training to utilize these technologies fully. Thus, leapfrogging is a pivotal strategy in the digitalization narratives of emerging countries, offering both accelerated progress and new challenges to address.

Methodology

Scope

The study aims to provide concrete policy recommendations for the APO members to guide their national productivity initiatives effectively. It offers an in-depth examination of emerging trends in priority sectors. It explores practical ways to increase productivity and enhance competitiveness by adopting new technologies and innovative practices. This research examines DX across critical

sectors within the APO member economies, aiming to identify emerging trends and innovations in the industry, agriculture, public, and service sectors. Employing a methodology grounded in horizon scanning and an extensive literature review, this study includes scenario analysis to pinpoint and address primary drivers of disruptive change.

This research delves into emerging DX and innovation trends across various sectors such as industry, agriculture, public, and service, focusing on the APO members. It aims to understand the impact of these trends on productivity and sustainability and the policy implications of adopting new technologies and innovations. This study's comprehensive approach is designed to yield nuanced policy recommendations and maintain consistency across country reports. It aims to explore the mechanisms of digital technology acceptance and productivity enhancement in each country, contributing significantly to understanding the dynamic interplay between digital technology and productivity enhancement in various national contexts.

Methodological Approach

The analytical framework comprises horizon scanning, identifying pivotal drivers, setting priorities, and analyzing fundamental scenarios from a macro external environment perspective. This enables the identification of multidimensional technological trajectories by considering country-specific differences. The goal was to provide detailed policy recommendations and understand the various stages of economic development and national circumstances. This study analyzes how digital technology is adopted and its impact on productivity in different countries. The findings are summarized in a comprehensive report highlighting commonalities and differences among countries.

This study adopts a horizon-scanning methodology supported by an extensive review of literature and documents related to digitization and megatrends. Workshops were conducted to identify these megatrends, followed by a scenario analysis to address key drivers of disruptive social change. This research involves horizon scanning, identifying critical drivers, setting priorities, and analyzing fundamental scenarios from a macro external environment. The process aims to identify multidimensional technological trajectories, considering specific conditions in each country, to provide detailed policy recommendations.

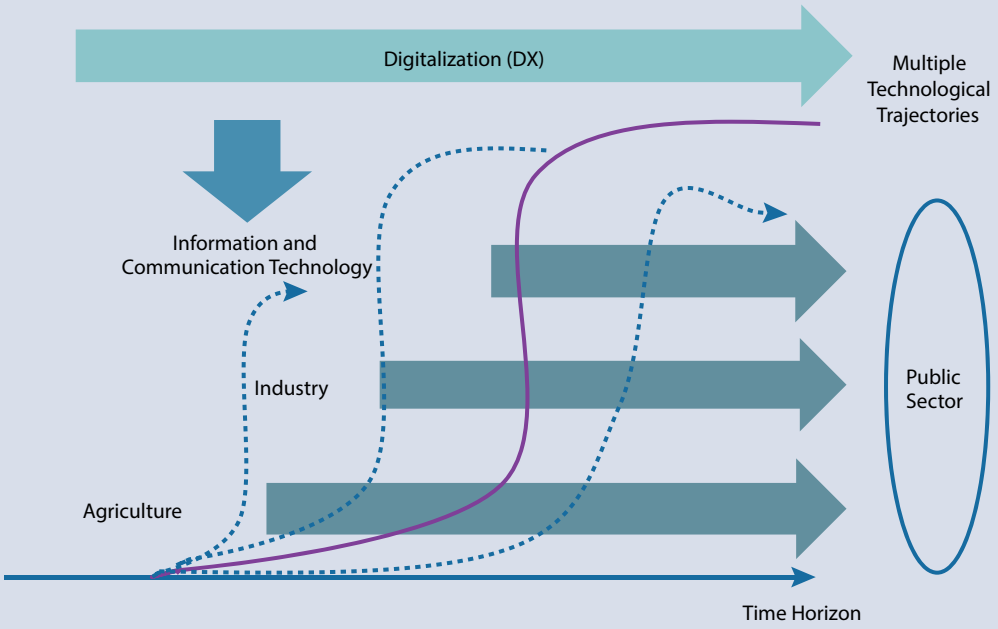
Unlike typical foresight reports that assume a uniform diffusion of technology, this study acknowledges the variability in digitization across countries. It applies a consistent analytical framework to accurately analyze technological trends and how different countries adopt digital technology. This helps in understanding digital technology's role in driving productivity growth. This Synthesis Report summarizes the survey from each country, identifies commonalities and differences, and categorizes them in a typology. It presents several scenarios for productivity gains that can be implemented in each country's context, depending on its stage of industrial development, leading to significant productivity gains without the need for gradual industrialization, surpassing previous limitations.

Analytical Framework

The research implementation procedures for the project include horizon scanning, identification of key drivers, priority setting, and analysis of basic scenarios based on macro-external environment analysis. It is followed by scenario-based identification of various technological paths based on differences in each country's conditions, resulting in policy recommendations.

FIGURE 1

FRAMEWORK MODEL: MULTIPLE TECHNOLOGY TRAJECTORIES OF DIGITALIZATION.



Source: Digital Transformation in Asian Economies: Enhancing Productivity, Socioeconomic Impacts, and Policy Insights, APO, 2024.

Country-Specific Analysis

The report summarizes surveys from each country, identifies commonalities and differences, and categorizes them into a typology. It presents scenarios for productivity gains based on each country's industrial development stage, allowing for significant productivity improvements without the need for gradual industrialization. This study meticulously investigates the impact of DX on productivity, considering various stages of economic development, geographical conditions, and national circumstances. It seeks to identify the common drivers of DX, analyze industrial focuses, identify barriers to productivity, and propose tailored policy recommendations. The ultimate goal is synthesizing findings depicting common changes and scenarios emerging from global DX experiences.

Emerging Trends in Digital Transformations

The study investigates the latest developments in digital technology and innovation within the industry, agriculture, public, and service sectors.

Country-Specific Analysis

This includes assessing how different the APO members are adopting new trends and technologies and the unique challenges and opportunities they encounter.

Impact on Productivity and Sustainability

This entails evaluating how emerging trends affect productivity improvements and sustainable practices.

Policy Implications

The report focuses on guiding national productivity movements and adopting emerging technologies by understanding their implications for policymaking.

Gap Analysis: Digitalization and Productivity Improvement in the APO Member Countries

A Multifaceted Strategic Approach to Digitization and Productivity Improvement

The DX strategies of 12 countries reveal a multifaceted approach, focusing on key economic sectors, such as industry, agriculture, and services. Countries like India and Thailand are tailoring digital advancements to boost industrial growth, smart agriculture, tourism, and manufacturing. Many countries, including Bangladesh and Cambodia, face a common challenge of addressing digital and financial illiteracy and enhancing infrastructure, especially in remote areas.

Public sector initiatives like 'Digital Bangladesh by 2021' and 'Digital Pakistan Policy' are pivotal in fostering e-governance and digital inclusivity. Integrating advanced technologies, such as AI, Machine Learning (ML), cloud computing, and IoT, is a significant trend across these nations aimed at driving economic growth. The role of Micro, Small, and Medium Enterprises (MSMEs) is particularly emphasized in countries such as India, highlighting their contribution to exports and GDP. Innovation and research and development (R&D) are critical, and countries like Mongolia and Vietnam are investing in renewable energy and AI. The overarching themes are addressing the digital divide, developing comprehensive policy frameworks, and aligning digital strategies with socioeconomic goals. These strategies collectively aim to leverage DX for economic growth and societal well-being while tackling challenges and ensuring equitable access and sustainability.

In conclusion, while each country has its unique focus and challenges in DX, common themes include integrating advanced technologies, emphasizing critical economic sectors, tackling the digital divide, and aligning digital strategies with broader socioeconomic development goals.

The summary of DX strategies across the 12 countries can be categorized based on their focus areas, challenges, and strategic approaches. The analysis in this report is based on the following key elements:

Key Economic Sectors

Most countries prioritize DX in major sectors such as industry, agriculture, and services. For instance, India emphasizes industrial growth and smart digital agriculture, whereas Thailand focuses on tourism, manufacturing, and agriculture.

Challenges with Digital Literacy and Infrastructure

Common challenges include digital and financial illiteracy, inadequate infrastructure, and limited Internet access, particularly in remote areas. Bangladesh and Cambodia face these challenges, necessitating robust strategies for widespread digital literacy and infrastructure development.

The Public Sector and e-Governance Initiatives

Several countries have leveraged DX to enhance public services and governance. For example, while the Digital Bangladesh by 2021 initiative focused on e-governance, e-learning, and e-commerce, Pakistan's Digital Pakistan Policy and Vision 2025 aims to create a digitally inclusive society.

Integration of Advanced Technologies

Significant emphasis is placed on integrating AI, ML, cloud computing, and IoT technologies to improve productivity and quality. Countries like India and Vietnam use these technologies to support economic growth.

Role of MSMEs

MSMEs play a crucial role, especially in economies like India, where they significantly contribute to exports and GDP. Governments encourage using digital platforms and e-commerce to increase visibility and opportunities for MSMEs.

Innovation and R&D

Countries have focused on innovation and R&D to drive DX. Mongolia's focus on renewable energy and Vietnam's strategy for AI innovation by 2030 are some examples of this approach.

Digital Divide and Accessibility

Addressing the digital divide is a crucial concern. For instance, the Philippines focuses on expanding digital infrastructure and bridging the digital divide, while Mongolia emphasizes overcoming infrastructural and resource allocation issues for digitalization.

Policy and Regulatory Frameworks

Comprehensive policies and regulatory frameworks are needed to support DX. Some examples are Thailand's 'Science, Technology, and Innovation Roadmap 2030' and Turkiye 'National Technology Initiative' and 'Digital Turkiye' strategies.

Socioeconomic Impact and Sustainability

Countries are aligning their DX initiatives with socioeconomic development and sustainability goals. For example, Vietnam's 'National Digital Transformation Program' reflects its commitment to digitalization and becoming a middle-income economy.

TABLE 1

KEY ELEMENTS OF ECONOMIC DEVELOPMENT AND DIGITAL TRANSFORMATION.

Key Elements	Details
Key Economic Sectors	Focus on industry, agriculture, and services (e.g., industrial growth in India and tourism growth in Thailand)
Challenges	Digital and financial illiteracy, inadequate infrastructure (highlighted in Bangladesh and Cambodia)
Public Sector Initiatives	e-Governance, digital inclusion (e.g., Bangladesh's Digital Bangladesh by 2021 and Pakistan's Digital Pakistan Policy)
Integration of Advanced Technologies	AI, ML, cloud computing, and IoT for economic growth (highlighted in India and Vietnam)
Role of MSMEs	Contribution to exports and GDP (highlighted in India)
Innovation and R&D	Focus on renewable energy and AI (highlighted in Mongolia and Vietnam)
Digital Divide	Expanding digital infrastructure and bridging the digital divide (highlighted in the Philippines and Mongolia)
Policy Framework	Developing comprehensive frameworks (e.g., Thailand's Science, Technology and Innovation (STI) Roadmap 2030 and Turkiye National Technology Initiative)
Socioeconomic Impact and Sustainability	Aligning DX with development goals (e.g., Vietnam's National Digital Transformation Program)

Source: Digital Transformation in Asian Economies: Enhancing Productivity, Socioeconomic Impacts, and Policy Insights, APO, 2024.

Country Reports

Summary

This report presents a table that encapsulates the DX strategies of 12 countries, structured in a two-column format for clarity and ease of comparison. The first column lists the countries as a simple reference, while the second column highlights the key points from each country report. These points cover various aspects of the DX process, including the general approach, targeted sectors for digital enhancement, prevalent challenges, and strategic measures employed to navigate and leverage digitalization effectively.

This layout has been chosen to facilitate an accessible and comprehensive presentation of information, enabling seamless comparison and a deeper understanding of the diverse DX strategies across these nations. It highlights each country's unique socioeconomic circumstances and strategic objectives in the digital realm and provides valuable insights into their various approaches to adopting DX.

TABLE 2

DIGITAL TRANSFORMATION STRATEGY SUMMARY.

	DX Strategy
Bangladesh	Focus on Digital Bangladesh by 2021, targeting key sectors with digital literacy and infrastructure challenges. National Industrial Policy 2022 for productivity using domestic resources.
Cambodia	Impact on industry, agriculture, and services, with government initiatives like the Pentagonal Strategy and STI Roadmap 2030. Emphasis on technologies like AI and cloud computing.
India	Focus on DX in sectors like industries, agriculture, and ICT. Leveraging AI, digital farming, and advanced manufacturing. Significant role of MSMEs.
Mongolia	Comprehensive mining, agriculture, and financial sectors strategy with digital advancements like AI and IoT. Focus on renewable energy and overcoming infrastructural challenges.
Nepal	Expanding digital infrastructure with the National ICT Policy and Digital Nepal Framework. Challenges include digital literacy and a lack of adequate infrastructure.
Pakistan	Initiatives like Digital Pakistan Policy and Vision 2025 focus on digital literacy, IT exports, and infrastructure, with an emphasis on agriculture and e-governance.
Philippines	Emphasis on expanding digital infrastructure and MSME digitalization. Focus on digital literacy, cybersecurity, and consumer protection.
ROC	A holistic digitalization approach in ICT, industry, and agriculture. Focus on AI, digital twins, digital literacy, and niche markets.
Sri Lanka	Focus on boosting digital infrastructure and literacy and promoting IT exports. Also, focus on public sector DX and national ICT policies.
Thailand	A digital economy framework focusing on IoT, 5G, and cloud computing, with manufacturing, agriculture, healthcare, and digital services strategies.
Turkiye	Industry 4.0 strategy in manufacturing focuses on SMEs and technology gaps. Initiatives include the National Technology Initiative and Digital Turkiye for DX.
Vietnam	Adoption of the digital revolution in services, manufacturing, and agriculture. Focus on AI, ML, cloud computing, and developing as an AI innovation center by 2030.

Source: Digital Transformation in Asian Economies: Enhancing Productivity, Socioeconomic Impacts, and Policy Insights, APO, 2024.

Bangladesh

Bangladesh's DX journey began with the government's ambitious initiative outlined in the Awami League's 2008 manifesto, aiming to achieve Digital Bangladesh by 2021, with an extended vision for Smart Bangladesh by 2041, ushering in an inclusive digital revolution across critical societal pillars. This vision entails integrating digital technology into crucial sectors like industry, agriculture, and public services to enhance efficiency, transparency, and inclusivity, especially in e-governance, e-learning, and e-commerce. However, despite these advancements, the journey is fraught with challenges, including digital and financial illiteracy, inadequate infrastructure, and limited Internet accessibility, particularly in remote areas.

The advent of revolutionary technologies, automation, and the 4IR significantly impacted industries, agriculture, the public sector, and services. Addressing these challenges requires developing and implementing robust strategies aligned with the demands of the 4IR. The National Industrial Policy 2022 seeks to leverage these technologies to improve productivity and quality using domestic resources, underscoring the need for a holistic approach to overcome barriers and realize the full potential of DX in Bangladesh.

Cambodia

Cambodia's DX initiatives have significantly impacted key sectors, such as industry, agriculture, and services, greatly enhancing the country's productivity, efficiency, and sustainability. However, they also identify challenges that must be addressed, including improving digital literacy, developing skills, and enhancing infrastructure, especially Internet access in remote areas.

The report discusses government initiatives and policy documents like the Pentagonal Strategy – Phase I and the Science, Technology & Innovation Roadmap 2030. These aim to develop digital government and citizens, foster a digital economy, and strengthen the institutional framework for science and technology. Moreover, it delves into specific technological trends, such as big data, AI, and cloud computing, emphasizing the need for policy support to utilize these technologies while addressing DX challenges effectively. The report offers Cambodia a comprehensive approach and strategic vision to leverage DX for a more prosperous and sustainable future.

Republic of China

ROC adopts a comprehensive approach to DX for productivity enhancement, emphasizing the need for digitalization across various sectors to address challenges like climate change, labor shortages, and operational inefficiencies. It underscores the importance of digital technologies in key sectors such as ICT, industry, agriculture, public services, and the service industry, underlining their role in enhancing operational efficiency and decision-making processes.

The report identifies specific strategies, such as AI integration, the use of sensors and digital twins in manufacturing, and adapting ICT to higher-value services. It also includes leveraging digital tools in agriculture for environmental control and food safety and aligning online offline channels in the service sector. Additionally, the report recommends the need to establish the Ministry of Digital Affairs for better policy coordination.

Challenges addressed include the digital divide, data privacy, and talent shortages. Recommendations focus on boosting digital literacy, investing in niche markets, and utilizing digital twins to improve operational efficiency. These strategies aim to bolster ROC's productivity, competitiveness, and sustainability through DX.

India

India's strategy for enhancing productivity revolves around its DX and sustainable development goals, aiming to position India as a developed nation by 2047. The focus lies on sectors such as industrial growth, smart digital agriculture, and ICT, where advancements are pivotal to the country's economic and social progression. India is leveraging emerging technologies, such as Generative AI, smart digital farming, and advanced manufacturing, to achieve the 17 SDGs and build a self-reliant economy. These technologies bolster India's status as one of the world's fastest-growing economies, supporting advancements like Unmanned Aerial Vehicles (UAVs), green energy, and quantum technologies.

Moreover, MSMEs play a crucial role in India's economy, contributing significantly to exports, manufacturing GDP, and the service sector. The government promotes MSME products through e-commerce platforms and the Government e-Marketplace (GeM) to increase visibility, streamline procurement processes, and enhance opportunities in government contracts. India's leadership in digital technologies is emphasized, particularly its contributions to digital and connectivity solutions worldwide, especially in the Global South. The government implements policies and frameworks supporting innovation and technology development, including initiatives like Common Research and Technology Development Hubs (CRTDHs), to encourage R&D among MSMEs.

Mongolia

Mongolia's digital transformation is a comprehensive strategy targeting vital economic sectors to boost productivity and sustainable development. In the mining sector, digital advancements, such as cloud computing, AI, and IoT, are being integrated to enhance transparency and efficiency, although challenges with complete and accurate reporting remain. Agriculture, a major GDP contributor, is witnessing a shift with digital initiatives and the e-Agriculture Strategy, aiming to modernize traditional herding and farming practices.

The financial sector is evolving rapidly through digital banking and mobile applications but faces challenges such as high inflation and consumer debt. Mongolia's energy sector is focused on self-sufficiency, with policies supporting renewable energy development despite obstacles in achieving these goals. Across these sectors, the government's Vision 2050 and New Recovery Policy are driving digitalization efforts; however, issues such as infrastructure, digital literacy, and resource allocation must be addressed to harness the potential of DX to fully enhance national productivity.

Nepal

Nepal's strategy to enhance productivity through DX involves several crucial elements and faces multiple challenges. Despite geographical barriers, expanding digital infrastructure and connectivity is a significant step forward, providing Internet access to over half of the population, including remote communities. The National ICT Policy and Digital Nepal Framework are at the forefront of the government's digitization efforts, targeting critical sectors such as agriculture, healthcare, education, tourism, and finance. This integration of technology is already visible in the transformation of the education system through digital resources, improvements in healthcare accessibility via telemedicine, and modernization of agricultural practices with digital tools. However, challenges such as limited digital literacy, especially in rural areas, infrastructural hurdles, and the need for robust policies and ICT investments remain significant.

The social and economic impact of digitization is potentially substantial and promising to boost GDP and job creation, especially in the tech sector, while enhancing communication, education,

and civic engagement. To ensure inclusive DX, strategies must improve infrastructure, enhance digital literacy, create favorable policy environments, and encourage private sector investment in ICT. International support, notably from the World Bank, plays a critical role in these efforts, with significant funding being allocated to projects aimed at improving digital engagement and regional connectivity. Overall, while Nepal is progressing well on its digital journey, addressing these challenges and implementing effective strategies are essential for fully realizing the benefits of DX.

Pakistan

Pakistan's DX strategy to enhance productivity encompasses several critical aspects across diverse sectors. The country, ranking 88th in the Global Innovation Index 2023, shows better performance in innovation outputs than inputs, partly attributed to digital advances in the public sector. Challenges persist in e-government development and digital education, which involve comprehensive ICT-related policies, including the Digital Pakistan Policy, Vision 2025, and e-Commerce Policy, focusing on digital literacy, IT exports, infrastructure, and cybersecurity. Efforts are directed towards creating a digitally inclusive society, transforming it into a knowledge-based economy, and promoting e-commerce. Key initiatives include enhancing the digital infrastructure, investing in human capital, and implementing e-governance.

The agricultural sector also features prominently in the DX agenda to improve productivity and efficiency through technological interventions. The report underscores the need to align national and provincial IT policies, develop ICT infrastructure, and encourage modern technologies like AI and cloud computing. The strategy advocates a holistic and integrated approach to DX to boost Pakistan's productivity and economic growth.

Philippines

Comprehensive policy recommendations are vital for enhancing the Philippines' DX and productivity improvement journey. The focus is on expanding digital infrastructure to address the low high-speed broadband penetration and bridging the significant digital divide, where nearly 60% of households lack Internet access. This effort should prioritize both urban and remote areas to ensure inclusive growth. Moreover, the Philippine Development Plan 2023–2028 emphasizes the digitalization of MSMEs and startups, supported by initiatives such as the Digital Cities Program and funding for ICT-based startups.

Policies should also reinforce digital literacy and government transparency by effectively implementing strategies from past plans and the Philippine Digital Transformation Strategy. Future directives should enhance cybersecurity, promote e-commerce and consumer protection, and ensure equitable digital access through initiatives such as the National Broadband Plan and Free Public Internet Access Program. These efforts collectively aim to position the Philippines as a competitive digital economy in the ASEAN region, aligned with the country's strategic geographic advantages.

Sri Lanka

National efforts must align with global technological trends to enhance productivity and DX in Sri Lanka. The country should focus on boosting its digital infrastructure, especially in crucial public services, agriculture, and ICT sectors. Improvements in digital literacy and the promotion of IT exports will further strengthen the economy. Sri Lanka should also compare its standing in global knowledge indices with other countries to identify areas for technological and innovation growth.

The government is encouraged to implement DX initiatives in public sector organizations, contributing to improved innovation output. This can be supported by developing comprehensive ICT policies at the national and provincial levels, emphasizing cybersecurity and the development of digital infrastructure. It is vital to establish IT boards across all provinces and encourage the adoption of cloud computing and AI technologies. Ensuring fast, reliable, and affordable Internet access nationwide will be crucial for the successful DX of Sri Lanka.

Thailand

Thailand's DX for productivity improvement provides a comprehensive analysis across various sectors, emphasizing the shift towards digital technology adoption, particularly during the COVID-19 pandemic. It outlines Thailand's digital economy framework, aligning with UNCTAD's concepts, and focuses on IoT, 5G, cloud computing, and big data to drive economic development and enhance the quality of life.

The Digital Economy Promotion Agency's (DEPA) implementation framework is based on four pillars: digital access, connectivity, data, and automation, aiming to create sustainable digital competitive advantages. Key sectors, such as tourism, manufacturing, and agriculture, have been identified for focused digitalization efforts.

The report identifies challenges, including the middle-income trap, R&D investment, labor shortages, and political uncertainty, and suggests sector-specific digitalization strategies, particularly in manufacturing, agriculture, healthcare, and digital services. In addition to policy recommendations, it advocates improving digital infrastructure, policy alignment, skill enhancement, and addressing the digital divide, underscoring the need for balanced policy implementation and international regulatory alignment.

Turkiye

Turkiye's approach to DX in the manufacturing sector focuses on advancing toward Industry 4.0 despite challenges, such as most SMEs still not transitioning to automation (Industry 3.0). SMEs play a crucial role in Turkiye's economy, with a significant presence in key sectors such as agriculture, defense, and tourism. Still, they face a technology gap, particularly in high-tech areas. The government's 11th Development Plan and the 'National Technology Initiative and Digital Turkiye' strategy emphasize DX across various manufacturing sectors, including chemicals, pharmaceuticals, electronics, machinery, automotive, and rail systems.

A SWOT analysis of Industry 4.0 in Turkiye highlights strengths such as a young population and growing awareness of Industry 4.0, but also weaknesses such as dependency on imports and low high-tech exports. The country is working to overcome these challenges through national strategies and initiatives, including establishing Model Factories to aid SMEs in DX and enhance productivity in manufacturing. This concerted effort signifies Turkiye's commitment to embracing Industry 4.0 and leveraging DX to bolster its manufacturing industry.

Vietnam

Vietnam is actively embracing the digital revolution, leveraging its stable political climate and strong global trade presence to address key challenges, such as digital literacy, an aging population, and climate change vulnerabilities. Amidst the 4IR, the country is experiencing a significant surge in digitalization, adopting emerging technologies such as AI, ML, cloud computing, and IoT, which promise to enhance the quality of life and economic efficiency. This digital shift is particularly

evident in Vietnam's core sectors, such as services, manufacturing, and agriculture, positioning the nation as an essential manufacturing hub in global supply chains.

The government's focus on smart manufacturing and DX in agriculture highlights its commitment to integrating advanced technologies. However, Vietnam faces challenges like skill shortages, infrastructural constraints, and environmental concerns. The government's strategy includes promoting technology adoption, R&D, human resource development, and creating innovation ecosystems, aiming to position Vietnam as an AI innovation center by 2030. This approach is part of a broader national DX plan that emphasizes the development of smart cities and foundational digital technologies to drive sustainable economic growth and societal well-being.

Mobilizing Scenarios

Digitalization Pathways: Navigating Productivity and Industry Development Across Diverse Economic Landscapes

This comprehensive report provides a detailed analysis of surveys conducted in various countries to identify the shared and unique aspects of their development. These findings have been systematically categorized into organized typologies. Central to the discussion are several scenarios tailored to each country's specific stage of industrial development. These scenarios are designed to enable dramatic productivity improvements, offering a departure from the traditional gradual path of industrialization.

Previously unattainable, these productivity gains are now within reach owing to innovative approaches adapted to each country's unique context. The report provides a nuanced perspective on productivity enhancement, addressing the diverse challenges and opportunities that DX presents to these economies. Furthermore, the report aims to provide strategic insights into how these countries can navigate the DX process and identify potential opportunities and challenges unique to their developmental contexts. This includes examining how digitalization can drive economic growth, improve public services, and potentially reshape these nations' social and economic landscape.

Scenarios: Strategic Digitalization

Tailoring Technology for Diverse Demographics and Economic Growth

These scenarios will likely address how nations with varying population densities and stages of economic development can leverage digital technologies to enhance productivity. For densely populated countries, scenarios might explore how digital solutions can address urban challenges and optimize resource use. By contrast, scenarios for less densely populated areas might focus on digital technologies to overcome geographical barriers and improve access to services.

The focus was on creating scenarios based on two primary axes: enhancing national productivity and developing specific industries. The Leapfrog Scenario envisages a significant improvement in productivity within each country's key industries, suggesting a rapid bypass of conventional societal development towards accelerated digitalization and economic growth. Conversely, the Lock-in Scenario portrays a situation in which the digitalization of specific industries leads to monopolization by dominant digital platforms such as GAFAM, potentially centralizing technological progress within a few large corporations and diminishing market competition.

The Industry 4.0 Scenario reflects a more gradual societal advancement in digitalization, mirroring the path of advanced Western nations, with countries aiming for comparable productivity enhancements. Finally, the Infrastructure Bottleneck Scenario highlights the challenges countries face with inadequate human resource literacy and infrastructural deficiencies in power and communication, posing significant barriers to digitalization across nations, regardless of their population size. These scenarios provide a comprehensive outlook on the potential pathways and challenges in these countries' DX journey.

Leapfrog Scenario

Asian countries will achieve significant productivity improvements in key industries. This has led to rapid economic development, potentially surpassing other regions worldwide. The swift advancement of digital technologies will bring innovations across various sectors, such as education, healthcare, and agriculture, improving quality of life.

Lock-in Scenario

While digitalization progresses in certain industries, some Asian countries may experience monopolization and oligopoly through major digital platforms. This scenario could limit the innovation potential and widen economic disparities. Economies may become overly dependent on digital platforms, leading to a fixed economic structure based on these platforms.

Industry 4.0 Scenario

Some of the APO member countries with large populations and consumer demand will likely achieve productivity improvements comparable to Western advanced nations through gradual societal and economic digitalization. The proliferation of smart factories, automation, and data-driven decision-making processes enhances economic efficiency and sustainability.

Infrastructure Bottleneck Scenario

Some of the APO member countries may face delays in digitalization due to a lack of human resource literacy and infrastructural deficiencies. This could create regions that cannot benefit from the digital economy, widening the gap in socioeconomic development with other countries. These countries may lose their international competitiveness.

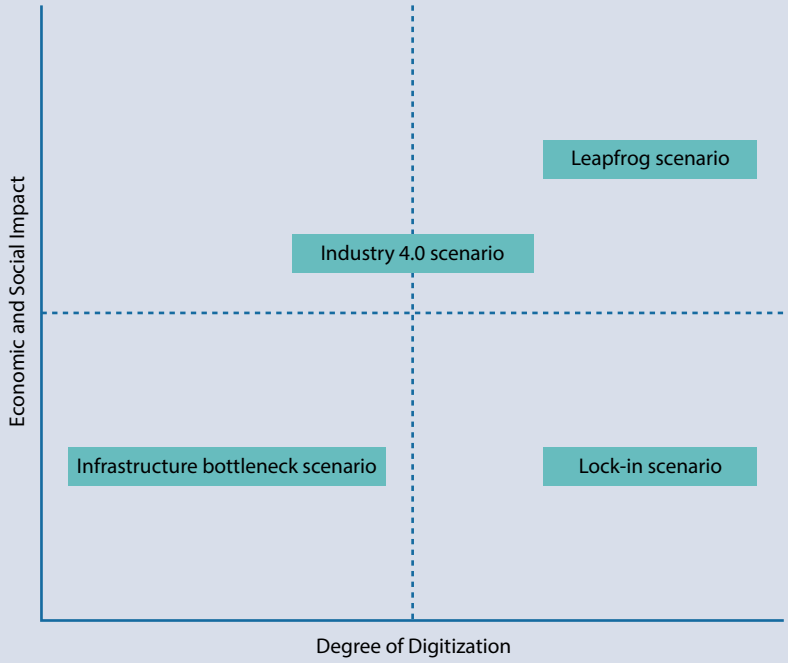
Analyzing Digitalization Scenarios in the APO Member Countries

To effectively analyze the various digitalization scenarios facing the APO member countries, a 2x2 matrix provides a clear and structured visual representation. Two key axes define the matrix: the digitization level, ranging from low to high, and the economic and social impacts, spanning from negative to positive. These axes categorize four distinct scenarios. The Leapfrog Scenario, positioned at high digitalization and positive effects, indicates substantial productivity gains and improved quality of life driven by advanced digital technologies. Conversely, the Lock-in Scenario, which is also high in digitalization, predicts a negative impact due to the rise in monopolies and widening economic disparities.

The Industry 4.0 scenario is characterized by moderate to high digitalization coupled with positive impacts, mirroring the gradual digital evolution and sustainable growth in Western nations. Lastly, the Infrastructure Bottleneck Scenario, marked by low digitalization and adverse effects, highlights the challenges and expanding socioeconomic divides caused by infrastructural and educational deficits. This matrix not only simplifies understanding of these complex scenarios but also aids in strategizing appropriate responses for the future digital landscape in these countries.

FIGURE 2

MATRIX OF DIGITALIZATION SCENARIOS IN THE APO ECONOMIES.



Source: Digital Transformation in Asian Economies: Enhancing Productivity, Socioeconomic Impacts, and Policy Insights, APO, 2024.

Policy Recommendations

Unleashing Productivity and Innovation: The Transformative Power of DX in the Global Economy

DX significantly enhances productivity by automating and optimizing business processes and streamlining manual and time-consuming tasks. This improvement in efficiency facilitates rapid innovation and the development of new business models, products, and services, spurring innovative growth and productivity on a macroeconomic scale. Moreover, DX's role in data management—collecting, analyzing, and sharing information—is pivotal in enhancing the quality of decision-making. This leads to faster and more effective responses in various sectors.

Additionally, digital technology expands market access beyond geographical boundaries, enabling businesses to leverage online sales, digital marketing, and global supply chains, thereby accessing broader markets. DX also contributes to sustainable development. Optimal resource utilization, increased energy efficiency, and reduced waste support long-term economic growth and enhance national productivity. However, the impact of DX varies across countries and is influenced by the integration of technology across different industries and the overall digital infrastructure.

It is crucial to address the gap between national and organizational productivity. Although specific industry dynamics and market environments influence organizational productivity, national productivity reflects the collective performance of diverse industries. Technology adoption at the organizational level directly impacts internal processes and workforce productivity; however, national-level productivity gains require widespread technological diffusion and robust digital infrastructure development.

Fostering Responsible Research and Innovation for National Productivity Enhancement

Individual organizations can invest in employee skill development to foster productivity. Conversely, broad human resource development programs and educational system reforms are necessary nationally. National policies and regulations significantly impact economic productivity but can also constrain certain industries. Public sector innovation and DX, while beneficial, may encounter productivity bottlenecks, particularly when supporting large industries. Thus, addressing economic disparity and inequality is essential; if economic benefits are concentrated in a few companies or regions, the overall national productivity gains may be limited.

Innovations by individual organizations can boost national productivity, but competition may hamper this. In addition, short-term productivity gains at the organizational level can negatively impact long-term environmental sustainability. Therefore, it is imperative to balance national productivity gains with environmental sustainability. Promoting Responsible Research and Innovation [14–17] is increasingly important for sustained growth and national productivity enhancement.

The Digital Paradigm Shift: A Focus on the APO Member Countries

In the contemporary global economic landscape, digitalization presents emerging nations with unprecedented opportunities for productivity improvement, transcending the traditional stages of economic development. This paradigm shift is particularly pertinent for member countries of the APO, where leveraging digital technologies in alignment with public policy and industrial promotion strategies is becoming increasingly crucial. Digitalization offers a unique pathway for these nations, allowing them to bypass some of the conventional, often lengthy phases of industrialization. By embracing digital technologies, the APO members can accelerate their transition to knowledge-based economies, foster innovation, and create new value chains. This digital leap can result in substantial gains in efficiency and productivity, which are essential for these nations to play a central role in the global economy.

However, adopting digital technology is challenging. To fully capitalize on these opportunities, the APO economies must develop and implement public policies and industry promotion strategies tailored to their unique national characteristics and traditions. This approach should encompass the technological aspects of digitalization and the broader socioeconomic context, including education, infrastructure development, and regulatory frameworks.

Bridging the Gap: Integrating Digital Technologies in Traditional Sectors with Government Support

Public policies play a critical role in creating an enabling DX environment. These policies should focus on building robust digital infrastructure, ensuring access to high-speed Internet, and fostering digital literacy among the population. Additionally, governments must establish clear regulatory frameworks that encourage innovation while protecting data privacy and security. On the industry promotion front, supporting the development of local digital ecosystems is vital. This includes nurturing startups and SMEs, encouraging R&D, and facilitating collaboration between academia, industry, and the government. Such an ecosystem can spur innovation and help local businesses scale up and compete in the global market.

Moreover, integrating digital technologies into traditional sectors, such as agriculture, manufacturing, and services, can transform these industries, making them more efficient, sustainable, and globally competitive. For example, digital tools in agriculture can lead to precision

farming, which enhances productivity and sustainability. Adopting Industry 4.0 technologies in manufacturing can optimize production processes and improve product quality.

Strategic Shift: Journey Towards a Sustainable Digital Economy

It is also important for the APO member economies to focus on inclusive digitalization. This means ensuring that the benefits of DX are shared across all segments of society, reducing the digital divide and preventing the exacerbation of inequalities. Inclusive digitalization can contribute to broader socioeconomic development and improve the quality of life of all citizens.

In conclusion, for the APO member countries, embracing digitalization to enhance productivity and foster economic growth is beyond just adopting new technologies. This represents a strategic shift towards creating a sustainable and inclusive digital economy that leverages each nation's unique characteristics and traditions. As these countries become more central in the world economy, their ability to harness digitalization will be key to their success and resilience in an increasingly interconnected world.

References

[1] Ministry of Economy, Trade and Industry. Digital Transformation Report (in Japanese). https://www.meti.go.jp/shingikai/mono_info_service/digital_transformation/pdf/20180907_03.pdf. Accessed on 2 April 2024.

[2] Ministry of Economy, Trade and Industry. Digital Transformation Report 2.1 (in Japanese). https://www.meti.go.jp/press/2021/08/20210831005/20210831005–2.pdf. Accessed on 2 April 2024.

[3] Organisation for Economic Co-operation and Development. Digitalisation and productivity: A story of complementarities. OECD Economic Outlook, vol. 2019, issue 1; pp. 56–83.

[4] Lasi H., Fettke P., Kemper H-G., et al. Industry 4.0. Business & Information Systems Engineering; 2014, 6, pp. 239–242.

[5] Oztemel E., Gursev S. Literature review of Industry 4.0 and related technologies. Journal of Intelligent Manufacturing; 2020, 31.1, pp. 127–182.

[6] Liao Y., Deschamps F., Loures E. de F. R ., et al. Past, Present and Future of Industry 4.0 – a Systematic Literature Review and Research Agenda Proposal. International Journal of Production Research; 2017, 55(12), pp. 3609–3629.

[7] Council for Science, Technology and Innovation, Cabinet Office, Government of Japan. Report on The 5th Science and Technology Basic Plan. https://www8.cao.go.jp/cstp/kihonkeikaku/5basicplan_en.pdf. Accessed on 2 April 2024.

[8] Fong M.W.L. Technology leapfrogging for developing countries. Encyclopedia of Information Science and Technology, Second Edition. IGI Global; 2009, pp. 3707–3713.

[9] Alzouma G. Myths of digital technology in Africa: Leapfrogging development? Global Media and Communication; 2005, 1.3, pp. 339–356.

[10] Schilling M.A. Technological Leapfrogging: Lessons from the U.S. Video Game Console Industry. California Management Review; 2003, 45(3), pp. 6–32.

[11] Singh J.P. Leapfrogging development?: The political economy of telecommunications restructuring. State University of New York Press; 1999.

[12] Steinmueller W.E. ICTs and the possibilities for leapfrogging by developing countries. International Labour Review; 2001, 140: 193.

[13] Brezis E.S., Krugman P.R., Tsiddon D. Leapfrogging: A theory of cycles in national technological leadership. 1991.

[14] Stilgoe J., Guston D. Responsible research and innovation. https://discovery.ucl.ac.uk/id/eprint/10052401/1/Stilgoe_Guston_responsible_innovation_2017.pdf. Accessed on 2 April 2024.

[15] Directorate-General for Research and Innovation (European Commission). Responsible research and innovation: Europe's ability to respond to societal challenges; 2014.

[16] Directorate-General for Research and Innovation (European Commission). Institutional changes towards responsible research and innovation: Achievements in Horizon 2020 and recommendations on the way forward; 2020.

[17] Directorate-General for Research and Innovation (European Commission). Responsible research and innovation (RRI), science and technology: Report; 2013.

BANGLADESH

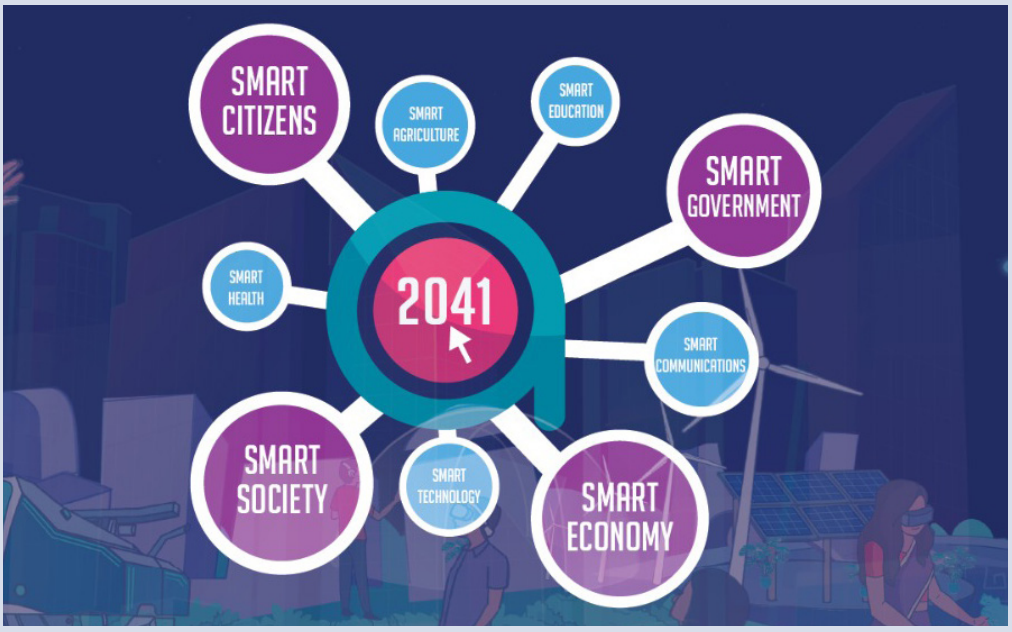
Introduction

DX integrates digital technology into all business areas, fundamentally changing how organizations operate and deliver customer value [17]. Digitalization has rapidly transformed various sectors, including industry, agriculture, and people across the globe. In recent years, Bangladesh has embraced digitalization to achieve greater productivity, competitiveness, and economic development. Integrating digital technologies in industry, agriculture, and the public sector promises to transform smart practices, streamline operations, and enhance efficiency. Bangladesh has been experiencing significant shifts in its economic landscape with the adoption of digital technologies. By exploring digital transformation's challenges, opportunities, and implications, this study contributes to a comprehensive understanding of the country's ongoing efforts to leverage digitalization and sketch emerging trends.

The Bangladesh Awami League, in their election manifesto of 12 December 2008, pledged to establish Digital Bangladesh by 2021. The manifesto stated, "Bangladesh will be with digitization and developed economy alongside bureaucracy going non-colonial." Smart Bangladesh aims to foster inclusive DX, envisioning a developed and prosperous nation built upon four pillars of Smart Citizens, Smart Government, Smart Economy, and Smart Society by 2041 (Smart Bangladesh Vision 2041). This vision entails sustainable digital solutions accessible to all citizens, regardless of their socioeconomic background, and businesses, irrespective of their size. It also involves expanding beyond 5G Internet,

FIGURE 1

SMART BANGLADESH VISION 2041.



Source: Aspire to Innovate. Prime Minister's Office. Government of Bangladesh [1].

achieving more than 100% smartphone penetration, exceeding more than 100% high-speed Internet penetration, and going beyond cashless transactions [1, 3]. Considering this, Aspire to Innovate (a2i) has spearheaded the initiative for Simplifying Public Services (SPS), which involves transitioning manual services to electronic or mobile-based services or E/M services.

Digitization has brought efficiency and transformed tools, enabling a more effective, transparent, accountable, and inclusive approach. These digital platforms encompass a holistic government approach, addressing various issues and institutions, including information dissemination, e-governance, e-learning, e-commerce, data-driven decision-making, and innovation. Notably, the government's digitization efforts have resulted in a 73% reduction in service time, a 68% decrease in costs, and an 85% decline in visits compared to the pre-digitization era [4]. As a part of the Smart Bangladesh initiative, the Government of Bangladesh (GoB) launched Bangabandhu Satellite-1 on 11 May 2018. Additionally, it established the country's first High-Tech Park in Gazipur to strengthen the IT sector and drive DX [43].

The 4IR and the vision of Smart Bangladesh 2041 have catalyzed DX across various industrial, agricultural, and public sectors. However, Bangladesh still faces challenges and needs to work on fully embracing digitalization. Factors such as a lack of digital and financial literacy and skills, unavailability of digital devices, poor mobile networks, and Internet connectivity–especially in remote areas–limited infrastructure for digital pathways, and a lack of awareness contribute to this gap.

The GoB formulated the National Industrial Policy 2022 to address these challenges. This policy aims to economically enrich Bangladesh, boost sector-wise productivity, and achieve excellence in quality by embracing the technological advantages of 4IR and promoting labor-intensive industrialization using domestic raw materials and resources [44]. Additionally, the GoB must develop policies aligned with the principles of 4IR and DX to meet future demands effectively.

Objectives of the Study

- Identify the emerging trends in DX within the industry, agriculture, and public sector in Bangladesh.
- Examine the adoption of emerging technologies and innovations across various sectors.
- Derive evidence-based policy implications related to these trends to enhance productivity in Bangladesh.

Scoping: Key Industry Sectors

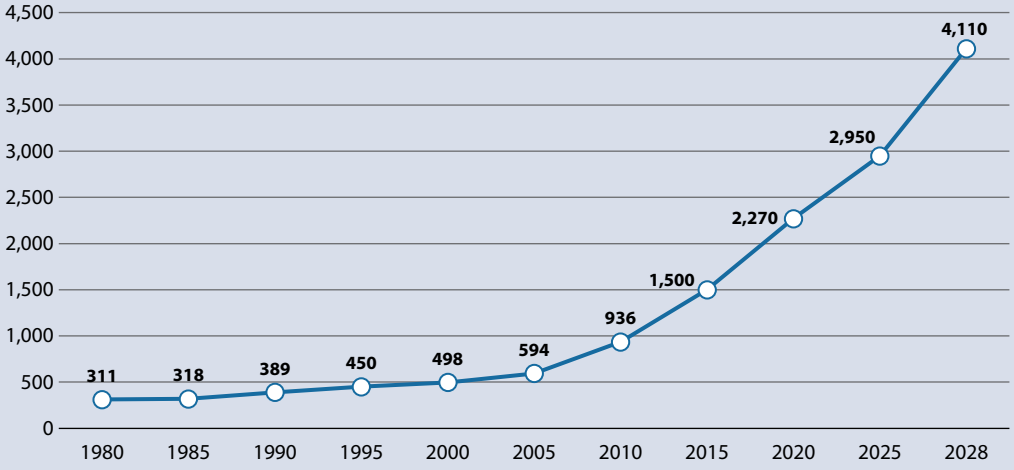
The introduction of the Internet to Bangladesh happened relatively late, in 1996 and it has gradually grown over the past few years [10]. As of 2022, Bangladesh's total population stands at 165 million. However, access to digital resources remains limited, with only 38.10% of households having access to the Internet, 8.70% owning computers, and 52.20% possessing smartphones [8,9]. Social media engagement is also modest, with only 29.7% of the population active on social media platforms, mainly on Facebook [30]. Furthermore, Internet access among students is notably low, with only 35% of secondary school students and less than 20% of primary school students having connectivity [1].

Challenges persist even in basic phone usage, as 30% of the population cannot make and receive phone calls, 51% cannot send and receive text messages, 37% struggle with phone menus, and 84% cannot use the Internet [12]. Moreover, technical and vocational education enrollment rates are relatively low, with only 16% of the Bangladesh population pursuing such education. The country's Science, Technology, Engineering, and Mathematics (STEM) enrolment rate in higher education stands at 21%, compared to 40% in India and 28% in Sri Lanka [13].

These statistics underscore a significant gap in the tools necessary for digitalization, posing challenges to achieving the goals of Digital Bangladesh. The main goal of Digital Bangladesh is to digitalize government services, and while the government has focused on digitizing its services, there remains a considerable gap. Nevertheless, the government's efforts have yielded some promising results. In 2022 alone, these efforts translated to savings of 16.83 billion days and USD21.92 billion in costs, along with 12.7 billion fewer visits for service recipients. Additionally, digitalization has contributed to ensuring transparency and accountability in public service delivery [6].

FIGURE 2

PER CAPITA GDP IN BANGLADESH FROM 1980–2028 (IN USD).



Source: International Monetary Fund [16].

Figure 2 illustrates a consistent upward trend in Bangladesh's per capita GDP growth rate from 1980 to 2028. It is estimated to reach USD4,110 in 2028, almost double the per capita GDP in 2020 and eight times compared to 2000. This remarkable growth can be attributed to the adoption of revolutionary new technologies such as automation and 4IR, which have significantly impacted various sectors, including industry, agriculture, the public sector, and services. Key components driving DX in Bangladesh include IoT-based digital devices, the future of work lab, blockchain, smart mobile apps, Computer-Aided Design (CAD) software and 3D modeling tools, a robust data ecosystem, digital healthcare initiatives, and e-government services.

Digitalization Initiatives and Programs in Bangladesh

Bangladesh's digitalization initiatives and programs aim to achieve the Smart Bangladesh vision by 2041. This vision revolves around inclusive DX, focusing on four pillars: Smart Citizens, Smart Government, Smart Economy, and Smart Society. It includes providing sustainable digital solutions for all citizens and businesses, regardless of socioeconomic background or size. This involves

scaling up beyond 5G Internet, achieving more than 100% smartphone penetration, exceeding more than 100% high-speed Internet penetration, and going beyond mere cashless transactions.

Several challenges hinder the progress of digitalization in Bangladesh, including a lack of necessary digital infrastructure, absence of a comprehensive e-government strategy, low level of digital literacy, limited availability of e-government services, shortage of skilled professionals, limited public awareness campaigns, concerns regarding data security and cybersecurity, lack of service integration, and poor Internet and mobile networks, especially in remote areas [1].

TABLE 1

DIGITALIZATION INITIATIVES AND PROGRAMS IN BANGLADESH.

Sectors	Initiatives and Programs
Industry	Future of Work Lab, blockchain
Agriculture	Experiment with 4IR technologies for smart agriculture, IoT-based smart meter for irrigation pumps, IoT-based decision-making of irrigation and fertilizer management, farmer-friendly smart agriculture data ecosystem, integrated service delivery and data-driven decision-making platforms to enhance agri production, digital agriculture supply-chain and standardization, vacuum frying machine, smart agriculture tech lab to accelerate farm mechanization, IoT-based smart fish farm, automation of the dairy industry in Bangladesh, e-traceability for agriculture management, e-traceability of ruminants for smart livestock management, Innovation Fund, Village Super Market, Krishoker Janala, Crop Production, DAE Office Directory, DigiCow, weather forecasting app, Fosholi App, Bottom Line
Public	Digital Service Design Lab (DSDL), iLab, Disability Innovation Lab (DIL), National Intelligence for Skills, Education, Employment and Entrepreneurship (NISE), digital financial inclusion, rural branchless banking, Electronic-Government Procurement (e-GP), Daraz, smart health accelerator, health data architecture, health financing, health system strengthening, maternal and child health, health education, EHR, primary healthcare, health data analytic tools, Non-Communicable Disease (NCD), Health Challenge Fund, National COVID-19 Dashboard, high-risk location identification and mapping, future of education, Blended Education Accelerator (BEA), MuktoPaath, Multimedia Classrooms (MMC), Shangshad TV, teacher's portal, national portal, MyCourt, e-Nothi, SPS, socioeconomic dashboard, MyGov, ekShop, eKPay, bKash, Nagad, Rocket, Ubar, Pathao, Shohoz, online patient appointment system, telemedicine, Ma Telehealth Centre, UDC, National Helpline 333, National Emergency Service 999, My Constituency, sanitation data governance, online newspapers and TV Channels

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

Methodology

The study is based on a horizon-scanning and literature review of official documents and an array of literature on digitization, including research papers, journals, published articles, newspapers, thesis papers, books, and websites. This comprehensive approach enabled the identification of emerging trends and megatrends in DX. Scenario analysis was employed to neutralize factors and determine megatrends and new trends in DX. Workshops, assessment of innovation, evaluation of technologies, productivity analysis, and sustainability considerations were integral to this process. The aim was to identify the scope, mobilization, transparency, conduct gap analysis, and make policy recommendations across various sectors, including industry, agriculture, public and service, and the services sectors in Bangladesh.

Literature Review

Sector 1: Digital Transformation in Industry

A study by Rana et al. in 2022 investigated the impact of digitalization on the economic growth of Bangladesh, revealing that the country's digitalization indicators have been more effective on the economic growth front. Traditional business methods are losing ground, and more goods and services are being made available to consumers through various digital channels to make their lives easier. Automation has notably improved efficiency in manufacturing, inventory management, and sales management. This has also led to a rise in digital technology players focused on addressing end-users and industries' digitalization needs [7].

In 2021, The Dhaka Tribune published an article, "Digital Bangladesh to Innovative Bangladesh: The road to 2041," focusing on future forecasting and digitalization in Bangladesh. It highlights that while the Bangladesh Awami League, in its 2008 election manifesto, promised Digital Bangladesh by 2021, the Bangladesh Vision 2041 goes way beyond the technological aspects. It commits to embracing the massive changes triggered by 4IR that are already catalyzing the merger of the physical and digital world with the biological world, with human capital being the most significant asset [3].

In partnership with the Digital Pathways at Oxford, the BRAC Institute of Governance and Development (BIGD) published a report, "Strategy Primer: For the Future of Digital in Bangladesh," in 2021. The report examined the overall impact of new technologies and how well they are adopted. The report indicates that there are 500,000 regular freelancers and 2,500 agencies who are serving on different platforms. Similarly, nearly one million freelancers in India dominate the global technology and software development market and contribute USD400 billion to the national GDP. In comparison, Bangladesh is the top supplier of sales and marketing support service freelancers, which generates only USD100 million annually. The country's STEM enrolment rate for higher education stands at 21%, which is 40% in India and 28% in Sri Lanka [13].

A study, Digital Bangladesh, a transformation for sustainable development, conducted by Hossain et al. in 2021, focuses on Bangladesh's strategies and acts toward rapid digitalization. The digital Bangladesh philosophy implies a widespread use of computers. It envisages using modern technologies to fulfill the promises to drive the economy, education, ecosystem, health care, job placement, and poverty alleviation. For DX, human capital is the most significant component by whom digitalization will be formed and conducted effectively. To develop a pool of essential human capital, Bangladesh focuses on science, technology, and research-based technical and modern education through modernizing education curricula, attracting and involving quality staff, developing infrastructure and environment, allocating budget, etc. Basic computer training is free and compulsory for all [11].

Ali conducted a study on 'Digitization of the emerging economy: an exploratory and explanatory case study' in 2020, focusing on the digitization of Bangladesh's economy. The study says that the benefits of transforming society into a digital economy may outweigh the negative impacts, turn threats into opportunities, reduce demand for labor and disguised unemployment, and narrow down the scope of creating new employment opportunities in the country. Referring to the large population of youths in Bangladesh, only 16% of the Bangladesh population was undertaking technical and vocational education and training and skill development programs under the government and still waiting to receive dividend benefits. Preparedness for ICT skills is more practically needed to be implemented [15].

Sector 2: Agriculture

Feed the Future published a report, Digital Insights on Agriculture in Bangladesh, in 2022. The study says that among all mobile phone users of the target populations, three out of five (60%) own at least one smartphone, but more than half of smallholder farmers rely on basic phones daily. The average person in the agriculture sector spends 39 minutes daily talking on their phone, primarily to friends and family but also substantially for business. Those with Internet access spent an average of 100 minutes each day connecting with family overseas and enjoying online entertainment through YouTube, Facebook, and, IMO, dominant apps. Interestingly, very few users are aware of the apps for agriculture, and less than one in ten have ever used them. Almost eight out of ten (79%) input sellers, service providers, and wholesale buyers use smartphones compared to just less than half of the farmers (48%) in the survey [18].

BIGD, in partnership with the Digital Pathways at Oxford (2021), published a report on Digital Readiness Assessment: The Future of Digital in Bangladesh. The report discusses the current status of digital readiness and explores some critical opportunities for the country to shape its digital future in Bangladesh. Studies show that a vast portion of the population of Bangladesh is still unaware of the use of phones, the Internet, and digital services. Digital literacy across the population is not satisfactory at all. 30% of the population cannot make and receive phone calls on a mobile phone, 51% cannot send and receive text messages, 37% do not know how to use the phone menu correctly, and 84% cannot use the Internet [12].

Sector 3: Public Sector

The Business Standard published an article, How digitization efforts on Time, Cost and Visit (TCV) make people's life easier, in 2023, which focused on how TCV, a digitalization measurement tool, minimizes the time, cost, and visit as well as simplifying public services. TCV measurement is a unique evaluation tool that assesses the service delivery process by measuring impacts from the citizens' point of view. This tool helps government agencies design more citizen-focused services through innovation and digitation. It is an effective tool for SPS, enhancing service recipients' satisfaction and reducing miseries. The tool was used to calculate TCV for 1,955 digital services belonging to 318 agencies and 39 ministries until December 2022. This indicates that the government's digitization efforts have saved service recipients 73% time, 68% cost, and 85% visits compared to the pre-digitization state [5].

In 2023, The Daily Messenger published an article, Digitization saves USD21.92 Billion for public service recipients, focusing on the results of digitalization in Bangladesh. The report highlights that the government's digitalization efforts have resulted in savings of 16.83 billion days, USD21.92 billion in costs, and 12.7 billion in visits savings for service recipients in 2022, along with ensuring transparency and accountability in public service delivery [6].

Similarly, in 2023, The Dhaka Tribune published an article, Going digital has been a godsend, that describes how digitalization has been adopted successfully in Bangladesh. One of the main benefits of digitization is the convenience it offers citizens. People no longer have to spend time waiting in long queues or making multiple visits to government offices to obtain public services. Digitization has also reduced the cost of accessing public services. Previously, people had to spend money on transportation, photocopying documents, and other expenses related to obtaining public services [4].

Another article in The Dhaka Tribune, E-government is the present and the future, published in 2022, focuses on the ideas, current status, and future digitalization trends in Bangladesh. The

concept of building a Digital Bangladesh was designed to achieve this by 2021. Bangladesh would create an economy that could call itself a digital nation, where digital tools were now primarily responsible for driving the country forward. Bangladesh has ranked 111th in the overall UN e-Government Development Index (EGDI) 2022 with a value of 0.5630; in 2020, it was 119th, and eight years ago, in 2014, it was 148th [2].

The Energy Bangla (2021) published an article, Digital Revolution in Bangladesh, focusing on the digital trends in different sectors in Bangladesh. The core commitment of Digital Bangladesh is to use digital tools to alleviate poverty and reduce corruption. The main goal of Digital Bangladesh is to digitalize government services. Notable digital services include e-commerce, e-banking, e-education, e-book, e-voting, e-health services, e-filing, e-mutation, e-paper, etc. Besides, digital passports, digital national voter IDs, digital land surveys, digital land development tax, mobile banking, online shopping, online admission, online registration, online income tax returns, online public exam results, transportation tickets telemedicine, are no longer a dream; these services have already been rolled out. Bangladesh has also established its first high-tech park spread across 202 acres at Kaliakair in Gazipur to strengthen the IT sector [14].

A report, The development trends and features of online news websites in Bangladesh, by Khan et al. in 2021, covers the digital media trends in Bangladesh. The Internet emerged in Bangladesh relatively late, in 1996, and it has gradually grown in the past few years. In the late 1990s and the beginning of 2000, all the leading newspapers created web versions for Internet users, and most national daily newspapers were already available electronically [10].

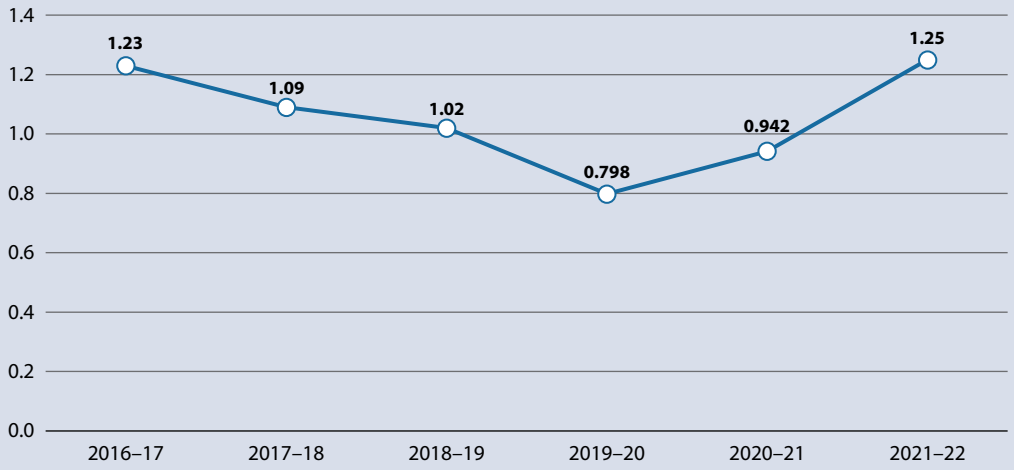
Gap Analysis

Sector 1: Digital Transformation in Industry

Lack of digital literacy among citizens, production delays, inventory inefficiencies, quality control, lack of technology knowledge, skills in operating digital tools and advanced machinery, and lack of real-time tracking are significant gaps in Bangladesh's industrial sector. Adopting technology in the readymade garment (RMG) and other industrial sectors is still slow in Bangladesh. The number

FIGURE 3

EXPORT OF LEATHER AND LEATHER PRODUCTS IN BANGLADESH FROM 2016–22 (IN USD BILLION).



Source: Kazi Waliul Islam. Leather Industry of Bangladesh: Challenges and Opportunities. Business Inspection, 7 January 2022 [19].

of female workers in the RMG sector has declined by 10.68% in four years due to a lack of skills [12]. A recent study indicates that as many as 60% of the jobs in the RMG sector will become automated by 2041, which, in effect, will make nearly two out of every five employees jobless in the industry [45]. Adopting cloud-based collaboration tools, investing in R&D automation, and implementing data integrity measures across sectors in Bangladesh are still challenging. Over the past few years, the export earnings of Bangladesh's leather industry have been declining.

Figure 3 shows that Bangladesh's exports of leather and leather products declined between 2016–19 but increased from 2020 to 2022. The country's raw leather preservation and processing systems are outdated, insufficient, and slow. The sector also lacks adequate skilled workforce, the use of digital technology, and design innovation, which is a big challenge and leads to declining trends in the sector.

Similarly, the jute sector in Bangladesh is facing massive challenges. These include an increase in production costs, a decline in export prices, a decrease in production efficiency due to obsolete machines, corruption, absenteeism, issues with labor unions, and the accumulation of substantial operational losses due to mismanagement. In July 2020, the GoB shut down all 25 state-owned jute mills due to huge year-on-year recurring losses [20]. The challenges of the paper, fertilizer, cement, sugar, and Light Engineering Sector (LES) include high resource consumption, production inefficiencies, environmental concerns, energy wastage, dependency on imported raw materials, logistical inefficiencies, inconsistent product quality, supply chain disruptions, and inefficient production processes.

Sector 2: Agriculture

In Bangladesh, 80% of farmers typically seek information on pest management and disease prevention [1]. However, due to a lack of knowledge and information, they continue cultivation based on their understanding without considering soil and weather forecasts. They lack 4IR tech-based solutions and cannot access smart solutions like advanced automated farming technologies, techniques, and devices. The inadequate presence of service delivery options, absence of agro-processing industries, poor business enabling environment, poor distance and digital connectivity, and fragile market structure dominated by cartels of intermediaries are hindering growth in the agricultural sector in the marginalized area of Bangladesh. Statistics show that 80% of farmers in Bangladesh lack knowledge of various agriculture-related digital innovations and challenges [1].

Sector 3: Public Sector

Bangladesh faces challenges leveraging technology, particularly electro-mechanical devices, IoT, and renewable energy. The main gap of DX in the public sector in Bangladesh is the lack of necessary digital infrastructure, lack of a comprehensive e-government strategy, low digital literacy, paper-based government service delivery leading to inefficiencies and delays, limited e-government services, limited access to digital services, poor data sharing among government departments, shortage of skilled professionals, limited public awareness campaign, data security and cybersecurity concerns, and the lack of service integration.

Rural areas of Bangladesh still need Internet access, the mobile network needs to be better, and there is limited access to financial services. There are also vast challenges of logistics, payment gateway issues, cyber security concerns, lack of awareness, and limited access to telehealth in rural regions. Also, the adoption of telemedicine still needs to be higher in Bangladesh. The country needs more digital literacy and skills, has no integration of digital literacy and technology-related subjects into the school curriculum, needs access to digital devices in remote areas, etc., are the main gaps for DX in the service sector in Bangladesh.

Bangladesh has about one million freelancers, most of whom do data entry and graphics design [13]. Due to the rapid pace of technological innovation, coding languages such as Python, R, SAS, statistical programming, SQL, ML, computer vision, 3D modeling and animation, robotic science, AI, etc. are in high demand. Bangladeshi freelancers have a vast knowledge and skill gap in this mega portion.

Priority Sector: Scope of Digital Transformation

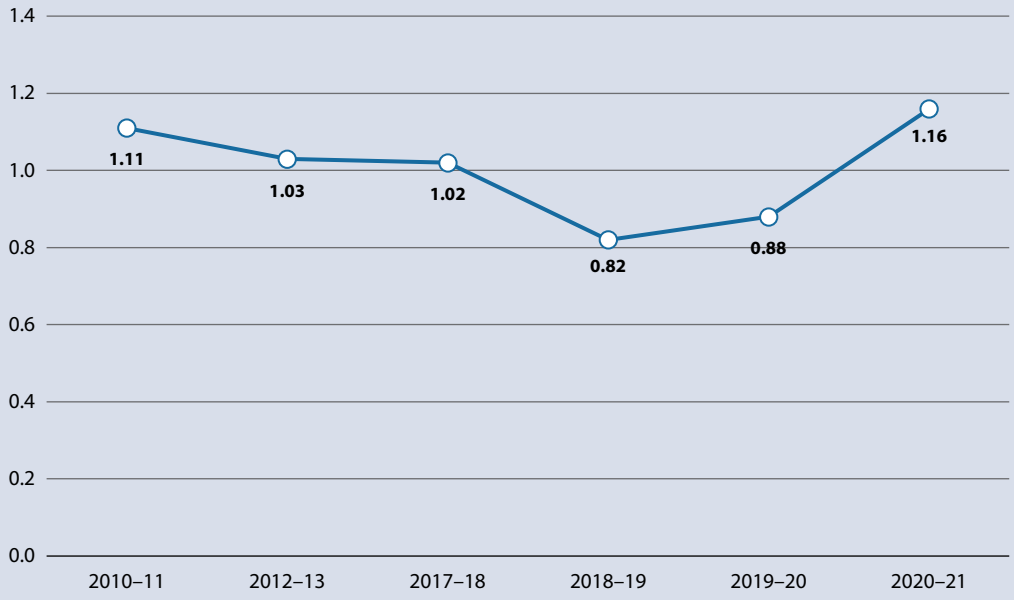
Sector 1: Digital Transformation in Industry

The primary industries of Bangladesh are cotton, textiles, garments, pharmaceuticals, leather and leather goods, jute, tea processing, paper newsprint, cement, chemical fertilizers, sugar, and light engineering. These sectors significantly contribute to the country's GDP. The National Industrial Policy 2022, announced by the GoB, aims to enrich Bangladesh economically, increase sector-wise productivity, and achieve excellence in quality by enabling the adoption of 4IR and labor-intensive industrialization using domestic raw materials and resources.

Bangladesh's RMG industry is one of the largest in the world, contributing more than 83% of the country's export revenue. With more than four million employees, it is the most significant contributor to Bangladesh's GDP. The pharmaceutical industry meets 98% of the country's total demand and exports medicines to several countries [46]. According to a report by the Directorate General of Drug Administration, the total market value of this industry is about three billion, contributing 1.83% of Bangladesh's GDP [21]. Bangladesh's leather industry is the second-largest source of foreign exchange after RMG. There are currently 200 tanneries and 3,500 MSMEs in Bangladesh [19]. Jute is known as the Golden Fiber and is one of the major cash crops of Bangladesh and the second-largest producer after India. About four million farmers in Bangladesh cultivate jute across over 8 lakh hectares. The jute sector contributes 0.26% to the GDP of Bangladesh [20].

FIGURE 4

TRENDS OF JUTE EXPORT EARNINGS FROM 2010–21 (IN USD BILLION).



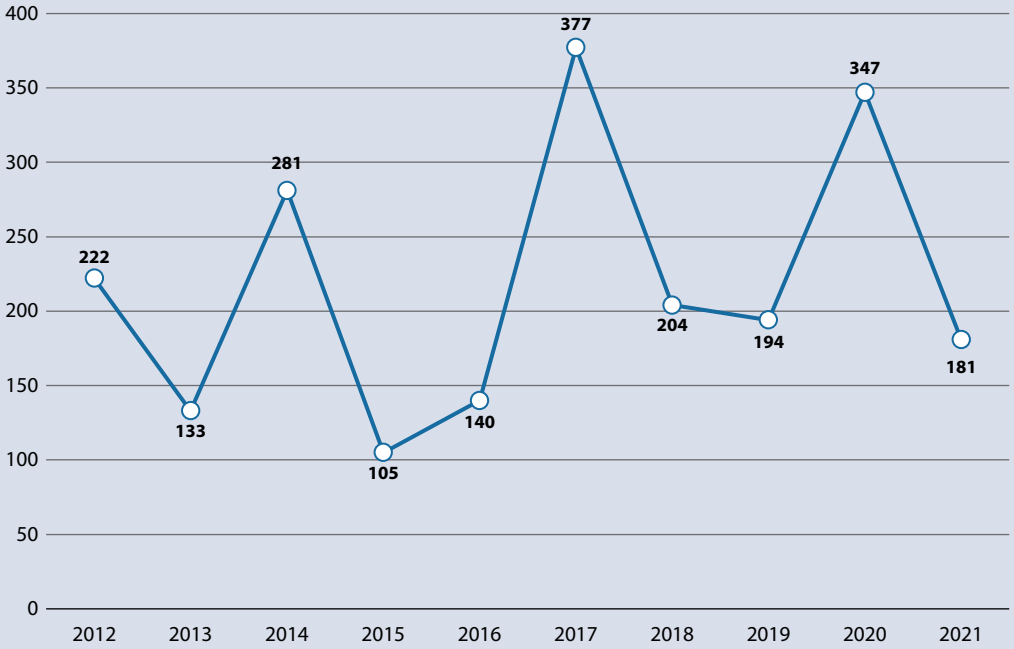
Source: The Business Haunt. Jute Industry in Bangladesh. History, Problems and Prospects. 17 August 2020.

Figure 4 shows that jute export trends have been almost steady over the last decade, though decreasing trends in 2019–2020 indicate an impact of COVID-19 on the sector.

Tea is Bangladesh's second largest cash crop after jute, contributing about 1% to Bangladesh's GDP. According to the Bangladesh Tea Board, there are 167 commercial tea estates and tea gardens in Bangladesh on 279,508 acres of land, where an average of 6 crores 74 lakh kg of tea is produced annually in Bangladesh, employing about 1.5 lakh workers. In addition, 3% of global tea is produced in Bangladesh. In 2021, the market size of the tea industry in Bangladesh was about BDT 3500 crore [22].

FIGURE 5

EXPORT VALUE OF TEA IN BANGLADESH FROM 2012–21 (IN BDT MILLION).



Source: Sajjad Hossan. Tea Industry of Bangladesh: Present Status and Future Needs. Business Inspection, 26 March 2022 [22].

Figure 5 illustrates that the value of tea exported from Bangladesh has increased in the last decade, between 2012–21.

After RMG and the leather industry, the paper industry plays a vital role in Bangladesh's national economy. According to the Export Promotion Bureau, the country exported paper products worth USD920,488 in 2016–2017. Around 70 private paper mills operate in the country, of which 105 are registered with the government. According to data from the Bangladesh Paper Mills Association, the country's paper market size is around BDT50 billion, registering an annualized growth of over 5% recently in 2021 [23]. Among the other sectors, according to the Bangladesh Cement Manufacturers Association, there are nearly 76 registered cement manufacturing companies in the country. This sector is in great demand in Bangladesh for increasing urbanization and real estate.

According to the Ministry of Agriculture, Bangladesh has a yearly demand of approximately five million tons of fertilizer, including 2.7 million tons of urea. In FY16, the demand for urea

was 2.8 million tons, while Bangladesh produced just 0.213 million tons. Similarly, the demand for urea was 2.7 million tons in FY15, while the domestic production was a meager 0.878 million tons [24].

The country has 15 sugar mills, one molasses-based distillery plant, and one engineering unit, the total area of which is 19,095 acres of land owned and managed by Bangladesh Sugar and Food Industries Corporation under the administrative Control of the Ministry of Industries. Still, most of the mills are not functioning. The current sugar production in Bangladesh is only about 5% of total demand. About 20% of the demand is fulfilled by jaggery production, mainly from sugarcane, and the remaining 75% of the total requirement is fulfilled by importation. The leading causes of the industry's lower sugar production include less sugarcane supply in the factories and poor sugar recovery [25].

Statistics show that there are 40,000 Light Engineering Enterprises operate in Bangladesh, and about one million people are employed in the sector. Annual turnover is USD1.6 billion, of which import of substitute products is worth around USD200 million. Another publication suggests that investment in LES is about USD14.8 billion, and export growth is approximately 30%. The government is providing a 10% cash incentive on the export of Light Engineering Products (LEPs). According to a talk held at the Dhaka Chamber of Commerce and Industry, the export income from the sector was USD510 million between 2011–16 and is expected to reach USD9 billion by 2021. It is predicted to attain USD15 billion by 2041. The world market is about USD7 trillion. This indicates an excellent opportunity to export LEPs [26].

The revolutionary new technology, automation, and 4IR significantly impact this industrial sector. As a result, this sector can benefit from digital tools for inventory management, supply chain optimization, production planning, use of data analytics, demand forecasting, utilizing blockchain for supply chain transparency, adopting IoT-based digital devices, adopting CAD software and 3D modeling tools to create and visualize designs before production, and digitalization in detecting defects [27].

Sector 2: Agriculture

Agriculture contributes approximately 14% of the country's GDP, employs about 40% of its workforce, and about 60% of its population depends on agriculture for their livelihood [1,18]. The total market size of the agriculture sector is 47.5 million dollars in 2021 [1]. Despite the constant development, the agriculture sector is still performing well below its potential. Bottlenecks like low production, post-harvest loss, low innovation of agricultural devices, inadequate supply of farm inputs like fertilizers and seeds, discriminatory prices, lack of real-time data-driven responsiveness information, lagging technology adoption, etc., prevent the agriculture sector from emerging to the peak.

Moreover, climate disasters are a major issue, and Bangladesh has suffered economic losses worth USD3.72 billion. Bangladesh's agricultural sector's adoption of technological innovation is poor compared to other developing nations. The lack of e-literacy in farmers' use of mobile-based apps is a bottleneck to developing informed and smart farmers. As a result, these challenges are accelerating major issues like food insecurity in Bangladesh.

The agriculture sector of Bangladesh is comprised mainly of marginal producers who work on their initiative on small plots of land. On top of that, people involved in agriculture are less educated and can't understand modern data-driven agriculture, mechanization, and precision agriculture. With

the imminent impact of the 4IR, the agriculture sector must embrace policies for access to digital finance, digital market, and automated advanced technological innovation culture.

Sector 3: Public Sector

The scope of DX in the public sector in Bangladesh is vast. It holds the potential to significantly improve government services, enhance transparency, reduce bureaucracy, promote efficiency in e-procurement, data management, e-government services, digital identity, cybersecurity, e-healthcare, digital payment and financial inclusion, digitalization of public records, e-tech, automation, digital health and telemedicine, data protection and many other things with opportunities for growth, innovation, and improved service delivery in financial services, e-commerce, healthcare, education, government services, transport, infrastructure, digital literacy, cyber security etc. Effective collaboration between government agencies, private sectors, and civil society organizations is essential to drive successful DX initiatives. Addressing the challenges and ensuring inclusive digitalization will be crucial for realizing the full potential of this transformation.

Mobilizing Scenarios

Sector 1: Digital Transformation in Industry

TABLE 2

DIGITALIZATION INITIATIVES AND PROGRAMS IN THE INDUSTRIAL SECTOR IN BANGLADESH.

Sl. No.	Initiatives and programs	Summary
1	Future of Work Lab [1]	A2i's Future of Work Lab addresses the changing nature of work, the workforce, and the workplace. It explores the potential of a data-driven adaptive system for skills and employment in Bangladesh aligned with 4IR requirements. To adapt to this global trend, the GoB has initiated an adaptive national system for jobs and skills through Future of Work.
2	CMSME [1]	Bangladesh's Cottage, Micro, Small and Medium Enterprises (CMSME) aims to bring in a higher percentage of the sector under digitization for inclusive innovation.
3	Blockchain Technology [1]	Adoption of blockchain technology for process control, implementation of quality control protocols, compliance, and optimization of distribution routes using digital tools.
4	Farmers' cooperatives to introduce digital tools [1]	Collaborate with tea farmers' cooperatives to introduce digital tools for data collection, enabling accurate demand forecasting.
5	Seminars and conferences [1]	It includes organizing seminars and conferences to educate cement industry stakeholders about the benefits of digitalization and energy-efficient technologies.
6	Financial incentives to chemical fertilizer companies [1]	Government bodies are now considering providing financial incentives to chemical fertilizer companies investing in digital technologies for efficient production.
7	Organize technology fairs and exhibitions [1]	Encourage engineering industry associations to organize technology fairs and exhibitions to showcase digital solutions and automation technologies.

Source: Aspire to Innovate. Prime Minister's Office, Government of Bangladesh [1].

CASE STUDY: FUTURE OF WORK LAB.

A2i's Future of Work Lab aims to address the changing nature of work, workforce, and workplace by exploring the potential of a data-driven adaptive system for skills and employment in Bangladesh. Over 50 4IR skills projects were launched in 2019. In 2021, the Cabinet Division and A2i facilitated the scaling up of 86 4IR skills projects undertaken by various government organizations. Curricula based on 4IR for 30 occupations have already been developed. Skills development programs have commenced for several 4IR occupations, such as smart electrical and electronics systems, blockchain technology, Maritime Autonomous Surface Ship (MASS) Operation, Augmented Reality and Virtual Reality (AR/VR), and 3D printing.

Source: Aspire to Innovate. Prime Minister's Office. Government of Bangladesh [1].

Sector 2: Agriculture

TABLE 3

DIGITALIZATION INITIATIVES AND PROGRAMS IN THE AGRICULTURAL SECTOR IN BANGLADESH.

Sl. No.	Initiatives and Programs	Summary
1	Experiment with 4IR Technologies for Smart Agriculture [1]	The GoB instructed the industry to incorporate 4IR technologies to establish a developed country by 2041. 4IR potentially brings a new set of actors: software companies, hardware companies for IoT devices and drones, data companies such as telcos, satellite companies, and others.
2	IoT-based Smart Meter for Irrigation pumps [1]	A potential solution for farmers is reducing operational costs and increasing crop production.
3	IoT-based Decision-Making for Irrigation and Fertilizer Management [1]	The solution proposes to monitor the soil condition of farming land, enabling farmers to learn about the need for irrigation or fertilizer usage in their fields and show recommendations accordingly.
4	Farmer-Friendly Smart Agriculture Data Ecosystem [1]	It incorporates big data and non-traditional data generated from different frontier technologies such as satellites, IoT, and weather stations and facilitates new innovative services.
5	Integrated service delivery and data-driven decision-making platforms to enhance Agri Production [1]	Updates knowledge and techniques dissemination on crop productions and advanced harvesting methods.

(Continued on next page)

(Continued from the previous page)

Sl. No.	Initiatives and Programs	Summary
	Digital Agriculture Supply-chain and Standardization [1]	A2i will develop a platform called 'Food for Nation' which can be used by everyone involved in the agricultural value chain.
6	Digital Agriculture Supply-chain and Standardization [1]	A2i aims to develop a platform, Food for Nation, which everyone in the agricultural value chain can use.
7	Vacuum Frying Machine [1]	Smart vacuum frying technology addresses post-harvest challenges, minimizing nutrition loss and food wastage.
8	Smart Agriculture Tech Lab to accelerate farm mechanization [1]	A2i proposes to address the challenges of the 4IR in Bangladesh by establishing cutting-edge automated farming technologies and 4IR devices and transformation.
9	IoT-based Smart Fish Farm [1]	This includes automating fish feed application systems, water distribution and exchange systems, Aeration systems, water quality systems, and environmental parameter monitoring systems.
10	Automation of the Dairy Industry in Bangladesh [1]	The solution proposes using IoT-enabled devices to track and monitor livestock health, known as livestock monitoring or precision livestock farming.
11	e-Traceability for Agriculture management [1]	E-traceability employing 4IR technology would offer simple access to resources and transform the agriculture sector by tracking the products' movement, location, and history.
12	e-Traceability of ruminants for smart livestock management [1]	E-traceability employing 4IR technology would offer simple access to resources and transform the livestock sector by tracking movement, location, vaccination, antibiotic history, etc.
13	Innovation Fund [1]	The proposed solution aims to enable the nation to innovate faster, solve local problems, and develop people skills by supporting research and innovation through value addition and ensuring a conducive policy environment.
14	Village Super Market	It is a business hub for farmers, traders, and national and international buyers. It has focused on digital processing, storage for quality control of agri–products, and waste management in the supply chain system. Solidaridad Network Asia established two Village Super Markets in the Khulna region in 2019 as a model of a modern commodity supply chain system.
15	Krishoker Janala [1]	Krisoker Janala, an app for disseminating agricultural information, started in January 2019. The user can easily identify any crop problem by looking at an image, and the solution to the problem is visible by clicking on the identified image. To date, the app has been downloaded by 150k users.
16	Crop Production [28]	The crop production app is designed to serve as a storehouse of all agricultural production data for a year.
17	DAE Office Directory [28]	Farmers can communicate with the officers easily in a personalized way.
18	DigiCow [28]	The platform operates to provide all the crucial health and reproduction data of an individual cow on a farm.

(Continued on next page)

(Continued from the previous page)

Sl. No.	Initiatives and Programs	Summary
19	Weather Forecasting App [28]	The weather forecasting app displays relevant information about a region on a micro-scale, allowing users to deduce changes and plan crop plantations and harvests accordingly.
20	Fosholi App [28]	One can get information about crop growth, plantation, nurturing, fertilizer use, and harvesting.
21	Bottom Line [28]	These Bangladeshi Agricultural apps significantly impact farming in the country, alleviating harvesting and reducing crop damage.

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

CASE STUDY: KRISHOKER JANALA

An AI-based platform for suggesting crop-disease and solutions, Krishoker Janala, was conceived in 2014 by Abdul Malek, an Upazila Agricultural Officer. Until now, the app has been downloaded by 150,000 users. Its effective use as an innovative tool for disseminating agricultural information started in January 2019. It enables user to easily identify crop problems by viewing image and access solutions by clicking on the identified image. The app has been used by extension officers to reduce time, costs, and the need for frequent visits by the farmer, thereby enhancing service quality [1].

Sector 3: Public Sector

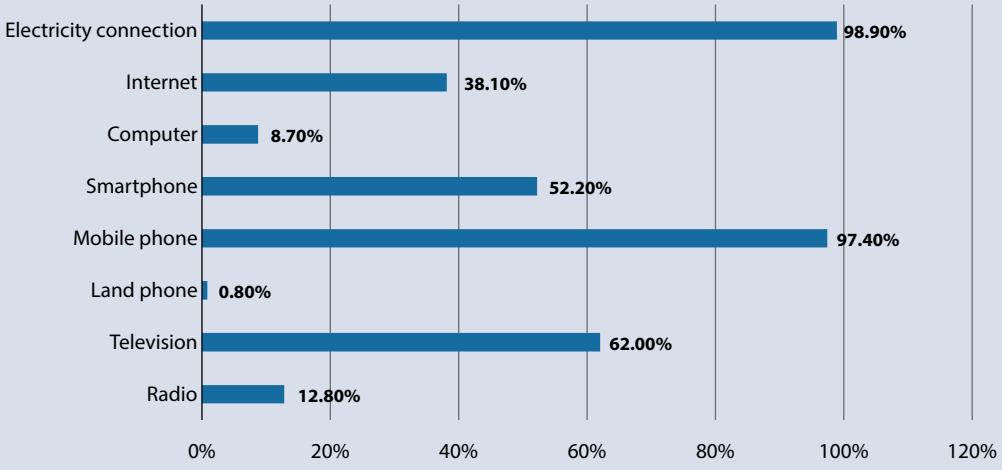
Bangladesh ICT Market Analysis

The Bangladesh ICT Market is expected to grow at a Compound Annual Growth Rate (CAGR) of 1.83% over the next five years, with the country's growing emphasis on digital technology, cloud technology, cyber security, AI, robotics, healthcare, and IT driving market growth [29].

Access to ICT at the Household Level in Bangladesh

FIGURE 6

ACCESS TO ICT AT THE HOUSEHOLD LEVEL IN BANGLADESH (IN 2022).



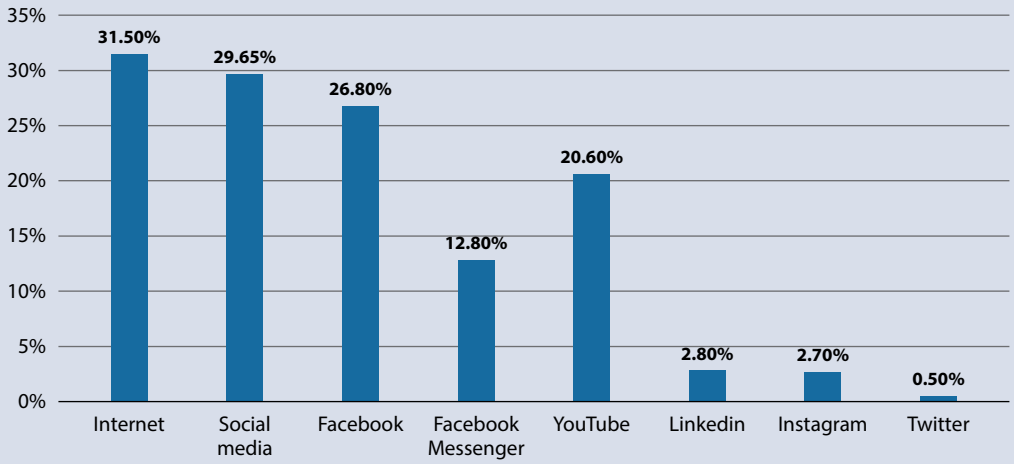
Source: Survey on ICT Use and Access by Individuals and Households 2022. Bangladesh Bureau of Statistics (BBS),. Ministry of Planning. GoB [8].

Figure 6 shows that Internet access among households in Bangladesh is only 38.10%, computers 8.70%, and smartphones 52.20%. These are critical for digitalization and indicate a considerable gap towards achieving the Digital Bangladesh dream.

Internet and Social Media Users in Bangladesh

FIGURE 7

INTERNET AND SOCIAL MEDIA USERS IN 2022 IN BANGLADESH (IN %).



Source: Simon Kemp. Digital 2022: Bangladesh. Datareportal, 15 February 2022 [30].

Figure 7 illustrates that only 31.50% of individuals in Bangladesh use the Internet, with 28.65% actively engaged in social media platforms, primarily Facebook. However, other significant platforms such as LinkedIn, Instagram, and Twitter have relatively smaller user bases. This analysis highlights Bangladesh's lag in embracing digital devices and networks, revealing a substantial gap in DX efforts.

TABLE 4

DIGITALIZATION INITIATIVES AND PROGRAMS IN PUBLIC SECTOR IN BANGLADESH.

Sl. No.	Initiatives and programs	Summary
1	DSDL [1]	GoB is designing DSDL to simplify services. To accelerate the digitalization of government services, GoB will prepare budgets and implementation plans involving service recipients (citizens) and service providers (concerned ministries).
2	iLab [1]	GoB has designed an iLab to incubate and scale up social innovations, electromechanical devices, IoT, and renewable energy.
3	DIL [1]	A2i's DIL encompasses various key areas, including assistive technology, accessible information, inclusive banking, disability and digital inclusion training, and inclusive education.
4	NISE [1]	This one-stop data platform offers a broad spectrum of unique services for matching supply and demand.

(Continued on next page)

(Continued from the previous page)

Sl. No.	Initiatives and programs	Summary
5	Digital Financial Inclusion [1]	The DFS Lab of a2i brings together key ministries, regulators, financial service providers, academia, and international experts to spread GOB's efforts to digitize Government-to-Person payments, including social safety net programs and Person-to-Government payments.
6	Rural Branchless Banking [31]	It is a branchless banking system for the unbanked across the country, and the total number of branches is 10,685.
7	e-GP [47]	GOB's online procurement portal provides equal access to Bidders and tenderers and ensures efficiency, transparency, and accountability in Bangladesh's public procurement process.
8	Daraz [32]	It is a prominent online shopping marketplace in South Asia with an active presence in Bangladesh. It has 30,000 sellers, 500 brands, and more than 2.5 million products and serves more than 5 million customers across the region.
9	Smart Health Accelera-tor [1]	It is an inclusive and effective healthcare ecosystem that provides digital health services for the poor.
10	Health Data Architec-ture [1]	Serves as an information hub, integrating and organizing health data across various sources.
11	Health Financing [1]	It focuses on ensuring equitable access to healthcare. It also aims to enhance financial stability, improve affordability, and promote high-quality healthcare services.
12	Health System Strengthening [1]	Focuses on enhancing infrastructure, facilities, staff, and services to improve system efficiency and service delivery.
13	Maternal and Child Health [1]	It focuses on the well-being of mothers and children, encompassing antenatal, postnatal, and pediatric care.
14	Health Education [1]	It promotes health literacy through targeted educational programs, interactive tools, and engaging resources.
15	HER [1]	It offers digitalized patient records that revolutionize healthcare management.
16	Primary Healthcare [1]	Primary healthcare services focus on delivering community-based, easily accessible healthcare services to citizens, particularly those in rural and hard-to-reach areas.
17	Health Data Analytic Tools [1]	These analytics tools have been developed to help healthcare professionals and policymakers make informed decisions.
18	Shukhi Jibon DHIS2 Data Platform	This is an initiative of Pathfinder International through the USAID-funded Shukhi Jibon Project. Family Planning (FP) and SRH data are available on this platform and helpful for evidence-based decision-making in Bangladesh's health and FP sector.
19	NCD [1]	It aims to reduce the burden of NCDs, improve patient outcomes, and promote a healthier society through evidence-based interventions, innovative technologies, and holistic approaches.

(Continued on next page)

(Continued from the previous page)

Sl. No.	Initiatives and programs	Summary
20	Health Challenge Fund [1]	E-Learning Platform for Health empowers professionals with online learning resources, while the Doctors Pool App optimizes healthcare staffing.
21	E-Learning App	It is an initiative of Cordaid International, funded by the EU SONGO project. Through this app, adolescents can easily access sexual and reproductive health-related learning material. The organization also tried to develop an app (BizSmart) for small business holders (Nutrition Sales Agents, Farm Business Advisors, and related entrepreneurs) through the SONGO project.
22	National Covid-19 Dashboard [1]	A2i has created a dashboard for the COVID-19 reporting system for the field administration.
23	High-Risk Location Identification and Mapping [1]	Using the map's zone-specific information, the government can expand area-based assistance.
24	Future of Education [1]	A digital education ecosystem that follows a multimodal approach, a combination of multiple high-tech, low-tech, and non-tech learning modalities.
25	BEA [1]	It is a national public-private collaboration platform. Teenagers can share, upload, and learn from creative multimedia content and important life lessons that can help develop their talent and social and personal skills. Over three million students are connected on this platform and accessing over 35,800 available content.
26	MuktoPaath [1]	It was launched in 2016 to bring skill-based professional and academic courses at affordable costs to every citizen's doorstep. The platform has over 208 online and offline courses for teachers, students, professionals, lawyers, doctors, migrant workers, and the poor and underserved.
27	MMC [1]	The MMC initiative, launched in 2012, was amongst the first milestones towards a digital Bangladesh. Currently, more than 45,000 schools are using MMC.
28	Shangshad TV [1]	Only about 35% of secondary school students and less than 20% of primary school students have Internet access. The Parliament TV broadcasts thousands of lessons in 19 classes daily, from morning to early evening, for primary, secondary, madrassa, and vocational education.
29	Teacher's Portal [1]	It is a capacity development hub for teachers, with over 590,000 teachers registered on it to date.
30	National Portal [1]	The portal is designed to facilitate access to e-services and websites. Over 150,000 citizens access the portal each day.
31	MyCourt [1]	It is a virtual court specially established to cope with the COVID-19 pandemic situation in Bangladesh in 2020.

(Continued on next page)

(Continued from the previous page)

Sl. No.	Initiatives and programs	Summary
32	e-Nothi [1]	It is a digital process that speeds up citizens' applications for services by electronically moving files across different administrative layers.
33	SPS [1]	A tool for reducing citizens' hassle through eliminating unnecessary steps within and between ministries.
34	Socioeconomic Dashboard [1]	It supports government agile decision-making through the availability of real-time sectorial data.
35	MyGov [1]	The app is a single and central platform for multiple solutions that allow users to complete service applications, check the status of service delivery, and make necessary payments for digital services from all ministries.
36	ekShop [33]	This unique assisted rural eCommerce model integrates the countrywide physical network with the Digital Centers. It bypasses multiple layers of traditional and high-cost intermediaries.
37	eKPay [34]	It is a one-stop bill payment solution.
38	bKash [35]	It is the first and most popular mobile financial service platform for sending money, cash out, mobile recharges, bill payments, savings, etc. It was set up in 2011 following the Digital Bangladesh initiative.
39	Nagad [36]	It is the popular mobile financial service platform after bKash for sending money, cash out, mobile recharge, bill payment, savings, etc., in Bangladesh.
40	Rocket [37]	Rocket is the first banking process without a bank branch or Dutch-Bangla Bank Limited, providing financial services to unbanked communities efficiently and at an affordable cost.
41	Uber [38]	It is a ride-sharing digital platform launched in Bangladesh in 2016. It quickly became popular in the country because it offers convenient, affordable, and safe ways to share rides.
42	Pathao [39]	It is a ride-sharing platform launched in March 2015 in Bangladesh and quickly became popular in the country due to the choice of offering convenient, affordable, and safe ways.
43	Shohoz [40]	Shohoz is a pioneer in Bangladesh's travel industry and, since 2014, has become the largest online ticket destination in the country.
44	Online Patient Appointment System [1]	A digital platform that allows individuals to schedule and manage their medical appointments online.
45	My Constituency [1]	It works as a consultant and encompasses data on 10 inclusive themes, including education, poverty, and health, launched in 2020.
46	Sanitation Data Governance [41]	This is a unique and timely evidence-based decision-making platform for WASH. It will be built through a National Sanitation Dashboard that will show the country's clear picture of WASH at a glance.
47	Online Newspapers and TV Channels [42]	Online news portals, TV channels, and magazines serving citizens' news and information through digital platforms started mainly after the 1990s in Bangladesh.

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

CASE STUDY: ELECTRONIC-GOVERNMENT PROCUREMENT

e-GP, short for Electronic-Government Procurement, is an online procurement portal of the Bangladesh government. Developed, owned, and operated by the Central Procurement Technical Unit (CPTU) within the Implementation, Monitoring & Evaluation (IME) Division of the Ministry of Planning, this comprehensive solution was introduced under the Public Procurement Reform Program with support from the World Bank. It is gradually being adopted by all government organizations. This online platform ensures equal access to the bidders/tenderers and promotes efficiency, transparency, and accountability in the public procurement process in Bangladesh. Initially implemented on a pilot basis, it applies to a select few Procuring Entities (PEs) from four target agencies: the Bangladesh Water Development Board (BWDB), Rural Electrification Board (REB), Roads and Highways Department (RHD), and Local Government Engineering Department (LGED). The system will later be rolled-out to all procuring entities in a phased manner [32].

CASE STUDY: ekSHOP

It is a unique assisted rural e-commerce model that integrates the countrywide physical network of nearly 7,000 digital centers. Through ekShop, Digital Center Entrepreneurs assist rural youth, artisans, refugees and farmers to reach new, urban customers directly, bypassing multiple layers of traditional, high-cost intermediaries. This enables them to secure a fair price for their produce by opening virtual shops to market and sell their products online. It also helps them receive assistance from the Digital Centre Entrepreneurs for advertisement and promotion, connect and negotiate cheaper prices with logistics partners, and receive and make payments digitally. To provide countrywide logistic network, ekShop has already engaged 16 local and four international e-commerce companies, enabling nearly one million entrepreneurs to join the platform. To date, five million transactions totaling USD10 million have been conducted on this platform [33].

Transparency: Responsible Research Innovation

Sector 1: Digital Transformation in Industry

1. Through the Future of Work Lab, over 40 industry associations, job seekers, and 32 government departments respond to current challenges and critical future trends [1].

2. Government agencies can now handle a higher volume of requests faster and more accurately through automation processes [4].

3. Developed innovation hubs and provided funding to research institutes working on digital applications in the industrial sectors.

4. Use blockchain to verify the authenticity and quality of products and build consumer trust.

5. Implement IoT devices to monitor compliance, process control, and product quality.

6. Develop digital catalogs showcasing industrial products with detailed specifications and transparent pricing.

Sector 2: Agriculture

1. Implementing IoT-based smart technology reduces farm labor and water use, saves significant money, increases crop production, prevents nutrients from degrading, and contributes to soil health.

2. Introduce the e-traceability of livestock and agriculture management that have access to the location, vaccination, antibiotic history; reduced operating costs; ensure the quality of the livestock products within the supply chain; detect disease outbreak in time and allows for quick reaction to emergencies, and reduces product wastage by at least 50%, postharvest loss by 25–50%; enhances quality control system; implements traceability in the market will increase agricultural export beyond 7.5%; assurance of food safety.

3. Smart food supply chain processing devices can reduce food wastage and strengthen food supply processing.

4. Mobile apps can easily identify crop diseases, suggest the precise amount of fertilizer to be used, and provide effective methods for pest prevention. They can also access all the existing crop-related diseases, solutions, and suggestions and reduce TCV for farmers and extension agents.

Sector 3: Public Sector

1. Digital Payment can reduce corruption, enhance financial transparency and reduce time.

2. E-government portals provide a single point of access to government services, information, and data, which can enhance transparency.

3. Digital health can ensure the efficient delivery of healthcare.

4. E-tech can help students and teachers access content easily.

5. Rideshare can help users quickly hire vehicles at a competitive price.

6. The digitization of public services has contributed to the growth of Bangladesh's digital economy by simplifying services [4].

7. With the widespread adoption of digital technologies, traditional forms of communication and social interaction are being transformed by digitalization [4].

8. With information available online, people are increasingly relying on digital media for news and information [4]. It helps reduce the TCV.

Policy Recommendations

Sector 1: Digital Transformation in Industry

1. Invest in technology, innovation, advanced machinery, digital literacy, and training for digital tools to improve production efficiency and quality and reduce costs.

2. Promote modernization and technological upgrades to improve production efficiency and product quality.

3. Create strategies for integrating IoT devices and blockchain technology for process control, implementing quality control protocols, compliance, and optimizing distribution routes using digital tools.

4. Develop and implement digital platforms to showcase and sell industrial products, such as leather, to consumers through e-commerce integration.

5. Invest in physical infrastructure that will promote the transfer of digitalization tools in the industrial sector.

6. Improve physical communication network for smooth digitalization tools and technologies operation.

7. Invest in R&D to develop innovative uses for the industrial sector beyond traditional applications.

8. Establish technical training programs to develop a skilled workforce for the industrial sectors focusing on modern technologies.

Sector 2: Agriculture

1. Nurture farmer-friendly smart agriculture data ecosystem.

2. Develop integrated service delivery and data-driven decision-making platforms.

3. Facilitate the setting up of digital agriculture supply chain and standardization to reduce post-harvest loss and improve the agro-processing industry.

4. Establish smart agriculture tech lab to accelerate farm mechanization through agricultural equipment and technology innovations.

5. Create policy framework to improve digital literacy among farmers and their ability to adopt digital technologies.

6. Make a policy to drive the use of IoT-based technologies and precision agriculture among end users.

7. Invest in physical infrastructure to transfer digitalization tools and promote its usage in the agricultural sector.

8. Improve physical communication network to enable operation of smooth digitalization tools and technologies.

9. Establish collaboration network hub between Farm-Extension-Research to ensure global best practices.

Sector 3: Public Sector

1. Launch a digital literacy program to educate citizens on digital technologies.
2. Establish robust data governance frameworks for evidence-based decision-making.
3. Expand the e-government services and make them more citizen-centric and user-friendly.
4. Strengthen cybersecurity measures to protect citizens' data.
5. Invest in high-speed broadband infrastructure to ensure all citizens can access the Internet, especially in rural and underserved areas.
6. Invest in physical infrastructure that will promote the transfer of digitalization tools in the public sector.
7. Improve the physical communication network for smooth digitalization of tools and technologies.
8. Expanding high-speed broadband Internet coverage and mobile networks to rural and underserved areas to ensure universal access.
9. Implement digital literacy programs in schools, colleges, and community centers to equip people with essential digital skills.
10. Promote financial literacy programs to educate individuals about digital banking and financial services, especially in rural areas.
11. Integrate digital literacy and technology-related subjects into the school curriculum.
12. Invest in better logistics infrastructure to support e-commerce delivery services, especially in rural areas.
13. Launch awareness campaigns to educate the public about the benefits and availability of telemedicine and other digital services.

Conclusion

The demand for 4IR and Smart Bangladesh 2041 has brought DX in various sectors, including industrial, agriculture, public, and services, focusing on leveraging technology to enhance productivity, production efficiency, and quality, reduce cost, and simplify service delivery in Bangladesh. The 5G connectivity, digital technology, e-commerce, and digital payments, precision agriculture using satellite and drone, digital healthcare, data ecosystem, data-driven decision making, IoT and smart infrastructure, supply chains optimization using digital tools, blockchain, automation, CAD and 3D designing, are the main emerging trends in DX over the period.

Bangladesh still needs to catch up with its adaptation due to a lack of digital and financial literacy, insufficient skills, unavailability of digital devices, poor mobile networks, and Internet connectivity,

especially in remote areas, unfavorable infrastructure in digital pathways, and a lack of awareness. Therefore, the country needs to make appropriate policies and strategies and implement them to align with digital transformation, meeting the demands of 4IR and Smart Bangladesh.

References

[1] Aspire to Innovate. Prime Minister's Office. Government of Bangladesh. https://a2i.gov.bd/. Accessed on 1 August 2023.

[2] The Dhaka Tribune. E-government is the present and the future. 4 September 2023. https://www.dhakatribune.com/opinion/op-ed/299300/e-government-is-the-present-and-the-future. Accessed on 5 August 2023.

[3] The Dhaka Tribune. Digital Bangladesh to Innovative Bangladesh: The road to 2041. 4 September 2023. https://www.dhakatribune.com/opinion/317126/digital-bangladesh-to-innovative-bangladesh-the. Accessed on 5 August 2023.

[4] The Dhaka Tribune. Going digital has been a godsend. 4 September 2023. https://www.dhakatribune.com/opinion/op-ed/307741/going-digital-has-been-a-godsend. Accessed on 6 August 2023.

[5] The Business Standard. How digitization efforts on Time, Cost and Visit (TCV) is making people's life easier. 30 April 2023. https://www.tbsnews.net/thoughts/how-digitisation-efforts-time-cost-and-visit-tcv-make-peoples-life-easier-623994. Accessed on 8 August 2023.

[6] The Daily Messenger. Digitization saves USD21.92 billion for public service recipients. 4 September 2023. https://www.dailymessenger.net/business/news/3895. Accessed on 8 August 2023.

[7] Rana M., Rekha R. S., Islam H. The Impact of Digitalization on the Economic Growth of Bangladesh. Journal of Business Studies. Pabna University of Science and Technology; 2022. https://pust.ac.bd/uploads/pust-journals/pdf/1676915980.pdf. Accessed on 10 August 2023.

[8] Bangladesh Bureau of Statistics. Ministry of Planning, Government of Bangladesh. Survey on ICT Use and Access by Individuals Households 2022. https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/b343a8b4_956b_45ca_872f_4cf9b2f1a6e0/2023-01-08-07-00-667cde6536494c707e86d483c0b618a5.pdf. Accessed on 12 August 2023.

[9] Bangladesh Bureau of Statistics. Ministry of Planning, Government of Bangladesh. Population and Housing Census 2022. https://sid.portal.gov.bd/sites/default/files/files/sid.portal.gov.bd/publications/01ad1ffe_cfef_4811_af97_594b6c64d7c3/PHC_Preliminary_Report_(English)_August_2022.pdf. Accessed on 13 August 2023.

[10] Khan A.K., Shnaider A. The development trends and features of online news websites in Bangladesh. EUREKA Social and Humanities 2021; doi: 10.21303/2504-5571.2021.001858. Accessed on 15 August 2023.

[11] Hossain M.N., Alam R.M.K., Musaddique M.H.M. Digital Bangladesh, a transformation for sustainable development. International Journal of Multidisciplinary Research and Development; 2021, 8(12), pp. 79–82.

[12] BRAC Institute of Governance and Development (BIGD) and Digital Pathways, Oxford. Digital Readiness Assessment: The Future of Digital in Bangladesh 2021. https://bigd.bracu.ac.bd/wp-content/uploads/2021/04/The-Future-of-Digital-in-Bangladesh_Digital-Readiness-Assessment.pdf. Accessed on 18 August 2023.

[13] BRAC Institute of Governance and Development (BIGD) and Digital Pathways, Oxford. Strategy Primer: For the Future of Digital in Bangladesh 2021. https://pathwayscommission.bsg.ox.ac.uk/sites/default/files/2021-11/Bangladesh%20Strategy%20Primer%20Accessible.pdf. Accessed on 18 August 2023.

[14] Mannan M. Digital revolution in Bangladesh. The Energy Bangla, 26 January 2021. https://www.energybangla.com/digital-revolution-in-bangladesh/. Accessed on 2 September 2023.

[15] Ali M.M. Digitization of the emerging economy: An exploratory and explanatory case study. Journal of Governance & Regulation 2020; 9(4), pp. 25–36. http://doi.org/10.22495/jgrv9i4art2. Accessed on 20 August 2023.

[16] International Monetary Fund. https://www.imf.org/external/datamapper/profile/BGD. Accessed on 3 September 2023.

[17] The enterprises project. https://enterprisersproject.com/what-is-digital-transformation. Accessed on 30 August 2023.

[18] Feed the Future. Digital Insights in Bangladesh Agriculture. https://files.digitalfrontiersdai.com/media/documents/Digital_Insights_on_Agriculture_in_Bangladesh_-_FINAL.pdf. Accessed on 24 August 2023.

[19] The Business Inspection. Leather Industry of Bangladesh: Challenges and Opportunities. https://businessinspection.com.bd/leather-industry-of-bangladesh/#google_vignette. Accessed on 27 August 2023.

[20] The Business Haunt. Jute Industry in Bangladesh. History, Problems and Prospects. https://businesshaunt.com/jute-industry-in-bangladesh-history-problems-and-prospects/. Accessed on 27 August 2023.

[21] The Business Inspection. Pharmaceutical Industry of Bangladesh: Prospects and Future Challenges. https://businessinspection.com.bd/pharmaceutical-industry-of-bangladesh/#google_vignette. Accessed on 28 August 2023.

[22] The Business Inspection. Tea Industry of Bangladesh: Present Status and Future Needs. https://businessinspection.com.bd/tea-industry-of-bangladesh/. Accessed on 28 August 2023.

[23] Uddin S. Bangladesh's paper industry holds huge export potential. The Financial Express, 8 December 2021. https://thefinancialexpress.com.bd/trade/bangladeshs-paper-industry-holds-huge-export-potential-1638932197. Accessed on 29 August 2023.

[24] Emerging Credit Rating Limited. Department of Research. Fertilizer Industry of Bangladesh; May 2017; 1. https://emergingrating.com/wp-content/uploads/2017/09/Fertilizer-Industry-of-Bangladesh-Vol-I.pdf. Accessed on 1 September 2023.

[25] Research Gate. Sugarcane and Sugar Industry in Bangladesh: An Overview. https://www.researchgate.net/publication/309596312_Sugarcane_and_Sugar_Industry_in_Bangladesh_An_Overview. Accessed on 1 September 2023.

[26] Ahmad F. Light engineering products: From local workshops to export baskets. The Business Standard, 27 January 2020. https://www.tbsnews.net/opinion/light-engineering-products-local-workshops-export-baskets-39481. Accessed on 2 September 2023.

[27] The Textile Focus. How 2023 may treat the apparel industry of Bangladesh. https://textilefocus.com/how-2023-may-treat-the-apparel-industry-of-bangladesh/. Accessed on 3 September 2023.

[28] The United News of Bangladesh. Top 5 Mobile Apps for Farmers in Bangladesh. 3 June 2021. https://unb.com.bd/category/Tech/top-5-mobile-apps-for-farmers-in-bangladesh/72333. Accessed on 26 August 2023.

[29] Mordor Intelligence Private Limited. Bangladesh ICT Market Size & Share Analysis - Growth Trends & Forecasts (2024–29). https://www.mordorintelligence.com/industry-reports/bangladesh-ict-market. Accessed on 10 August 2023.

[30] Datareportal. Digital 2022: Bangladesh. https://datareportal.com/reports/digital-2022-bangladesh. Accessed on 10 August 2023.

[31] Uddin Z.A.K.M. Branchless banking gaining ground. The Daily Star, 25 April 2021. https://www.thedailystar.net/business/news/branchless-banking-gaining-ground-2083361. Accessed on 1 September 2023.

[32] Daraz. https://www.daraz.com.bd/about-us/?spm=a2a0e.home.footer_top.11.40ff12f7mOK28C&scm=1003.4.icms-zebra-100022982-2888463.OTHER_6051348799_2538033. Accessed on 3 September 2023.

[33] ekShope. https://www.ekshop.gov.bd/. Accessed on 3 September 2023.

[34] eKPay. https://ekpay.gov.bd/#/about-us. Accessed on 3 September 2023.

[35] bKash. https://www.bkash.com/. Accessed on 4 September 2023.

[36] Nagad. https://nagad.com.bd/pg/?n=about-nagad. Accessed on 4 September 2023.

[37] Rocket. https://www.dutchbanglabank.com/rocket/rocket.html. Accessed on 4 September 2023.

[38] Uber. https://www.uber.com/global/en/cities/dhaka/. Accessed on 2 September 2023.

[39] Pathao. https://pathao.com/bn/. Accessed on 2 September 2023.

[40] Shohoz. https://www.shohoz.com/about-us/en. Accessed on 2 September 2023.

[41] GWSC. https://www.gwsc.ait.ac.th/sanitation-data-governance-unleashing-opportunities-and-tackling-challenges-for-improved-sanitation/. Accessed on 10 August 2023.

[42] All Bangla Newparerlist.com. https://www.allbanglanewspaperslist.com. Accessed on 5 September 2023.

[43] Aerospace Technology. Bangabandhu Satellite 1 (BD-1 Communication Satellite). https://www.aerospace-technology.com/projects/bangabandhu-1-bd-1-communication-satellite/. Accessed on 8 August 2023.

[44] National Industrial Policy 2022. https://www.projectsprofile.com/info/Policy_Industrial_2022.pdf. Accessed on 12 August 2023.

[45] Albakar M.H. Automation to replace 60% RMG jobs by 2041. The Business Standard, 8 December 2019. https://www.tbsnews.net/economy/automation-replace-60-rmg-jobs-2041. Accessed on 25 August 2023.

[46] Bangladesh Garment Manufacturers and Exporters Association. About Garments Industry of Bangladesh. https://www.bgmea.com.bd/page/AboutGarmentsIndustry. Accessed on 25 August 2023.

[47] Bangladesh Public Procurement Authority. e-GP. https://cptu.gov.bd/e-gp.html. Accessed on 2 September 2023.

CAMBODIA

Introduction

Cambodia, situated in Southeast Asia, sprawls across the Mekong River delta and the Gulf of Thailand. The country with a population of over 16 million people, shares borders with Thailand in the west, Laos in the north, and Vietnam in the east. Its capital is Phnom Penh.

Source: WorldAtlas.com.

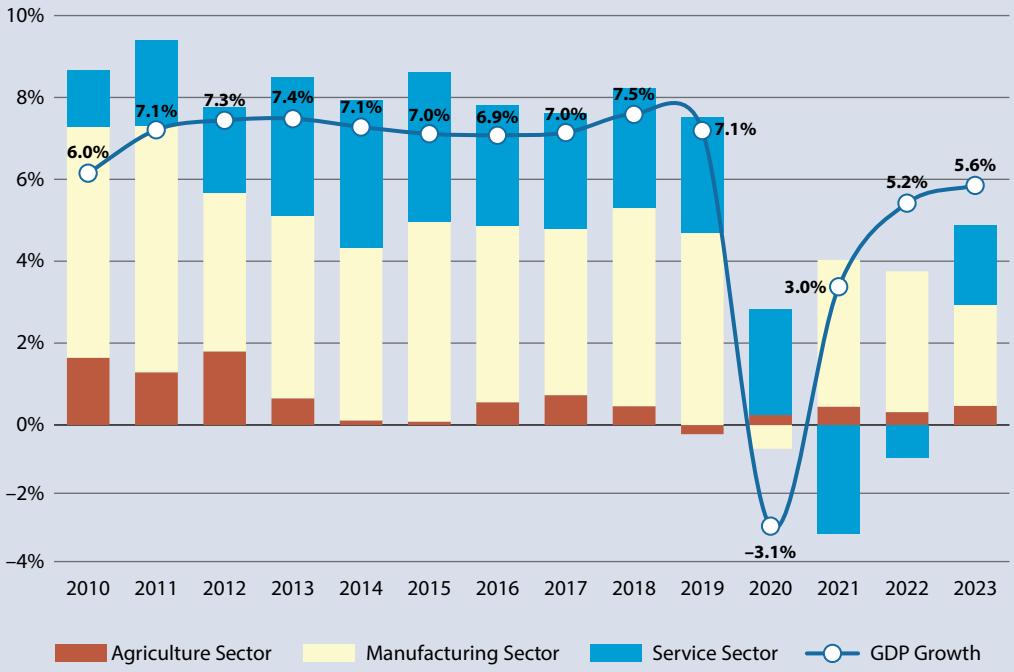
The digital technology landscape in Cambodia is undergoing rapid evolution, which has been marked by a sharp increase in Internet and mobile phone usage in recent years. As of 2022, the country had approximately 18 million Internet users and 19.6 million mobile phone subscribers [1]. This surge has led to the emergence of several digital startups and businesses, especially in the e-commerce, fintech, and agriculture sectors.

However, despite these advancements, the global crisis of 2020 negatively impacted the economy in Cambodia, resulting in a –3.1% drop in the general growth rate, as illustrated in Figure 1. This downturn primarily stemmed from contractions in the industrial sectors, even though the agricultural and services sectors managed to sustain growth rates during the COVID-19 pandemic [2].

To recover from the economic impact and setback of the crisis in 2020, the Royal Government of Cambodia (RGC) recognized the pivotal role of digital technology in fostering economic growth.

FIGURE 1

THE MACRO ECONOMIC EVALUATION OF CAMBODIA (2022–23).



Source: Ministry of Economic and Finance, Government of Cambodia, 2023.

The RGC launched Phase One of its Pentagonal Strategy in early August 2023. As depicted in Figure 2, the strategy delineates five key objectives [3].

- **Building digital government and citizens:** This aims to enhance government efficiency and effectiveness using digital technologies. It also seeks to educate citizens on the benefits of digital tools and how to use them safely and responsibly.

- **Developing the digital economy, digital business, e-commerce, and digital innovation systems:** This objective focuses on fostering the digital economy by developing a robust digital infrastructure and a supportive business environment. It also aims to encourage the development of innovative digital businesses and services.

- **Establishing and enhancing digital infrastructures:** It seeks to improve the quality and accessibility of digital infrastructure throughout Cambodia, including setting up new networks, improving existing ones, and providing digital access to rural areas.

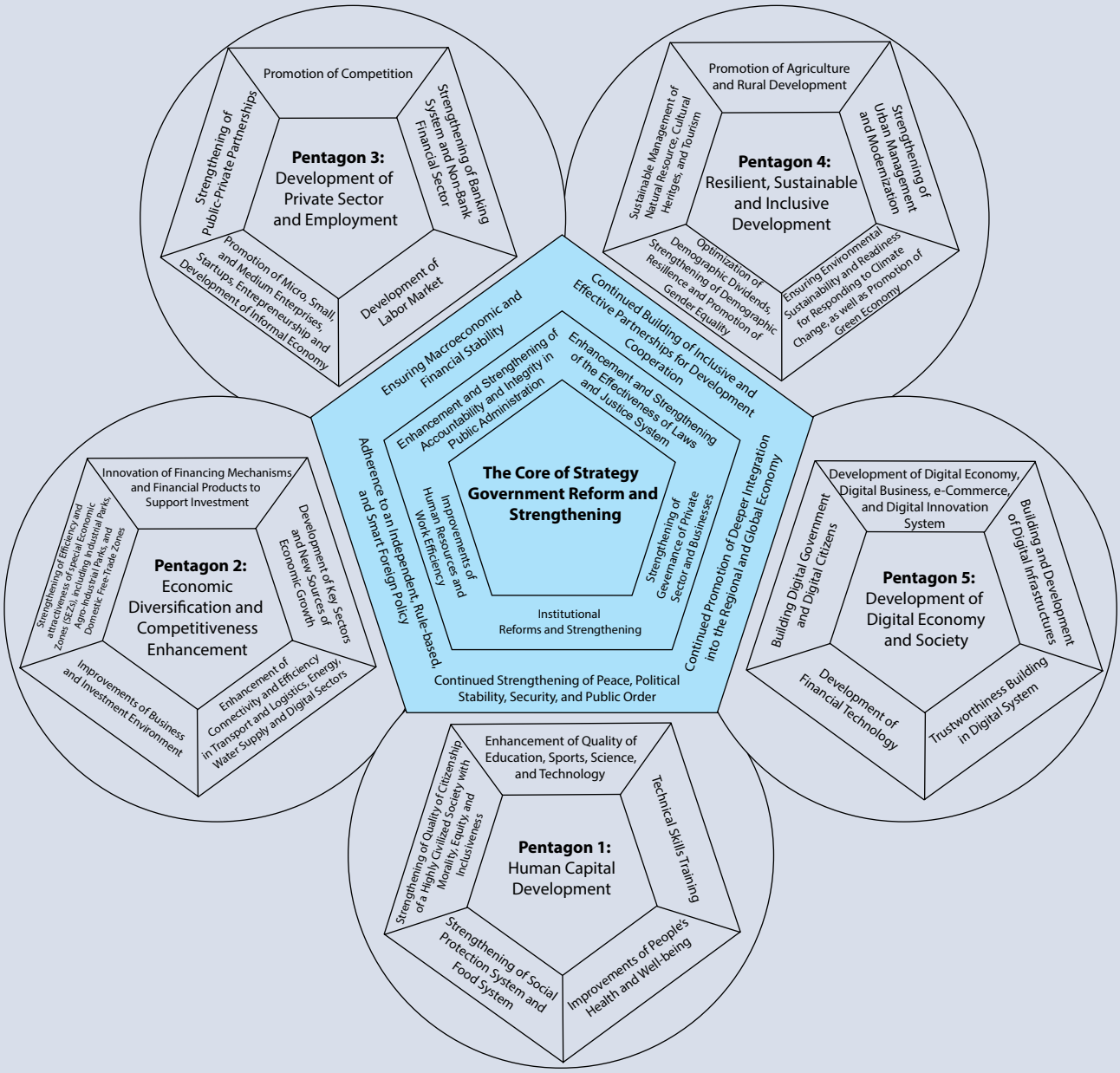
- **Creating trustworthiness in digital systems:** This goal aims to establish a secure and trustworthy digital ecosystem. This involves formulating laws and regulations to safeguard data privacy and security and building the capacity to enforce these regulations.

- **Development of financial technology:** This goal aims to foster the development of financial technology in Cambodia, including developing digital payment systems, mobile banking, and other financial services accessible to all Cambodians.

The Pentagonal Strategy Phase I is designed to propel Cambodia toward its goal of becoming a high-income country by 2050. Rooted in the principles of growth, employment, equity, efficiency, and sustainability, it holds the promise of being a key driver of Cambodia's economic development in the years to come, with the RGC committed to implementing it as a paramount catalyst for the nation's advancement. Comprehensive and ambitious, the Pentagonal Strategy – Phase I outlines a roadmap for DX in Cambodia. It will majorly impact the country's economy and society if successfully implemented.

FIGURE 2

CAMBODIA'S PENTAGONAL STRATEGY – PHASE 1.



Source: The Royal Government of Cambodia.

In addition to the Pentagonal Strategy – Phase I, Cambodia has instituted various national strategies, policies, and frameworks to facilitate the assimilation and utilization of emerging technologies. These include:

- Cambodia's Science, Technology and Innovation Roadmap 2030
- National Research Agenda 2025
- Cambodia Digital Economy and Society Policy Framework 2021–2035
- Cambodia Digital Government Policy (CDGP) 2022–2035
- Six technology roadmaps focusing on six priority sectors.

Notably, one of these technology roadmaps, the Digital Tech Roadmap, stands out as the core technology supporting the implementation of other tech roadmaps. This integrated approach underscores Cambodia's commitment to harnessing the transformative potential of digital technologies across various sectors to drive sustainable development and prosperity.

TABLE 1

SUMMARY OF DIGITALIZATION POLICIES IN CAMBODIA.

Policy Framework	Summary
Cambodia's Science, Technology and Innovation Roadmap 2030 [4]	The roadmap identifies five key pillars: • STI governance: This pillar focuses on strengthening the institutional framework for STI and promoting effective stakeholder coordination. • STI workforce: This pillar focuses on developing a skilled workforce, driving STI to support the country's economic and social development. • Research and development (R&D): This pillar focuses on increasing investment in R&D to strengthen the capacity of Cambodian research institutions. • Innovation and technology diffusion: This pillar promotes innovation and technology diffusion throughout the economy. • Enabling environment: This pillar focuses on creating an enabling environment for STI, including developing supportive policies and regulations. The roadmap proposes specific measures to achieve these objectives. • Establishing a National STI Council to coordinate STI policy and its implementation. • Developing a national STI strategy. • Increasing investment in R&D to 1% of GDP by 2030. • Establishing a national innovation fund to support the development and commercialization of new technologies. • Developing a national STI workforce development plan. • Reviewing and updating STI-related policies and regulations.

(Continued on next page)

(Continued from the previous page)

Policy Framework	Summary
National Research Agenda 2025 [5]	It serves as a strategic blueprint, spotlighting pivotal scientific challenges for Cambodia's future and determining the allocation of research resources based on priorities. The missions of Cambodia until 2030 is centered on research in priority areas, specifically: • Local food: 70% of Cambodia's food consumption is produced locally. • Reliable energy supply: 90% of energy consumption is generated locally. • Quality education: Education meets international quality standards. • Electronic and mechanical spare parts: Cambodia exports 70% of its electronic and mechanical spare parts. • Cloud-based services: Cambodia's cloud-based services development is at par with others in the ASEAN region. • Electricity and potable water: All Cambodians have access to reliable electricity and safe potable water. The National Research Agenda 2025 also identifies several cross-cutting research areas, such as gender, equity, social inclusion, DX, and disaster risk reduction. The agenda emphasizes the importance of public-private partnerships and international collaboration in supporting research and development. It calls for the strengthening of research capacity and infrastructure in Cambodia.
Cambodia Digital Economy and Society Policy Framework 2021–35 [6]	The framework focuses on enabling Cambodia to achieve its vision: "Building a vibrant digital economy and society by laying the foundations to promote digital adoption and transformation in all social actors, including the state, citizens, and businesses, to accelerate new economic growth and promote social welfare in the new normal." This policy framework identifies five main goals: • Developing infrastructures • Building reliability and confidence in digital system • Building digital citizens • Building digital government • Enabling digital businesses The policy framework also considers several necessary measures to prevent, reduce, and manage the economic and social impact of a new turning point in driving DX initiatives.
Cambodia Digital Government Policy 2022–35 [7]	CDGP's vision is to establish a digital government to improve citizens' quality of life and build trust through better public service provision. This policy has four strategic goals: • Promote the development of digital government infrastructure. • Build digital governance and create digital public services. • Build capacity for digital technologies and innovation. • Promote cooperation and partnerships between public and private sectors.

(Continued on next page)

(Continued from the previous page)

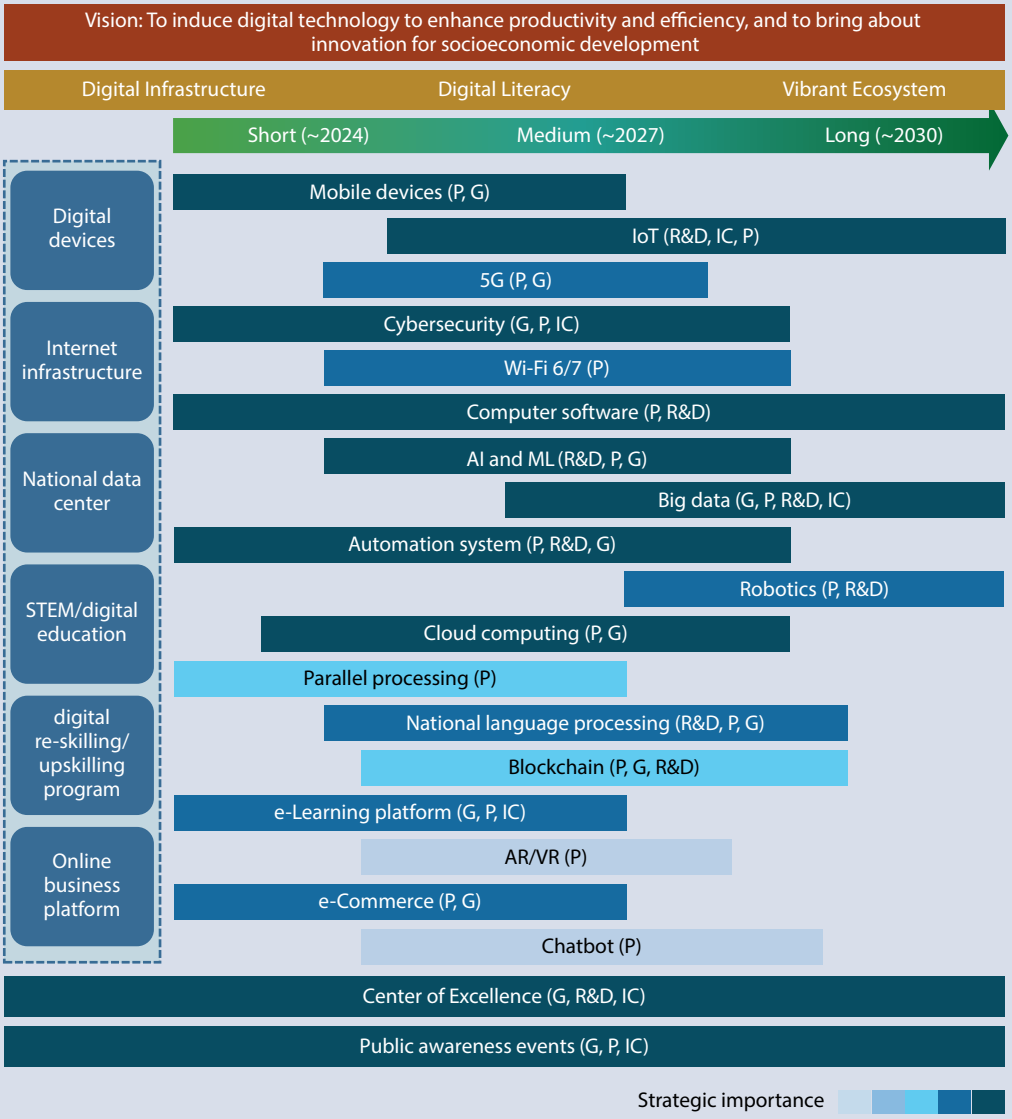
Policy Framework	Summary
Digital Tech Roadmap [8]	The roadmap aims to introduce digital technologies to enhance productivity and efficiency and foster innovation for Cambodia's socioeconomic development. The roadmap identifies three goals: • Leverage digital literacy and IT skills as a foundation for human capital development. • Diversify digital infrastructure in the national innovation system for priority sectors. • Build a vibrant ecosystem through connectivity within digital and physical spaces. As part of the roadmap, an environmental analysis assessed opportunities and threats across social, technological, economic, environmental, and political dimensions. The roadmap identifies strategic products, such as National Data Centers and Online Business Platforms, and aligns them with critical technologies, such as National Language Processing and Cloud Computing.
EduTech Roadmap [9]	The EduTech Roadmap is a comprehensive plan to guide Cambodia's efforts in integrating technology into education. Its vision is to build the next-generation technology-enhanced learning ecosystem with a focus on improving innovation and entrepreneurship skills. The roadmap entails identifying products and services like HRMS and digital learning platforms and mapping them with critical technologies like Python and blockchain.
Tourism Tech Roadmap [10]	The Tourism Tech Roadmap of Cambodia aims to accelerate Cambodia's status as the top tourism destination in the region by 2030 by harnessing innovative technologies, sustainability, and inclusivity. The roadmap identifies products and services such as ecotourism, tourism security, and safety services and maps them with key technologies like the IoT, AI, and OBP.
AgriTech Roadmap [11]	The AgriTech Roadmap aims to increase the productivity of agricultural commodities and high-value-added production/services for the global supply chain through technology and innovation by 2030. As part of the roadmap, an environmental analysis assessed opportunities and threats across social, technological, economic, environmental, and political dimensions. The roadmap helps identify products and services, such as farm machinery, water management, irrigation systems, etc., mapping them with critical technologies like fertilizer and water management, GIS, remote sensing, etc.
Energy Tech Roadmap [12]	The Energy Tech Roadmap's vision is to make Cambodia an energy self-sufficient nation by 2030 by deploying technology and innovation and leveraging renewable energy sources for sustainable development. The roadmap identifies products and services like fossil energy, power stability, etc., and maps them with critical technologies like solar thermal, energy tech management, etc.
HealthTech Roadmap [13]	The HealthTech Roadmap aims to increase the health and well-being of Cambodians through research and development, innovation, and technologies. The roadmap identifies products and services, such as digital electronic medical records and personal healthcare applications, and maps them with critical technologies like natural language generation, medical sensors, etc.

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024

As outlined in the Digital Tech Roadmap (see Figure 3), launched in July 2023, the document delves into the vision, direction, strategic products, and critical technologies. It also provides an analysis of their strategic significance for short-, medium-, and long-term strategies [8].

FIGURE 3

DIGITAL ROADMAP OF KEY TECHNOLOGIES SUPPORTING STRATEGIC PRODUCTS AND FUNCTIONS (2023–30).



Source: Ministry of Industry, Science, Technology & Innovation (MISTI), 2023.

Scope

This report assesses the impact of DX and innovation on Cambodia's industry, agriculture, and services sectors. It focuses on emerging trends in innovation and technologies within Cambodia and their effect on productivity and sustainability. Additionally, the report explores the policy implications of deploying emerging technologies and innovation trends.

Methodology

The methodology adopted for this report revolves around horizon scanning, a process focused on identifying emerging trends and potential disruptions. The horizon scanning entails a thorough review of official documents and other literature on digitization. Megatrends are identified during workshops, followed by scenario analysis conducted after neutralizing the key factors driving disruptive social change.

Analytical Framework

The analytical framework for this report was based on the concept of technology trajectories, which are long-term patterns of technological development. By examining technology trajectories, the country expert could identify patterns, recognize potential breakthroughs, and make predictions about specific technologies or technological domains. This information can be valuable for industries, policymakers, investors, and innovators to make informed choices about resource allocation, investments, research and development efforts, and strategic planning.

Scoping: Key Industry Sectors

The Cambodian economy has been evaluated based on three main sectors: industry, agriculture, and services. As illustrated in Figure 1, the rise and fall of economic growth are closely related to these three sectors [2].

The three sectors are relevant to economic growth, and emerging technology needs to be considered to improve productivity and ensure competitiveness. Meanwhile, understanding the three sectors is necessary to make technology adaptation more precise.

Agriculture is a large sector of the Cambodian economy, accounting for about 21.9% of GDP [14]. DX in agriculture can potentially improve productivity, efficiency, and sustainability. For example, drones can monitor crops and soil conditions, and sensors can track water usage. This can help reduce costs and improve yields, which is vital for Cambodia, which relies heavily on agriculture. To raise public and ministerial awareness of the sector, the RGC prepared the AgriTech Action Plan (2022).

Industry is the second largest sector of the Cambodian economy, accounting for about 18% of GDP [15]. DX in industry can help automate tasks, improve efficiency, and reduce costs. For example, robots can perform dangerous or repetitive tasks, and 3D printing can create customized parts. This can help make Cambodian industries more competitive, essential for a country trying to industrialize.

Services is another critical sector driving the Cambodian economy, accounting for 33.7% of GDP [16]. DX in services can improve customer service, efficiency, and profitability. For example, chatbots can answer customer questions, and big data analytics can be used for target marketing campaigns. This can help make Cambodian businesses more competitive, which is essential for a country trying to develop a strong services sector.

Priority Sector

DX is rapidly changing the way people live and work, leading to the emergence of new trends in digital technologies, such as AI, blockchain, and the IoT. These trends have the potential to significantly impact the industry, agriculture, and services sectors in Cambodia.

For example, AI could improve the efficiency of production processes in the industry sector. blockchain could be used to trace the provenance of agricultural products, ensuring food safety and traceability. IoT could monitor and manage water resources in the services sector.

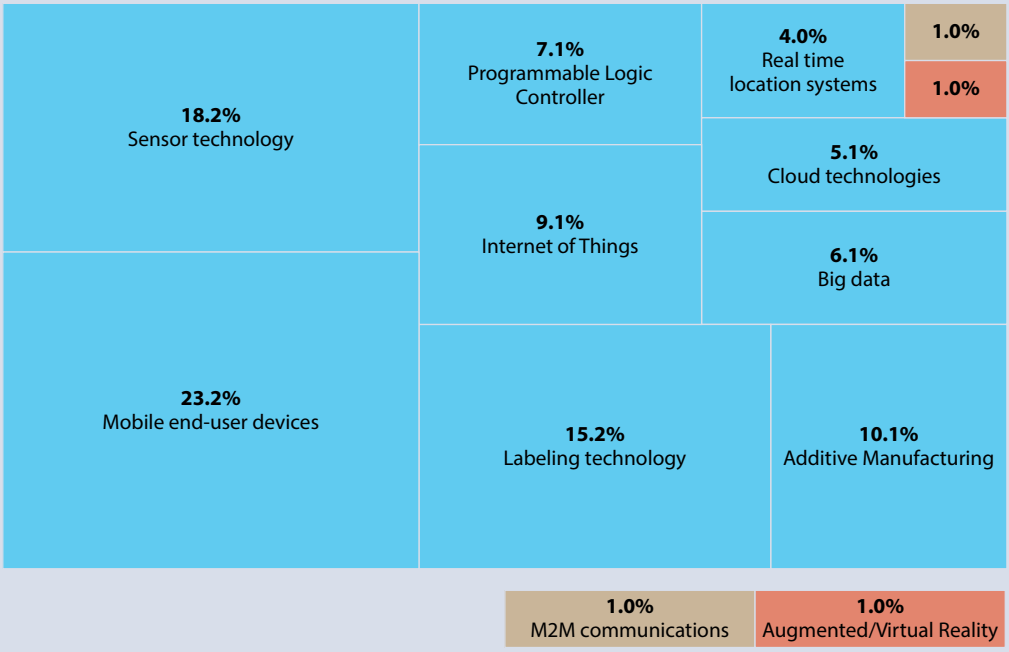
By assessing the potential impact of these emerging trends, Cambodia can identify opportunities to leverage them to its benefit. For example, the government could invest in research and development in AI, blockchain, and IoT. It could also provide tax breaks and other incentives to businesses that adopt these technologies.

Industry Sector

Digitization is rapidly changing the industry. Emerging technologies are being used to automate tasks, improve efficiency, and create new products and services.

FIGURE 4

TECHNOLOGY ADOPTION IN CAMBODIA'S INDUSTRY SECTOR.



Source: MISTI. 2023.

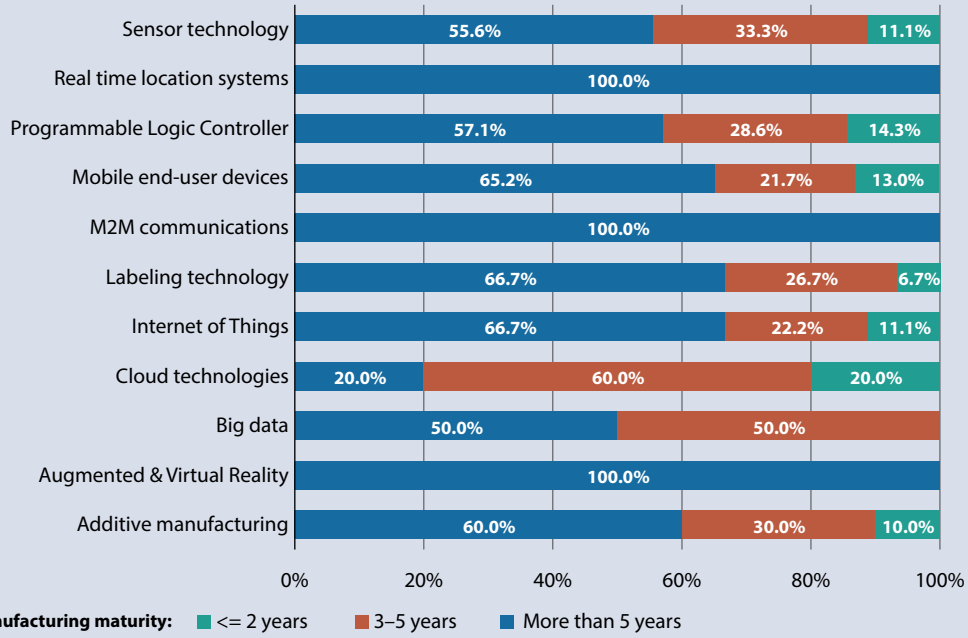
These trends significantly impact the industrial sector, leading to increased productivity, enhanced efficiency, and new opportunities for innovation. According to a survey conducted by the Cambodian Ministry of Industry, Science, Technology, and Innovation in 2023, the adoption rate for various technologies was as follows: approximately 23.2% for mobile devices, 18.2% for sensor technology, 15.2% for labeling technology, and 10.1% and 9.1% for additive manufacturing technology and IoT, respectively. Additionally, the adoption rate for programmable logic controllers (PLCs) stood at 7.1%, as illustrated in Figure 4. These key technologies are known for enabling comprehensive access to machines.

Figure 5 illustrates that agricultural enterprises with extended operating periods are more likely to adopt technology than those with shorter operating periods. This tendency could stem from more

mature enterprises typically possessing greater resources and experience to invest in new technologies. They may also be more aware of the benefits of technology and its potential to enhance their operations.

FIGURE 5

RELATIONSHIP BETWEEN TECHNOLOGY ADOPTION AND ENTERPRISE OPERATING PERIOD IN THE INDUSTRY SECTOR.



Source: MISTI, 2023.

Agriculture Sector

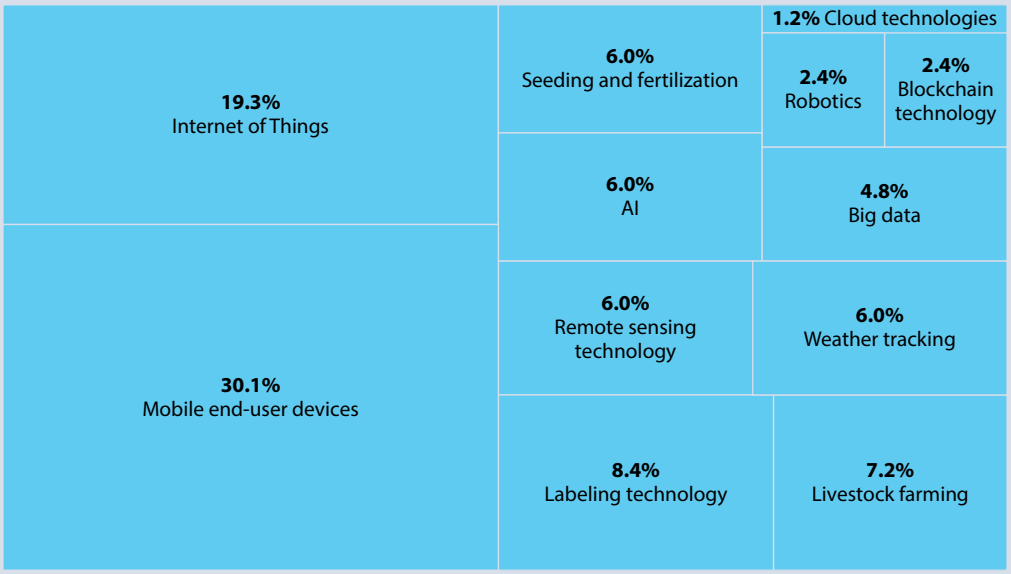
The agriculture sector is undergoing DX, leveraging new technologies to enhance productivity, sustainability, and food security.

Key Industrial Revolution 4.0 technologies are emerging in precision and production agriculture, significantly impacting the sector, leading to higher productivity, improved sustainability, and new opportunities for innovation. For example, using drones and satellite imagery helps farmers monitor their crops and livestock more effectively while using sensors provides farmers with valuable data about their soil and environment. As illustrated in Figure 6, these technologies are 30.1% related to mobile end devices, 19.3% relevant to IoT, 8.4% to relabeling technology, 7.2% to livestock technology, 6.0% to remote sensing technology, 6.0% to AI, 6.0% to seeding and fertilization, and 6.0% to weather tracking [17].

Figure 7 shows that agricultural enterprises operating for more than five years have adopted various technologies for their operations. These technologies include cloud computing, robotics, livestock farming, mobile devices, labeling technology, the IoT, big data analytics, weather tracking, and remote sensing [17]. Enterprises have implemented these technologies to improve and streamline their agricultural operations.

FIGURE 6

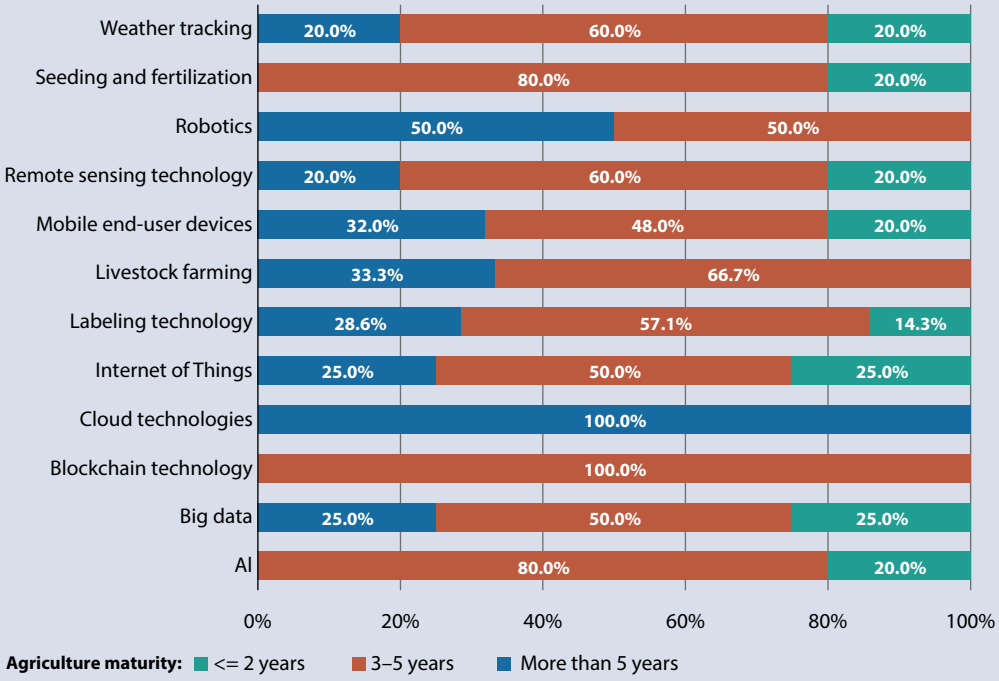
TECHNOLOGY ADOPTION IN THE AGRICULTURE SECTOR.



Source: MISTI, 2023.

FIGURE 7

RELATIONSHIP BETWEEN TECHNOLOGY ADOPTION AND ENTERPRISE OPERATING PERIOD IN THE AGRICULTURE SECTOR.



Source: MISTI, 2023.

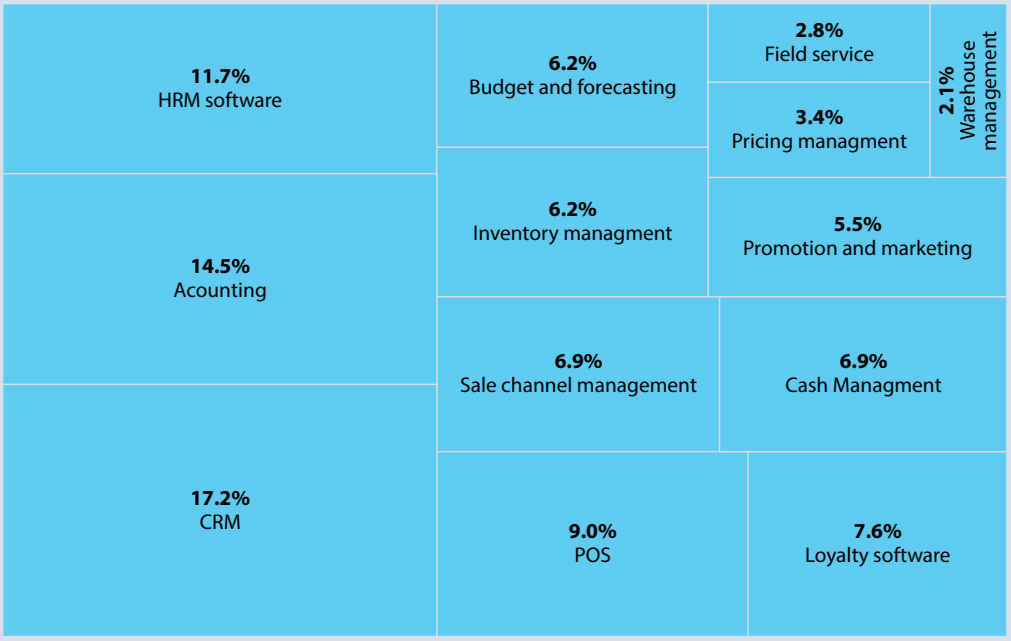
Services Sector

Digitalization is also transforming the services sector. New technologies are being used to improve customer service, automate tasks, and create new business models. These trends significantly impact the services sector, leading to increased customer satisfaction, improved efficiency, and new opportunities for innovation.

The MISTI survey of 2023 collected data in three categories: sales-related technology, operational technology, and financial-related software. As illustrated in Figure 8, the most used systems were CRM by 17.2%, accounting 14.5%, human resource management software (HRM) 11.7%, point-of-sale systems (POS) 9.0%, loyalty software 7.6%, sale channel management and cash management 6.9%, inventory management and budgeting and forecasting software 6.2%, promotions and marketing software 5.5%, and pricing management 3.4%.

FIGURE 8

TECHNOLOGY ADOPTION IN THE SERVICES SECTOR.



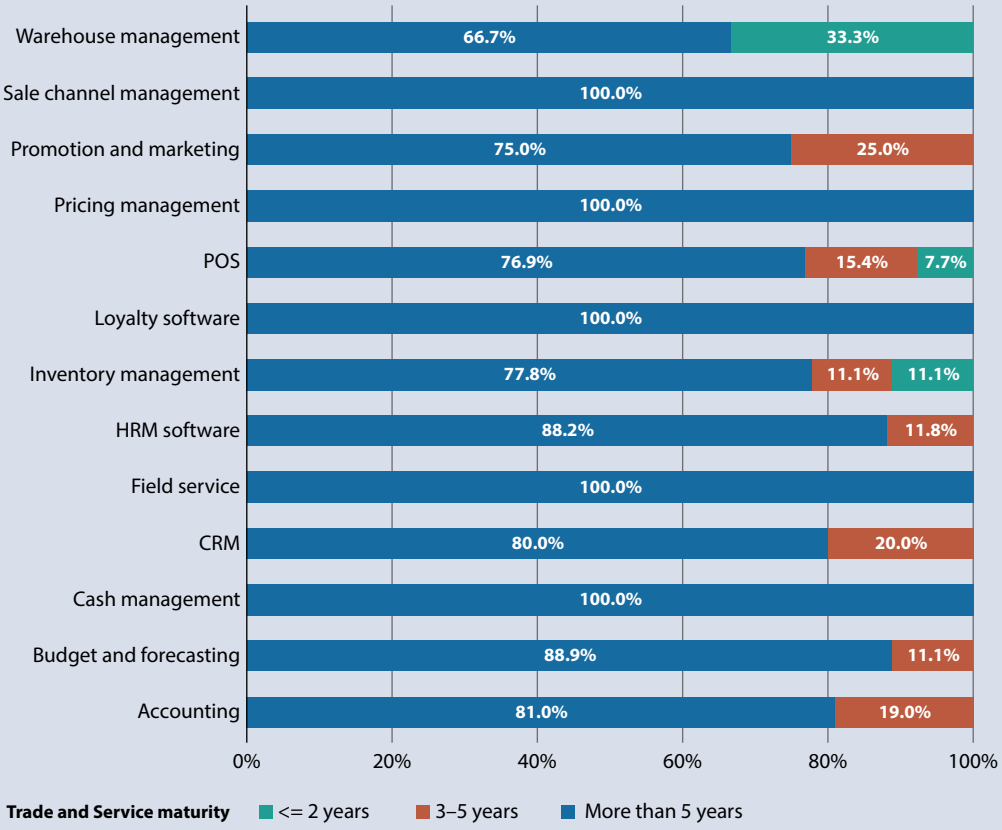
Source: MISTI, 2023.

According to a survey by MISTI (2023), trade and services enterprises that have been in operation for more than five years have adopted a wider range of technologies than those that have been in operation for less time, as illustrated in Figure 9. This may be because more mature enterprises have more resources and experience to invest in new technologies. They may also be more aware of the benefits of technology and how it can help them improve their operations.

In contrast, enterprises that have been in operation for three to five years and less than two years seem to be investing less in cutting-edge technologies. This may be because they are still focused on establishing their businesses and may not see the immediate benefits of investing in new technologies. Additionally, they may be concerned about the return on investment (ROI) for technology adoption.

FIGURE 9

RELATIONSHIP BETWEEN TECHNOLOGY ADOPTION AND ENTERPRISE OPERATING PERIOD IN THE SERVICES SECTOR.



Source: MISTI, 2023.

Competencies of Industry 4.0 Skills

Industry 4.0 is the fourth industrial revolution that is characterized by the use of cyber-physical systems, the IoT, big data analytics, and AI. These technologies are used to connect physical devices, collect data, and analyze it to improve efficiency, productivity, and decision-making [18].

Furthermore, it assures that employees are adaptable in multiple dimensions to implement advanced technologies successfully. The ability of employees to handle such dynamic work situations will be an essential aspect of the success of advanced technologies. A lack of skills can slow down the benefits of Industry 4.0 technologies, affecting a company's performance.

In addition, as indicated in Figure 10, skill competence challenges that most enterprises face are the availability of local expertise in terms of knowledge capability, experience, professional attitude, and high productivity rate [17]. The following skill competencies are defined by their terms as listed:

- The availability of expertise refers to access to people with a high level of knowledge, skill, and experience in a particular field.

- Knowledge capacity refers to the ability of an individual or organization to acquire, retain, and use knowledge. This includes the ability to learn new information, to understand and apply existing knowledge, and to share knowledge with others.

- Experience is a valuable asset that can help individuals learn and develop, providing them with the knowledge and skills they need to navigate complex and challenging situations.

- A professional attitude is a way of behaving and thinking considered appropriate and respectful in a professional setting. It is characterized by a commitment to excellence, a willingness to learn and grow, and a respect for others.

  Here are some of the critical components of a professional attitude:

  - **Reliability:** This means being counted on to do your job well and on time. It means meeting deadlines, following through on commitments, and being dependable.

  - **Accountability:** Being accountable means taking responsibility for your actions and decisions. It means owning up to your mistakes and learning from them.

  - **Respect:** It means treating others with dignity and courtesy, regardless of their position or status. It means listening to others' ideas and avoiding personal attacks, even if you disagree with them.

  - **Ethical behavior:** This behavior means doing the right thing, even when no one is watching. Ethical behavior also means following workplace rules and regulations and behaving in a fair and just way.

  - **Commitment to learning and development:** A commitment to learning and development means being open to new ideas and experiences and always striving to improve your skills and knowledge. It means being willing to take risks and try new things.

- High productivity rate is the work done in a given period, measured in quantity or efficiency. It indicates that an individual or enterprise can achieve a significant amount of work output even though using minimal resources, time, or effort.

  Here are six components that contribute to a high productivity rate:

  - **Effective time management:** This refers to the ability to use time wisely and efficiently. It includes setting goals and priorities, planning and scheduling tasks, and avoiding distractions.

  - **Clear goals and objectives:** This refers to clearly understanding what needs to be achieved. It includes setting specific, measurable, achievable, relevant, and time-bound goals.

  - **Quality of work:** This refers to the level of excellence in the work produced. It includes meeting or exceeding standards, avoiding mistakes, and providing high customer service.

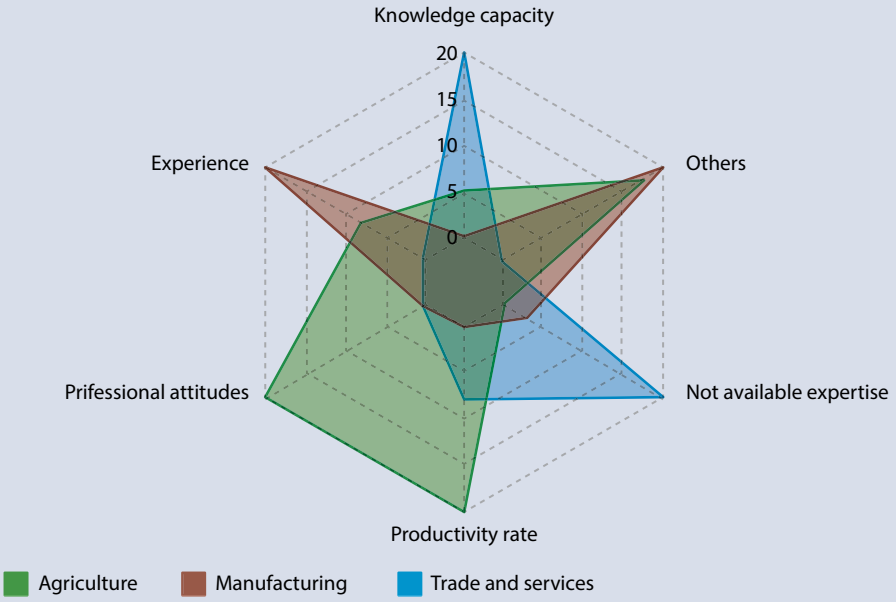
- **Efficient processes and systems:** This refers to having systems and processes in place that are designed to work effectively and efficiently. It includes using the right tools and resources and avoiding unnecessary steps.

- **Focus and concentration:** This refers to staying focused on the task and avoiding distractions. It includes setting aside time for uninterrupted work and creating a distraction-free environment.

- **Continuous improvement:** This refers to the ongoing effort to improve processes, systems, and results. It includes identifying areas for improvement and implementing changes to improve performance.

FIGURE 10

BARRIER AS A FREQUENCY TO RECRUITMENT OF LOCAL EXPERT.



Source: MISTI, 2023.

Mobilizing Scenarios

DX has the potential to significantly change industry sectors in Cambodia. By investing in emerging technologies and adopting new business models, businesses can improve their efficiency, productivity, and competitiveness.

Impact of Digital Transformation and Innovation on Productivity and Sustainability

Productivity

DX and innovation have led to a positive impact on productivity in all sectors of the economy.

The impact of DX on productivity can be seen in several ways. For example, AI and robotics are automating tasks previously done by humans, freeing workers to focus on more complex tasks. The IoT also enables businesses to collect and analyze data in real-time, which helps them improve their operations and make better decisions.

Sustainability

DX and innovation can also help improve sustainability. For example, using drones and satellite imagery in agriculture can help farmers monitor their crops and livestock more effectively, reducing water and pesticide usage. Big data analytics can also help businesses identify and reduce their environmental impact.

The impact of DX on sustainability can be seen in several ways. For example, digital technologies make using renewable energy sources, such as solar and wind power, possible. Smart grids are also helping to improve energy efficiency.

Technology Adoption

Mobile-first strategy: This means developing and delivering applications and services that are optimized for mobile devices. This is important because the majority of people in Cambodia use mobile phones.

Cloud-based solutions: Cloud computing provides a scalable, secure, and cost-effective way to host applications and data. This is a good option for businesses of all sizes.

IoT and sensor technology: This technology collects and analyzes data from physical objects, improving efficiency, productivity, and decision-making.

Radio-frequency identification (RFID) technology: This technology can be used to track inventory and assets, improving efficiency and reducing losses.

Data analytics: This technology analyzes data to gain insights into customer behavior, market trends, and business operations, which can help businesses make better decisions.

Cybersecurity: This is essential to protect data and systems from cyber threats. Businesses should invest in security software, conduct regular security audits, and train employees on cybersecurity best practices.

Machine-to-machine (M2M) technology: This technology can automate tasks and improve efficiency. It is a crucial enabler of Industry 4.0.

Maturity and the Way Forward for Firms

For agriculture, enterprises should be encouraged to adopt cloud computing, robotics, blockchain, and weather tracking, as these can significantly improve the efficiency and productivity of agricultural processes. Specifically, for enterprises operating between 3 to 5 years, efforts are to encourage the adoption and transfer of cloud technology, while for those enterprises operating for less than two years, steps must be taken to help them overcome the uncertainties and challenges in adopting new technologies like robotics, blockchain, and cloud.

For manufacturing enterprises that have been operating for less than five years, special attention is being paid to the adoption and transfer of some needed technologies, including M2M communication, real-time location systems, and AR and VR, as they lead to improvements such as cost-effectiveness, reduced human error, and increased traceability.

For service enterprises, it is recommended that potential benefits from adoption and transfer is to adapt to emerging technologies and re-evaluate their return-on-investment calculations quickly.

While it is true that the ROI for some technologies may initially appear low, it is essential to consider the potential long-term benefits, such as increased efficiency, better customer service, and, ultimately, higher profits. Enterprises can also consider strategies to minimize the initial investment, such as selecting cloud-based solutions that do not require significant physical infrastructure or hiring temporary contractors with tech experts.

Enterprises must be updated on emerging technologies and their potential benefits. Participation in trade shows, conferences, webinars, and communicating with SMEs and SME associations can help achieve this. Enterprises in the trade and services sector can position themselves for long-term growth and success.

Enterprises in the three investigated fields are urged to establish in-house training and education programs that use innovative approaches to upskill or reskill the workforce with the necessary knowledge and technologies.

Human Capital for Industrial Innovation

The Future Workforce

- Enterprises in the future will need a workforce with fundamental, soft, and technical skills, primarily digital and business-specific skills.
- Cambodia's enterprises need a workforce adaptable to new technical advancements.

The Role of Education

- The formal education system needs a comprehensive strategy to meet the needs of the private sector.
- This includes alleviating the skill gap and skill mismatch for STEM majors.
- Enterprises demand a range of essential technologies, including digital technology skills, IT infrastructure, data analytics, automation technology, and system development.
- While local technology is still limited, enterprises must have in-house training in collaboration with mature or robust corporations to transfer technology to employees.

Collaboration Between the Private Sector and Educational Institutions

- Joint curriculum development between the private sector and educational institutions like universities and TVET schools is necessary to meet the current demand.
- It is essential to design curricula from early childhood education that foster an entrepreneurial spirit in future generations.
- Investing in quality public or private sector researchers is essential to produce innovative knowledge for local demand.

Transparency: Responsible Research Innovation

The report's transparency section identifies DX's potential risks and ethical challenges. These include job displacement, data privacy, and cybersecurity risks. Recommendations for mitigating

and addressing these risks have also been raised, emphasizing the importance of transparency and accountability in the DX process.

Responsible Research Innovation (RRI) is an approach to research and innovation that emphasizes the importance of transparency, accountability, and ethics. It seeks to ensure everyone shares the benefits of research and innovation and minimizes the risks.

Two essential infrastructural elements are imperative to facilitate DX: a reliable electricity supply and robust Internet connectivity. Regarding the availability of electricity in Cambodia, there are no significant hindrances. Former director general of EDC, Keo Ratanak, affirmed in July 2023 that the current electricity provision adequately fulfills the requirements for development across various sectors, encompassing industries, factories, businesses, and households. Cambodia can generate 3,464 MW of domestic power from diverse sources such as solar, hydropower, biomass, coal, and oil.

Presently, the highest demand for electricity hovers around 2,400 MW, signifying an adequate supply. Approximately 80% of Cambodia's electricity is generated domestically, with the remaining 20% procured from neighboring nations like Laos, Vietnam, and Thailand. As of the end of 2022, 98.27% of the total villages nationwide, totaling 13,923, had been connected to the national grid. Only 1.73% (245 villages) remain unconnected due to their remote locations or being situated on islands [19]. Mobile penetration in Cambodia is notably high, reaching 19.6 million, equivalent to 116% of the Cambodian population. Furthermore, the number of Internet subscribers stands at 18 million, corresponding to 107.3% in comparison to the Cambodian population [20, 21].

Identification of conflicting elements that may hinder digitization. Several conflicting elements may hinder digitization. These include:

- The digital divide refers to the gap between those with access to digital technologies and those without access.
- Businesses and workers may not have the skills, so they need to adopt new technologies.
- The security risks include businesses and governments being vulnerable to cyberattacks.
- There are several ethical, legal, and social risks associated with DX.
- Financial barriers are among the most common obstacles firms face. Investment in new technology often requires a significant financial commitment, and SMEs may not have the necessary financial resources. Moreover, the lack of available funding, high interest rates on loans, and complicated credit conditions can prevent firms from making crucial investments in new technology.
- Technological barriers also exist, such as the lack of available skilled personnel to operate new equipment, insufficient compatibility between current and latest technology, or difficulties in integrating new technology into existing systems, as illustrated in Figure 10.

- A lack of awareness and education on the benefits of new technology may prevent firms from embracing change. Resistance to change and a preference for the status quo can impede progress toward adopting innovative approaches.

- Finally, technology transfer barriers in the agriculture, manufacturing, and services sectors.

    - **Agriculture:** According to the survey results on barriers to technology transfer in Cambodia's agricultural sector, shown in Figure 13, the most significant barrier is a "poor understanding of IP," with a percentage of 29.4%. This indicates that farmers and stakeholders may not fully understand the importance of protecting their intellectual property rights (IPR) when they develop new technologies or products. According to the survey, the second significant barrier is "low R&D investment," with a percentage of 23.5%. This means that investment in R&D in the agricultural sector in Cambodia is not as significant as it needs to be to drive technological innovation and progress. The "financial barriers" were identified as a substantial challenge by 20.6% of the respondents. This suggests that financing technological innovations in the agricultural sector can be challenging, particularly for small and medium-sized farmers. The "laws and regulations" were identified as a barrier to technology transfer by 14.7% of respondents. This indicates that bureaucracy and regulations may hinder the transfer of new technology in Cambodia's agricultural sector. Finally, "bureaucratic procedures" were identified as a challenge by 11.8% of respondents. This means complex bureaucratic processes and hurdles in acquiring licenses or permits can hinder technology transfer in Cambodia's agricultural sector.

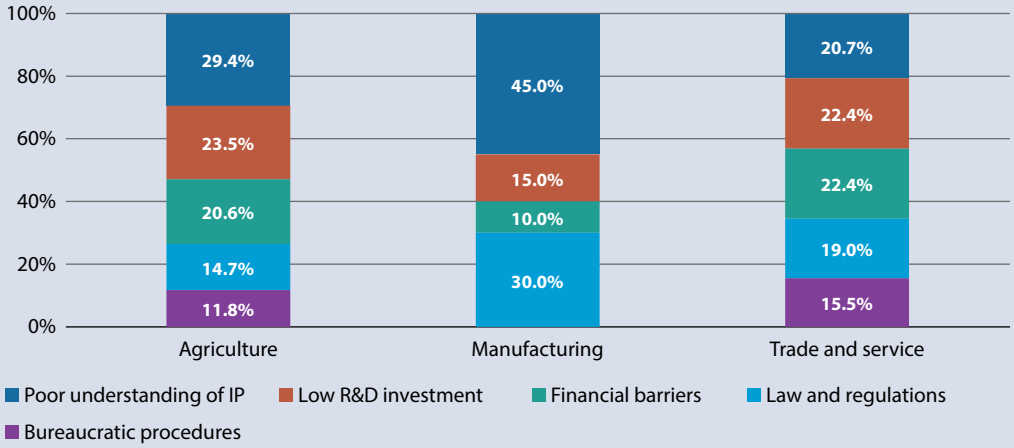
    - **Manufacturing:** According to the survey results on barriers to technology transfer in Cambodia's manufacturing sector, shown in Figure 13, the most significant barrier is a "poor understanding of IP," with a percentage of 45.0%. This indicates that stakeholders in the manufacturing sector may not fully understand the importance of protecting their intellectual property rights when they develop new technologies or products. According to the survey, the second significant barrier is "law and regulations," with a percentage of 30.0%. This means that bureaucracy and regulations may hinder the transfer of new technology to the manufacturing sector in Cambodia. The "financial barriers" were identified as a significant challenge by only 10.0% of the respondents. This suggests that financing technological innovations in the manufacturing sector may be less challenging than Cambodia's agricultural sector. The "low R&D investment" was identified as a barrier to technology transfer by only 15.0% of the respondents. This indicates that investment in R&D in the manufacturing sector in Cambodia is slightly better than in the agricultural sector. Notably, the percentage of "poor understanding of IP" in the manufacturing sector is significantly higher than in the farm sector, indicating a need for greater emphasis on intellectual property protection in the manufacturing sector.

    - **Services:** According to the survey results on barriers to technology transfer in Cambodia's trade and services sector, as shown in Figure 13, the most significant obstacles are low R&D investment and financial barriers, with a percentage share of 22.4% each. This indicates that investment in R&D and financing technological innovations in Cambodia's trade and services sector are significant challenges.

Poor understanding of IP was identified as a barrier to technology transfer by 20.7% of the respondents. This suggests that trade and services sector stakeholders must be educated on the importance of intellectual property protection when developing new technologies or products. Inadequacies in laws and regulations were identified as a challenge by 19.0% of the respondents. This means that bureaucracy and regulations may hinder the transfer of new technology to Cambodia's trade and services sector. The bureaucratic process was identified as a challenge by 15.5% of respondents. This means complex bureaucratic processes and hurdles in acquiring licenses or permits can hinder technology transfer in Cambodia's trade and services sector.

FIGURE 11

BARRIERS TO TECHNOLOGY TRANSFER IN AGRICULTURE, MANUFACTURING, TRADE, AND SERVICES.



Source: MISTI, 2023.

Policy Recommendations

Several policy recommendations can be made to help Cambodia reap the benefits of DX and mitigate the risks. These recommendations include:

- **Invest in digital infrastructure:** The government must invest in digital infrastructure, such as high-speed Internet and data centers. This will help to bridge the digital divide and make it easier for businesses and individuals to adopt new technologies.

- **Provide training and support to businesses and workers:** The government must train and support businesses and workers to help them adopt new technologies. This will help ensure that businesses can compete in the global market and that workers have the skills they need to succeed in the digital economy. Since there is a lack of human resources, video tutorials are encouraged to be developed to complement written training material.

- **Create a more conducive environment for innovation:** The government must create a more conducive environment for innovation by providing tax breaks, startup grants, and a digital platform where businesses can meet. This will help attract businesses and innovators to Cambodia, foster innovation, and create new jobs.

- **Protect patents:** The government needs to raise awareness of patent benefits and how to apply for them to reward innovators for their work. This will encourage businesses to invest in research and development and help create new products and services.

- **Adopt privacy-protective practices:** Businesses and governments must develop privacy policy documents and adopt privacy-protective practices, such as anonymizing data and using encryption. This will help protect individuals' privacy and mitigate the risk of data breaches.

- **Invest in cybersecurity:** Businesses and governments must invest in cybersecurity to protect themselves from cyberattacks. This includes using firewalls, antivirus software, and security patches.

- **Be transparent and accountable:** Businesses and governments must be transparent and accountable about how they use data. This includes providing privacy notices and giving individuals control over their data.

- **Address the ethical issues:** Businesses and governments must address the moral issues of DX. This includes being careful not to discriminate against individuals or groups and being transparent about how they use data.

By following these policy recommendations, Cambodia can reap the benefits of DX and mitigate the risks. Digital transformation and innovation are transforming the world around us. These technologies can improve productivity, sustainability, and the quality of life for all. However, ensuring these technologies are used responsibly and ethically is essential. Governments, businesses, individuals, and civil society organizations all have a role to play in ensuring that DX benefits all members of society.

References

[1] Telecommunication Regulator of Cambodia. Mobile Phone Subscriptions. September 2022. https://trc.gov.kh/en/mobile-phone-subscriptions/. Accessed on 18 June 2024.

[2] Ministry of Economy and Finance, Royal Government of Cambodia. Assessing Cambodia's Economic Growth in 2022. 28 April 2023. https://mef.gov.kh/macro-economic/macro-economic-2022-2023/. Accessed on 18 June 2024.

[3] Royal Government of Cambodia. The Pentagonal Strategy - Phase I. 2023.

[4] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. Cambodia's Science, Technology & Innovation Roadmap 2030.

[5] National Research Agenda 2025.

[6] Cambodia Digital Economy and Society Policy Framework 2021–2035.

[7] Cambodia Digital Government Policy 2022–2035.

[8] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. Digital Tech Roadmap; 2023.

[9] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. EduTech Roadmap; 2022.

[10] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. Tourism Tech Roadmap; 2023.

[11] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. AgriTech Roadmap; 2022.

[12] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. Energy Tech Roadmap; 2023.

[13] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. HealthTech Roadmap; 2022.

[14] World Bank. Agriculture, forestry, and fishing, value added (% of GDP); 2022. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=KH. Accessed on 18 June 2024.

[15] World Bank. Manufacturing, value added (% of GDP) – Cambodia; 2022. https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=KH. Accessed on 18 June 2024.

[16] World Bank. Services, value added (% of GDP) – Cambodia; 2022. https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS?locations=KH. Accessed on 18 June 2024.

[17] Ministry of Industry, Science, Technology & Innovation, Royal Government of Cambodia. Industrializing Cambodia: Enterprise's Embracing Technological Advancement. Phnom Penh, 2023.

[18] Kaur R., Awasthi A., Grzybowska K. Evaluation of Key Skills Supporting Industry 4.0 – A Review of Literature and Practice; in Sustainable Logistics and Production in Industry 4.0: New Opportunities and Challenges. Cham: Springer International Publishing; 2020, pp. 19-29.

[19] Vanyuth C. Govt subsidises $150M to stabilise electricity tariffs in 2023. Khmer Times, 19 July 2023.

[20] World Bank. Population, total – Cambodia. 2022.

[21] Telecommunication Regulator of Cambodia. Statistic. 2022.

REPUBLIC OF CHINA

Introduction

As the industrial structure evolves, many sectors in the Republic of China (ROC) face climate change, labor shortages, and human oversights. However, these challenges have not deterred industries in the ROC. Specifically, climate change poses significant challenges to agriculture, rendering farmers unable to harvest effectively. Besides, continuously rising labor costs have increased expenses in many industries. Businesses in the ROC see digitalization as a critical solution to address these issues. They utilize digital technology to reduce operational costs and leverage learning algorithms to enhance decision-making capabilities in high-value sectors.

Scoping: Key Industry Sectors

This chapter primarily illustrates the current status and trends of DX in the ROC. To comprehend the impact of digitization, the study employs two main principles to select key industry sectors.

- Key sectors emphasized in the ROC's economic development history.
- Sectors that heavily rely on digital technology.

These two principles help identify key industry sectors for the study, including ICT, industry, agriculture, public, and service sectors. This selection enables a focused exploration of the digital development priorities within each sector.

Industry Sector

The industry needs to undergo DX to respond to the rapidly changing market conditions and ensure future competitiveness. Previously, manufacturers in the ROC were primarily Original Equipment Manufacturers, and the economy was even dubbed as the 'Kingdom of Manufacturing.' However, with declining profit margins in recent years, manufacturers in the ROC are actively seeking opportunities for change, and digitalization is viewed as the most pivotal strategy. Digitization in the ROC's industrial sector aims to reduce labor costs, improve production efficiency, and develop emerging technologies.

- **Reduction of labor costs:** The sector heavily relied on manual operations in the past, leading to high personnel costs. As worker salaries continued to rise, the manufacturing sector gradually integrated AI algorithms and processes, reducing the demand for human labor and improving overall yield rates.
- **Enhancing production efficiency:** The sector may produce defective items during manufacturing, leading to additional labor and material requirements and poor efficiency. In recent years, the industry has been installing sensors and establishing Digital Twins to strengthen control over factory operations.
- **Emerging technologies:** Emerging technologies such as 5G, IoT, and AI are fast becoming a significant driving force for traditional products. DX enables businesses to harness these

technologies better, creating more innovative value-added products while enhancing efficiency and user experience.

ICT Sector

The ROC holds a key partnership position in the global ICT industry, with its information hardware production ranking first worldwide. Its focus on manufacturing within the ICT sector resulted in intense price competition among many businesses, leading to a decline in the overall industry revenue capabilities.

In recent years, the ICT industry in the ROC has been focusing on enhancing its value and profitability through digitalization, seeking to elevate the sector's potential through this transformation. Digitization in the ROC's ICT sector is aimed at changing business models, shortening product life cycles, and industry specialization.

- **Changing business models:** The industry has begun to seek higher-value products or services. It is even transitioning from a primarily manufacturing-focused business model to a service-oriented one, elevating overall revenue.

- **Shortening product life cycle:** The life cycle of ICT products is gradually shortening. This leads to rapidly changing market demands for products, requiring businesses to adjust their product structures quickly. DX enables businesses to be more agile, allowing them to roll out new products and features faster to meet market demands.

- **Industry specialization:** The sector has a detailed division of labor, and the stability of the global supply chain greatly influences the sector. DX can enhance collaboration with suppliers and achieve more efficient supply chain management, ensuring the timely supply of raw materials, components, and products.

Agriculture Sector

The ROC initially built its economy on agriculture. However, with the industrial development, labor forces in rural areas gradually shifted. In recent years, the agricultural industry in the ROC has faced challenges such as an aging workforce, the outflow of young talents from rural areas, limited land availability, and the impacts of extreme weather conditions. This has led to labor shortages and increased production costs in agriculture.

To align with the recent trends of global trade and economic integration, agricultural policies have shifted their focus from merely increasing production. Those involved in the agricultural sector are now emphasizing enhancing the added value of agricultural products to boost farmers' incomes. The role of digitalization in the agricultural sector is becoming increasingly vital. Its primary functions can be categorized into environmental control and ensuring food safety.

- **Enhancing environmental control:** Environmental control is essential for agricultural workers to cope with extreme climate conditions. As the effects of climate change intensify, not only is crop growth significantly impacted, but pest issues are also becoming more severe. Digitalization has become crucial for those in agriculture to respond to climate change.

- **Ensuring food safety:** After experiencing food safety incidents, food traceability has become an essential regulatory concern. In recent years, the government has stipulated

that agricultural products must adhere to the Taiwan Good Agricultural Practice guidelines [1], ensuring that the entire production process can be tracked through the government's electronic system. Traceable Agricultural Products enable consumers to gain insight into the food's journey from its production origin to transportation and packaging.

Public Sector

Since multiple ministries were earlier responsible for driving digital initiatives within the central government in the ROC, the cost of internal coordination was high when promoting specific digital policies. To coordinate and consolidate the units originally responsible for digital affairs in various ministries, the ROC established the Ministry of Digital Affairs in 2023, allowing for a smoother implementation of digital policies.

The core task of the Ministry of Digital Affairs is to strengthen its citizens' digital resilience. Through digital tools, the ROC can quickly respond and recover from crises when faced with adverse conditions. Promoting DX within the government departments in the ROC has numerous critical objectives and advantages. Its impact extends beyond providing more efficient and convenient public services, shaping the governance capabilities of the nation on various levels.

- **Enhancing efficiency:** The primary purpose of DX is to enhance the efficiency of public services. With digitalization, the government can save time and resources, streamline processes, and enable citizens and businesses to handle various tasks more swiftly and conveniently, such as paying taxes, filing documents, and applying for licenses.

- **Disaster response:** DX plays a crucial role in the ROC's disaster response and public safety. Digital tools enable the government to release warning messages during disasters promptly and quickly convey critical information or emergency instructions. This helps reduce disasters' impact on the public and enhances the government's response speed and efficiency during crises.

Services Sector

With the adjustment of industrial structure and the revitalization of the domestic service industry after the epidemic, the employment proportion of the ROC's service industry surpassed 60% for the first time in 2023. Impacted by the COVID-19 pandemic, consumer habits have shifted, leading to a swift DX across various industries, with the service sector standing out the most. Retailers, facing unforeseen challenges and market changes, must swiftly adapt to a digital landscape, unable to rely solely on traditional methods. However, in the past, retailers often regarded physical storefronts and e-commerce as two distinct departments, causing a disconnect in information—members might have to register twice, once online and another in-store. This phenomenon underscores the importance of integrating online and offline experiences and highlights digital technology's retail sector.

Moreover, the hotel and tourism industry were significantly affected by the pandemic. The outbreak led to a sharp decline in tourist numbers, and in the post-pandemic era, these numbers rebounded rapidly, causing many businesses to be understaffed. To address this issue, many hotel and tourism operators have begun implementing automated systems to remedy the workforce shortage. Traditional financial institutions face pressure to undergo DX in the financial industry as online banking and related emerging financial models rise.

Additionally, the Financial Supervisory Commission recently released the ROC's FinTech Development Roadmap 2.0. This strategic approach covers four main dimensions: optimizing financial technology legislation and policies, enhancing support resources and talent development, promoting financial technology solutions and applications, and increasing financial inclusivity and digital financial literacy. The government's introduction of this new Development Roadmap aims to accelerate innovation in financial technology, ultimately achieving sustainable FinTech advancements.

In summary, digitalization in the services sector can be broadly categorized into three main aspects: alignment between online and offline channels, workforce resilience, and achieving sustainability.

- **Alignment between online and offline channels:** In recent years, retailers have been actively deploying e-commerce strategies. However, a misalignment between online and offline channels has posed two major challenges for them. One, there is a lack of understanding of the consumer profile. Although retailers are familiar with the online-to-offline (O2O) concept, they treat the online channel merely as a tool for guiding shoppers and leading online users to physical stores. This allows only an understanding of online consumer habits, thus limiting retailers' overall marketing strategy planning. Two, they are unable to maximize value. A consumer's online and offline transactions are viewed as two separate entities. This also means that retailers cannot discern the connection between a customer's online and offline purchasing behavior, further restricting their understanding of the consumer profile.

- **Enhancing workforce resilience:** The hotel and tourism industry in the ROC has long been plagued by high working hours and low starting salaries. In recent years, the hotel and tourism industry has faced an even more severe workforce shortage, driven by three main factors. One, the emergence of the Gig Economy has led many individuals to opt out of the hotel and tourism industry in favor of new job formats, such as becoming food delivery drivers for platforms like Foodpanda or working as drivers for Uber to earn higher wages. Two, the competitive salaries offered by foreign hotel and tourism industries significantly influence the willingness of graduates to enter this field. Lastly, the pandemic has caused a significant talent drain as many previously employed individuals in related roles have switched careers.

- **Achieving sustainability:** In recent years, sustainability issues have gained significant attention worldwide. In August 2023, the ROC released its FinTech Development Roadmap 2.0 [2], emphasizing the importance of sustainable development. This roadmap aims to create a more inclusive, fair, and sustainable financial technology ecosystem, aligning with international trends in financial technology development. Specifically, financial institutions must pay closer attention to sustainability-related matters while pursuing financial innovation within this context.

Gap Issues: Industrial Sector Analysis

Human Errors

Quick and accurate production is paramount for the manufacturing industry, especially in this era of pursuing high-added value. In the semiconductor sector, yield is not just an issue of the manufacturing process but is also crucial for a company's cost control. As such, yield is often viewed as a testament

to a wafer fab's operational capability. However, during wafer manufacturing, defects might arise due to human oversights, equipment malfunctions, or subpar environmental conditions.

Labor Issues

Labor issues encompass both labor costs and the aging workforce. Many industries, especially manufacturing, face significant expenses due to rising wage structures. This puts pressure on industries to transform because they have historically relied heavily on human labor.

Furthermore, industries face challenges as their labor force grows older. This leads to various issues, including a decrease in overall production efficiency, difficulty in effectively passing down industry experience, and resistance to innovations among older employees. Currently, many businesses are grappling with the issue of an aging workforce. For instance, in agriculture, the average age of farmers in the ROC is 64, negatively impacting agricultural production efficiency as the workforce ages.

Mobilizing Scenarios

This section primarily introduces the measures taken in the ROC to execute sector transformation through digitalization.

AI-Based Defect Detection

Companies have implemented AI in wafer defect detection to mitigate the damage caused by human errors in the production process of high-tech products. Through full automation, labor costs can be reduced, and inspection efficiency can be significantly enhanced. For instance, packaging and testing company Siliconware Precision Industries Limited utilizes AI algorithms to monitor the quality of wafer bumping packaging [3] with assistance from NVIDIA. This reduces manufacturing costs and accelerates delivery speed while ensuring a higher-quality product.

Agricultural IoT

In the face of escalating climate change, farmers have integrated IoT into their farms to enhance the control and management of the crop environment. Specifically, farmers utilize IoT to obtain data on crop temperature, humidity, and even soil conditions. This allows them to closely monitor changes in the agricultural environment and implement relevant countermeasures. Moreover, the digitization of the agricultural environment ensures that crop production is no longer heavily reliant on experience but is cultivated scientifically, enhancing the production efficiency of crops.

Digital Twins

As emerging information technologies like IoT, AI, AR, VR, etc. mature, many industries have started to install sensors in their facilities to capture relevant environmental data. Industries process, analyze and interpret this data to create virtual models. Specifically, this virtual environment relies on past physical conditions, helping managers quickly grasp the site's operational status. Digital Twins have been widely applied in various fields. For instance, the manufacturing industry uses digital twins for predictive maintenance of production equipment. Similarly, while hospitals utilize it to optimize medical service processes, the retail sector employs digital twins to simulate consumer interaction environments.

Digital Servitization

Digital servitization refers to intelligence-based industrial solutions encompassing products, services, software, and analytics [4]. Such solutions, grounded in digital technologies, generate

services that bolster a company's competitive advantage, performance, and competitiveness [5]. According to the 2022 SME White Paper published by the Ministry of Economic Affairs in the ROC, there are over 1.59 million SMEs in the ROC, constituting more than 98% of all businesses [6]. Due to their limited scale and resources, SMEs struggle to digitize their operations effectively. To assist these SMEs in their transformation, a major machine tool manufacturer in the ROC, Fair Friend Group, the world's third-largest manufacturer of machine tools, has begun offering smart manufacturing service solutions.

Blockchain for Agri-Food Traceability

The United Nations Development Programme report indicates that farm-to-table traceability may become limited due to the involvement of a series of actors in the agri-food supply chains, such as farmers, processors, product manufacturers, distributors, retailers, and consumers [7]. The report further notes that the unique features of blockchain can reduce supply chain inefficiencies and enhance trust among diverse stakeholders, thereby strengthening the traceability of agri-food supply chains.

Digital Resilience

In times of sudden disasters, the government needs to respond swiftly to major shocks to mitigate their impact. Termed as Digital Resilience, this ability enables organizations to withstand significant disturbances, adapt to disruptions they cause, and evolve to a new equilibrium, effectively handling these substantial shocks [8]. As part of the effort, the Ministry of Digital Affairs in the ROC plans to launch a Disaster Roaming verification project in 2024. During emergencies, even if citizens' communication services are disrupted, they can still access the networks of other telecommunications providers. This will ensure continuity of communication, allowing people to establish external contacts when needed and obtain information related to emergency evacuation.

Simultaneously, the Ministry will collaborate with the National Fire Agency to validate the Public Protection and Disaster Relief. This communication system, similar to walkie-talkies, is not limited to voice calls; it can transmit real-time audio and video data. At certain network bandwidth speeds, it empowers firefighters and medical personnel to conduct remote-controlled rescue operations and simultaneously gather feedback and information from the scene.

Commercial Drone Business

Drones are not constrained by geographical conditions and can enhance overall operational efficiency. Their commercial applications have garnered attention in recent years. In agriculture, farmers use drones to spray pesticides and collect data related to crops. Through image processing and big data analysis, they achieve precision farming. In the construction industry, drones reduce the need for human labor and decrease potential risks for personnel. For instance, workers can operate drones to get a real-time view of the construction site when dealing with bridge pillars or high-rise buildings, mitigating traditional manual-related risks. For emergency response, drones can flexibly monitor disaster sites, especially when critical transportation routes are damaged, and deliver emergency medical supplies.

Online Merge Offline (OMO)

OMO is a business model that merges online and offline customer bases from various distributions and offers a cohesive shopping experience by gathering customer information. For example, a retailer in the ROC, PX Mart, has adopted an OMO digital strategy by implementing Appier's AI system. This system integrates online and offline consumer data, consolidating multiple channels

of PX Mart, including its website, mobile payment app PX Pay, e-commerce platform PXGo!, and offline point-of-sale (POS) data. This integration enhances the personalized interactive experience for consumers [9].

PX Mart, the largest supermarket chain in the ROC, has not been efficiently utilizing its vast amount of offline data in the past. However, with the implementation of the OMO strategy, PX Mart has integrated data from both online and offline sources, such as the types of products purchased, brands, items, quantities, purchasing stores, methods, amounts, and membership points. By analyzing customer buying behaviors, it can more precisely cater to consumer demands.

OMO differs from the traditional O2O approach. While O2O primarily focuses on directing online shoppers to brick-and-mortar stores, OMO underscores the importance of integrating online and offline data to understand the consumer profile of the target audience.

Transparency: Responsible Research Innovation

Considering that internal and external factors can influence the digital innovation and transformation process, this chapter introduces the potential risks faced in the digitalization journey. The detailed analysis is as follows:

Digital Divide

While the ROC has advantages in technological development, the digital divide still exists in certain areas and among specific demographics. Even though the ROC is one of the most digitally advanced countries globally, many areas still lack access to the Internet due to geographical and environmental factors. This deficiency not only results in limited job opportunities but also leads to inadequate access to healthcare and education resources. Moreover, some populations might lack appropriate digital skills or opportunities to use digital tools, potentially leading to inequality and restricting their chance to enjoy digital services.

Data Privacy and Security

Digitalization involves massive data collection and storage, sparking concerns about privacy and security. The government must ensure proper data protection measures to prevent the misuse or leak of sensitive information. For businesses, DX is accompanied by significant challenges related to potential data breaches and privacy infringements, which may impact business operations and associated legal liabilities. Financial institutions, for instance, can incur substantial losses due to cybersecurity incidents, including fund theft, data breaches, or hacking attacks. Furthermore, in recent years, there have been numerous cybersecurity incidents within the retail industry, possibly due to three main reasons:

- Retailers have progressively invested in relevant digital resources, leading to an increase in vast transactional data. As these volumes grow, the risk of information security breaches also intensifies.

- The retail industry involves numerous upstream and downstream partners, and collaboration with entities raising security concerns can contribute to cybersecurity risks.

- Among the challenges of digitization, team members' cybersecurity awareness remains a significant concern. Businesses can be exposed to risks if team members lack adequate knowledge to detect online traps.

Digital Boundary

DX entails a series of data integrations. The primary boundary challenges in this process can be divided into technical and managerial boundaries.

On the technical dimension, issues such as data format discrepancies or versioning conflicts can impede effective integration. Expressly, DX necessitates bridging data across various versions and platforms to boost overall interoperability. To illustrate, firms may encounter data incompatibility issues within the industrial sector due to differences in machine versions or varying brands, leading to disparate data formats.

From the managerial dimension, even as the significance of data integration is acknowledged, there may often be a reluctance to share information due to conflicting interests. Taking organizations as an example, although all departments belong to the same entity, they might hesitate to share information. Most departments view their data as proprietary, believing that sharing it might jeopardize their position or interests.

Collective Participation and Trust

DX requires stakeholders' joint participation and trust. Even though people can perceive the benefits of digital technology, they might resist when it personally impacts them. At the organizational level, if DX leads to an increased workload, employees may fear for their interests and choose to resist. Moreover, even if the DX does not increase their workload, veteran employees might resist the change simply because they are "not used to it."

Talent Shortage

The talent shortage is another issue requiring attention, as DX demands individuals with digital skills and knowledge. A lack of such talent could hinder the smooth progression of the transformation. Many top AI talents in the ROC might be attracted to sectors like semiconductor or hardware manufacturing, which are relatively disconnected from artificial intelligence, raising the challenge of retaining AI professionals. In this constantly evolving wave of technology, ensuring sufficient expert participation has become critical for the ICT industry's continued innovation and development.

Misalignment Intelligence

Over the past decade, digitalization has been a hot topic. With the rapid advancement of digital technologies, today's concept of digitalization is markedly different from a decade ago. Digitalization now goes beyond merely addressing labor-intensive issues; it encompasses many decision-making aspects. However, when there is a misalignment between AI recommendations and the prior beliefs of decision-makers, how should decisions be made?

Decision-makers cannot make swift choices when faced with opaque algorithms. Conflicts between AI suggestions and doctors' judgments in the medical industry could be even more pronounced [10]. After all, a doctor's final decision concerns human lives. Current developments in digitalization are striving to make algorithms more interpretable, ensuring that doctors or other decision-makers have access to more information to aid their decisions.

Case Study: Inventec Corporation's Digital Twins

In recent years, with the rapid development of technology, many businesses have adopted Digital Twins to create virtual identities for physical objects like people or items. This enables organizations

to monitor overall operational status through computers. For instance, the Taiwan-based Original Design Manufacturer (ODM) Inventec has tackled the challenge of achieving precise indoor positioning using Digital Twins. Previously, obstructions between users and mobile communication base stations often resulted in inaccurate location information. Inventec Corporation's solution involves using multiple positioning data to map the real-world environment, ensuring data accuracy in the virtual world. Moreover, Inventec has developed a 5G Private Network Solution to help different sectors establish Digital Twins. This allows real-time tracking of various statuses using indoor positioning, such as asset management at airports (e.g., buggies and trolleys), inventory management for retailers, or tracking the location of wheelchairs in hospitals.

Inventec has integrated both technologies and developed a hybrid positioning engine currently used at airports to overcome limitations that may arise from relying solely on IoT devices or Radio Information for positioning. This allows the airport's ground service to track various information through a dashboard. Specifically, this service enables quick trolley and staff dispatching at the airport and paves the way for developing additional AI applications within the airport environment. Essentially, this solution replicates physical entities from the real world onto a digital platform, creating a virtual counterpart. In the future, this technology can assist in industry monitoring or equipment management, improving production or manufacturing processes, and even reducing operational costs.

Policy Recommendations

This study reviews the current development status of digitalization in the five sectors based on official documents and relevant online resources in the ROC. Drawing from the analysis, this study offers the following policy recommendations.

Phased Digital-Driven Inclusion

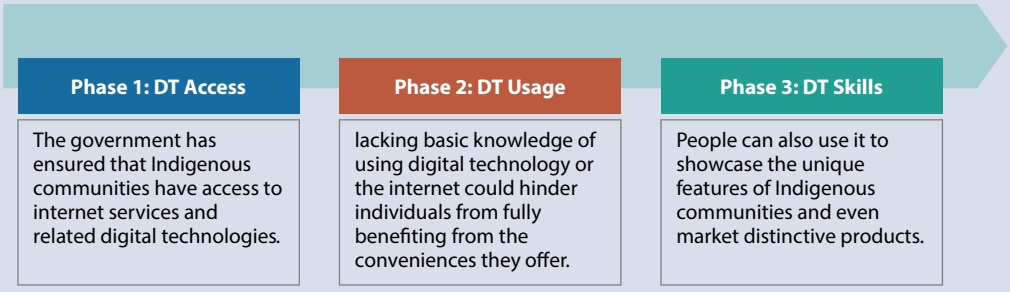
Digital technology plays a significant role in today's society, enabling everyone to engage with and benefit from the digital world. Consequently, promoting policies related to digital inclusion is crucial for a nation's development. Digital inclusion refers to the activities necessary to ensure that all individuals and communities, including the most disadvantaged, access and use ICT and other digital technologies [11]. In the ROC, the government has established the i-Tribe program to develop the Internet infrastructure for indigenous communities [12]. This initiative aims to improve wireless broadband connectivity, enabling these communities to access the advantages of digital technology, including digital healthcare services, digital education, and opportunities in e-commerce.

While ensuring access to Internet services and digital technologies for indigenous communities is important, setting up the infrastructure is just the beginning of digital inclusion. Subsequent challenges involve promoting usage and providing training for relevant skills. For instance, the lack of basic knowledge in using digital technology or the Internet could restrict individuals from fully benefiting from its conveniences. Conversely, a lack of fundamental digital literacy might lead to unintended consequences, such as children worsening their myopia due to improper usage of digital technology.

Moreover, digital technology operates as a two-way channel, extending beyond the mere reception of external information. People can also use it to showcase the unique features of indigenous communities and market distinctive products. This enhances the competitiveness of these communities and helps preserve their local culture.

FIGURE 1

PHASED DIGITAL-DRIVEN INCLUSION.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

This study suggests that the government can promote Digital Inclusion through the three-layered approach of digital access, digital usage, and digital skills, as shown in Figure 1. By focusing on these three levels, the total value of digital infrastructure can be realized. It contends that digital equality is achieved when the government provides equal access to the same infrastructure. However, additional assistance should be offered to individuals residing in remote areas or those unable to access relevant digital skill training. This could include organizing workshops to teach people how to use digital technology or providing courses to help them acquire digital skills, thereby achieving digital equity.

Digital equality entails evenly distributing the same digital resources to everyone. In contrast, digital equity involves tailoring different digital resources according to individual needs and circumstances, ensuring everyone can access similar opportunities. Therefore, this study emphasizes that policies related to digital inclusion should prioritize digital equity as the primary objective to ensure that all individuals can access opportunities.

Digital Literacy Skill Improvement

This study recommends enhancing digital literacy skills to ensure more individuals can navigate global digitization trends. Historically, the ROC was renowned for its high-tech sector, which offered attractive salaries and became the preferred choice for many graduates in information-related disciplines. However, this development has led to other industries struggling to access talent with backgrounds in information-related fields. In recent years, these sectors have started looking for graduates from diverse academic backgrounds to handle tasks related to digital technology. This poses challenges for these sectors, as companies must invest more effort into training newcomers in digital literacy skills, as shown in Figure 2.

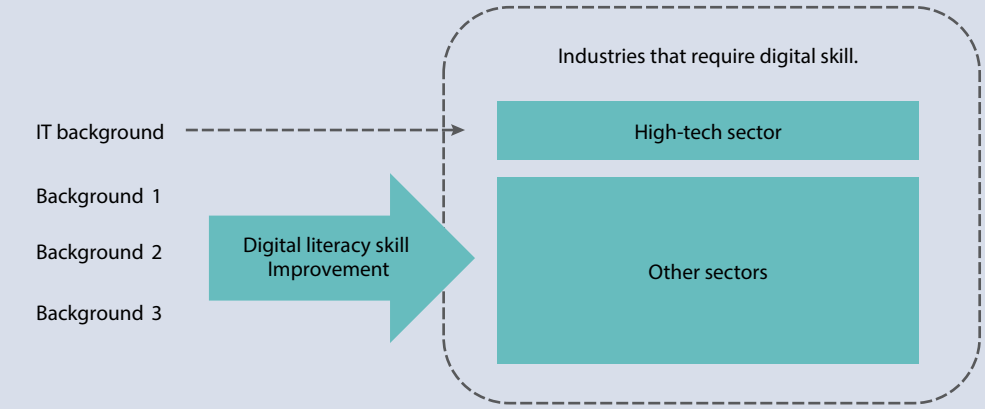
Considering that digital literacy skills are essential across most sectors, this study suggests that educational institutions could address this issue by offering courses in emerging fields relevant to various disciplines. This approach would ensure that graduates possess the digital knowledge and skills needed by businesses, helping them overcome the challenges posed by the changing landscape of the digital world.

Encouraging Businesses to Invest in Niche Markets

Given the relatively small domestic market in the ROC, the country's industrial development heavily relies on external markets. This study suggests that the government leverages this DX

FIGURE 2

DIGITAL LITERACY SKILL IMPROVEMENT.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

opportunity to encourage businesses to tap into niche markets. By doing so, companies can enhance profitability and ensure operational resilience through product and service differentiation. For instance, many ICT companies in the ROC solely focused on manufacturing in the past, leading to intense price competition among manufacturers. Investing in niche markets reduces a company's replaceability and contributes to higher economic stability at the national level.

In terms of practical policy, the government can support businesses entering niche markets through two aspects: incentives and transformation consulting.

Firstly, under the incentives approach, the government could reward small and medium-sized enterprises based on their R&D achievements, such as patents or innovation awards. This could involve providing financial incentives or tax deductions to encourage these enterprises to allocate more resources to R&D, fostering the development of less easily replaceable technological services. Additionally, government-sponsored entrepreneurship competitions should include more niche market categories to guide aspiring entrepreneurs toward the directions envisioned by the government.

Secondly, under the transformation consulting aspect, recognizing that many businesses require transformation but lack the necessary ideas, the government could recruit experienced business managers who have successfully navigated transformation in the past. These individuals could then offer tailored DX strategies to assist companies in transitioning to niche markets, thereby enhancing the nation's competitive edge.

References

[1] Taiwan Agriculture and Food Traceability System. Status Quo and Prospect of Taiwan Traceable Agricultural Product. https://taft.coa.gov.tw/cp-1063-1577-08263-2.html. Accessed on 3 September 2023.

[2] Financial Supervisory Commission, ROC. FinTech (Taiwan's FinTech Development Roadmap). https://www.fsc.gov.tw/ch/home.jsp?id=478. Accessed on 3 September 2023.

[3] NVIDIA. Customer Story Siliconware Precision Industries Limited (SPIL). https://resources.nvidia.com/en-us-triton-inference-server/spil-customer-story. Accessed on 3 September 2023.

[4] Porter M.E., Heppelmann J.E. How smart, connected products are transforming competition. Harvard Business Review, November 2014. https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition. Accessed on 3 September 2023.

[5] Pizzichini L., Temperini V., Caboni F., et al. The role of digital knowledge servitization in supply chain management. International Journal of Physical Distribution & Logistics Management, 2023. https://www.emerald.com/insight/content/doi/10.1108/IJPDLM-06-2022-0202/full/html. Accessed on 3 September 2023.

[6] Ministry of Foreign Affairs, ROC. Smart Manufacturing, Green Industry—Trends in Taiwan's Machine Tool Sector. https://nspp.mofa.gov.tw/nsppe/news.php?post=236627&unit=410&unitname=Stories&postname=Smart-Manufacturing,-Green-Industry:-Trends-in-Taiwan%E2%80%99s-Machine-Tool-Sector. Accessed on 3 September 2023.

[7] UNDP. Blockchain for Agri-Food Traceability. https://www.undp.org/publications/blockchain-agri-food-traceability. Accessed on 3 September 2023.

[8] Boh W., Constantinides P., Padmanabhan B., et al. Building digital resilience against major shocks. MIS Quarterly; 2023, 47:1, pp. 343-360. https://aisel.aisnet.org/misq/vol47/iss1/14/. Accessed on 3 September 2023.

[9] Appier. Go back PX Mart Strengthens OMO Digital Strategy Deployment with Appier. https://www.appier.com/en/press-media/pxmart-adopts-appier-enterprise-solutions. Accessed on 3 September 2023.

[10] Huang C.H., Chou T.C. Examining the Dilemma Between Artificial Intelligence Techniques and Professional Medical Service: A Hybrid Balancing Perspective. IT Professional, 2023. https://ieeexplore.ieee.org/document/10124010. Accessed on 3 September 2023.

[11] National Digital Inclusion Alliance. The Words Behind Our Work: The Source for Definitions of Digital Inclusion Terms. https://www.digitalinclusion.org/definitions/. Accessed on 3 September 2023.

[12] Freedom House. Freedom on the net 2021 Taiwan. https://freedomhouse.org/country/taiwan/freedom-net/2021. Accessed on 3 September 2023.

INDIA

Introduction

The chapter provides the blueprint for India's inclusive growth by adopting emerging technologies such as Generative AI (Gen AI), smart digital farming, silent smart factories, best practices of agroecology, and digital manufacturing transformation associated with 4IR. These advancements aim to achieve self-reliance, sustainability, and economic leadership, contributing towards achieving the SDGs.

The study is particularly relevant to various sectors such as industrial growth, smart digital e-agriculture, and information and communication technology, establishing a strong connection with public sector corporations. Its findings and recommendations are tailored to address the specific needs and challenges of these sectors, making it a valuable resource for policymakers and stakeholders.

The report explores inclusive strategies, smart planning, gaps and findings, mobilization, and transparency through responsible research innovation and framework in science, technology, engineering, and math. It spans various domains, including climate change, global space ecosystems, net-zero emissions, energy and food security, advanced smart manufacturing, precision and digital e-farming, healthcare, edtech, fintech, logistics, and infrastructure.

The report concludes with robust policy recommendations backed by significant elements discussed above. It also delves into the background, methodologies, and framework for growing an inclusive economy through innovation and technology commercialization for startups and MSMEs. Additionally, it emphasizes strong policy implementation on technology and entrepreneurship, various schemes, and India's success stories through case studies.

The study provides a comprehensive analysis of policies and schemes to address the challenges of the global economy, climate change, and sustainability research. It also examines the outcomes of research and innovation facilities available in MSME technology development centers, making a significant contribution to the Indian economy.

Background

India remains the world's fastest-growing large economy. The country's GDP for the April-June quarter of 2023 grew by 7.8% to INR40.4 trillion, maintaining its position as the world's fastest-growing large economy. Figures 1A and 1B illustrate that the country is rated very high on all investment and macroeconomic indicators. India is spearheading the achievement of all 17 SDGs, starting with zero poverty, good health and well-being, quality education, gender equality, innovation and infrastructure, economic growth, clean energy, peace, and strong global partnership.

The country is now a hub of Unmanned Aerial Vehicles (UAVs), especially for smart and precision farming, green energy (green hydrogen, lithium-ion battery-based electric vehicles, and ethanol-based automotive), quantum computing and sensors, semiconductor technologies, smart digital manufacturing, AI, blockchain technology, and the Industrial Internet of Things (IIoT).

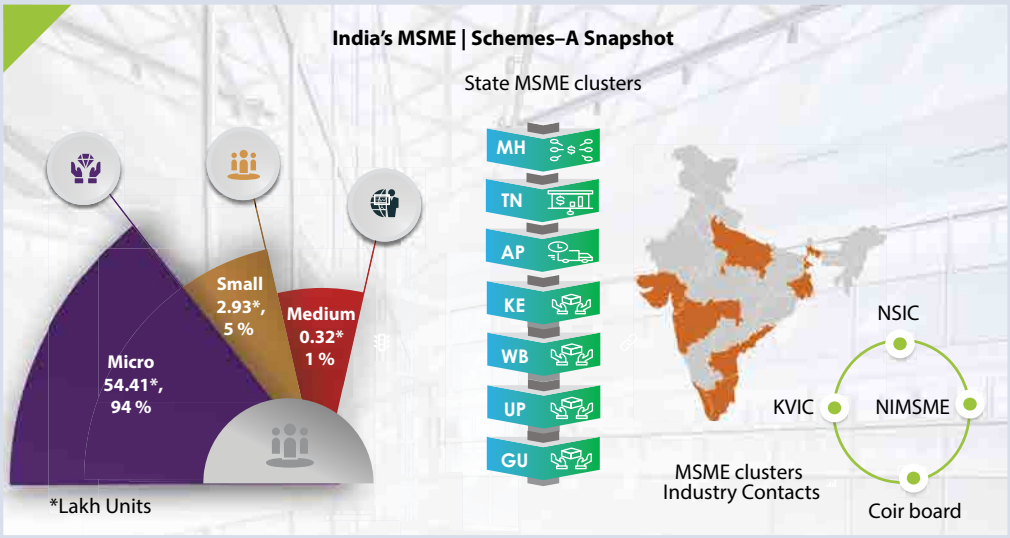
MSMEs in India

The MSME sector has been empowering India's growth engines. The seeds sown during the early days of the new economic policy in the 1990s, recognizing the different facets of small enterprises of all forms and sizes, have now grown into a benevolent tree providing even stronger roots to the Indian economy. Over the decades, the Indian MSME sector has significantly contributed to the country's economic and social growth. With more than 63 million MSMEs, the sector has contributed nearly 40% of India's overall exports. As illustrated in Figures 1A and 1B, this is approximately 6.11% of the country's manufacturing GDP and 24.6% of the GDP from the services sector.

MSMEs play an important role in socioeconomic development by generating employment, reducing inequalities, balancing regional imbalances, and providing low-cost raw materials to support large industries. Additionally, they contribute to innovation, economic diversification, local development, women and youth empowerment, export promotion, and social and environmental sustainability. Overall, MSMEs have generated 115.7 million employment opportunities in India, including 27.9 million for women. Therefore, supporting MSMEs is crucial for fostering inclusive and sustainable growth.

FIGURE 1A

SNAPSHOTS AND STATISTICS OF MSMEs IN INDIA.

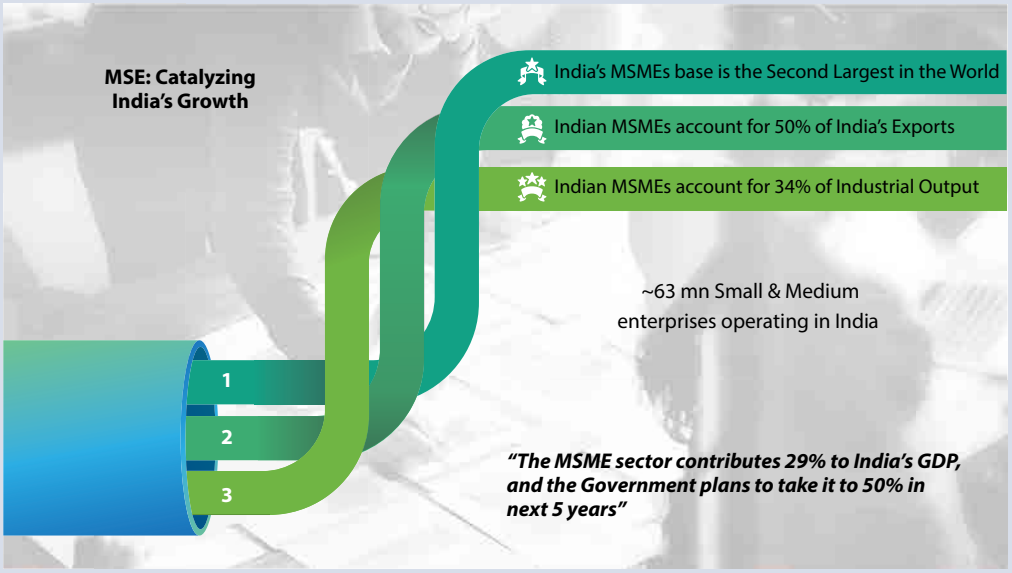


Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

To facilitate the growth of MSMEs, there is a strong emphasis on promoting their products through e-commerce platforms, particularly the GeM portal and initiative, as evident from Figure 2. GeM is an online platform owned and operated by the government, serving as a centralized procurement portal for ministries and public sector undertakings (PSUs). By making their products available on GeM, MSMEs gain increased visibility and access to potential buyers within the government sector. This initiative helps to streamline the procurement process and fosters transparency, as well as create opportunities for MSMEs to secure government contracts and expand their business.

FIGURE 1B

SNAPSHOTS AND STATISTICS OF MSMEs IN INDIA.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

FIGURE 2

GOVERNMENT E-MARKETPLACE PORTAL FOR PROCUREMENT OF RAW MATERIALS AND PRODUCTS DEVELOPED BY MSMEs IN INDIA.

Source: Ministry of Micro Small & Medium Enterprises, Government of India.

MSME industries are at the forefront of contributing to the *Amritkal* (empowering inclusive economy), *Aatmanirbharat Bharat* (self-reliant India), and the Vocal for Local initiative. They drive self-reliant and sustainable product design and development innovation across various sectors, including medical devices, fire and safety, handloom, furniture, and computers (refer to Figure 3).

As of May 2023, the GeM portal had processed 15.45 million orders worth INR4,288.04 billion, with MSEs contributing to INR2,237.07 billion (52%). These orders were fulfilled by 815,190 registered MSEs, including sellers and service providers. Overall, India's total number of registered MSMEs stood at 16.5 million.

The Government of India has proactively ensured ease of doing business for MSMEs. With a strong objective of promoting Make in India, *Aatmanirbhar Bharat*, Vocal for Local, Digital India, and Startup India missions, the government has initiated multiple schemes at different levels. These initiatives aim to help MSMEs reorganize production, optimize resource utilization, capitalize on economies of scale, and enhance return on investment (ROI). This support enables MSMEs to scale their business and invest in innovation, standards, and human capital, ultimately leading to increased productivity and economic growth.

FIGURE 3

GOVERNMENT E-MARKETPLACE PORTAL FOR PROCUREMENT OF PRODUCTS DEVELOPED BY MSMEs IN INDIA.

Source: Ministry of Micro Small & Medium Enterprises, Government of India.

To promote startups and MSMEs and facilitate frugal innovations in the country, the Government of India has initiated various schemes. The Department of Scientific and Industrial Research, under the Ministry of Science and Technology, has launched the CRTDH scheme to encourage research and technology development by MSMEs.

The schemes provide partial financial support as grant-in-aid to enable MSMEs to conduct industrial R&D and innovation activities in the Council of Scientific and Industrial Research (CSIR) laboratories established in India. These hubs facilitate MSEMs in undertaking new or improved product and process development and skill enhancement activities. Collaborating institutions offer hands-on training, skill development, and research information facilities to the MSMEs alongside research and technology development infrastructure. The creation of CRTDH aims to enhance productivity, increase the innovative skills of the MSMEs, help them become globally competitive, and generate more employment.

The scheme provides hand-holding support for MSMEs to pitch ideas and facilitates brainstorming sessions with scientific experts. It also provides mentorship support, technological inputs, and access to research laboratories. It establishes pilot plants to conduct research and develop a proof of concept (POC) and prototypes, enabling them to achieve a technology readiness level (TRL) 9.

Launching national missions and policies, such as the Hydrogen Mission, Semiconductor Mission, blockchain technology, AI, the IoT, and cyber-physical systems, has paved the way for startups and MSMEs to innovate cutting-edge algorithms. Further, India's Department of Science and Technology launched the Hydrogen Valley on 30 September 2022 to promote and facilitate the green hydrogen mission.

Overall, India stands as a powerhouse in innovation, intelligence, inclusion, and the implementation of digital technologies and schemes.

India's G20 Presidency

The G20 presidency is an opportunity for the country to reinforce its role as a global communication leader and expand its use of digital technologies. The forum allowed India to promote investment in digital infrastructure, encourage innovative and agile governance, enhance digital skills and training, improve the free flow of data with trust, enforce intellectual property rights, and boost technology adoption by MSMEs.

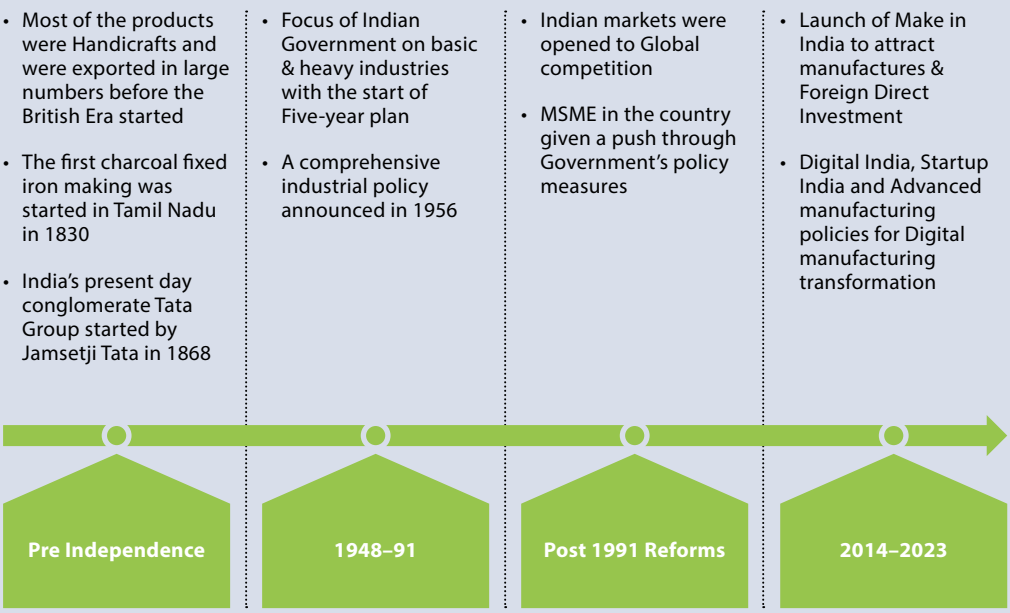
Scoping: Identifying Key Industry Sectors

Manufacturing Industry in India

India is leading the global DX journey and also being the powerhouse for emerging technologies starting from quantum computing-teleportation, supercomputing nanotechnologies, blockchain, 5G, UAVs, green hydrogen, electric vehicles (EVs), smart digital devices such as the IoT-based health monitoring, AI-based healthcare management, and smart manufacturing, has achieved enormous growth in the inclusive economy especially in the digital era, as illustrated in Figure 4.

FIGURE 4

EVOLUTION OF THE MANUFACTURING SECTOR IN INDIA.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

The manufacturing sector in India continued to grow strongly, fostering inclusive economic growth, especially in the second quarter of FY 2022–23, when the Purchasing Managers' Index surged from 57.7% in July to 58.6% in August 2022. Benchmarking indices recorded significant single-day gains, leading to strong economic growth and capturing the global market.

Key Industry Sectors of India Mapped with National Mission Policies

Agriculture and Food Products in India

India ranks first in milk production, contributing 24% to global milk production in 2021–22, marking a 51% increase in eight years, from 2014–15 to 2021–22.

- India ranks 3rd in global egg production, producing nearly 129.53 billion eggs in 2021–22, at a growth rate of 8% per annum.

- India is the 3rd largest fish-producing country, accounting for 8% of the global fish production, while the country ranks 2nd in aquaculture production. In 2021–22, fish production in India reached an all-time high of 16.24 MMT, marking a 10.34% growth.

- India's food service market is expected to reach USD79.65 billion by 2028, growing at a CAGR of 11.19% from USD41.1 billion in 2022.

- The Government of India is promoting the use of drones in agriculture by providing financial assistance through the Sub-Mission on Agriculture Mechanization.

- The government aims to make India a global hub for Shree Anna. It plans to support the Indian Institute of Millet Research, Hyderabad, to become the Centre of Excellence (CoE) for sharing global best practices, research, and technologies.

- The National Agriculture Market is a pan-India electronic trading portal that networks the existing Agricultural Produce and Livestock Market Committee (APMC) mandis (markets) to create a unified national market for agricultural commodities. Integration of APMCs across the country through a common online market platform to facilitates pan-India trade in agriculture commodities, providing better price discovery through a transparent auction process based on produce quality and timely online payment.

Case Study: Nano Urea Plant in Gujarat

Indian Farmers Fertilizer Cooperative Limited (IFFCO), is a multi-state cooperative society wholly owned by the Cooperative Societies of India. As highlighted in Figure 5, IFFCO has established the world's largest nano urea plant in Gujarat, manufacturing nanotechnology-based fertilizers, with an investment of INR1.75 billion.

Manufacturing in India

- The manufacturing sector contributed 16–17% of India's GDP in the pre-pandemic era and is projected to be one of the fastest-growing sectors.

- The machine tool industry is the nuts and bolts of the manufacturing industry in India. Today, technology has stimulated innovation, with DX providing an edge in this highly competitive market.

FIGURE 5

WORLD'S LARGEST NANO UREA PLANT IN INDIA'S GUJARAT.

India accelerated Green Agro-economy through Nano Urea:
World's first nano urea plant in Gujarat

India's dream of Sahkar Se Samriddhi and Atmanirbhar Bharat

- World's first nano urea liquid plant established in India by Indian Farmers' Fertilizer Cooperative Limited
- First IFFCO nano urea (liquid) production unit at Kalol has been made with an investment of INR175 crore
- Capacity to produce 1.5 lakh bottles of 500ml capacity of nano urea per day
- Indian patent on its revolutionary Nanotechnology-based fertilizers IFFCO Nano Urea and IFFCO Nano DAP.
- More than 5 lakh bottles of IFFCO nano urea is being exported to more than 25 countries including Brazil, South Africa and Sri Lanka

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

- The manufacturing sector of India is estimated to have the potential to cross the USD1 trillion mark by 2025.

- Manufacturing is emerging as an integral pillar of the country's economic growth, driven by the performance of key sectors like automotive, engineering, chemicals, pharmaceuticals, and consumer durables.

Toy Industry in India

The MSME Scheme of Fund for Regeneration of Traditional Industries toys cluster in India demonstrates the capabilities of skilled artisans who have adopted technology to scientifically design and develop traditional Indian toys, enabling them to earn a livelihood as a rural and social entrepreneur. These clusters employ traditional and indigenous materials such as bamboo, Dudhi wood, and organic cotton, utilizing natural resources and adding value to the toys.

The MSME toy cluster employs over 5,000 artisans and uses biodegradable packaging and recycling material. The toys developed in these clusters date back to the Indus Valley Civilization. The clusters have in-house design studios that cater to the technological and scientific production of toys, meeting market demands. The growing demand for toys, especially due to the Government of India schemes, helps promote toys in both domestic and global markets. The clusters are digitized through the Industry 4.0 initiatives. There are plans to manufacture antibacterial and digital-based toys using technologies such as IoT, additive manufacturing, system-on-microprocessor chips, RFID sensors, a voice recognition system, and sensors-on-chip.

The Indian toy retail market was valued at ~INR160 billion (USD2.2 billion) in 2020, accounting for less than 1% of the global market. Currently, 85% of the domestic demand for toys is met through imports; 80% of imports are from China, with the remainder sourced from Germany, Hong Kong, Malaysia, Sri Lanka, and the USA. According to a report by Business Standard and The Times of India, published on 2 September 2023, compared to import volumes, India's toy exports merely stand at INR7.3 billion (USD 100 million). This trade deficit is alarmingly large, given the potential for India to be self-reliant in an industry that is likely to grow at 10–15%, against the global average of 5%.

Information and Communication Technology

The global mobile data traffic has increased considerably over the last few years. According to an assessment by the International Telecommunications Union (ITU), global mobile data traffic is expected to reach 607 Exabytes (EBs) per month by 2025 and 5,016 EB by 2030. The data traffic per subscriber is projected to be around 39 EB by 2025 and about 257 EB by 2030. The main drivers of the dramatic growth in data traffic are connectivity devices such as Customer Premise Equipment (CPE), AR/VR devices, tablets, laptops, smartphones, intelligent connected vehicles, surveillance cameras, and M2M devices.

The design of 5G technology has been primarily motivated by eMBB or enhanced mobile broadband and is still mobile and smartphone-centric, with IoT devices accommodated as an afterthought. In 6G, it is anticipated that smartphones will be just one of the many device types: CPEs, cameras, AR/VR devices, IoT devices (industrial, civic, etc.), and other device categories will be more predominant.

Public Sector Undertakings in India

PSUs are vital in developing India's economy, especially in the research and development sector. Prominent PSUs include National Thermal Power Corporation, Bhabha Atomic Research Centre, Defense Research and Development Organization, Central Scientific Industrial Research, Indian Oil Corporation, Steel Authority of India Limited, Bharat Heavy Electricals Limited, Bharat Electronics Limited, and Hindustan Aeronautical Limited.

Gap Analysis: Issues in the Industrial Sector

The challenges in conventional manufacturing technologies are significant. Many MSMEs in India lack the information and awareness to transition to digital manufacturing. There are other factors, such as the need for investments, hand-holding support, expert directions, land cost, infrastructure improvement, and strong connections with large enterprises and industry associations, as explained in Figure 6. Also, there is a need to develop digital readiness tools and a strong connection for MSMEs to access these. Training MSMEs in implementing digital practices is crucial.

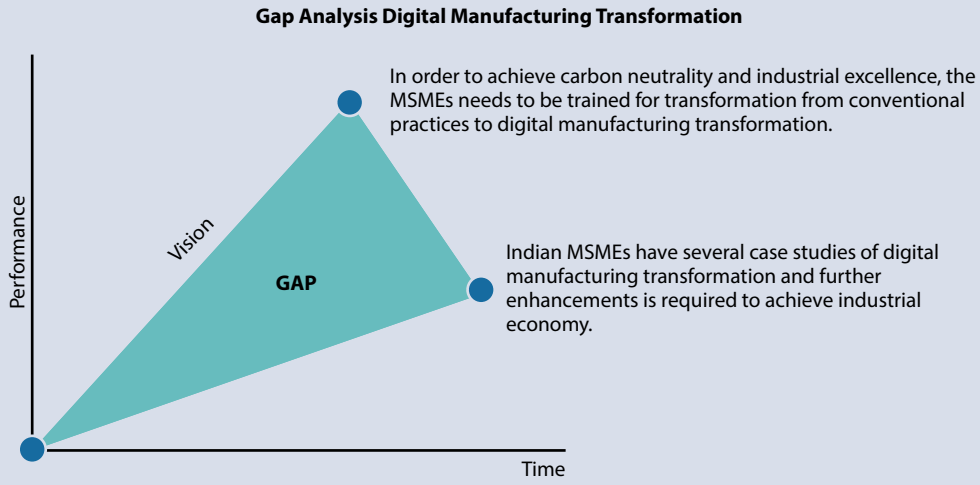
India is working to support MSMEs through various schemes and policies, such as *Aatmanirbhar Bharat*, Vocal for Local, and *Amrit Kal*. These policies provide inclusive support for different stakeholders, leading to the growth of MSMEs, which form the backbone of the country's economy.

Mobilizing Scenarios

India has been globally recognized for its capacity to innovate in the digital space. It is leading the campaign to support various countries, especially in the Global South, in learning from each other

FIGURE 6

GAP ANALYSIS OF THE MANUFACTURING SECTOR IN INDIA.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

and tackling digital and connectivity challenges. Over the last few years, DX has shifted from being a boardroom buzzword to a strategic priority for governments and businesses. While India has long been known for its vast IT talent and high technology adoption in industries, it is also at the forefront of leveraging technology to empower its citizens and strengthen governance. With more than 500 million Internet users, India is among the leading and fastest-growing digital consumer markets. Additionally, its vibrant start-up market fosters further innovation and the standardization of new technologies.

The Digital India program was launched to create a digitally empowered society and a knowledge-based economy, ensuring digital access, inclusion, and empowerment through initiatives such as Aadhaar, DigiLocker, Digital Village, and the Aarogya Setu App. The rise of the Fintech sector has accelerated financial inclusion in the country, with the expansion of digital payments being a crucial pivot for creating a more equitable, prosperous, and financially inclusive India.

In recent years, significant technological advancements and improved computing power have enabled more people globally to join the digital economy. Further enhancement of digital capabilities is expected to strengthen connectivity, significantly impacting various sectors and the overall economy. There is a rising trend across sectors wherein digital platforms are reshaping relationships between customers, employees, and employers. The pandemic accelerated technological transformation by many years, making technology the backbone of continuity across various sectors and ensuring financial and social inclusion for the citizens. It also allowed India to set global benchmarks in leveraging technology for enhanced transparency, increased compliance, improved delivery of public services, expanded digital payments, and strengthened e-governance.

As India focuses on enhancing its manufacturing prowess and establishing itself as a preferred hub across global value chains, DX, driven by emerging technologies such as AI, ML, IoT, robotics, blockchain, and cloud computing, will generate substantial economic value. With the advent of the 4IR, these technologies are being leveraged to enhance competitiveness. Harnessing their full

potential to strengthen competitiveness must be supported by policy frameworks that ensure these technologies work responsibly for people and the planet.

India's software and services industries have been significant growth drivers for the past few decades. The country is now positioning itself to seize semiconductor design and manufacturing opportunities. In many ways, almost every industry is now a technology industry, with semiconductors driving innovation and efficiency in a digitized world. As India aims to strengthen self-reliance and increase the share of domestic production in the market, consistent efforts must be made towards skilling, R&D, and IP protection.

Transparency: Responsible Research Innovation

RRI is a concept developed and majorly adopted in Europe [1–3], especially in STEM research. The principles of RRI have been incorporated into policies, schemes, and programs in Europe and other countries. Developing countries like India have adopted the concept of RR to enhance protocols and practices for research and development, leading to product and process development and technology commercialization.

RRI originates from the European Commission's Sixth Framework Program (FP6) (2002–06), which established the conceptually new program Science and Society. Its main objective was to promote responsible research and application of science and technology (Owen et al., 2021). Subsequently, FP6 evolved into the Seventh Framework Program (FP7), aiming to achieve responsible research and application, which then led to the Horizon 2020 program.

RRI has emerged in India as an important concept and practice in the STI of disruptive technologies. The concept of RRI has been in practice in India for several years in research laboratories such as the Council of Scientific & Industrial Research, Defense Research and Development Organization, Indian Space Research Organization, Technology Information, Forecasting and Assessment Council, the Technology Think Tank of Government of India [4–8]. Additionally, organizations like the National Research and Development Corporation have incorporated RRI through the formation and implementation of various schemes and policies from government departments, including the Ministry of Science and Technology, Ministry of New and Renewable Energy, Ministry of Agriculture, Niti Aayog, Ministry of Earth Sciences, and Ministry of Defense.

RRI is a transparent interactive process in which key constituents, such as societal actors and innovators, play a vital role through mutual responsiveness, contributing to the country's growth. In India, RRI fosters the design of inclusive and sustainable research and innovation, resulting in marketable solutions that meet ethical, sustainability, and societal desirability objectives. This approach aims to achieve an inclusive economy and drive growth, which aligns with the Amrit Kaal vision.

For India, the objective of RRI [9–14] is to cohesively align the innovation research process with tangible outcomes that meet the needs, expectations, and values of society and the nation. Important stakeholders in RRI include scientists and researchers, industries, industry associations such as PHD Chamber of Commerce, ASSOCHAM, FICCI, Confederation of Indian Industries, as well as academia like the Indian Institute of Technology, Indian Institute of Science, Bangalore, International Institute of Information Technology, central and state universities, and several government departments. Citizens also play a crucial role in this. India has achieved excellence in

research and innovation through six key dimensions: public engagement, gender equality, science education, open access, ethics, and governance.

RRI has been the theme of several scientific and engineering projects, and research literature on the topic has significantly increased. The framework of RRI in India has been implemented through policies in several domains, including smart farming (agriculture), nanotechnology, cyber-physical systems, green hydrogen, energy storage, and information and communication technologies such as quantum technologies, 5G and 6G, Gen AI, AI, blockchain, IIoT, and digital healthcare.

The government of India has established the National Research Foundation, an apex body, to provide high-level strategic direction for scientific research in the country. This initiative follows the recommendations of the National Education Policy and has a total outlay of INR500 billion over five years (2023–28).

TABLE 1

TANGIBLE OUTCOMES OF RESPONSIBLE RESEARCH INNOVATION IN INDIA.

National Policies	Schemes	Disruptive Technologies On-board in India	Technology Hubs in India
Make in India • Samarth Udyog Bharat 4.0 • National Quantum Mission • National Semiconductor Mission • National Hydrogen Mission • National Solar Mission • National Rural Health Mission • National Education Policy 2020 Mission Policies for Cyber-physical Systems, IoT, blockchain, AI, Advanced Manufacturing	• Production Linked Incentive scheme for telecom and networking products to include design-led manufacturing of 5G products • Design Linked Initiative • Digital Public Infrastructure	• Embedded System with ARM and Design • Real Time Operating System and Robotics Operating System (ROS) • Embedded Programming and ES Design using MATLAB. • IoT (Raspberry Pi and Node Mcu ESP8266) • Robotic Process Automation (RPA) • 3D printing • Virtual Reality and Augmented Reality headsets • Machine Vision Systems • Collaborative Robot • Telepresence Robots and Autonomous Guided Vehicles • Drones • Cloud servers and Micro data center • Quantum teleportation, computing, sensors, and quantum dots • Spintronics • Gen AI and AI	**World-class infrastructure for building Industry 4.0 technology projects in India** • World Economic Forum • Software Technology Parks of India • Research and Innovation Park • Common Engineering facility centers • CoE, National Productivity Council (NPC), Government of India

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

TABLE 2

DIGITAL INDIA INITIATIVES.

Sl.No	Digital Initiative	Description
1.	Digibunai	Digital computer-aided software for textile design
2.	Bashini	Multilingual AI model platform using natural language processing and AI
3.	ONDC	Open Network for Digital Commerce (ONDC)
4.	e-Sanjeeveni	Telemedicine
5.	DigiLocker	Digital wallet
6.	UPI | UPI ATM	Unified Payment Interface
7.	Umang	One app many government services
8.	Arogyasetu	COVID-19 contact tracing, syndromic mapping, and self-assessment digital service app.
9.	Cerebral Palsy	Digital app for facilitating palsy
10.	Dakpay	UPI by IPPB is a safe, easy, and reliable payment app that allows users to make payments using BHIM UPI on their mobile phones.
11.	ABHA-based Scan and Share	One crore OPD tokens were generated using ABHA-based Scan and Share service within one year of implementation.
12.	DigiDhristi	DigiDrishti is a digital eyecare delivery system comprising a mobile app for citizens and vision guardians and a web-based teleophthalmology system.
13.	Web-linked Centralized Remote Ophthalmology system	It is a web-based eye care delivery system that supports a vision center.
14.	Vision Guardian mobile app	A peer-to-peer connection application that allows customers to view live camera feeds from their phones when away from the office.
15.	Digital Infrastructure for Knowledge Sharing (DIKSHA)	A platform designed to explore and advance school education. It is an initiative of the National Council for Educational Research and Training (NCERT) under the Ministry of Education.
16.	Indian Disaster Resource Network (IDRN) API services	It is a web-based platform for managing the inventory of equipment, skilled human resources, and critical supplies for emergency response
17.	MANAS – Mental Wellness APP	This is a comprehensive, scalable, national digital wellbeing platform.
18.	Poshan Tracker	This mobile app is a job aid for Anganwadi workers, enabling efficient service delivery and reflecting their efforts.

Source: Digital India. Ministry of Electronics & Information Technology, Government of India (see Figures 7 and 8).

Digital India: A Premier Program of the Government of India

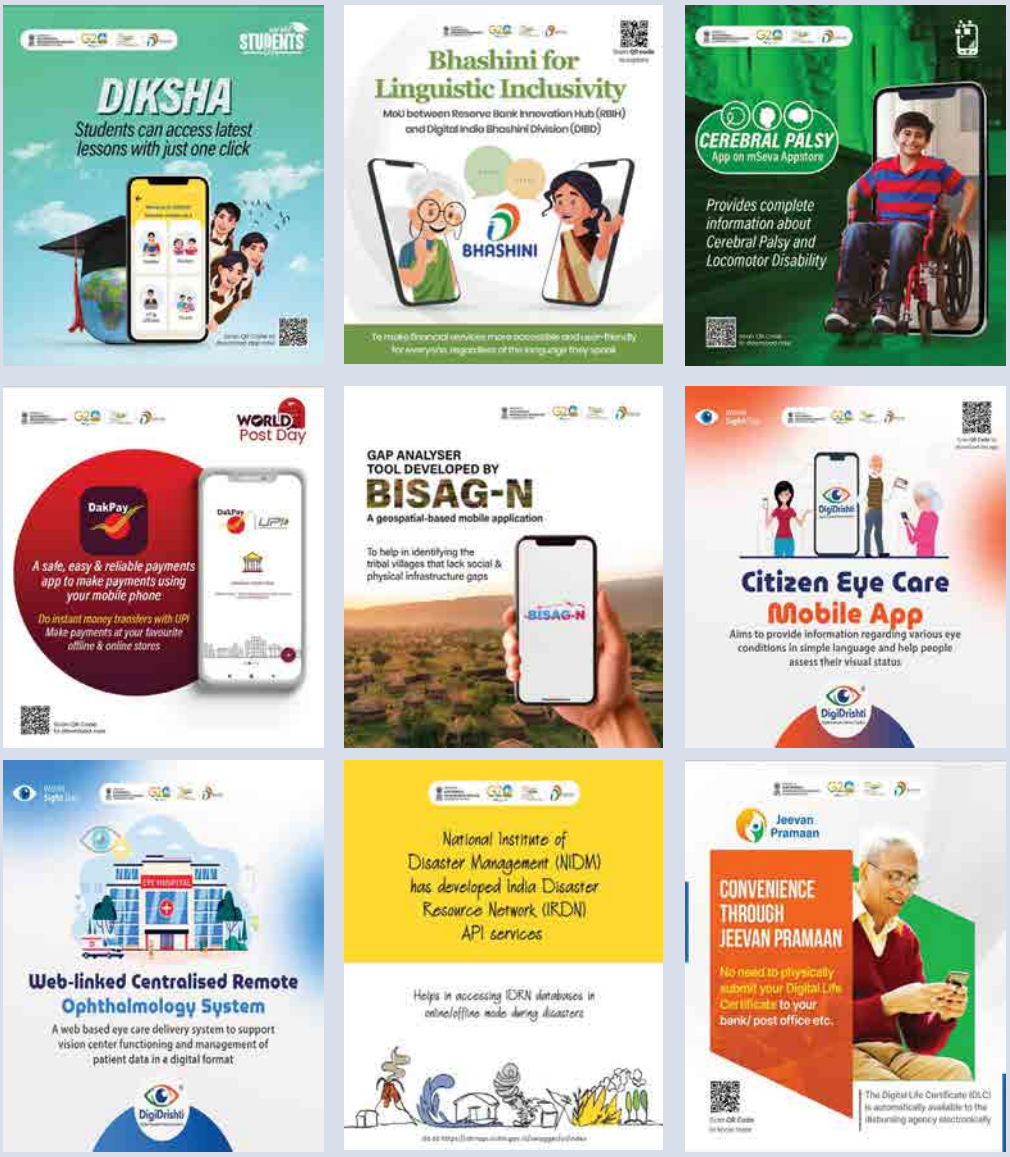
Digital India is a program to transform India into a digitally empowered society and knowledge economy. The focus is on leveraging Indian talent and IT to shape India tomorrow.

IT (Indian Talent) + IT (Information Technology) = IT (India Tomorrow)

The umbrella program encompasses multiple government ministries and departments, weaving together numerous ideas and initiatives into a comprehensive vision where each element contributes to a larger goal. It is coordinated by the Ministry of Electronics and Information Technology (MeitY) and implemented across the entire government. The program aims to consolidate many existing schemes, which will be restructured, re-focused, and implemented in a synchronized manner. Many elements involve process improvements with minimal cost implications. The common branding of these programs as Digital India underscores their transformative impact (see Figures 7 and 8).

FIGURE 7

EMERGING TECHNOLOGIES DRIVING DIGITAL INNOVATIONS IN INDIA [15].



Source: Digital India. Ministry of Electronics & Information Technology, Government of India.

FIGURE 8

TANGIBLE OUTCOMES OF DIGITAL INDIA INITIATIVES [15].

Source: Digital India. Ministry of Electronics & Information Technology, Government of India.

Digital Experience Zones

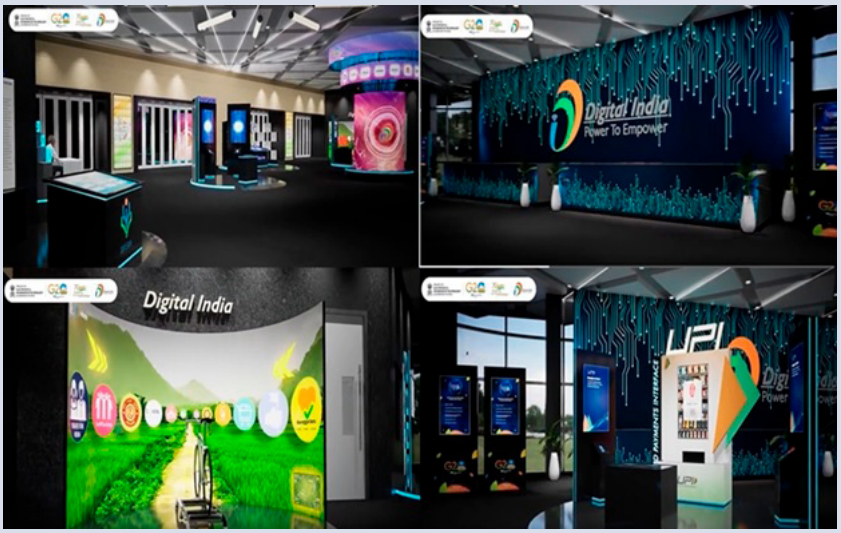
To facilitate the sharing of experience and best practices in implementing Digital Public Infrastructures (DPIs) in the country and to make global stakeholders aware of scalable and replicable projects, MeitY has established two state-of-the-art Digital India Experience Zones. These zones, located in Hall 4 and Hall 14 at Pragati Maidan, offer visitors a unique opportunity to experience the power of technology first-hand (see Figure 9).

The ethos behind the expo is to showcase world-class initiatives that facilitate ease of living, ease of doing business, and ease of governance.

The Digital India Experience Zone is a treasure trove of cutting-edge technology, brimming with knowledge and insights into crucial initiatives of Digital India. Seven key initiatives have been selected to showcase the best practices in implementing DPIs: Aadhaar, DigiLocker, UPI, eSanjeevani,

FIGURE 9

DIGITAL INDIA EXPERIENCE ZONE AND INTERNATIONAL MEDIA CENTRE.



Source: Digital India. Ministry of Electronics & Information Technology, Government of India.

DIKSHA, Bhashini, and ONDC. The exhibition provides an immersive experience, enabling visitors to explore DPI repositories in India and gain insights for the betterment of the global community.

The live demonstration of Aadhaar Face Authentication Software enables attendees to gain hands-on experience while providing an opportunity to interact directly with cutting-edge technology. The UPI exhibit encourages visitors to explore and discover various UPI applications worldwide. Additionally, visitors can scan QR codes to purchase goods and initiate seamless transactions with nominal payments.

Guests can also learn about the practical utility of India's DigiLocker, showcasing its role in streamlining processes and enhancing efficiency across sectors such as education, finance and banking, travel, transport, real estate, legal, and judiciary.

The eSanjeevani exhibit highlights that doctors from various domains, such as cardiology, mental health, ophthalmology, and general medicine, are present to provide online consultation and give visitors real-time health analysis and advice, along with an e-prescription.

The DIKSHA exhibit offers an immersive and intuitive experience, allowing visitors to explore the wealth of educational resources available through the application. At the Bhashini exhibit, visitors can experience real-time speech-to-speech translation in all Indian and six UN languages. The JugalBandi Telegram Bot facilitates further interaction, allowing visitors to ask questions and interact in any language they choose. A grand display of Digital India's iconic journey takes visitors through the major milestones of the program since 2014, bringing to life the advancements made in the digital space through simulated virtual reality. Additionally, visitors can explore DPI's core principles and the evolution of Digital India initiatives in the Digital Tree exhibit.

Users can also interact to see how ONDC collaborates with sellers, customers, and network providers on a large scale. A kiosk introducing the Gita application enables visitors to ask questions about life, as explained in the revered Hindu scripture Shrimad Bhagwat Gita.

The Digital India Experience Zone employs cutting-edge technologies like interactive displays, Virtual Reality, and more. Each installation has been crafted to resonate with the target audience, ensuring meaningful engagement and age-appropriate content.

The Government of India has collaborated with IBM and several countries to promote emerging technologies such as AI, semiconductors, and quantum computing. The Digital India initiative has paved the way for setting up a CoE to showcase emerging technologies such as Samarth Udyog Bharat 4.0, Software Technology Parks of India, MSME Technology Centers, and National Small Industries Corporation Technical Centers. It has also enabled the establishment of a CoE in automated manufacturing and NASSCOM CoE to facilitate IoT, AI, machine learning, and big data technologies. NASSCOM has also partnered with MeitY to promote skilling in emerging technologies through the Future Skills program and Yuva AI to promote AI among school students

Case study: Frugal Innovations in India

Emerging technologies have paved the way for innovations in AI-based technologies in India, such as high-resolution imaging systems, hydrogen e-bikes, smart hand tools, AI, and quantum-based UAVs for precision farming and fitness trainers. These innovations align with the vision of national policies on AI, semiconductor technology, drone technology, the hydrogen mission, and the digital health mission (see Figures 10 and 11).

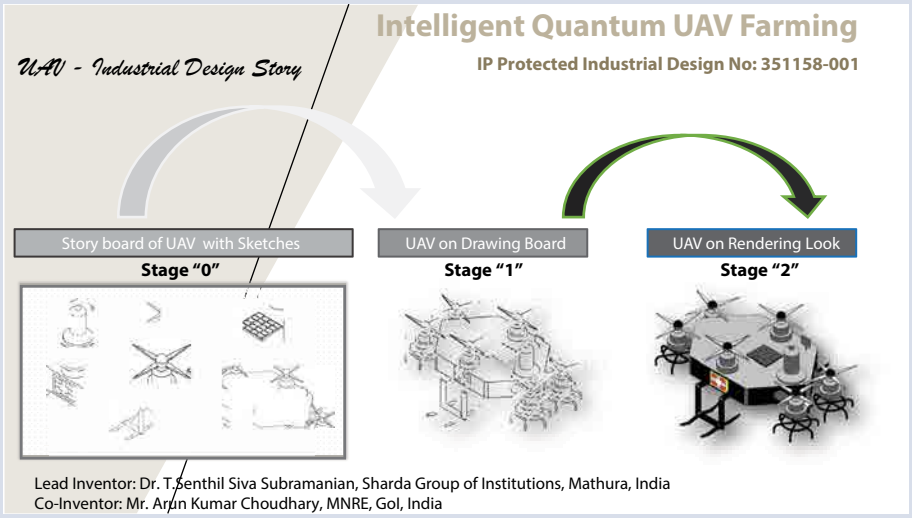
FIGURE 10

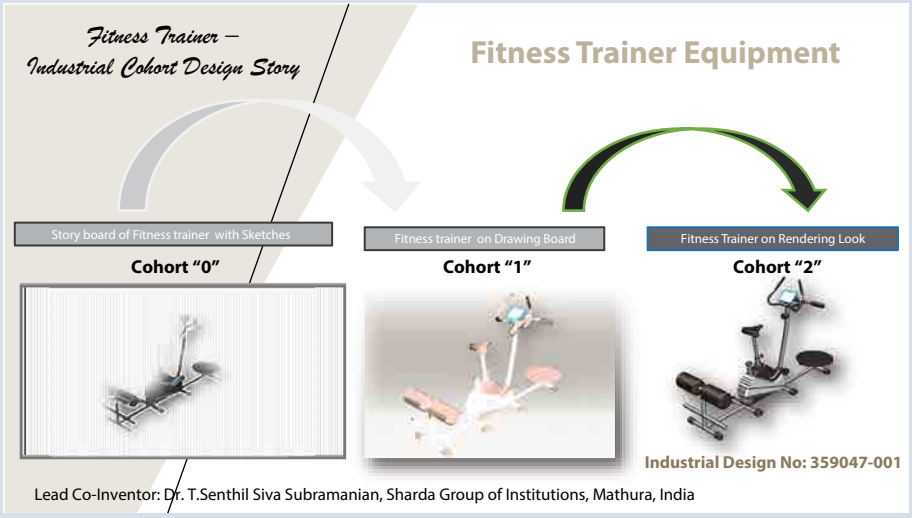
AI-DRIVEN TECHNOLOGIES IN INDIA.

Source: Digital India. Ministry of Electronics & Information Technology, Government of India; Program document, Hydrogen technology in the automotive sector (Technology transfer of patent hydrogen e-bike to Comuti Energy, Hyderabad).

FIGURE 11

PATENT TECHNOLOGIES IN SMART HAND TOOL, UAV, AND FITNESS TRAINER.

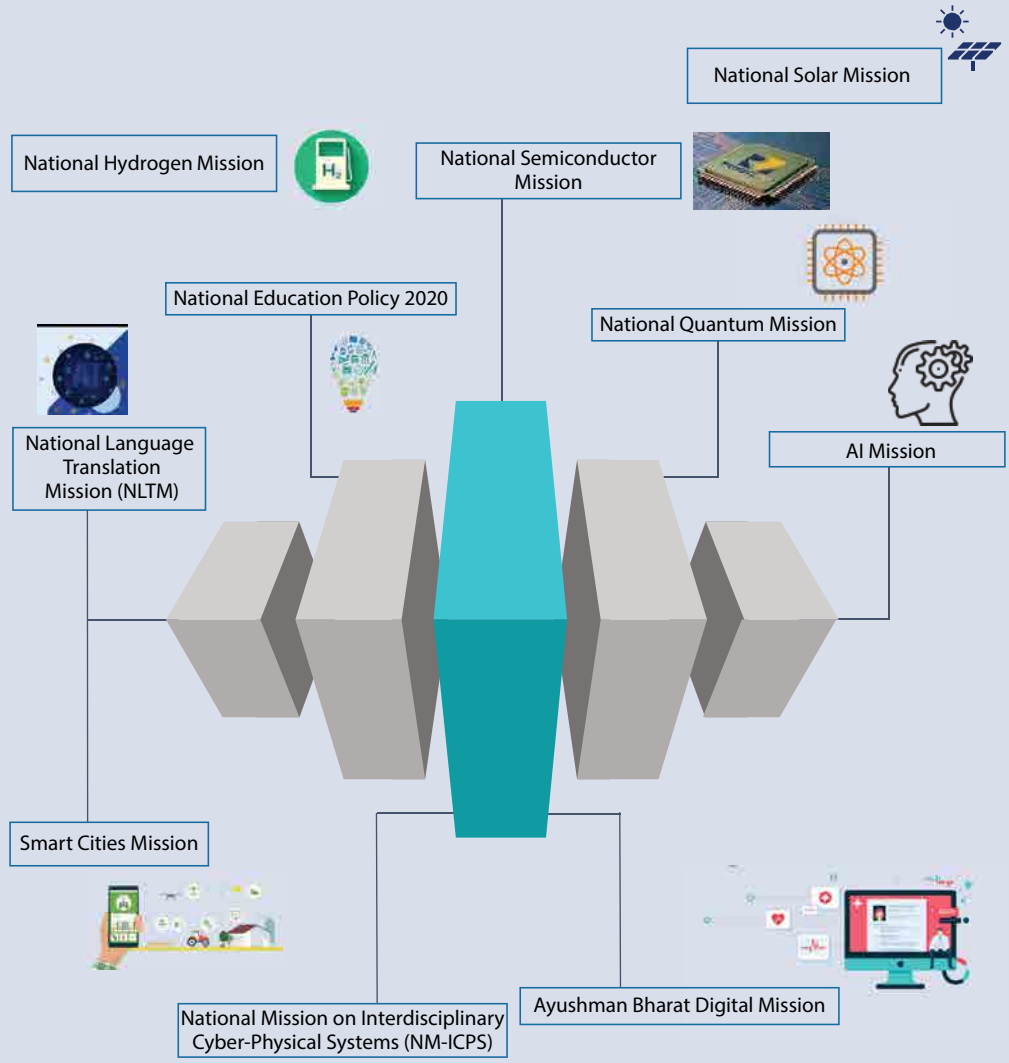




Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

Policy Recommendations

Overview of National Policies on Emerging Technologies in India



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

Recommendations

National Policy on Capacity Building (Skilling)

The Government of India's policies on innovation, advanced smart manufacturing, and drones have paved the way for national and multinational companies to set up world-class manufacturing facilities in India. Hence, there is a need for a skilled workforce to operate advanced automation machines and process systems. Although there is a skill mission for dropouts, training those passing out from the Industrial Training Institutes (ITIs) is necessary. A policy framework to transform all industrial training institutes into CoEs in partnership with industries will help reskill and upskill the workforce in technologies such as system design, additive manufacturing, AI and research, material research, IoT, data science, nanotechnology, biotechnology, hydroponic, and embedded technologies.

The Government of India has granted NCERT deemed university status, and the policy framework may help connect these CoEs (ITI) with NCERT to reskill, upskill, and award degrees to youth.

National Policy for Technology Transfer

Innovation is the nation's backbone and propels the economy through research and development. Product innovations, whether ideas, concepts, POCs, or developments, are largely limited to the laboratory scale. Policies to promote the technology transfer of innovations and patents to industries, especially with a focus on MSMEs, are needed.

This policy may also lay the foundation for addressing the various challenges in achieving the technology readiness level 9, ensuring that products can be commercialized and made available in the market.

National Policy to Develop and Adopt Digital Readiness Tool for Indian MSMEs

Adopting digital manufacturing transformations by industries facilitates productivity growth, sustainability, low ROI, and precision quality and supports industrial excellence, thereby driving the nation's economic development. Digital manufacturing transformation is imperative for MSMEs in India as they form a vibrant sector of the nation's economy.

Many Indian MSMEs, however, still rely on traditional technologies for manufacturing, leading to several challenges. There is a pressing need to assess MSMEs to transition to digital manufacturing using digital readiness tools. This can be done using the Bharat 4.0 readiness tool developed by NPC. Besides, a policy framework, especially by the Ministry of MSME, is necessary to develop digital readiness tools that enable MSMEs in the country to assess and provide guidelines for transitioning to digital manufacturing.

National Policy to Connect Academic Institutions and Universities with MSMEs

A policy framework to promote collaboration and partnership and serve as an interface between academic institutions, MSMEs, and large enterprises is urgently needed to raise awareness of experimental and practical knowledge, hands-on training, and skill building for students and faculty members of academic institutions.

The collaboration will offer students and faculty members opportunities to receive training on cutting-edge emerging technologies and facilitate the transformation of innovation from idea or concept to industry through technology transfer policies.

Students and faculty members can address problem statements and expectations regarding the TRL of the MSMEs, as well as the design and development, manufacturing, and financial challenges faced by these entities.

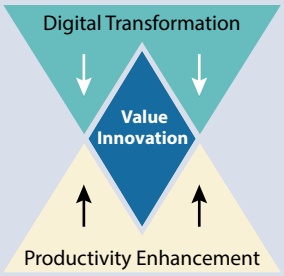
National Policy Alignment with the APO Vision and Mission

India's vision aligns closely with the APO 2025 vision, aiming to achieve excellence in innovation, intelligence, and inclusivity. Adopting best practices in digital manufacturing transformation will increase green productivity and sustainability.

Various success stories have demonstrated the successful implementation of the vocal for Local initiative and product and process innovations, making India self-reliant or *Aatmanirbhar Bharat* and leading to empowerment in an inclusive economy.

FIGURE 12

ALIGNING INDIA'S VISION WITH THE APO AND STRATEGIES FOR NATIONAL GROWTH.

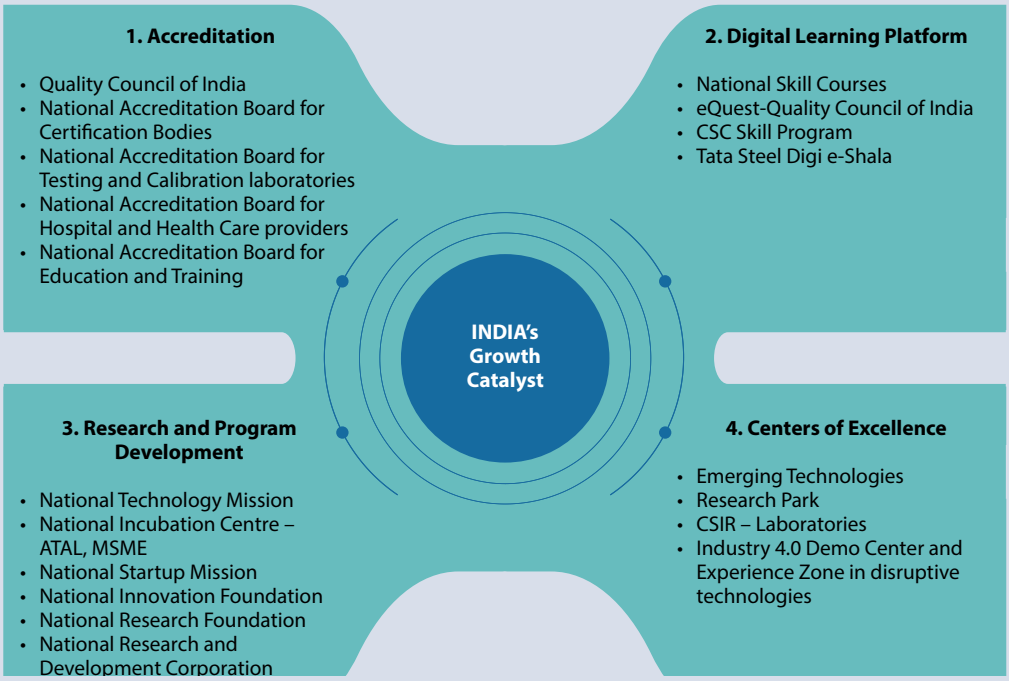


Smart Transformation	Quality of the Workforce	Green Productivity Green Technologies
Smart factory at the Indian Institute of Science Bangalore	Smart practices	Solar Grid, Wind
Bajaj Automotive Silent Factory, Maharashtra	Optimum use of resources	Green Hydrogen
Modern Railway Coach Factory, Uttar Pradesh	Openness to accept the changes in digital transformation	Lithium-Ion battery
Smart cities across India	Assets and capabilities	Ethanol production
Samarth Udyog Bharat 4.0 Smart manufacturing & Digital Transformation Centers, PAN India	Product and service offerings	Agri voltaic

Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

FIGURE 13

INDIA'S GROWTH CATALYST VS. APO'S REGIONAL CATALYST.



Source: National Expert. Digital Transformation in Asian Economies, APO; 2024.

Conclusion

The report highlights various initiatives and growth across industries, agriculture, information and communication technologies, and PSUs in India. Implementing policies and schemes in research and innovation, particularly in emerging technologies, has accelerated the growth of an inclusive economy. Emerging technologies, especially in Indian MSMEs, have contributed to increased productivity, sustainability, and self-reliance. India is progressing towards becoming a global leader in emerging technologies, enhancing livelihood through cost-effective and affordable techno-commercial solutions.

References

[1] European Commission. Responsible research and innovation – Europe's ability to respond to societal challenges. Directorate-General for Research and Innovation, Publications Office; 2012. https://data.europa.eu/doi/10.2777/11739. Accessed on 24 August 2023.

[2] Delaney N., Iagher R. Institutional changes towards responsible research and innovation – Achievements in Horizon 2020 and recommendations on the way forward. European Commission, Directorate-General for Research and Innovation, Publications Office; 2020. https://data.europa.eu/doi/10.2777/682661. Accessed on 24 August 2023.

[3] Christensen M.V., Nieminen M., Altenhofer M., et al. What's in a name? Perceptions and promotion of responsible research and innovation practices across Europe. Science and Public Policy; 2020; 47 (3): 360–370. https://doi.org/10.1093/scipol/scaa018. Accessed on 24 August 2023.

[4] Abraham I. The two faces of India's new science and tech policy. Science The Wire, 17 May 2021. https://science.thewire.in/the-sciences/india-national-research-foundation-draft-stip-2020-science-and-technology-policy-review/. Accessed on 25 August 2023.

[5] Abraham I. Why 2003 was an important year for India's Science &Technology policy resolutions. 18 May 2021. https://science.thewire.in/the-sciences/why-2003-was-an-important-year-for-indias-st-policy-resolutions/. Accessed on 25 August 2023.

[6] Asveld L., van Dam-Mieras R., Swierstra T., et al. eds. Responsible Innovation 3. Springer Cham; 2017. https://doi.org/10.1007/978-3-319-64834-7_1. Accessed on 25 August 2023.

[7] Beumer K. Nation-building and the governance of emerging technologies: the case of nanotechnology in India. NanoEthics; 2019; 13, pp. 5–19. https://doi.org/10.1007/s11569-018-0327-8. Accessed on 26 August 2023.

[8] Bhaduri S., Talat N. RRI beyond its comfort zone: initiating a dialogue with frugal innovation by 'the vulnerable.' Science, Technology & Society; 2020; 25(2), pp. 273–290. https://doi.org/10.1177/0971721820902967. Accessed on 27 August 2023.

[9] Department of Science and Technology, Government of India. Technology Policy Statement. National Science & Technology Management Information System; 1983. http://www.nstmis-dst.org/TPStatement.aspx. Accessed on 27 August 2023.

[10] Department of Science and Technology, Government of India. Science and Technology Policy; 2003. https://indiabioscience.org/media/articles/STP-2003.pdf. 28/08/2023.

[11] Department of Science and Technology, Government of India. Science, Technology and Innovation Policy; 2013. http://dst.gov.in/sites/default/files/STI%20Policy%202013-English.pdf. Accessed on 28 August 2023.

[12] Department of Science and Technology, Government of India. Science, Technology and Innovation Policy (Draft); 2020. https://dst.gov.in/sites/default/files/STIP_Doc_1.4_Dec2020.pdf. Accessed on 29 August 2023.

[13] Department of Science and Technology, Government of India. Scientific Social Responsibility (SSR) Guidelines; 2022. https://dst.gov.in/sites/default/files/SSR%20Guidelines%202022%20Book_0.pdf. Accessed on 20 August 2023.

[14] Department of Science and Technology, Government of India. Scientific Social Responsibility (Draft); 2020.

[15] Digital India. Ministry of Electronics & Information Technology, Government of India. https://www.meity.gov.in/. Accessed on 1 September 2023.

MONGOLIA

Introduction

Mongolia is a landlocked country in Central Asia, bordered by Russia on the north and China on the south. It is divided into 21 aimags (provinces), the first-level administrative subdivisions, and six regions.

TABLE 1

MONGOLIA: A SNAPSHOT.

Population	3,409,939 people
Total Area	1,564,116 square kilometers
Religion	Buddhist (51.7%), Non-religious (40.6%), Muslim (3.2%), Shamanist (2.5%), Christian (1.3%), Other (0.7%)
Ethnicity	Khalkh (83.8%), Kazakh (3.8%), Durvud, Bayad, Buriad, and other
Language	Mongolian (official)
Literacy Rate	99%
Higher-Education Rate	26.5%
ICT use	Internet: 64.7%
Mobile phone: 87.8%	Ulaanbaatar
Capital city	Ulaanbaatar
Population	1,539,252 people
Area	470.4 square kilometers

Geopolitical factors significantly influence Mongolia's economic structure. The country's economy heavily depends on its neighboring countries, China and Russia. China accounts for 80% of Mongolia's exports and 40% of its imports, while Russia accounts for 10% of exports and 30% of imports. Additionally, Mongolia's economy heavily relies on the mining and quarrying sector, which contributes approximately 25% to the GDP.

TABLE 2

ECONOMIC FACTSHEET OF MONGOLIA.

Indicators	2018	2019	2020	2021	2022
Labor force (in '000)	1,358.6	1,273.9	1,250.6	1,225.4	1,265.2
Employed	1,253	1,146.2	1,162.9	1,125.6	1,180.5
Labor force participation rate (in %)	61.0	60.5	58.8	56.9	58.6
Employment to population ratio (in %)	56.3	54.4	54.6	52.3	54.7
Unemployment rate (in %)	7.8	10	7.0	8.1	6.7

(Continued on next page)

(Continued from the previous page)

Indicators	2018	2019	2020	2021	2022
GDP, at current prices (in MNT billion)	32,582.6	37,839.2	37,453.3	43,555.5	52,867.4
GDP per capita, at 2015 constant prices (in USD)	4,248	4,440	4,194	4,188	4,315
Mobile cellular telephone registered users (in '000)	5,867.6	6,214.7	6,294.6	6,660.6	6,914.4
Mobile cellular telephone active users (double counting, in '000)	4,222	4,418.9	4,363.9	4,607.6	4,834.2
Permanent Internet users (in '000)	3,726.7	3,921.7	3,907.2	4,137.3	4,187.6
Number of herdsmen	288,700	285,482	298,789	305,430	305,079

Source: Khaliun B. Mongolia's missing millions: What happened to a decade-long mining boom. 2021.

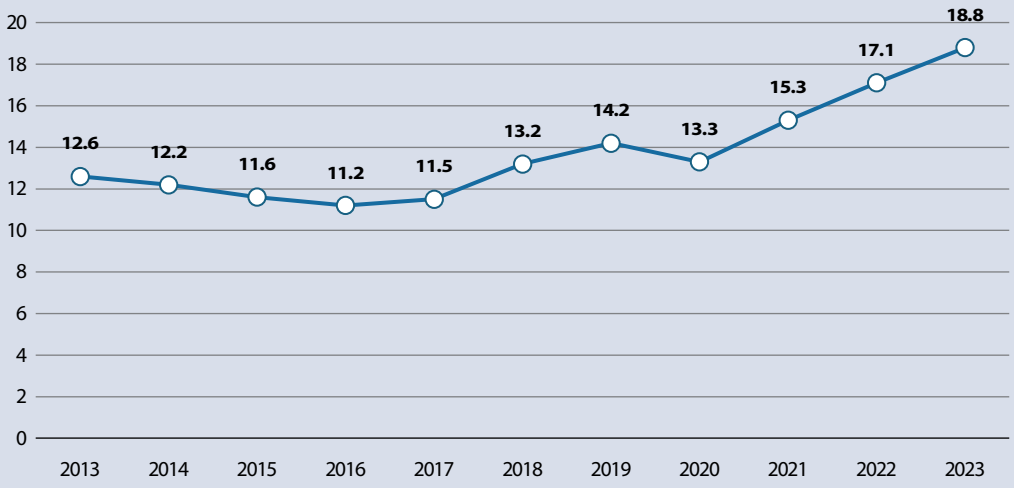
Economy

Mongolia experienced a mining boom in 2011, driven by significant coal deposits at Tavan Tolgoi and copper deposits at Oyu Tolgoi. This boom accelerated the economy temporarily [4], but the wealth was not effectively capitalized upon, resulting in minimal long-term improvement in the overall economy, except within the mining industry.

Following the peak in GDP growth at 17.3% in 2011, the economy began to decline, reaching a low of 1.5% in 2016. In 2017, investments from the IMF and a change in leadership, including the president and prime minister, resulted in the economy's recovery, with GDP growth rebounding to 5.6%. However, the COVID-19 lockdown and the prolonged closure of the China border had a negative impact on Mongolia's economy, causing GDP growth to drop by –4.6%. In 2021, increasing global demand for raw materials raised market prices for Mongolia's export products, such as coal, gold, and silver. The demand helped the country recover from the negative impacts of the lockdown. As a result, GDP growth rose to 5.5% in 2023.

FIGURE 1

MONGOLIA'S GDP AT CURRENT PRICES (IN USD BILLION).

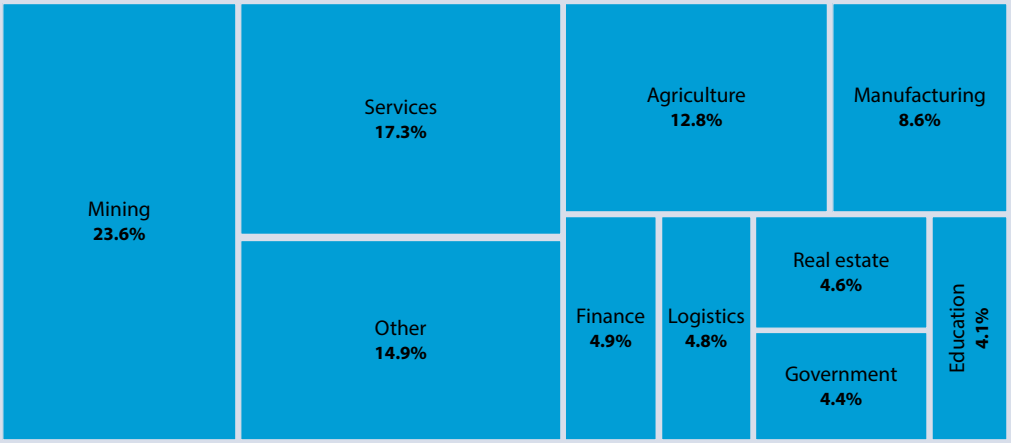


Source: IMF. GDP, current prices. 2023 [5].

As of 2022, the mining industry accounts for almost a quarter of Mongolia's GDP, making it the largest contributor. The service industry is second, contributing 17.3% to the total GDP. Despite Mongolia's nomadic heritage and a significant population of domesticated livestock, the agriculture industry represents only 12.8% of the GDP. Overall, mining, services, and agriculture sectors accounted for 53.7% of Mongolia's GDP in 2022.

FIGURE 2

SECTOR-WISE CONTRIBUTION TO MONGOLIA'S GDP.



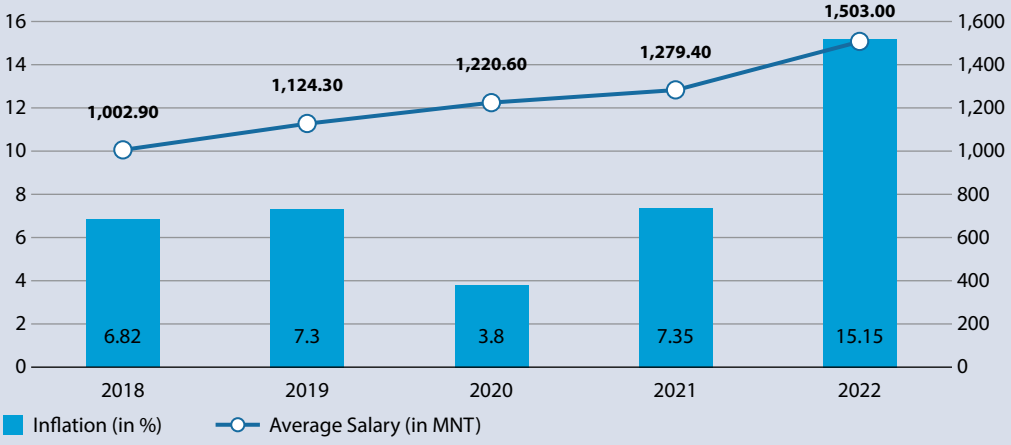
Source: National Statistics Office (NSO) of Mongolia. Gross Domestic Product. 2023 [6].

Labor

In 2022, Mongolia was ranked 133rd out of 217 countries by population [7]. It is one of the least populated countries in the world, with approximately 2 km^2 per person [8] and a total population of 3,340,454. According to data from the National Statistics Organization, the country's working-age population is 2,159,568, with only 59% currently registered with the government as employed or actively seeking work.

FIGURE 3

AVERAGE SALARY AND INFLATION IN MONGOLIA.



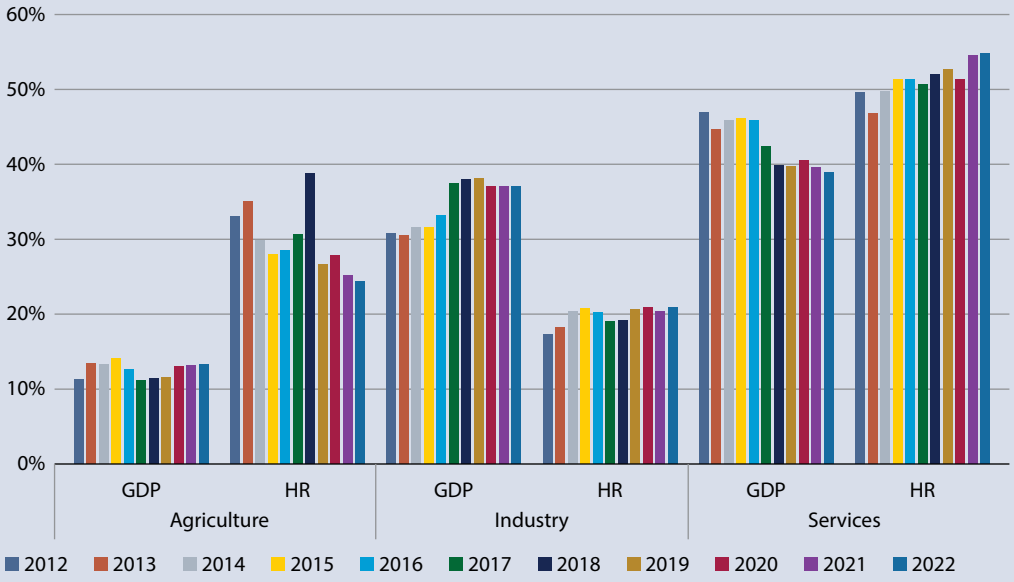
Source: National Statistics Office of Mongolia. Wages. 2023 [9].

The COVID–19 pandemic had a significant negative impact on the country's economy, leading to record high inflation of 15.15% in 2022, the highest in five years. During this period, the average wage increased by around 17%, but the rising global cost of raw materials caused a sharp increase in the prices of essential products. For example, by 2022, the cost of raw materials in construction had risen by 30% [10], and real estate prices had increased by more than 24%, which was not proportional to the wage growth.

Figure 4 shows the share of economic sectors in GDP and the distribution of employment by economic sector for 2011–22.

FIGURE 4

SECTOR-WISE CONTRIBUTION TO MONGOLIA'S GDP AND EMPLOYMENT DISTRIBUTION.



Source: Statista. Mongolia: Share of economic sector in the gross domestic product from 2012 to 2022. 2023 [11].

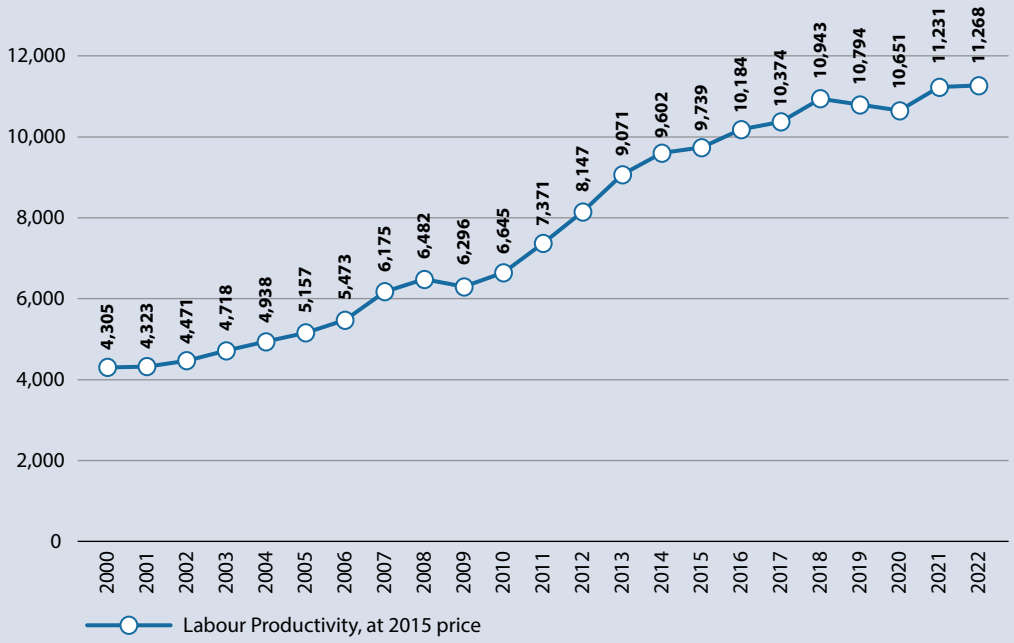
As illustrated in Figure 4, about 30% of Mongolia's workforce is engaged in agriculture, contributing approximately 13% to its GDP. About 20% of employment is in the industrial sector, contributing around 35% to the economy. The number of people employed in the services sector increased to 54.8% in 2022, but their contribution to the economy decreased to 38.9%.

As indicated in Figure 5, labor productivity in Mongolia shows an increasing trend. However, at a global scale, it remains relatively low. For instance, between 2000–17, the average labor productivity in Mongolia stood at USD6,800. This figure is significantly lower than that of high-income countries, which averaged USD85,500, marking a 12.5-fold difference. Similarly, it is 3.2 times lower than upper-middle-income countries (USD21,600) and 1.7 times lower than middle-income countries (USD12,000). In contrast, it surpasses the average labor productivity of lower-middle-income nations by 1.6 times higher than lower-middle-income (USD4,200) and low-income countries by 5.7 times (USD1,200).

From 1970 to 1990, Mongolia's labor productivity, measured by the number of employees, averaged 0.58. Notably, this figure exceeds that of high-income nations by 42.3%, upper-middle-income countries by 18.6%, and lower-middle-income countries by 9.5%. However, in the early 1990s, Mongolia experienced a downturn, with the annual growth rate plummeting to –13.97%. From

FIGURE 5

LABOR PRODUCTIVITY IN MONGOLIA (IN USD).



Source: ILO. Labor Productivity of Mongolia. 2023 [12].

1990–2010, its labor productivity indexes lagged behind those of higher, upper-middle, and lower-middle-income countries by 10.1%, 11.7%, and 3.9%, respectively. Nevertheless, post-2010, Mongolia exhibited a remarkable turnaround, outperforming the average for each income level and demonstrating exceptional growth.

Table 3 illustrates labor productivity indicators among lower-middle-income countries. Mongolia ranks 6th among the 49 countries in this category.

TABLE 3

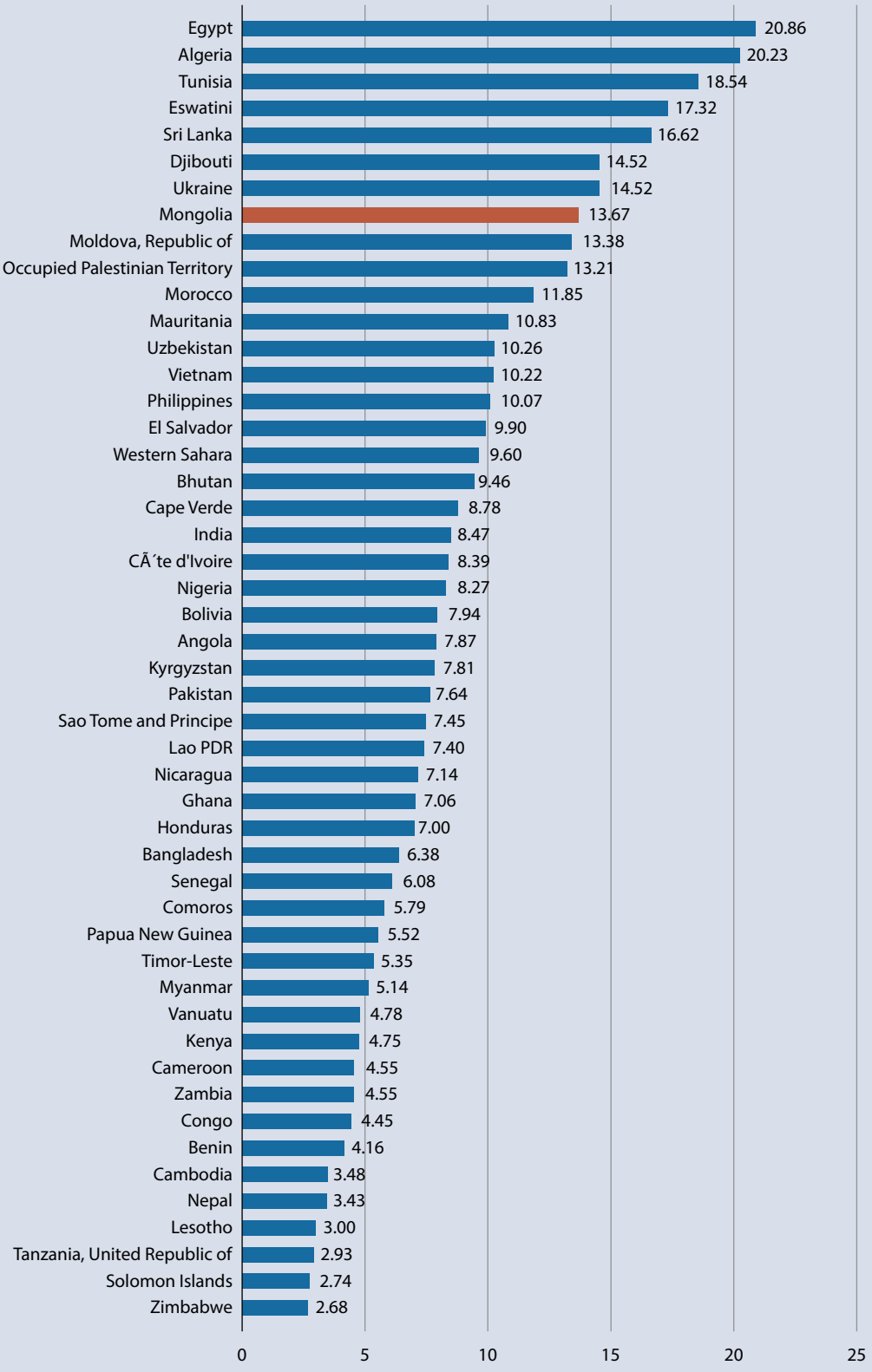
LABOR PRODUCTIVITY IN MONGOLIA.

Indicators	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020
High-Income Countries	0.28	0.34	0.41	0.51	0.63	0.72	0.82	0.94	1.03	1.11
Growth Rate (in %)		21.16	20.02	26.35	23.45	13.94	13.73	14.42	9.65	7.97
Upper Middle-Income Countries	0.39	0.45	0.48	0.52	0.63	0.74	0.83	0.96	1.05	1.21
Growth Rate (in %)		14.17	8.07	7.63	20.80	17.83	12.43	16.07	8.49	15.25
Lower Middle-Income Countries	0.47	0.49	0.50	0.53	0.58	0.66	0.75	0.91	1.08	1.30
Growth Rate (in %)		3.98	1.32	5.80	10.81	13.59	13.09	21.10	18.85	20.21
Mongolia	0.39	0.50	0.61	0.68	0.59	0.64	0.69	0.88	1.27	1.58
Growth Rate (in %)		26.41	22.37	11.93	–13.97	8.40	8.69	27.50	43.68	24.81

Source: World Bank. Labor productivity based on number of employees indices of Asian countries: World Bank income level categories. 2023 [13].

FIGURE 6

GDP PER HOUR WORK IN LOWER-MIDDLE INCOME COUNTRIES.



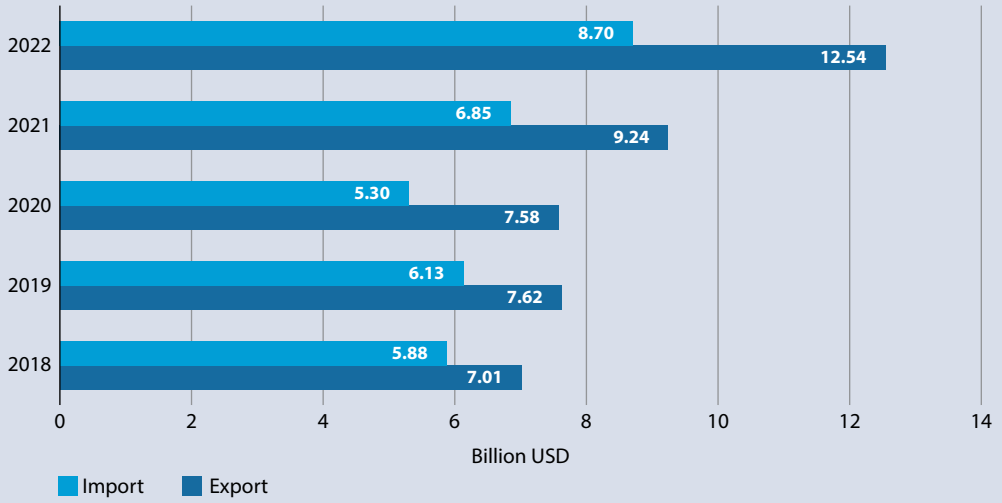
Source: ILO. Country Profiles. 2023 [14].

Foreign Trade

Mongolia's foreign trade relies heavily on the mining industry, with approximately 84% of total exports comprising quarrying products such as coal, copper, gold, and silver as of 2022, according to the National Statistics Committee [15]. Because of its landlocked location, most foreign trade is conducted with neighboring countries, particularly Russia and China. In 2022, China accounted for over 80% of exports and 35% of imports, while Russia contributed more than 30% of Mongolia's imports.

FIGURE 7

EXPORT AND IMPORT TRENDS IN MONGOLIA.



Source: National Statistics Office of Mongolia. Foreign Trade. 2023 [15].

Manufacturing, wholesale, retail, and other value-added industries remain underdeveloped in the country, contributing to its unbalanced industrial structure, which relies heavily on mineral resources. Additionally, the agricultural and livestock sectors face challenges in establishing robust value chains due to harsh climate conditions and the vastness of national land, limiting production output.

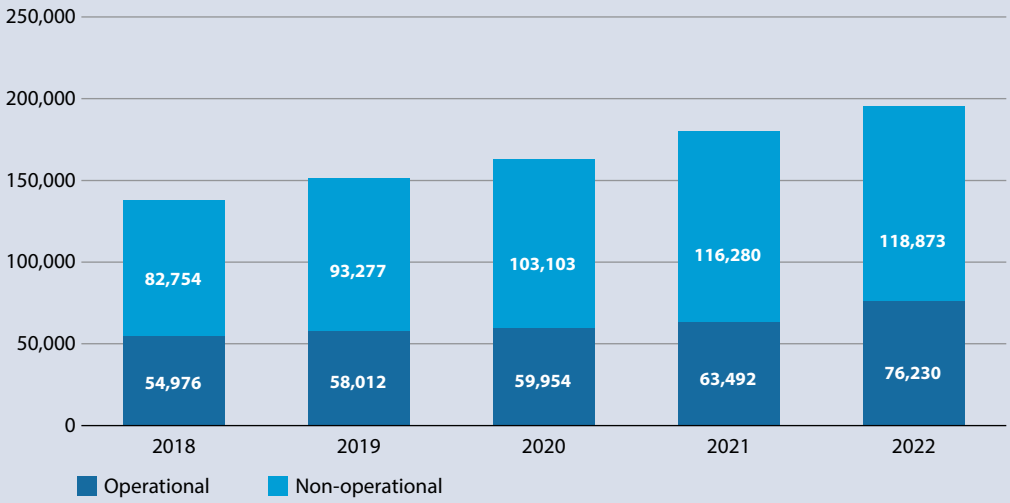
Recognizing the importance of achieving a balanced economic structure, the Government of Mongolia has focused on developing agriculture and livestock structures, promoting ICT and other emerging industries, improving public finance management practices, and enhancing human resource development. These initiatives align with the objectives outlined in the New Recovery Policy, which addressed severe economic setbacks resulting from events such as border closure due to COVID-19 and the financial repercussions of the Russian invasion of Ukraine.

Private Sector

In 2022, 195,103 private companies were registered with the NSO, of which 39% were operational companies. Compared to the previous year, there was a 9% increase in total registered companies and a 20% increase in operational companies. Non-operational companies increased by 2%, with approximately 5,000 temporary non-operational companies shifting to fully non-operational status. By analyzing the data, it can be inferred that out of nearly 15,000 new companies registered, around 6,000 are fully operational startups.

FIGURE 8

STATUS OF PRIVATE COMPANIES IN MONGOLIA.

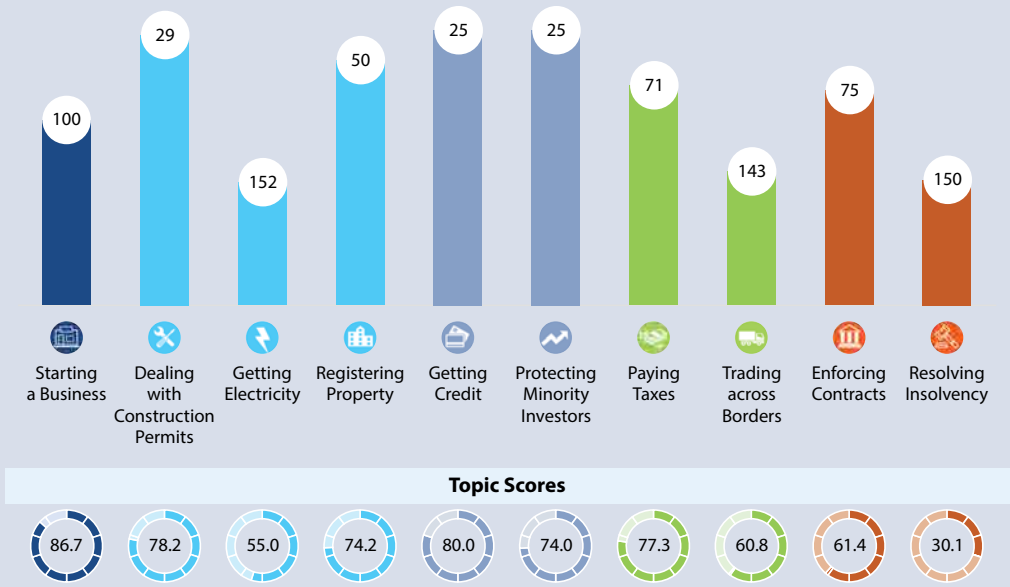


Source: National Statistics Office of Mongolia. Private Companies. 2023 [16].

With the World Bank discontinuing the Ease of Doing Business Index in 2021, direct data on recovery policy is unavailable in 2021 and 2022. However, in 2020, Mongolia dropped seven ranks to 81st from 74th, with a low score in resolving insolvency, enforcing contracts, and trading across borders.

FIGURE 9

MONGOLIA'S RANKING ON THE DOING BUSINESS INDEX.



Source: World Bank. Doing Business 2020.

E-Nation Policy

Mongolia's provinces, sum centers, and major settlements are connected to the mobile communication network through 49,943 km of fiber optic cable and 8,400 km of radio relay network. The number of mobile phone users increased from 235,000 in 2002 to 6.914 million in 2022, surpassing the averages of developing countries and the world. The government introduced 4G in 2016, and by 2022, there were more than 2.9 million users. The policy document for introducing 5G in Mongolia has been approved, and preparations are underway to roll it out soon.

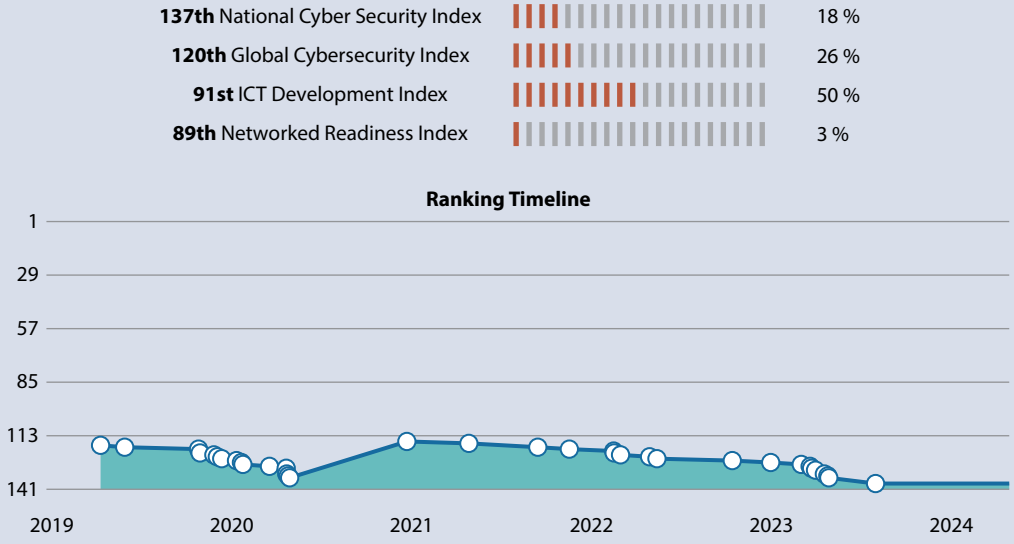
Regarding the Internet infrastructure, more than 70 companies have been providing these services since its introduction in Mongolia 26 years ago, with the volume of external gateway traffic reaching 780 Gbit per second. Overall, there are 4.187 million Internet users in Mongolia, 94.4% of whom use mobile broadband services. Six companies currently use 444 MHz frequency bands of satellites to provide Internet, cellular communication, and broadcasting services to users, as well as radio navigation communication in space communication and broadcasting services.

The Government of Mongolia has adopted a policy for developing e-governance and implemented a project program. However, due to a lack of coordination and leadership among government institutions, the progress of e-transition has slowed down, leading to a drop in the country's ranking on the e-Government Index, from 84 in 2016 to 92 in 2020.

With the establishment of the Ministry of Electronic Development, the digitization process in Mongolia got a significant push, and the country jumped to 74th rank on the e-Governance Development Index in 2022, higher than the world average. In 2021, Mongolia adopted the Law on Cyber Security and the Law on the Protection of Personal Information, creating a system to ensure cybersecurity. Despite these advancements, according to the National Cyber Security Index, Mongolia ranks 120th out of 193 countries in 2022. Figure 10 shows the level of cybersecurity in Mongolia.

FIGURE 10

MONGOLIA'S RANKING ON THE GLOBAL CYBERSECURITY INDEX.



Source: National Cyber Security Index. e-Governance Academy Foundation. 2022.

Mongolia's indicator of universal e-skills in 2018 was 31%. However, a joint survey by the National Statistics Committee and the Department of Communications and Information Technology in 2021 revealed that 43.8% of all respondents have e-skills.

Key Industry Sectors

Mining Sector

Mongolia ranks 7th globally in mineral resources, with around 1,170 known deposits and over 10,000 occurrences of 80 minerals [19]. Since the discovery of the Oyu Tolgoi and Erdenes Tavan Tolgoi mineral deposits in 2011, the mining industry has attracted significant interest and investment from around the world. This investment has helped in the rapid development of Mongolia's mining sector, which accounts for 80% of the country's exports and a quarter of its GDP.

Mongolia must address logistical and trading partner challenges due to its landlocked geography to further advance the industry. The country's leading mining and export products include gold, silver, copper, iron ore, zinc, and coal, with deposits of gold, copper, coal, and fluorite ranking among the top 10 globally [20].

In April 2023, the 'Digitalization in Mining Mongolia' convention introduced technologies such as cloud computing, AI, IoT, and ML. Australian companies such as Maptek, DomainMCF, and Petra Data Science [21] presented their technologies. During the convention, Oyu Tolgoi announced the world's first fully autonomous, driverless, heavy-duty AutoHaul technology, which has been used for approximately 7 million kilometers.

In 2010, Mongolia adopted a medium-term (2010–14) strategy for implementing the Extractive Industries Transparency Initiative (EITI). This initiative aims to disclose income from natural resources like minerals, oil, and natural gas to the public, strengthening good governance and increasing stakeholders' responsibility in adequately managing these resources for the public good.

The EITI aims to ensure transparency in the following areas:

- Licenses
- Contracts
- Product production and sales
- Taxes, fees, and charges paid to state and local budgets
- Distribution and expenditure of revenue
- Investments, development, donations, and support within the framework of corporate social responsibility (CSR)
- Conservation expenses and advance deposits
- Transparency of state-owned companies

However, the 2021 EITI report published in 2022 indicates that the quality, flow, and transparency of information did not meet the required standards, as evidenced by numerous comments.

The 2021 EITI report highlights discrepancies due to some local organizations' failure to input tax and payment information into the electronic reporting system. Additionally, acquiring relevant information for reporting purposes was often necessary, leading to difficulties in reconciliation. While companies in the report cooperated by responding to clarifications, the EITI secretariat received no response from the state side, particularly from the MET.

Previous reports, including the 15th report, consistently recommended that companies and government institutions ensure the timely submission and accuracy of reports. However, progress had been minimal, a trend that persisted in 2023. Misreporting and underreporting remain common among government entities and companies [22].

Within the framework of Mongolia's New Revival Policy, approved in 2022, and the 5SH Anti-Corruption Operation, several major corruption cases have been uncovered, including instances of coal theft. Had the EITI initiative, launched in 2011, been appropriately implemented, it could have helped prevent the theft of mining resources. Another digitization initiative undertaken by the government is mapping digital transition in Mongolia's mining sector, jointly implemented with the Government of Australia in 2021. The project aims to support the establishment of a digital geological database.

In January 2014, the country adopted the Mongolian State Minerals Policy (2014–25), which provided guidelines to support the sustainable economic development of the mining sector. The policy explicitly enabled the creation of a national geo-information database. Subsequently, an amendment to the Minerals Law included a provision for establishing a national geological database to be managed by the National Geological Survey. This policy and legal change paved the way for the launch of the National Geoscience Database project, which commenced implementation in January 2019 and concluded in December 2021.

The project's outcome is a national geological database, representing a cutting-edge digital platform for capturing, storing, processing, analyzing, and disseminating critical geological information on Mongolia's existing mineral resources and potential. The National Geological Database is accessible at https://mris.mn/.

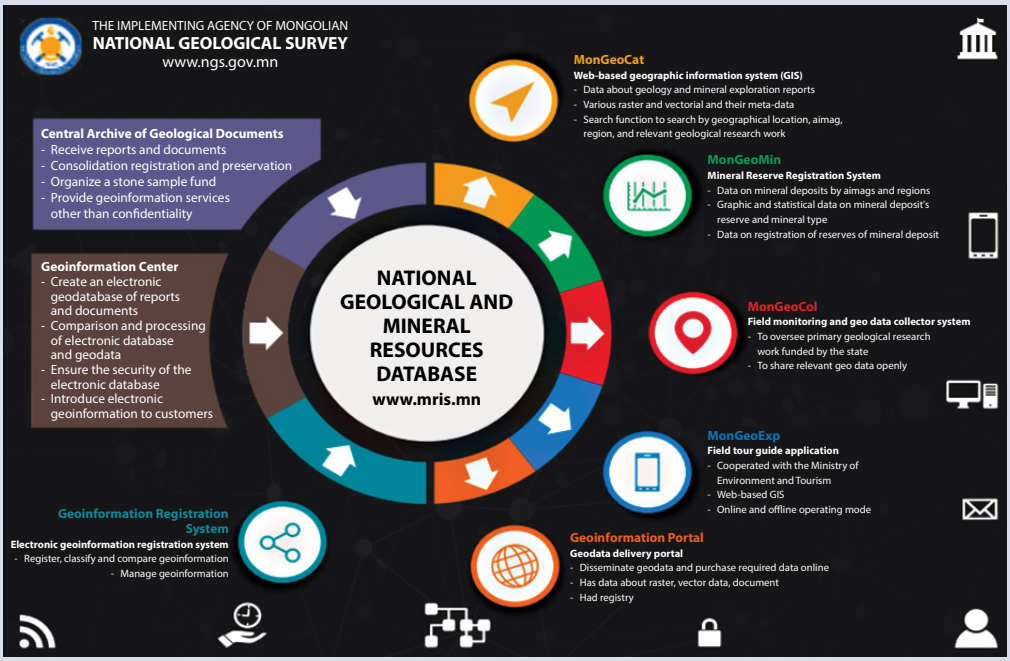
Commenting on the project, the Law in Transition Journal of 2022 said: "It is clear that geodata provides a foundation to facilitate economic growth, social development, and improved environmental management."

Agriculture Sector

The agriculture industry, especially livestock herding, has long been a primary source of income and a significant contributor to Mongolia's GDP. Traditionally, Mongolia has practiced nomadic herding of horses, cows, camels, sheep, and goats. Even today, many herders in rural areas continue this nomadic lifestyle, primarily focusing on sheep and goats for milk, cashmere, wool, and meat. Since the transition to a market economy in 1991, herders have increasingly focused on raising goats for economic reasons. Before 1991, the ratio of goats to total livestock was around 20%, which jumped to almost 40% in 2022 [24]. Concerns have been raised about the growing goat population potentially leading to ecological imbalance and the accelerated expansion of deserts due to the unique grazing habits of goats [25].

FIGURE 11

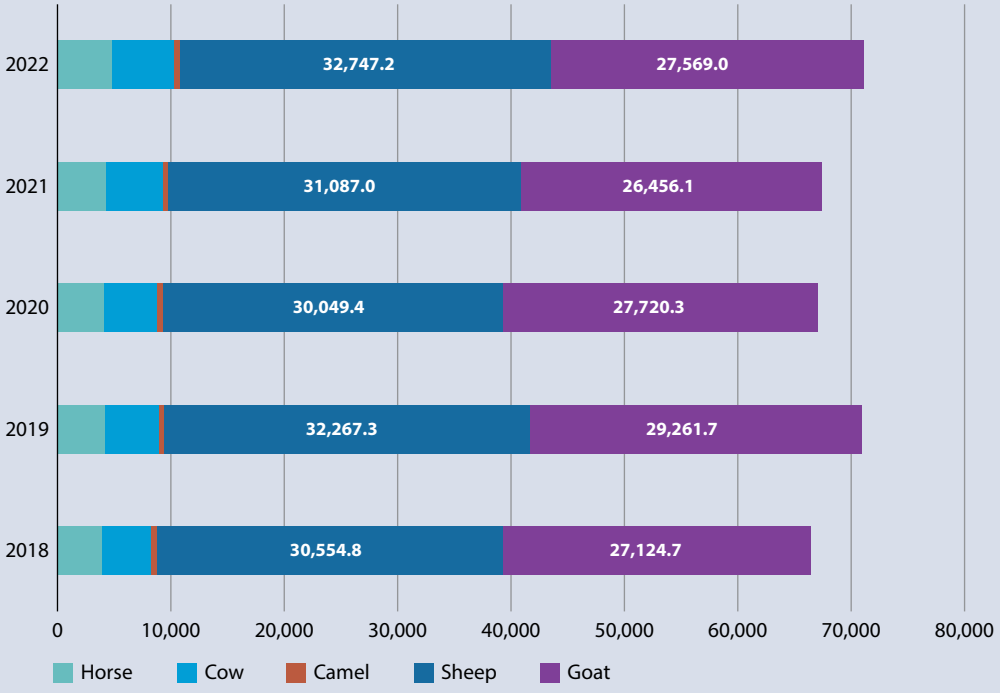
HOW MONGOLIA'S NATIONAL GEOLOGICAL DATABASE WORKS?



Source: National Geological Survey of Mongolia. 2023 [23].

FIGURE 12

STATUS OF LIVESTOCK IN MONGOLIA.



Source: National Statistics Office of Mongolia. Livestock. 2023 [24].

Some corporations have entered the market with innovative financing models in recent years. One example is Kukh Sureg, which offers financing similar to an IPO but with livestock as the product, dairy or cashmere products as interest, and meat as the principal repayment at the end of the agreed financing term. These companies have implemented systematic planning in the livestock industry, resulting in increased productivity and reduced casualty rates compared to individual herders.

The government has implemented the E-Agriculture Strategy as part of The Vision 2050 policy to advance the agriculture sector further. The strategy aims to integrate digital systems into agriculture value chains, improve traceability and food systems, and enhance various aspects such as animal identification and registration systems, meat factory systems, animal health and veterinary systems, and plant registration systems [26].

Finance Sector

The financial sector has historically been dominated by banking, but the stock market has shown excellent results in recent years. For instance, the top 20 index experienced a remarkable 132.7% growth in 2022 [27]. During the lockdown in 2020–21, the cryptocurrency bubble, including Non-Fungible Tokens (NFTs) and tokens, gained traction, although it burst in 2022. Nevertheless, this period introduced people to an actively investing culture, and the Mongolian Stock Exchange capitalized on this opportunity by introducing commodity products, derivatives, and a few IPOs.

Digitalization in the banking and financial sector has seen significant growth in the last five years, driven by increased smartphone usage. Almost every financial company now has applications for their products, with commercial banks leading the way by digitizing most of their product offerings to the public, accounting for 90% of the transactions through the Khur system [28]. While only a few major brokering firms had mobile applications and back-office programs for online transactions in 2017, recent initiatives by the Mongolian Financial Regulatory Committee and increased competition have prompted most brokerage firms to invest in digitalizing their products.

In 2020, banks and non-banking financial companies accounted for 91.3% of the financial sector, with insurance at 6.7% and the capital market at 1.8% [29]. The ease of access offered by mobile applications has allowed users to increase their debt, leading to a decrease in business loans [30]. According to the World Bank, once the borders opened after COVID–19, the country's inflation jumped to 15% in 2022 [31]. Even though consumer expenditure in Mongolia has increased over the years, average wages have not kept pace with prices, driven by inflation and the impact of the pandemic. This has led many young couples and families to accumulate consumer-based short-term debt with little possibility of saving.

Although the capital market has grown, most citizens' investment portfolios include borrowed money for quick returns. Investing with borrowed funds is risky, particularly in the stock and derivatives market, where losing everything is possible.

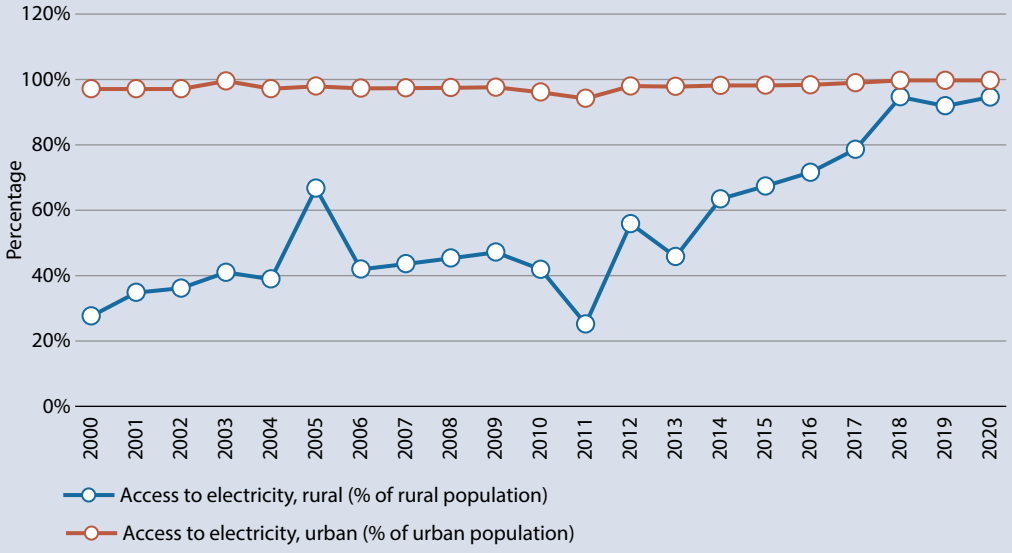
Energy Sector

A report by ourworldindata.org indicates that in 2020, around 99.7% of people in Mongolia had access to electricity in urban areas and 94.6% in rural areas. However, data from NSO suggest that in 2022, only 16% of herder households in the country had a reliable source of electricity [32].

This shows that about 83% of the herder households in rural areas do not have access to electricity.

FIGURE 13

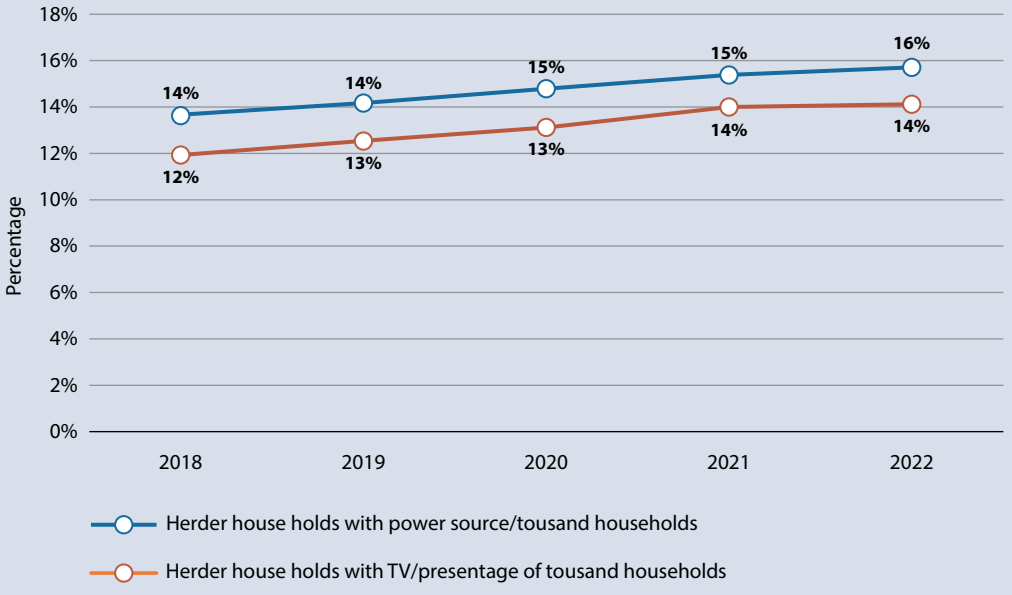
STATUS OF ELECTRICITY DISTRIBUTION IN MONGOLIA.



Source: Our World in Data. Electricity Distribution: Mongolia [32].

FIGURE 14

PERCENTAGE OF HERDER HOUSEHOLDS WITH POWER SOURCES IN MONGOLIA.

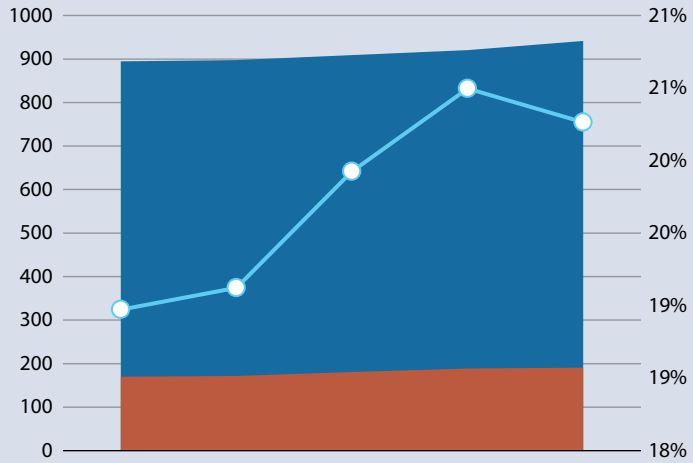


Source: Our World in Data. Electricity Distribution: Mongolia [32].

As shown in Figure 15, herder households account for about 20% of the total number of households. Since only 16% of these have a fixed electricity source, approximately 160.2 million herder households have no electricity connection.

FIGURE 15

OVERALL Vs SHARE OF HERDER HOUSEHOLD IN MONGOLIA.



	2018	2019	2020	2021	2022
Households, thousand households	894.5	897.4	908.7	920.2	941.5
Herder households	169.7	171.6	181.1	188.6	190.8
Percentage of herder HH-s	19%	19%	20%	20%	20%

Source: Our World in Data. Electricity Distribution: Mongolia [32].

Priority Sector

Agriculture

The agriculture sector in Mongolia has the potential to grow more than the mining or services sector. The industry holds significant promise, with around 71 million livestock and 1,333 hectares of arable land. However, due to issues such as inconsistent diet and frequent illness among livestock, Mongolia faces export bans from neighboring countries. With government support, including e-chips and digitalization, there has been significant progress in resolving export issues with China, resulting in five new permanent trading partners. Mongolia's main agricultural exports are cashmere, meat, and wool. To further develop the industry, there is a need to increase the production of value-added products such as cheese and other livestock-related products.

In 2019, the Ministry of Food and Agriculture developed the E-Agriculture Strategy Document with the support of the FAO and the ITU. Mongolia currently has 54 programs and systems for the agriculture sector, but about 50% of the systems in use before 2020 have become obsolete and need updating. The purpose of the currently used systems and software is shown graphically.

As shown in Figure 16, 24.4% of the software focuses on livestock and veterinary services. This emphasis is understandable since livestock is the most significant contributor to the GDP within the agricultural sector.

Food

Mongolia has taken several steps to improve food security. Figure 17 provides an overview of the ministry's work on food supply. The software marked in green has been developed and tested, while the software marked in red and yellow is still in the development and testing phase.

FIGURE 16

STATUS OF E-AGRICULTURE IN MONGOLIA.

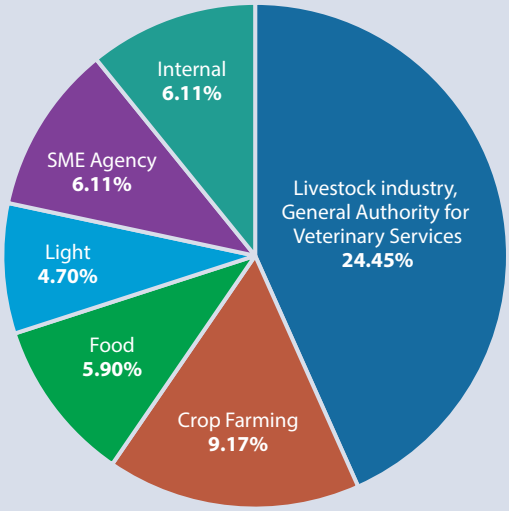
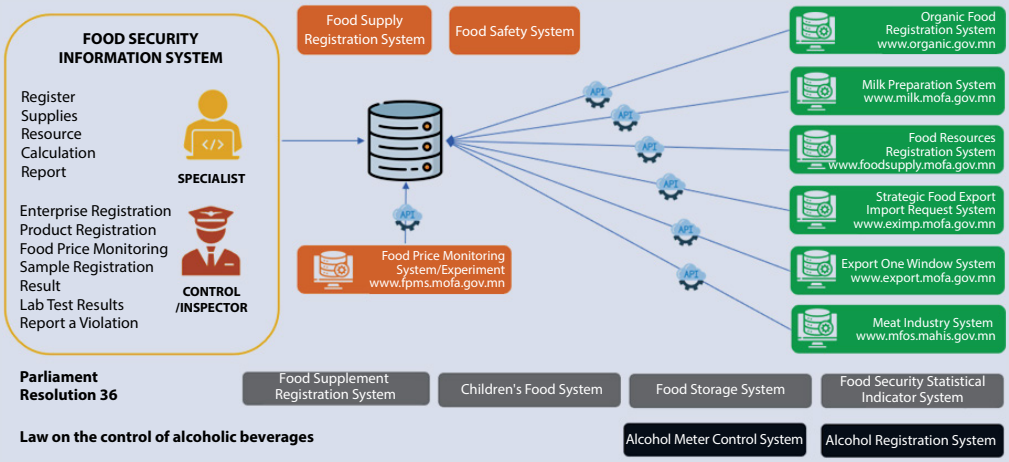


FIGURE 17

INITIATIVES FOR DRIVING FOOD SECURITY IN MONGOLIA.



Source: Reproduced with permission from J. Batsaikhan. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. IT and Statistics Department, MOFALI. 2023 [33].

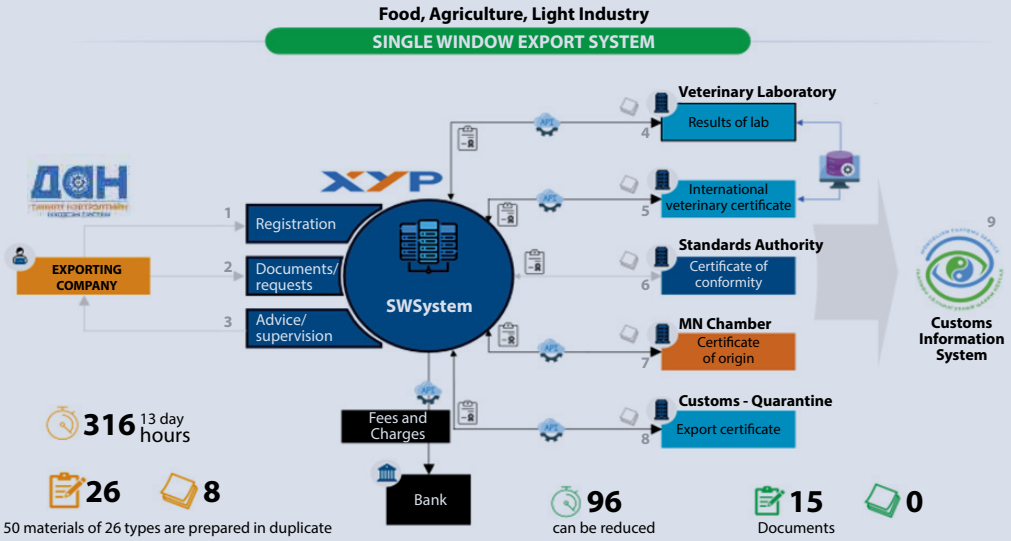
The meat traceability program has been implemented with the direct support of national producers. However, milk and dairy product producers have not yet taken action beyond testing, as the traceability of the origin of these products can affect their prices.

The digitization initiatives taken up in the agricultural sector appear effective and have the potential to revolutionize food imports positively, impacting organic food production, pasture utilization, and harvest. Nonetheless, the implementation stage remains questionable, particularly regarding reaching all herders and farmers.

Digitization services for special licenses issued by the ministry have been implemented, allowing documents such as laboratory reports required for special licenses can be directly downloaded from the relevant department. This has significantly improved productivity, reducing the time needed to obtain a special license from 326 to 96 hours and decreasing the required documents from 26 to 15. Figure 18 provides an overview of the licensing process in the country's agricultural sector.

FIGURE 18

E-SYSTEM FOR AGRICULTURAL SECTOR IN MONGOLIA.

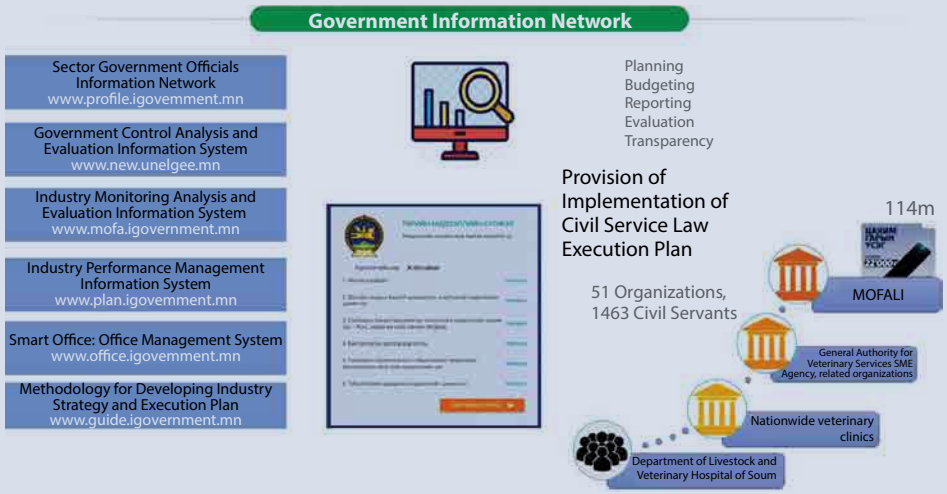


Source: Reproduced with permission from J. Batsaikhan. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. IT and Statistics Department, MOFALI. 2023 [33].

Figure 19 shows that the ministry has developed a state information system that connects them.

FIGURE 19

THE GOVERNMENT INFORMATION NETWORK IN MONGOLIA.



Source: Reproduced with permission from J. Batsaikhan. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. IT and Statistics Department, MOFALI. 2023 [33].

The head of the IT and Statistics Department at MOFALI, Mr. J. Batsaikhan, emphasizes that while there is a robust system covering all sectors responsible for the computerization of the food and agriculture industry, specific challenges exist at the implementation stage:

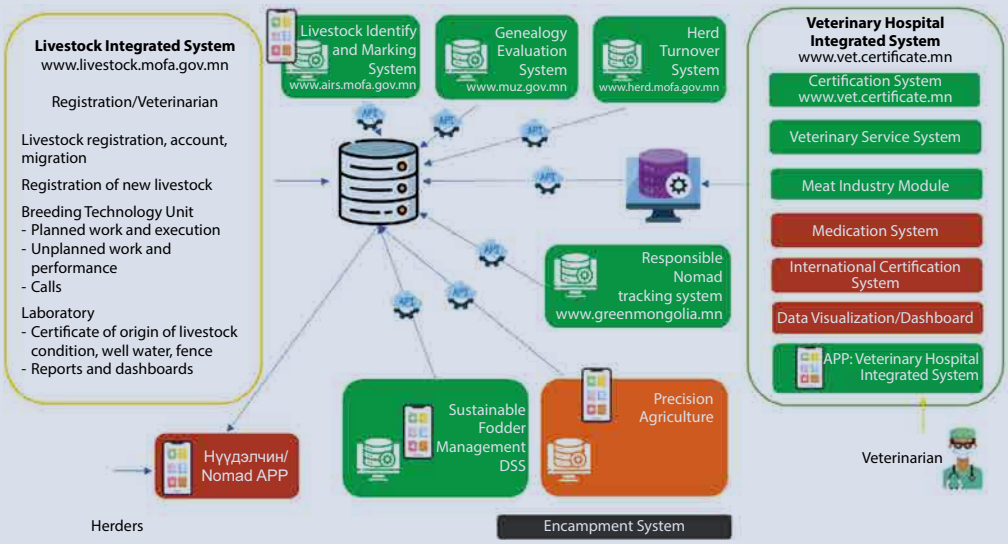
- Increasing human resources for IT as the e-Mongol academy cannot solely be responsible for the development of the sector
- Financing of e-agriculture projects for system development
- Lack of local experts
- Installing the vertical system
- Creating sustainable work opportunities
- Training, technique, and equipment improvement
- Internet-enabling farmlands, pastures, and industrial regions
- Enhancing the electronic technology knowledge of breeders and farmers

Livestock

Figure 20 provides an overview of the digitization work done by the Ministry of Food and Agriculture in the field of livestock as of 2023.

FIGURE 20

THE E-AGRICULTURE INITIATIVES IN MONGOLIA.



Source: Reproduced with permission from J. Batsaikhan. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. IT and Statistics Department, MOFALI. 2023 [33].

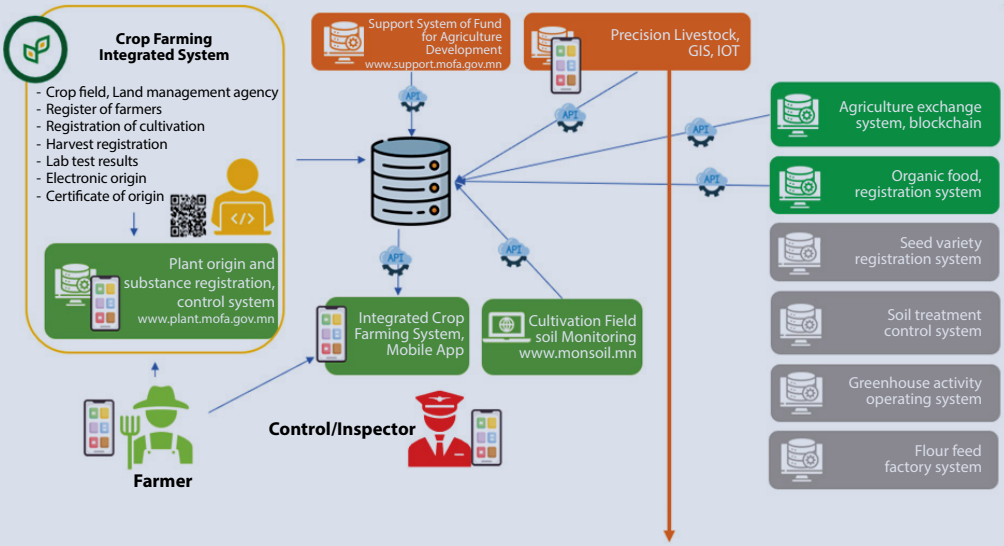
Currently, the following applications have been tested and are operational:

- **Livestock Identification and Marking System:** www.airs.mofa.gov.mn/
- **Genealogy Evaluation System:** www.muz.gov.mn/
- **Herd Turnover System:** www.herd.mofa.gov.mn/
- **Certification System:** www.vet.certificate.mn/
- **Responsible Nomad Tracking System:** www.greenmongolia.mn/
- **Sustainable Fodder Management DSS:** www.fodder.mofa.gov.mn, www.dss-mongolia.org/

The software marked in green in the figure has been developed, tested, and used in several enterprises and farms. Figure 21 provides an overview of the work in the agricultural sector, both completed and planned.

FIGURE 21

OVERVIEW OF THE INITIATIVES IN MONGOLIA'S AGRICULTURE SECTOR.



Source: Reproduced with permission from J. Batsaikhan. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. IT and Statistics Department, MOFALI. 2023 [33].

The following software have been tested and are ready for use in the agricultural sector.

- **Plant Origin and Substance Registration, Control System:** www.plant.mofa.gov.mn
- **Cultivation Field Soil Monitoring:** www.monsoil.mn/

Additionally, the systems marked in green are being tested and used in selected enterprises.

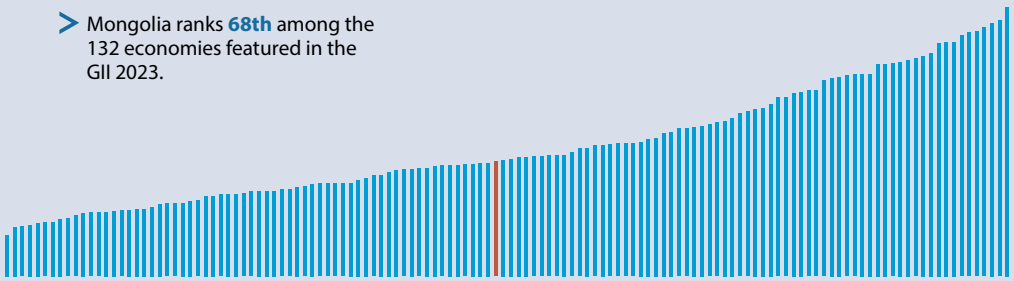
Gap Issues: Industrial Sector Analysis

Innovations in Mongolia

According to the Global Innovation Index (GII) 2023, Mongolia is ranked 68th out of 132 countries.

FIGURE 22

GLOBAL INNOVATION INDEX 2023.

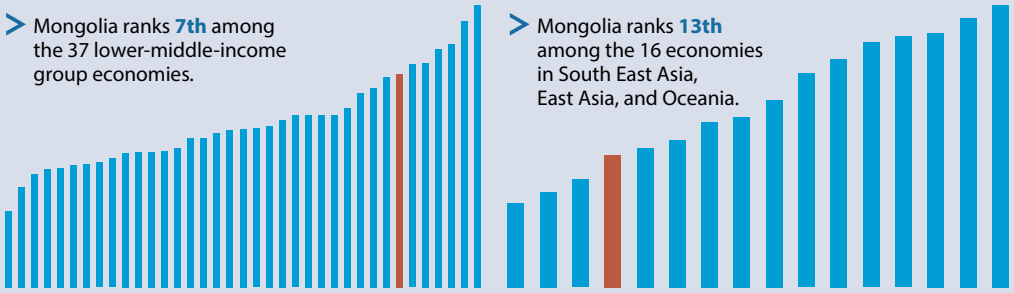


Source: WIPO. Global Innovation Index. 2023 [34].

In 2023, the country ranked 79th in innovation inputs, up from 81st in 2022 and 60th in innovation outputs, compared to 64th in the previous year. Figure 24 shows the rankings of Mongolia over four years.

FIGURE 23

GLOBAL INNOVATION INDEX 2023–24.



Source: WIPO. Global Innovation Index. 2023 [34].

FIGURE 24

MONGOLIA'S RANK IN INNOVATION INDEX (2020–23).

	GII Position	Innovation Inputs	Innovation Outputs
2020	58th	65th	54th
2021	58th	65th	55th
2022	71st	81st	64th
2023	68th	79th	60th

Source: WIPO. Global Innovation Index. 2023 [34].

Table 4 provides an overview of Mongolia's indicator strengths and weaknesses in the GII 2023. The country's main innovation strengths are industrial designs (ranked 1st), trademarks by origin (ranked 1st), and utility models by origin (ranked 1st), all measured per billion dollars of GDP, adjusted for PPP.

TABLE 4

THE INNOVATION INDEX 1.

Strengths			Weaknesses		
Rank	Code	Indicator Name	Rank	Code	Indicator Name
1	7.1.4	Industrial designs by origin/bn PPP$ GDP	129	7.2.4	Creative goods exports, % total trade
1	7.1.2	Trademarks by origin/bn PPP$ GDP	107	4.3.2	Domestic industry diversification
1	6.1.3	Utility models by origin/bn PPP$ GDP	106	6.2.4	High-tech manufacturing, %
3	5.1.2	Firms offering formal training (in %)	95	5.2.5	Patent families/bn PPP$ GDP
4	3.2.3	Gross capital formation (% of GDP)	85	5.1.3	GERD performed by business, % GDP
7	5.3.4	FDI# net inflows (% of GDP)	77	7.1.1	Intangible asset intensity, top 15, %
12	2.1.1	Expenditure on education (% of GDP)	74	7.1.3	Global brand value, top 5,000
18	1.2.3	Cost of redundancy dismissal	71	2.3.4	QS university ranking, top 3
23	5.1.5	Females employed with advanced degrees (in %)	48	6.2.2	Unicorn valuation, % GDP
29	6.1.1	Patents by origin/bn PPP$ GDP	40	2.3.3	Global corporate R&D investors, top 3, million USD

Note: FDI, Foreign Direct Investment.
Source: WIPO. Global Innovation Index. 2023 [34].

The table shows the main indicators of Mongolia's innovation index. According to the data, Mongolia's innovation output indicators are its weakness, while the input indicators fare better. Notably, Mongolia ranks 130th out of 132 countries in terms of knowledge impact and 129th in creative goods exports.

TABLE 5

THE INNOVATION INDEX 2.

Output Rank	Input Rank	Income	Region		Population (in million)	GDP, PPP$ (bn)		GDP Per Capita, PPP$
60	**79**	**Lower Middle**	**SEAO**		**3.4**	**47.1**		**13,611.4**
Input			**Score**	**Rank**	**Outputs**		**Score**	**Rank**
Institutions			46.0	80	Knowledge and technology output		15.8	88
Human capital and research			31.2	65	Knowledge impact		5.3	130
Global corporate R&D investors, top 3, million USD			–	40	Unicorn valuation % GDP		–	48
QS university ranking, top 3					High-tech manufacturing %		3.8	106

(Continued on next page)

(Continued from the previous page)

Input	Score	Rank	Outputs	Score	Rank
Infrastructure	36.0	81	Creative outputs	33.7	40
Market sophistication	23.7	101	Intangible asset intensity, top 15, %	–42.5	77
Domestic industry diversification	42.8	107	Global brand value, top 5,000	–	74
Business sophistication	27.9	67	Creative goods exports, % total trade		129
Gerd performed by business % GDP		85			
Patent families /bn PPP% GDP		95			

Source: WIPO. Global Innovation Index. 2023 [34].

The report also mentions that Mongolia's data evaluating the innovation index indicators are unclear. Table 6 shows the uncertain parameters.

TABLE 6

THE INNOVATION INDEX 3.

Code	Indicator Name	Economy Year	Model Year	Source
1.3.2	Entrepreneurship policies and culture	n/a	2022	Global Entrepreneurship Monitor
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	2019	UNESCO Institute for Statistics
2.1.4	PISA scales in reading, math, and science	n/a	2018	OECD, PISA
4.1.1	Finance for startups and scale-ups	n/a	2022	Global Entrepreneurship Monitor
4.2.1	Market capitalization (% of GDP)	n/a	2020	World Federation of Exchanges; World Bank
4.2.2	Venture Capital (VC) investors, deals/bn PPP$ GDP	n/a	2022	Refinitiv; International Monetary Fund
4.2.3	VC recipients, deals/bn PPP$ GDP	n/a	2022	Refinitiv; International Monetary Fund
4.2.4	VC received value (% of GDP)	n/a	2022	Refinitiv; International Monetary Fund
5.3.5	Research talent % in businesses	n/a	2021	UNESCO Institute for Statistics; Eurostat; OECD; RICYT
6.2.1	Labor productivity growth (in %)	n/a	2022	The Conference Board
7.2.2	National feature films/mn (population aged 15–69)	n/a	2021	OMDIA; United Nations, World Population Prospects
7.2.3	Entertainment and media market/th (population aged 15–69)	n/a	2022	PwC, GEMO; United Nations, World Population Prospects; International Monetary Fund

Source: WIPO. Global Innovation Index. 2023 [34].

According to the list, expressing some indicators is carried out in Mongolia (1.3.2, 2.1.2, 4.1.1, 5.3.5), and these should be recorded and documented.

Industrial Sector Analysis

Governance

For 30 years, Mongolia has adopted numerous development policies and objectives across various sectors. However, successful implementation has often fallen short. This can be attributed to inadequate budget, resources, organizational management, infrastructure, stakeholders' involvement, responsibilities, outcomes, and citizen participation.

In December 2020, the government launched the Vision 2050 program, outlining a comprehensive plan for Mongolia's next 30 years. The program aims to position Mongolia as a leading Asian country in terms of development, economic growth, and citizens' quality of life. It integrates the SDGs by aligning them with Mongolia's current situation. Since the program's inception, there has been a visible development in digitalization, agriculture, energy, and the financial sector.

In 2021, the Government of Mongolia introduced a new recovery policy to address the negative socioeconomic impacts of COVID–19. Designed to overcome challenges hindering Mongolia's medium- to long-term growth, the New Recovery Policy focuses on six key areas.

1. **Recovery of border checkpoints:** This involves developing hard and soft infrastructure at border checkpoints to increase passenger and cargo processing capacities. Additionally, it includes establishing connections between border checkpoints, roads, and railways to enhance transport and logistics competitiveness.

2. **Recovery of the energy sector:** This focuses on renewing deteriorated thermal power plants, expanding the transmission network system, and developing renewable energy sources to the appropriate level.

3. **Recovery of industries:** This aims to develop processing facilities for mineral resources and leather to increase the added value of export products. It also involves boosting production outputs in agriculture and stock raising and promoting ICT and digitalization.

4. **Recovery of central and rural areas:** This includes developing public transportation to alleviate congestion in Ulaanbaatar and establishing satellite cities and special economic zones.

5. **Recovery of green development:** This focuses on removing environmental pollutants and constructing waste treatment facilities to improve the meadow environment.

6. **Recovery of efficiency of public administration agencies:** This involves developing laws and digitalizing administrative procedures to create a better business environment, promoting public-private partnerships, and eradicating corruption.

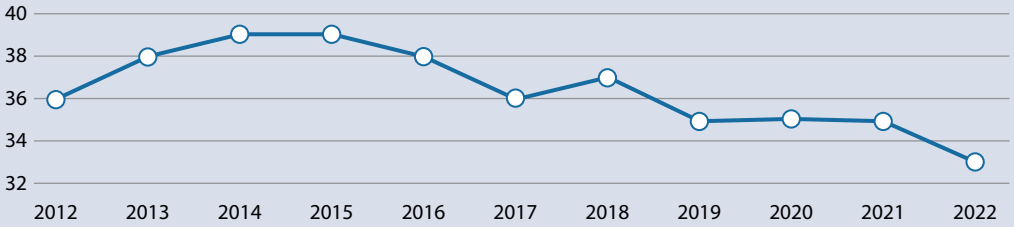
Corruption

Mongolia has consistently struggled with public sector corruption, ranking relatively low on the global Transparency International Index. According to the latest data, Mongolia ranked 116th out

of 180 countries on the Corruption Perception Index, with a score of 33. In 2022, Mongolia's score dropped two points, resulting in a fall of two ranks (35).

FIGURE 25

MONGOLIA ON THE CORRUPTION INDEX.



Source: Transparency International. Corruption Perceptions Index - Mongolia. 2023 [35].

Agriculture Sector

Nomadic herding in Mongolia has traditionally faced high livestock casualties due to bad weather, predators, and poachers. However, systematic herding, the implementation of tracking chips by companies and the government, and digitalization have significantly reduced this risk. Mongolia needs to open more livestock-related farms and avoid wasting livestock byproducts to capitalize on and increase production.

The current use of IoT and technology in agriculture has highlighted a significant workforce gap in the sector [36]. With young people pursuing careers in the city and more than half the population residing in the capital, Ulaanbaatar, there is a pressing need to focus on modern farming and accelerate the development of IoT in the sector. The crop farming industry, in particular, can greatly benefit from digitalization, as it opens up more farmland with less human capital, a resource Mongolia severely lacks. Sensors, drones, AI, and robotics can eliminate tedious farm work and increase productivity.

However, the initial investment cost for these technologies can be a major roadblock for small farms and herders. Also, most countryside residents have limited knowledge of these technologies due to a lack of exposure. Addressing these challenges could lead to self-sufficiency in food production beyond meat, wheat, and potatoes, reducing the need for large imports from neighboring countries.

Transitioning from traditional nomadic herding to modern methods may be troublesome, especially given Mongolia's extreme weather. The taste of meat from nomadically herded livestock is distinctly different from that of industrial livestock, and the quality of cashmere and other byproducts also varies.

The government has introduced various annual incentives to support farmers, such as tax levies, social insurance discounts, and easier access to low-interest loans.

Energy Sector

Mongolia imports around 20% of its energy; most of the remaining 80% of energy generated within the country comes from thermal power plants [37]. Despite government initiatives offering

advantages such as purchasing renewal energy at higher prices and tax levies, the country still cannot offset its energy imports. Although establishing an additional thermal power plant has been on the government's agenda since 2019, no significant progress has been made [38].

The State Energy Policy 2015–30 focuses on three main areas: energy security, efficiency, and environmental impact and development. Under this policy, Mongolia plans to develop renewable energy sources to reduce its reliance on imported energy from Russia [39].

TABLE 7

MONGOLIA'S PLANS FOR ENERGY SECURITY.

Goal	2016–20 (in %)	2021–25 (in %)	2026–30 (in %)
National Production	85	90	100
Renewal Energy	20	25	30

Source: Energy Regulatory Commission. A Tleykhan: We have an opportunity to increase our installed energy capacity at a very low cost and twice the time. 12 September 2019 [37].

As shown in Table 7, while the policy aimed to scale up the country's power generation capacity to 85% by the end of 2020, the total national production stood at 79.1%, according to the Energy Regulation Committee (ERC) [40]. To support the policy, the ERC introduced various schemes offering advantages for renewable energy, including higher prices for green energy and easing the permit process for power plants. Furthermore, banks have started to increase green loans for businesses investing in this.

Mobilizing Scenarios

As of 2023, Mongolia's efforts in digitalization have yielded positive results in sectors such as e-government, e-agriculture, and the billing systems of financial companies. However, technological development, investment funding, logistics, and the sparse population in rural areas may pose challenges for smooth digitalization.

The current economic situation in Mongolia has led to the disappearance of median-income households due to high inflation and stagnant wages, leading to an increase in personal debt and slow wealth creation. While personal debt (household debt) may temporarily boost consumption, in the long run, it could impact GDP growth, with every 1% increase in debt leading to a 0.1% decrease in GDP growth [41]. Households with a debt-to-income ratio of more than 50% tend to refrain from participating in the marketplace, negatively impacting the digitalization of the services industry. Moreover, higher household debt means that business loans or investments will shrink proportionally to the debt.

Policy Recommendations

Agriculture Sector

The Ministry of Food and Agriculture has developed and tested digitization software as part of international projects. Notable implementations include the livestock digital system, sustainable fodder management project, digital agricultural system, food information system, and integrated digital information system. However, these complex systems have no legs as they have limited access to pastoralists and farmers in real life.

As illustrated in Figure 15, the electricity adequacy survey indicates that 83% of herders do not have an independent energy source. There are also significant issues with Internet connectivity in the vast pastoral areas. Without a fixed power source and a reliable Internet network, herders primarily use mobile phones for basic communication, and their ability to operate smartphones and online tools is limited. This risks delaying the implementation of a promising project at the ministry level and could make the software obsolete before it can be effectively used.

Fixed energy sources and Internet connectivity are also crucial for farmers. Although herders and farmers can use software solutions in more concentrated settlements such as sum and provincial centers, they often lack sufficient IT specialists and experts. According to Batsaikhan, there are not enough IT professionals in these areas. Therefore, to support the digitization program being carried out at the ministry level, it is necessary to develop the essential infrastructure for energy and the Internet, establish Internet cafes in urban areas, and ensure that employees of the governor's office at sum and provinces are trained to work as experts on these programs.

It is also necessary to improve coordination between the Ministry of Energy, Ministry of Electronic Development, and Ministry of Food and Agriculture to implement the second Thousand Sunlight project designed to provide independent renewable energy sources for herders and farmers.

Public service employees in the sum and provincial capital should be trained to work with the new incentive software program. This includes incorporating software proficiency into the civil service exam and improving the IT knowledge of herders and farmers. Additionally, it is advisable to organize general training sessions to help people understand the benefits of business digitization programs and develop the ability to work with smartphones and digital tools in rural areas.

The government must also implement policies to support start-up initiatives such as Kuh Soreg and encourage citizens to roll out digitalization policies in the agriculture sector.

Services Sector

Mongolia's digitization policy has been implemented relatively successfully in the public service sector, including initiatives like E-Mongolia, E-Documents, E-Land, and E-Tax projects. E-Mongolia aims to provide prompt government services, integrate policy, planning, and management for e-development, and create conditions for prompt, responsible, and accessible delivery of public services. In 2022, Mongolia ranked 94 out of 192 countries in the e-governance index.

However, experts from the Government Control and Implementation Department suggest that while information is collected from users electronically, it is still stored in paper form, significantly increasing the burden on public service employees. They recommend adopting cloud technology to address this issue.

The service industry workforce has grown with the introduction of international chain supermarkets like CU and GS25, fast-food chains like Burger King and Pizza Hut, and the fast-growing banking sector. However, the influence of the services sector on the GDP remains subpar. To increase the public benefits, these companies offer measures such as raising the minimum wage and regulating the maximum number of imported product types they can sell should be considered. Additionally, there is a need for a more comprehensive platform for the freelance and entry-level job market and ways to regulate this type of work.

Industry Sector

The medium-term strategy of 2010–14 for implementing transparency initiatives for the mining sector led to the introduction of a digitalization policy in Mongolia. However, shortcomings, such as incorrect and incomplete information, still affect its proper implementation. Besides, several enterprises engaged in mining are not correctly registered.

This issue was highlighted in the 15th and 16th reports of the International EITI. The ministry's response to these recurring concerns, including enhancing accountability and improving records to make the mining process more transparent, is crucial. Addressing these challenges will allow Mongolia to leverage its underground resources better while reducing corruption.

Compared to the agricultural sector, enterprises in the mining sector have better capabilities and access to more human resources. Therefore, strict policies that demand responsibility and tangible results from mining companies are essential.

References

[1] National Statistics Office of Mongolia. Mongolian Statistical Yearbook 2022.

[2] World Bank. The Role of the State in Mongolia's Mining Sector. 2001.

[3] National Statistics Office of Mongolia. Key Economic Indicator. 2023

[4] Khaliun B. Mongolia's missing millions: What happened to a decadelong mining boom. Nikkei Asia, 13 October 2021. https://asia.nikkei.com/Spotlight/The-Big-Story/Mongolia-s-missing-millions-What-happened-to-a-decadelong-mining-boom. Accessed on 10 November 2023.

[5] IMF. GDP, current prices. 2023. https://www.imf.org/external/datamapper/NGDPD@WEO/MNG?zoom=MNG&highlight=MNG. Accessed on 1 February 2024.

[6] National Statistics Office of Mongolia. Gross Domestic Product. 2023. https://www.1212.mn/mn/statistic/statcate/573052/table-view/DT_NSO_0500_021V1. Accessed on 1 February 2024.

[7] World Bank. Mongolia Population. https://databank.worldbank.org/. Accessed on 10 November 2023.

[8] World Population Review. World Population by Country 2023. https://worldpopulationreview.com/. Accessed on 10 November 2023.

[9] National Statistics Office of Mongolia. Wages. https://www.1212.mn/mn/statistic/statcate/48171320/table/48171320. Accessed on 1 February 2024.

[10] Ardsecurities. Real Estate Industry. Real Estate Industry Research, 3; 2022.

[11] Aaron O'Neill. Mongolia: Share of economic sector in the gross domestic product (GDP) from 2012 to 2022. Statista, 11 January 2024. https://www.statista.com/statistics/727627/share-of-economic-sectors-in-the-gdp-in-mongolia/. Accessed on 10 November 2023.

[12] ILO. Labor productivity of Mongolia. 2023. https://ilostat.ilo.org/search/?q=mongolia. Accessed on 10 November 2023.

[13] World Bank. Labor productivity based on number of employees indices of Asian countries: World Bank income level categories. worlbank.org. Accessed on 10 November 2023.

[14] ILO. Country Profiles. https://ilostat.ilo.org/data/country-profiles/. Accessed on 10 November 2023.

[15] National Statistics Office of Mongolia. Foreign Trade. 2023. https://www.1212.mn/mn/statistic/statcate/573062/table/573062. Accessed on 1 February 2024.

[16] National Statistics Office of Mongolia. Private Companies. 2023. https://www.1212.mn/mn/statistic/statcate/573060/table/573060. Accessed on 1 February 2024.

[17] World Bank. Doing Business 2020. https://archive.doingbusiness.org/content/dam/doingBusiness/country/m/mongolia/MNG.pdf. Accessed on 10 November 2023.

[18] National Cyber Security Index, 2022. https://ncsi.ega.ee/country/mn_2022/. Accessed on 10 November 2023.

[19] Erdenechimeg E., Asralt B., Khurelbaatar.G. Distribution of Mongolian Mineral Resources, Transportation and Logistics Analysis. 2023.

[20] Mongolian National Chamber of Commerce and Industry. Why Mongolia? https://www.mongolchamber.mn/p/314. Accessed on 10 November 2023.

[21] Bold B. Mining industry innovation will help young people motivation to work. Montsame News Agency, 21 April 2023. https://montsame.mn/mn/read/317328. Accessed on 10 November 2023.

[22] Extractive Industries Transparency Initiative. 16th EITI Reconciliation Report 2021.

[23] Gereg. https://gereg.mn/news/67175. Accessed on 10 November 2023.

[24] National Statistics Office of Mongolia. Livestock. 2023. https://www.1212.mn/mn/statistic/statcate/573054/table/573054. Accessed on 10 November 2023.

[25] Adyasuren E. (2007, june 16). Too much goat will bring poverty. Gogo Mongolia, 16 June 2007. https://gogo.mn/r/v9l0. Accessed on 10 November 2023.

[26] FAO. Special Event on “Innovation, Science and Digitalization” . 2022. https://www.fao.org/3/cb8994en/cb8994en.pdf. Accessed on 10 November 2023.

[27] Tumurtogoo A., Bayartsogt K. Market sportlight. Nikkei Asia, 10 January 2022. https://asia.nikkei.com/Spotlight/Market-Spotlight/Mongolia-stock-market-turns-heads-with-133-gain. Accessed on 10 November 2023.

[28] XacBank. Tsevegjav G: Digital transformation is going successfully. https://www.xacbank.mn/article/gtsevegjav-digital-transformation-is-going-successfully. Accessed on 10 November 2023.

[29] Gauli Investment Securities. Mongolian Financial Industry. 2020. https://gauli.mn/866. Accessed on 10 November 2023.

[30] Bayartogtokh B. Civilian loan increased, business loan decreased. iTom, 28 March 2023. https://www.itoim.mn/a/2023/03/28/economy/ckc. Accessed on 10 November 2023.

[31] World Bank. Inflation, consumer prices (annual %) - Mongolia. 2023. https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?locations=MN. Accessed on 10 November 2023.

[32] Our World in Data. Electricity distribution-Mongolia. 2023. https://ourworldindata.org/search?q=mongolia. Accessed on 10 November 2023.

[33] Batsaikhan J. Introduction to Digitalization Strategy of Food, Agriculture and Light Industry. Presentation at Ulaanbaatar: Head of IT and Statistics Department, MOFALI.

[34] WIPO. Global Innovation Index. 2023. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023/mn.pdf. Accessed on 10 November 2023.

[35] Transparency International. Corruption Perceptions Index - Mongolia. 2023. https://www.transparency.org/en/cpi/2023/index/mng. Accessed on 10 November 2023.

[36] Chadraabal Ch. Smart farming is key to development. UB Post, 14 February 2022. https://theubposts.com/ch-chadraabal-smart-farming-is-key-to-development/. Accessed on 10 November 2023.

[37] Tleikhan A. We can increase power supply with 2 times low cost and time. 12 September 2019. https://erc.gov.mn/web/mn/print/337?date=true. Accessed on 10 November 2023.

[38] Barilgamn. Thermal power plant 5 project just signed. 6 November 2019. https://www.barilga.mn/n/6939/. Accessed on 10 November 2023.

[39] Sumyajav S. Digital Bolomj. Research paper; 2019.

[40] Energy Regulatory Commission. Energy Statistics. Ulaanbaatar: ERC; 2022.

[41] Marco Lombardi M.M. The real effects of household debt in the short and long run. BIS Working Papers, 13; 2017.

NEPAL

Introduction

Agriculture, manufacturing, and services are the three major sectors of Nepal's economy. A long-standing consensus is that economic development typically moves from agriculture to manufacturing and services [1]. The development of the industrial sector is a critical factor in creating wealth and employment, alleviating poverty, promoting trade, and increasing national income.

Industrialization in Nepal started after the launch of the First Five-Year Plan in 1956. The Fifteenth Plan of the National Planning Commission for FY 2019–20 till 2023–24 charted a course towards prosperity and sustainable development, driven by the vision of establishing a socialist-oriented and self-reliant national economy. It aimed to improve people's well-being by elevating living standards to address biological and human needs. With a solid commitment to eradicate absolute poverty in the country, the plan targeted reducing the number of people living below the poverty line to single digits over the plan duration [2]. In line with the development direction set by the Constitution, it outlined strategies for achieving accessible and sustainable economic growth, stability, better governance, and citizen satisfaction [3].

An integral part of Nepal's endeavor is the aspiration to improve the country's status from the Least Developed Country to a developing nation and to achieve the SDGs, eventually elevating Nepal to the status of a Middle-Income Country by 2030 [3]. The vision hinges on generating additional revenue, fostering a skilled human capital base, and mitigating financial risks.

A major challenge in Nepal is the quality aspect of employment, which is linked to the dominance of the informal segment of the economy, where productivity and income are low and working conditions are poor. Nepal's economy relies heavily on remittances, which account for up to 30% of the GDP. Agriculture is the backbone of the economy, supporting almost two-thirds of the population but contributing less than one-third of the GDP. In the fiscal year 2011–12, the sector's contribution to the GDP, including agriculture, forestry, and fisheries, was 33.3%. Notably, it has gradually decreased in recent years and was estimated to be 24.12% in the fiscal year 2022–23 [4, 5]. Overall, agricultural productivity is very low due to insufficient fertilizers, improved seeds, and inefficient technology. Besides, the manufacturing sector's contribution to Nepal's GDP is also low and steadily declining yearly. In 2010–11, the manufacturing sector's contribution to the country's GDP was just 6.29%, which decreased to 5.32% in 2022–23 [4, 5].

Digital Nepal

Digital innovation in Nepal, still in its early stages, is already one of the fastest-growing sectors. The Nepalese business landscape is shifting towards digitization with the emergence of technology startups. The dynamic and growing IT sector emphasizes application development, consulting, and system integration services, as well as increasing the export of IT services. The digital economy is becoming increasingly important in the country's economic landscape. The success of Nepalese companies in providing high-quality IT services to international clients has led to an increase in foreign exchange. These accomplishments highlight the competitiveness and competence of the IT sector in Nepal, thereby contributing to the country's economic development. Nepal's IT service

export industry is worth approximately USD515 million, with over 106 IT export service companies, 14,728 freelancers in software development and technology, and 51,781 IT-enabled Services (ITeS) freelancers involved in exporting IT services through various digital platforms. IT service exports accounted for 1.4% of GDP and 5.5% of foreign exchange reserves in 2022 [6].

The Digital Nepal Framework (DNF) was launched by the government in 2019 as a significant step towards digitizing its services. The government considers DNF an ambitious strategy to promote digital literacy and the development of Nepal's ICT sector. Several ICT policy and regulatory frameworks support DNF. For instance, the 2015 National ICT Policy aims to accelerate the transformation of Nepal as a knowledge and information society by leveraging rapid progress in the ICT sector. Similarly, the 2016 National Broadband Policy provides a framework to promote broadband access and availability throughout the country [7]. This serves as a roadmap for the digital economic future of eight different sectors, further divided into 80 different digital initiatives. However, DNF has not yet been fully implemented [6].

Due to the COVID-19 lockdown, schools and colleges started operating online, increasing the use of digital platforms. Similarly, the use of technology in the health sector also increased as people began using healthtech platforms to order medicine and seek counseling. Hotels use digital platforms to let guests book rooms and receive travel guidance. Additionally, citizens have been using mobile phones and the Internet to make financial transactions. To aid in the economy's recovery, the government has adopted various fiscal and monetary policies [8].

COVID-19 has resulted in the advancement of digital technologies, which have been integrated into all socioeconomic sectors [9]. ICT has been implemented to make government services paperless and faceless. However, Nepal's IT sector faces several challenges, including a need for high-level technical and managerial expertise and experience, regulatory challenges such as weak intellectual property enforcement, and a need for access to finance and digital infrastructure. Hence, Nepal's efforts to digitize government services and digitalize all sectors for quality development have not been as successful as expected.

Methodology

The research is based on secondary literature and data sources. References include national-level reports, constitutions, laws, and policies, as well as publications and website reports from various ministries, departments, and national and international organizations, have been utilized. The summary analysis is based on data from earlier available years for most institutions and recent data for a few institutions.

Scoping: Key Industry Sectors

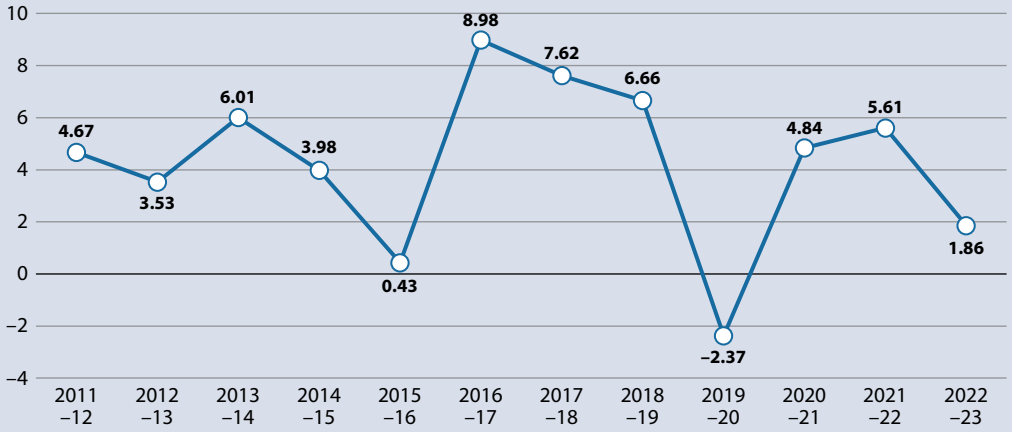
Dynamics of Economic Growth

Based on the National Statistics Office (NSO) annual estimates for 2022–23, Nepal's GDP growth rate at Purchaser's Price is projected to be 1.86%. Notably, the growth rate was –2.37% in 2019–20, which increased to 4.84% in 2020–21 and 5.61% in 2021–22, before declining to 1.86% in 2022–23. The growth rate of Nepal's GDP from FY 2011–12 to 2021–23 is shown in Figure 1.

While Nepal's GDP growth trends are uneven, GDP per capita, Gross National Income (GNI) per capita, and Gross National Disposable Income (GNDI) per capita show uniform growth. Figure 2 illustrates the growth of GDP, GNI, and GNDI in USD.

FIGURE 1

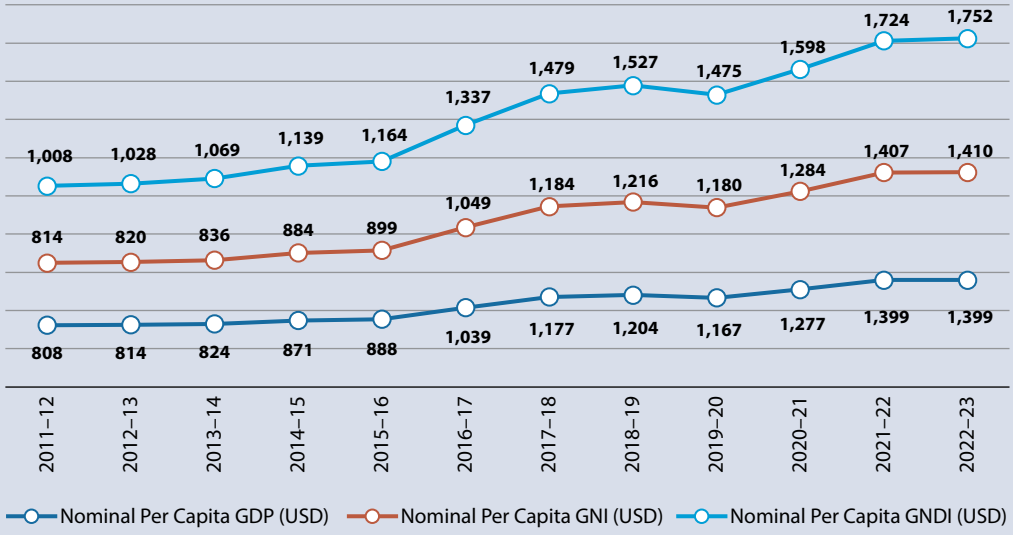
NEPAL'S GDP GROWTH RATE AT PURCHASER'S PRICE (IN USD).



Source: NSO, Government of Nepal; 2023 [5].

FIGURE 2

PER CAPITA GDP, GNI, AND GNDI IN NEPAL (IN USD).



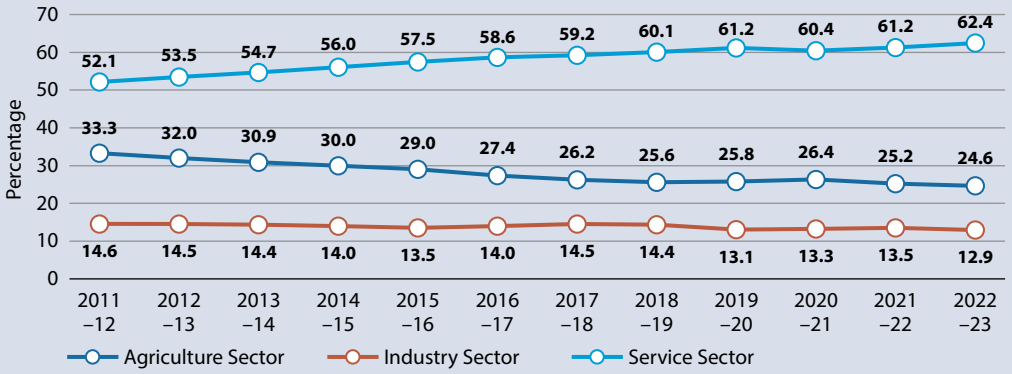
Source: NSO, Government of Nepal; 2023 [5].

Nepal's GDP growth heavily depends on the services sector, followed by the agriculture and industry sectors. The services sector accounts for 62.4%, agriculture for 24.6%, and industry for 12.9% of the GDP. Figure 3 shows the GDP (in %) by sector.

Agriculture is the mainstay of the economy, supporting almost two-thirds of the population but contributing less than one-fourth of the GDP. Its contribution has gradually decreased in recent years, estimated at 24.12% in FY 2022–23 [3, 4]. Similarly, the manufacturing sector's contribution to Nepal's GDP is low, at 5.32% in 2022–23, steadily declining year by year. Figure 4 shows the GDP distribution (in %) by broad industry segments in 2022–23.

FIGURE 3

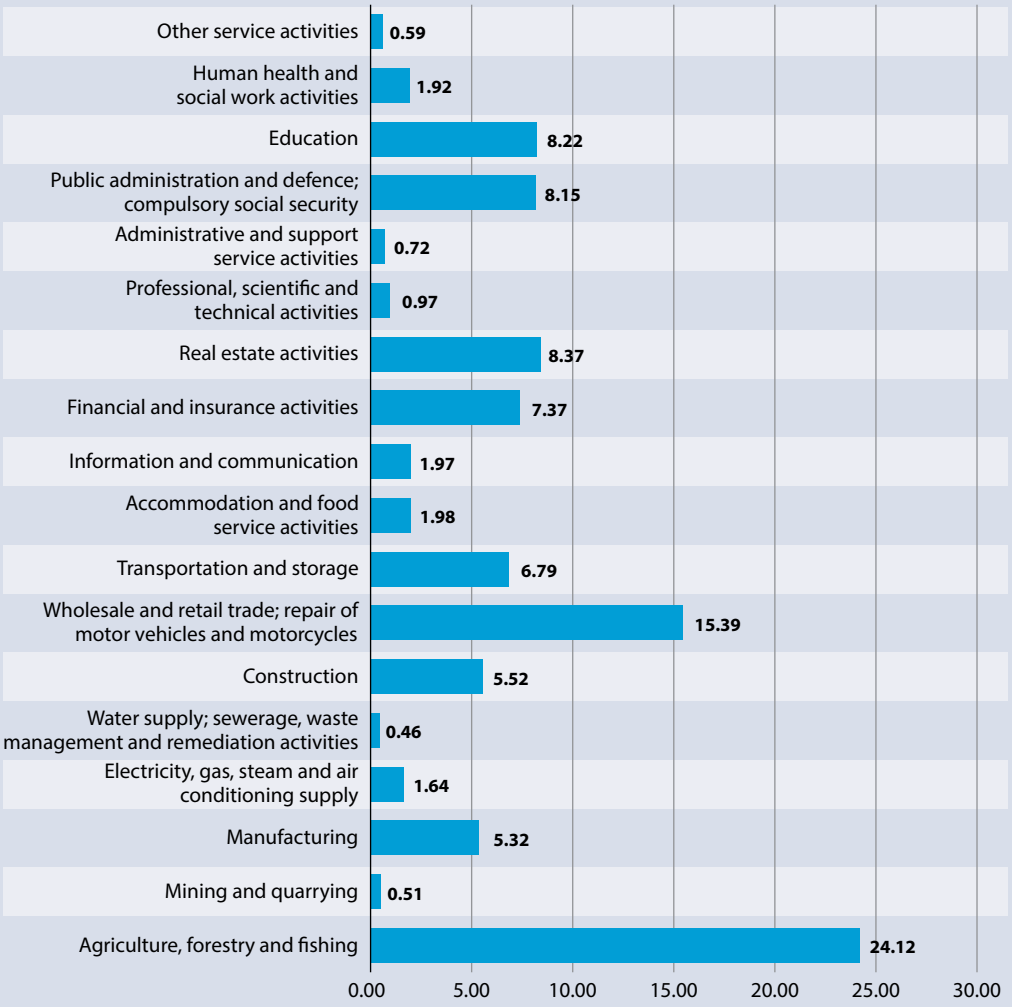
COMPOSITION OF NEPAL'S GDP BY SECTOR (IN %).



Source: NSO, Government of Nepal; 2023 [5].

FIGURE 4

COMPOSITION OF NEPAL'S GDP BY INDUSTRY IN 2022–23 (IN %).



Source: NSO, Government of Nepal; 2023 [5].

Digital Nepal Transformation

Nepal has made rapid progress in ICT compared to other sectors, but there is still room for improvement. As part of its Digital Nepal Strategy, Nepal envisions a future of digital governance with three national goals: accessible modern infrastructure with extensive connectivity, sustainable production and productivity, and good governance. The core objective of Digital Nepal is to ensure a multi-dimensional transformation of the economy, with the expected outcome being the smooth delivery of public services through digital technology.

The government has announced several initiatives and formulated legislation to support the necessary infrastructure for a smooth digital transition. The laws include the Telecom Policy 2004, IT Policy 2010, Broadband Policy 2010, Broadband Policy 2015, ICT Policy 2015, and Cybersecurity Bylaw [8]. The primary goal of Digital Nepal is to provide the economy with multidimensional change, aiming for efficient public service delivery using digital technology.

Review of Policies, Strategies, and Acts

The government's economic liberalization policy has opened the door for multinational companies to conduct business in Nepal. The growing concept of globalization and the WTO agreement have created a vast business scope for multinational companies in Nepal. Business activities in the country are shifting from manufacturing to the services sector, with new private companies being established to operate in this area. These companies in the services sector have attracted significant investments in recent years.

The rapid development of IT has also influenced businesses in Nepal, improving operational efficiency through computer programs, email, the Internet, and network systems. Information Technology is now considered an essential component of economic activity in Nepal. Today, consumers are investing more time and money into proprietary communication platforms such as websites, mobile apps, and customer support channels. Furthermore, there has been a significant surge in consumer conversion rates, and the Return on Investment (ROI) from social media and digital video channels is the highest. Table 1 summarizes the policies, acts, and strategies supporting the Digital Nepal initiative and the IT sector.

TABLE 1

SUMMARY REVIEW OF POLICIES, ACTS, AND STRATEGIES SUPPORTING DIGITAL NEPAL AND THE IT SECTOR.

Policy, Strategy, Act, and Guideline	Summary
	One of the main objectives of the directive is to ensure the creation of a safe digital environment for users. The policy also addresses cybersecurity's current status and history while providing a framework for the future.
National Cyber Security Policy, 2080 (2023) [10]	It offers details of the country's current Internet status and outlines the vision, mission, objectives, strategy, and work plans for securing cyberspace in government, private, and non-governmental entities. The directive emphasizes establishing a national cyber security center, promoting ethical hacking, including cybersecurity education in schools, educational programs targeting vulnerable groups such as women, children, and older people, developing standards, and issuing necessary policies.
	The government's new cybersecurity policy aims to provide resilient cyberspace and establish a national cyber emergency response team in all seven provinces.

(Continued on next page)

(Continued from the previous page)

Policy, Strategy, Act, and Guideline	Summary
Digital Nepal Framework 2019 [7]	Digital Nepal aims to ensure a multi-dimensional transformation of the country's economy. The expected result is the smooth delivery of public services through digital technology. The government views the DNF as an ambitious approach to improve digital literacy and support ICT development in Nepal. The framework was developed as a roadmap for how digital efforts can contribute to economic growth. It also aims to find new solutions to efficiently address critical societal concerns and identify opportunities for Nepal to participate in the global economy. The DNF includes 80 activities divided into eight categories: digital foundations, agriculture, health, education, energy, tourism, finance, and urban infrastructure.
The Fifteenth Plan (Fiscal Year 2019–20 to 2023–24) [3]	This document aims to ensure good IT access for all and increase its use, make IT services accessible and reliable, improve quality, increase employment opportunities by developing IT-enabled industries, and improve social, economic, and governance systems through digitalization.
e-Governance Master Plan (2015–19) [11]	E-governance aims to enable good governance, provide efficient and effective services, and bring national, provincial, and local governments closer to the people. However, the Government of Nepal faces several obstacles in implementing e-governance. Nepal's e-Government Master Plan (eGMP) was prepared by the Korea IT Industry Promotion Agency (KIPA) from 2007–11. However, the government could not approve the eGMP prepared by KIPA. eGMP2 (2015–19) provides a roadmap for implementing e-government programs that add value to governance, increase service efficiency, achieve transparent government, and create interoperability between government services and stakeholders.
ICT Policy, 2072 (2015) [12]	Nepal's first policy to support the IT sector was the Information Technology Policy 2000. Under this policy, the National Center for Information Technology was established in 2002. This policy was revised in 2004, and a draft was published but not adopted. The policy was revised six years later, and IT Policy 2067 (2010 AD) was published. The objective of the Nepal ICT Policy 2072 is to promote an efficient, accessible, secure, reliable, and sustainable national ICT infrastructure that is aligned with local needs and regional, national, and international standards.

(Continued on next page)

(Continued from the previous page)

Policy, Strategy, Act, and Guideline	Summary
National Broadband Policy, 2071 [13]	The broadband policy aims to provide safe, meaningful, affordable, and reliable on-demand broadband services in urban areas and universal access to broadband services in Nepal's rural, unserved, and underserved areas. It also aims to encourage broadband adoption by early and influential users, including government and business, and socially important users such as education and healthcare, stimulating demand and content creation and building user capacity.
The Electronic Transactions Act, 2063 (2006) [14] Electronic Transactions Rules 2064 (2007) [15]	The Act provides a legal framework to regulate electronic transactions and prevent cybercrimes. The law contains provisions to punish cybercriminals and protect the rights of victims. According to the law, cybercrime is any activity carried out with the intent to harm or deceive someone using electronic means. This includes unauthorized access to computer systems, hacking, identity theft, and other forms of cybercrime.
Telecommunication Policy, 2060 (2003) [16]	The Government of Nepal has accepted telecommunication service as a basic requirement for development. The Telecommunication Policy of 2056 (1999 AD) has created an enabling environment to promote private sector participation in the telecommunication sector. The government is committed to creating open competition in the industry by keeping the telecom sector open through this policy since 2004 AD. Its main objective is to create an enabling environment that ensures telecommunication services are reliable, accessible, and affordable for everyone in Nepal. The policy seeks cooperation with the private sector to support the country's economic and social development.
Nepal e-Government Interoperability Framework (NeGIF) Main Report [17]	NeGIF provides a framework for sharing, collaborating, and integrating information and organizational processes using common standards. Enabling such interoperability using open standards is critical to the success of the NeGIF framework and ensuring the selection of the correct technical standards and guidelines appropriate to the environment.
National Payments System (NPS) Development Strategy (2014) [18]	This document presents the strategy for developing NPS and outlines Nepal Rastra Bank's (NRB) strategic approach to its development. It describes the envisioned future state of NPS in Nepal. Throughout this document, internationally accepted principles and practices are highlighted and elaborated upon, taking into consideration Nepal's specific circumstances.

ICT is critical in Nepal's transition from a traditional to a knowledge-based society. Successive governments in Nepal have envisioned that prosperity can be achieved through the optimal utilization of advanced technologies. In addition to the policies described in Table 1, ministries, government departments, and offices are encouraged to integrate IT into their sectoral policies and programs. With the current federal mechanism, central, provincial, and local governments are gradually adopting advanced digital technologies to provide public services transparently.

Priority Sector

In October 2019, the government introduced the Digital Nepal Framework (DNF), which outlines a comprehensive strategy encompassing one country, eight sectors, and 80 digital initiatives. The framework prioritizes establishing a fiber broadband network, implementing 5G technology, and creating a special economic zone for the IT sector to enhance the country's ICT sector. The DNF also aligns with the UN SDG and aims to bolster good governance initiatives [19].

The government views DNF [6] as an ambitious approach to enhance digital literacy and advance ICT in Nepal. It serves as a roadmap for leveraging digital efforts to drive economic growth, address societal challenges, and identify opportunities for Nepal to participate in the global economy. The program seeks to enable Nepal to realize its development potential by exploiting opportunities and promoting financial development. With its focus on eight digital foundation areas of agriculture, health, education, energy, tourism, finance, and urban infrastructure, the DNF aims to propel Nepal toward becoming a digital nation in the foreseeable future.

Using the Digital Nepal initiative, the government seeks to harness the transformative powers of digital technologies and connectivity to promote e-governance, digital entrepreneurship, and digital literacy. The initiative aims to propel Nepal's overall development trajectory through technology-driven governance, agriculture, health, and education advancements.

FIGURE 5

NEPAL'S DIGITAL FRAMEWORK.

Source: Digital Nepal Framework, 2019 [7].

Digital Nepal Framework Initiative

The DNF encompasses eight key sectors: digital foundation, agriculture, health, education, energy, tourism, finance, and urban infrastructure. Within these sectors, the DNF identifies 80 digital initiatives to drive socioeconomic development in Nepal. These initiatives are designed to address critical challenges while harnessing each sector's full potential. Table 2 presents the proposed initiatives for DNF sectors.

TABLE 2

PROPOSED SECTORS, SUMMARY, AND INITIATIVES FOR DIGITAL NEPAL FRAMEWORK.

Sectors	Summary of the Sectors	Initiatives
Digital Foundation	The Digital Foundation dimension of the DNF is built upon three key pillars: digital connectivity, skills, and governance. Serving as the bedrock of the Digital Nepal program, the digital foundation aims to address the challenges of Internet penetration, affordability, access, and digital literacy that persist among a significant portion of the Nepalese population. The program seeks to bridge this gap by providing broader access to connectivity through public-private partnerships and government initiatives.	• Establish the Internet as an essential service • Improve spectrum availability, management and optimization • Take the lead in 5G networks deployment • National Optical Fiber Network • High-speed Internet connectivity for efficient delivery of Public services • Special economic zones for the ICT sector • Government of Nepal App • e-Governance 2.0 • Paperless government to promote collaboration • Public Wi-Fi Hotspots • National Cyber Security Center • Provincial Data Center Establishment • National Language Computational Resource Pack • National Biometric ID Card 15) Digital Signature • Digital Innovation and Co-creation Hub • Digital Skill Development Initiative • Government eLearning Platform • ICT in Education
Agriculture	The Digital Nepal initiative in agriculture focuses on leveraging technological solutions to maximize yield and minimize agricultural input. By harnessing agritech solutions, it aims to enhance farm productivity and sustainability, thereby addressing the increasing demand for food consumption and boosting farmers' incomes.	• eHaat Bazaar • Precision Agriculture • Agriculture Tools Sharing • Digital Disbursement for MSP & Subsidies • Digitization of Land Records • Smart Irrigation Project • Smart Livestock and Wildlife Management • Televet Medical Center Establishment • Agriculture Input and Output Product Quality Tracking System • Education and training programs for farmers • State of the Art Knowledge Centers and Government Agriculture Centers

(Continued on next page)

(Continued from the previous page)

Sectors	Summary of the Sectors	Initiatives
Health	In the health sector, Digital Nepal initiatives are designed to help the country achieve its goals of providing basic health services to all Nepalese. The program envisions leveraging digital technologies such as video conferencing, electronic learning, and mobile health to address healthcare access, affordability, and quality challenges.	• National Digital Healthcare Program • Next-Generation Digital Healthcare Facilities • Electronic Health Records 2.0 • Mobile Health Units • e-Maternal Care • Drones for delivery of emergency medical supplies • Centralized Telemedicine Center
Education	The Digital Nepal education initiatives aim to cultivate human capital capable of seizing new economic opportunities by enhancing the teaching and learning environment. This includes leveraging digital technologies to support teaching methods, enhance learning experiences, and optimize educational outcomes.	• Smart Classrooms • OLE Nepal 2.0 • Online Learning Platform • Rent-a-Laptop Program • EMIS 2.0 • Centralized Admission System • Biometric Attendance Systems and CCTV Cameras • Mobile learning centers in rural areas
Energy	Digital initiatives in the energy sector seek to develop sustainable and efficient green energy infrastructure. By deploying intelligent solutions such as customer-centric services, intelligent transmissions, and distributed networks, the aim is to reduce costs and strengthen energy networks.	• Smart Metering • GIS Smart Grid Project • Pan-Nepal roll-out of Nepal Electricity Authority (NEA), Any Branch Payment System • NEA Official Mobile App 2.0 • Smart Building/Energy Management Project • NEA Field Force Automation Solutions • NEA Customer Service Portal • NEA e-Learning Platform • Contract Management Information System

(Continued on next page)

(Continued from the previous page)

Sectors	Summary of the Sectors	Initiatives
Tourism	In the tourism industry, digital initiatives aim to promote Nepal globally, attract tourists, and generate employment opportunities for Nepalese. Through strategies like omnichannel marketing solutions, e-commerce, and disruptive technologies like Augmented Reality, the goal is to drive tourism growth, enhance human capital, and improve tourist experiences.	• Welcome Nepal Website and Mobile App 2.0 • Electronic Visas and Immigration Process Improvement • Multilingual Helpline • Augmented and Virtual Reality Tours • Electronic Tour Guides • Omnichannel Marketing • Tourist Security Infrastructure
Finance	To bolster the financial services sector, Digital Nepal initiatives leverage digital technology and telecommunication infrastructure to target the large unbanked population, thereby promoting financial inclusion and economic prosperity.	• National Payment Gateway • Credit Ratings (Individual/ Corporate Accounts) • Information Management System for Nepali Migrants • Policy interventions to allow Telecom Operators to offer mobile wallets • Encourage digital payments in Nepal • Development of a single window for business & industry promotion • Development and promotion of e-commerce and ITeS ecosystem • Digital Payments Campaign
Urban Infrastructure	Digital Nepal's initiatives on urban infrastructure aim to leverage disruptive technologies to improve the quality of life in cities. This includes enhancing essential services such as water and solid waste management, public transportation, and traffic management.	• Water ATMs • Smart metering for water • Intelligent Waste Management • Automated Waste Sorting • Municipality Mobile Application • Connected Public Transport/ Public Transport Mobile App • Intelligent Traffic Management • Intelligent Parking Lot Management • Intelligent Toll Booths • National Disaster Management System • Disaster Management Training

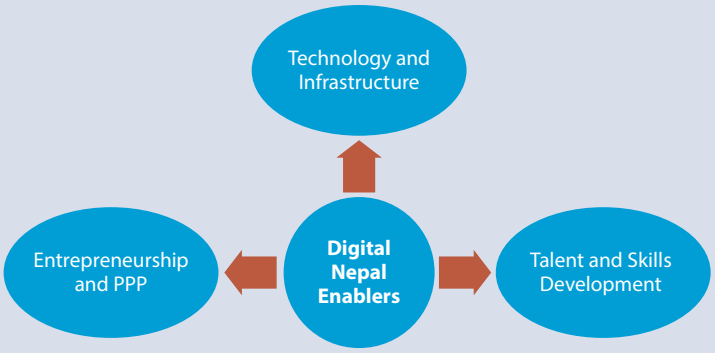
Source: Digital Nepal Framework, 2019 [7].

Digital Nepal Enablers

Nepal is making significant strides towards a digital economy by developing a digital transaction ecosystem, including infrastructure, education, data security, laws, and other elements. Figure 6 illustrates the critical areas that the country needs to focus on to create a conducive environment for the successful implementation of Digital Nepal initiatives.

FIGURE 6

FACTORS ENABLING THE DIGITAL NEPAL INITIATIVES.



Source: Digital Nepal Framework, 2019 [7].

With the emergence of technology startups in the country, businesses in Nepal have started digitalizing their operations. The country's IT sector is experiencing dynamic growth, especially in application development, consulting, and system integration services, with a notable increase in the export of IT services. The growth of the private IT sector aligns with the Government of Nepal's goals to position digital development as a primary driver for sustainable and inclusive growth and development. This vision is embedded in the DNF, a pioneering national program adopted in 2019. It seeks to promote innovation and competitiveness in the private sector [20]. Some possible actions for digital enablers are outlined in Table 3.

TABLE 3

ACTION POINTS FOR DIGITAL NEPAL ENABLERS.

Technology and Infrastructure	Entrepreneurship/PPP	Talent and Skills Development
Digital connectivity must be a key priority. Possible actions include: • Establishing Internet access as a fundamental right for every citizen • Enhancing service coverage and quality by improving the availability of spectrum to the operators • Taking a leadership role in driving 5G adoption in South Asia • Establishing a nationwide fiber network	Encourage private sector participation by: • Digitally streamlining the PPP application system to facilitate private investment • Offering tax holidays and incentives for investment in the Digital Nepal program • Implementing a startup accelerator program to build a robust ecosystem for nurturing innovation and entrepreneurship	Improve digital education through the following actions: • Implementing mandatory IT education in schools and colleges • Expanding the education system's capacity to impart advanced ICT education • Creating ICT literacy programs for rural communities and underprivileged Nepalese • Ongoing communication and celebration of digital stories of success

(Continued on next page)

(Continued from the previous page)

Technology and Infrastructure	Entrepreneurship/PPP	Talent and Skills Development
Facilitate the development of a robust financial ecosystem through the following actions: • Promote digital payments to encourage cashless transactions • Attract investments in fintech by fostering the growth of startups and telecom companies, enabling them to offer services that drive financial inclusion	Encourage foreign direct investment in priority areas by: • Streamlining FDI applications for Digital Nepal initiatives to expedite the process • Allowing 100% FDI and facilitating easier repatriation of funds for Digital Nepal initiatives	Making public-sector employees digitally-ready is essential. Possible actions include; • Providing digital skills training for public sector employees

Source: Digital Nepal Framework, 2019 [7].

Gap Issues: Industrial Sector Analysis

Status of the Sector in the Global Context

The main driver of DX is e-government, which provides national or local government information and services via the Internet or other digital media. According to the UN Department of Economic and Social Commission (UNDESA) survey, eGovernment has far-reaching potential to improve institutional processes, deliver public services, expand inclusion, participation, accountability, and transparency, and build trust between societies and governments [21]. The UNDESA releases the E-Government Survey Report every two years, which collects data from all UN member states. The survey uses three dimensions to track the progress of e-government development via the UN EGDI. The methodology used in the study is described in Box 1.

The global average has increased slightly, from 0.5988 in 2020 to 0.6102 in 2022, primarily due to advances in telecommunications infrastructure [22]. The survey includes data analysis in global and regional contexts, a study of local e-government growth based on the UN Local Online Service Index, consideration of inclusion in the hybrid digital society, and a concluding chapter that outlines trends and developments related to the future of digital government.

The UNDESA 2022 survey highlights the continued advancement of global e-government emerging trends and the transition of many nations from lower to higher EGDI levels. In comparison to 57 countries in 2020, 60 countries in this edition have very high EGDI values ranging from 0.75 to 1.00, representing a 5.3% increase for this group. Fifty-three countries fall into the middle EGDI group with values between 0.25 and 0.50, while 73 countries have high EGDI values between 0.50 and 0.75. Low EGDI values range from 0.00 to 0.25 in seven countries, one fewer than in 2020. Denmark ranked 1st in the world, with a score of 0.9717, according to UNDESA's E-Government Development Survey 2022 assessment report. Finland ranked 2nd, South Korea ranked 3rd, and it was also in the "very high" range [22].

BOX 1

METHODOLOGY USED IN EGDI.

The EGDI, which assesses e-government development at the national level, is a composite index based on the weighted average of three normalized indices.

- One-third is derived from the Telecommunications Infrastructure Index (TII) based on data provided by ITU.
- One-third of the Human Capital Index (HCI) based on data mainly provided by the United Nations Educational, Scientific and Cultural Organization.
- One-third of the Online Service Index (OSI) is based on data collected from an independent online assessment conducted by UNDESA. This assessment assesses the national online presence of all 193 United Nations Member States and is complemented by a Member State Questionnaire.

The survey questionnaire assessed several characteristics of online service delivery, including whole-of-government approaches, open government data, e-participation, multi-channel service delivery, mobile services, adoption, the digital divide, and innovative partnerships using ICT.

The detail of the methodology is obtained from the UNDESA Survey Report 2022, Annex A [22]

Source: UN, 2022 [22].

Status of the Sector in the SAARC Context

With a score of 0.51, Nepal is ranked 125th in the world rankings and sixth among the South Asian Association of Regional Cooperation (SAARC) countries. It is listed among the high EGDI group. With a score of 0.63, Sri Lanka is ranked 95th globally and first among the SAARC countries. Similarly, with a score of 0.59, Maldives is ranked 104th globally and second in the SAARC region. Table 4 and Figure 7 show the comparative scores of SAARC countries for 2020 and 2022.

TABLE 4

RANK AND EGDI OF SAARC COUNTRIES.

Country Name	e-Government Rank		SARRC e-Government Index Rank		e-Government Index		Online Service Index		Human Capital Index		Telecommunication Infrastructure Index	
	2020	2022	2020	2022	2020	2022	2020	2022	2020	2022	2020	2022
Afghanistan	169	184	8	8	0.32	0.27	0.41	0.28	0.37	0.35	0.18	0.19
Bangladesh	119	111	5	4	0.52	0.56	0.61	0.65	0.57	0.59	0.37	0.45
Bhutan	103	115	3	5	0.58	0.55	0.68	0.60	0.51	0.53	0.54	0.53
India	100	105	2	3	0.60	0.59	0.85	0.79	0.58	0.58	0.35	0.40

(Continued on next page)

(Continued from the previous page)

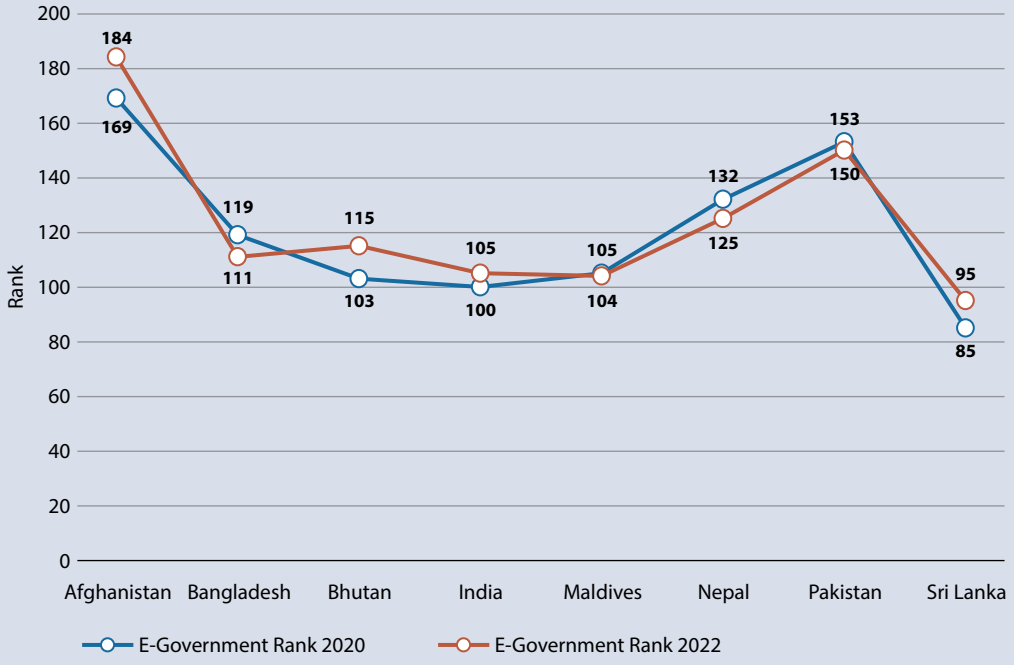
Country Name	e-Government Rank		SARRC e-Government Index Rank		e-Government Index		Online Service Index		Human Capital Index		Telecommunication Infrastructure Index	
	2020	2022	2020	2022	2020	2022	2020	2022	2020	2022	2020	2022
Maldives	105	104	4	2	0.57	0.59	0.44	0.49	0.69	0.69	0.60	0.58
Nepal	132	125	6	6	0.47	0.51	0.40	0.46	0.54	0.56	0.47	0.51
Pakistan	153	150	7	7	0.42	0.42	0.63	0.57	0.38	0.39	0.24	0.31
Sri Lanka	85	95	1	1	0.67	0.63	0.72	0.56	0.77	0.77	0.53	0.55

Source: UN, 2022 [22].

India scores 0.59, ranking 105th globally and third among SAARC countries. In the overall tally, Bangladesh, with a score of 0.56, Bhutan at 0.55, Pakistan at 0.42, and Afghanistan at 0.27, stand at 111th, 115th, 150th, and 184th in the world ranking, respectively. Among the SAARC countries, Bangladesh ranks fourth, Bhutan fifth, Pakistan seventh, and Afghanistan eighth.

FIGURE 7

EGDI-BASED RANKING OF SAARC COUNTRIES (2020 AND 2022).

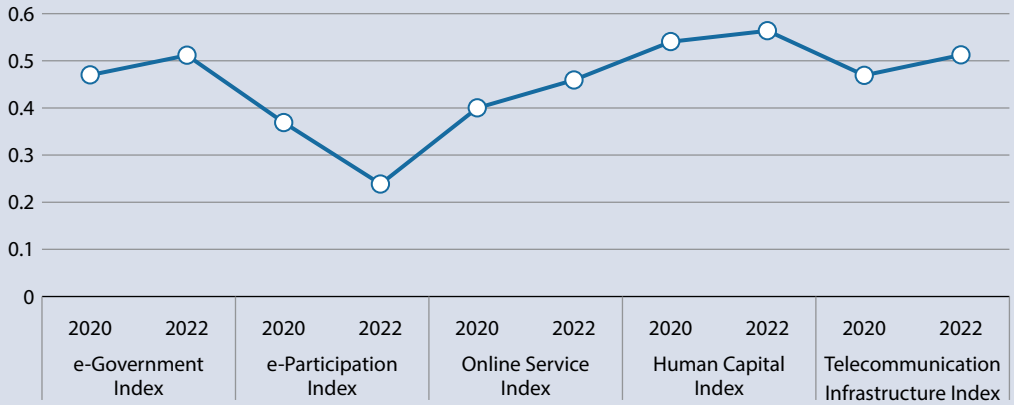


Source: UN, 2022 [22].

Nepal ranked 132nd among 193 countries in the 2020 survey and improved its position to 125th in 2022. However, compared to the rapid progress made by other South Asian countries such as Bangladesh, Sri Lanka, and India, the country lags in ICT development. While trends in digital government development indicate continued growth and improvement, and notable progress has been made in several areas, significant challenges still require attention. The various comparative indices of Nepal for 2020 and 2022 are shown in Figure 8.

FIGURE 8

EGDI PERFORMANCE MATRIX OF NEPAL (2020, 2022).



Source: UN, 2022 [22].

Industrial Sector Analysis

One of the biggest challenges DX projects face in developing countries is the need for more infrastructure. Many developing countries have a different technological infrastructure than developed countries, making it difficult to deploy new technologies. Significant urban-rural disparities exist in South Asian infrastructure despite 3G and 4G connectivity improvements over the past decade. Device affordability, gender gap in digital literacy, urban-rural division, and accessibility issues for people with disabilities, to mention a few, are some of the gaps that still exist. Comprehension of these gaps, as well as access to relevant information, still needs to be improved. Challenges in digital adaptation, such as insecure digital infrastructure, low awareness of the safe use of digital systems, slow policy updates, and infrastructure development, must be addressed for effective DX [23].

Initiatives, Status, and Issues

The adoption of new services is also reflected in Nepal being the first SAARC country to roll out 3G services. Nepal also ended its dependence on India for global connectivity in January 2018 by operationalizing fiber optic links with China [24]. Nepal's digital landscape has experienced remarkable growth in recent years, revolutionizing many areas of business and society. Despite the inherent limitations a landlocked country faces, Nepal has made great strides in embracing and harnessing digital technology for growth and prosperity [25].

The emphasis on DX is increasing across many sectors in Nepal and other nations. This includes e-governance initiatives, adopting digital platforms, and incorporating technology into products and services. Some of the digital initiatives undertaken by the government in Nepal are listed.

Digital Foundation

Nepalese government agencies have digitized their services with two main goals: maintaining transparency and delivering public services smoothly, effectively, and quickly. The government, recognizing the potential of ICT as an enabler of development, is now striving to bring broadband Internet access to all 753 local governments, community schools, and health posts. Federal, provincial, and local levels are gradually becoming accessible online. Initiatives undertaken in the digital foundation are shown in Box 2.

BOX 2

INITIATIVES UNDERTAKEN TO STRENGTHEN NEPAL'S DIGITAL FOUNDATION.

Digital connectivity has exponentially increased as mobile and Internet access in Nepal has increased dramatically in recent years. The government is also moving ahead with the testing phase of 5G technology. The government has made some efforts to digitize public services. This includes the following:

- Digitization of property tax office data
- Launch of Nagarik APP (Civil APP)
- Launch of Nepal National Single Window (NNSW) system
- National ID card, digital signature
- Fiber optic networking and various types of Internet technologies like Very Small Aperture Terminal (VSAT)
- Virtual Private Network (VPN)
- Nepal Vital Registration
- Cybersecurity, data center, supply chain, and delivery
- Installation and test of microwave radio for mid-hill

Source: Digital Nepal Framework, 2019 [7].

In recent years, services in government offices have been digitized from central to local. People can avail of all government services through online mechanisms. However, due to the lack of electricity and telecommunications services, people in remote villages still need access to the Internet. Due to various limitations, Internet literacy in Nepal could be more encouraging.

Agriculture Sector

The Government of Nepal has launched a digital marketplace called Krishi Bazaar and e-Haat Bazaar to connect farmers directly to the regional and central agricultural market. The government has made some efforts to digitize the agricultural sector. Some initiatives undertaken in the agriculture sector are shown in box 3.

However, efficient implementation of these resources is still required. Farmers can find agricultural information on the Internet, and some mobile applications have been developed to provide them with the information they need. However, the reach of this information is limited because many who work in the agricultural sector are digitally illiterate and have poor access to the Internet [7, 26].

BOX 3

INITIATIVES UNDERTAKEN BY NEPAL IN THE AGRICULTURE SECTOR.

Farmer Support Call Centers (Kisan call centers) have been established to aid farmers, and mobile applications have been developed to assist farmers with plant health and other farming-related news and alerts. Some other initiatives are:

- Agricultural Atlas of Nepal
- Agricultural Management Information System
- Land Use Monitoring and Analysis
- Use of GIS and Remote Sensing Along with Use of ICT
- Land Use Zone Maps Based on Soil Quality and Crop Suitability
- National Geographic Information Infrastructure
- Management Information System of Tea and Coffee Sub-Sector of Nepal
- Digital Training Methodology for Author of Pesticide Analysis
- Tomato and Kausi Kheti (Home Terrace Cultivation) Mobile Application
- Krishi Application launched by Nepal Agriculture Research Council
- Proper Price Tracking System, Food and Safety (Pesticide Tracking)
- Online Seedling Ordering System, Land Registry Information Management System
- National Geoportal, Bhumi Sushaasan Application
- Land Parcel Digitization, Field Book and Land Register Scanning
- Calculation Registration Fee and Capital Gains Tax Application, Spatial Application Extension Software and Parcel Editor Software

Source: Digital Nepal Framework, 2019 [7].

Health Sector

The provision of reliable and timely data and the development of digital infrastructure deliver new insights and analytical capabilities, thereby strengthening the role of the government as a decision-maker for the policies and management of the health sector. This is especially important in the

context of the federalization of Nepal, where responsibility for budgeting and planning for health service delivery has been transferred to the local level. Some initiatives undertaken in the health sector are shown in box 4.

BOX 4

INITIATIVES UNDERTAKEN BY NEPAL IN THE HEALTH SECTOR.

Digital health initiatives have increased over the past decade and now support many aspects of the health industry, from maintaining health service records to financing and quality of care. Some of the initiatives are as follows:

- E-Childcare, ELMIs – Electronic Logistics Management Information System
- HMIS – Health Management Information System
- Early Warning and Reporting System, Health Infrastructure Information System
- DHIS2 and Trackers
- SMS Messaging
- Mobile Health, MDIS malaria and disease information system and telemedicine

Digital health initiatives have proliferated over the past decade and now support many aspects of health system operations and service delivery, from health service data and human resources to health financing and quality of care. However, many of these applications have been developed without considering the need or potential for data exchange. Difficulties in aggregating data and creating synergies between disparate digital systems hinder the potential of digital technology to strengthen health systems and delivery.

Source: Digital Nepal Framework, 2019 [7]; LinkedIn [25].

The COVID-19 pandemic has boosted digital health services, as numerous online web-based physical and mental health counseling services have thrived. Likewise, the pandemic allowed the government to expand its digital health information management system. Nonetheless, there are still numerous ways the Nepalese healthcare sector can undergo DX [7, 26].

Education Sector

Initiatives to digitize the education sector include integrating digital technologies into classrooms to enrich the learning experience and improve educational outcomes. Many universities and schools are conducting classes online and via Zoom meetings. The lockdowns caused by COVID-19 provided an opportunity for the government and education stakeholders to reevaluate teaching and learning methods. However, studies conducted by various organizations showed that online education proved less effective as large numbers of students were excluded from virtual learning because they needed access to online study materials and the Internet [7, 26].

Energy Sector

The implementation of smart meters in power distribution has made progress. Overall, 90,000 single-phase, 44,000 three-phase, and 27,000 three-phase smart meters have been distributed to new customers. Similarly, sites have been identified to launch the GIS smart grid system. The official mobile application of the NEA and the customer service portal were also launched as part of Urzas' digital initiative. Electricity tariffs can be paid from any branch in the Kathmandu Valley, and a system that can be implemented in other locations is under development [27].

Tourism Sector

Digital tourism efforts aim to promote Nepal internationally, attract visitors, and provide employment opportunities to Nepalese citizens. Nepal Tourism Board has taken the initiative to create a mobile application with an online booking and payment system that aims to connect different businesses relating to tourism, such as accommodation, aviation, and entertainment, to mention a few. However, progress in this regard could be faster. The immigration department of the tourism sector provides printed visas with QR codes. Likewise, the Nepal Port has been developing, operating, and adapting new software and solutions as required [27].

Finance Sector

Digital Nepal's efforts to advance the financial services sector aim to reach the country's large unbanked population. The financial sector currently leads in digitization across the industry in Nepal. Box 5 shows some of the initiatives undertaken in the finance sector.

BOX 5

INITIATIVES UNDERTAKEN BY NEPAL IN THE FINANCE SECTOR.

- Initiatives such as the National Payment Gateway, credit ratings, mobile wallet services, digital payments, and the development and promotion of e-commerce have been successfully implemented.
- Customs has developed a system to pay duties electronically and is piloting it at the Dry Port Customs Office.
- Eventually, Nepal Rashtra Bank RTGS will be connected to NCHL's National Payment Interface/Payment Switch of Electronic Fund Transfer system [25].
- Payments to local governments are also increasingly being made online.
- According to monthly statistics from Nepal Rastra Bank, over 3 million transactions are processed through Connect IPS monthly. Likewise, an average of 13.5 million mobile banking transactions, 13.3 million mobile wallet transactions, and 1.7 million QR-based payments are made each month [23].
- Currently, several e-commerce companies operate in Nepal, providing a wide range of services such as food delivery, shopping, payment, etc., and the number is increasing daily.

Source: Asia Competitiveness Institute, 2023 [23], LinkedIn [25].

The growth of e-commerce and the freelance industry can be attributed mainly to the widespread use of the Internet. Additionally, substantial international investments in the sector have facilitated the adoption of best practices. The rising popularity of social media has also provided people with a platform for digital marketing. Small or home-based businesses, in particular, benefit from this trend as minimal upfront investment is required to establish an online presence. However, Nepal currently lacks legislation governing e-commerce. Although the Ministry of Industry, Commerce and Supplies has introduced the e-Commerce Bill in Parliament, it has yet to be approved [24].

Urban Infrastructure

Using modern technologies, DNF aims to improve the quality of life in Nepalese cities by improving essential services such as water management, waste management, public transport, and traffic management. However, more progress has yet to be made on this front. An information system for reconstruction management has been developed, the problem of complaint management has been dealt with, an integrated disaster information system has been developed through interaction with the information systems of various agencies engaged in disaster management, and data from the health emergency center has been transferred to the disaster portal and integrated [26,27].

Mobilizing Scenarios

Impact of Digital Transformation

Nepal's digital ecosystem has grown tremendously in recent years, revolutionizing many areas of business and society. Despite the inherent limitations of being a landlocked country, Nepal has made significant strides in embracing and harnessing digital technology for growth and prosperity [25]. DX has had a positive and far-reaching impact on the country's economy, society, and governance. The digital revolution has opened up new possibilities, empowered people and businesses, improved access to services, and enabled inclusive growth. As Nepal continues its DX journey, it is well-positioned to harness the full potential of digital technologies for sustainable growth and development.

Nepal has undertaken significant initiatives such as building a national fiber optic network, connecting and operating key 4G LTE devices, and operating a mobile device management system as a gateway to the national e-payment system. Additionally, the country is exploring the feasibility of using digital signatures to deliver government and electronic equity services. Broadband Internet service is being implemented across all local-level offices, ward offices, health centers, and community secondary schools. As of mid-March 2023, broadband Internet has been provided at 753 local-level offices, 6,743 ward offices, 4,390 health centers, and 5,318 community secondary schools.

Also, optical fiber has been laid across 12,238 kilometers, providing high-speed Internet to Mid-Hill Highway and surrounding districts. Additionally, 319 Government Cloud services and 719 virtual machines have been integrated into the IT system [28]. Moreover, 55 services have been added to the Nagarik (Civil) app. Digital competitiveness is of utmost importance for Nepal due to the country's rapid digitization, which includes 94.25% mobile broadband penetration, 36.75% fixed broadband connections, and a fourfold increase in Internet users between January 2013 and January 2023.

Over 700,000 additional users joined social media between 2021 and 2022, increasing Nepal's user base to 12.7 million, 12.7% of the total population [23, 28]. In terms of financial access, 61% of people had mobile money accounts, 18% made digital payments, 8% used mobile phones or the

Internet to send money, and 6% used mobile phones or the Internet to pay their bills in 2022. Although the DNF put forward by the government is expected to bring credible changes in the digital sector, the country has yet to witness noteworthy achievements [23].

With fast Internet access nationwide, Nepalese businesses and individuals have switched to e-commerce and the gig economy. The e-commerce and gig economy sector offers a wide range of services such as delivery, shopping, payments, and ride-sharing services, and it is growing every day. This growth in e-commerce and the gig economy can largely be attributed to the increased use of the Internet and significant international investments in this sector that help provide mechanisms for better practices. The increase in the use of social media has also provided people with a platform to sell goods and services. It is easier for small or home-based businesses to do this as there is little to no initial cost to establish an online service [24].

Service delivery in Nepal has been transformed by digital technology, making it more accessible, efficient, and people-centered. Using e-government programs has accelerated government procedures, reduced bureaucratic barriers, and increased transparency. Citizens can now apply for official paperwork, pay taxes, and access information online, saving time and minimizing visits to government buildings. Digital financial services have also increased access to banking and financial goods, especially for previously disadvantaged people. Good governance and development are long-cherished dreams in Nepal. There is no choice but to adopt digital governance for good governance, which is one of the pillars of development. Identifying gaps in policies and practices and implementing necessary reforms at the legal, institutional, procedural, and practical levels is essential for DX in the country [25].

Challenges of Digital Transformation

Nepal has several legal tools to develop the IT industry and strengthen e-governance. These include the IT Policy 2000, IT Policy 2004, E-Transaction Law 2004, Telecommunications Policy 2004, E-governance Master Plan, IT commitments in different plan periods, Electoral Transaction and Digital Signature Act 2000, Copyright Act 2000, Telecommunication Act and Regulation 1997 and National Communication Policy 1992. While these policies and initiatives have fostered innovation, collaboration, and investment in the digital sector, Nepal still faces significant challenges [29].

- **Underdeveloped ICT infrastructure:** The country's ICT infrastructure is not yet robust enough to support widespread DX.
- **Legislation and public policy:** To effectively govern and support the digital sector, more comprehensive and up-to-date legislation and policies are needed.
- **Human resource management and development:** The management and development of human resources necessary for the IT sector are inadequacies.
- **Insufficient digital and electronic knowledge:** Many sectors, including the government, lack the necessary digital and electronic knowledge to implement IT solutions effectively.
- **Political issues:** These include a lack of human resources, an incomplete legal framework, low per capita income, and insufficient public awareness of IT.

Addressing these challenges is crucial for Nepal to fully realize the potential of its DX initiatives.

FIGURE 9

CHALLENGES OF IMPLEMENTING DIGITAL TRANSFORMATION IN NEPAL.

Source: Giri S. E-Government Development in Developing Countries: Emerging challenges, ICT policy and Legal Issues in Nepal. 2020 [29].

Government services are typically constrained by political and legal policies, technology, and human capital [28]. Changing the traditional human-based administrative system into a machine-based system is challenging for least-developed countries. Providing services by combining computer-based technology with a human-based administrative system is challenging and takes time and effort.

Over the past few years, the government has created policies and frameworks that present a broad range of digital initiatives and goals but fail to present a cohesive, coordinated, and cross-sectoral roadmap of what DX in Nepal should achieve and how it can be achieved.

The 2015 National ICT Policy set ambitious five-year connectivity and digital literacy goals. Several planning documents are available, but many of these targets must be realized.

Transparency: Responsible Research Innovation

Nepal's digital innovation ecosystem is in its infancy. However, it is one of the fastest-growing industries. A new generation of national IT service providers has emerged, providing innovative and specialized solutions to meet a wide range of local needs [30]. The Nepal Standard Industrial Classification (NSIC) classifies most IT-related businesses into programming, IT consulting, web portals, and computer and IT service operations. Due to unclear or outdated laws, innovative technology startups need help complying with the regulations. When IT companies try to register their business with the government, they often need a specific category. Entrepreneurs are usually discouraged from taking risks and implementing innovative ideas due to the need for more supportive policies for technological businesses. However, to overcome this, the government of Nepal has introduced the E-Commerce Bill, which is still being discussed [30].

The government has revealed its plans to activate the National Cyber Security Center to minimize cybersecurity threats in the budget speech for Fiscal Year 2080–81 (2023–24). Additionally, various initiatives related to DX are underway. Measures are being taken to regulate and oversee social networks, digital platforms, and digital media. The government intends to establish a comprehensive data security policy to ensure proper electronic data security, storage, and utilization management.

On 8 August 2023, the Cabinet in Nepal approved the Cybersecurity Policy 2023. The policy aims to establish a reliable, secure, and progressive cyber landscape in the country. One of the main features of this policy is that it promotes the creation of a safe cyberspace for users. It also assesses the state and landscape of cybersecurity and develops a reliable framework for the future [31]. However, cooperation with civil society, the public, and the private sectors is limited and ineffective.

Engagement is essential for building credible partnerships, meeting the needs of citizens and stakeholders, and closing gaps in government skills and capabilities. The inability to address these factors effectively leads to a lack of data-driven practices, poor digital governance, scarce e-government services, and a failure to protect against cyber threats [32]. The approach to digital governance is limited, focusing primarily on hardware purchases and point investments rather than government-wide efforts to digitize, streamline, and enhance data, operations, and services. In addition to these limitations, systemic challenges impede the government's ability to successfully execute the country's digital vision.

These challenges include inconsistencies between planning and implementation, improper governance structures, lack of understanding of cybersecurity and data interoperability, and lack of engagement with key stakeholders such as the private sector and civil society groups. Such challenges hinder the government's ability to build a sustainable digital policy landscape for the country and impede the growth of the ICT sector as a whole [32].

Figure 10 illustrates Nepal's key ethical, legal, and social challenges in its DX journey.

FIGURE 10

KEY ETHICAL, LEGAL, AND SOCIAL CHALLENGES IN NEPAL'S DX JOURNEY.

Ethical Issues	Legal Issues	Social Issues
• Privacy • Security • Integrity • Trust • Bias • Accountability • Digital divide • Digital literacy	• Cybersecurity threat • Lack of cyber law • Lack of e-commerce law	• Social disconnect • Cultural barriers • Job insecurity • Addiction

Source: Institute for Integrated Development Studies, 2022 [24]; USAID, 2022 [32]; Shah D.K, 2023 [33]; Basnet A, 2023 [34].

Many developing countries are struggling with extreme poverty, and there have been no significant changes in people's lives for many years. One notable reason for this is corruption. Traditional forms of governance, manual systems, unethical behavior of civil servants, public procurement

systems, and bureaucratic delays have all contributed to corruption [33]. The transition to digitization was intended to address this issue. However, despite implementing digital systems, Nepal has yet to eradicate corruption.

Similarly, collecting and using personal data through digital services raises ethical questions about data protection and privacy. As digital platforms become more integral to daily life, there is a growing need to establish strong data protection regulations to safeguard individuals' privacy rights. Cybersecurity attacks on regional governments and financial institutions further complicate this issue. The spread of fake news and misinformation is another concern [24].

Moreover, online platforms for purchasing goods have not always proven reliable. There have been numerous instances where the products delivered differ from what was displayed. Using online platforms for deception and selling damaged or substandard products is also a major ethical issue, leading to skepticism. Hence, building trust and confidence in the digital economy is the first and most important step for fostering digital growth.

Nepal has a significant rural population with limited access to digital infrastructure and technology. The ethical concern lies in ensuring that DX does not exacerbate existing inequalities, leaving rural and marginalized communities further behind in terms of access to education, healthcare, and economic opportunities. The rapid pace of DX can lead to a gap in digital literacy, especially among older generations or those with limited exposure to technology. Ensuring people have the skills to use digital tools responsibly is an ethical obligation.

Legal Issues

Like in many other countries, DX in Nepal has raised various legal issues that must be addressed to ensure a smooth transition to a digitally driven society. Despite the government's efforts to develop policies encouraging digitization, concerns about data security and privacy still need to be addressed adequately. Government offices have been accused of disclosing private information to the public, and the initial presentation of the Nepal Special Services Bill, which allowed authorities to intercept communications, including telephone tapping, faced significant criticism.

Moreover, government services have been frequent targets of cyberattacks, rendering them nonfunctional. In January of 2023, a cyberattack on the Integrated Government Data Center affected 400 government offices. The attack was carried out using a distributed denial of service technique, which lasted four hours and severely impacted Tribhuvan International Airport, leading to delays in international flights by up to three hours. The rise of social media and online platforms also presents legal challenges related to online behavior, cyberbullying, harassment, and hate speech. Legal frameworks must address these issues while preserving freedom of expression.

Additionally, Nepal has very few specific regulations for Internet-based businesses, including security or taxation. This regulatory gap often results in applying ill-suited regulations to the digital business context, making it difficult for some companies to operate and grow. Interviewees referred to this phenomenon as the regulatory environment "squeezing" businesses, especially startups, which deters entrepreneurs from taking risks and launching innovative business ideas [32].

Social issues

The Digital Nepal Framework 2019 provides a roadmap for digital initiatives to contribute to economic growth, address social challenges with fewer resources, and identify opportunities.

However, despite the government's efforts to develop policies promoting digitization, data protection and privacy concerns have not been adequately addressed. While the government has actively promoted digitization, agencies have fallen victim to cyberattacks and have been accused of publishing personal data [34].

Regarding access to technology, Nepal's population is diverse, leading to potential inequalities exacerbated by the digital divide between urban and rural areas and between various socioeconomic groups. Those lacking access to digital resources may lose healthcare, education, and financial opportunities. As technology becomes more integrated into the fabric of Nepal's society, several social issues that need proper attention may arise. Media manipulation is common due to the ease of editing digital media, including images, audio, and video. The distinction between real and fake is no longer always clear-cut, as software like Photoshop can alter photographs, and digital audio and video can be edited. As technology advances, these problems are likely to worsen.

People increasingly prefer socializing and communicating through digital devices over in-person interactions, which can lead to feelings of alienation and loneliness. Humans have evolved over thousands of years to have real contact, and removing this can have various adverse effects that the world is only starting to understand. Studies show that many people experience depression and other types of mental illness due to a lack of real-life interaction. Social media, video games, messaging apps, and dating websites all have a high potential for addiction.

Nowadays, many jobs can be done remotely over the Internet, leading to significant changes in how people live and work. People now work from home and conduct their banking, shopping, and bill-paying activities online. As digital machines increasingly replace humans, society tends to become more impersonal.

Policy Recommendations

The effective implementation of the DNF and the realization of all 80 initiatives across the eight sectors require improved ICT infrastructure and skilled human resources. The government can only achieve this goal with the support of the private sector, which is driving the technological transformation in Nepal. To facilitate this, the government must invest in developing the necessary infrastructures and enhancing cybersecurity through public-private partnerships. Creating policies that foster an environment conducive to digital initiatives is also essential. The government should organize comprehensive skill development programs to develop a pool of skilled workforce.

The Government of Nepal is committed to creating and implementing necessary laws and policies, such as the ICT bill, cybersecurity and startup policies, and e-governance and e-commerce acts. There is also a strong emphasis on making public service delivery effective, simple, and accessible by ensuring people's adoption of ICT. Concerned organizations must prioritize the swift implementation of relevant policies, laws, and regulations.

As digital technologies have been rapidly adopted in Nepal for banking, online shopping, online education, and health services, the government should focus on data privacy and safety in the private sector. Developing and implementing laws to address the misuse of private company data is essential. The government should also address instances where citizens' private information has been made public. It must ensure that any personal information gathered through its apps is secure

and cannot be abused, even by the government. Building trust and confidence in the digital economy is a crucial role for the government.

Nepal's emerging digital finance ecosystem consolidates digital infrastructure and resources into a unified platform, improving financial access, reducing gender gaps, and empowering disadvantaged groups. Collaborative efforts from all stakeholders are needed to support and accelerate the digital payments revolution in Nepal. Policymakers should prioritize investments in digital infrastructure, streamline regulatory processes, and improve understanding of digital finance. Private sector actors must continue to innovate, reduce transaction costs, and improve interoperability.

Internet usage and penetration have increased significantly, requiring the government to take timely steps and consider the various problems that may arise with the digitization of the economy. It is important to ensure that the implemented solutions are sustainable in the long run and can be scaled to accommodate future growth in digital services and user demand. Data centers in strategic locations can provide the necessary infrastructure for cloud computing and storage services. Cloud services allow users to access and store data remotely, making it easier for individuals and businesses to use digital solutions remotely without needing large local hardware. Similarly, providing incentives, training, and resources and demonstrating the benefits of digital tools in terms of efficiency, cost savings, and increased market reach can encourage rural and remote businesses to use and adopt digital solutions.

While the proposed DNF holds promise for bringing significant and credible changes in the digital sector, the country has yet to witness any remarkable achievements. Hence, it is imperative to reassess Nepal's DX initiatives, identify the gaps in policies and practices, and institute necessary legal, institutional, procedural, and practical reforms to propel the country's DX.

References

[1] Dahal M.P. Stride of Service Sector in Nepal's Trajectories of Structural Change. Economic Journal of Development Issues; 2018, 21(1–2). https://www.nepjol.info/index.php/EJDI/article/view/19024. Accessed on 2 August 2023.

[2] National Planning Commission, Government of Nepal. National Review of Sustainable Development Goals, June 2020. https://npc.gov.np/images/category/SDG_Review_Report_2020.pdf. Accessed on 30 July 2023.

[3] National Planning Commission, Government of Nepal. The Fifteenth Plan (Fiscal Year 2019/20–2023/24). https://www.npc.gov.np/images/category/15th_plan_English_Version.pdf. Accessed on 30 July 2023.

[4] Ministry of Finance, Government of Nepal. Economic Survey 2021/22. https://www.mof.gov.np/uploads/document/file/1674635120_Economic_Survey_2022.pdf. Accessed on 30 July 2023.

[5] National Statistics Office, Government of Nepal. National Accounts Statistics of Nepal (2022/23 Annual Estimates).

https://nsonepal.gov.np/national-accounts-statistics-of-nepal-2022-23-annual-estimates/. Accessed on 30 July 2023.

[6] Institute for Integrated Development Studies. Unleashing IT: Advancing Nepal's Digital Economy Expanding jobs and exports July 2023. https://www.iids.org.np/publications/details/books/unleashing_it__advancing__nepal___s_digital_economy?id=278. Accessed on 2 August 2023.

[7] Ministry of Communication and Information Technology, Government of Nepal. 2019 Digital Nepal Framework, Unlocking Nepal's Growth Potential. https://drc.gov.np/storage/backend/pages/resources/others/D8lp6S0TBu0kqwXB7V90hB9aodF4v6qTLGzUvN7M.pdf. Accessed on 1 August 2023.

[8] Institute for Integrated Development Studies. Covid-19 Pandemic and Nepal's Road to Post-Pandemic Recovery. Nepal Risk Outlook, June 2022. www.riskoutlook.or. Accessed on 3 August 2023.

[9] Jun S., Park J., Kim J.Y. Digital Transformation Landscape in Asia and the Pacific: Aggravated Digital Divide and Widening Growth Gap. United Nations ESCAP, Information and Communications Technology and Disaster Risk Reduction Division, Bangkok; July 2022. http://www.unescap.org/kp. Accessed on 3 August 2023.

[10] Ministry of Communication and Information Technology, Government of Nepal. National Cyber Security Policy, 2080 (in Nepali). https://api.giwms.gov.np/storage/22/posts/1691665949_27.pdf. Accessed on 10 October 2023.

[11] Department of Information Technology Ministry of Science and Technology, Government of Nepal. https://nitc.gov.np/assets/img/fileSystem/download/23-07-27-021435-E%20Governance%20Master%20Plan-DoIT%202015-2019%20Draft%20(3).pdf. Accessed on 10 October 2023.

[12] Ministry of Communication and Information Technology, Government of Nepal. ICT Policy, 2072 (in Nepali). https://api.giwms.gov.np/storage/1/posts/resource_1508168188.pdf. Accessed on 10 October 2023.

[13] Ministry of Communication and Information Technology. Nepal e-Government Interoperability Framework, Main Report. National Broadband Policy, 2071. https://api.giwms.gov.np/storage/22/posts/1663070880_14.pdf. Accessed on 10 October 2023.

[14] Department of Information Technology, Ministry of Communication and Information Technology, Government of Nepal. The Electronic Transactions Act, 2063 (2007). https://api.giwms.gov.np/storage/1/posts/resource_1502777292.pdf. Accessed on 10 October 2023.

[15] Department of Information Technology, Ministry of Communication and Information Technology, Government of Nepal. Electronic Transactions Rules 2064 (2008). https://nitc.gov.np/assets/img/fileSystem/download/20-11-09-012731-Electronic_Transaction_Rule_2064.pdf. Accessed on 10 October 2023.

[16] Nepal Telecommunications Authority. Telecommunication Policy, 2060 (2003) (in Nepali). https://www.nta.gov.np/uploads/contents/Dursanchar-Niti-2060.pdf. Accessed on 3 October 2023.

[17] National Information Technology Center, Ministry of Communication and Information Technology, Government of Nepal. Nepal e-Government Interoperability Framework. https://nitc.gov.np/downloads. Accessed on 8 October,2023.

[18] Nepal Rastra Bank. National Payments System (NPS) Development Strategy (2014). https://www.nrb.org.np/contents/uploads/2019/12/Nepal_National_Payment_System_Development_Strategy.pdf. Accessed on 10 October 2023.

[19] Ghimire S. Efforts at digitizing government services in current federal set-up. My Republica, 15 April 2021. https://myrepublica.nagariknetwork.com/news/government-efforts-at-digitizing-its-services-are-paying- accessed off/. Accessed on 5 August 2023.

[20] The World Bank. Connecting Nepal with the Global Digital Economy. 16 April 2023. https://www.worldbank.org/en/events/2023/04/12/connecting-nepal-with-the-global-digital-economy. Accessed on 19 October 2023.

[21] United Nations, Shaping Our Digital Future Asia-Pacific Digital Transformation Report 2022. https://www.unescap.org/kp/2022/asia-pacific-digital-transformation-report-2022-shaping-our-digital-future. Accessed on 6 August 2023.

[22] United Nations. E-Government Survey 2022 The Future of Digital Government 2022 https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2022/. Accessed on 6 August 2023.

[23] Asia Competitiveness Institute, Lee Kuan Yew School of Public Policy, National University of Singapore. Nepal's Digitalization Journey: Experiences and Challenges in Digital Transformation and the Future Ahead https://aciperspectives.com/2023/03/13/nepals-digitalisation-journey-experiences-and-challenges-in-digital-transformation-and-the-future-ahead/. Accessed on 10 August 2023.

[24] Institute for Integrated Development Studies. Digitization of Nepali Economy amid Covid-19 Pandemic. Nepal Risk Outlook, April 2022. https://www.iids.org.np/images/publications/4c7be52a3a2b3ad7500c3f3aeef5c5a5.pdf. Accessed on 4 August 2023.

[25] LinkedIn. Digital Transformation: How has Nepal Digitally Transformed? https://www.linkedin.com/pulse/digital-transformation-how-has-nepal-digitally-transformed. Accessed on 12 August 2023

[26] Bajracharya S.N. Nepal Economic Forum. How far has the Digital Nepal Framework come? https://nepaleconomicforum.org/how-far-has-the-digital-nepal-framework-come/. Accessed on 12 August 2023.

[27] Aryal M. The Slow Advancement of the Game-changing 'Digital Nepal Framework'. ICT Frame, 24 August 2022.

https://ictframe.com/the-slow-advancement-of-the-game-changing-digital-nepal-framework/. Accessed on 15 August 2023.

[28] Ministry of Finance, Government of Nepal. Economic Survey 2022–23. https://www.mof.gov.np/uploads/document/file/1687415151_Economic%20Survey%207980.pdf. Accessed 20 August 2023.

[29] Giri S. E-Government Development in Developing Countries: Emerging challenges, ICT policy and Legal Issues in Nepal. February 2020, https://www.researchgate.net/publication/338986635_E-Government_Development_in_Developing_Countries_Emerging_challenges_ICT_policy_and_Legal_Issues_in_Nepal/link/5e36eaaa92851c7f7f17a067/download. Accessed on 25 August 2023.

[30] Bajracharya S.N. Nepal Economic Forum. Barriers to Local Digital Innovation in Nepal. 27 December 2022. https://nepaleconomicforum.org/barriers-to-local-digital-innovation-in-nepal/. Accessed on 25 August 2023.

[31] myRepbulica. Govt approves National Cyber Security Policy 2023. 9 August 2023. https://myrepublica.nagariknetwork.com/news/govt-approves-national-cyber-security-policy-2023/. Accessed on 30 August 2023.

[32] USAID. Digital Ecosystem Country Assessment, Nepal. https://www.usaid.gov/sites/default/files/2022-05/USAID_Nepal_Digital_Ecosystem_Country_Assessment_FINAL.pdf. Accessed on 1 September 2023.

[33] Shah D.K. Towards a digital Nepal. The Kathmandu Post, 21 January 2023. https://kathmandupost.com/columns/2023/01/21/towards-a-digital-nepal-1674315168. Accessed on 25 August 2023.

[34] Basneet A. Digital Transformation and Privacy Concerns. New Business Age, 2 June 2023. https://www.newbusinessage.com/MagazineArticles/view/3883. Accessed on 30 August 2023.

PAKISTAN

Introduction

In recent years, the world has witnessed rapid technological advancement, impacting all sectors of society. Adopting disruptive technologies leading to DX in organizations can significantly boost economic growth and enhance the quality of life for the population. Embracing this transformation is not merely a matter of staying current with global trends; it is a strategic imperative that promises to revolutionize productivity, efficiency, and service delivery.

Pakistan, a predominantly agricultural economy and a growing public sector, stands to gain significantly from embracing DX in both its agriculture and public sector organizations. However, this potential can only be realized if the country develops comprehensive policies and implementation procedures and builds a supportive infrastructure per the needs identified at the outset of such an initiative. Pakistan's Digital Policy seeks to improve the country's digital infrastructure and e-government services to spur innovation and accelerate DX [1].

In the 21st century, new technologies have disrupted every area of life, necessitating the development of novel DX policies to cope with current and future challenges. Digital innovations and technology adoption are essential for the transformation of organizations through disruptive technologies such as AI, IoT, and ICT, among others [2]. The requirements include supportive national policies, the affordability and availability of technology, the necessary skill sets for its use, ICT education, and a strategic approach to successful transformation.

The WEF Global Competitiveness Index 2019 ranked Pakistan 124 out of 141 nations in technology and innovation, which is not encouraging [3]. This situation needs to be addressed by exploring the challenges and impediments to development in the country. As mentioned earlier, state-of-the-art technology and innovation can play a significant role in digitization and the adoption of DX. The answer to the critical question of where Pakistan stands in adopting digitalization and implementing e-services to fulfill national needs and facilitate its citizens in every aspect of life requires input from researchers and practitioners to develop potential solutions.

One of the main objectives of this APO research project is to understand the current status and initiatives regarding Pakistan's digital transformation. This research project identifies important objectives and components of DX policy formulated at the national level by the Government of Pakistan. In addition to the national transformation policy, significant aspects and initiatives at the province level are also identified. This research focused on two important sectors: agriculture and public sector organizations. The DX initiatives and policies regarding these sectors are discussed, along with their benefits and challenges.

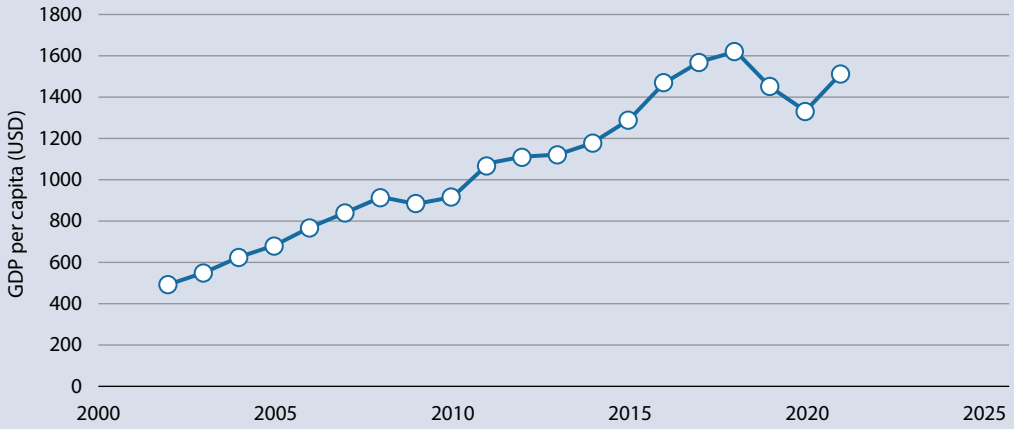
Dynamics of Economic Growth in Pakistan

The economic growth of any country is primarily reflected through metrics such as GDP per capita. Figure 1 depicts the trend of GDP growth in Pakistan over the last 20 years [4]. As illustrated, GDP per capita in Pakistan experienced a negative impact during 2009–10 and 2018–20. Despite these

downturns, the overall trend shows gradual growth, indicating economic development. This trend suggests an improvement in the economic wellbeing of citizens during this period. The increase in GDP per capita could be partially attributed to the adoption and implementation of advanced technologies, which have the potential to enhance productivity, efficiency, economic growth, and innovation across various sectors.

FIGURE 1

GDP GROWTH TRENDS IN PAKISTAN.

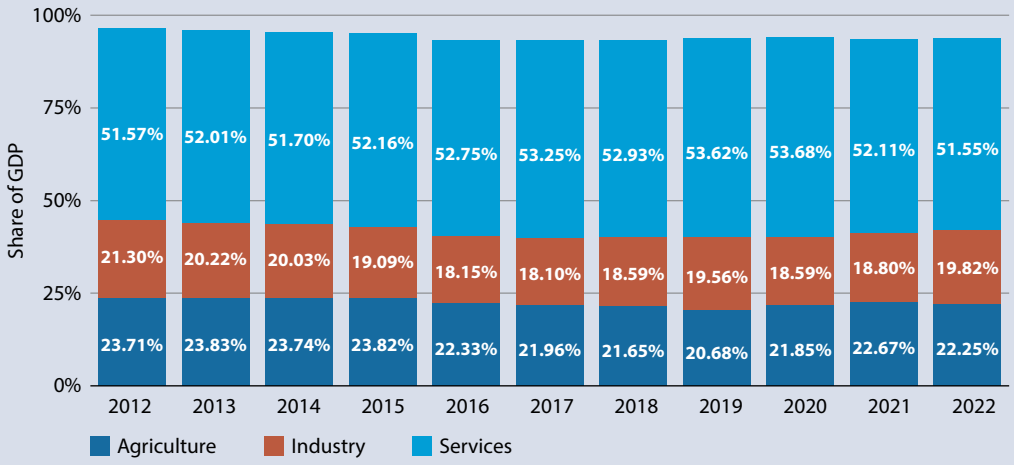


Source: Data Catalog. The World Bank. https://datacatalog.worldbank.org/home.

Pakistan's GDP is mainly based on three major sectors: agriculture, industry, and services, as depicted in Figure 2. In 2022, agriculture contributed around 22.25%, 19.82% came from the industry, and over half of the economy's contribution to GDP came from the services sector to the GDP of Pakistan [5].

FIGURE 2

GDP CONTRIBUTION OF PAKISTAN'S THREE MAJOR SECTORS.



Source: Aaron O'Neill. Pakistan: Distribution of gross domestic product across economic sectors from 2012 to 2022. Statista, 11 January 2024. https://www.statista.com/statistics/383256/pakistan-gdp-distribution-across-economic-sectors/#:~:text=Distribution%20of%20gross%20domestic%20product%20(GDP)%20across%20economic%20sectors%2.

Agriculture is vital for GDP growth in Pakistan, yet data shows that the service sector holds a significant share. Although more than 50% of people in Pakistan are employed in the agriculture sector [6], its contribution to GDP is not substantial. This is primarily due to the lack of emphasis on advancing the agriculture sector through innovative technologies and their timely implementation. The agriculture sector in Pakistan requires a significant technological transformation. As technology advances and becomes more accessible, it has the potential to revolutionize agriculture and, subsequently, positively impact the overall economy.

Significant improvements in key indices such as the Human Development Index, Innovation Index, and Global Knowledge Index (GKI) are imperative for successfully transforming various sectors in Pakistan.

Comparative Analysis of Key Global Knowledge Indices

This study compared the global knowledge indices of 11 countries that are part of this research [7]. As indicated in Table 1, Japan ranks 12th globally, a noteworthy standing in the GKI. In contrast, Pakistan's placement at the lower end emphasizes the urgent need for substantial advancements in knowledge, innovation, and technological capabilities.

TABLE 1

GLOBAL KNOWLEDGE INDEX OF THE APO MEMBERS.

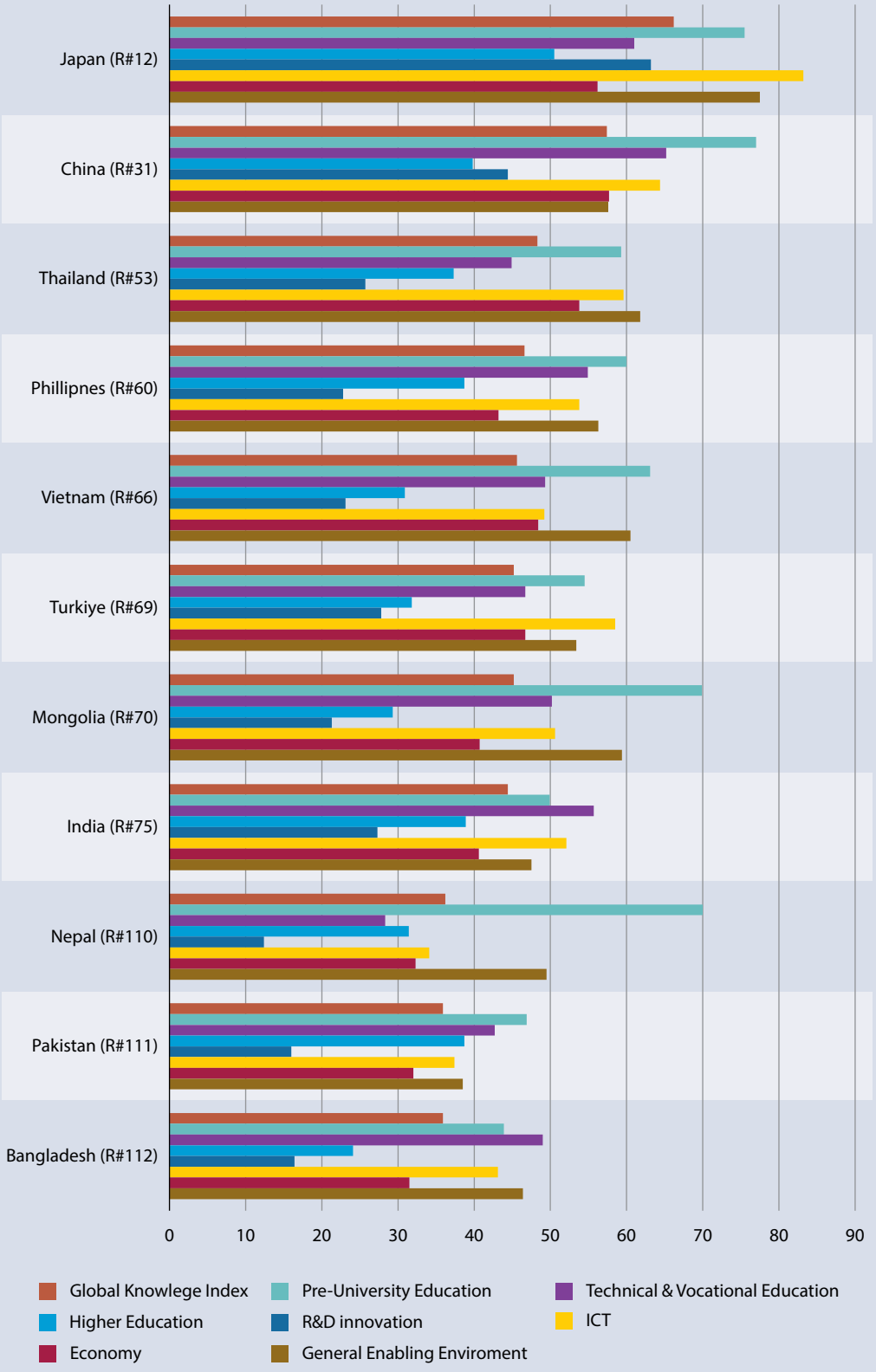
Country Data (2020)	Rank	Global Knowledge Index	Pre University Education	Technical and Vocational Education and Training	Higher Education	R&D and Innovation	ICT	Economy	General Enabling Environment
Japan	12	66	75.5	61	50.5	63.2	83.2	56	78
People's Republic of China	31	57	77	65.2	39.8	44.4	64.4	58	58
Thailand	53	48	59.3	44.9	37.3	25.7	59.6	54	62
Philippines	60	47	60	54.9	38.7	22.8	53.8	43	56
Vietnam	66	46	63.1	49.3	30.9	23.1	49.2	48	61
Turkiye	69	45	54.5	46.7	31.8	27.8	58.5	47	53
Mongolia	70	45	69.9	50.2	29.3	21.3	50.6	41	59
India	75	44	49.9	55.7	38.9	27.3	52.1	41	48
Nepal	110	36	70	28.3	31.4	12.4	34.1	32	50
Pakistan	111	36	46.9	42.7	38.7	16	37.4	32	39
Bangladesh	112	36	43.9	49	24.1	16.4	43.1	32	46

Source: Global Innovation Index 2023. World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023/pk.pdf.

The statistics do not reflect an encouraging sign for Pakistan, highlighting the need for DX to enable the country to compete at the global level. Progress in education, research and development, technology infrastructure, and policies supporting innovation will be pivotal in elevating Pakistan's position in the GKI and fostering economic and societal growth.

FIGURE 3

GLOBAL KNOWLEDGE INDEX OF THE APO MEMBERS.



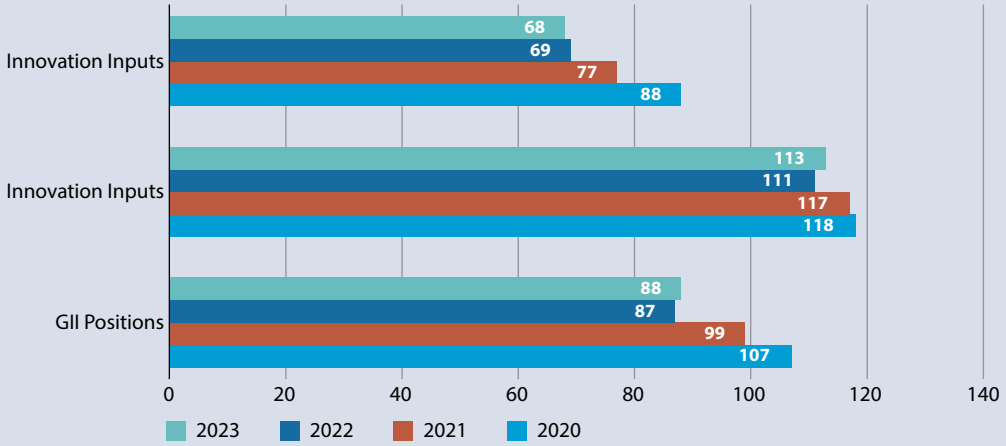
Source: Global Innovation Index 2023. World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023/pk.pdf.

Global Innovation Index

A detailed analysis of the Global Innovation Index based on 80 indicators for 132 countries is shown in Figure 4. Pakistan ranks 88th among the 132 economies featured in the GII 2023 [8]. The fluctuations in Pakistan's GII rankings are apparent in Figure 4. In 2023, Pakistan performed better in innovation outputs than in innovation inputs. It ranks 113th in innovation inputs, lower than the previous year, whereas it ranks 68th in innovation outputs, a higher position than last year. The improved ranking in innovation outputs could reflect DX efforts within public sector organizations. These organizations may have implemented digital solutions to enhance service delivery, streamline processes, and increase transparency. For example, e-governance initiatives, digital public services, and online platforms for citizen engagement may have contributed to this improvement.

FIGURE 4

THE GLOBAL INNOVATION INDEX (2020–23).



Source: Global Innovation Index 2023. World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023/pk.pdf.

Digital Standing of Pakistan

Pakistan's digital standing has been evaluated based on several key indices, as shown in Table 2. The analysis of these digital indices highlights Pakistan's significant challenges in the digital landscape [7, 8, 30, 31, 36].

TABLE 2

PAKISTAN'S DIGITAL RANKING ON KEY GLOBAL INDICES.

Indicator	e-Government Development Index (1–193)	Individuals Using Internet (% of the population)	Digital Skills in Education Country Rank (1–131)	Strength of the Digital Entrepreneurship Ecosystem Country Rank (1–113)	Preparedness to Prevent Cyberthreats and Cyber Incidents
Source	UN e-Government Development Index 2022	World Bank 2020	Network Readiness Index 2022	Global Index of Digital Entrepreneurship 2022	National Cybersecurity Index 2020
Pakistan	150	25%	89	97	42.86

Source: Compiled by the national expert.

The indices regarding Internet usage and digital skills in education are particularly critical and require urgent attention. Although ample opportunities for improvement exist, effective strategies and policies for developing and adopting the latest technologies in various sectors must be planned and implemented. The initiatives by different countries, especially the APO members, in adopting digital technologies across sectors can guide Pakistan's senior management in developing effective and proactive strategies. The next part of this research identifies some of the initiatives undertaken by Pakistan's public and private sectors.

Review of ICT-Related Policies of Pakistan

As listed, seven policy documents on Pakistan's public sector ICT policies have been summarized and analyzed for their commonalities.

- Digital Pakistan Policy [1]
- Digitalization: Pakistan's Vision 2025 [20]
- E-Commerce Policy of Pakistan [9]
- National Broadband Policy 2021 [22]
- National Cyber Security Policy 2021 [23]
- National IT Policy [19]
- Pakistan Cloud First Policy [21]

FIGURE 5

ICT-RELATED POLICIES IN PAKISTAN.

Source: Compiled by the national expert from multiple sources [9, 19–23].

This research analyzed each policy's primary objectives and key themes, followed by a detailed analysis of the common factors across these documents. Given the depth and breadth of these documents, the study focused on key themes, strategic objectives, policy initiatives, and commonalities in approaches towards ICT development in Pakistan.

Digital Pakistan Policy

The Government of Pakistan revised its DX policy in 2021 [1] with the vision "To become a strategic enabler for an accelerated digitization ecosystem to expand the knowledge-based economy and spur socioeconomic growth." This policy aims to transform Pakistan into a digitally advanced nation by enhancing digital infrastructure, promoting IT exports, developing digital skills, and ensuring widespread Internet access. Key initiatives include investment in human capital, strengthening the IT and telecom sectors, promoting e-governance, and encouraging digital financial services.

Objective

The key objectives of this policy are:

- To create a digitally progressive and inclusive Pakistan by fostering digital infrastructure, investing in digital skills, and ensuring access to the Internet for all citizens.
- To rapidly create a digital ecosystem with infrastructure and institutional frameworks to deliver innovative digital services, applications, and content.
- To promote the use of technology in education, health, agriculture, and other key socioeconomic sectors.
- To promote e-commerce and mobile commerce.
- To ensure improved access to health and education and equitable participation in social, political, and economic spheres.
- To promote innovation, entrepreneurship, and incubators/startups in the IT sector.
- To increase software exports, IT remittances, and the domestic market.
- To improve Pakistan's ICT ranking based on international indices and benchmarks.
- To provide ICT facilities to all the citizens of Pakistan (rural/urban).
- To ensure efficiency, transparency, and accountability through e-governance.

The primary objective of the Digital Pakistan Policy is to transform the country into a digitally advanced and inclusive nation. This policy aims to enhance the country's digital infrastructure, boost IT exports, and improve digital literacy and skills. It seeks to ensure universal access to the Internet, fostering a digital ecosystem conducive to economic growth and innovation. The policy focuses on empowering citizens with digital skills, improving government service delivery through digitalization, and creating a favorable environment for IT businesses and startups. It emphasizes the importance of cybersecurity and aims to establish Pakistan as a global player in the IT sector.

Key Themes

- Digital literacy
- Promotion of IT exports
- Development of digital infrastructure
- Enhancing cybersecurity

Strategies

Investment in human capital, strengthening the IT and telecom sectors, promoting e-governance, and digital financial services.

Digitalization: Pakistan's Vision 2025

This policy document outlines a strategic vision to make Pakistan a knowledge-based economy with competitive IT and telecom sectors. It emphasizes innovation, technology-driven solutions, IT exports, and smart city development. The strategy involves strengthening IT institutions, fostering public-private partnerships, and focusing on technology incubation centers.

Objective

Pakistan's Vision 2025 for digitalization aims to transform the country into a knowledge-based economy, making it competitive in the global IT and telecom sectors.

It seeks to integrate digital technologies into all sectors of the economy, promoting innovation and technological solutions. The policy focuses on enhancing IT exports, developing digital infrastructure, and creating smart cities. It strives to improve citizens' quality of life through technology-driven governance and services. It also aims to foster a culture of entrepreneurship and innovation, particularly in the IT and digital sectors.

Key Themes

- Innovation
- Technology-driven solutions
- Enhancement of IT exports
- Development of smart cities

Strategies

Strengthen IT institutions, increase IT exports, foster public-private partnerships, and focus on technology incubation centers.

e-Commerce Policy of Pakistan

This policy is designed to promote and facilitate e-commerce activities in Pakistan. It aims to increase digital transactions and ensure consumer protection in the digital space. Key themes include developing the e-commerce market, enhancing digital payment systems, facilitating cross-border trade, and implementing cybersecurity measures.

Objective

The e-Commerce Policy of Pakistan aims to establish a robust framework for e-commerce activities and enhance digital transactions while ensuring consumer protection in the digital marketplace. It aims to develop a thriving e-commerce ecosystem that supports businesses and consumers, facilitates cross-border trade, and integrates with global e-commerce networks. The policy focuses on improving the digital payment infrastructure, ensuring fair market competition, and fostering trust in online transactions. It also aims to provide a supportive environment for SMEs to transition into the digital economy.

Key Themes

- e-Commerce market development
- Digital payment systems
- Cross-border trade facilitation
- Cybersecurity measures

Strategies

Development of an integrated e-commerce platform, promoting digital literacy among businesses, and enhancing logistic frameworks for e-commerce.

National Broadband Policy 2021

The policy document aims to provide universal, affordable, quality broadband access throughout Pakistan. It focuses on expanding broadband coverage, fostering competition in broadband services, and incentivizing infrastructure development. The policy aims to ensure broadband accessibility for all citizens.

Objective

The National Broadband Policy 2021 of Pakistan aims to provide universal, affordable, high-quality broadband access throughout Pakistan. The objective is to bridge the digital divide, ensuring that people across urban and rural areas can benefit from the digital economy. This policy focuses on expanding broadband infrastructure, improving the quality of broadband services, and making them affordable for the general population. The policy also intends to foster a competitive market for broadband services, encouraging innovation and investment in the telecom sector.

Key Themes

- Broadband for all
- Infrastructure development
- Affordability
- Quality of service

Strategies

Expansion of broadband coverage, fostering competition in broadband services, and incentivizing infrastructure development.

National Cyber Security Policy 2021

This policy aims to protect Pakistan's cyberspace from threats and manage cyber risks. It focuses on cybersecurity, information protection, national cyber incident response, and international collaboration. The policy includes establishing a national cybersecurity response mechanism and developing skilled cybersecurity professionals.

Objective

The National Cyber Security Policy 2021 aims to safeguard Pakistan's cyberspace against internal and external threats. The objective is to establish a secure and resilient digital environment that protects national interests and citizens' data. The policy focuses on strengthening the national cybersecurity infrastructure, developing a skilled workforce in cybersecurity, and enhancing the country's capabilities to respond to cyber incidents. It also aims to collaborate with international bodies to align with global cybersecurity standards and practices.

Key Themes

- Cybersecurity
- Information protection
- National cyber incident response
- International collaboration

Strategies

Establish a national cybersecurity response mechanism, develop a skilled workforce, and cooperate with international bodies for cyber governance.

National IT Policy

The National IT Policy is focused on developing Pakistan's IT sector as a major exporter and innovation-driven industry. It covers IT infrastructure development, human resource development, innovation, and IT governance. The policy emphasizes strengthening IT education and promoting software development.

Objective

The National IT Policy of Pakistan focuses on developing its IT sector as a leading global exporter and innovation hub. The objective is to create a conducive environment for the growth of the IT industry, enhance IT infrastructure, promote research and development, and foster human capital development in IT. The policy aims to boost IT exports through supportive measures and incentives, improve IT education and training, and encourage entrepreneurship and innovation in the IT sector.

Key Themes

- IT infrastructure
- Human resource development
- Innovation
- IT governance

Strategies

Strengthen IT education, promote software development, and enhance IT exports through policy support and incentives.

Pakistan Cloud First Policy

This policy promotes the use of cloud computing by government and public sector entities for efficient service delivery. It centers on cloud adoption, data sovereignty, service delivery efficiency, and security. The policy includes establishing cloud infrastructure and data center guidelines and promoting public-private partnerships in cloud services. The policy aims to establish a secure and reliable cloud infrastructure, promoting cloud services for better governance and public service delivery. It focuses on data sovereignty, ensuring the security and privacy of data hosted in the cloud. The policy also encourages public-private partnerships to develop cloud services and aims to foster an ecosystem that supports cloud technology adoption across various sectors.

Objective

The Pakistan Cloud First Policy aims to accelerate the adoption of cloud computing in government and public sector organizations, enhancing efficiency and service delivery.

Key Themes

- Cloud adoption
- Data sovereignty
- Service delivery efficiency
- Security

Strategies

Establish cloud infrastructure, data center guidelines, and promotion of public-private partnerships in cloud services.

Common Factors Across ICT Policies

This analysis highlights the common strategic objectives across different ICT policies in Pakistan. The common aspects are summarized in Table 3.

TABLE 3

KEY COMMONALITIES IN PAKISTAN'S ICT POLICIES.

Digital transformation	All policies emphasize transforming Pakistan into a digitally advanced society, focusing on enhancing digital infrastructure.
Human capital development	Each policy highlights the importance of developing digital literacy and a skilled workforce to support the IT sector.
e-Governance and digital services	A common theme is the promotion of e-governance for efficient public service delivery through digital platforms.
Cybersecurity and data protection	It emphasizes the need for robust cybersecurity measures to protect data and ensure safe digital transactions.
IT exports and innovation	Shared objectives include boosting IT exports and fostering an environment for innovation, especially in software and e-commerce.

(Continued on next page)

(Continued from the previous page)

Public Private Partnerships	It advocates collaboration between government and private sectors to advance the digital agenda across policies.
Inclusivity and accessibility	Ensures that digital services and infrastructure are accessible across the population, including remote areas.
International collaboration	Recognition of the importance of aligning with international standards and engaging in global partnerships.
Supportive regulatory frameworks	Establishing conducive regulatory environments and policy frameworks to encourage investment and growth in the IT sector.
Emerging technology adoption	Emphasis on exploring and adopting emerging technologies like AI, IoT, and cloud computing.

Source: Compiled by the national expert from Digital Pakistan Policy 2018, Ministry of IT & Telecom, Government of Pakistan [1].

Provincial Level Policies

Considering the main components of the national DX policy, several initiatives have been taken at the provincial level by respective information technology boards like the Punjab Information Technology Board and KPK Information Technology Board. The other two provinces, however, have not set up dedicated boards like Punjab and KPK. Instead, the initiatives in these areas are managed by the traditional departments like the Science & Technology Department in Baluchistan and the Science & IT Departments in Sindh.

TABLE 4

PROVINCIAL-LEVEL INITIATIVES IN PAKISTAN.

Province	Departments Responsible for ICT Initiatives	Web Links to Access Details About the IT Initiatives
Punjab	Punjab Information Technology Board [10]	https://pitb.gov.pk/digital_punjab
Sindh	Information Science & Technology Department, Sindh [11]	https://istd.sindh.gov.pk/special-initiative
Baluchistan	Science & IT Department, Baluchistan [12]	https://sit.balochistan.gov.pk/policies-and-acts/
KPK	Khyber-Pakhtunkhwa Information Technology Board [13]	https://www.kpitb.gov.pk/project

Source: Compiled by the national expert from multiple sources [11–13].

Gap Issues: Industrial Sector Analysis

The detailed analysis of the department websites reveals differences in policy formulation and alignment with national ICT policies. The transformation of agriculture in all provinces in Pakistan is somewhat comparable. However, Punjab and KPK can be placed in the upper bracket. The provincial policies of KPK and Punjab focus on key pillars such as IT Infrastructure, human development, training and development, health, education, and automation of essential functions at the provincial level.

All provinces have planned initiatives to transform the agriculture sector using various technologies. National-level ICT policies align closely with the provincial policies of Punjab and KPK. Conversely, while Sindh and Baluchistan mention certain IT and cloud-level infrastructure initiatives, they do not provide a clear IT policy on their website. Details about IT-related initiatives and policies can be accessed through the links mentioned in Table 4.

Revolutionizing Pakistan: DX Across Sectors

Digital technologies will continue to disrupt and transform the global economy at an accelerating pace. The Government of Pakistan has taken various steps to promote and propel DX. Pakistan Vision 2025 and the Digital Policy of Pakistan 2018 [1] have paved the way for transforming the digital landscape. Table 5 summarizes some digital initiatives undertaken by the Government of Pakistan [10, 11, 29, 36, 38, 39].

TABLE 5

DIGITAL INITIATIVES BY THE GOVERNMENT OF PAKISTAN.

Sector	Summary
Information and Communication Technology	ICT has played a central enabling role in the emerging dynamics of a knowledge society and economy. Pakistan's ICT sector is carving out a differentiated position as the preferred source for software development, Business Process Outsourcing, and freelancing. This has enabled a skilled-based economy within the country and acts as a catalyst for the export of services, facilitating foreign remittance and alleviating the country's poor foreign reserves. The country's IT exports grew by 146% between FY 2018 and 2022, reaching USD2.6 billion in 2022.
e-Governance	Pakistan is steadily advancing toward implementing e-governance. As of 2020, the Pakistan Citizen's Portal hosts 1.3 million registered members and boasts a 91% resolution rate, allowing swift and efficient resolution of citizens' needs [9].
Agriculture and Food	The agriculture and food sectors are projected to be Pakistan's largest economic beneficiary of technology [11]. Technology-enabled services, such as Land Records Management systems and digital ecosystems, have empowered farmers to address various agricultural challenges. New technologies and digitalization can help increase crop yields and improve land use efficiency. The agriculture sector recorded a remarkable growth of 4.40% in 2022–23 compared to 3.48% in the previous year, exceeding the 3.5% growth target for the year.
Digital Banking	The banking sector in Pakistan witnessed a boom, especially in the years 2021 and 2022, impacted by COVID-19, where the economic downturn has not dampened prospects for growth. Initiatives that validated the government's commitment to digital banking include the digital payment platform RAAST, the mandatory use of digital channels in tax payments to improve tax revenues, and the permission for brick-and-mortar commercial banks to open bank accounts digitally. Private banks have also started offering various online banking services. These initiatives are vital in providing banking convenience, extending banking services to remote areas, reducing the risk of counterfeit currency, and improving gender disparity in banking.
Healthcare Sector	More than 60% of Pakistan's population lives in underserved rural areas that lack medical personnel, have sparse healthcare facilities, and have high costs of treatment in private healthcare institutes. However, virtual medical consultation is now possible through digitalization. The digital revolution will help expand access to healthcare and generate employment opportunities. Moreover, digital technologies offer Pakistan the potential to improve national responses to infectious disease threats and strengthen primary healthcare, as seen during the COVID-19 pandemic. Notably, during the pandemic, the telemedicine sector experienced an 800–900% growth, empowering 3.1 million citizens with healthtech and consultations.

(Continued on next page)

(Continued from the previous page)

Sector	Summary
Digital Finance Services (DFS) and Fintech	DFS enables users to save time and costs, increase security, and perform faster payments. In the future, these services can play a significant role in fostering inclusive economic growth, improving industry value chains, enhancing socioeconomic well-being, and bringing transparency to the economy. Pakistan has a nascent DFS ecosystem, allowing Fintech to define the DFS landscape by adopting globally successful strategies. The future of the Fintech ecosystem in Pakistan holds abundant potential. Recognizing this, the State Bank of Pakistan launched a licensing and regulatory framework for digital banks in year 2023 , allowing an initial quota of five digital banks to begin operations in the country.
Education and Training	Digital education is a new approach to learning in Pakistan that employs digital tools to solve traditional educational challenges. Currently, 25 million children are out of school in Pakistan, while more than 86% of schools are in rural areas lacking Internet and mobile connectivity. To reach more learners, especially those in remote areas, e-learning schools equipped with the latest ICT tools and technologies are being implemented in different provinces.

Source: Compiled by the national expert from multiple sources [10, 11, 29, 36, 38, 39].

Success Stories in Public Sector DX

The Government of Pakistan, with the help of the Ministry of IT, National Information Technology Board (NITB), and National Database and Registration Authority (NADRA), took important initiatives driving DX in the public sector [33, 36, 40, 41]. Some of the successful case studies in the context of the Public sector are:

- Online Registration of Citizens (NADRA)
- Automation of passport office
- Safe City Projects in Lahore and Islamabad
- Digitization of Ministries (40 ministries transformed through e-Office)
- ICT implementation in the health sector (PIMS and Polyclinic Hospital)
- Online Complaint Service (Prime Minister Portal)
- Land Record Management System (Punjab/KPK)
- Automation of the Federal Board of Revenue

The Government of Pakistan is also in the process of transforming the following departments through technology:

- ERP implementation in WAPDA
- Automation of Pakistan Railway

Considering the limitations of this research in terms of time and scope, only two success stories are discussed in this chapter. Implementing new technologies in public sector organizations is always a challenging task. Past research has identified a high failure rate in transforming public sector organizations. However, the success stories of public sector organizations attract researchers' attention. This research attempts to briefly discuss the success stories of public sector organizations in Pakistan.

Case Study: NADRA

It has helped Pakistan develop a foundational, biometric-based ID system maintained in a national digital registry. Pakistan is one of the early adopters of this capability and technology. The introduction of biometric technology as a core identifying credential for the National ID Card (NIC) has helped transform other sectors like banking, vehicle registration, and pension disbursements. It also helped maintain transparency in disaster relief activities during COVID-19 and floods in the country.

The Computerized NIC (CNIC) has now been upgraded to a Smart National Identity Card (SNIC), which displays all information in the CNIC along with additional features, such as a chip and QR code containing the user's biometric data. The SNIC is being offered to all citizens of Pakistan. NADRA has successfully registered the maximum population of Pakistan, covering 99% of Punjab, 98% of KPK, 96% of Sindh, and 83% of Baluchistan.

NADRA has constantly been upgrading its infrastructure and adopting new technologies like AI, IoT, data analytics, and cloud computing. These efforts have been instrumental in transforming the country into a digital Pakistan.

Case Study: NITB

The case study examines how the Government of Pakistan transformed various ministries through the e-Office project, a flagship initiative of the Federal Ministry of Information Technology & Telecommunication. Built on an advanced technology solutions stack, e-Office transforms traditional siloed workflows into interconnected, interoperable, participatory, and synchronized processes. Developed and implemented by the NITB, e-Office facilitates 40 government ministries' transition to a paperless environment. Its primary objectives are to enhance internal operational efficiencies, increase transparency in governmental processes, and monitor and track records.

The transformation at government organizations begins with developing a comprehensive plan to strategize each aspect of implementing an e-Office to improve efficiency and effectiveness through electronic administration. NITB focuses on strategizing aspects related to team formation, exploration of inefficiencies in current processes, stakeholder involvement, survey to respective ministries, required IT infrastructure, governance of the transformation process, overcoming resistance to change, and employee training for e-Office use.

By implementing the e-Office suit, NITB completely overhauled the processes of all government ministries. They used the Business Process Reengineering approach to redesign all organizational processes radically. Additionally, 72 kilometers of optical fiber-based dedicated Internet links connect all federal divisions to a data center. The internal communication module supports all the processes related to document creation, documenting forwarding, and file movement.

DX has benefitted government ministries immensely. The benefits include:

- Savings of up to PKR300 million on stationary by achieving a paperless working environment.
- Up to 80% reduction in operating time and instant communication with internal and external organizations.
- Up to 80% increase in efficiency.

DX in the Agriculture Sector

The agricultural sector is the prime source and backbone of Pakistan's economy. Approximately 19.3% of Pakistan's GDP and 35.9% of the country's labor force are attributable to the agricultural sector (FY 2020). In the agricultural domain, Pakistan has long depended on traditional farming methods, which have caused various inefficiencies in production, resource allocation, logistics, and distribution, negatively affecting economic gains [18, 24, 25, 29, 35].

Issues and Challenges of the Agriculture Sector in Pakistan

- **Lack of ICT adoption and digitalization:** There is a lack of ICT integration in the agriculture sector and in efforts to digitalize the pre-field, in-field, and post-field stages of the value chain.
- **Lack of cohesive, enabling ecosystem:** There is a lack of integration among the stakeholders and a conducive environment, impeding the development of a flourishing ecosystem.
- **Low productivity:** Low yields are due to the lack of implementation and integration of technology, as well as over-reliance on traditional farming practices
- **Poor infrastructure and value chain processes:** Due to serious logistics and supply chain issues, 30–40% of Pakistan's fruit and vegetable crops are lost before reaching consumers.
- **Farmers' lack of knowledge and skills:** Over 30–50% of post-harvest losses in certain products are due to a lack of appropriate pre- and post-harvest management operations.
- **Quality issues at the international level:** Insufficient efforts have been made regarding the certification and branding of agricultural commodities.
- **Inadequate access to Inputs and marketplace:** Selling losses are often due to improper grading, testing, and packaging.
- **Lack of information for stakeholders:** Correct information is not available at the right time, place, and format for stakeholders.
- **Water management concerns:** Nearly 35% of water is wasted due to obsolete agricultural techniques.
- **Insufficient access to credit and financing:** Lack of financial support prevents poor farmers from adopting new technologies.

Improving agricultural productivity is a big challenge for farmers in Pakistan due to numerous factors, including their lack of awareness of technological innovations, water security and management issues, inadequate crop health analysis, insufficient R&D initiatives, gaps in education and training of farmers, reactive decision-making, outdated farming techniques, and the absence of a free market economy. The other factors include loss of soil fertility, pest attacks, lack of timely access to crucial information, shortage of agricultural resources, and climate change challenges [4, 15–17].

Farmers in Pakistan also face challenges of data scarcity, outdated farming methods, and the absence of a free market. These issues highlight the need for DX in Pakistan's agriculture sector. The next part of this research discusses the initiatives made by the public and private sectors regarding the DX of the agriculture sector in Pakistan.

Public Sector Initiatives in Agriculture

The Government of Pakistan, realizing the importance of agriculture to the country, continues to introduce policies and initiatives to boost the sector and enhance productivity. Coping with increasing demand and countering emerging challenges requires a multi-pronged approach focusing on extensive R&D, adopting modern technologies, educating farmers on these technologies, and promoting agricultural finance to provide easy access to modern tools and machinery. Some of the prominent initiatives taken in this regard are:

Agriculture Development Strategy

The agricultural development strategy for the 12th Five-Year Plan aims to improve productivity substantially and bridge the yield gap by systematically applying better inputs and technology. The overall objective is to achieve an average agriculture growth rate of 3.2% and reduce food insecurity by 30% and malnutrition by 30–50% to support the overall GDP growth trajectory.

Prime Minister Agriculture Emergency Program

Realizing the sector's potential, the government has introduced this program worth PKR277 billion to revolutionize the agriculture and livestock sectors. Objectives of the program include:

- Improvements in water availability
- Soil conservation
- Shrimp farming
- Establishing new agricultural markets

Access to Agricultural Credit

The Agricultural Credit Advisory Committee set the indicative agricultural credit disbursement targets of PKR1,350 billion for FY 2020, which is 15% higher than last year's disbursement of PKR1,174 billion.

National Integrated Pest Management Program

The National Integrated Pest Management Program was established in 2000 at the National Agricultural Research Center—Pakistan Agriculture Research Council, Islamabad. It aims to assist farmers in growing healthy crops by facilitating regular and critical field observations, as well as

providing expert guidance. By empowering farmers to understand the interactions of pests and predators, the program helps them to make informed plant protection decisions.

Agriculture Transformation Plan and Policy (2025)

The Planning Commission of Pakistan sponsored a project to develop agriculture transformation guidelines and policies to address challenges at both national and international levels. The Agriculture Transformation Plan for Pakistan has been developed after analyzing the value chains of 33 agriculture commodity clusters across the country. [18]. To enhance international competitiveness, the agriculture sector is transitioning from traditional supply-driven to demand-driven approaches through vertical integration rather than horizontal expansion of value chain activities. This transformation plan was drafted after a comprehensive review of issues pertaining to provincial, national, and international agriculture sectors.

Main Objectives of the Agriculture Transformation Plan

To address the identified issues, the Agriculture Transformation Plan aims to achieve the following key objectives:

- Enhance productivity
- Reduce post-harvest losses
- Improve export performance or reduce imports
- Improve the value chain to enhance quality in domestic and international markets
- Promote the processing of agricultural commodities as a cottage industry in rural areas
- Replace inefficient farm operations

Important Initiatives and Strategies

The transformation plan at the national level has recommended and proposed several key initiatives at both national and provincial levels, which are outlined in Table 6.

TABLE 6

STRATEGIES AND INITIATIVES DRIVING PAKISTAN'S AGRICULTURE TRANSFORMATION PLAN.

Initiatives	Summary
Establishing new commodity-specific research and development centers	To promote R&D in the agriculture sector, Pakistan proposes to set up 16 research centers in its main provinces. These centers will focus on specific crops based on their regional or national importance.
Social mobilization and networking	Social media and networking are encouraged at all levels to promote effective stakeholder communication. The formation of Farmers Enterprise Groups will help facilitate the sharing of timely information.
Promotion of contract farming	Contract farming is encouraged to ensure quality and compliance from individual farmers. The government aims to develop a regulatory framework for this purpose.

(Continued on next page)

(Continued from the previous page)

Initiatives	Summary
Capacity building of stakeholders	Providing training facilities to all stakeholders, including farmers, middlemen, transporters, exporters, service providers, nursery operators, etc., regarding the latest tools and techniques will help increase the productivity and quality of agricultural commodities. Equipped with the necessary skills, they can handle and process raw items into high-quality processed products.
Financing services for technology adoption	The agriculture transformation plan prioritizes providing financing services to farmers to facilitate their adoption of the latest tools and technologies at different phases, including pre-field, in-field, and post-field stages.
Promotion of certified nurseries	Establishing certified nurseries in different provinces will facilitate the production of genuine, healthy, and high-potential fruits and vegetables. Such initiatives will be encouraged at the provincial level in Pakistan.
Linking farmers with domestic markets	Small farmers often encounter challenges accessing the market, leading to difficulties in selling their products in urban areas. Access to information on supply-demand dynamics, prices, quality requirements, and emerging production technologies can help them better connect with the markets.
Replacing inefficient farm and value chain operations	The agriculture transformation plan suggests major changes in value chain operations to reduce process inefficiencies and costs. This includes identifying and addressing inefficiencies throughout the agriculture supply chain, recommending changes in processes and technology adoption, and redefining roles and responsibilities. Introducing technological solutions and mobile apps will be crucial in addressing supply chain challenges.
Seed track and trace system	The agriculture transformation plan proposes implementing an information system to track and trace seeds. The objective is to ensure the right seeds reach the right farmers at the right locations. This system has already been introduced and planned at the national level and has been implemented in major provinces of Pakistan.

Source: Transformation Plan 2020. https://www.pc.gov.pk/uploads/report/Transformation_Plan_2020.pdf.

Modern Technology Adoption in the Agriculture Sector

Table 7 reflects the use of advanced technologies introduced by the public and private sectors in Pakistan's agriculture sector. It also gives some information about leading startups in the sector [25–29, 34, 35].

TABLE 7

TECHNOLOGY ADOPTION IN PAKISTAN'S AGRICULTURE SECTOR.

Technology	Organization/ Department	Summary
Satellite-based crop monitoring system	SUPARCO, in collaboration with the Ministry of Food and Agriculture	A satellite-based crop monitoring system provides fast-track and accurate information on crops and covers any catastrophic situations. The agricultural mask of Pakistan was developed based on high-resolution data.
MIS for seed track and trace	Ministry of Food and Agriculture	The system ensures that the right seed is delivered to the right farmer at the right time and place.

(Continued on next page)

(Continued from the previous page)

Technology	Organization/ Department	Summary
Agriculture technology under CPEC	Pak China Economic Corridor (CPEC)	The plan aims to facilitate the transfer of agricultural technologies to agrochemicals, pesticides, seeds, and fertilizers.
Integrated Agro ECO System	Growtech Services	Provides environment-friendly digital farm solutions to improve productivity and efficiency. Its main goal is to equip every farmer with modern technology while integrating relevant stakeholders like banks, microfinance, input suppliers, supply chains, and bulk buyers.
AI in agriculture	Industrial Vision Systems	The startup uses artificial intelligence to scan fruits and vegetables through a machine that grades them and identifies defects.
Mobile platform	Ricult	Provides a mobile platform to the agriculture industry that farmers can use to procure farm input products, market their farm products, obtain credit for working capital management, and obtain agronomic services from service providers
Bakhabar Kissan	Telenor	A capacity-building platform for farmers, providing them with skills, knowledge, tools, and expertise to optimize their yield
Smart irrigation optimization solution	Radical Growth Solutions	Collects real-time data from the field to determine how much water each plant needs and delivers exactly that. The solution is suitable for any farm or crop type.
IoT-based water resource management	Aqua Agro	State-of-the-art system to enhance productivity with maximum irrigation water usage efficiency. Increases yield by 40% and saves water up to 50%.
Data analytics	Agri-Lytics	A comprehensive crop statistics generation system helps analyze data for effective decision-making.
Drones for surveillance	Qumaq	Drones are used for mapping and land inspection
ICT-Agri-value chain	Pak Agri Market	An online matchmaking and marketing platform that brings together all the stakeholders so they may connect for sale, purchase, and collaboration.

Source: Compiled by the national expert from multiple sources [25–29, 34, 35]

Benefits of DX in the Agriculture Sector

The DX initiatives introduced by various organizations have positively impacted the agriculture sector in Pakistan. Several case studies, including those conducted by Growtech Services in collaboration with Punjab Bank and other donor agencies [25], have identified the following benefits of such technologies in Pakistan's agriculture domain:

- Better ecosystem (pre-field/infield/post-field)
- Yield improvement (shown in the table)

- Information sharing among stakeholders (weather forecasts and alerts)
- Improved farmer's health through telehealth and insurance
- Water conservation through a need-based irrigation system
- Reduction in cost and inefficiencies in processes
- Reduction in emissions (due to need-based use of pesticides and fertilizers)
- Agri-commerce (facilitates selling and buying of commodities)

Table 8 reflects the overall benefits achieved after introducing major interventions in the agriculture sector. It summarizes the benefits explored through case studies.

TABLE 8

BENEFITS OF TRANSFORMATION: GROWTECH SERVICES AND PUNJAB BANK.

Case Study 1: Wheat (2021–22)	Case Study 2: Rice (2022)
• 29% reduction in use of Urea	• 30% reduction in use of Urea
• 23.7% reduction in use of DAP use	• 40% reduction in use of DAP
• 14% increase in Yield	• 15% increase in yield
	• 30% reduction in irrigation
	• 43% increase in farmers' income

Source: Growtech Services. https://www.growtechsol.com/.

Mobilizing Scenarios

The agriculture sector of Pakistan has been transformed with the help of public and private sector initiatives, as discussed above. A claim exists that digitization may change every part of the Agri-domain condition if successfully digitally transformed. However, it always needs technology adoption, encouraging agripreneurial and innovation culture, and digital skills set as enablers leading to a major transformation in existing agricultural farming systems.

Digital technology adoption in Pakistan can bring about a paradigm shift. For example, precision agriculture, enabled by sensors, drones, and data analytics, empowers farmers to make informed decisions based on the availability of real-time data and relevant proactive or reactive actions, whatever is feasible under the prevailing circumstances. This optimizes resource utilization, such as water and fertilizers, and improves crop yields. Moreover, digital platforms can connect farmers directly with markets, reducing intermediaries and ensuring fair prices for their produce. Using different technologies in the agriculture sector witnessed such benefits in Pakistan.

Traditional agricultural practices and techniques are still being followed across most areas in Pakistan, consequently causing problems and impeding agricultural growth. Farmers can only be digitally empowered if they are literate (ICT education) and are aware of the benefits of technology practice in contemporary countries that have adopted innovative technologies and reformed the work processes accordingly. Moreover, a big challenge exists for farmers living in remote areas,

unaware of the use of innovative technologies due to availability, affordability, and infrastructure, which are the backbone of ICT implementation. To overcome such challenges, there is a need to transform agricultural operations by introducing cutting-edge technologies in all the central provinces of Pakistan.

Conclusion and Recommendations

This research project successfully achieves its objectives of comprehending DX policies, trends, and technologies within the context of developing countries like Pakistan. Significant insights have been gained by comparing the country's scores and rankings on international indices with those of other APO member countries. The low rankings across most international indices underscore the need for more efforts at national and provincial levels. Despite these challenges, Pakistan has shown some improvement, particularly in the innovation index. Moving forward, Pakistan must compare and evaluate the indices and identify the areas for improvement.

Pakistan's economy has numerous challenges, including low GDP and high inflation rates. The effective use of technology across various sectors presents an opportunity to minimize these economic challenges. This research's findings underscore the significant strides made by the Government of Pakistan in formulating effective ICT policies aimed at transformation and cybersecurity at the national level. This report elaborates on the pivotal aspects of these policies.

At the national level, the transformation policies underscore the critical role of ICT infrastructure, human capital development and innovation, and fostering a conducive environment for software export and departmental automation. Notably, the transformation policies implemented by Punjab and KPK provinces through their respective information technology boards have been instrumental in delivering essential services to citizens and devising effective strategies. These strategies encompass various facets such as ICT infrastructure, health, education, ICT training, and the development of software technology parks. These two provinces have successfully rolled out various projects aligned with their strategies.

However, a notable disparity is observed in the initiatives undertaken by Sindh and Baluchistan, as evidenced by the absence of comprehensive information regarding planned efforts on their respective websites. This discrepancy may be attributed to the lack of functional and planned information technology boards in these provinces, highlighting the need for concerted efforts to establish and operationalize such entities to foster technological advancement and socioeconomic development uniformly across all regions of Pakistan.

The findings of this research also reflect the DX initiatives in Pakistan's agriculture sector. The government of Pakistan has made efforts to formulate an effective strategy for agriculture by understanding the challenges and problems faced by different stakeholders. The agriculture transformation plan (2025) has been developed to address the challenges different stakeholders face. This research discusses various initiatives undertaken by the private sector to transform the agricultural sector. It also covers the technologies used in different phases, such as pre-field, in-field, and post-field stages. The benefits of implementing these technologies include reduced cost, time savings, increased efficiency, and significant improvements in yield.

This research project also highlighted efforts to transform public sector organizations in Pakistan, showcasing some of the country's important success stories of public sector transformation.

Policy Recommendations

Following are the important recommendations.

- **Development of ICT infrastructure:** Enhance efforts to develop ICT infrastructure at national and provincial levels, ensuring fast, reliable, and affordable Internet service for all Pakistani citizens.
- **Expanding broadband services:** Broadband services should be expanded to remote areas, especially in provinces like KPK and Baluchistan.
- **Improvement in Network Readiness Index:** Improve the digital regulatory environment, ensure gendered access to the Internet, and make significant efforts to enhance service delivery from public and private organizations.
- **Alignment of ICT policies:** Align the National ICT Policy with provincial ICT policies to ensure cohesive development and implementation.
- **Establishment of technology boards:** Establish Information Technology Boards in all the provinces, including Baltistan and Kashmir.
- **Encouragement of cloud computing:** Promote the use of cloud computing facilities in public sector organizations to improve efficiency and data management.
- **Development and implementation of AI policies:** Formulate and implement a national AI policy across different sectors to harness the benefits of AI.
- **Advanced training centers:** Develop advanced training centers in all provinces to meet the future demands of IT professionals, focusing on AI, cloud computing, cyber security, blockchain, and big data.
- **Cybersecurity policies and laws:** Develop and implement robust cybersecurity policies and laws to build user trust in e-systems and facilitate the adoption of digital payment systems.
- **Integration of NADRA ID system:** Integrate the NADRA ID system with other government departments to streamline processes and enhance service delivery.
- **Development of Digital Skills:** Promote digital skills development among digital farmers and children at the school level to prepare the next generation for a digital economy.
- **Financial support for farmers:** Provide more financial support and incentives to farmers for implementing technologies in pre-field, in-field, and post-field phases of the agriculture value chain.

References

[1] Ministry of IT & Telecom, Government of Pakistan. Digital Pakistan Policy; 2018. https://moib.gov.pk/Downloads/Policy/DIGITAL_PAKISTAN_POLICY%2822-05-2018%29.pdf. Accessed on 20 June 2023.

[2] Mihai F., Aleca O.E., Gheorghe M. Digital Transformation Based on AI Technologies in European Union Organizations. Electronics; 2023, 12(11), p. 2386.

[3] Trading Economics. Pakistan Competitiveness Rank, 2019. https://tradingeconomics.com/pakistan/competitiveness-rank#:~:text=Pakistan%20is%20the%20110%20most,by%20the%20World%20Economic%20Forum. Accessed on 27 June 2023.

[4] The World Bank. GDP Growth Pakistan. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=PK. Accessed on 23 June 2023.

[5] Aaron O'Neill. Pakistan: Distribution of gross domestic product (GDP) across economic sectors from 2012 to 2022. Statista, 11 January 2024. https://www.statista.com/statistics/383256/pakistan-gdp-distribution-across-economic-sectors/#:~:text=Distribution%20of%20gross%20domestic%20product%20(GDP)%20across%20economic%20sectors%2). Accessed on 9 July 2023.

[6] Khan Z.A., Koondhar M.A., Khan I., et al. Dynamic linkage between industrialization, energy consumption, carbon emission, and agricultural products export of Pakistan: an ARDL approach. Environmental Science and Pollution Research; 2021. 28: pp. 43698-43710.

[7] UNDP. Global Knowledge Index 2020. https://www.undp.org/publications/global-knowledge-index-2020. Accessed on 3 June 2023.

[8] Pakistan ranking in the Global Innovation Index 2023. In: Global Innovation Index 2023. World Intellectual Property Organization; 2023. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023/pk.pdf. Accessed on 25 June 2023.

[9] Ministry of Commerce, Government of Pakistan. e-Commerce Policy of Pakistan, October 2019. https://www.commerce.gov.pk/wp-content/uploads/2019/11/e-Commerce_Policy_of_Pakistan_Web.pdf. Accessed on 2 Jun 2023.

[10] Punjab Information Technology Board. Digital Punjab. https://pitb.gov.pk/digital_punjab. Accessed on 11 August 2023.

[11] Information Science and Technology Department, Sindh. https://istd.sindh.gov.pk/special-initiative. Accessed on 3 August 2023.

[12] Science and IT Department, Balochistan. Available from: https://sit.balochistan.gov.pk/. Accessed on 12 July 2023.

[13] Information Technology Board, Khyber Pakhtunkhwa. Towards a digital Khyber Pakhtunkhwa. Accessed on 15 June 2023.

[14] Ministry of Information Technology and Telecommunication, Government of Pakistan. National Cyber Security Policy 2021. https://moitt.gov.pk/SiteImage/Misc/files/National%20Cyber%20Security%20Policy%202021%20Final.pdf. Accessed on 29 June 2023

[15] Fahad S., Wang J. Climate change, vulnerability, and its impacts in rural Pakistan: a review. Environmental Science and Pollution Research; 2020, 27: pp. 1334-1338.

[16] Saqib S.E., Arifullah A., Yaseen M. Managing farm-centric risks in agricultural production at the flood-prone locations of Khyber Pakhtunkhwa, Pakistan. Natural Hazards; 2021, 107: pp. 853-871.

[17] Ullah W., Nafees M., Khurshid M., et al. Assessing farmers' perspectives on climate change for effective farm-level adaptation measures in Khyber Pakhtunkhwa, Pakistan. Environmental Monitoring and Assessment; 2019, 191: pp. 1-18.

[18] Ali M. Agriculture Transformation Through Cluster-Development – Vision 2025. Ministry of Planning, Development and Special Initiatives, Government of Pakistan; 2020. https://www.pc.gov.pk/uploads/report/Modernizing_Agriculture.pdf. Accessed on 20 July 2023.

[19] IT and Telecommunications Division, Ministry of Science and Technology, Government of Pakistan. IT Policy and Action Plan, 18 August 2000. https://lgkp.gov.pk/wp-content/uploads/2014/03/National-IT-Policy.pdf. Accessed on 20 July 2023.

[20] Ministry of Planning, Development and Special Initiatives, Government of Pakistan. Pakistan Vision 2025. https://www.pc.gov.pk/uploads/vision2025/Pakistan-Vision-2025.pdf. Accessed on 23 July 2023.

[21] Ministry of IT and Telecommunication, Government of Pakistan. Pakistan Cloud Policy. https://moitt.gov.pk/SiteImage/Misc/files/Pakistan%20Cloud%20First%20Policy-Final-25-02-2022.pdf. Accessed on 5 June 2023.

[22] Life in Pakistan. National Broadband Policy. 8 February 2021. https://lifeinpakistan.net/ministry-of-it-to-roll-out-national-broadband-policy-2021/. Accessed on 10 August 2023.

[23] Ministry of IT and Telecommunication, Government of Pakistan. National Cyber Security Policy of Pakistan. https://moitt.gov.pk/SiteImage/Misc/files/National%20Cyber%20Security%20Policy%202021%20Final.pdf. Accessed on 21 June 2023

[24] Ministry of Planning, Development and Special Initiatives, Government of Pakistan. Agriculture Transformation Plan Pakistan. https://www.pc.gov.pk/uploads/report/Transformation_Plan_2020.pdf. Accessed on 10 June 2023.

[25] Growtech Services. https://www.growtechsol.com/. Accessed on 28 June 2023.

[26] Bakhabar Kisan. https://bkk.ag/. Accessed on 12 June 2023.

[27] Ministry of Food Security and Research, Government of Pakistan. https://mnfsr.gov.pk/. Accessed on 7 July 2023.

[28] Startup Grind. Building Successful Agritech Startups In Pakistan. https://www.startupgrind.com/events/details/startup-grind-islamabad-presents-building-successful- agritech-startups-in-pakistan/. Accessed on 19 July 2023.

[29] Futurology. Most Innovative Starups in Agriculture in Pakistan. https://www.futurology.life/10-most-innovative-pakistan-based-agriculture-technology-companies-startups/. Accessed on 25 July 2023.

[30] Portulans Institute. Network Readiness Index 2022. https://networkreadinessindex.org/country/pakistan. Accessed on 7 July 2023.

[31] UN. E-Government Knowledge Base (EGOVKB): Pakistan. https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/128-Pakistan. Accessed on 11 July 2023.

[32] Ignite–National Technology Fund. https://ignite.org.pk/. Accessed on 29 July 2023.

[33] Ministry of IT and Telecommunication, Government of Pakistan. National Broadband Policy 2021. https://moitt.gov.pk/SiteImage/Misc/files/National%20Broadband%20Policy%20 2021%20Consultation% 20Draft(1).pdf. Accessed on 15 July 2023.

[34] Tracxn. AgriTech Startups in Pakistan. https://tracxn.com/explore/AgriTech-Startups-in-Pakistan/. Accessed on 31 July 2023.

[35] Amin A., Nadeem U., Arshad S. AgriTech: Crafting Pakistan's Journey to Impact. Tabadlab, 6 July 2022. https://tabadlab.com/agritech-crafting-pakistans-journey-to-impact/. Accessed on 7 July 2023.

[36] Fatima H., Qazi N. Untethering from Legacy Infrastructure: Pakistan's Cloud First Policy. Tabadlab, 22 June 2022. https://tabadlab.com/pakistans-cloud-first-policy/. Accessed on 13 July 2023.

[37] Punjab Information Technology Board. Punjab Digital Policy (Draft Version) 2021–2025. https://policy.pitb.gov.pk/system/files/PunjabDigitalPolicy2021-25_DraftVersion.pdf. Accessed on 18 July 2023.

[38] Khan A., Rashid N., Fatima H. Digital Now: A Guide to Pakistan's Digital Transformation. Tabadlab, 28 April 2023. https://tabadlab.com/digital-now-a-guide-to-pakistans-digital-transformation/. Accessed on 31 July 2023.

[39] Fair Tech Institute. Unlocking Pakistan's digital potential: The economic opportunities of digital transformation and Google's contribution. https://fairtechinstitute.org/researches/unlocking-pakistans-digital-potential. Accessed on 5 July 2023.

[40] National Information Technology Board. https://nitb.gov.pk/AllProjects. Accessed on 26 July 2023.

[41] NADRA Pakistan. https://www.nadra.gov.pk/local-projects/. Accessed on 31 July 2023.

PHILIPPINES

Introduction

The Philippines, an archipelagic nation in Southeast Asia, is strategically located near three continents of Asia, North America, South America, and Oceania. It lies between the eastern and western hemispheres. Figure 1 illustrates the strategic location of the Philippines within the Asia-Pacific region.

FIGURE 1

STRATEGIC LOCATION OF THE PHILIPPINES.

Note: This figure shows a map demonstrating the Philippines' strategic position in Asia-Pacific.
Source: Adapted from the presentation Opportunities for Taiwanese Investors in Philippine Economic Zones by L.B. de Lima at Philippine Investment Seminar, Taipei, Taiwan, 27 March 2015. https://slideplayer.com/slide/4899266/. Accessed on 07 March 2024.

State of Digitalization and the IT Industry

The Philippines has earned recognition as the fastest-growing digital economy among major ASEAN member-states, experiencing an impressive 93% year-on-year expansion during 2020–21 [1]. According to a report by Google, Temasek, and Bain & Company [2], the country achieved a gross merchandise value of USD17 billion through digital transactions. The same report predicts a further expansion of the Philippine Internet economy to USD40 billion by 2025 [2].

A separate study conducted by the AlphaBeta consultancy firm [3] suggests that effectively leveraging DX could contribute PHP5 trillion (approximately USD97 billion) to the Philippine economy by 2030. As the nation aims to recover from the adverse impacts of the COVID-19 pandemic, the adoption of these digital technologies is deemed crucial for enhancing the

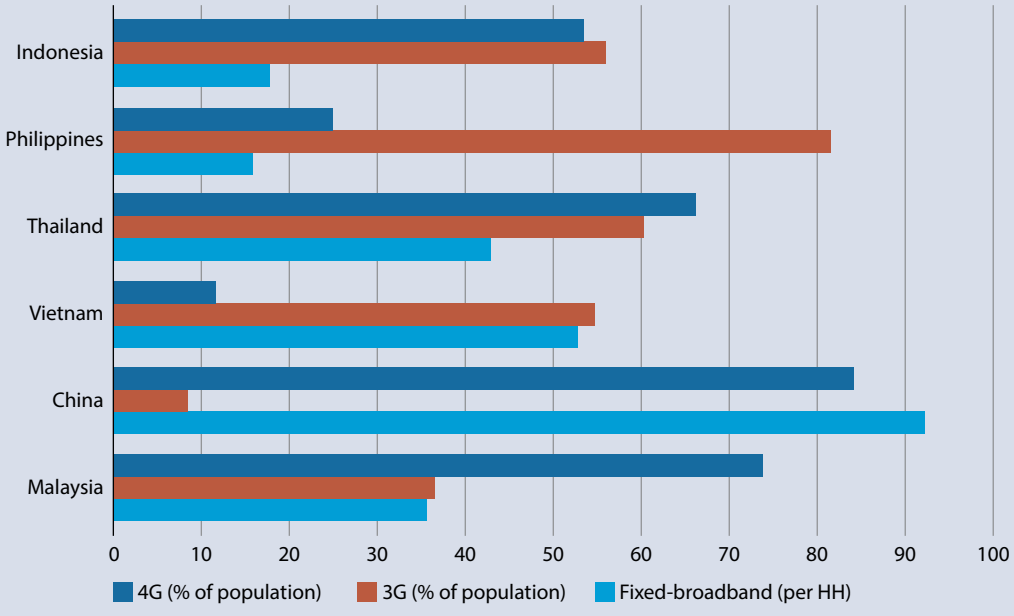
competitiveness and resilience of businesses in adapting to the evolving business environment [3]. Realizing this potential has the opportunity to drive the nation's recovery and simultaneously align with the vision of "*matatag, maginhawa, at panatag na buhay para sa lahat* (stable, comfortable, and secure life for all)" outlined in AmBisyon Natin (Our Ambition) 2040 [1].

The COVID-19 pandemic underscored the importance of digitalization for economic and social resilience. Globally, mobility and economic activities were restricted, and the Philippines was no exception. With limitations on face-to-face interactions and activities due to movement restrictions and social distancing measures, the accessibility of affordable digital technologies became crucial for resilience. Digital technologies enabled businesses, government entities, and schools to continue operations online, preventing complete shutdowns. E-commerce and digital payments facilitated ongoing business transactions and deliveries, online communication platforms supported work from home, virtual meetings, and remote classes, and many countries used online processes for swift delivery of social assistance to vulnerable households.

Unfortunately, not all countries could fully harness digital technologies due to poor access to high-quality Internet and entrenched analog practices. In the case of the Philippines, COVID-19 accelerated the adoption of digital technologies. However, the country still faced constraints due to low high-speed broadband penetration, trailing behind neighboring middle-income countries (see Figure 2). The digital divide in the Philippines was substantial, with nearly 60% of households lacking Internet access and unable to enjoy the benefits of digitalization. Consequently, face-to-face interactions and analog practices continued to dominate, leading to economic costs associated with social distancing. For instance, cash and checks remained prevalent modes of payment, and obtaining permits and licenses typically involved an exchange of physical documents. Waiting in a queue for goods and services was common in the Philippines.

FIGURE 2

HIGH-SPEED BROADBAND PENETRATION AMONG THE PHILIPPINES' PEERS (DECEMBER 2018).



Source: Based on data from Telegeography and GSMA.

Insufficient ICT infrastructure poses a significant challenge, particularly in non-urbanized regions with limited Internet access. Mirandilla-Santos [4] emphasizes the government's role in addressing areas deemed non-profitable by the private sector [4]. By the end of 2020, the National Telecommunications Commission reported 22,834 telco towers, a sharp contrast to Vietnam's estimated 90,000 towers [4]. The affordability of Internet access remains a hurdle, with high costs cited as the primary reason for 40% of Filipino households lacking Internet access [1]. Although the Philippines has made strides in reducing Internet costs, the 2% affordability target remains a challenge for the poorer 40% segment of the population [1].

A pressing concern is the need for strengthening cybersecurity, with 82% of SMEs in the Philippines expressing increased worry about cyberthreats [1]. Immediate recovery and early detection are crucial in the event of a cyberattack, an area where the Philippines needs improvement. The nation faces declining digital competitiveness, ranking as the least digitally competitive economy among middle-income ASEAN members [1]. Weaknesses in regulatory and technological frameworks, including communications technology, Internet bandwidth speed, starting a business, and enforcing contracts, contribute to this decline [1].

Low digital adoption among MSMEs is another challenge, as indicated by the Baseline Survey on MSME Digitalization [1]. While some businesses use basic ICT tools, a considerable percentage do not use any digital tools [1]. A concerted effort is needed to promote digital literacy and incentivize MSMEs to embrace advanced digital tools.

The Philippines ranks low in the Business-to-Consumer e-Commerce Index across the overall business ecosystem [1]. This points to a need for concerted efforts to enhance elements such as the percentage of Internet users, mobile-money account penetration, postal reliability index, and secure Internet servers. Further, the high cost of logistics, where about 27% of sales of a Philippine manufacturing firm goes toward logistics, presents a considerable challenge [1]. Efforts to streamline logistical processes and reduce costs are essential to enhance the competitiveness of the business environment.

Possible Measures and Threats to Productivity Improvement Through DX

The Philippine Development Plan 2023–28 outlines strategies to revitalize the local industry. One of these strategies is accelerating the digitalization and innovation among the MSMEs and startups [5]. This can be achieved by intensifying support for DX of MSMEs, which constitute more than 95% of establishments in the country, and by fostering the growth and development of startups [5].

As part of the Startup Ecosystem Mapping initiative, the Department of Information and Communications Technology (DICT) evaluates the startup environment in selected cities outside Metro Manila. This is closely linked to the Digital Cities Program, where the department identifies optimal locations nationwide for information technology and business process management companies. Furthermore, the program encourages these cities to enhance their innovation ecosystem to support local startups.

DICT is creating the One Philippine Startup Portal, an online repository for startups and entities that support startups. This portal will offer access to statistical data, annual reports, and various research studies on the startup landscape in the Philippines. Additionally, the department plans to

establish innovation studios, which will serve as collaborative workspaces with the necessary hardware and software to assist startups.

Through the ICT Industry Development Bureau, DICT also intends to introduce a funding program to support early-stage ICT-based startups and connect them with mentors and coaches. Eligible startups can apply for grants ranging from PHP500,000 to PHP1 million. These grants are open to all startups working to address societal challenges, whether they need assistance in developing prototypes for their POC or resources to create a minimum viable product.

Furthermore, the government has launched several strategies to address 21st-century trends and aims to achieve its vision of the Philippine Government Online through the Philippine Digital Transformation Strategy (PDTS) [6]. The PDTS follows previous efforts to establish an electronic or digitally ready government in the country, utilizing state-of-the-art developments in the ICT sector. These efforts include the Philippine Digital Strategy of 2011–16, the Government Information Systems Plan, the Philippine Strategic ICT Roadmap of 2006–10, and the eGovernment Master Plan of 2012.

The Philippines launched several DX strategies between 1992 and 2022. Subsequent subsections briefly discuss each plan.

National Information Technology Plan for the 21st Century (1997) 1992–98

The Philippines embraced a strategy to advance the nation rapidly, set ambitious goals, and fortify society and the economy. This strategic plan unfolded in multiple phases and hinged on collaborative efforts between the government and industry, each playing pivotal roles in actualizing the development of the country's IT sector. The government's role in IT development was centered on establishing the national information infrastructure, implementing cutting-edge IT applications, and leading key IT projects for collaboration with businesses, academia, the science and technology community, and civil society.

As outlined in the IT plan, the goal was to ensure that every business, government agency, academic institution, and household in the country should have access to technology by 2000. This involved creating a conducive policy environment, improving physical infrastructures, cultivating the IT workforce base, fostering IT industry development, instituting institutional reforms, and promoting the national IT plan for the 21st century [6]. By 2005, the expectation was for companies in the country to produce competitive IT products for the global market [6]. Additionally, the 1997 Information Technology Plan aspired for the Philippines to become the knowledge center in Asia by the first decade of the 21st century [6].

E-Philippines Strategy Government Information Systems Plan (2000) 1998–2001

Building on the prior goals of ICT development, the government information system plan, formulated by the National Information Technology Council, facilitated the establishment of policy and institutional infrastructure [6]. This encompassed defining the direction, priorities, and benchmarks for the computerization of essential government processes over the next five to ten years from 2000 [6]. The primary objective was to leverage the full potential of ICT for promoting good governance and enhancing transparency in government operations and transactions [6]. The plan entailed a methodology for identifying various information systems, recognizing gaps in government information systems, and determining suitable technology solutions to address these gaps [6].

Philippine ICT Roadmap 2006–10

This strategic roadmap was designed to establish a framework from 2006 to 2010, offering comprehensive policy direction and rationalizing decisions regarding ICT [6]. Its vision was to enhance awareness and appreciation for ICT, pinpoint key initiatives to unite stakeholders and encourage complementary efforts aligning with the government's short- and medium-term ICT development plans [6]. The roadmap aimed to create investment opportunities, articulate sustainable strategies for future ICT development, provide the private sector with a reliable reference for future planning, and enhance coordination in implementing ICT programs to achieve desired impacts and outcomes [6].

Crafted by the Commission on Information and Communications Technology, this strategic roadmap aspired to build a people-centered, inclusive, and development-oriented information society that fostered sustainable development and enhanced the quality of life for all. It aligned with the country's belief in ICT as a vital tool for economic growth and development, further emphasizing the empowerment of the nation and its citizens [6].

Numerous projects and initiatives were implemented, including efforts to ensure universal access to ICT, such as the development of the Community e-Center Program (CeC) [6]. This program addressed the digital divide among citizens by collaborating with private sectors, local governments, and civil society stakeholders to establish diverse community-based options for telecommunications and Internet access [6]. Specialized training programs tailored to specific needs were also provided to ensure the sustainability and effective operational management of these centers [6].

The iSchools project, aimed at equipping public high schools with computers featuring broadband Internet connectivity, along with educator training and technical support, reflected the Philippines' commitment to enhancing digital access and education [7]. The Business World report of 2019, cited by Trecene and Abides in 2020, highlighted the Philippines leading the global ranking for the highest Internet usage [8]. eCare centers focused on providing access and training for persons with disabilities, eLGU CeCs enhanced local government services and Internet access, and Regional ICT Centers drove regional development through ICT in education [7].

The strategic roadmap encompassed various initiatives, including developing human capital through investments in ICT competency standards and ICT for Education, promoting efficiency and transparency in government using ICT, and supporting the growth of the ICT sector [7]. Initiatives such as PC ng Bayan aimed to provide low-cost computers, and the National Broadband Plan ensured adequate bandwidth for ICT development [7].

The roadmap underscored the importance of resources and initiatives to sustain competitiveness. It sought to enhance business competitiveness globally through strategic development and ICT integration. As part of economic growth, the roadmap proposed the establishment of the Department of Information and Communications Technology to coordinate and implement the national ICT agenda. This involved transforming the National Telecommunication Commission into a politically independent regulatory body, enacting laws on privacy, data protection, cybercrime, and freedom of information.

Philippine Digital Strategy of 2011–16

The Commission on Information and Communications Technology formulated the Philippine Digital Strategy (PDS) spanning from 2011 to 2016, building upon the groundwork of its predecessor, the strategic roadmap. Unlike the preceding ICT roadmap, the PDS embraced a broader perspective, acknowledging the pervasive influence of ICT on the global and domestic

economy and society. It recognized ICT as an indispensable tool, akin to critical infrastructures such as transportation, water, and electricity, touching virtually every facet of society and the economy directly or indirectly.

The PDS delved into the transformative potential of ICT across key sectors like government and governance, education, the economy, employment, industries, and small businesses [7]. It explored how ICT could contribute to national development, empowering citizens, combating corruption and poverty, and reforming government practices [7]. The overarching goal of the strategy was to demonstrate how ICT could effectively address government priorities [7].

This strategic approach presented a renewed vision for ICT, envisioning the transformation of Philippine society into a competitive force in the digital economy by 2016 [7]. The development of the strategy was an inclusive process involving a diverse array of stakeholders, including government entities at all levels, private industry, and civil society [7]. It incorporated ICT best practices from other countries, aiming to leverage collective expertise for comprehensive and effective implementation.

The PDS served as a comprehensive plan detailing how the nation and its citizens could leverage ICT for advancements in governance, the economy, and overall quality of life. Emphasizing transparency in government and the efficient delivery of services, the digital strategy aimed to foster Internet opportunities accessible to all, promoting inclusive growth and contributing to poverty eradication. An essential component of the strategy involved investing in improving digital literacy, aiming to enhance overall digital proficiency across the country. Additionally, it sought to establish and promote innovation in the ICT industry and business, aligning with broader national development objectives.

Philippine e-Government Master Plan of 2012

The government's ongoing efforts to revitalize e-government, spanning from the National Information Technology Plan for the 21st Century in 1997 to the PDS 2011–16, led to the introduction of the Philippine e-Government Master Plan in 2012. This plan aimed to address the stagnant growth of e-government, particularly in policy-making and policy implementation. Designed for a four-year timeframe, the master plan sought to provide a comprehensive vision for e-government, enabling the government to respond more effectively to economic and climate changes [6]. It also aimed to introduce innovative practices within the government system to enhance efficiency and promote increased citizen engagement in the decision-making processes of the public sector [6].

The master plan outlined 15 prioritized projects, including initiatives such as bolstering e-government security, developing an electronic document and archiving system, establishing a government portal, enhancing the government information network, creating e-community centers, implementing a national disaster and safety management system, automating business activities, developing IT governance, establishing a government integrated data center, constructing a national database, implementing a government foreign system, introducing Work Net, launching government e-procurement services, implementing electronic agriculture systems, and instituting a government enterprise architecture [6].

Philippine Digital Transformation Strategy 2022

The DICT developed the Philippine Digital Transformation Strategy of 2022 (PDTS 2022) to propel the country to the next level of DX [7]. Anchored on the 2015 ASEAN ICT Master Plan

(AIM 2015), PDTS 2022 is built upon three pillars—economic transformation, people engagement, and innovation—with foundations in infrastructure development, human capital development, and bridging the digital divide [7]. The strategy is motivated by a commitment to national interests while aligning with the ASEAN economic agenda [6].

The government's initiatives within the PDTS 2022 focus on promoting DX for transparency and accountability in governance, operational efficiency, direct citizen engagement, and fostering an environment for innovation. Referred to as e-government 2.0, this strategy incorporates features such as the social web, user-generated content, the utilization of open data, and network effects through increased user engagement [8]. The goal of e-government 2.0 is to achieve genuine citizen engagement by establishing closed-loop, multi-dimensional, and multidirectional communication channels [6].

Crucial to the success of the transformation strategy is its implementation, moving beyond conceptualization to realize its full potential. It is emphasized that the government should prioritize policies that facilitate the effective execution of the DX strategy.

Transparency: Responsible Research Innovation

Despite supportive policies and initiatives, several factors hinder the growth of the digital economy in the Philippines. The country's performance in various aspects of digital connectivity falls behind that of most of its counterparts in the Southeast Asian region [9]. Inadequate digital infrastructure is a significant obstacle to the development of smart cities and a key reason for the country's delay in DX [9]. Outdated laws and regulatory hurdles obstruct infrastructure development, while bureaucratic obstacles increase the expenses associated with expanding networks [9]. The implementation of government programs aimed at providing Internet access has faced setbacks due to factors like insufficient funding, technical issues, and procurement challenges [9].

A shortage of capital poses a critical challenge for both businesses and government initiatives. The limited availability of venture capital for startups poses a threat to the growth of financial technology or fintech in the Philippines, which lags behind other ASEAN countries in terms of fundraising deals [9]. The expansion of fintech faces various constraints, including a shortage of fintech talent and inadequate tools to assess and monitor performance, hindering the Philippines' position in the global fintech landscape [9]. In the realm of smart city development, critical limitations include high development and operational costs, insufficient technical and financial support at the local government level, and a shortage of skilled workers outside major urban centers [9].

Additional concerns encompass a lack of skills and low adaptability to digital technologies. According to the 2021 PIDS-DICT Online Survey of Market and Nonmarket Work, Filipinos engaged in online platforms predominantly perform tasks at the lower end of the value chain, such as marketing/sales and clerical/data entry [9]. Further, trust issues and concerns about data privacy undermine the adoption of digital platforms and services. For instance, the Philippine fintech industry faces distrust in technology due to issues related to access points. Distrust is compounded by unreliable connectivity and the high cost of Internet access.

Policy Recommendations

The Philippines has made significant progress in developing the country's industrial sector. The following recommendations will help strengthen its digital initiatives and achieve its goals.

Key Actions

The constitution of a robust framework for fostering innovation necessitates a reasonable and systematic approach. In pursuance of this objective, the proposal recommends the designation of individuals of distinction as stalwart advocates for startup enterprises to be appointed to the National Innovation Council. This advisory body, comprising 25 distinguished members, should be chaired by the President. The ensemble includes 16 department secretaries, each contributing specialized knowledge alongside National Economic and Development Authority representatives, ensuring a comprehensive and multidimensional perspective.

The envisioned Council transcends a mere aggregation of titles; it aspires to function as a dynamic and cohesive unit, a confluence of visionary ideation, strategic policymaking, and proactive implementation. This assembly's mission is clear: to champion startup enterprises, act as custodians of innovative ideas, and orchestrate progress through collaborative endeavors and prescient foresight.

However, the efficacy of this proposal hinges not only on the theoretical underpinnings but, more crucially, on the precision of its execution. Hence, the Council is tasked with overseeing the implementation of two seminal legislative acts: the Innovative Startup Act and the Philippine Innovation Act. These legislative frameworks transcend the status of mere statutory instruments; they represent architectural designs for a future where innovation exists and thrives. The National Innovation Council, distinguished by its collective expertise, thus metamorphoses into more than an advisory body, emerging as a catalytic force, transforming legislative intent into tangible, transformative action.

In this scenario, startup enterprises are not merely envisaged to subsist; they are projected to burgeon and flourish. In this formalized framework, innovation transcends the realm of rhetorical flourishing to become an embedded ethos. The National Innovation Council, fortified by its advocates and propelled by an unwavering commitment to progress, positions itself at the vanguard, sculpting a paradigm where innovation's seeds burgeon into towering success edifices. It is not merely a council but an orchestrated symphony of ambition—a harmonious crescendo propelling the nation toward a future of ingenuity and progress.

Programs and Regulations

Perpetually monitor and meticulously optimize newly instituted programs to ascertain and augment their effectiveness. This iterative process, characterized by a commitment to ongoing evaluation and refinement, ensures that initiatives remain dynamic, responsive, and aligned with evolving objectives.

Establish a co-financing arrangement where the national and local government units actively participate to foster local ecosystems. This collaborative financial model seeks to provide sustained support and investment in regional innovation hubs, thereby nurturing the organic growth of local ecosystems. Such a symbiotic approach ensures that resources are strategically pooled, leveraging the strengths of both levels of government for a more robust and inclusive impact.

Advocate for simplifying prerequisites governing grant programs to alleviate administrative burdens and enhance accessibility. This initiative aims to catalyze greater participation from diverse stakeholders by rationalizing and streamlining the application process, fostering a more inclusive and agile environment for potential beneficiaries.

In pursuing administrative modernization, emphasize the need for expeditious digitalization across regulatory frameworks, program management, and procurement processes. This entails a comprehensive overhaul, integrating digital technologies to enhance efficiency, transparency, and accessibility. Such DX accelerates processes and creates a more agile and responsive administrative apparatus.

These proposed measures collectively represent a strategic blueprint for administrative refinement and innovation. The commitment to continuous improvement, collaborative financing, streamlined processes, and DX aligns with the overarching objective of fostering a conducive environment for sustained growth, innovation, and development.

Incubators and Accelerators

Pursue an unwavering commitment to establishing and maintaining high-quality standards within newly instituted incubators. This commitment involves a meticulous approach to curating and sustaining an environment that fosters innovation, creativity, and strategic growth. It implies adherence to established best practices and a proactive endeavor to set new benchmarks in the incubation landscape. The focus is not solely on quantity but, more critically, on the qualitative impact these incubators can impart to burgeoning startups.

Promote and incentivize the development of accelerator programs tailored explicitly to startups in the advanced stages of their evolution. Acknowledge the diverse needs and challenges these mature startups face and tailor accelerator initiatives to address their unique requirements. This strategic emphasis on advanced-stage startups recognizes their potential to contribute substantially to economic development and innovation. It also acknowledges these startups' distinct challenges, from scaling operations to market expansion, and endeavors to provide targeted support through specialized accelerator programs.

In essence, the dual commitment to high-quality standards in incubators and the promotion of tailor-made accelerator programs signifies a holistic approach to nurturing startups across the spectrum of their growth. It's not just about creating spaces for innovation; it's about crafting environments that catalyze success, empower advanced-stage startups, and contribute to the vibrancy and sustainability of the broader entrepreneurial ecosystem.

Digital Infrastructure and Literacy

Broaden the reach of economical digital services to ensure that a wider demographic can partake in the benefits of the digital age. This involves not only making digital services financially accessible but also strategically expanding their availability to reach underserved and marginalized communities. The goal is to democratize access, breaking down economic barriers and ensuring that the advantages of the digital realm are accessible to all, regardless of socioeconomic status.

Advance digital inclusion through targeted initiatives designed to enhance digital literacy. Recognizing that access alone is insufficient, these initiatives focus on equipping individuals with the necessary skills and knowledge to navigate and leverage digital technologies effectively. This encompasses training programs, educational campaigns, and community outreach efforts to bridge the digital divide. These initiatives empower individuals to use digital services and participate actively and confidently in the digital ecosystem by fostering digital literacy.

The dual strategy of expanding access to affordable digital services and fostering digital inclusion through improved digital literacy represents a comprehensive approach to bridging the digital

divide. It's not just about providing the tools; it's about ensuring that individuals have the skills and knowledge to harness the transformative power of digital technologies for personal and collective advancement. This two-pronged approach is integral to creating a more inclusive, equitable, and empowered digital society.

Procurement and Endorsement

Initiate comprehensive awareness campaigns to disseminate information about the Philippine Government Electronic Procurement System (PhilGEPS), the designated public procurement platform. This involves informing key stakeholders and proactive outreach to various sectors, including government agencies, private enterprises, and potential suppliers. The objective is to create a widespread understanding of PhilGEPS' functionalities, benefits, and streamlined processes it offers for public procurement. By fostering awareness, the government seeks to enhance transparency, efficiency, and accessibility in public procurement procedures, promoting a more accountable and inclusive procurement ecosystem.

Elevate the level of support dedicated to health technology startups through strategic endorsements. This support entails financial backing and official recognition, mentorship, and endorsement from relevant authorities. By garnering official endorsements, health technology startups gain credibility, visibility, and access to a broader network of opportunities. This multifaceted support is designed to catalyze growth, innovation, and sustainability within the health technology sector, ultimately contributing to advancements in healthcare solutions and bolstering the overall ecosystem for startups in this critical domain.

In essence, the combined efforts of raising awareness about PhilGEPS and boosting support for health technology startups represent a synergistic approach towards fostering transparency in public procurement and driving innovation in a vital sector. It's not just about creating awareness; it's about building bridges of support that empower startups and contribute to the nation's overall economic and technological progress. These initiatives align with a broader vision of efficient governance and dynamic entrepreneurial growth, reinforcing the pillars of a thriving and forward-looking society.

Incentives for Investors

Introduce a comprehensive tax credit incentive tailored specifically for early-stage startup investors. This initiative stimulates investment in burgeoning entrepreneurial ventures during their nascent phases. The tax credit serves as a strategic encouragement, recognizing the inherent risks associated with investing in early-stage startups and aiming to offset these risks by providing financial incentives to investors. This measure attracts capital to fuel startup growth by fostering a conducive investment environment. It bolsters the broader ecosystem by incentivizing individuals and entities to participate in the vital early stages of startup development.

Mitigate the imperative for startups to undergo registration in foreign jurisdictions by streamlining and optimizing domestic registration processes. This involves meticulously reviewing and restructuring existing bureaucratic frameworks to minimize red tape and procedural complexities. The goal is to create an environment where startups find registering domestically more feasible and advantageous, thus retaining intellectual property, fostering local economic contributions, and simplifying compliance requirements. This strategic reduction in the necessity for foreign registration not only eases the operational burden on startups but also contributes to developing a robust and self-sustaining domestic entrepreneurial landscape.

In summary, the tandem implementation of a tax credit for early-stage startup investors and the reduction in the necessity for startups to register abroad embodies a holistic approach to nurturing a thriving startup ecosystem. It's not merely about attracting investment or simplifying registration; it's about creating an environment that actively supports the growth and sustainability of startups while concurrently positioning the domestic landscape as an attractive hub for innovation and entrepreneurial endeavors. These initiatives reflect a commitment to fostering a business-friendly environment and fortifying economic growth and innovation pillars.

Talent Development

Implementing a voucher system entails the introduction of a structured incentive mechanism to encourage students to enroll in STEM courses. The voucher system is a financial incentive, providing students tangible benefits such as reduced tuition fees, scholarships, or educational credits. The goal of aligning these incentives with STEM education is to attract more students to these crucial disciplines. This approach addresses potential financial barriers and serves as a motivational tool, emphasizing the societal importance and future career prospects associated with STEM fields. The voucher system thus becomes a strategic investment in cultivating a talent pool that can contribute significantly to technological advancements and innovation.

Integrating STEM components into agricultural curricula in senior high schools and vocational institutes involves a holistic approach to education that recognizes the interdisciplinary nature of modern agriculture. This integration goes beyond traditional silos, infusing agricultural education with elements of science, technology, engineering, and mathematics. Students learn the practical aspects of agriculture and acquire a profound understanding of the scientific principles, technological tools, and engineering practices that underpin modern farming. This integration ensures that graduates have hands-on agricultural skills and a STEM-oriented mindset, enabling them to adapt to evolving agricultural technologies and contribute to sustainable farming practices.

In essence, both initiatives represent proactive strategies to enhance the quality and relevance of education in key sectors. The voucher system strategically attracts students to STEM disciplines, addressing potential barriers. At the same time, integrating STEM components into agricultural curricula ensures that future professionals in agriculture possess a comprehensive skill set aligned with the demands of contemporary farming practices. Together, these measures lay the foundation for a skilled workforce that can drive innovation and advance critical sectors in the nation's development.

Conclusion

The comprehensive set of proposals outlined above paints a picture of a nation committed to progressive and strategic development across multiple fronts. Each initiative is crucial in the mosaic of a forward-thinking society, from cultivating innovation in startup ecosystems to enhancing digital services, promoting STEM education, and streamlining administrative processes.

The envisioned National Innovation Council, with its diverse and expert membership, stands as a testament to the commitment to innovation at the highest levels of governance. It is not merely an advisory body but a dynamic force poised to transform legislative intent into tangible progress.

Simultaneously, the emphasis on digital services and literacy, along with the tax credits for early-stage startup investors, creates an environment conducive to technological growth. By reducing

bureaucratic complexities and incentivizing investment, the nation is positioning itself as an attractive hub for innovation and entrepreneurship.

The strategic moves to incentivize STEM education through a voucher system and integration into agricultural curricula underscore a commitment to nurturing a skilled workforce. This workforce is equipped with the technical expertise required by emerging industries and possesses a mindset attuned to adaptability and innovation.

These initiatives collectively represent a holistic approach to nation-building that prioritizes innovation, inclusivity, and adaptability. The envisioned future is not just about economic growth but about fostering a society where the benefits of progress are accessible to all, education is a catalyst for empowerment, and innovation is the heartbeat of a thriving, forward-looking nation. It is a blueprint for a future where every sector, from startups to education, digital services to agriculture, plays a harmonious role in steering the nation toward sustained growth, resilience, and global prominence.

The constraints of the pandemic have expedited DX in anticipation of the 4IR, which is driven by digital technologies. To advance e-commerce, the focus is on reinforcing DX programs, particularly the E-commerce Philippines Roadmap 2022, led by the Department of Trade and Industry. This roadmap aims to enhance e-commerce contributions by creating a secure and efficient ecosystem. Establishing a legal framework for Internet transactions, including an Internet Transactions Act, is proposed to regulate online activities and protect consumers.

Utilizing existing digital partnership agreements, such as the ASEAN Agreement on Electronic Commerce and ASEAN Digital Integration Framework, is emphasized for seamless cross-border transactions. The Bangko Sentral ng Pilipinas's (BSP's) collaboration with the Monetary Authority of Singapore aims to link payment systems for efficient cross-border transfers. Implementing the BSP's Digital Payments Transformation Roadmap 2020–23 is recommended to boost digital payments. A Digital Payments Act is proposed to mandate government entities to prioritize digital transactions. Consumer protection is highlighted through the Financial Products and Services Consumer Protection Act, ensuring trust in financial inclusion.

Cybersecurity measures, including the National Cybersecurity Plan 2022, are crucial to safeguarding critical infrastructure. Legislation on SIM card registration aims to deter crimes and balance security and privacy rights. The importance of consumer protection programs and budget allocation for cybersecurity initiatives is emphasized.

Enhancing the overall digital environment involves adequate funding for the National Broadband Plan to improve Internet speed nationwide. The Free Public Internet Access Program aims to bridge the digital divide, but efforts should prioritize geographically isolated areas. The government remains pivotal in ensuring consumer protection, fostering inclusion, and creating a secure and competitive digital business environment.

References

[1] Mendoza A., Macadato M. The growing Philippine digital economy: A focus on ecommerce and digital payments. CPBRD Notes, June 2022. https://cpbrd.congress.gov.ph/images/PDF%20Attachments/CPBRD%20Notes/CN2022-01_The_Growing_Philippine_Digital_Economy.pdf. Accessed on 7 March 2024

[2] Google, Temasek, and Bain and Company. Reaching new heights: Navigating the path to profitable growth; 2023. https://services.google.com/fh/files/misc/philippines_e_conomy_sea_2023_report.pdf. Accessed on 7 March 2024.

[3] AlphaBeta for Google. The growing digital economy in the Philippines: Opportunities, challenges, and Google's contributions; October 2021. https://cdn.accesspartnership.com/wp-content/uploads/2023/01/philippines-economic-impact-report.pdf. Accessed on 7 March 2024.

[4] Mirandilla-Santos M.G. Bridging the digital infrastructure gap: Policy options for connecting Filipinos. Policy Notes, PIDS; September 2021.

[5] National Economic and Development Authority. Philippine Development Plan 2023–2028. Pasig City; 2023. https://pdp.neda.gov.ph/philippine-development-plan-2023-2028/. Accessed on 7 March 2024.

[6] Alampay E.A. Harmonizig e-Government initiatives in the Philippines: A collaborative institutional framework. In: 7th International Conference on Theory and Practice of Electronic Governance; 2013, pp. 260–263. https://dl.acm.org/doi/pdf/10.1145/2591888.2591935. Accessed on 7 March 2024.

[7] Trecene J.K., Abides R.J.P. A study on the variations of internet usage among male and female BS Information Technology students. In: International Journal of Advanced Engineering and Management; 2020, 5:1, pp. 12–17.

[8] Boughzala I., Janssen M., Assar S. Eds. Case studies in e-government 2.0: Changing citizen relationships. Springer, 2014.

[9] Philippine Institute for Development Studies and International Development Research Centre. Critical issues in the Philippine digital economy, Quezon City, 2023.

SRI LANKA

Introduction

The ancient Sri Lankan economic system was characterized by agricultural and industrial production. Rock inscriptions indicate that various goods, including salt, rice, cotton clothing, ceramics, metal goods, freshwater and brackish fish, were traded under the local barter system. In the unique feudal system of Sri Lanka, kings held ownership of all land in the kingdom. Their heirs managed their allotted regions to protect peasants, increase production, and levy taxes on behalf of the state. The feudal system's philanthropic nature towards the country and its economy ensured that trade and agriculture received official patronage.

Sri Lanka's historical economic sectors have evolved over the years, reflecting the island nation's rich cultural and trade heritage. In ancient times, the agriculture sector played a pivotal role, with rice cultivation forming the backbone of the economy as early as 1000 BCE. By 1153 AD, Sri Lanka was known as the Granary of the East for exporting rice to several Southeast Asian nations, earning significant foreign exchange and demonstrating the high standards of its economy and production for trade. The maritime Silk Road brought prosperity to Sri Lanka through international trade, particularly in spices, gemstones, and ivory during the medieval period.

The colonial era marked a significant shift in Sri Lanka's economic landscape with the emergence of plantation economies. In the 19th century, the British introduced cash crops such as tea and rubber, shaping Sri Lanka's export-oriented agriculture. This period was a turning point in Sri Lanka's economic history, setting the stage for the post-independence era, where industrialization gained momentum, marked by the development of the textile, manufacturing, and services sectors. Throughout this historical trajectory, Sri Lanka has navigated economic shifts. In recent years, sectors like tourism, foreign employment, and IT have gained prominence, contributing to the country's economic landscape.

This research report delves into the key trends and developments within essential sectors, highlighting how digitalization is ushering in a new era of growth, efficiency, and accessibility in the island nation. It emphasizes increasing productivity and ensuring sustainability through evidence-based policy and decision-making.

Current Trends in the Sri Lankan Economy

Even though the agriculture, industry, public, and service sectors have historically influenced the economy in Sri Lanka, there has been a longstanding consensus that the country's economic development trajectory is moving away from agriculture, gravitating towards the manufacturing and services sectors. In recent years, Sri Lanka has witnessed a remarkable shift towards embracing DX across various sectors, including industry, agriculture, services, and the public sector.

As the nation grapples with the challenges and opportunities of the digital age, many emerging trends have begun to shape and redefine these sectors. From integrating Industry 4.0 technologies in manufacturing to precision agriculture practices revolutionizing the farming landscape, the government's

pursuit of comprehensive e-governance initiatives, and the rapidly expanding digital services and e-commerce ecosystem, Sri Lanka's DX journey is a dynamic tapestry of innovation and adaptation.

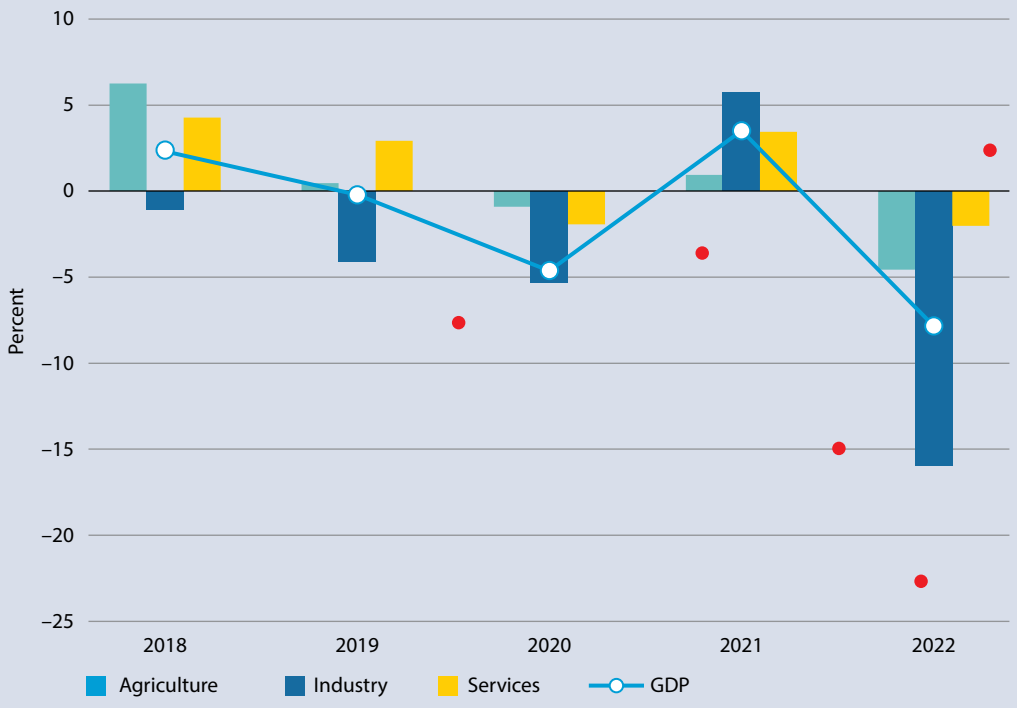
The Government of Sri Lanka and other key stakeholder institutions have kept working to improve the digital infrastructure to facilitate the digital transformation of the economy. A strong growth trend was observed in the telecommunication industry during the first half of 2022, primarily motivated by the persistence of web-based methods for employment, online education, and other digitalized everyday actions implemented immediately after COVID-19. Further, the pandemic has hastened the adoption of digital technologies, with many businesses and people relying on online platforms for communication and work.

In 2022, the Sri Lankan economy experienced its most significant economic decline since gaining independence in 1948. This decline was primarily a result of the widespread economic crisis triggered by both domestic and global challenges with political instability, which in turn reversed the progress made during the post-pandemic recovery period. According to provisional estimates from the Department of Census and Statistics, the country's GDP in 2022 shrank by 7.8%, a sharp contrast to the 3.5% growth observed in 2021 [1]. This contraction in the economy can be attributed to longstanding macroeconomic weaknesses, notably the persistent twin deficits characterized by ongoing budget shortfalls and external current account deficits.

These weaknesses were exacerbated during 2022 due to delays in addressing the imbalances over the years, particularly in recent times. Additionally, poorly timed and inadequately implemented

FIGURE 1

ANNUAL GDP GROWTH RATE OF SRI LANKA (2018–22).



Source: Central Bank of Sri Lanka (CBSL), 2023.

reforms in areas such as taxation and agricultural policies played a key role in this situation. The shortage disrupted supply chains and prolonged power outages, led to a scarcity of raw materials due to import constraints, and resulted in a surge in production costs. These factors contributed to this economic trend [1].

The Sri Lankan economy experienced a notable expansion of 37.2% year-on-year in 2022, compared to a growth rate of 12.3% in the previous year. This expansion was primarily attributed to a significant deflator during the year. However, when measured in US Dollar terms, the overall size of the economy contracted to USD77.1 billion in 2022, down from USD88.5 billion in 2021. This decline was primarily due to a substantial depreciation of the exchange rate. Consequently, per capita GDP declined, dropping from USD3,997 in 2021 to USD3,474 in 2022 [1].

Figure 1 depicts the GDP growth trajectory from 2018 to 2022, including the contribution of the Agriculture, Industry, and service sectors. The negative GDP growth necessitates quick action to turn the trend towards positive growth in these sectors. Sri Lanka possesses significant potential to shift its economy towards the digital economy. It is imperative to swiftly embrace advancement in the global digital arena to fully leverage the benefits of the digital era and support the anticipated economic rebound.

Key Factors Contributing to the Economic Decline in Sri Lanka

In 2022, Sri Lanka experienced an economic crisis characterized by a combination of poorly timed and inadequately implemented reforms, particularly in taxation and agricultural policies. Some other key factors also contributed to this economic decline.

Poorly Timed Tax Reductions

In the latter part of 2019 and the commencement of 2020, antecedent to the onset of the COVID-19 pandemic, the government instituted substantial tax reductions to fulfill an electoral commitment. This initiative resulted in the attrition of an estimated one million taxpayers from 2020 to 2022, presenting a formidable challenge for an economy already grappling with pervasive tax evasion. This consequential reduction in the taxpayer base significantly impedes the fiscal landscape, exacerbating pre-existing concerns related to widespread non-compliance with taxation regulations.

During 2019–20, several direct and indirect taxes were amended. The Value Added Tax (VAT) was reduced from 15% to 8%, while the 2% Nation Building Tax (NBT) was abolished. However, NBT has been combined with the Ports and Airport Levy at a rate of 10%. The tax on telecommunication tariffs was reduced to 25%. The economic service charge, debit tax on banking and financial institutions, capital gain tax on share markets, VAT on sovereign property, pay-as-you-earn tax, withholding tax on interest income, and other credit service taxes were eliminated. As a result of these tax reductions, the General Treasury experienced a loss in tax revenue of approximately LKR600–800 billion [3].

The budget deficit saw a notable expansion, reaching 11.1% of GDP in 2020 and further increasing to 12.2% in 2021, compared to 9.6% in 2019. This surge was primarily attributed to tax reductions, the impact of COVID-19 on revenue generation, and pandemic relief measures. Consequently, the government debt-to-GDP ratio rose from 86.9% in 2019 to 100.6% in 2020 and 104.6% in 2021. This trend has led to the region's lowest revenue-to-GDP ratio.

Throughout 2020 and 2021, the economy experienced net repayments to foreign creditors, resulting in the entirety of the budget deficit being covered by domestic sources, notably CBSL. The substantial reliance on monetary financing from the central bank has exacerbated both inflation and exchange rate challenges. Given the critical nature of this situation, fiscal consolidation, entailing measures for revenue augmentation and prudent expenditure management, is necessary [3].

Reforms in Agricultural Policies

Agricultural policies also played a crucial role in the crisis. The government introduced reforms without adequate planning and stakeholder consultation to address specific agricultural challenges. This disrupted the agricultural sector, affecting the livelihoods of farmers and leading to food scarcity. The mismanagement of agricultural policies directly impacted the sector and had cascading effects on related industries and the overall economy.

After the presidential election of 2019, the Government of Sri Lanka articulated a ten-year vision to transition the country into a state of comprehensive organic farming. However, in April 2021, the government imposed a complete ban on the import of agrochemicals. This initiative aimed to mitigate the health repercussions of using chemical fertilizers and pesticides in agriculture while concurrently fostering the adoption of ecologically sustainable agricultural practices. It also served as a strategic measure to address the challenges posed by the rapid depletion of Sri Lanka's foreign exchange reserves led by diverse import activities [3].

However, one may argue that the abrupt and irrational transition to organic farming was the ultimate reason that brought Sri Lanka's economy to this stage. When making reform decisions, this offers insights to agriculture policymakers, particularly for Global South nations. The sudden shift to organic farming, while seemingly ecologically conscious, revealed hidden problems. Although this policy reform was seen as environmentally friendly, implementing new production techniques led to complex issues, resulting in significant consequences for the country's economy, deviating from the country's customary practices.

Notably, rice yield fell by 20%, leaving about 33% of farmland idle. Within just seven months, rice prices increased by 50%, necessitating imports from countries like China and Myanmar to prevent an impending food shortage due to the disturbance in the country's ability to produce enough rice domestically. The apparent result led to a reduction in forex reserves and adversely affected the foreign exchange conditions in the economy.

The tea sector, formerly a significant exchange commodity, suffered losses of over USD425 million. Between June 2021 and April 2022, Sri Lanka's foreign exchange reserves experienced a substantial decline from USD4.06 billion to USD1.92 billion. Therefore, an abrupt agricultural policy reform was another key factor contributing to the country's economic decline [3].

Collapse of Tourism

The tourism industry contributes 12% to Sri Lanka's GDP, ranking as the nation's fifth-largest source of foreign exchange earnings. However, the sector was severely impacted by power outages, excessive gasoline prices, and the worsening economic situation of the island nation. In 2018, travel earned USD4.4 billion, constituting 5.6% of GDP. During the pandemic in 2020, this percentage plummeted to a mere 0.8%. The cumulative consequence of several economic crises the country encountered one after the other is the significant impact of the tourist sector on GDP.

Besides, the downfall of the tourism industry is one of the reasons for the economic declining trend in Sri Lanka.

Approximately 250 people were killed in a series of well-planned terrorist suicide bombings in Colombo on Easter Sunday in April 2019. This had a disastrous impact on tourism. Following the disaster, many businesses remained closed for days, and travelers began to leave, resulting in fewer people traveling in May and June than in the corresponding months of the previous year. In 2020, COVID-19 led to a 50% decrease in revenue, further contributing to the decline in tourism and the economy of Sri Lanka.

The impact of the economic crisis in Sri Lanka and a severe lack of foreign exchange further exacerbated these occurrences. While travelers could potentially aid the disaster-stricken nation with its foreign exchange issues, the aftermath of crises, violence, and the declaration of an emergency endangered the sector crucial to a viable economic solution. Additionally, traveling around the nation has become more challenging due to fuel shortages, resulting in lengthy queues of motorcycles and taxis backed up at service stations as they wait for scarce gasoline. Travelers were also concerned about Sri Lanka's future due to the government's ban on social media platforms like Facebook and Twitter on 3 April 2020 [3].

The conflict between Russia and Ukraine has made matters worse for Sri Lanka and severely damaged its tourist industry. In January 2022, Russians and Ukrainians comprised over 25% or over 20,000 of all visitors to Sri Lanka, whereas in January 2018, they comprised less than 10% of all tourists. Nearly 30% of tourists in 2022 came from Russia, Ukraine, Poland, and Belarus. However, the conflict poses a threat to halting the flow of visitors. According to the Annual Statistical Reports of the Sri Lanka Tourism Development Authority, the tourism industry contributed USD3.6 billion in revenues in 2019. However, two years after the crisis hit, the revenues from the sector dropped to less than one-fifth [3].

External Debts

Without a doubt, Sri Lanka's current economic problems result from its international debt issues. First, the economy has been impacted by the complex interactions of internal and external macroeconomic factors due to the country's reliance on commercial borrowings without addressing the economy's structural weaknesses, such as decreased trade as a percentage of GDP from 33% in 2000 to 13% in 2019, low levels of foreign direct investment, and declining tax revenues, among other issues. Secondly, before Sri Lanka makes any more return commitments that will be challenging to fulfill in the upcoming years, a closer examination of the Chinese capital inflow into the nation is necessary. Indeed, international debt restructuring and credit diversification will be paramount to Sri Lanka [3].

Other Factors

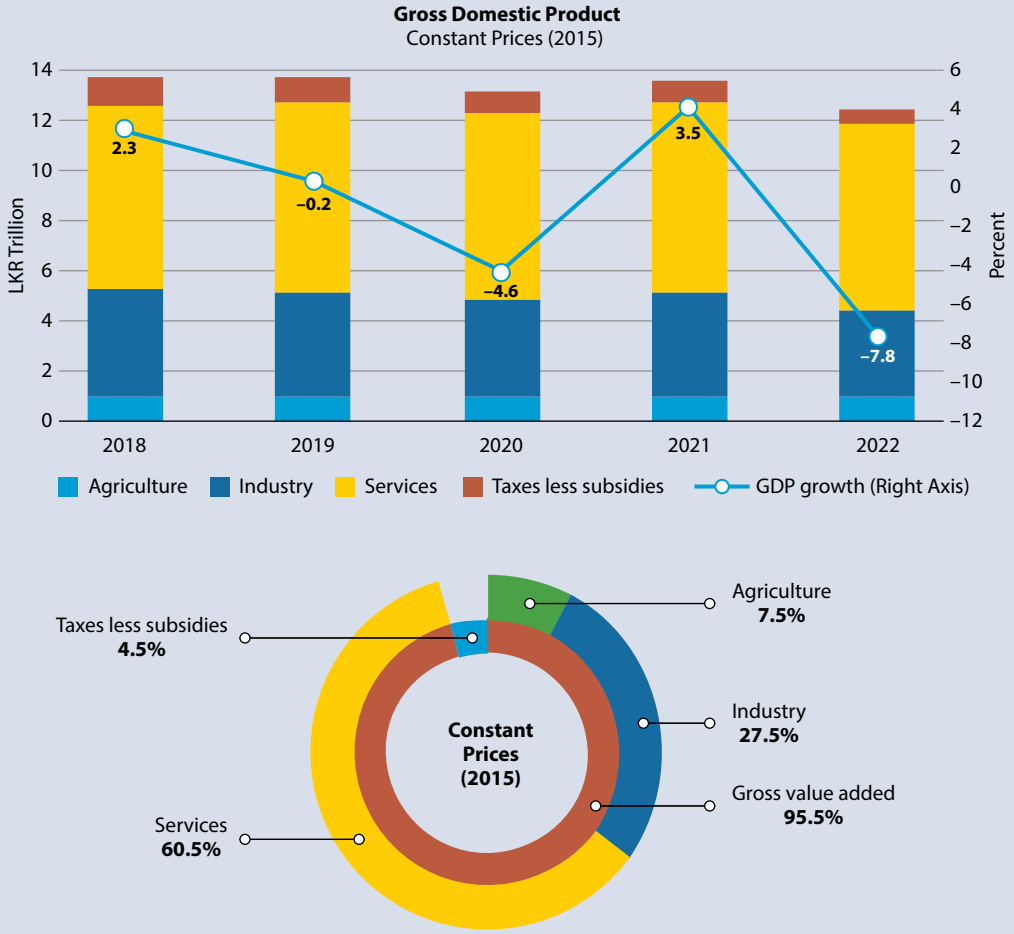
Inadequate governance and corruption also contributed to the economic decline. Mismanagement of public funds and a lack of transparency eroded investor confidence and hindered the effectiveness of economic reforms. The failure to address corruption undermined the trust of both domestic and foreign investors, hampering economic recovery efforts.

The misalignment of exchange rate policies exacerbated the balance of payments crisis in 2022. The currency's depreciation increased the cost of imports, contributing to inflationary pressures. The inability to maintain a stable exchange rate further strained the external sector, impacting the country's overall economic stability.

Scoping: Key Industry Sectors

FIGURE 2

CONTRIBUTION OF KEY INDUSTRY SECTORS IN SRI LANKA'S GDP.



Source: Central Bank of Sri Lanka, 2022.

Figure 2 shows the percentage contribution of key industry sectors to Sri Lanka's GDP. The main sectors contributing to the economy are services, industry, and agriculture.

Agriculture Sector

The agriculture sector contributed 7.5% to the GDP in 2022. Having underperformed since 2019, it saw a contraction of 4.6% compared to the previous year. This decline can be primarily attributed to severe shortages in chemical fertilizers and other agrochemicals, rising raw material costs, and disruptions in supply networks. The growth of rubber, vegetables, tea, and other cereals decreased throughout the year. However, there was an increase in the production of fruits, spices, oleaginous fruits (including coconut), forestry, logging, and agriculture support activities.

In 2022, the government implemented several initiatives to address current problems in the agriculture industry, aiming to raise the sector's long-term productivity using innovative technologies [1].

Industry Sector

In 2022, the industry sector contributed 27.5% to GDP but saw a significant contraction of 16.0% year-on-year. This decline was primarily driven by the subdued performance of the construction and manufacturing subsectors, which were severely impacted by shortages in raw materials and rising input costs. The energy crisis and tighter monetary conditions also harmed the performance of industry subsectors.

The construction subsector, accounting for 28.0% of the industry sector, experienced a substantial year-on-year contraction of 20.9%. Meanwhile, manufacturing activities, constituting approximately 59% of the total industry sector, contracted 12.6% year-on-year in 2022. Within the manufacturing sector, the production of coke and refined petroleum products and food, beverages, and tobacco products reported significant contractions of 58.2% and 14.2%, respectively. In contrast, the textile manufacturing subsector, apparel, leather, and related products registered a year-on-year growth of 8.1% in 2022. Furthermore, mining and quarrying activities also experienced a year-on-year contraction of 31% in 2022 [1].

Services Sector

The service sector was the main contributor to GDP in 2022, accounting for 60.5%. Despite the sector's resilient performance during the first quarter of 2022, as it gradually rebounded from the impacts of the COVID-19 pandemic, economic challenges that intensified later in the year hindered further expansion. This resulted in an overall contraction of 2% year-on-year in the services sector for 2022.

While subsectors such as accommodation, food and beverage, and transportation of goods and passengers showed substantial recoveries with year-on-year growth rates of 27% and 3.5%, respectively, the overall performance of the service sector was dampened by significant contractions in subsectors like wholesale and retail trade, financial services, and real estate activities throughout the year [1].

Public Sector

In Sri Lanka, the public sector has historically played a significant role in the country's economy and governance as a cross-cutting sector. However, the economic and political landscape can change rapidly, and new challenges and opportunities may occasionally emerge in the public sector.

The public sector in Sri Lanka is undergoing DX, reshaping government operations and interactions with citizens. Key trends include e-governance initiatives, data-driven decision-making, citizen-centric services, cybersecurity, and inclusive digital access. These trends reflect the government's ongoing efforts to enhance transparency, efficiency, and accessibility in the public sector [1].

Foreign Employment Sector

Worker remittances are an essential component of the economy in Sri Lanka. In 2019, remittances amounted to USD6.9 billion, accounting for 8% of GDP and 84% of the trade deficit [2]. Over the past decade, remittances have been the single largest source of external revenue for Sri Lanka. According to CBSL, the country received USD1.1 billion in remittances in 2000, USD4.1 billion in 2010, and USD7.2 billion in 2016. However, there has been a declining trend, with remittances falling to USD7.1 billion in 2017, USD7 billion in 2018, and USD6.7 billion in 2019 [2]. Despite an increase to USD7.1 billion in 2020 due to COVID-19, remittance declined to USD5.4 billion in 2021 and USD3.7 billion in 2022 for various reasons.

The average amount of remittances per household in Sri Lanka is LKR40,000 per month [4], and approximately one in every 11 households receives remittances [5]. Although worker remittances have declined recently, they remain essential to household income and the national economy. Given the country's shortage of foreign currency, a strategic approach is needed to boost remittances.

The average number of departures for foreign employment from Sri Lanka has shown significant variation over the years. It was 35,869 during the 1986–91 period, 150,483 during 1992–2001, 246,057 during 2002–16, and 211,000 during 2017–19. This increasing trend of out-migration has led to an estimated 25% of the workforce being employed in other countries [4].

The male-female ratio of international migration for employment from Sri Lanka was 60% to 40% in 2013, increasing to 66% to 34% in 2016. Departures for domestic employment opportunities for females have declined from 96,900 in 2013 to 65,127 in 2016, with 61,569 departures in 2019 [2]. However, after the COVID-19 pandemic, departures dropped drastically during 2020 and 2021 but increased to 311,161 by December 2022 [1]. Most migrant employees from Sri Lanka are classified as contract migrants due to specified term contracts. According to the data available from different government sources, there are 2 to 2.5 million Sri Lankan migrant employees in other countries [6].

Priority Sector

The analysis of current trends and contributions to the GDP indicates that the service sector in Sri Lanka holds a larger share of more than 60.5%, compared to agriculture, industry, and other sectors, within which the public sector is a cross-cutting sector. Therefore, prioritizing digitalization in the public sector to improve productivity and ensure competitiveness is essential for the country. This is also critical because the digital economy will continue as a priority sector for Sri Lanka.

Technology drives economic activity and generates growth and financial efficiencies in a digital economy. This is achieved through improved public convenience, increased connectivity, transparency, more effective resource allocation, real-time data access, and the ability to make evidence-based policy decisions to accelerate development.

As Sri Lanka has a vast public sector, digitalization should be focused on enabling it for this emerging digital era and digital economy. The emergence of digital infrastructure in Sri Lanka has led to significant advancements in the fintech, e-government, and software IT sectors. Many multinational corporations have established operations in these domains, generating new opportunities for innovation and entrepreneurship. In this regard, the government's National Digital Transformation Strategy (2021–24), built on the three pillars of digital government, digital economy, and digital services, is admirable [1].

Telecommunications is a vital platform for the digital economy. However, the sector's performance declined in the latter half of 2022, partly due to the slowdown in the demand for communications solutions that had increased during the pandemic and the overall economic slowdown.

By the end of 2022, fixed and mobile phone penetration, measured in connections per 100 people, was 12% and 142%, respectively, while Internet penetration was 97.7%. The *Gamata Saniwedanaya* project, initiated by the Telecommunication Regulatory Commission of Sri Lanka (TRCSL), aims to improve 4G coverage throughout the island to ensure seamless access to digital services nationwide. Although the original plan was to establish 276 tower sites across 10 districts between

2021 and 2024, economic crises led to the rescheduling of the project to 2026. Nonetheless, by the end of 2022, 38 tower sites had been completed and broadcast.

Additionally, TRCSL hopes to make commercial 5G services available by 2023. Meanwhile, Sri Lanka also passed a comprehensive data protection law, the Personal Data Protection Act No. 9 of 2022, in March 2022, becoming the first nation in South Asia to do so. The enactment of this law and the Data Protection Authority established in 2023 are expected to protect public data using an effective oversight and legal framework.

These initiatives and the digitalization of the public sector will boost productivity across industries, driving the country's sustainable development [1].

Gap Issues: Industrial Sector Analysis

The UN EGDI is a valuable tool for assessing the progress of e-government initiatives. The report ranks Sri Lanka 95th, placing it within the high EGDI group, with an EGDI value of 0.6285 in 2022. This composite index comprises three fundamental components: the Human Capital Index, the Telecommunication Infrastructure Index, and the OSI [7].

Specific gaps in these components have been identified in the Sri Lankan context. Challenges may exist in optimizing the skills and knowledge base necessary for effective e-governance implementation, which is important for HCI. The TII reveals areas where improvements are essential, perhaps reflecting issues related to accessibility, coverage, or technological robustness. Lastly, the OSI underscores potential gaps in the provision and quality of digital services, necessitating a closer examination of service delivery mechanisms.

This nuanced assessment highlights Sri Lanka's commendable standing within the high EGDI group and emphasizes the need for targeted interventions to address specific gaps within the three crucial components. By employing the EGDI as a diagnostic tool, policymakers and stakeholders can draft informed strategies to fortify human capital, enhance telecommunication infrastructure, and optimize online service provision, fostering a more inclusive and resilient e-government landscape.

Infrastructure and Connectivity Challenges

With a score of 0.5644, Sri Lanka is listed under the high OSI category in 2022 [7]. Within this framework, the institutional component recorded a commendable score of 0.8462, indicating a robust foundation for digital governance. Notably, the content provision aspect scored 0.6, reflecting the country's commitment to delivering diverse and substantive digital content. The service provision index stands at 0.6138, indicating a substantial capacity for rendering online services. However, a critical challenge in Sri Lanka's digital industrial transformation has been the state of its digital infrastructure and connectivity.

In assessing the TII, Sri Lanka falls within the high TII category with an index of 0.5486 in 2022. While the mobile cellular telephone subscription rate is notably high at 120 per 100 inhabitants, the percentage of individuals using the Internet remains relatively modest at 35%, presenting a dichotomy with the pervasive mobile phone penetration. Fixed or wired broadband subscriptions per 100 inhabitants stand at 8.32%, while active mobile broadband subscriptions per 100 inhabitants demonstrate a higher adoption rate of 73.27% [7].

Despite the commendable mobile cellular subscription rate, the challenge lies in the limited Internet usage, particularly in rural areas where connectivity hurdles persist. In contrast, the urban regions exhibit relatively favorable Internet access. Bridging this digital divide by expanding high-speed Internet infrastructure across all regions is imperative. This expansion is crucial to ensure that industries, especially those in remote areas, can fully harness the benefits of DX, thereby fostering inclusive and comprehensive technological advancement.

State of Digital Infrastructure and Digital Government Projects

Sri Lanka's digitalization of government services aims to create a more efficient, accessible, and transparent administration. Initiatives in digital government focus on optimizing public services to align with citizens' changing needs through strategic technology integration. Here is a list of a few such initiatives, some of which have been successful and continued while others have been shelved.

Sri Lanka Tele Centre (Nenasala) Project

Initiated in 2004 and completed in 2016, the project was a pivotal effort to bridge the digital divide in rural communities. Recognizing the transformative impact of ICT on poverty reduction, education, healthcare, and economic growth, the project established 1,000 Nenasala telecentres across South, North, and East Sri Lanka. These centers provided affordable access to computers, the Internet, and related services, empowering underserved groups like farmers, students, SMEs, women, youth, and marginalized communities.

The initiative significantly enhanced ICT literacy, fostering technology adoption in everyday life. While advanced services like e-health and e-commerce were not widespread, the project laid a foundational framework for digital inclusion and empowerment, marking a substantial step toward reducing disparities and fostering sustainable development in rural areas [8].

Public Wi-Fi Project

Initiated in January 2016, the project aimed to provide free Internet access to citizens, particularly in rural areas, and to unemployed individuals, youth, women, and marginalized populations. Despite the visionary intent and initial efforts, the project was canceled. Its overarching goal was accelerating digital inclusion, offering citizens access to vital information, services, and opportunities.

The project planned to establish over 1,000 Wi-Fi locations nationwide, integrating a Common Core User Authentication System for secure access. With over 1,400 locations created, including state universities, railway stations, hospitals, public parks, and more, the project laid the foundation for digital connectivity, promoting economic development and fostering a more equitable and prosperous society [8].

Cross-Government Document Management System.

The Sri Lankan government identified a significant challenge in its heavy reliance on paper documents across various sectors, leading to inefficient office space utilization and the risk of decay and loss of crucial records. To address this, the Information and Communication Technology Agency (ICTA) initiated the Cross Government Digital Document Management System project to digitize processes in 80 key government institutions. Despite a successful pilot phase demonstrating enhanced document management in 20 organizations, the project was canceled due to financial constraints. The initial achievements underscored the potential benefits of transitioning to a digital system but also emphasized the importance of sustained financial support for large-scale transformative projects like this [8].

Digital Government Forms Project

Initiated in 2021 and currently operational, the project represents a significant step forward in modernizing government service delivery in Sri Lanka. Through the platform forms.gov.lk, citizens can remotely access and submit various service request forms, reducing the reliance on physical visits and paperwork. The project, facilitated by ICTA, aims to enhance efficiency, promote informed decision-making through data analysis, and foster greater accessibility to government services.

Notable achievements include onboarding ten organizations during the pilot phase, with plans to expand to 40 organizations. The project's impact is evident in the increased availability of government services online, encouraging citizens to embrace digital interactions with government organizations. The initiative's ongoing success hinges on sustained funding and supportive government policies promoting continued digitization efforts [8].

Digital Libraries for Knowledge Enhancement Project

Initiated in March 2017 and concluded in June 2022, the project revolutionized the accessibility of educational resources in Sri Lanka. Addressing challenges faced by traditional libraries, such as insufficient funding and outdated infrastructure, the project established 26 digital libraries equipped with ICT tools and connected to global repositories. It aimed to counter the decline in physical library visits, particularly among the youth, by fostering easy access to electronic resources.

The project raised awareness about library services, significantly increased access to digital information and e-books, and improved reading habits. With positive impacts on revenue collection, user registrations, and digital library usage, the initiative showcased its effectiveness in bridging the gap between traditional and modern library services, catering to the evolving preferences of the tech-savvy audience [8].

e-Land Registry System

The ongoing e-Land Registry System project, initiated in 2018 as part of the broader Integrated Land Registry initiative, aims to enhance the country's investment climate and bolster its position in the World Bank's Ease of Doing Business Index. Spearheaded by National Task Forces under the Ministry of Development Strategies and International Trade, the project has been designed to revolutionize land registries by implementing a Core Document Management System, providing electronic access to land registry information, and ensuring the safety of valuable documents. With components including advanced information systems, infrastructure enhancements, and digitization of land records, the project also focuses on capacity-building programs for seamless implementation.

Anticipated outcomes encompass improved document registration processes, reduced workloads for registries, enhanced public accessibility, prevention of fraudulent transactions, and streamlined access to land information in digital format. These promise significant advancements in efficiency, security, and public service. The project reflects a commitment to modernizing land administration for sustainable and accessible urban development [8].

Electronic Revenue License System (eRL 2.0)

The eRL 2.0 project, initiated in March 2020 for the Provincial Department of Motor Traffic, underscores the government's commitment to modernizing the Electronic Revenue License system. Recognizing the limitations of the existing system, which had been operational since 2009, the project aims to address inefficiencies, including lengthy waiting queues.

Focused on providing convenience for vehicle owners, enhancing online services, and improving overall user experience, the project has successfully achieved milestones such as DSRS submission, technical design, user training, and UATs. The ongoing parallel run in two provinces showcases progress, and the vision for the future involves implementing the enhanced eRL system nationwide, reflecting a dedication to technological advancement for streamlined citizen services and administrative efficiency in motor traffic management [8].

Skills and Workforce Gaps

In 2022, Sri Lanka found itself positioned within the very high HCI group, boasting an impressive HCI value of 0.7726. This accomplishment is notably reflected in the adult literacy rate, which stands at a commendable 92.25%, attesting to the country's commitment to educational attainment and human development. Conversely, when evaluating the E-Participation Index (EPI), Sri Lanka assumes a place within the middle EPI group, securing the 107th rank. This nuanced perspective is characterized by an E-Information subindex of 0.4364 and an E-Consultation subindex of 0.5. Noteworthy, however, is the absence of E-Decision Making, registering a zero value. This divergence in rankings underscores the duality in the country's performance, excelling in human capital development but indicating room for improvement in leveraging electronic platforms for participatory governance and decision-making processes. [7]

Another significant gap was the shortage of digital skills and a trained workforce. To leverage digital technologies effectively, industries need a workforce that understands and can work with these tools. This means not only technical skills but also the ability to manage, analyze, and apply data effectively. Bridging this skills gap required investments in education and training programs.

Initiatives to Address the Shortage of Digital Skills

The transformative potential of knowledge and skills is a driving force in changing lives and fostering digital innovation. Capacity Building programs are tailored to empower individuals, organizations, and communities throughout Sri Lanka, providing them with the necessary tools and expertise to thrive in the ICT sector. A few ongoing initiatives are listed.

Career Guidance National Rollout Project

Initiated in 2021, the ongoing project addresses the critical need for awareness and preparedness in ICT-focused careers among secondary and high school students. Recognizing the pervasive knowledge gap hindering the workforce's readiness for the digital age, the project aims to disseminate information about the ICT job market, entry requirements, and in-demand skills. It focuses on empowering education officers to provide effective career guidance, introducing ICT concepts into educational curricula, and training teachers on emerging technologies.

The project strives to expose students to diverse tech careers, integrate technology into STEM education, and promote gender diversity in the ICT field. With a comprehensive scope and the involvement of key stakeholders, the initiative sets a roadmap for transforming education and fostering a skilled ICT workforce [8].

Digital Government Competency Framework Project

Initiated in April 2021, the project achieved a notable milestone by successfully completing assessments for 350 government officials. Rooted in the complexity of the government workforce with varying competencies, the project introduced a comprehensive competency framework to address the lack of a unified approach to capacity building. Led by ICTA, the initiative aims to

enhance the skills and knowledge of government officials at all levels, streamlining their active participation in digital transformation efforts.

The project's scope includes formulating the framework, developing competency assessments and tools, and conducting assessments for critical infrastructure information organizations. The collaborative involvement of stakeholders, industry consultants, and Chief Digital Information Officers underscores the commitment to fostering a digitally capable government workforce [8].

Rapid Teacher Transformation Project

Launched in 2022, the Rapid Teacher Transformation Project is a transformative initiative aimed at modernizing education in Sri Lanka by integrating digital technologies into teaching methodologies. In response to challenges such as a lack of teacher training in digital technologies and regional disparities in resources, the project aims to create a conducive environment for implementing the Digital Education Policy.

With clear objectives, including the formulation of a comprehensive teacher competency framework, the project has made significant progress, completing curriculum development for multiple levels and successfully training over 900 teachers. Collaborating with stakeholders like the country's Ministry of Education and UNICEF, the project showcases a concerted effort to bridge the digital divide and enhance the quality and accessibility of education across the country [8].

National Freelancer Development Endeavor in Sri Lanka

Initiated in 2022 by ICTA, the initiative addresses the evolving global labor market, particularly in the ICT and IT-enabled services sector. Recognizing the significant economic contributions of freelancers, the project aims to empower the youth in Sri Lanka with the skills and digital competencies necessary for success. With clear objectives, including a target of USD3 billion contribution to the national digital economy by 2024, the initiative outlines strategies such as capacity building, establishing a freelancer forum, and training programs.

The project aims to reduce youth unemployment, increase job opportunities, improve employability in the ICT industry, and enhance collaboration among stakeholders. It emphasizes inclusivity, with diverse stakeholders and partners contributing to its success [8].

Government eLearning Platform

Initiated by ICTA in June 2017, the Government eLearning Platform (GeLP) has successfully transformed how government officials in Sri Lanka acquire knowledge and skills. Completing Version 1.0 in April 2019, the project focused on creating an adaptive learning platform and interactive digital content to meet diverse learning needs. With over 5,000 enrolled users and more than 50 courses, GeLP has made significant strides in providing relevant and up-to-date training materials.

Building on this success, Version 2.0, launched in January 2023, aims to extend the platform's reach by establishing instances in five provinces and partnering with the UNDP for enhanced capacity. The ongoing project underscores a commitment to continuous improvement and the democratization of education for government officials in Sri Lanka [8].

Lighting Digital Youth Bootcamps Project

Launched by ICTA in 2021, the project aims to empower 34,000 youths by providing them with employment-focused digital skills for the ICT industry. Targeting diverse segments of the

population, including NVQ holders, non-ICT jobholders, and school leavers, the project conducts regional boot camps in collaboration with stakeholders, fostering motivation for ICT careers and digital entrepreneurship.

The project has seen notable success, with the completion of five boot camps resulting in the creation of startups, increased membership in professional societies, and successful workforce entries. The initiative imparts valuable skills, nurtures an entrepreneurial spirit, and encourages ICT growth in Sri Lanka [8].

Tech Boost Tourism Project,

It was initiated by ICTA in July 2022 and is poised to revolutionize Sri Lanka's tourism and hospitality sector. With a focus on empowering businesses through cutting-edge technology solutions, the project aims to enhance competitiveness, drive economic growth, and promote sustainable practices. The initiative seeks to create seamless and efficient tourism experiences by raising awareness and providing practical tech solutions, strengthening the industry's reputation, and advancing its digitalization.

Partnering with key stakeholders and targeting a diverse audience, the project aspires to achieve outcomes such as improved technological capabilities, enhanced operational efficiency, increased competitiveness, and significant economic growth, thereby contributing to the overall development of the tourism sector in Sri Lanka. The success of the project will be measured through tech adoption rates, customer satisfaction, job creation, environmental impact, and revenue growth [8].

Regulatory and Policy Challenges

Sri Lanka needed a more conducive regulatory and policy environment for driving DX in industries. Outdated regulations and a lack of clear guidelines for data privacy and cybersecurity were hurdles for businesses looking to embrace digital solutions. A more supportive and innovation-friendly regulatory framework is essential to encourage investments and innovation in the digital sector.

Industry Sector Analysis

Sector A: Public Sector

This analysis delves into the evolution of the public sector in Sri Lanka, highlighting key trends driving its transformation. Understanding these trends provides valuable insights into how the public sector is evolving to meet the demands of the digital era. Until 2022, several noteworthy trends have characterized the growth of the public sector in Sri Lanka.

- **Digital transformation:** Sri Lanka gradually embraced digitalization in the public sector. Initiatives such as e-governance and digitizing government services aim to improve efficiency, accessibility, and transparency.

- **Infrastructure development:** Investment in infrastructure projects, including roads, ports, and energy, was a key focus. These projects aimed to enhance connectivity, stimulate economic growth, and improve citizens' overall quality of life.

- **Public private partnership:** The government explored PPP options to facilitate infrastructure development and service delivery. This approach aims to leverage private-sector expertise and resources for public-sector projects.

- **Social welfare programs:** The public sector continues to invest in social welfare programs to address poverty, healthcare, education, and other critical needs of the population.

- **Environmental sustainability:** The public sector is increasingly aware of environmental sustainability. Initiatives related to renewable energy, conservation, and waste management are being pursued.

- **Fiscal challenges:** Sri Lanka faced fiscal challenges, including high public debt levels. Managing these fiscal pressures while sustaining public sector growth remained a complex issue.

- **Regional development:** Efforts were being made to promote regional development, reduce regional disparities, and decentralize decision-making powers to local authorities.

- **Public administration reforms:** The government was working on public administration reforms to improve governance, reduce bureaucracy, and enhance the effectiveness of public institutions.

- **Healthcare and education:** Investments in healthcare infrastructure and education were ongoing to improve access and quality of services.

- **Foreign investments:** Sri Lanka aimed to attract foreign investments into the public sector through initiatives such as the Colombo Port City Project

The trend also highlights the central role of digitalization in enhancing government transparency, efficiency, and accessibility. E-governance initiatives have gained prominence in Sri Lanka, with the government leveraging digital technologies to streamline administrative processes, improve service delivery, and engage citizens.

Perera and Fernando [9] emphasize the impact of e-governance in enhancing government-citizen interactions and administrative efficiency in the country. Data-driven decision-making is another trend that has gained traction in the Sri Lankan public sector. Data analytics are vital in enabling evidence-based policymaking and service delivery improvements. [10]. Designing public services with citizens' needs at the forefront is essential. The focus on citizen-centric services is evident in the country's DX journey. Government initiatives aim to provide accessible and citizen-focused digital services [11].

As digitalization progresses, ensuring cybersecurity is a critical trend. Emphasizing the need for robust cybersecurity measures to protect sensitive government data and ensure citizens' trust is vital. The Sri Lankan Computer Emergency Readiness Team provides insights into cyber security efforts in the country [12]. Also, inclusivity remains a key trend, with efforts to bridge the digital divide and ensure that digital services are accessible to all citizens in Sri Lanka.

Initiatives under the National Digital Transformation Strategy were spearheaded by ICTA. As of 2022, ICTA oversaw 23 projects, including mega-scale endeavors like the Lanka Government Network 2.0, Lanka Government Cloud 2.0, Sri Lanka Unique Digital Identity Framework Project, Technology Diffusion Program, and Capacity Development for Digitally Inclusive Sri Lanka. These projects aimed to enhance the efficiency of governmental service delivery and bolster competition in the IT and BPO sectors.

Additionally, ICTA provided technical expertise for 17 projects implemented under the national strategy, marking significant progress in the communications sector. ICTA also implemented the National Fuel Pass QR code system in collaboration with two leading private-sector communication and IT companies. The system played a vital role in alleviating social tensions related to the distribution of petroleum oil in 2022 and is poised to catalyze the transition of other public services to similar digital platforms.

Sector B: Digital Initiatives in Other Sectors

TABLE 1

DIGITAL INITIATIVES ACROSS DIFFERENT SECTORS IN SRI LANKA.

Sector	Digital Initiatives	Summary
Agriculture	Goviya: e-Agriculture platform	An e-agriculture platform aimed at providing farmers with digital tools, information, and resources to enhance agricultural practices, improve crop yields, and access market information.
	Agrinet	A digital platform designed to connect farmers and agricultural stakeholders through mobile and web applications to share agricultural information, weather updates, and market data.
Industry	Industry 4.0 Initiative	Sri Lanka has been gradually implementing Industry 4.0 technologies to modernize its manufacturing sector. These technologies include automation, IoT, and data analytics in the textiles, electronics, and automotive industries.
Services	e-Commerce and Digital Payment Growth	Sri Lanka has seen growth in e-commerce platforms and digital payment solutions, which make it easy for businesses and consumers to transact online.
Health	e-Health Initiatives	Various e-health initiatives to digitize health records, expand telemedicine, and improve healthcare services. This includes implementing Electronic Health Records (EHRs) and telehealth platforms.
Education	e-Learning Platform	The COVID-19 pandemic accelerated the adoption of e-learning platforms and digital educational tools for remote and blended learning, providing online access to education.

Source: Information and Communication Technology Agency.

Initiatives and Representative Programs

TABLE 2

INITIATIVES AND PROGRAMS FOR DX IN SRI LANKA.

Subject	Initiative Program	Summary
Policy Initiatives	National Digital Government and Governance Policy	This serves as the foundation for all other related policies. It encompasses six core principles: citizen governance, citizen participation, citizen's rights, cost saving, transparency, and innovative transformation.

(Continued on next page)

(Continued from the previous page)

Subject	Initiative Program	Summary
	Digital Transformation in Education Policy	The Ministry of Education and ICTA collaborated to develop this policy, aiming to establish guidelines to equip students, faculty, and administrative staff across all three education sectors—schools, universities, and vocational training centers—with the necessary skills and knowledge to use technology and reap its benefits effectively. The policy addresses the social and professional realities of the 21st century. It resulted from a series of workshops arranged by ICTA in partnership with the Ministry of Education, business leaders, academics, and other relevant stakeholders, incorporating their thoughts, opinions, and proposals.
	Government Email Policy	The government's e-mail policy is a part of the digital government and governance policy, created after recognizing email as the primary means of communication for businesses and citizens. It promotes email use by all government employees to ensure timely, effective, and efficient communication, thereby enhancing service delivery.
	Information Classification Policy	The policy aims to recognize the value of information assets held by government agencies and appropriately classify them based on their sensitivity and importance. It provides guidelines for data sharing and accessibility while supporting information security's confidentiality, integrity, and availability principles.
	Digital Signature Policy	A significant turning point in the ICTA policy roadmap is the Digital Signatures Policy, which the government has authorized and acknowledged for implementation. The policy encourages government employees to use digital signatures to verify official documents. Since digital signatures are more reliable and secure for the confidentiality and integrity of official documents and data, their proper use would address the issues associated with manual signatures. The policy represents a significant step in supporting and enhancing the government's DX roadmap.
	Government Cloud Policy	It highlights the significance and requirement of switching to more reliable and secure data storage methods while maintaining data security from conventional methods. The policy acknowledges Cloud storage as the most appropriate and safe way for government agencies to keep storing their data while removing the risks, inefficiencies, delays, and time/cost constraints related to manual data storage techniques. To enable an efficient and successful service delivery, government organizations must make the best use of emerging technological advancements.

(Continued on next page)

(Continued from the previous page)

Subject	Initiative Program	Summary
	Digital Document Management Policy	The policy directs and encourages government agencies to move away from the conventional paper-based culture and towards digital document management to meet citizen expectations and increase productivity, accountability, efficiency, and interoperability. It offers government organizations a method for consistently creating, maintaining, sharing, and destroying electronic records.

Source: Information and Communication Technology Agency.

Mobilizing Scenarios

Digital Transformation Through National Digital Strategy

Sri Lanka aspires to become one of the digital leaders in the Asia Pacific region by fully integrating digital technologies to transform the nation's economy and society. This entails ensuring global competitiveness in entrepreneurship, innovation, and digital skills. Additionally, it promotes inclusivity and sustainability in the digital economy to guarantee that no one is left behind and all citizens benefit from the opportunities presented by the digital revolution.

Sri Lanka's National Digital Strategy will help the country establish one of the three pillars of the new economy. The strategy aims to accelerate the country's transition from a developing nation to a developed one. The strategic plan also aims to help Sri Lanka leverage digital technologies to achieve the following goals:

- Boost economic competitiveness to increase foreign exchange earnings and exports.
- Provide well-paying jobs for women, young people, and those living in rural areas.
- Deliver inclusive and reliable public service to all individuals everywhere.

Component of Sri Lanka's National Digital Strategy

The National Digital Strategy includes the thematic areas as listed in Table 3.

TABLE 3

THEMATIC AREA OF INTERVENTION UNDER NATIONAL DIGITAL STRATEGY IN SRI LANKA.

Thematic Area of Intervention	Summary	Success Indicator
Access, usage, and connectivity of broadband	Promoting universal access to inclusive, affordable, safe, and resilient connectivity and usage through effective telecommunications policy and regulation, stimulating broadband infrastructure investment, and boosting digital literacy and access to internet-connected devices.	• Universal access to affordable high-speed broadband (>100 Mbps)

(Continued on next page)

(Continued from the previous page)

Thematic Area of Intervention	Summary	Success Indicator
Digital data and services infrastructure	Maximizing the social and economic value of data by encouraging investment in data infrastructure and services, strengthening data governance, and developing integrated data management infrastructure, platforms, and analytical capabilities.	• Citizen-centric digital channel for all public services
Digital transactions	Create secure and trusted mechanisms, including identification and financial services, for people, businesses, and government to engage in transactions seamlessly, creating the basis for an inclusive, transparent, and efficient digital economy.	• All Sri Lankan people and businesses can transact online
Digital safeguards	Building and strengthening trust in digital platforms and services among people, governments, and businesses by improving privacy protections, raising cyber awareness, and building capacity to protect critical infrastructure and systems from cyberthreats.	• Ensuring critical infrastructure and businesses in Sri Lanka are secure from cyberthreat • Personal data is protected through a consent architecture
Digital industry, skills and jobs	Boosting economic growth and creating jobs by encouraging investment in ICT and ICT-enabled services industries; facilitating industry-academia partnerships to develop digital skills, talent pool, and job placement programs tailored to market demand.	• IT services exports contribute a significant share of national trade • Sri Lanka is recognized as a leading global destination for digital services • The Sri Lankan education system is in sync with the emerging technology trends
Accelerate digitization of key economic sectors	Supporting sectors to accelerate the deployment of digital technologies and utilization of data to drive innovation, increase operational efficiency, and develop more accessible, user-friendly, and productive digital products, services, and other use cases. Identify 3–5 critical sectors as beachheads to drive DX.	• SMEs and businesses across sectors adopt digital tools and technologies • Key sectors of the economy like agriculture, education, and health use digital technologies to boost productivity and innovation

Source: Information and Communication Technology Agency [8].

Transparency: Responsible Research Innovation

Responsible Research Innovation involves Identifying conflicting elements hindering digitization and analyzing risks that may become ethical, legal, and social issues, as discussed below.

Ethical

Ethical factors serve as guiding principles that navigate the complex interplay between technological advancements and societal well-being. In the dynamic digital era, they also facilitate the harmonious coexistence of innovation and ethical imperatives, including equity, transparency, and responsible governance.

As digital technologies continue to reshape societies and industries, it is imperative to address ethical questions concerning data privacy, algorithmic fairness, digital inequalities, cyber security, and responsible AI development.

Ethical Dimensions in Data Privacy

A central theme in the literature is the ethical dimension of data privacy. Johnson et al. [13] delve into the ethical considerations surrounding data collection, usage, and storage in the digital age. They emphasize the need to balance the benefits of data-driven technologies and protecting individual privacy rights.

Addressing Algorithmic Bias and Fairness

Algorithmic bias emerges as a prominent ethical concern within the digitalization discourse. Researchers like Chen and Singh [14] stress the ethical obligation to mitigate biases inherent in algorithms, particularly in domains critical to social justice, such as finance, healthcare, and criminal justice.

Bridging Digital Divides Ethically

Ethical considerations extend to bridging digital divides that perpetuate inequalities among different communities. Smith and Jones [15] highlight the ethical imperative of ensuring equitable access to digital resources, infrastructure, and opportunities for all members of society.

Cybersecurity Ethics

The ethical dimension of cyber security represents another pivotal area of significance. Anderson and Brown [16] explore the ethical responsibilities of organizations and governments in safeguarding digital systems against cyber threats while upholding principles of transparency and accountability.

Responsible AI and Ethical AI Development

The ethical development and deployment of technologies like AI have become paramount in the digital era. Scholars such as Lee and Kim [17] argue that AI technologies must adhere to ethical frameworks prioritizing human welfare, non-discrimination, and responsible decision-making.

The Impact of Legal Factors on Digitalization

Digitalization has revolutionized industries and sectors worldwide, driving innovation, efficiency, and economic growth. However, it is not without its challenges, and legal factors are emerging as significant obstacles to digitalization. This literature review provides an in-depth examination of the legal aspects that hinder digitalization, focusing on issues such as outdated regulations, data privacy concerns, intellectual property rights, cyber security, and liability. By analyzing existing research and relevant documents, this review aims to shed light on the critical role of the legal landscape in shaping the DX landscape.

Compliance Challenges with Pre-Digital Regulations

One of the primary challenges facing digitalization efforts is the need to comply with existing laws and regulations formulated in a pre-digital era. These regulations often fail to adequately address

the complexities of modern digital technologies, leading to uncertainties and compliance difficulties for businesses [18]. The lack of legal clarity and adaptability hampers the seamless integration of digital solutions across industries.

Data Privacy and Cross-Border Operations

Legal data privacy and protection frameworks vary widely across different regions, posing a significant challenge for organizations engaged in cross-border data transfers and operations [19]. The European Union's General Data Protection Regulation (GDPR) and similar laws have introduced stringent data protection requirements that necessitate compliance efforts and impact global digital operations.

Intellectual Property Rights and Innovation

Intellectual property rights, including copyright and patent laws, have the potential to either facilitate or hinder innovation and DX [20]. Balancing intellectual property protection with the need for collaboration and open innovation remains a complex legal challenge.

Cybersecurity and Liability

Issues related to cyber security and liability in the event of cyber-attacks or data breaches require clear legal frameworks, often lacking or evolving slowly [21]. The legal landscape's inability to keep pace with rapidly evolving cyber threats can expose organizations to legal and financial risks.

The legal landscape plays a pivotal role in determining the success of digitalization efforts across industries and sectors. Outdated regulations, data privacy concerns, intellectual property challenges, and cyber security issues all demand careful attention and adaptation to the digital era. Policymakers, legal experts, and businesses must work collaboratively to address these legal factors to facilitate the seamless adoption of digital technologies, and support continued innovation and growth in the digital age.

The Impact of Social Factors on Digitalization

This literature review delves into the pivotal and dynamic influence of social factors on the trajectory of digitalization within our ever-evolving digital landscape. Social factors encompass influences from user behaviors and digital literacy to societal norms and cultural attitudes toward technology. The adoption and success of digitalization initiatives are intricately intertwined with how individuals and communities interact with and adapt to digital technologies. These factors play a fundamental role in shaping the diffusion of digital innovations, influencing consumer preferences, and delineating the contours of the digital divide. Moreover, the profound impact of social factors extends to digital inclusion, influencing the equitable distribution of digitalization's benefits among diverse populations. Understanding and proactively addressing these social factors are essential for fostering a digitally inclusive and socially responsive digital era.

In the rapidly evolving digital landscape, the impact of social factors on digitalization has emerged as a pivotal and dynamic dimension. This comprehensive literature review aims to provide a holistic exploration of the multifaceted role of social factors in shaping the digitalization process. Social factors encompass various influences, from individual user behaviors and digital literacy to broader societal norms and cultural attitudes toward technology. These factors profoundly influence the adoption and success of digitalization initiatives, intricately guiding how individuals and communities interact with and adapt to digital technologies.

As digitalization continues to redefine the world, these social factors play a foundational role in shaping the diffusion of digital innovations, influencing consumer preferences, and delineating the contours of the digital divide. Moreover, their impact extends to digital inclusion, significantly affecting the equitable distribution of digitalization's benefits among diverse populations. This literature review highlights the importance of understanding and proactively addressing social factors to foster a digitally inclusive and socially responsive digital era.

Social Factors in User Behaviors

One of the central themes within the literature is the influence of social factors on user behaviors in the digital realm. Research by Johnson et al. [22] delves into how social norms and peer influences affect individuals' online behaviors and preferences, impacting the adoption of digital technologies.

Digital Literacy and Societal Norms

The role of digital literacy and societal norms in digitalization is also critical. Smith and Brown [23] examine how cultural attitudes toward technology and varying levels of digital literacy contribute to the digital divide and influence individuals' access to and use of digital resources.

Shaping the Digital Divide

Social factors have a profound impact on the digital divide, influencing who gains access to digital technologies and who is left behind. Chen and Singh [14] discuss how social factors intersect with economic disparities to create and perpetuate the digital divide, emphasizing the need for targeted interventions.

Digital Inclusion and Equitable Distribution

The literature underscores the importance of social factors in driving digital inclusion efforts. Anderson and Lee [24] explore how social factors, including community engagement and social cohesion, can promote equitable distribution of digitalization's benefits, especially in underserved communities.

This comprehensive literature review highlights the pivotal and dynamic influence of social factors on digitalization. As digital technologies continue to reshape societies and industries, understanding and proactively addressing social factors emerge as essential imperatives. These factors guide the diffusion of digital innovations, influence consumer preferences, and play a fundamental role in shaping the digital divide. Moreover, their impact extends to digital inclusion and the equitable distribution of digitalization's benefits, making them critical considerations for fostering a digitally inclusive and socially responsive digital era.

Policy Recommendations

A gap analysis of digitalization in the public sector of Sri Lanka reveals a significant divide between the aspirations for a digitally transformed government and the current challenges faced in achieving this vision. While there is a growing commitment to harnessing digital technologies to enhance government services, several issues persist. These include overcoming infrastructure limitations in certain regions, ensuring citizens' comprehensive digital literacy, and establishing robust cybersecurity measures to safeguard sensitive government data. Additionally, enhancing inter-agency data sharing and streamlining bureaucratic processes remain challenges. However, the gap analysis also underscores opportunities for improvement, such as promoting e-governance initiatives, fostering public-private partnerships, and addressing digital divides. Bridging these

gaps is essential for Sri Lanka to fully realize the potential of digitalization in the public sector, ultimately leading to more transparent, efficient, and accessible government services.

The following crosscutting areas to be considered when making policy decisions

Digital Environment

Helping governments design, construct, acquire, and manage climate-resilient infrastructure, lowering greenhouse gas emissions through the construction and operation of climate-resilient green infrastructure, and managing e-waste. This also comprises assisting governments in utilizing data and digital technologies to expedite climate change action, minimize the environmental impact, and enhance the climate resilience of digital systems and infrastructure. It also involves implementing Data, business models, and digital technologies to reduce greenhouse gas emissions, promote climate resilience, and work in several important sectors.

Social Integration

Decreasing the cost, removing social, cultural, and physical barriers, and increasing the accessibility, uptake, and utilization of digital technologies, data, and services using digital tools to improve access to job opportunities, markets, and educational prospects for everyone.

Private Investment and Fundraising

It includes coordinating large-scale private investment in digital services and infrastructure. This involves encouraging institutional, governmental, and regulatory changes to improve the favorable conditions for private investments in the digital industry and encouraging the use of risk-reduction strategies and public funding to close the gap in viability for individual digital investments.

Reforming Institutions and Laws, and Building Capacity

To ensure that the conditions are favorable for the growth of the digital economy, reform and streamline the institutional and legal frameworks. Adaptable to shifting societal goals, business models, and technological advancements. Increasing the ability of public servants and employees to plan, carry out, and spearhead the country's DX, particularly by offering superior public services and carrying out the plan

Strengthening the Identity of Sri Lanka

Sri Lanka's digital strategy is heavily influenced by its national identity. As a multicultural country with a deep cultural history and distinct identity, including and advancing these components in its digital endeavors is crucial.

Reference

[1] Central Bank of Sri Lanka, Government of Sri Lanka, Annual Report 2022. Colombo; 2022.

[2] Central Bank of Sri Lanka, Government of Sri Lanka, Annual Report 2019. Colombo; 2019

[3] Bhowmick S. Understanding the economic issues in Sri Lanka's current debacle. Observer Research Foundation; 2022.

[4] ILO. Comprehensive Analysis of Remittances Sri Lanka. ILO Country Office for Sri Lanka and the Maldives. Colombo; 2020.

[5] Weeraratne B. Migration and Remittances: Impact on Financial Behaviour of Families Left Behind in Sri Lanka. Labour and Migration Research Series No. 201, Institute of Policy Studies of Sri Lanka. Colombo; 2019.

[6] Karunaratne D.H. International Labour Migration, Remittances and Income Inequality in a Developing Country: The Case of Sri Lanka. The Housei University Economic Review; 2008, 75(4), pp. 21-65. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.835.6554&rep=rep1&type=pdf. Accessed on 5 October 2023.

[7] UN. E-Government Survey 2022. New York; 2022.

[8] Information and Communication Technology Agency. www.ICTA.lk. Accessed on 15 October 2023.

[9] Perera K., Fernando N. E-Governance in Sri Lanka: Enhancing Government-Citizen Interactions. Journal of Digital Governance and Technology; 2021, 15(2), pp. 89-105.

[10] Silva R., Rajapakse S. Data-Driven Decision-Making in Sri Lanka's Public Sector. Public Policy Review 2020; 12(4), 345-362.

[11] Jayasinghe A. Citizen-Centric Services: A Path to Effective Governance in Sri Lanka. International Journal of Public Administration; 2019, 23(3), pp. 567-583.

[12] Sri Lankan Computer Emergency Readiness Team (SLCERT). Annual Report on Cyber security Measures; 2021. https://www.slcert.gov.lk/publications/reports/annual-report-2021. Accessed on 12 September 2023

[13] Johnson A., Smith B., Davis C. Data Privacy in the Digital Age: Balancing Benefits and Risks. Journal of Digital Ethics; 2020, 8(3), pp. 123-140.

[14] Chen L., Singh R. Algorithmic Bias and Fairness in Decision-Making: Ethical Considerations. Ethics in Technology Quarterly 2019; 6(2), pp. 45-61.

[15] Smith E., Jones P. Bridging Digital Divides: An Ethical Imperative. Digital Inclusion Journal; 2021, 15(4), pp. 567-583.

[16] Anderson S., Brown M. Cyber security Ethics: Ensuring Transparency and Accountability. Journal of Cyber Ethics; 2018, 14(1), pp. 89-107.

[17] Lee H., Kim J. Responsible AI: Ethical Considerations in Artificial Intelligence Development. AI Ethics Review; 2020, 27(3), pp. 345-362.

[18] Smith J. Legal Challenges to Digitalization: Navigating the Regulatory Landscape. Digital Business Journal; 2018, 15(2), pp. 45-62.

[19] Baker A., Johnson L. Data Privacy Laws and Cross-Border Data Transfers: A Comparative Analysis. International Journal of Data Protection; 2019, 25(4), pp. 567-583.

[20] Thompson R., Williams M. Intellectual Property Rights and Their Implications for Digital Innovation. Journal of Digital Transformation; 2020, 8(1), pp. 31-47.

[21] Anderson S., White P. Cyber security Legal Frameworks: Challenges and Solutions for the Digital Age. Journal of Cyber Security Law; 2021, 14(3), pp. 225-243.

[22] Johnson A., Smith B., Davis C. Social Norms and User Behaviors in the Digital Age. Journal of Digital Society; 2019, 7(2), pp. 89-105.

[23] Smith E., Brown M. Digital Literacy and Cultural Attitudes: Implications for the Digital Divide. Digital Inclusion Journal; 2020, 16(1), pp. 45-62.

[24] Anderson S., Lee H. Social Factors and Digital Inclusion: Promoting Equity in Digitalization Efforts. Digital Equity Review; 2021, 24(4), pp. 345-362.

THAILAND

Introduction

Embracing DX is imperative for every country to maintain competitiveness and sustain economic growth. The COVID-19 pandemic has ushered in a wave of digital disruption across every sector. While numerous individuals and organizations have adeptly embraced digital technology and flourished, a substantial portion still faces challenges in adaptation. Various factors drive this divide; some encounter restricted access to digital devices, while others struggle to harness digital tools effectively.

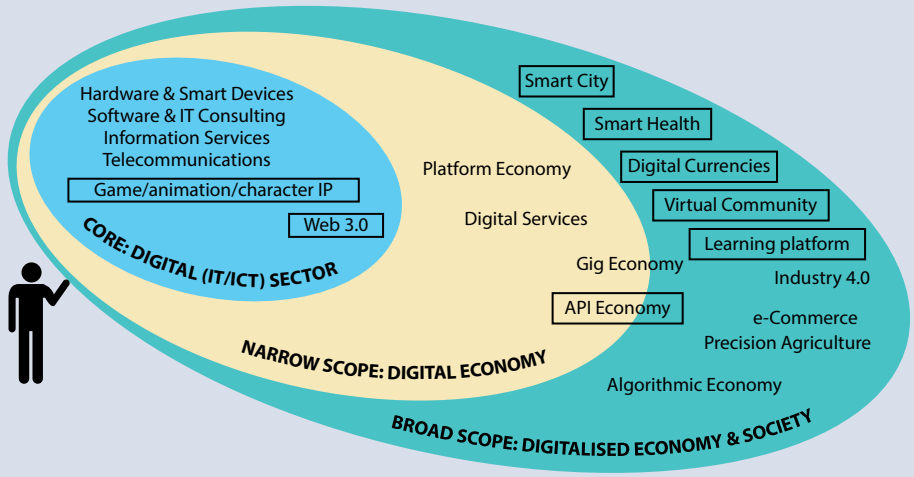
This contrast became particularly evident in education, where the transition to online platforms has been paramount. A lack of devices hinders several students from pursuing their studies, while many older adults encounter difficulties using mobile applications. These challenges collectively underscore the emergence of a pervasive digital divide, a pressing issue that demands immediate attention. The urgency of addressing this digitalization challenge earnestly cannot be overstated, as it directly impacts the future of economies and societies.

Thailand has formulated its digital economy framework by embracing the concept advocated by UNCTAD, tailored to align with Thailand's unique context. In its broadest scope, the digital economy encompasses digital society, an emerging paradigm shaped by digital technology and innovation that influences lifestyles, culture, and social interactions. This includes communication systems and advanced technologies like IoT, 5G, cloud computing, big data, and human-computer interfaces.

This interconnected digital society, closely intertwined with the economy, drives economic development and introduces concepts like smart cities and intelligent health platforms, ultimately enhancing the overall quality of life within the nation. Smart cities are established to utilize modern

FIGURE 1

DIGITAL ECONOMY IN THAILAND.



Source: Reproduced with permission from the Digital Economy Promotion Agency (DEPA) [1].

technology and innovation to sustainably facilitate management, stimulate the economy, and improve people's quality of life.

According to the Digital Economy Promotion Agency, the implementation framework is based on four pillars for building sustainable digital competitive advantages to drive economic and social development.

Digital access: Strengthen the capacity to access digital technology, information, and data storage. Develop manufacturers' proficiency in leveraging digital data for swift prototyping while enabling businesses to harness digital platforms for tailored mass customization to cater to individual customer preferences.

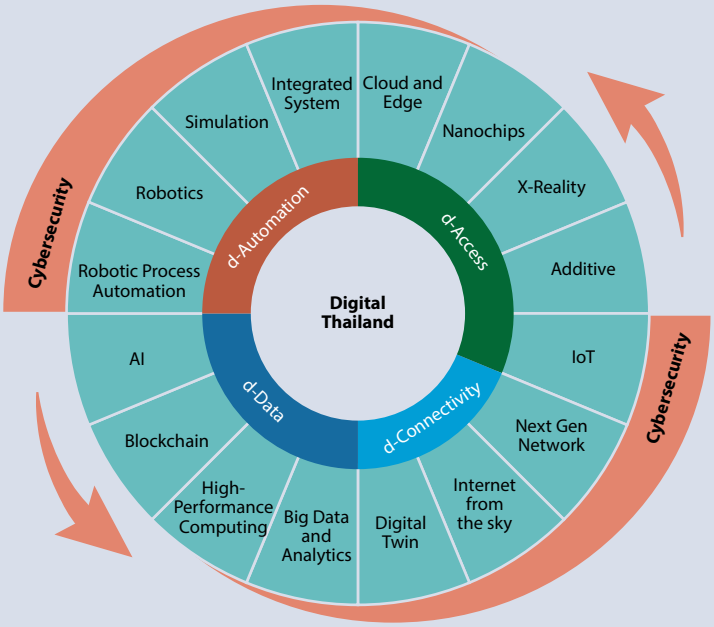
Digital connectivity: Elevate digital connectivity in real and virtual realms, bridging economic and social divides. This upgraded connectivity across devices, individuals, businesses, and society empowers simultaneous thriving in both domains.

Digital data: As the interconnection of devices, individuals, businesses, and society proliferates, it generates invaluable data reserves. Thailand should augment its capability to harness this data to bolster economic and social advancement.

Digital automation: The age of automation, propelled by enhanced digital access and interconnectivity, yields vast volumes of data. This treasure trove of data facilitates automated production, management, and distribution of goods and services. Automation delivers rapid, precise, and comprehensive outcomes, ready for use without human intervention. Digital data, encompassing big data and deep techs like blockchain and AI, is the cornerstone of sustainable competitiveness.

FIGURE 2

COMPETITIVE ADVANTAGES OF DIGITAL INITIATIVES IN THAILAND.



Source: Reproduced with permission from the Digital Economy Promotion Agency [1].

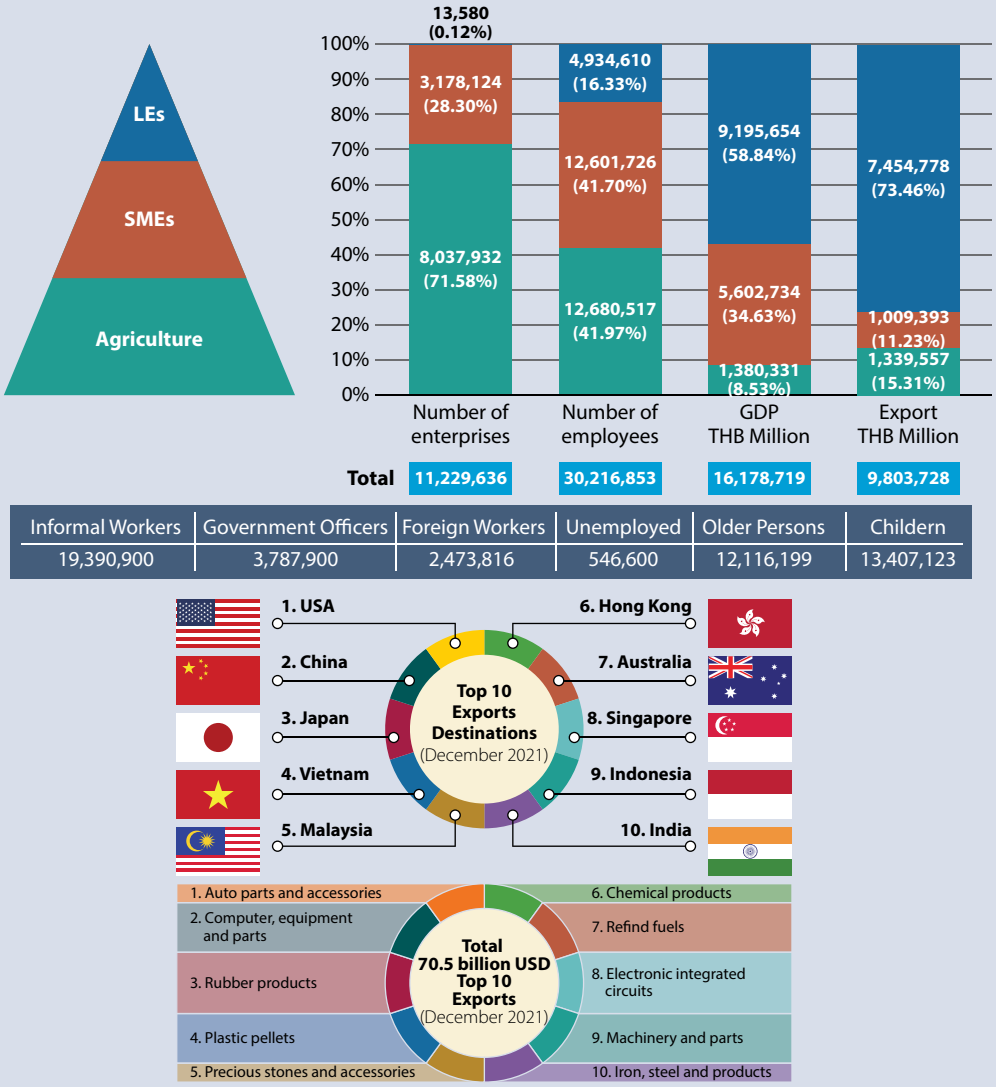
Scoping: Key Industry Sectors

Tourism, manufacturing, and agriculture are major sectors generating significant revenues in Thailand. Main export products include auto parts, computer parts, rubber products, plastic, and electric appliances. Given its high dependence on exports and tourism, Thailand must support these sectors to strengthen digitalization. Furthermore, evolving societal trends like an aging population and an increasing emphasis on environmental, social, and governance or ESG concerns necessitate addressing these challenges through digitalization.

A digitalization plan, however, cannot be fully implemented across all sectors simultaneously. Instead, it needs to take a step-by-step approach. Therefore, the Government of Thailand is focusing on key sectors that drive the domestic economy and have a significant impact, proactively engaging in those pivotal areas.

FIGURE 3

THAILAND'S ECONOMIC STRUCTURE AND EXPORT.

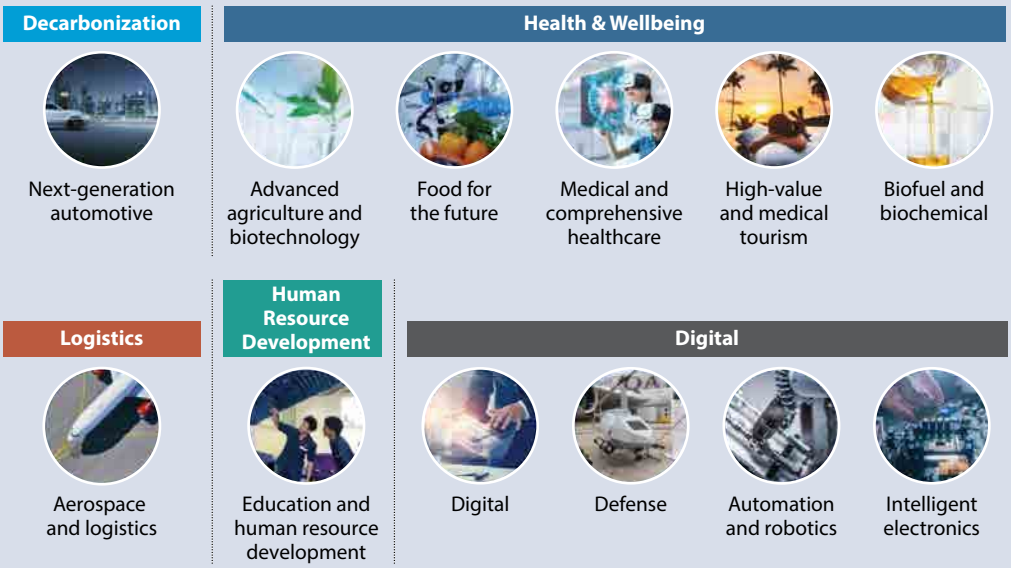


Source: Reproduced with permission from the Digital Economy Promotion Agency [1] and the Ministry of Commerce, Government of Thailand [4].

The Government of Thailand has established four primary sectors of focus for digitalization: manufacturing (particularly automotive), agriculture, healthcare, and digital services.

FIGURE 4

PRIORITY SECTORS FOR DIGITALIZATION IN THAILAND.



Source: Reproduced with permission from the EMBA SMU Southeast Asia [13].

Manufacturing Sector

Responding to the need for de-carbonizing, the automotive manufacturing sector is leveraging digital innovation to enhance efficiency, elevate quality, enable customization, and drive fresh solutions aligned with evolving demand. By integrating IoT, data analytics, and real-time monitoring, digitalization optimizes processes while customization and innovation respond to the shifting market dynamics, positioning the sector at the forefront of sustainability and competitiveness.

Agriculture Sector

In the agriculture sector, digitalization can significantly enhance farmer operations in Thailand by providing innovative solutions that improve efficiency, productivity, and sustainability. This includes a centralized information system, precision technologies, remote monitoring, supply chain optimization, and smart machinery. Such enhancements can bolster Thailand's competitiveness and open doors for valuable partnerships. DEPA and other IT government agencies are focusing on joint funding initiatives and establishing a dedicated platform to enhance digital skills within the workforce. The goal is to create a digital workforce skills development platform in agriculture and a robust, comprehensive ecosystem that supports the development of digital competencies in various dimensions.

Medical Sector

In the context of healthcare tourism and the challenges posed by an aging society, transforming the delivery of medical services becomes increasingly important. Innovative approaches like telehealth and smart home technologies enhance patient outcomes by enabling remote consultations and personalized care and streamlining administrative processes through efficient healthcare data

systems. Implementing these advancements can help Thailand achieve its goals and build its reputation as a healthcare tourism hub, creating a comprehensive ecosystem that caters to diverse healthcare needs and ensures a seamless and fulfilling experience for visitors.

Digital Service and Logistics Sector

The digital service sector holds immense significance in catalyzing DX across industries by providing essential technological infrastructure, expertise, and innovative solutions. Its role as an enabler of digitalization lies in offering cloud computing, data analytics, and software development that facilitate modernization and operational efficiency. By delivering expertise and consultation, the sector guides businesses through the complexities of transformation, ensuring informed technology adoption. With a continuous focus on innovation, customization, and tailored solutions, digital service providers empower companies to enhance products, services, and customer engagement. Furthermore, their data management, scalability, and agility support enable data-driven decision-making, global market access, cost savings, and operational optimization.

Digitalization in the logistics sector also significantly boosts the performance of other sectors by revolutionizing supply chain operations. It accelerates operations, reduces costs, enhances customer experiences, and contributes to overall economic growth and competitiveness by using advanced technologies such as data analytics and blockchain to improve visibility, traceability, and efficiency throughout the supply chain. This leads to reduced lead times, optimized inventory management, and minimized wastage. Hence, digitalization in the logistics and digital service industries will play an important role in Thailand's DX initiatives, eventually elevating the industry's competitiveness, reducing costs, and enhancing income.

Gap Issues: Industrial Sector Analysis

Overall Gap

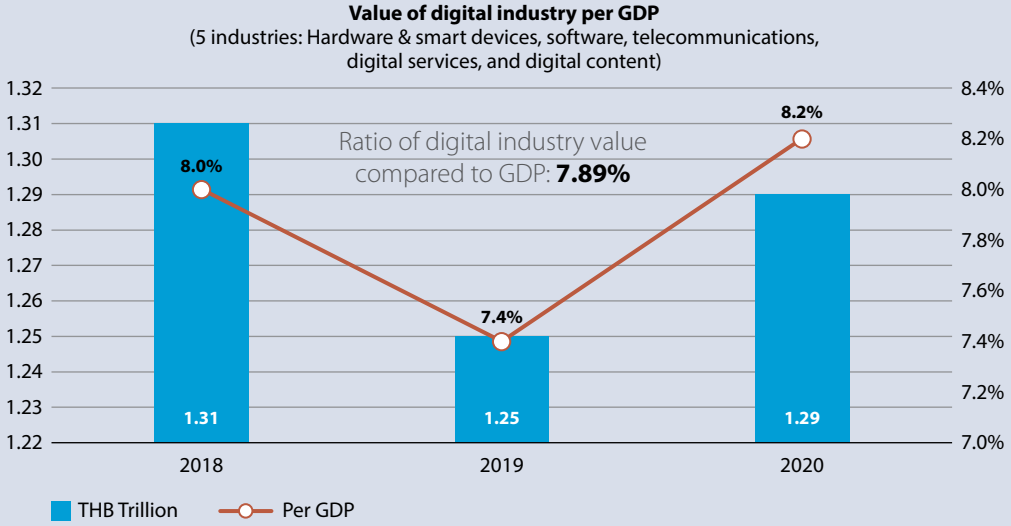
One of Thailand's important development goals is to overcome the middle-income trap, where the country struggles to maintain rapid economic growth due to challenges in transitioning from low-value industries to higher-value sectors, limited investment in research and innovation, workforce skill gaps, labor shortage, education deficiencies, and political stability issues. To overcome this trap, Thailand must focus on structural reforms, improving education and workforce skills, promoting innovation and technological advancement, and creating an environment conducive to sustained economic growth and development. Digitalization stands as a promising solution that can effectively bridge these gaps.

Low R&D: Thailand's R&D landscape is relatively low compared to the total GDP annually. The value of the digital industry is only at 7.89% of the total GDP and has remained steady over the past few years. Although the business sector has achieved notable market and organizational innovations, transitioning to a higher echelon of competition demands product and process innovation. This deficit in R&D investment hinders the nation's advancement into a more competitive economic sphere.

Labor shortage: Thailand grapples with a prolonged labor shortage encompassing both skilled and unskilled labor categories. The situation will likely worsen due to an aging workforce and demographic shifts. Relying on foreign workers is not a sustainable solution, as it perpetuates the cheap labor development model and is hampered by the economic progress of neighboring countries, which restricts the availability of foreign labor.

FIGURE 5

VALUE OF THE DIGITAL INDUSTRY IN THAILAND.



Source: Reproduced with permission from the Digital Economy Promotion Agency [1].

Skills training gap: The skills training landscape in Thailand, particularly for low-skilled workers, is marked by a discernible incomplete market. These workers seek public training opportunities to align with market demands. However, the existing training courses offered by the government do not cater to these demands. While higher skills training faces a lesser crisis due to firms training their employees to meet specific needs, the discrepancy remains challenging.

Education challenges: Thailand's education system struggles to equip graduates with the skills necessary for a globally competitive labor market. The absence of essential competencies such as ICT and leadership skills hampers graduates' employability and diminishes foreign and domestic investors' interest. Consequently, Thailand is caught in a limbo between labor-intensive and capital-intensive economic structures, impeding progress.

Political uncertainty: Thailand has a history of political instability and faces challenges in achieving sustained economic growth and attracting long-term investments. Protests and reelections have occurred several times in the past few years. Frequent changes in government and political unrest can erode investor confidence, dissuading domestic and foreign investment. The resulting policy unpredictability disrupts business plans and could delay critical infrastructure projects. With tourism being a significant economic contributor, political turmoil can discourage tourists from visiting, reducing revenue and employment.

Industry Sector Analysis

When considering priority sectors for digitalization, the primary gaps within each industry can be delineated as follows:

Digital Sector

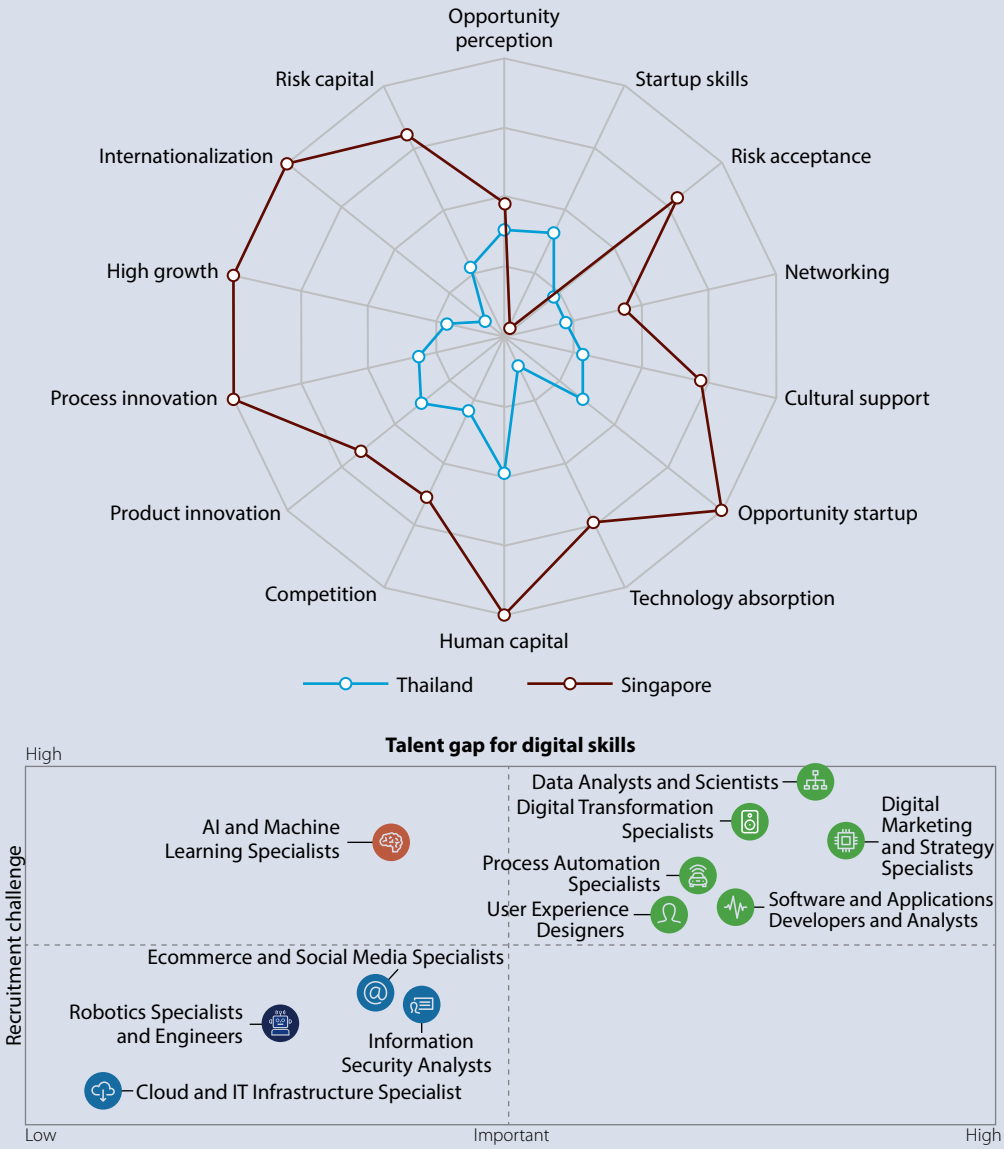
Thailand has made notable strides in digital advancement, driven by initiatives like its industrial transformation strategy (Thailand 4.0). The global trend, amplified by the COVID-19 pandemic

and associated safety measures, has hastened the digital revolution. However, the country has substantial potential for enhancing digital infrastructure and fostering R&D. The assessment in Figure 6 indicates that a comprehensive strategy focusing on innovation, technology investment, and training is essential to improve Thailand's digitalization progress fully.

Additionally, the rapidly evolving digital landscape often outpaces the education system's ability to provide relevant and up-to-date digital skills. Many educational programs may not be aligned with the latest technological trends and job market demands, leading to a disconnect between the skills graduates possess and those required by employers. According to a KPMG survey, Thailand has difficulty recruiting new talents in various digital expertise areas, such as data scientists, DX specialists, and digital marketing specialists.

FIGURE 6

DIGITALIZATION GAP IN THAILAND.



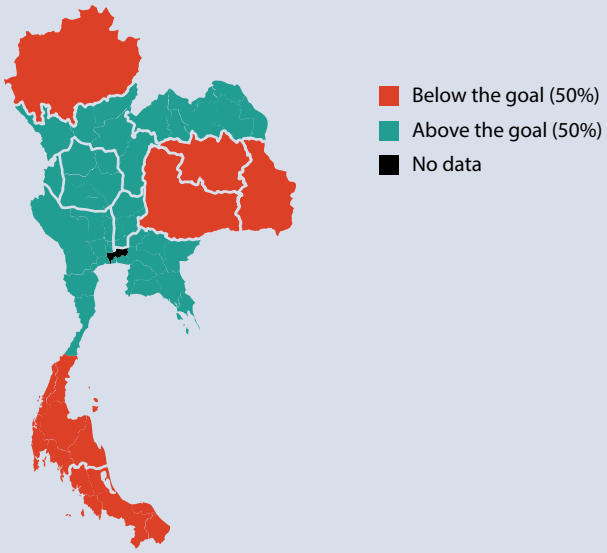
Source: Reproduced with permission from International Entrepreneurship Development Data [14] and Deloitte Thailand Digital Transformation Survey Report 2020 [10].

Healthcare Sector

The main gaps in this industry include limited access to healthcare services, health information technology, and healthcare infrastructure. While Thailand has made strides in providing universal healthcare coverage through its Universal Coverage Scheme, disparities in access to quality healthcare services still exist, especially in rural areas. According to Thailand Direct Research Investment (TDRI) research, smart hospitals are concentrated in certain areas, and a proper central data system is not yet in place, creating barriers when patients move between hospitals. Data security and cost-saving systems are also insufficient. Hiring IT and network specialists in small hospitals would burden the budget, potentially passing costs to patients. The socioeconomic gap further segregates the less fortunate, making them invisible in the digital health market. The government still lacks a policy to support these small hospitals in rural areas. If these hospitals cannot adopt smart healthcare solutions, which often involve efficient data collection, the problem of limited access to the healthcare system will worsen. Additionally, limited equipment and human resources in some small hospitals are issues that digitalization, such as AI, can help address by improving operational efficiency and replacing some human resource functions.

FIGURE 7

SMART HOSPITALS IN THAILAND.



Source: Reproduced with permission from TDRI [6].

Agriculture Sector

In Thailand, the agriculture sector encompasses various disparities within the industry. It highlights differences in agricultural practices, technology adoption, and income levels between urban and rural areas, mirroring the typical pattern in many countries. Urban regions have more advanced agricultural development and resources than their rural counterparts. The technological gap underscores variations in adopting modern farming technologies and practices among Thai farmers. Access to advanced agricultural machinery, irrigation systems, and information is relatively limited and can vary significantly, with some farmers embracing modern methods. In contrast, others continue to rely on traditional farming techniques.

Manufacturing Sector

In Thailand's automotive manufacturing industry, digitalization gaps are evident across multiple dimensions. While certain manufacturers have incorporated digital technologies into specific processes, comprehensive integration across the entire value chain remains lacking since production, supply chain management, and customer engagement rely on traditional methods. The intricate supply chain suffers from limited visibility and real-time tracking, leading to inefficiencies. Despite data generation at various stages, there is underutilization for informed decision-making, notably in areas like advanced analytics, predictive maintenance, and performance optimization. The concept of smart factories leveraging IoT, automation, and robotics is not fully realized, hampering efficiency and flexibility. Similar to other sectors, a scarcity of digitally skilled workers exacerbates challenges, hindering the operation and maintenance of advanced technologies. The industry's innovation gap is underscored by limited R&D investment in cutting-edge areas like electric vehicles and autonomous driving, with insufficient collaboration within the ecosystem, impeding knowledge-sharing and best practices.

Mobilizing Scenarios

Driving Industry Sector Change Through Digital Transformation

Transform Human Capital for the Digital Economy and Society

Thailand's response to its weak digital capacities, as highlighted by the World Digital Competitiveness Rankings for 2021, centers on transforming human capital for the digital economy and society. The strategy aims to address the high demand for digital skills across all sectors by enhancing digital literacy among students, upskilling the existing workforce, and attracting digital talents from abroad. The strategic goal is to develop 500,000 workers with digital skills by adopting three key strategies.

1. **Building new skills for new generations** by collaborating with educational institutions to prepare students as experts in digital technology and innovation.

2. **Upskilling and reskilling the existing workforce** through partnerships with various ministries, departments, and private entities to meet market demand.

3. **Filling the digital talent pool** by bringing in digital workers from abroad in collaboration with several government bodies and councils.

Notable programs and projects include providing scholarships for bachelor's degrees in digital fields, offering coding and digital skills classes, facilitating self-learning through project-based approaches, and promoting digital learning among existing workers. The strategy also aims to attract digital professionals and nomads to Thailand by improving conditions and establishing digital certification centers for various skill levels.

A key initiative supporting the mobility of foreign experts is the Smart Visa, a specialized visa created to speed up the process for foreign individuals who want to invest or work in Thailand. The objective is to draw in skilled professionals, experienced executives, and entrepreneurs with advanced skills and knowledge to engage in the designated S-Curve industries and contribute to the country's growth. These experts cover several areas, including smart electronics, next-generation automotive, agriculture and biotechnology, affluent medical and wellness tourism, automation and robotics, food for the future, biofuels and bio-chemicals,

aviation and logistics, medical hub, digital and environmental management, and renewable energy, as well as alternative dispute resolution and human resource development in science and technology.

Transform Traditional to High-Value Digital Economy

Thailand's plan to accelerate its DX is outlined with strategic goals and strategies. The Digital Readiness Assessment in 2021 indicated a need for improvement in the economic sector's digital and data adoption. The focus is on adopting multiple strategies to transform traditional businesses into digital enterprises to increase productivity, agility, and innovation.

Accelerating digital startups' global reach: Collaboration with multiple government ministries and bodies aims to elevate digital startups to the international stage. Emphasis is on transforming R&D into viable products, fostering local and global business growth.

Boosting value creation by the digital industry: This strategy seeks to empower Thailand's digital sector and position it as a competitive player in the global market in partnership with government bodies and industry organizations.

Facilitating digitalization of core sectors: Collaboration across ministries and private sector associations aims to enhance business processes' adaptability, ensuring readiness for digital disruption and global competition.

Empowering local economies through digitalization: Efforts are focused on enhancing community economies and agricultural productivity through digital technology and innovation. Collaboration with various ministries and associations aims to achieve this goal.

Promoting digital education and innovation: Establishing centers for the expansion of digital startups, turning outdated factories into ICT hardware production facilities, and enhancing public-private platforms are essential to encourage innovation.

Digitalizing traditional sectors: Enhancing the quality of life in local communities by incorporating technology and digital innovation and promoting the adoption of digital technologies across all regions is a crucial aspect of Thailand's strategy.

A current project supporting technology investment is implementing the Board of Investment (BOI) project, which aims to attract capital, advanced technology, and expertise to create jobs and enhance innovation. This initiative attracts highly innovative projects with tax and non-tax benefits, including exemption from corporate income tax for up to 13 years and exemptions from import duties on machinery, raw materials used for export, and goods imported for research and development purposes. In 2022, this supportive investment in the digital industry grew to 114 projects with an investment value of THB34,746.15 million. These projects mainly involve software development platforms to provide digital services or digital content.

The Electronic Transaction Development Agency (ETDA) also uses the Digital Service Sandbox project as a testing platform to support innovation and service development. It provides actual services within a restricted environment. Service providers or individuals intending to provide electronic transaction services, such as government or private organizations, startups, or accredited groups, can participate in testing innovations or services before offering them in a real-world

environment. This supports new business models while ensuring security, safety, reliability, and compliance with current regulations.

DEPA and its partners have introduced the Digital Infinity: Smart Living project, encompassing various domains such as agriculture and healthcare. Within the agricultural sector, the project involves deploying the Fah Fon platform, an intelligent agricultural technology employing smart weather monitoring devices and data analysis systems. The platform aids farmers with production and cultivation planning.

The initiative employs health data storage devices in the healthcare sector to capture, store, interconnect, and authenticate health-related information for the elderly and individuals with disabilities. This system promptly alerts caregivers of health-threatening signals, ensuring vigilant monitoring and comprehensive care.

Create New Opportunities and Ensure Inclusive Development

Thailand's comprehensive strategy for bridging the digital divide and fostering extensive digital opportunities employs a multifaceted approach. Acknowledging discrepancies between urban and rural regions and across age demographics, the strategy operates on two fronts. Firstly, it involves establishing livable smart cities to augment the quality of life and attract technology-based investments. This effort is supported by collaborative assessments involving pertinent ministries and local entities.

The second initiative involves cultivating inclusive economic prospects by equipping marginalized populations with digital skills and platforms in collaboration with diverse ministries. Additionally, the strategy prioritizes nurturing a secure and knowledgeable digital society through enhancing digital literacy among vulnerable groups, promoting digital innovations to address societal challenges, and educating the public about responsible digital behaviors and cybersecurity. The overarching goal is to foster an equitable and flourishing digital ecosystem.

Optimize Digital Infrastructure

Thailand is committed to advancing its digital infrastructure, both tangible and intangible. Key initiatives include the National Master Plan for Digital Development (2018–37) and the Thailand Strategic Digital Plan for Economic and Social Development (2020–24). Launched in 2018, the Connected Netpacharat initiative aimed to deliver affordable high-speed Internet to over 24,000 underserved villages. A significant showcase of dedication emerged with establishing a Digital Park in Chonburi province, furnished with submarine cables, a cable landing station, and a data center. Further emphasizing its determination, Thailand established a 5G committee in May 2020 to guide the adoption of 5G technology and foster collaborative efforts across multiple agencies.

In addition, Thailand aims to amend outdated laws and regulations that impede the development of the digital economy and society, such as the law on foreign business operations and the Civil and Commercial Code (convertible notes and vesting of stock options). Several public agencies prioritize the development of standards, regulations, and quality control of products and services and explore new laws and incentives that will promote the future development of the digital economy and society.

Recently, in 2023, ETDA has been promoting the use of AI with strong governance principles to reduce risks and enhance competitiveness. There has also been a strong emphasis on extending the utilization of Digital Identification, especially within government services. This entails the creation

of a minimum of 24 ID Providers (IDPs) that conform to Digital ID standards and speeding up the development of essential standards, such as those related to the secure storage of identity documents, identity verification for non-citizens, and the authorization process for legal entities. The Face Verification Service (FVS) expansion is also a top priority.

Analysis of Possible Measures and Threats to Productivity Improvement

Despite significant advancements in digitalization, Thailand lags behind its counterparts, such as China, Malaysia, Singapore, and Vietnam. Persisting challenges include unequal access, pricing disparities, and limited ICT proficiency. Notably, in 2020, only 19% of households had computers at home, with Internet penetration in rural areas at 69% and urban areas at 81%. The variation in ICT skills is evident, with only 1% of the population considered advanced and around 20% possessing basic ICT skills.

Despite declining digital service prices over the past decade, adjustments for purchasing power parity reveal that costs, particularly for fixed broadband, have not decreased as anticipated. Comparatively higher prices for broadband and mobile services in Thailand, partly attributed to spectrum allocation methods, persist in contrast to neighboring countries. In summary, while the government has made commendable strides in infrastructure and accessibility, the challenges of disparate access, relatively elevated costs, and constrained ICT skills remain formidable obstacles.

Transparency: Factors Hindering Digitization

Conflicting elements may hinder digitization. The following analysis of the risks that may become ethical, legal, and social issues is provided.

Job Displacement and Workforce Changes

Digitalization in Thailand has led to a transformative shift in the job landscape, resulting in both job displacement and changes in workforce dynamics. Automation and AI have digitalized routine tasks, potentially displacing certain low-skilled positions. To navigate this, reskilling and upskilling are crucial to align workers with emerging roles. Concurrently, digitalization contributes to job polarization, boosting demand for high-skilled and low-skilled jobs while diminishing middle-skilled roles and affecting income distribution. Older workers lacking digital skills may face displacement, leading to social and inequality issues in corporations.

Privacy, Data Security, Digital Misinformation, and Manipulation

Concerns about privacy, data security, digital misinformation, and manipulation are growing. In Thailand, cases of data privacy breaches have significantly increased as more personal information is collected and stored digitally, heightening the risk of data leaks. Inadequate internal data control can expose individuals to identity theft, financial fraud, and unauthorized access to sensitive information.

The proliferation of digital platforms and social media has provided fertile ground for spreading misinformation and manipulating public perception. Recently, Thailand's Digital Ministry initiated its first legal action against Facebook, X (formerly Twitter), and Google for ignoring some requests to remove content that violates local laws. The ease of creating and sharing content has led to disseminating false information, impacting public discourse and decision-making. The number of cybercrimes involving misuse of contents from well-known institutions, disrupting essential services, and compromising national security is increasing. Advanced technologies like AI and deepfakes further heighten the potential for sophisticated deception and manipulation.

Addressing these challenges necessitates robust data protection regulations, investment in cybersecurity infrastructure, media literacy programs to combat misinformation, and policies that ensure accountability and transparency in the digital world. Thailand must strike a balance between harnessing the benefits of digitalization and safeguarding individuals and society from the perils of privacy breaches, data insecurity, and digital manipulation.

Digital Divide

The uneven distribution of technological infrastructure and economic constraints can hinder marginalized populations' access to digital opportunities. Thailand's focus on digitalization in a few sectors and main cities and the prolonged transformation process risks widening the gap in rural areas. A lack of digital skills and literacy, particularly among rural and lower-income communities, may hinder effective engagement with online platforms, educational resources, and job opportunities. Additionally, the shift of essential services online can exclude those without access, deepening the divide.

Bridging this gap requires concerted efforts, including improved rural infrastructure, affordable connectivity, digital literacy initiatives, localized content, and policies prioritizing inclusivity. These measures will help ensure that the benefits of digitalization are accessible to all segments of society.

Cybersecurity Threats

As the National Cyber Security Agency reported, Thailand has witnessed a substantial surge in cybersecurity threats, from 135 in 2021 to 772 in 2022. These threats have predominantly targeted public and educational websites, underscoring the vulnerability of these sectors to cyberattacks. Furthermore, cybersecurity breaches have extended to encompass prominent commercial banks, magnifying their impact by eroding public confidence in the security of financial institutions.

This trend highlights the pressing need for robust cybersecurity measures across various sectors to mitigate risks, safeguard sensitive information, and restore trust in digital platforms.

Regulatory and Legal Challenges

The rapid pace of technological evolution has the potential to surpass the establishment of comprehensive regulatory frameworks, leading to uncertainties within the legal landscape. This challenge is further intensified by the emergence of ethical, legal, and social issues from regulatory gaps and the unclear interpretation of current laws in the digital domain. The business sector faces heightened risks due to the absence of existing laws to govern the implementation of rapidly changing technologies.

Enforcing regulations within the dynamic digital sphere proves intricate, underscoring the necessity for strategic actions to bridge these gaps, ensure legal clarity, and effectively address the complex network of ethical, legal, and various social dimensions inherent in the digital age.

Conclusion

Overall Digitalization Policy in Thailand

In recent years, Thailand has adopted a strategic and comprehensive approach to digitalization, indicating a significant shift in its policy landscape. With a steadfast commitment to embracing technological advancements, the country's digitalization policy reflects a multifaceted initiative to foster innovation and enhance connectivity, as listed in Table 1.

TABLE 1

KEY DIGITALIZATION POLICIES IN THAILAND.

Initiatives and Programs	Summary
Optimize Digital Infrastructure	
• Smart City and Smart Health projects	To foster a digital society and encourage the adoption of advanced telecommunications and digital technologies, including IoT, 5G, cloud computing, big data, human-computer interfaces, intelligent health platforms, and telemedicine.
• Joint funding initiatives for digitalization platforms in the agricultural sector	DEPA and other IT government agencies establish a dedicated platform to enhance digital skills within the workforce. The goal is to create a digital workforce skill development platform in agriculture and a robust, comprehensive ecosystem to support the development of digital competencies.
• Connected Netpacharat project	Deliver affordable high-speed Internet to over 24,000 underserved villages.
• Digital Park in Chonburi province	Establish an ecosystem cluster complete with digital infrastructure, including submarine cables and a cable landing station in Chonburi province.
• 5G Committee	Guide the adoption of 5G technology and foster collaborative efforts across multiple agencies.
• Digital Identification Project	Create IDPs, expand the FVS, and expedite the development of essential standards, such as secure storage of identity documents.
Improve Human Capital	
• Scholarship in the digital field and support for digital learning.	Enhance digital literacy among vulnerable groups and educate the public about responsible digital behaviors and cybersecurity to build new skills, upskill, and reskill the existing workforce.
• Smart Visa	Specialized visas to improve the process for foreign skilled professionals who want to invest or work in Thailand aimed at attracting experienced executives and entrepreneurs with advanced skills to engage in the designated S-Curve industries.
Enhance the Existing Digital Environment	
• BOI's project of tax benefits to accelerate digital startups' global reach	BOI supports the technology investment of domestic firms and foreigners by offering tax benefits, including exemption from corporate income tax for up to 13 years, import duties on machinery, raw materials used for export, and goods imported for research and development purposes.
• The Digital Service Sandbox project	A testing platform to support innovation and service development to service providers by providing real services within a restricted environment.
• Digital Infinity: Smart Living project	Encompass various domains such as agriculture and healthcare, including smart weather monitoring devices and health data storage devices to capture, store, interconnect, and authenticate health-related information for the elderly and individuals with disabilities.

Examples of Distinctive Digitalization Policies in Thailand

SMART CITY AND SMART HEALTH

This initiative involves building advanced infrastructure, improving transportation systems, enhancing energy efficiency, streamlining public services through digital platforms, monitoring and reducing environmental impact, and fostering economic development and innovation. For smart health initiatives, it utilizes ICT to revolutionize healthcare delivery and access. These initiatives include telemedicine for remote medical consultations, digitization of EHRs for improved patient care coordination, health information exchange (HIE) for data sharing among healthcare providers, mobile health (mHealth) for patient empowerment, health analytics for data-driven decision-making, integration of IoT healthcare devices for real-time health monitoring, and enhancing healthcare access through digital means.

BOI'S PROJECT TO BOOST DIGITALIZATION

Thailand Board of Investment has launched a project to accelerate digital startups' global reach by offering a range of tax and non-tax benefits. This initiative includes reduced corporate income tax rates, exemptions from import duties on necessary equipment, and support for export promotion. Additionally, BOI streamlines administrative processes, offers networking opportunities, and facilitates access to investment promotion services, creating a conducive environment for technology-based businesses to grow and thrive in Thailand. Non-tax incentives include permission for foreign firms to bring in expatriates and own land, further enhancing the appeal for international investors and companies.

Policy Recommendations

As aforementioned, the role of the digital economy in Thailand has undergone significant growth in the past decade. However, concerns about Thailand's digital development trajectory have emerged amidst this progress. These concerns include relatively modest investments in digital and digital-related industries, disparities in access to digital resources, insufficient digital infrastructure, and a shortage and mismatch of ICT skills. Importantly, these challenges are closely intertwined with the policies implemented within the country's framework.

One pivotal factor contributing to the relatively restrained levels of investment in the digital landscape is the prevailing deterioration of the business environment, particularly exacerbated by the impact of the COVID-19 pandemic. This adverse business climate has led to a subdued appetite for investment. Adding to this, the investment incentives established by the BOI have been notably skewed towards specific geographic areas, particularly the Eastern Economic Corridor (EEC), while disregarding the existing development clusters responsible for producing critical digital products. These clusters encompass domains such as electronics and automotive sectors, spread across regions like Pathum Thani, Phra Nakhon Si Ayutthaya, Samut Prakan, and Chachoengsao.

Additionally, the slow progress in infrastructure development, especially those facilitating seamless connectivity between the EEC and other parts of Thailand, has created additional hurdles on the

journey towards a fully realized digital economy. Another critical issue is the uncertainty faced by local and foreign investors, particularly those involved in targeted industries, which can potentially cast a shadow over the overall investment climate.

In response to the changing landscape, the Government of Thailand has begun focusing on the Bio-Circular-Green Economy Model, a shift from its previous emphasis on S-curve and new S-curve industries. While this move towards diversification, the attempt to identify winners beyond the country's current comparative advantage might inadvertently introduce economic inefficiency and unpredictability for potential investors. In other words, the government should avoid promoting specific industries like manufacturing because it may not align with the country's strengths or areas of expertise. The misalignment could create uncertainty in the business environment, making potential investors hesitant to commit their resources.

Thailand also faces uncertainty regarding budget allocations for investment in long-term digitalization initiatives. This is particularly evident with the Ministry of Digital Economy and Society (MDES), which has experienced a decline in budget allocation over the years. The MDES budget decreased from THB20,173 million in 2017 to THB6,825 million in 2022, raising questions about the commitment to building a robust digital infrastructure and promoting the digital industry. The trend is not isolated; budget allocations for education and research-related ministries have also experienced similar reductions.

Another related issue is the continuity in policy frameworks over time. Given the considerable unpredictability within the political landscape, including potential shifts in government and alterations to long-term strategic plans, the government must acknowledge this risk and take steps to ensure the uninterrupted progress of its long-term digitalization objectives.

Regarding collaboration with the private sector, the Thailand 4.0 initiative emphasizes collaboration between the public and private sectors. While the private sector leads through business endeavors and investments, the government is a facilitator and promoter. This approach aims to stimulate more significant investment in industries reliant on digital technology, with the government offering attractive incentives to encourage investments in these sectors.

Similarly, government agencies must collaborate to achieve efficient budget utilization and timely development outcomes. Despite efforts to collaborate and work together, multiple government bodies have rolled out overlapping policies to enhance labor skills for Industry 4.0, resulting in potentially inefficient budget deployment. Various organizations striving to achieve similar goals increase the chances of duplication of efforts. This challenges the creation of innovation-based institutions that can effectively support firms and investors in pursuing public assistance. Hence, a better and unified approach to DX is needed.

Excessive implementation of new policies could burden businesses and potentially impede the broader landscape for DX in Thailand. Introducing several policies quickly, without sufficient coordination or consideration of their collective impact, could overwhelm enterprises and create a complex regulatory environment. This can lead to compliance, resource allocation, and adaptability challenges, deterring businesses from fully embracing the DX process. The interconnected nature of these policies, if not carefully managed, could contribute to inefficiencies and confusion, making it harder for businesses to align with the overarching vision of DX. Therefore, a balanced approach that ensures policies are well-considered, strategically aligned, and introduced in a manner that

allows businesses to absorb and adapt to changes is essential for fostering a conducive environment for successful DX in Thailand.

On the regulatory front, Thailand needs to align its digital laws with international standards, covering aspects such as e-transactions, consumer protection, privacy, data protection, and cybercrime, to address the rapid pace of digitalization adequately.

Lastly, service providers have raised concerns due to uncertainties surrounding new requirements and burdens from cybersecurity and personal data protection laws enacted in 2019. These laws grant the government increased authority to demand sensitive information from IT service providers, potentially raising concerns about confidentiality. Striking a balance between ensuring a secure environment and nurturing a conducive business climate for digital growth is essential.

References

[1] The Digital Economy Promotion Agency. Digital Economy Master Plan 2023–2027. https://www.depa.or.th/en/master-plan-digital-economy/master-plan-for-digital-economy-66-67. Accessed 25 August 2023.

[2] Thailand Board of Investment. Thailand Investment. https://www.boi.go.th/en/intro/. Accessed 25 August 2023.

[3] Office of the National Economic and Social Development Council. Gross Domestic Product: 2022. https://www.nesdc.go.th/nesdb_en/ewt_news.php?nid=4490&filename=index. Accessed 25 August 2023.

[4] Ministry of Commerce. Foreign Trade Statistics of Thailand 2021. https://tradereport.moc.go.th/File/BookStatistic2564.pdf. Accessed 25 August 2023.

[5] The ASEAN. The ASEAN Issue 23, 2023. www.theaseanmagazine.asean.org. Accessed on 26 August 2023.

[6] Thailand Development Research Institute. TDRI Quarterly Review March 2023. https://tdri.or.th/en/category/publication/. Accessed on 25 August 2023.

[7] Thailand Development Research Institute. TDRI Quarterly Review June 2022. https://tdri.or.th/en/category/publication/. Accessed on 27 August 2023.

[8] Juthathip Jongwanich. 2023. Readiness of Thailand Towards the Digital Economy. Journal of Southeast Asian Economies; 40: 64-95.

[9] Digital Economy and Society. Insights of digitalization of Thailand Industry. https://www.huawei.com/en/huaweitech/industry-insights/outlook/thailand-digitalization-whitepaper. Accessed on 26 August 2023.

[10] Deloitte Thailand. The Thailand Digital Transformation Survey Report 2020. https://www2.deloitte.com/content/dam/Deloitte/th/Documents/technology/th-tech-the-thailand-digital-transformation-report.pdf. Accessed on 26 August 2023.

[11] Ministry of Commerce. Foreign Trade Statistics of Thailand. https://www.moc.go.th/en/content/page/index/id/2874. Accessed on 26 August 2023.

[12] Bukhit and Heeks. Defining Conceptualizing and Measuring the Digital Economy. Manchester University; 2017.

[13] EMBA SMU Southeast Asia. Thailand and ASEAN Business Overview? Paper presented at SASIN School of Management Executive, 18 April 2022.

[14] The Global Entrepreneurship And Development Institute. International Entrepreneurship Development Data. http://thegedi.org/tool/. Accessed on 26 August 2023.

TURKIYE

Introduction

The industrial sector is a cornerstone of national economic development due to the added value it produces and its positive impact on other sectors. With its ability to transform the agriculture and services sectors, the industrial sector is also at the forefront of technological adaptation. Mechanization, which has evolved through three phases since the onset of industrialization, is now advancing towards its fifth phase. This new period includes innovations such as autonomous vehicles, electric motors, communication technologies, IoT, software, and cloud technology.

Turkiye actively participates in this transformation through its National Technology Move, the 2023 Industry and Technology Strategy Document, and advanced technology policies. The transformation of the Turkish economy over the past twenty years is significant in this context. Having nearly doubled its share in the global economy, foreign trade, and world industry, Turkiye's trajectory will be closely tied to its advanced technology initiatives over the next thirty years. Turkish industry is gearing up for the fifth industrial revolution with a focus on clean and renewable energy policies.

The industrial sector has nearly tripled its production value in the last twenty years, rising from 23rd to 15th place globally. With its rapid development, Turkish industry is poised to lead in the advanced technological era and is expected to become the seventh-largest industrial economy in the world in 2050.

In recent years, efforts to increase productivity in the manufacturing industry have been a major focus in Turkiye. Establishing facilities that provide applied training and consultancy services (model factories) and expanding these throughout the country are among Turkiye's key strategies for enhancing the manufacturing industry.

Scoping

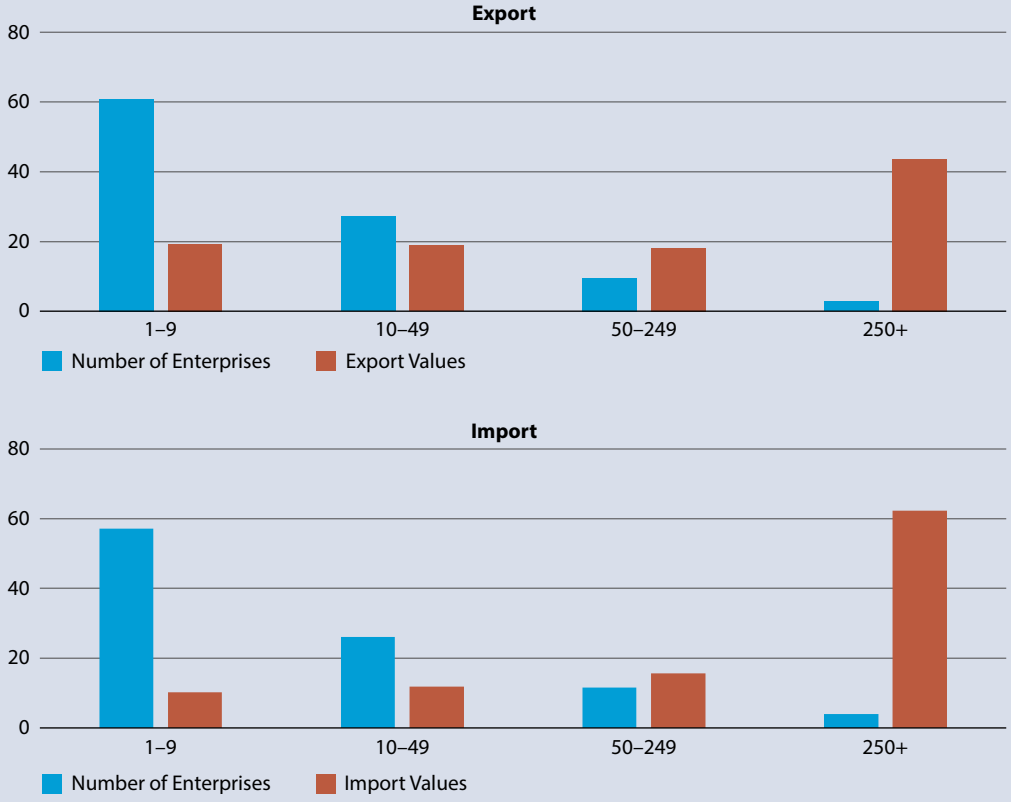
Key Industry Sectors

According to research conducted by the Scientific and Technological Research Council of Turkiye (TUBITAK) involving approximately 1,000 companies that received support from the institute, regardless of their scale and sector, the industry level in Turkiye was found to be 2.6. This indicates that most SMEs have not yet transitioned to automation, such as Industry 3.0, and may be vulnerable during the transition to Industry 4.0 [1].

SMEs play a crucial role in the Turkish economy, comprising 99.8% of all enterprises, representing 78% of all employment, and accounting for 55% of GDP and 50% of total investment. In 2019, micro enterprises (1–9 employees) accounted for 19.2% of total exports and 60.8% of exporting enterprises. The export shares of small enterprises (10–49 employees), medium-sized enterprises (50–249 employees), and large enterprises (250+ employees) were 18.9%, 18.2%, and 43.7%, respectively. In total imports, micro-enterprises had a share of 10.2%, small enterprises 11.9%, medium-sized enterprises 15.6%, and large enterprises 62.3%. Interestingly, large enterprises constituted only 4.0% of importer enterprises, as illustrated in Figure 1 [2].

FIGURE 1

SHARE OF EXPORT AND IMPORT IN TURKIYE BY EMPLOYMENT SIZE (2019).



Source: Turkish Statistics Institute. Foreign Trade Statistics by Enterprise Characteristics, 2019. 11 September 2020. https://data.tuik.gov.tr/Bulten/Index?p=External-Trade-Statistics-by-Enterprise-Characteristics-2019-33899.

According to the 2020 statistics from the Turkish Statistics Institute (TUIK), 56.8% of exports and 53.4% of imports in 2019 were driven by enterprises in the industrial sector. Enterprises primarily engaged in trade accounted for 39.7% of exports and 32.5% of imports. Large enterprises contributed 68.9% of the industry sector's exports, while small and medium enterprises contributed 91.4% of the trade sector's exports. For imports, large enterprises led in the industry sector at 80.5%. In other sectors, the share of small and medium enterprises increased from 29.7% to 29.8%, with large enterprises leading at 70.1%, as indicated in Table 1 [2].

TABLE 1

TRADE BY MAIN ECONOMIC SECTORS BASED ON EMPLOYMENT SIZE (IN %).

	Export				Import			
	2018	2019	2018	2019	2018	2019	2018	2019
	1–249		250+		1–249		250+	
Total	55.7	56.3	44.3	43.7	37.1	37.7	62.9	62.3
Industry	30.7	31.1	69.3	68.9	19.3	19.5	80.7	80.5

(Continued on next page)

(Continued from the previous page)

	Export				Import			
	2018	2019	2018	2019	2018	2019	2018	2019
	1–249		250+		1–249		250+	
Trade	90.9	91.4	9.1	8.6	69.2	71.0	30.8	29.0
Others	61.4	67.4	38.5	32.5	29.7	29.8	70.2	70.1

Source: Turkish Statistics Institute. Foreign Trade Statistics by Enterprise Characteristics, 2019. 11 September 2020. https://data.tuik.gov.tr/Bulten/Index?p=External-Trade-Statistics-by-Enterprise-Characteristics-2019–33899

According to 2016 statistics from TUIK, the percentages of enterprises with 1–19 employees operating in low technology, medium-low technology, medium-high technology, and high technology sectors, as per the OECD manufacturing technology classification, were 60.4%, 31.1%, 8.3%, and 0.3%, respectively. The respective percentages for enterprises with 20–49 employees were 53%, 28.4%, 17.6, and 0.9%. Only 0.3% of SMEs operate in high-technology sectors, as explained in Table 2 [3].

TABLE 2

DISTRIBUTION OF ENTERPRISES BASED ON TECHNOLOGY LEVELS AND NUMBER OF EMPLOYEES.

Employment Size Class	Technology Level			
	High Technology	Medium-High Technology	Medium-Low Technology	Low Technology
Total	**0.3**	**9.1**	**30.9**	**59.6**
1–19	0.2	8.3	31.1	60.4
20–49	0.9	17.6	28.4	53.0
50–249	1.5	17.4	31.4	49.7
SME (1–249)	0.3	9.1	31.0	59.7
250+	2.6	18.8	24.7	54.0

Source: Istanbul Commodity Exchange. https://www.istib.org.tr/resim/siteici/files/K%C3%BC%C3%A7%C3%BCk%20ve%20Orta%20B%C3%BCy%C3%BCkl%C3%BCkteki%20Giri%C5%9Fim%20%C4%B0statistikleri%202016.pdf

Priority Sectors

The 11th Development Plan for 2019–23 has identified agriculture, defense, and tourism as key development areas for Turkiye. The priority sectors in the manufacturing industry are listed [4].

- **Chemical industry:** The main objective is to make sustainable and coordinated investments that use high technology to produce high value-added, environment-friendly, and competitive products in the chemical sector

- **Pharmaceuticals and medical devices:** The main objective is to increase global market competitiveness in the pharmaceutical and medical devices sector, elevating Turkiye's position in the value chain.

- **Electronics:** The main objective is to increase competitive production and exports based on R&D in the electronics sector

- **Machinery and electrical equipment:** The main objective is to enhance global market competitiveness by improving the competitive and efficient domestic production infrastructure in the machinery and electrical equipment sectors, thus advancing the country's position in the value chain.

- **Automotive:** The main objective is to increase international market share by developing high-tech domestic brand vehicle production and a highly competitive supply industry.

- **Rail system vehicles:** The main objective is to improve the R&D, design, and manufacturing capabilities of domestic industries for manufacturing rail system vehicles and their critical components, creating a national brand in this sector

Gap Analysis

This study uses an Industry 4.0 SWOT analysis to reveal Turkiye's gap analysis within the manufacturing industry and digitalization scope. The relationship between Turkiye's current situation and its targeted goals is summarized in Table 3.

Industry 4.0 SWOT Analysis of Turkiye

A SWOT analysis conducted in 2022 revealed Turkiye's current state of the manufacturing industry. The country has kept industrialization on its agenda for many years and has implemented the state-supported economy, mixed economy, and finally, liberal economy models in this direction [5].

TABLE 3

SWOT ANALYSIS OF TURKIYE FOR INDUSTRY 4.0.

Strengths	Weaknesses
• Turkiye's young and dynamic population • Exports of medium-high technology products • Increasing awareness of Industry 4.0 in the private sector • Increase in productivity with Industry 4.0 • Reduction of production costs • A higher level of profitability • Increase in industrial production • Target to exit the middle-income trap • Facilitating access to foreign markets • Growth in high-paying jobs • Being a country that attaches importance to human capital and raising individuals who are experts in their fields • Strengthening the control mechanism in the production process, increasing flexibility, increasing diversity, and the formation of important values other than the product • Increased competitiveness of industries in high-tech products • Raising awareness of energy saving • Internet infrastructure has become very widespread • Increase in academic research and studies on the subject with the addition of Industry 4.0 to the course contents	• Incomplete automation process • Unemployment • High dependence on imports and high dependence of exports on imports, • Low exports of high-tech products, insufficient emphasis on the production of value-added products Insufficient level of awareness in the society • Insufficient investments in R&D and innovation and acquisition of technologies through imitation • Lack of qualified labor force, • Lack of strategic partners and insufficient investments • High investment costs • Inadequate support for entrepreneurship • Success rates in international indices are not at the desired level

(Continued on next page)

(Continued from the previous page)

Opportunities	Threats
• Dynamic IT sector • Young and dynamic labor force • Understanding and principle of producing quality products • Increased customer satisfaction through personalized production and product diversity • Turkiye's desire to increase its global market share, especially in production • Desire to reach the level of developed countries in the adoption and implementation of Industry 4.0 tools • Opportunity for Turkiye to become a global manufacturing center based on its geographical location • The opportunity to develop new leading markets for products and the potential to create new markets • Probability of an increase in GDP growth rates • Increasing the number of researchers and scientific studies • Exit from the middle-income trap is possible if the importance given to high technology increases	• Lagging behind technology and rapid progress of the Industry 4.0 process • Lack of emphasis on R&D activities and decrease in competitiveness • Insufficient understanding of the changes that the process will bring • Cybersecurity threats • Increased competition in domestic and foreign markets • Negative perception of unemployment and low level of confidence • Lack of effective cooperation and development opportunities • Increasing unemployment and inflation rates and stagnation of investments • Effective use of Industry 4.0 by competing countries

Source: Council of Higher Education Publications and Documentation, Department National Thesis Center. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp .

According to studies conducted in Turkiye, the country is between Industry 2.0 and 3.0 regarding digital maturity. One of its weaknesses is the incomplete automation process. Rapid adoption of know-how and technology transfer methods is crucial at this point.

Turkiye's most significant strength is its young population, which comprises one-third of the country's population: 25 million people under 18. Turkiye's young population is believed to adapt to Industry 4.0 transformation much faster.

With robots taking an active role in production, the need for the workforce is expected to decrease. Robots capable of coding other robots with AI will inevitably dominate production. Addressing the employment problem is one of the key issues that the country needs to solve.

The Industry 4.0 process will rapidly increase the demand for skilled labor. To avoid losing a qualified labor force, Turkiye must improve its national income per capita by adopting the country's values and supporting the young population.

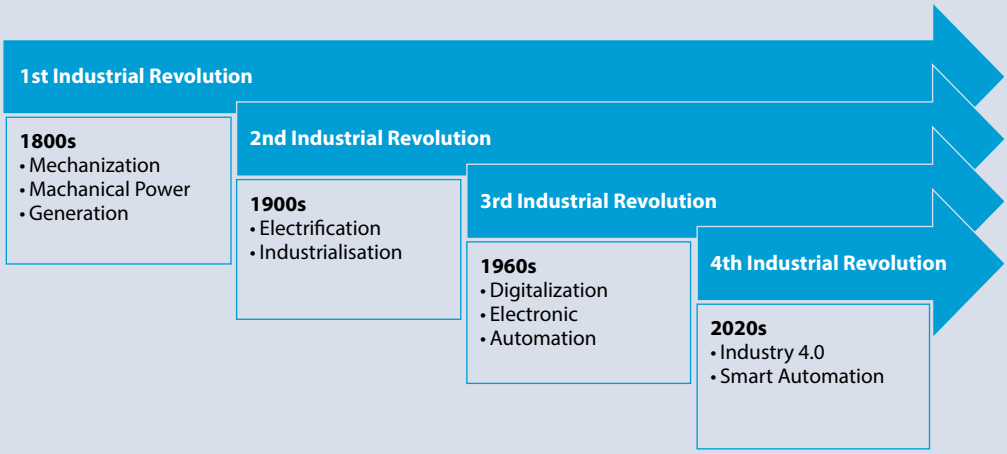
Investments should focus on high-value-added areas. Private sector R&D and innovation investments should be increased. The share of high-tech products in exports should be increased, and the automation process should be completed. Globally, investments should not be excluded from the process; strategic partnerships should be established, and investments should be made.

The Origin and Basics of Industry 4.0

The term Industry 4.0 is used for the industrial revolution taking place currently. This industrial revolution has been preceded by three other industrial revolutions as seen in Figure 2.

FIGURE 2

PHASES OF THE INDUSTRIAL REVOLUTION.



Source: Rojko A. Industry 4.0 Concept: Background and Overview. Online Journal, 27 April 2017. https://online-journals.org/index.php/i-jim/article/view/7072/4532.

The first industrial revolution began in the 1800s with mechanization and mechanical power generation, transitioning from manual work to early manufacturing processes. Improved quality of life was the main driver of this change. The second industrial revolution was triggered by electrification, which enabled industrialization and mass production. Henry Ford's famous quote, "You can have any color as long as it is black," encapsulates the introduction of mass production, albeit without product customization.

The third industrial revolution is characterized by digitalization, with the introduction of microelectronics and automation. This facilitates flexible manufacturing, where various products are manufactured on flexible production lines with programmable machines. Such production systems, however, still lack flexibility concerning production quantity [6].

Industry 4.0 differs from previous revolutions in two key aspects. First, it is the first industrial revolution predicted a priori, not observed ex-post. This allows companies and research institutes various opportunities to shape the future actively. Second, the economic impact of this revolution is supposed to be enormous because it promises significantly increased operational efficiency and the development of entirely new business models, services, and products [7].

Main Components and Technologies of Industry 4.0

Cyber-Physical Systems (CPS)

CPS combines intelligent physical components (e.g., machines), objects, and systems with embedded computing and storage possibilities. These systems are connected through networks and enable the smart factory concept of Industry 4.0 within an IoT, data, and services framework, focusing on processes [8].

The Internet of Things

Integrating the IoT with the Internet of Services (IoS) in manufacturing initiated the fourth industrial revolution. The IoT allows things and objects, such as RFID, sensors, actuators, and mobile phones, to interact with each other and cooperate with their neighboring smart components to achieve common goals. Based on the definition of CPS, "things" and "objects" can be understood as CPS. Therefore, the IoT can be defined as a network in which CPS cooperates through unique addressing schemas. Examples of IoT applications include smart factories, smart homes, and smart grids [9].

The Internet of Service

The IoS enables service vendors to offer their services via the Internet. The IoS consists of an infrastructure for services, business models, and services. Services are offered and combined into value-added services by various suppliers, communicated to users and consumers, and accessed via various channels [10]. This development allows a new and dynamic variation in the distribution of individual value chain activities. It is conceivable that this concept will extend from single factories to entire value-added networks. Factories may offer specialized production technologies instead of just production types, providing these technologies over the IoS for product manufacturing or to compensate for production capacities.

Smart Factories

Figure 3 depicts the Industry 4.0 smart factory. The core process is the digital to physical conversion in a reconfigurable manufacturing system. Reconfigurable manufacturing systems represent the latest advancement in manufacturing system development. The initial step involved fixed production lines with machines dedicated to specific tasks, allowing only one product to be produced. The next step was flexible production systems with programmable machines, enabling the production of various products but offering no flexibility in production capacity [11]. The latest development is reconfigurable manufacturing systems that can adapt their hardware and software components to meet ever-changing market requirements for product types and quantities [12].

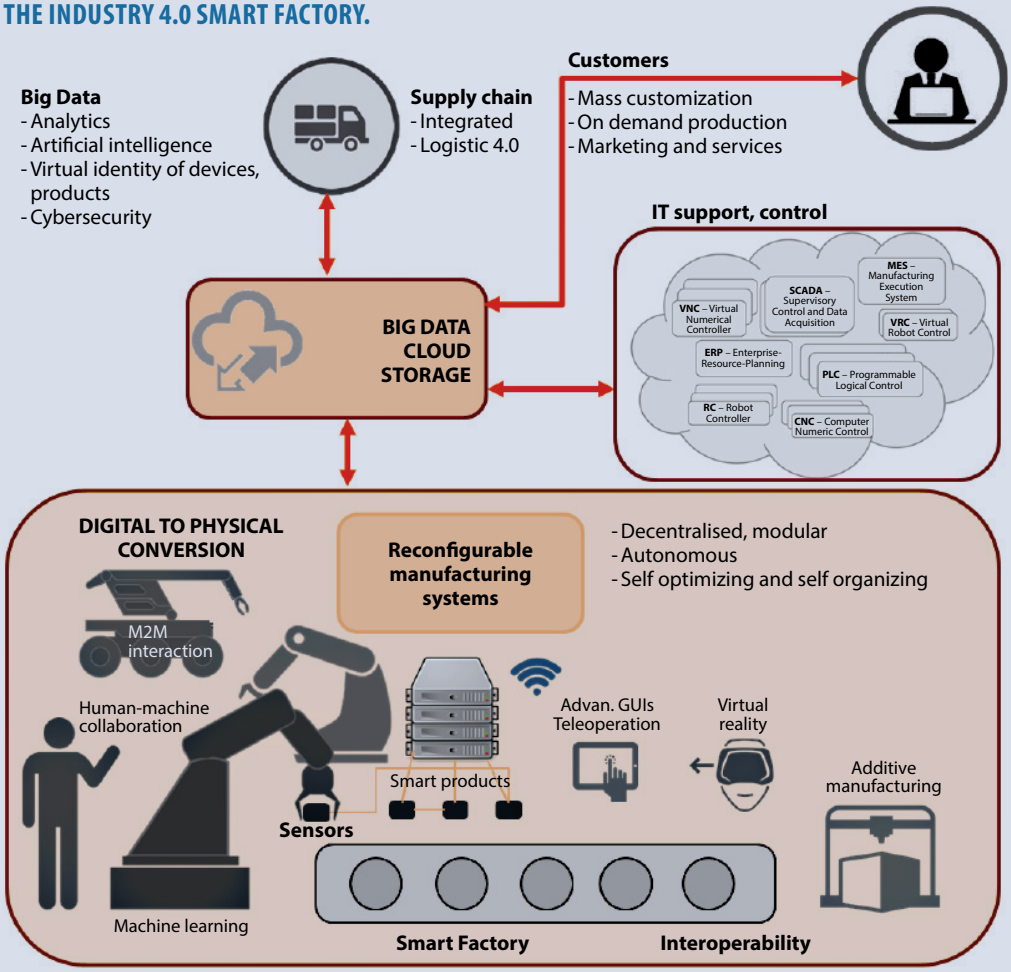
Machines in Industry 4.0 factories are CPS, i.e., physical systems integrated with ICT components. They are autonomous systems that can make decisions based on ML algorithms, real-time data capture, analytics results, and recorded successful past behaviors. Typically, programmable machines—Computer Numerical Control (CNC) and Numerical Control (NC)—with a large share of mobile agents and robots capable of self-organization and self-optimization are used [6].

Products manufactured in such factories are also "smart," equipped with embedded sensors that use a wireless network for real-time data collection to track localization and measure product state and environmental conditions. These smart products have control and processing capabilities, allowing them to manage their logistical path through production and even optimize the production workflow. Additionally, smart products can monitor their state throughout their life cycle, enabling proactive, condition-based maintenance. This is especially valuable for products embedded in larger systems, such as power converters in electric grids [13].

In Industry 4.0, production elements also have a virtual identity—a data object stored in the data cloud and their physical representation. This virtual identity can include various data and information about the product, such as documents, 3-D models, individual identifiers, current status data, historical information, and measurement/test data [6].

FIGURE 3

THE INDUSTRY 4.0 SMART FACTORY.



Source: Rojko A. Industry 4.0 Concept: Background and Overview. Online Journal, 27 April 2017. https://online-journals.org/index.php/i-jim/article/view/7072/4532 .

Key elements of the Industry 4.0 concept are interoperability and connectivity. A continuous flow of information between devices and components, M2M interaction, manufacturing systems, and actors is essential. Through this connectivity, machines, products, and factories can connect and communicate via the IIoT, which is mostly based on wireless networks.

Human-to-machine collaboration is also crucial, as some production tasks are too unstructured to be fully automated. Much research is currently being invested in collaborative robotics, where human workers and specially designed compliant robots work together to execute complex and unstructured tasks on the manufacturing production line. Advanced user interfaces are being developed for new machine-to-human (M2H) communication forms, often incorporating teleoperation and augmented reality environments [6].

Industry 4.0 Technologies

Main Technologies

Major advances in nine key technology areas are driving transformation in the manufacturing industry. The application areas are explained below and illustrated in Figure 4 [14].

1. **Advanced manufacturing solutions:** It is used in autonomous industrial robots and standardized interfaces.

2. **Additive manufacturing:** It is used in 3D printing for spare parts and prototypes.

3. **Augmented reality:** Applied for maintenance logistics and standard operating procedures.

4. **Simulation:** It simulates value networks and optimizes based on real-time data.

5. **Horizontal and vertical integration:** Employed in data integration based on data transfer standards.

6. **Industrial Internet:** Facilitates multidirectional communication between networked objects.

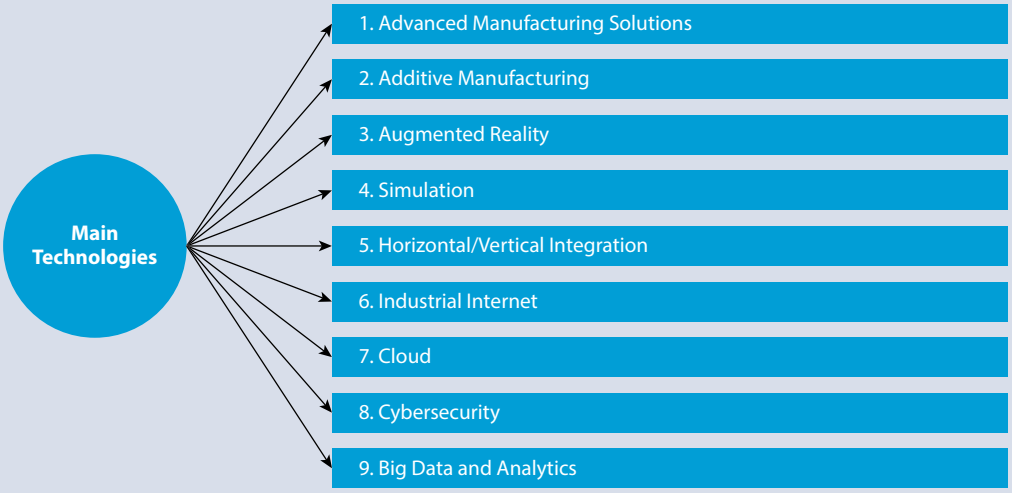
7. **Cloud:** Enables real-time communication in production systems.

8. **Cybersecurity:** Ensures a high level of networking between intelligent machines, products, and systems.

9. **Big Data and Analytics:** Supports real-time decision-making and optimization.

FIGURE 4

NINE ADVANCED TECHNOLOGIES TRANSFORMING INDUSTRIAL PRODUCTION IN TURKIYE.



Source: Boston Consulting Group (BCG). Sprinting to Value in Industry 4.0: Perspective from and Implications from US Manufacturers. December 2016. https://www.slideshare.net/TheBostonConsultingGroup/sprinting-to-value-in-industry-40.

Supportive Technologies

- Hyperconnectivity describes an environment of ubiquitous connectivity, often with specialized functionality adapted to the demands of a particular application.

- Sensors and actuators are the basic technology for embedded systems as the entire system obtains a control unit, usually one or more microcontrollers.

- Human-machine interfaces are combined hardware and software components that enable humans to interact with machines.
- Real-Time Location Systems and RFID technologies generate value in manufacturing and logistics operations.
- Mobile devices ensure the Internet-enabled receiving and processing large amounts of information.
- Cloud manufacturing is a research field that integrates cloud computing and traditional product design and manufacturing.
- Digital Twin technology is a digital representation of a real-world entity or system that includes attributes and behaviors sufficient to meet the requirements of a set of use cases.
- Product Lifecycle Management is a software that helps manage products from concept phase to disposal by integrating data, workflows, and systems across a value chain.
- Wearable technologies often track a user's vital signs and biofeedback, which indicates emotions.
- Networking technologies encompass many technologies and protocols that facilitate communication and data exchange between devices in a computer network.
- Automated guided vehicle is a materials handling system that uses automated vehicles such as carts, pallets, or trays programmed to move between manufacturing and warehouse stations without a driver.
- Blockchain is a specific type of database. It differs from a typical database in how it stores information. It stores data in blocks that are then chained together.

Key Trending Technologies

In Deloitte's 2020 annual Global Industry 4.0 report, the "big four" technologies—IoT, AI, cloud, and big data analytics—are still expected to have the most profound impact on organizations of surveyed executives. These executives, however, do not primarily represent SMEs. Figure 5 illustrates the expected impact according to the respondents [15].

Mobilizing Scenarios

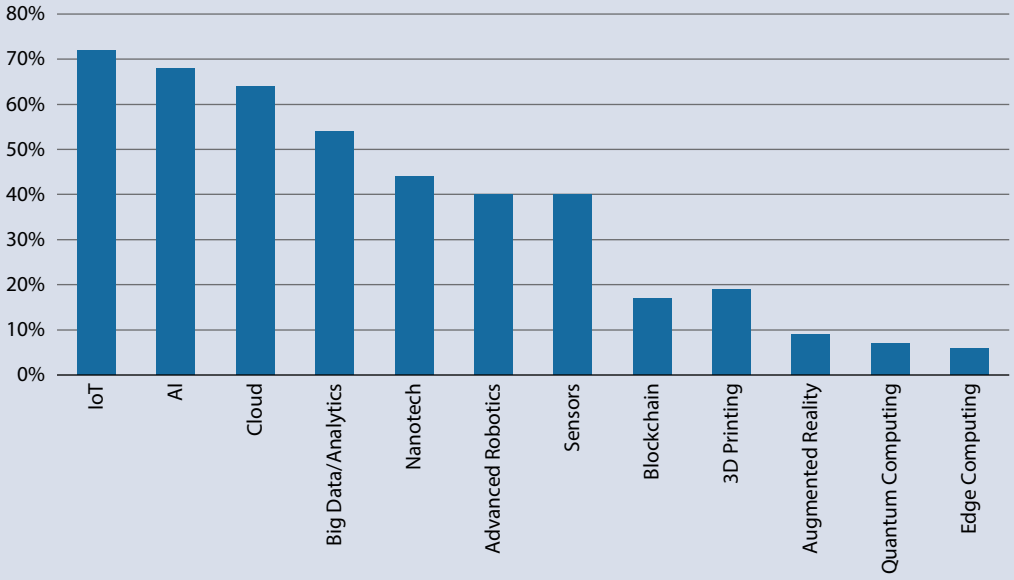
Strategies, Policies, Laws, Programs, and Initiatives Driving Industry 4.0 in Turkiye

Turkiye embraces the Industry 4.0 era with its perspective, the National Technology Initiative and Digital Turkiye. This ensures that the country's strategies, policies, and programs are designed around this vision. The government established the General Directorate for National Technology under the Ministry of Industry and Technology to facilitate technological transformation on 14 April 2020. Some of the duties and powers of the General Directorate for National Technology are listed.

- Contribute to the implementation of high-impact programs and projects to improve Turkiye's technological competence within the scope of the National Technology Initiative.

FIGURE 5

DISTRIBUTION OF THE EXPECTED IMPACT OF TECHNOLOGICAL APPLICATIONS (IN %).



Source: Deloitte Insights. Are you successfully navigating the intersection of readiness and responsibility in the Industry 4.0 era? 2020. https://www2.deloitte.com/content/dam/insights/us/articles/us32959-industry-4-0/ReadinessInfographic_LowRes.pdf.

- Carry out activities for the development of individual competencies and social awareness and culture in technology development and digital transformation of individuals and businesses in cooperation with relevant stakeholders in line with the objectives of the National Technology Initiative,

- Take measures to increase the competencies of individuals and businesses in subjects such as big data and AI, develop and expand smart systems based on these technologies, implement support and incentive programs, and carry out programs and projects.

- Take the necessary measures to coordinate and cooperate with the relevant public institutions and organizations to develop digital economy applications and grow the ecosystem in this field. This will increase the economic benefit of digitalization and contribute to the creation of legislation.

- Implement programs and projects to develop digital economy infrastructures and applications in parallel with digital technologies and trends.

- Take the necessary measures to develop and implement applications for the growth and competitiveness of the informatics and advanced technology sectors. This includes maintaining a register of businesses operating in these sectors and harmonizing the technical regulations regarding the products of these sectors, excluding those used in the electronic communication sector. It also comprises preparing and implementing the technical legislation and the relevant standard lists, determining or having the features that will serve as the basis for inspecting products that lack technical regulations and standards.

- Determine the qualifications that conformity assessment bodies and technical service organizations to be authorized within the scope of technical regulations, to assign these bodies, and to suspend or cancel the assignment as needed temporarily.

The Small and Medium Enterprises Development Organization (KOSGEB) and the TUBITAK, under Turkiye's Ministry of Industry and Technology (MoIT), offer grant programs to support DX of SMEs. Key policies and strategies concerning Industry 4.0 include the 11th National Development Plan (NDP), the 2023 Industry and Technology Strategy, and the Smart Production Systems Technology Roadmap.

In July 2019, Turkiye adopted the 11th NDP, which had a five-year perspective for 2019–23. The 11th Development Plan of the Presidency of the Republic of Turkiye, Strategy, and Budget outlined the policies and DX strategies for conventional sectors. The DX and R&D and Innovation sections of the strategy, policies, and measures aim to boost productivity and competitiveness in priority sectors by accelerating digital transformation. Additionally, the plan focuses on strengthening the manufacturing industry's R&D and innovation capability to enable value-added production, increase the capacity for innovative product development, and provide an innovation-based structure.

The 11th NDP outlines Turkiye's long-term vision for economic and social development. It serves as the primary roadmap for public policy, guiding all governmental institutions in preparing strategic processes and action plans. The plan highlights the main pillars of STI policies, emphasizing the need to enhance the capacity to produce and use knowledge and to focus R&D and innovation activities in both academia and the private sector, supporting high value-added production through an efficient R&D and innovation ecosystem.

The Plan also emphasizes entrepreneurship and commercialization activities tailored for different actors, such as SMEs and large enterprises, and the transfer of knowledge and technology to enable the socioeconomic impacts of R&D results. In terms of R&D and innovation, the primary goals are to enhance R&D and innovation capabilities, increase value-added production, boost the share of high-tech sectors in both the manufacturing industry and exports, and ensure a conducive environment for innovation.

To achieve these goals, R&D and innovation support systems must evolve into an integrated structure that supports every phase, from basic research to commercialization, focusing on the distinctive structures and characteristics of mid-high tech and high-tech sectors. Priority sectors identified include the chemical industry, pharmaceuticals and medical devices, electronics, machine and electrical equipment, automotive and rail systems. Critical technologies for further support include AI, IoT, AR, big data, cybersecurity, energy storage, advanced materials, robotics, micro-nanoelectromechanical systems, biotechnology, quantum technologies, sensors, and additive manufacturing technologies.

The Plan has given the utmost importance to increasing competitiveness in priority sectors, improving R&D and innovation capacity, and developing internationally competitive and high-value-added new sectors, products, and brands in critical technologies.

Turkiye has also published the 2023 Industry and Technology Strategy of MoIT. The strategy has five pillars: High Technology and Innovation, Digital Transformation and Industrial Move,

Entrepreneurship, Human Capital, and Infrastructure. Sub-strategies supporting this umbrella strategy include the Digital Transformation of the Industry, the National Artificial Intelligence Strategy, the 5G and Beyond Technologies Strategy, the Mobility Vehicles and Technologies Strategy, the Smart Life, Health Products and Technologies Strategy, and the Digital Transformation of Finance and Commerce Strategy. These sub-strategies are in the process of publication and implementation.

The main purpose of the Digital Transformation of the Industry strategy is to enhance Turkiye's competitiveness by improving efficiency and self-efficacy. The strategy's targets are listed below.

- Establishing a governance mechanism for the industry's DX program with the cooperation of the public and private sectors.
- Developing tools to manage DX of the industry, monitor its performance, and ensure efficient use of resources.
- Announcing the DX support program.
- Completing the infrastructure for DX.
- Helping existing and emerging workforce acquire new skills and competencies, enabling DX.
- Developing competitive products and solutions in operational technologies.
- Creating competitive products and solutions in information technologies.
- Developing competitive products and solutions in transactional technologies.

DX in the manufacturing industry is considered critical in Turkiye. Coordinated by TUBITAK under the MoIT framework, all sectoral stakeholders contributed to establishing the Smart Production Systems Technology Roadmap in 2016. This roadmap identifies 29 critical products across eight critical technology areas: big data and cloud computing, digitalization, cybersecurity, IoT, sensor technologies, additive manufacturing, advanced robotics, and advanced automation and control technologies.

The critical products and technologies identified as priority RDI themes of Smart Production Systems in Turkiye include the following:

- Development of algorithms and applications for secure, smart, and scalable end-to-end cloud service platforms, including predictive maintenance of data.
- Development of cybersecurity solutions for Industry 4.0.
- Simulation, modeling, and virtualization technologies for Industry 4.0.
- The establishment of interoperable, secure, and reliable IIoT digital platforms and the development of high-value-added smart service applications.

- Development of software and/or hardware for M2M, M2H, and machine-to-infrastructure communication.
- Development of physical, chemical, biological, optic, and micro-nano sensors for industrial use.
- Development of smart manufacturing robots, equipment, software, and executive systems that are globally competitive and easily accessible by SMEs.
- Development of raw materials, production machines, and required software and automation systems for additive manufacturing, including additive manufacturing machines, additive manufacturing materials, and additive manufacturing software.
- Development of smart manufacturing execution systems, components, and required middleware technologies.

Initiatives Driving DX and Industry 4.0

Capability and DX Centers

Eight model factories, established under the MoIT initiative, provide consultancy and training solutions for businesses to complete their lean projects and DX plans. In the coming years, new model factories are planned for different areas of Turkiye. Businesses that seek services from model factories can benefit from financial support through the government agency KOSGEB and other development agencies.

The Center for the Fourth Industrial Revolution

The Center for the Fourth Industrial Revolution is a multi-stakeholder initiative that supports global collaborations and develops new policies to accelerate the benefits of science and technology. Launched in December 2020 by WEF, Turkish Employers Association of Metal Industries, and MoIT. Here are some salient features of the center:

- It focuses on maximizing the benefits of science and technology for society.
- As of January 2020, it was WEF's 7th affiliated organization (Affiliate Center).
- Its main work areas include IoT, robotics, smart cities, AI, and ML.
- Active projects: Increasing the Impact of IIoT in SMEs, Responsible Use of AI, Human-Oriented AI for Human Resources, Shaping Future Technology Control: AI and ML.

Accelerating Digital Transformation of SMEs Through IoT

MoIT is a stakeholder in the project Accelerating Digital Transformation of SMEs through IoT, operated jointly by the Fourth Industrial Revolution Center and Turkish Management Science Institute (TUSSIDE). The project aims to create a model for building a roadmap for companies. This pilot project includes the following steps:

- Digital maturity assessments of SMEs
- Matching technology users and providers and creating a use case scenarios pool
- Storing application scenarios in an industrial cloud

D3A Digital Transformation Assessment Tool

The D3A Digital Transformation Evaluation Tool was developed by Boğaziçi University – Industry 4.0 Platform. TUBITAK–TUSSIDE ensures the implementation of this assessment tool for SMEs. Given that SMEs constitute 99% of Turkiye's industry, this assessment tool aims to provide roadmaps for them, focusing on five dimensions: organization, customer, product development, supply chain, and production management, D3A helps determine the needs of SMEs and facilitates their DX processes.

KOSGEB: SME Development Support Program (KOBIGEL)

In 2019, KOSGEB announced two calls for proposals to support SMEs' DX. The first program supports SMEs developing digital technologies for the industry sector, offering USD115,000 in financial support through a project-based program. The second program targets SMEs operating in the industrial sector.

Strategic Product Support Program

This program funds SMEs' investment projects for manufacturing high-value-added products in the medium-high and high-technology sectors. It also aims to increase the production of critical products for developing these sectors in Turkiye, within the scope of the Technology Oriented Industry Move Program conducted by MoIT.

Technical and Social Infrastructure of DX in Turkiye

Current Situation of Digitalization and Industry 4.0 in Turkiye

The 11th Development Plan [4] outlines several obstacles and challenges encountered in the digitalization of enterprises.

- Low level of awareness about DX among enterprises in the manufacturing industry.
- Insufficient understanding of the importance and content of DX among enterprises.
- Difficulty in accessing accurate, timely, and sufficient information about DX among enterprises.
- Inability of enterprises to prepare a DX roadmap.
- Disconnect between local technology providers and technology users.
- Insufficient incentive mechanisms to promote the usage of digital technologies.
- Limited number of local technology providers.
- Lack of common terminology related to DX that all stakeholders could understand.
- Inaccessibility of data for technology providers due to the absence of an open access policy.
- Preference for foreign technology providers over local ones in many industries.
- Lack of educated and qualified personnel for DX.

The Journey of Industry 4.0 in Turkiye

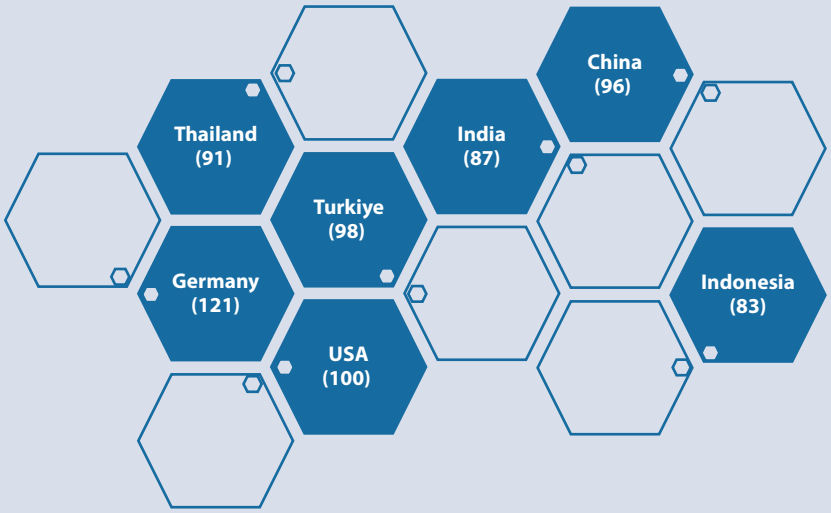
Turkiye has competitively positioned itself along the global value chain by leveraging its geographical location for logistical advantages and providing low-cost labor for flexible and cost-efficient production. According to BCG's Global Manufacturing Cost-Competitiveness Index, which assesses competitiveness based on manufacturing wages, productivity, energy costs, and currency exchange rates compared with the US dollar, Turkiye scores 98 compared to the US benchmark score of 100 and Germany's 121.

This indicates that direct manufacturing costs in Turkiye is 23% lower than those in Germany and 2% lower than in the US. This cost advantage gives Turkiye a competitive edge in gaining a share of the global value chain and building an export platform, as illustrated in Figure 6 [16].

FIGURE 6

TURKIYE'S POSITION IN THE GLOBAL VALUE CHAIN.

BCG MANUFACTURING COST INDEX 2014 (US=100).



Source: Turkish Industry and Business Association. https://tusiad.org/en/reports/item/9011-industry-40-in-Turkiye-as-an-imperative-for-global-competitiveness.

Turkiye aims to maintain and grow its participation in the global value chain but faces several structural challenges.

- High import dependency for exports
- Low share of value-added products
- Limited workforce skills and capabilities
- High employee turnover

The country is actively working on solutions to these challenges through its institutions and human resources.

Current DX Competency Level of Turkiye

The Turkish Informatics Industry Association (TUBISAD) has prepared Turkiye's Digitalization Index Report since 2019. This report assigns a score between 1 and 5 to represent the digitalization status of Turkiye's economy and society. The digitalization ratings were 2.94 in 2019, 3.06 in 2020, 3.21 in 2021, and 3.12 in 2022 [17].

The Index is computed considering 10 dimensions under four main components: ecosystem, competency, usage, and transformation, using 64 performance indicators. Of these 64 indicators, 30 are derived from surveys conducted with business community members, and 34 are sourced from international databases.

TABLE 4

TURKIYE'S DX INDEX.

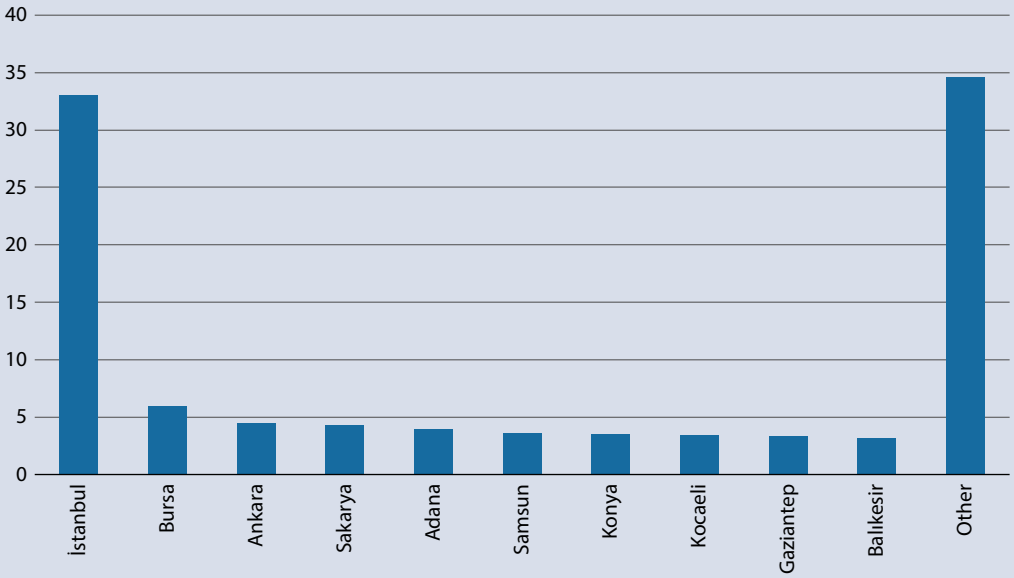
	2019	2020	2021	2022
Turkiye Digital Transformation Index	**2,94**	**3,06**	**3,21**	**3,12**
A. Ecosystem Component	**2,87**	**2,95**	**3,09**	**3,02**
1. Dimension: Legal Ground and Functioning	2,76	2,82	3,01	2,94
2. Dimension: Innovation and Investment Environment	2,98	3,09	3,17	3,11
B. Competence Component	**3,19**	**3,24**	**3,27**	**3,26**
3. Dimension: Infrastructure	2,34	2,27	2,32	2,44
4. Dimension: Affordability	4,54	4,54	4,43	4,49
5. Dimension: Skills	2,69	2,89	3,07	2,85
C. Usage Component	**2,88**	**3,16**	**3,36**	**3,21**
6. Dimension: Individual Use	3,20	3,22	3,29	3,37
7. Dimension: Business Use	2,77	3,32	3,41	3,10
8. Dimension: Public Use	2,66	2,92	3,37	3,17
D. Transformation component	**2,81**	**2,88**	**3,14**	**2,97**
9. Dimension: Digitized Economy	2,36	2,18	2,25	2,16
10. Dimension: Digitized Society	3,26	3,58	4,03	3,78

Source: Turkish Informatics Industry Association; 2022. https://www.tubisad.org.tr/tr/images/pdf/DDE-2022-Raporu-Final.pdf

The Independent Industrialists and Businessmen's Association (MUSIAD), in collaboration with AGS Global, published a report on the effects of digitalization on business processes [18]. The research involved 340 MUSIAD member enterprises operating in 52 cities, as illustrated in Figure 7, and 25 sectors, as shown in Figure 8. The percentage of enterprises with over 101 employees was 20,6%, indicating that most of the enterprises were SMEs. The digitalization level of these enterprises is shown in Figure 9.

FIGURE 7

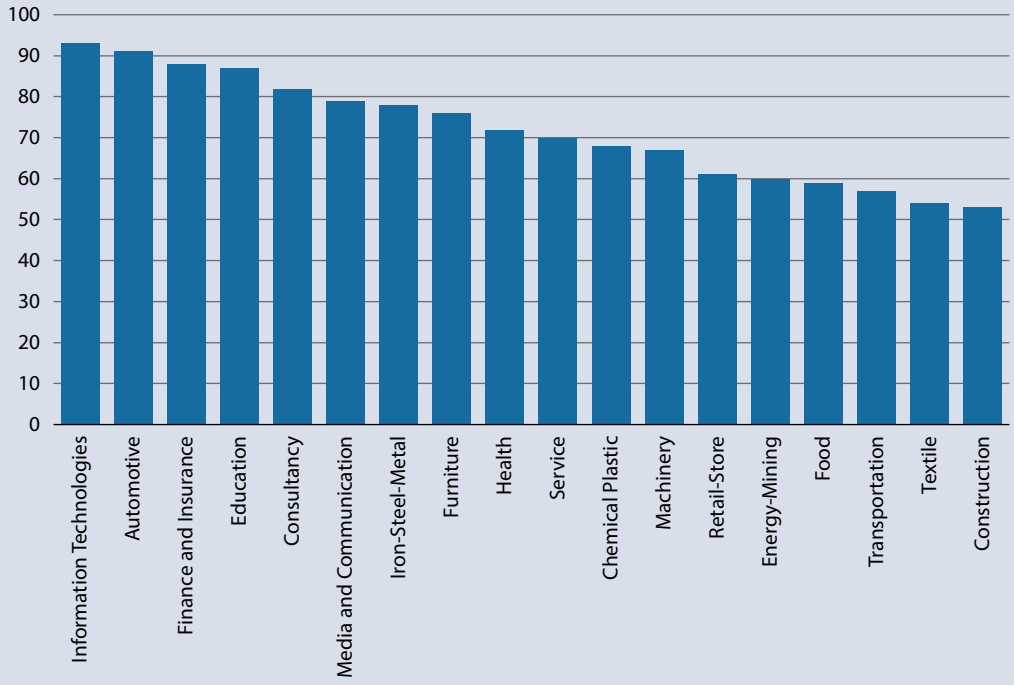
DISTRIBUTION OF ENTERPRISES IN TURKIYE BASED ON CITIES.



Source: Independent Industrialists and Businessmen Association. https://www.musiad.org.tr/icerik/yayin-40/ptn-3.

FIGURE 8

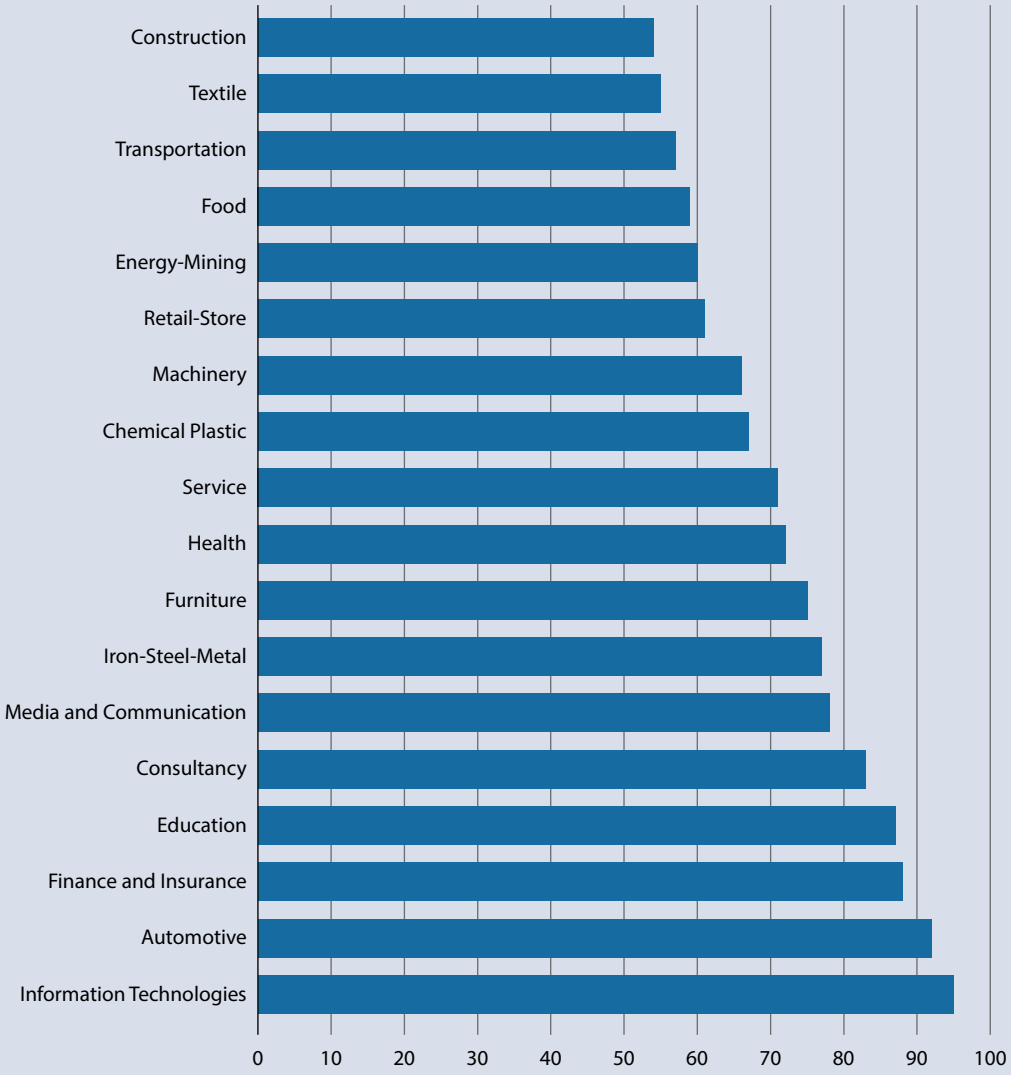
DISTRIBUTION OF ENTERPRISES IN TURKIYE BASED ON SECTORS.



Source: Independent Industrialists and Businessmen Association. https://www.musiad.org.tr/icerik/yayin-40/ptn-3.

FIGURE 9

LEVEL OF DIGITALIZATION IN TURKIYE ACROSS SECTORS.



Source: Independent Industrialists and Businessmen Association. https://www.musiad.org.tr/icerik/yayin-40/ptn-3.

The report shares key insights into the DX status of companies in Turkiye.

Expectation of DX

- 70.8% of companies anticipate a DX wave affecting their business processes. The expectation is particularly high in the services sector.

Current DX status

- 37.4% of companies had begun their DX process before COVID-19.
- 36.5% of companies recognize the need for DX to respond quickly to customer demands (68.2%), improve operational efficiency (62.4%), and access new markets and customers (54.4%).

Technology readiness

- 80.6% of companies operate with low to medium-level technology.
- Companies fully ready for DX constitute 19.4%, predominantly large-scale companies with over 101 employees.
- 58.5% of companies are partially ready for the transformation.

Digital infrastructure usage

- 69.7% of companies use digital infrastructure at varying levels.
- Commonly used technologies include CRM (42.2%), smart machines and devices (38.8%), and cloud technologies (37.1%).
- 60.2% of companies without a digital infrastructure plan to adopt one.

Challenges to DX

- Main challenges include a shortage of financial resources (42.4%), insufficient human resources (40%), lack of knowledge about the technology needs (23.8%), and lack of a strategic road map (23.8).

Plans for managing digitalization

- 51.8% of companies plan to manage digitalization with the support of expert companies.
- 31.4% of companies intend to establish an internal team for this purpose.

Policy Recommendations

Capability and DX Centers in Turkiye

To address productivity challenges and accelerate the DX process in the manufacturing industry, enterprises should enhance their infrastructure and core capabilities in lean manufacturing, digitalization (Industry 4.0), quality management, innovative product development, and energy efficiency. SMEs can be supported through well-developed transformation programs and practice-based training to improve the capabilities of their technical staff, engineers, and mid-level managers. One effective solution applied in many developed countries over the last two decades is to build well-designed competency centers, known as Model Factories. These centers provide a real didactic manufacturing environment (real products, assembly lines, machines, processes, and operators) and specialized training programs based on hands-on and step-by-step exercises to improve manufacturing processes within a transformation context.

Model Factories can be defined as tools that disseminate operational excellence principles in a scalable way using experiential learning techniques. They aim to change the existing mindset of SMEs and enable them to use human resources, machinery, equipment, raw materials, time, and energy resources more efficiently. Through training and consultancy services on continuous improvement, lean production, and DX, model factories address productivity challenges in the manufacturing industry, help SMEs absorb higher levels of labor force due to an expanded manufacturing base, support DX, and increase their competitiveness.

DX Infrastructure in Model Factories

Model Factories facilitate the DX of the enterprises they serve through the following usage scenarios.

- Human-to-robot and/or M2M collaboration
- Digital Assistance System
- Condition Monitoring
- Digital Quality Management
- Pick-by-light for Assembly and Logistics Operation
- Digital Performance Management
- Digital Product Shadow – product tracking and tracing
- Real-time Cycle Analysis

Conclusion

Turkiye's efforts in Industry 4.0, digitalization, and innovation are on an upward trend. It follows policy and strategy documents prepared by various institutions and organizations and closely monitors international activities. Established by MoIT to increase productivity in different regions and provinces, the Model Factories are prominent tools for the manufacturing industry. These centers provide training and consultancy services, directly transferring productivity-enhancing knowledge to enterprises.

Positive productivity improvement results from this approach have already been observed in Turkiye, and this model can serve as an example for other APO member countries.

References

[1] TUBITAK. New Industrial Revolution Smart Production Systems Technology Roadmap *(Yeni Sanayi Devrimi Akilli Uretim Sistemleri Teknoloji Yol Haritasi)*, in Turkish. 2017.

[2] TUIK, External Trade Statistics by Enterprise Characteristics. Press Release, 2020. https://data.tuik.gov.tr/Bulten/Index?p=External-Trade-Statistics-by-Enterprise-Characteristics-2019–33899. Accessed on 10 August 2023.

[3] TUIK. Small and Medium Sized Enterprises Statistics, Press Release *(Küçük ve Orta Büyüklükteki Girişim İstatistikleri. Basın Bülteni)*, in Turkish. 2016. https://www.istib.org.tr/resim/siteici/files/K%C3%BC%C3%A7%C3%BCk%20ve%20Orta%20B%C3%BCy%C3%BCkl%C3%BCkteki%20Giri%C5%9Fim%20%C4%B0statistikleri%202016.pdf. Accessed on 20 August 2023.

[4] SBB, Presidency of the Republic of Turkiye. 11th Development Plan. 2019. https://www.sbb.gov.tr/wp-content/uploads/2022/07/Eleventh_Development_Plan_2019-2023.pdf. Accessed on 10 August 2023.

[5] Tuncel F. Impact of Industry 4.0 on Economic Growth and Development in Turkiye. Master Thesis, Isparta; 2022.

[6] Rojko A. Industry 4.0 concept: Background and overview. ECPE European Center for Power Electronics e. V., Nuremberg, Germany; 2017, 11(5).

[7] Kagermann H., Wahlster W., Helbig J. Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group; 2013.

[8] Pascual D.G., Daponte P., Kumar U. Handbook of Industry 4.0 and Smart Systems. CRC Press, Taylor & Francis Group, Boca Raton, FL; 2020.

[9] Bauernhansl T., Hompel M., Vogel-Heuser B. Industry 4.0 in production, automation and logistics: application, technology, migration *(Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung, Technologie, Migration)*, in Turkish. 2014.

[10] Buxmann P., Hess T., Ruggaber R. Internet of services. Business & Information Systems Engineering; 2009: 5, pp. 341–342.

[11] Dhar UR. Flexible manufacturing systems: Major breakthrough in manufacturing management. Elsevier Engineering Management International; 1989, 5:4, pp. 271-277.

[12] Korena Y., Shpitalnib M. Design of reconfigurable manufacturing systems. Elsevier Journal of Manufacturing Systems; October 2010, 29:4, pp. 130–141.

[13] Morello B.C., Ghaouar B., Varnier C., et al. Memory tracking of the health state of smart products in their lifecycle. Industrial Engineering and Systems Management, Proceedings of 2013 International Conference on Rabat; 2013.

[14] BCG. Sprinting to Value in Industry 4.0. 8 December 2016. https://www.slideshare.net/TheBostonConsultingGroup/sprinting-to-value-in-industry-40. Accessed on 5 August 2023.

[15] Deloitte Insights. Are you successfully navigating the intersection of readiness and responsibility in the Industry 4.0 era? 2020. https://www2.deloitte.com/content/dam/insights/us/articles/us32959-industry-4-0/ReadinessInfographic_LowRes.pdf. Accessed on 7 August 2023.

[16] TUSIAD. Industry 4.0 in Turkiye as an Imperative for Global Competitiveness: An Emerging Market Perspective; 2016.

[17] TUBISAD. Turkiye's Digital Transformation Index 2022 *(Türkiye'nin Dijital Dönüşüm Endeksi 2022)*, in Turkish. https://www.tubisad.org.tr/tr/images/pdf/DDE-2022-Raporu-Final.pdf. Accessed on 7 August 2023.

[18] MUSIAD. Effects of Digital Transformation on Business Processes *(Dijtial Dönüşümün İş Süreçlerine Etkileri)* in Turkish, Istanbul; July 2020. https://www.musiad.org.tr/icerik/yayin-40/ptn-3. Accessed on 15 August 2023.

VIETNAM

Introduction

The world stands at the brink of a new era of digital innovation and disruption, which are poised to reshape our lives. These transformative technologies promise a better quality of life, enhanced economic efficiency, and improved decision-making. Yet, they also present challenges to social cohesion, equality, and security, underscoring the need for careful navigation.

Cutting-edge technologies can transform the region, integrating into every aspect of life and reshaping economies. With its stable political environment and strategic position in the global trading system, Vietnam is poised to seize the opportunities presented by these emerging trends. Over the past decades, the country has charted a course of impressive economic growth and human development, demonstrating its readiness and confidence to embrace DX.

However, Vietnam is not immune to challenges. Though still relatively young, the country's population is aging at an alarming rate. The low levels of digital literacy present a significant hurdle to its low-cost export-led growth strategy. The vulnerability of Vietnam's natural environment and agricultural sector to climate change is a pressing concern that demands immediate attention.

The report delves into Vietnam's policies and agencies in these emerging trends. The Government of Vietnam has identified technology as a key driver of growth, focusing on developing high-value manufacturing industries and digitizing the economy. These policies underscore the government's commitment to ensuring the equitable and ethical spread of digital development nationwide.

The COVID-19 pandemic accelerated the adoption of digital technologies, reflecting the need for more flexible, resilient, and connected working methods. This research analyzes emerging trends in Vietnam and examines the impact of innovation systems on productivity performance.

Scope and Priorities for Adopting Emerging Trends

International Context

4IR has brought an explosion of digitalization and new technologies. Advanced digital technologies, including IIoT, big data and analytics, advanced robotics, AI and ML, cloud computing, and additive manufacturing (3D printing), have driven digital production. These technologies have radically transformed the industry, particularly manufacturing. Technology has become increasingly crucial to standards development, driven by multiple factors.

- Rapid technology change across platforms, delivery methods, and software capability.
- Significant shifts in the business model.
- Transition from a document-based standard to a neutral format for improved flexibility in presenting information.

- Growing demand from stakeholders, contributors, customers, and staff.

The move from analog to digital affects every aspect of economies, industries, and personal lives, influencing resource efficiency, security and data privacy, health, employment, and environmental protection, including climate change mitigation. Critical and emerging technologies differ from earlier phases of industrial development by their intelligence level. Intelligent machines and technologies are increasingly shaping and augmenting lives, promising enhanced quality of life, greater economic efficiency, and better decision-making.

As networks of interconnected machines proliferate, systems interoperability will become critical. New technologies will present novel cybersecurity challenges in addition to current ones. Authorities must also consider equitable access to these powerful new technologies that have the potential to disrupt existing economic and employment models [1].

Emerging trends should be defined as technologies that can significantly enhance or pose risks to national interests, including prosperity, social cohesion, and national security.

With the onset of 4IR, the focus on improving productivity and competitiveness has shifted from production, business efficiency, and quality to innovation and creativity. In businesses, innovation can manifest in products, services, processes, equipment, technologies, management methods, business models, and virtually all production activities. Innovation can range from small, incremental changes to disruptive or radical innovations.

Innovation has strongly promoted human development and prosperity, particularly in the modern economy, by introducing new ideas and technologies that transform daily life and society. Since the pioneering works of Joseph A. Schumpeter, economics has focused extensively on technological development and innovation. Theoretically and empirically, economic studies have clarified that R&D and innovative activities are vital for modern economies, industries, and firms to achieve growth and sustainable development [2].

The rapid change in the production and business environment and globalization have strongly impacted enterprise development. This includes the emergence of new technologies, new competitors, new legal requirements, and more stringent customer and consumer demands. Hence, the ability to innovate is a critical and necessary success factor for most businesses in the new environment.

DX refers to an organization's adoption of digital technology to digitize non-digital products, services, or operations. The goal is to increase value through innovation, invention, customer experience, and efficiency.

Scoping: Key Industry Sectors

Industry and Economy

Since beginning market reforms in the 1980s, Vietnam has recorded remarkable economic growth and human development. The government and policymakers have demonstrated an openness and ambition to adopt new technologies to achieve developmental goals. There is a notable willingness to seek knowledge from international experts and incorporate it into policymaking [5].

Vietnam is currently entering the next phase of economic development. While the previous phase focused on market development and shifting from agricultural output to manufacturing, the next phase must emphasize efficiency gains.

Vietnam's economy has also shown impressive resilience in the face of the COVID-19 pandemic. The country was on track to achieve 7% GDP growth in 2022, the highest figure of any nation in East and Southeast Asia, and managed to avoid the extreme inflation experienced by some economies in the year, with the inflation of Consumer Price Index inflation peaking at 3.8% [9]. This is partly due to continued extensive state control of prices in the economy. However, this control may be challenging to maintain as Vietnam seeks further liberalization and economic development.

In 2020, services accounted for 42% of the Vietnamese economy, followed by the manufacturing and construction sector at 34% and agriculture at 15%. Despite the impact of COVID-19, Vietnam's total import-export value reached USD543.9 billion in 2020, with exports accounting for USD281.5 billion, resulting in a trade surplus of USD19.1 billion [10]. These manufacturing and export figures highlight Vietnam's evolution into a significant manufacturing hub for the global economy. It has become an integral part of the worldwide textiles, footwear, and electronics supply chain. Major companies such as Adidas, Nike, and Samsung have a manufacturing presence in Vietnam, making it one of the most trade-intensive economies in the world, with some of the region's highest FDI to GDP ratios. Vietnam's FDI has grown over 200 times since 1986, from USD40,000 to USD15.8 billion in 2018 [6].

Example from the SME Sector

Truong Hai Company, for instance, produces automobile tweezers using 70–80% factory automation. The automation has improved the factory's production capacity from 6,000 tons to 10,000 tons per year and reduced annual production costs by 5%.

Smart Manufacturing

Smart manufacturing utilizes advanced technologies and data analytics to create highly automated, flexible, and efficient production processes.

The 4IR is developing an environment for smart factories. It incorporates technologies such as the IoT, AI, ML, big data analytics, and robotics to connect machines, products, and people in a seamless and interconnected system. By leveraging these technologies, smart manufacturing enables real-time monitoring, analysis, and optimization of production processes to improve productivity, reduce costs, enhance quality, and increase flexibility.

Smart manufacturing also involves integrating physical and digital systems, enabling the creation of digital twins: virtual models of physical production systems that can simulate and optimize production processes before implementation in the physical world. This helps to minimize the risks and maximize the efficiency and quality of the manufacturing process. Smart manufacturing represents a transformative shift in producing goods, enabling a more agile, data-driven, and connected manufacturing ecosystem.

DX has made headway, but more can be done. Vietnam has reached significant milestones in the digital economy in the past few years. For example, its Internet economy has grown 16% from 2019 to USD14 billion, among the highest in Southeast Asia, as per a report by Google. The report projected that Vietnam would grow its digital economy from 2020 to 2025 by 29%, second only to

the Philippines at 30%. It is also estimated that by 2025, Vietnam's Internet economy will be worth about USD52 billion.

DX in Agriculture

Agriculture is a traditional sector of Vietnam's economy that is ripe for the uptake of emerging technologies. Vietnam enjoys many comparative advantages in agriculture. From a country threatened by hunger in the 1980s, Vietnam now ranks second in Southeast Asia for agricultural exports, with a diversified agrarian economy producing high-quality rice, coffee, pepper, tea, cashews, rubber, cassava, aquaculture products, and timber. Vietnam's agricultural sector ensures national food security, with its per capita food availability ranking among the top for middle-income countries. Nevertheless, the industry still employs inefficient practices, from production methods to logistics, and faces threats from climate change. Leveraging advanced technologies may enable Vietnam to mitigate these challenges.

Over the past decades, agricultural digitalization has grown in popularity due to its potential to boost productivity and provide consumers with greater transparency in the production process. Many experts believe that rapid DX is the best way for the agriculture sector in Vietnam to recover and develop in the post-pandemic period, affirming its role as one of the critical pillars of the country's economic growth. Amid challenges from climate change, market fluctuations, and changes in consumption trends, digitalization is expected to open up a new era for the sustainable development of the country's agriculture industry.

AgriTech involve software and hardware tools for the entire agricultural value chain. Some examples include using blockchain for food traceability, robotics for automated harvesters, and IoT sensors that provide real-time data to improve crop yield. The most important applications of these technologies include precision crop farming, aquaculture, indoor farming, and livestock monitoring and management. However, for any AgriTech system to be successful, the interoperability of different technologies and the compatibility of various data sources is critical.

For instance, IoT technology has helped farmers in Vietnam grow rice with less water through an irrigation system where paddy fields are alternately watered and dried. Eighty smallholder farmers and one farm enterprise used the IoT technology in three provinces in the Mekong Delta (Can Tho, Tra Vinh, and An Giang) under a project funded by the World Bank Partnership Facility.

Currently, the country has 12 areas certified for high-tech agriculture. Hau Giang, Phu Yen, and Bac Lieu are the three most prominent zones. Additionally, over 20 enterprises in the Central Highlands of Vietnam have already applied AgriTech in their operation and farming, linked with computers, smartphones, and electronic traceability systems [4].

Vinamilk Company is an example of DX in the country's agricultural industry. Its agricultural DX model has achieved outstanding success by applying IoT technology to livestock monitoring. Every aspect of the livestock-raising process, from diet to care and hygiene, is closely monitored according to innovative agricultural standards. As a result, Vinamilk's farm has been certified as an organic farm, meeting European standards, with the volume of milk collected increasing to 23 liters per cow per day.

Another example is Bayer's Made in Farm platform, which connects smallholder agricultural products directly with consumers or merchants. The platform has helped farmers and buyers meet,

trade, and transact online, facilitating transactions worth over EUR10 million and connecting 13 million users.

Other Industries

The logistics sector has expanded along with the e-commerce boom. In recent years, logistics enterprises have grown by 14–16% (USD40–42 billion) annually. These companies are transforming their traditional logistics operations into e-commerce logistics management to cope with competition and new markets. According to data from the Vietnam Logistics Business Association, the number of enterprises applying technology in their operations increased from 15–20% to 40–50% in recent years. However, over half of these businesses have yet to adopt significant technology [3].

Under Industry 4.0, Vietnam's tourism sector has rapidly changed and increased service quality using the smart tourism model. In addition, 64% of international tourists booked their trips to Vietnam online. Nearly 100% of enterprises in the country's tourism sector use websites to disseminate product information. However, only 50% of domestic enterprises have successfully applied online sales and payment methods [11].

Vietnam's health sector has widely adopted digital technologies to develop a smart health system focusing on three main pillars: innovative disease prevention, competent examination and treatment, and smart medical administration. The online portal Medihub provides official information on each hospital's services, procedures, regulations, and information on diseases and new treatments.

Major hospitals in Vietnam, such as Thu Duc District Hospital in Ho Chi Minh City, have begun implementing the Smart Medical Clinics model. This will enable patients to register their medical appointments through a central system connected to the hospital's management software. Visitors receive automated ticket numbers and can wait for their appointment with greater comfort and convenience, with several screens around the hospital displaying the order of ticket numbers [11].

On the national DX strategy front, Vietnam has progressed in e-government development, particularly in digital infrastructure. The tax authority in Vietnam has implemented e-filing, e-payment, and e-customs initiatives that have improved tax collection and management while lowering taxpayers' compliance costs.

Gap Issues: Industrial Sector Analysis

Industry Sector Overview

Vietnam's economy today is dominated by services and manufacturing, positioning itself as a crucial link in the global supply chain. Historically, Vietnam has been a hub for manufacturing lower-value-added goods like clothing and footwear, but it is now moving into manufacturing more advanced products. Major technology companies such as Apple, Google, and Microsoft have added manufacturing facilities in Vietnam to their supply chain.

However, Vietnam's development is outpacing its capacity in some ways, with high-tech companies struggling to find appropriately skilled staff and experiencing bottlenecks across physical and digital infrastructure systems. To support its highly trade-intensive economy, Vietnam must upskill its population and ensure the development of necessary infrastructure.

Vietnam faces various environmental challenges as it continues its rapid economic development. These include deforestation and soil degradation from expanded agriculture, water pollution and overfishing, air pollution, and general environmental degradation from rapid urbanization. Many countries have successfully dealt with these environmental challenges, and Vietnam, too, has ambitious and comprehensive ecological policies in place. These include the National Action Plan on Sustainable Consumption and Production and the Vietnam Green Growth Strategy.

The country is aware of these challenges and has begun formulating policies to reduce greenhouse gases and adapt to the effects of climate change. At COP26 2021, Prime Minister Pham Minh Chinh announced the country's commitment to phase out coal power generation by the 2040s and achieve net-zero carbon emissions by 2050. The Ministry of Industry and Trade's draft Power Development Plan 8 aims to switch about 75% of generation capacity to renewables by 2045. Of this, about 100 GW will be solar power, and about 120 GW will be wind power, with even higher solar targets being discussed. The ministry also announced plans to use hydrogen and ammonia in thermal generation, paving the way for green hydrogen to replace fossil fuels partially [7].

In the transportation sector, government policies have encouraged the adoption of EVs, the development of EV-charging infrastructure, and the electrification of public transit. The Ministry of Finance has reduced EV registration fees, and metro projects are underway in Hanoi, Ho Chi Minh City, and Da Nang, which may reduce the reliance on personal vehicles. Hanoi and other cities have discussed banning two- and three-wheel vehicles with Internal Combustion Engines and have pedestrianized some neighborhoods on certain days. The Ministry of Transport is also planning to build a high-speed rail system, which could reduce the number of domestic flights.

Productivity gains across the industry in Vietnam through technology adoption are crucial if the country is to avoid the middle-income trap and progress to a higher income status. The digital technology industry has enormous growth potential, given the increasing popularity of IoT, the rapid penetration of e-commerce, priority investment in smart cities, and the use of Industry 4.0 technologies such as AI, AR/VR, blockchain, and 5G.

The institutional framework for developing e-government, digital government, and digital economy has gradually improved in Vietnam.

Government Policies

Vietnam has implemented a series of strategic policies to support its socioeconomic development and actively participate in Industry 4.0.

- The 10-year socioeconomic development strategy 2021–30
- Resolution 23-NQ/TW dated March 22, 2018, on orientations for building national industrial development policies to 2030, with a vision to 2045
- Resolution 20-NQ/TW on S&T development to serve the cause of industrialization and modernization in the context of a socialist-oriented market economy and international integration
- Conclusion 50-KL/TW on continuing to implement Resolution 20-NQ/TW
- Resolution 52-NQ/TW on mechanisms and policies to actively participate in Industry 4.0

- National Strategy on Industry 4.0 to 2030
- Strategy on Intellectual Property to 2030
- National Digital Transformation Program to 2025, with orientation to 2030
- Decision 681/QD-TTG dated June 4, 2019, promulgating a roadmap for implementing Vietnam's sustainable development goals until 2030

These policies demonstrate Vietnam's commitment to leveraging DX and advanced technologies to drive economic growth and sustainable development.

Science and Technology

Recent national plans and strategies have led to a significant overhaul of science and technology regulations in Vietnam. Promoting national capabilities in R&D has been a top priority under the Socio-Economic Development Strategy 2011–20 and the Socio-Economic Development Plan 2016–20. The 2013 amendment of the Law on Science and Technology brought significant regulatory improvements, such as expanding the rights of R&D organizations to conduct business, promoting the development of the R&D market, reserving incentives for R&D enterprises in high-tech fields, and introducing explicit provisions on tax, credit, and funds for R&D activities.

The Law on Technology Transfer and Decree 76/2018/ND-CP supports creative start-up ideas by recognizing property rights to ownership, using scientific research and technological development results, and allowing these rights to be used as collateral for investment loans. Organizations and individuals investing in and supporting innovative start-ups are entitled to tax incentives. The government has also announced policies supporting individuals and groups of individuals starting new ventures, assisting start-ups in exploiting scientific research results, developing technical infrastructure, and the national technology startup support center.

Vietnam has introduced several ambitious policies concerning emerging technologies in recent years. The Strategy for Science, Technology, and Innovation Development until 2030 outlines national ambitions for advanced technologies such as quantum computing and space technology. Similarly, the National Strategy on Research, Development and Application of Artificial Intelligence aims to position Vietnam as a global center for AI development by 2030, including specific targets like creating research organizations and data processing centers [8].

The National Committee's Digitization Plan addresses foundational aspects of technology, focusing on connectivity and cybersecurity. It seeks to promote the digitization of daily life by promoting e-commerce, the digitization of SMEs, and the digitization of government services and state institutions. Cybersecurity is an area of strength for the government, with dedicated policies and laws earning Vietnam a score of 94.59 in the ITU's Global Cybersecurity Index in 2020, ranking it 25th globally and 7th in the Asia Pacific region.

Vietnam's National Master Plan 2021–30 aims to support the country's goals of becoming an upper-middle-income country by 2030 and a developed, high-income nation by 2050. The plan outlines five key targets to achieve these development goals.

1. Rational arrangement of national development space to ensure efficient linkages between regions and maximize their comparative advantages.

2. Focus on key areas with strong economic growth and development potential.

3. Efficient use of natural resources and development of a circular, green economy while protecting the environment and addressing climate change.

4. Modernization of infrastructure and harmonious development of urban and rural areas.

5. Develop policies for the rational development of both land and marine territories

The digital economy is predicted to account for 30% of GDP by 2030.

Strategy for Science, Technology, and Innovation Development Until 2030
The Government of Vietnam launched its new Strategy for Science, Technology, and Innovation Development until 2030, showcasing its impressive openness and flexibility in answering key development questions. This strategy highlights Vietnam's willingness to collaborate and learn internationally, incorporate findings, and develop innovative policies.

The strategy places science and innovation at the center of Vietnam's national development agenda, focusing on specific technologies.

- Information and communications technologies, including quantum and terahertz technologies

- Biotechnology and AgriTech

- Advanced materials across multiple sectors

- Automation and additive technologies

- Marine technologies, especially for managing Vietnamese waters and adapting to climate change

- Energy technologies, including renewable energy, smart grids, and mining technologies

- Environmental technologies, such as recycling and circular economy systems

- Space technology

- Advanced construction, transportation, and infrastructure technologies

The SMEdx Program

The Government of Vietnam launched the SMEdx program in 2021 to promote DX among SMEs. The Ministry of Information and Communications (MIC) assessed and selected 27 digital platforms and technologies to participate in SMEdx, which SMEs would use to aid their digitization efforts. Approximately 62,000 Vietnamese SMEs have utilized the platforms [12].

Eligible businesses receive financial support for DX from the state budget, including a 50% subsidy on renting or purchasing platforms and solutions certified by the MIC for transformation initiatives.

Start-ups and Digital Entrepreneurs

Both state and municipal/city governments have initiated various programs to encourage digital start-ups and the commercialization of new technologies.

- The National Agency for Technology, Entrepreneurship and Commercialization Development
- The National Technology Innovation Fund
- Hoalac Hitech Service Centre
- Saigon Silicon City Centre
- The National Innovation Centre
- The National Start-up Centre
- ICT and Digital Economy Policies

ICT and Policies for the Digital Economy

In 2022, the Vietnamese government restructured the National Committee on e-Government, renaming it the National Committee on Digital Transformation. The restructuring broadened the committee's remit and increased its profile, with the committee now chaired by Prime Minister Pham Minh Chinh.

The Committee's Digital Transformation Digitization Plan outlines goals for digital infrastructure, e-government, and the digital economy and society. This broad plan assigned 18 tasks to the committee's 16 members drawn from different government agencies. These tasks include universalizing smartphones, electronic identities, and broadband fiber optic cables. The plan aims to enhance network information safety and security, develop EHR, support online teaching, and digitally transform SMEs.

Other goals involve promoting digital payment methods, boosting e-commerce and digital commerce, focusing on smart urban planning, and increasing spending on scientific research for DX. The plan also aims to operationalize an agricultural database and create a national database on cadres, civil servants, and public employees.

Case Study: Samsung Vietnam

In February 2022, Vietnam's Ministry of Industry and Trade signed a Memorandum of Understanding with Samsung to cooperate on smart factory development. The program aimed to support the development of smart factories in 50 enterprises and train 100 Vietnamese experts in smart factory consulting over the next two years. The COVID-19 pandemic accelerated efforts towards automation, robotics, and DX to support the future of the supply chain.

This cooperation program between Samsung and Vietnam was designed to support and train local manufacturing businesses to digitize and optimize their management and production processes

through smart technologies. For example, they utilized barcode scanning to manage production results and inventory status and software to manage production, equipment, and defect rates.

Challenges and Barriers

The advancement of the digital economy in Vietnam presents several challenges and barriers. One significant issue is the potential loss of employment. As technology gets more integrated into processes, the need for human resources diminishes, leading to job losses. For instance, online banking reduces the need for traditional banking staff.

Another major challenge is the lack of experts. The digital economy relies on complex processes and technologies, necessitating experts and trained professionals to build and maintain these platforms. However, such expertise is often unavailable, especially in rural and semi-rural areas.

Additionally, the digital economy demands heavy investment. Establishing a robust infrastructure, including high-speed Internet, strong mobile networks, and telecommunication, requires considerable time and financial resources. Developing infrastructure and networks in Vietnam is often slow, tedious, and costly.

Finance constraints and insufficient information are the significant barriers to further digitalization at the enterprise level in Vietnam's manufacturing and agriculture sectors. Moreover, a lack of coordination among different public agencies complicates the implementation of national digital economy strategies, hindering the overall progress of DX.

Mobilizing Scenarios

Emerging technologies can potentially change the cost-benefit equation or create an entirely new product portfolio that can transform production activities in Vietnam. Technologies such as biotechnology, nanotechnology, advanced materials, energy, and digital technologies have the potential to drive fundamental changes in global industries. The quick adoption of digital technologies in several leading Vietnamese firms indicates the country's capacity to lift productivity and growth.

Artificial Intelligence

AI holds immense potential to drive significant economic, social, and environmental benefits in all economies. It can unlock innovation and create and expand markets and revenue streams by enhancing decision-making processes, improving operational efficiency, and boosting productivity. Indeed, the adoption of AI is already impacting the APO member economies across the industry, from healthcare to manufacturing and technology.

It is no surprise that there is excitement surrounding the opportunities that AI presents to unlock transformative economic, societal, and environmental benefits in the Asia region. A recent Microsoft-IDC Study found that almost all businesses believe that AI is central to their growth, with 80% of business leaders in the Asia-Pacific region reporting that it is instrumental to their organization's competitiveness. The same study found that the businesses surveyed believe that AI will almost double the rate of innovation in the short term.

AI has enormous potential to advance economic and societal well-being and enable improved environmental outcomes within the APO. It is already driving innovation and efficiencies and

is supporting the creation of unprecedented new products, systems, and services across the region, from automated health diagnostics in hospitals to smart agriculture and precision farming systems optimizing farm gate yields. It offers vastly improved decision-making and cost reduction, enabling businesses and policymakers to boost productivity, speed, scale, and consistency of service.

When done right, AI has proven to deliver tangible benefits.

- **Automation:** AI can automate repetitive tasks, driving productivity efficiency and freeing up human resources to focus on more complex and creative tasks.
- **Decision making:** AI can analyze large amounts of data and provide insights and recommendations, supporting more informed decision-making and recommendations.
- **Improved accuracy:** AI algorithms can perform highly accurate and precise tasks, reducing errors and improving overall quality.
- **Safety and security:** AI can be used for threat detection and to support surveillance and cybersecurity by helping to identify and prevent risks and threats.
- **Efficiency:** AI can help analyze and predict outcomes, leading to more accurate and timely interventions. This has proven to be particularly beneficial in healthcare.
- **Innovation and creativity:** AI can help create new ideas, designs, and solutions by analyzing vast amounts of data and identifying patterns and trends.
- **Enhanced personalization:** AI can analyze user data and behavior to provide personalized experiences and recommendations and support customer service by providing instant customer support.

National Strategy on Research, Development and Application of AI Until the Year 2030
Vietnam's national AI strategy, launched in 2021, conceptualizes it as a backend technology critical for 4IR. The policy aims to position Vietnam as a center of AI innovation by 2030, with specific targets to be achieved by 2030.

Establish AI as an essential technology in Vietnam

- Vietnam is ranked among the top four countries in the ASEAN region and the top 50 globally in research, development, and application of AI.
- Setting up ten renowned AI centers in the region.
- Developing three national centers for big data storage and high-performance computing, connecting domestic and high-performance computing centers to create a shared network for big data and computing for AI.
- Developing 50 open, linked, and connected data sets in different economic sectors and socioeconomic fields serving AI research, development, and application.

Establish Vietnam as a center for innovation and developing solutions through the use of AI

- Establishing three national innovation centers for AI.
- Building a contingent of high-quality human resources working on AI, including a team of experts and engineers applying AI applications. Rapidly increasing the number of scientific projects and patent applications for AI in Vietnam.
- A minimum of one representative ranked in the ASEAN region's top 20 AI research and training institutions.

Foster a creative society, protect national security, maintain social order, and promote sustainable economic growth

- Universalizing the basic skills of AI applications to direct workers, promote innovation, reduce costs, boost labor productivity, and improve the living standard of the people.
- Apply AI in national defense and security, rescue operations, natural disaster prevention, and incident and epidemic response.

Digital Trade Enablers and Foundational Technologies

Digital trade and Vietnam's digitization goals rely on several critical components and enablers. First, mobile-friendly connectivity to ensure widespread access and usability. Second, digital identities for verification, validation, and authentication of buyers and sellers. Third, digital payments and messaging systems to enable transactions between individuals and entities. Lastly, cybersecurity and privacy policies and technologies to manage risk and protect stakeholders.

Mobile Connectivity

Connectivity provides the foundational means for participation in the digital economy, allowing users to access digital services, content, and communications. Without a reliable, fast, low-latency, high-capacity telecommunications network, little digital trade can occur. Interoperability and standardization enable different networks (e.g., fixed, mobile, open-loop, proprietary, etc.) to connect and communicate, facilitating the movement of goods and services and the exchange of electronic information, which underlies digital trade. Vietnam enjoys a very high mobile penetration, with 143 mobile subscriptions per 100 people.

When conceptualizing emerging technology, it can be helpful to divide technologies into those that enable and enhance traditional industries and those representing entirely new fields of economic activity. Such enabling digital and computing technologies cut across multiple industries and have a variety of applications. The enabling technologies or emerging trends discussed here include AI, IoT, blockchain, and edge and cloud computing. Cybersecurity is also an essential aspect of these technologies. They also have the potential to overlap and interact, collectively enabling the individual industries and technologies critical to Vietnam's economy, such as smart manufacturing, smart cities, and agriculture.

Smart Cities

A smart city is sustainable, prosperous, livable, and puts people first. While technology and digital data are essential enablers, the ultimate goal is to enhance residents' quality of life. In Vietnam, Ha Noi and Ho Chi Minh City are at the forefront of this transformation into smart cities.

Vietnam is in the early stages of developing smart city policies and strategies. In 2022, the government issued a resolution on the planning, management, and development of Vietnam's urban areas out to 2030, with a vision until 2045.

Currently, 40 cities and provinces are developing smart city services. Seventeen cities and provinces have either started building or have agreed to build smart city operating centers. Additionally, 17 provinces have launched smart tourism service applications, and more than 10 are using apps for smart traffic, urban orders, and security. The government views the development of smart cities as part of broader DX policies across the country. These initiatives, including the National Committee on Digital Transformation's digitization plan, will likely evolve as Vietnam enhances its general capabilities in this domain.

Blockchain

Blockchain is a type of distributed ledger technology (DLT) in which information is created and stored by a network of computers in 'blocks.' No single database or system controls this information, and once it is entered into the block, it becomes incredibly complicated to remove or amend. This allows parties in a transaction to reliably record and store information (such as money, property, or contracts) without requiring a central authority.

The financial services and banking sectors are the most enthusiastic adopters of blockchain. Cryptocurrencies and non-fungible tokens have entered popular culture, but blockchain's applications extend far beyond these. DLT can enable the execution and management of contracts without the need for lawyers, manage digital rights (such as copyright or intellectual property ownership), and manage supply chains. According to Gartner Research, the global business value-add of blockchain is expected to grow to more than USD176 billion by 2025 and exceed USD3.1 trillion by 2030.

Digitalization in the traceability of farm produce is critical as Vietnam aims to build transparent agriculture. Digitization in agricultural product traceability requires the engagement and coordination of all parties, including state management agencies, enterprises, cooperatives, and farmers. Effective state management in this area aims to meet the requirements of international integration, improve transparency and accountability in the sector, and enhance the interests of farmers.

Policy Recommendations

Technology has always been at the center of socioeconomic development. The promotion of technological change through the introduction and utilization of new technologies has become a critical component of development strategies throughout the world. There are also intensive studies on technological change and how technology is created, diffused, adapted, and implemented to generate economic outcomes. Many studies confirm the impact of technology creation and adoption in determining the aggregate productivity growth of an economy. Productivity can be boosted by leveraging existing capabilities and resources, reducing costs, and reaching untapped demand and markets through new technology.

Vietnam's key to maintaining rapid and sustainable growth and leapfrogging through the next development phase is technology adoption and creation. Strong leadership and robust institutions will be crucial for Vietnam to leverage these opportunities and unblock bottlenecks for further economic development.

Some recommendations are as follows:

Identification of regional and national priorities for critical and emerging technologies.

A crucial next step towards improving the APO's engagement in these areas will be to develop a core group of priority focus areas, with input from policymakers, industry, academia, and standard-setting organizations. These priority focus areas will allow for targeted support and clear direction for national experts.

Improve technology adoption among businesses

- Develop sectoral strategies for technology adoption.
- Accelerate DX and Industry 4.0 technology adoption.
- Improve 'spillover' effects and forward and backward linkages.

Improve technical efficiency among businesses

- Accelerate the implementation of programs to develop the skills and expertise of managers.
- Increase the awareness and adoption of efficiency/productivity enhancement tools for management and business.

Promote R&D and emerging industries to lift the technology frontier

- Monitor innovation and technology adoption and identify clusters and emerging industries.
- Strengthen IPR protection through increasing IPR consultancy and IPR management.
- Select leading technology performers as technology models to showcase and build competitiveness.
- Incentivize the private sector to drive R&D.

Develop human resources

- Attract foreign researchers and experts, especially Vietnamese living in foreign countries.
- Enhance the skills of the S&T labor force.

Develop policy instruments and implementation mechanisms to synthesize and stimulate technology development efforts

- Undertake foresight exercises.
- Develop a database on technology adoption and creation and a systematic methodology to prioritize investment.

Building and developing innovation ecosystems in industries, agriculture, and services is essential for Vietnam's integration into domestic and global value chains and industry clusters. Large enterprises play a significant role in leading innovation activities, while state management agencies are responsible for creating a favorable institutional environment and policies. These agencies must

facilitate linkages between enterprises, production organizations, research institutes, universities, and supporting organizations to promote research, application, and innovation activities.

The country is deploying open innovation platforms and networks to attract domestic and foreign resources, from basic and applied research to implementation, experimentation, and new technologies and products. This effort also aims to facilitate the formation of new businesses.

Digital technology enterprises should be central to digital technology development. Policies to incentivize the development of digital technology companies are also needed. Similarly, Vietnam must implement policies to control the quality of Make-in-Vietnam digital technology products and services, attract foreign investment, and build talent.

Vietnam must strive to adopt standards across these enabling spaces to ensure that the potential of new enabling technologies flows into traditional industries. Standardization across systems of intelligent machines will be crucial for future economic competitiveness, as proliferating devices require increasing interoperability.

Vietnam's National Digital Transformation Programme has been approved with goals for 2025 and an orientation towards 2030. The initiative reflects the priority towards digitalization as Vietnam has identified opportunities for technology and digital services to transform the country and progress as a middle-income economy.

TABLE 1

DX INITIATIVES IN VIETNAM.

DIGITAL TRANSFORMATION HAS PERMEATED NEARLY ALL TYPES OF BUSINESSES AND AT MANY LEVELS.

Organization	Summary of Initiatives
Truong Hai (automobile)	Production of automobile tweezers with 70–80% factory automation. The automation improves the factory's production capacity from 6,000 tons to 10,000 tons annually and reduces annual production costs by 5%. Train and update personnel management skills and capabilities; continuously upgrade technological infrastructure, machinery equipment, and production processes toward building smart factories and industrial parks.
Vinamilk	This company has applied IoT technology to livestock monitoring. Everyone involved in the livestock raising process, from diet to care and hygiene, is closely monitored according to innovative agricultural standards. Vinamik's farm has been certified as an organic farm per European standards, and the volume of milk collected has increased to 23 liters per cow per day.
Thu Duc District Hospital in Ho Chi Minh City	The online portal Medihub.vn provides official information on each hospital's services, procedures, regulations, diseases, and new treatments. People visiting the hospital can now register their medical appointments through a central system connected to overall hospital management software. Visitors receive automated ticket numbers and can wait for their appointments with greater comfort and convenience. Several screens around the hospital display the order of ticket numbers.

(Continued on next page)

(Continued from the previous page)

Organization	Summary of Initiatives
Samsung Vietnam	In February 2022, the Vietnamese Ministry of Industry and Trade signed a Memorandum of Understanding with Samsung on cooperation on innovative factory development. The program aims to support the development of smart factories for 50 enterprises and train 100 Vietnamese experts in smart factory consulting in the next two years. It was noted that the COVID-19 pandemic accelerated the efforts towards automation, robotics, and DX to support the future of the supply chain. The cooperation program between Samsung and Vietnam is designed to help and train local manufacturing businesses in digitizing and optimizing their management and production processes through smart technologies. For example, barcode scanning can be utilized to manage production results and inventory status, and software can be employed to manage production, equipment, and defect rates.
The Military Industry and Telecommunications Group (Viettel)	This is a model enterprise for the DX of large telecommunications enterprises in Vietnam. The group has presented a roadmap for DX across sectors, including information technology and digital services, high-tech industrial production, and logistics.
Bank	Digital banking is the integration of digitization and digital technology into all areas of banking. This integration enables new or modified existing business processes, cultures, and customer experiences to meet the changing market requirements and customer expectations. DX helps banks save costs and streamline operational processes. Digital banks can perform most banking transactions online via the Internet. When using digital banking transactions, customers do not have to go to the bank's branches, and related paperwork is minimized. The security of digital banking is absolute and is closely monitored by the banks. Specifically, VIB (Vietnam International Commercial Joint Stock Bank) continues to be among the top leaders in growth (the number of credit cards and spending on cards is two times higher than the average of the banking industry, according to a report by the international card organization Mastercard). This bank's non-interest income in the first six months of 2021 increased by 41%, of which net interest alone increased by 34% over the same period in 2020 and accounted for 19% of total income. At BIDV (Joint Stock Commercial Bank for Investment and Development of Vietnam), income from non-credit activities (mainly services) was projected to grow strongly in 2023 thanks to insurance services and digital banking motivation.

References

[1] International Organisation for Standardisation. ISO Foresight Trend Report 2022.

[2] UN Conference on Trade and Development. Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development; 2018.

[3] World Bank; Ministry of Planning and Investment of Viet Nam. Viet Nam 2035 – Towards Prosperity, Creativity, Equity and Democracy; 2016.

[4] World Bank. Vietnam: Science, Technology and Innovation Report 2020; 2022.

[5] VnExpress. Vietnam's human capital ranks second in SEA; 2020.

[6] Department of Foreign Affairs and Trade, Government of Australia. Vietnam Country Brief; 2022.

[7] The Diplomat. Why Vietnam's future is bright; 2022.

[8] Vietnam Plus. Strategy for Science, Technology and Innovation Development until 2030 approved; 2022.

[9] IMF. Vietnam Bucks Asia's Weakening Growth Trend; 2022.

[10] The BTI Project. BTI 2022 Vietnam Country Report; 2022.

[11] Vietnam Plus.

[12] Ministry of Information and Communications, Government of Vietnam. More SMEs participating in digital transformation after pandemic; 2022.

LIST OF TABLES

SRI LANKA

THAILAND

TURKIYE

VIETNAM

LIST OF FIGURES

MONGOLIA

NEPAL

PAKISTAN

PHILIPPINES

SRI LANKA

THAILAND

TURKIYE

LIST OF ABBREVIATIONS

4IR	Fourth Industrial Revolution
A2i	Aspire to Innovate
ABPS	Any Branch Payment System
AgriTech	Agriculture Technology
AI	Artificial Intelligence
APMC	Agricultural Produce & Livestock Market Committee
APO	Asian Productivity Organization
BBS	Bangladesh Bureau of Statistics
BCG	Boston Consulting Group
BDT	Bangladeshi Taka (currency)
BEA	Blended Education Accelerator
BIGD	BRAC Institute of Governance and Development
BOI	Board of Investment
BSP	Bangko Sentral ng Pilipinas
CAD	Computer-Aided Design
CAGR	Compound Annual Growth Rate
CBSL	Central Bank of Sri Lanka
CeC	Community e-Center Program
CMSME	Cottage, Micro, Small and Medium Enterprises
CNC	Computer Numerical Control
CNIC	Computerized NIC
CoE	Centre of Excellence
CPE	Customer Premise Equipment
CPEC	Pak China Economic Corridor
CPS	Cyber-Physical Systems
CRTDH	Common Research and Technology Development Hub
CSIR	Council of Scientific & Industrial Research
DBBL	Dutch-Bangla Bank Limited
DEPA	Digital Economy Promotion Agency
DFS	Digital Financial Service
DICT	Department of Information and Communications Technology
DIL	Disability Innovation Lab
DLT	Distributed Ledger Technology

DNF	Digital Nepal Framework
DPI	Digital Public Infrastructure
DSDL	Digital Service Design Lab
DX	Digital Transformation
E/M services	Electronic or Mobile-Based Services
EEC	Eastern Economic Corridor
EGDI	e-Government Development Index
eGMP	e-Government Master Plan
E-GP	Electronic-Government Procurement
EHR	Electronic Health Records
EITI	Extractive Industries Transparency Initiative
ERC	Energy Regulation Committee
ETDA	Electronic Transaction Development Agency
EV	Electric Vehicles
FDI	Foreign Direct Investment
FVS	Face Verification Service
FY	Fiscal Year
GDP	Gross Domestic Product
GeLP	Government eLearning Platform
GeM	Government e-Marketplace
Gen AI	Generative AI
GII	Global Innovation Index
GKI	Global Knowledge Index
GNDI	Gross National Disposable Income
GNI	Gross National Income
GoB	Government of Bangladesh
HCI	Human Capital Index
ICTA	Information and Communication Technology Agency
IDP	ID Provider
IFFCO	Indian Farmers Fertilizer Cooperative Limited
IIoT	Industrial Internet of Things
INR	Indian Rupee (currency)
IoS	Internet of Services
IoT	Internet of Things
IPR	Intellectual Property Rights
ITeS	IT-enabled Services
ITI	Industrial Training Institute

ITU	International Telecommunications Union
KIPA	Korean IT Industry Promotion Industry
KOSGEB	Small and Medium Enterprises Development Organization of Turkiye
LEP	Light Engineering Product
LES	Light Engineering Sector
LKR	Sri Lankan Rupee (currency)
M2H	Machine-to-Human
M2M	Machine-to-Machine
MDES	Ministry of Digital Economy & Society
MeitY	Ministry of Electronics & Information Technology
MESS	Turkish Employers Association of Metal Industries
MISTI	Ministry of Industry, Science, Technology & Innovation
ML	Machine Learning
MMC	Multimedia Classrooms
MNT	Mongolian Tugrik (currency)
MoIT	Ministry of Industry and Technology
MSME	Micro, Small, and Medium Enterprise
MUSIAD	Independent Industrialists and Businessmen's Association
NADRA	National Database and Registration Authority
NBT	Nation Building Tax
NCD	Non-Communicable Disease
NDP	National Development Plan
NEA	Nepal Electricity Authority
NeGIF	Nepal e-Government Interoperability Framework
NIC	National ID Card (Pakistan)
NISE	National Intelligence for Skills, Education, Employment and Entrepreneurship
NITB	National Information Technology Board
NPC	National Productivity Council
NPS	National Payments System
NSIC	Nepal Standard Industrial Classification
NSO	National Statistics Office
O2O	Online-to-Offline
OMO	Online Merge Offline
OSI	Online Service Index
PDS	Philippine Digital Strategy 2011–16
PDTS	Philippine Digital Transformation Strategy
PhilGEPS	Philippine Government Electronic Procurement System

PHP	Philippine Peso (currency)
PKR	Pakistani Rupee (currency)
POC	Proof of Concept
PSU	Public Sector Undertaking
R&D	Research & Development
RFID	Radio Frequency Identification
RGC	Royal Government of Cambodia
RMG	Readymade Garment
RMG	Ready-Made Garments
ROI	Return on Investment
RRI	Responsible Research and Innovation
SAARC	South Asian Association of Regional Cooperation
SME	Small and Medium Enterprise
SNIC	Smart National Identity Card
SPS	Simplifying Public Services
STEM	Science, Technology, Engineering, and Mathematics
STI	Science, Technology and Innovation
TCV	Time, Cost and Visit
TDRI	Thailand Direct Research Investment
THB	Thai Baht (currency)
TII	Telecommunications Infrastructure Index
TRCSL	Telecommunication Regulatory Commission of Sri Lanka
TRL	Technology Readiness Level
TUBISAD	Turkish Informatics Industry Association
TUBITAK	The Scientific And Technological Research Council Of Turkiye
TUIK	Turkish Statistical Institute
TUSIAD	Turkish Industry and Business Association
TUSSIDE	Turkish Management Sciences Institute
UAV	Unmanned Aerial Vehicle
UDC	Union Digital Centre
UNDESA	United Nations Economic and Social Commission
USD	US Dollar
VAT	Value Added Tax

LIST OF CONTRIBUTORS

CHIEF EXPERT

Dr. Nobuyuki Shirakawa
Associate Professor, Faculty of Engineering, Niigata University
and Vice Director, Research Centre on Emerging Technology and Governance,
Institute of Research Promotion
Japan

NATIONAL EXPERTS

BANGLADESH

Md. Abdul Awal
Senior Statistician
Socio-Economic Research Division
Centre for Sustainable Social and Technology Development
Bangladesh

CAMBODIA

Seng Molika
Director
Science, Technology, and Innovation Data Management Department
Ministry of Industry, Science, Technology & Innovation
Cambodia

REPUBLIC OF CHINA

Dr. Chen-Hao Huang
Assistant Professor
Department of Business Administration
National Cheng Kung University
Republic of China

INDIA

Dr. T. Senthil Siva Subramanian
Head
Institute Industry Interface Program
Sharda Group of Institutions
India

MONGOLIA

Unurtsetseg Chagtsal
Advisor
Mongolian Productivity Organization
Mongolia

NEPAL

Ritu Pantha
Under Secretary
Planning, Monitoring, and Coordination Division
Statistical Analysis Section, Ministry of Forest and Environment
Nepal

PAKISTAN
Dr. Abdul Zahid Khan
Chairman
Department of Technology and Project Management
International Islamic University Islamabad
Pakistan

PHILIPPINES
Dr. Ian Jester M. de Vera
University Extension Specialist
Research Department
UP Institute for Small-Scale Industries
Philippines

SRI LANKA
Kanthasamy Nikarilkanth
Senior Assistant Secretary
Foreign Employment Division
Ministry of Labour and Foreign Employment
Sri Lanka

THAILAND
Dr. Pattarawan Prasarnphanich
Assistant Professor
Faculty of Operations and Technology
Behavioral Research Informatics Research Unit
Sasin School of Management, Chulalongkorn University
Thailand

TURKIYE
Serkan Ulu
Industry and Technology Expert
Directorate General for Strategic Research and Productivity,
Ministry of Industry and Technology
Turkiye

VIETNAM
Vu Thi Thu Phuong
Acting Director
International Cooperation Department
STAMEQ
Vietnam

APO SECRETARIAT
Kyung Hyun Park
Program Officer
Asian Productivity Organization


+23.456
-10.4646