SOUTH-SOUTH AND TRIANGULAR COOPERATION IN A DIGITAL WORLD

NEW IMPETUS AND NEW APPROACHES

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Preface

On 19 March 2019, the South-South Cooperation in the Digital World Conference was held in Argentina alongside the Second High-level United Nations Conference on South-South Cooperation and the 40th Anniversary of the Buenos Aires Plan of Action (BAPA+40). The 2018 South-South Cooperation report South-South Cooperation in a Digital World, jointly prepared by the Finance Center for South-South Cooperation (FCSSC) and the United Nations Office for South-South Cooperation (UNOSSC), was released at the conference. Thereafter, numerous partners initiated various initiatives to help advance this agenda. Therefore, FCSSC and UNOSSC continued to focus on the topic, and to dig even deeper, and chose South-South and Triangular Cooperation in a Digital World: New Impetus and New Approaches as the theme for our 2020/2021 report.

Excitingly, Southern countries are at the forefront of South-South and Triangular Cooperation and the digital world has created new dynamics, which have enriched the knowledge and experience of international cooperation and development. Digital technology has exerted an increasingly wide-spread and far-reaching influence on South-South Cooperation. The positive influence of digital technology on the economic and social development of Southern countries in key areas such as agriculture and food safety, climate change, natural disaster prevention and reduction, finance, education, health care and financing is becoming more and more significant. Furthermore, innovative development models keep springing up in Southern countries. These advances are inspiring new concepts of how to push further ahead with South-South and Triangular Cooperation.

E-commerce, particularly cross-border e-commerce, has brought flexible employment opportunities to small- and medium-sized business owners, including women, meanwhile integrating developing markets into global supply and value chains. Artificial intelligence (AI) has been applied in agriculture more and more extensively – for example using unmanned aerial vehicles (UAV) for the targeted management of water and fertilizer – enabling small farmers to benefit from the progress of the technology. Digital access to education (distance learning), tele-medicine, financial services (AI risk control), among other services, has provided easier ways to equalize public service and allowed services to reach more remote, rural and poverty-stricken regions. The Digital Silk Road, Digital Africa, the Digital Association of South-East Asian Nations and other emerging technology-forward development frameworks are helping to meet the needs of developing countries and regions as well.

Through the promotion of cooperation mechanisms for sustainability, South-South Cooperation has become a fundamental framework for the conceptualizing of innovative and collaborative development agendas. The increasing number of Southern countries participating in projects and initiatives through South-South Cooperation platforms reflects the demand for strong regional platforms that can leverage existing and future digital opportunities. In hopes of narrowing the global digital divide, this report is concerned with assessing various approaches that have become essential to the strengthening of South-South and Triangular Cooperation in the face of the modern technology revolution. This includes highlighting ways in which the digital universe can enable various South-South and Triangular Cooperation platforms to leverage digital frontiers for the expansion of digital cooperation frameworks. As such, this is an attempt to foster a propulsive discourse in addressing shifts in the digital world and to provide a way forward for those who have been left out of the revolutionary digital transformation acceleration. From the major industries of agriculture, health and finance to the critical concerns of climate change, the report underlines the significance of promoting and leveraging South-South and Triangular Cooperation for building digital capacities across the global South. The introduction of frameworks for enhanced access to information effectively address challenges presented by digital technologies.

At present, South-South Cooperation in the digital technology field initiated by some Southern countries, notably Brazil, China, India and Kenya, has achieved considerable success. Thanks to efforts in this regard, participating countries have expanded partnerships and an important complement has been made to the current mechanisms for international development cooperation. In addition, innovative financial modes, from institutions such as the African Development Bank (AfDB), Asian Infrastructure Investment Bank (AIIB), New Development Bank (NDB) and Silk Road Fund (SRF), have brought about new financing channels and opportunities for the realization of the United Nation's 2030 Sustainable Development Goals.

The COVID-19 pandemic swept across the world, threatening people's lives and health and severely impacting economic and social development. As of September 3, 2021, the total confirmed cases around the globe were nearly 219 million, resulting in over 4,5 million deaths, and the figures are still growing (WHO, 2021). The pandemic is more than just an isolated public health emergency. It is exerting tremendous impacts on the world order and the economic and social development of every country. The World Bank reported that global GDP dropped by 4.3 percent in 2020, the most serious global recession since the end of World War II and the most severe economic recession caused by a pandemic in human history. In essence, this next decade is central to determining how the global South progresses towards the 2030 Agenda, and as such, the way in which Southern countries address the challenges and risks of this technology transition is not only pivotal to their economic advancement, but also to their social and political development going forward. Rather than taking part in individual conversations on how to navigate these unchartered waters, Southern actors must come together to collectively address digital development challenges through processes and platforms that can enhance knowledge sharing and technical cooperation. Increasing this momentum among Southern actors will determine whether or not developing regions effectively harness and manage new technologies.

The execution unit of this 2020/2021 report is the Institute for Six-Sector Economy at Fudan University, with funding from the South South Education Foundation. The three Co-Editors-in-Chief of the report are: Professor Wang Xiaolin, Professor and Deputy Dean, Institute for Six-Sector Economy and Professor at School of International Relations and Public Affairs, Fudan University; Dr. Hany Besada, Senior Research and Programme Advisor at UNOSSC; and Dr. Liu Qianqian, Deputy Director-General of FCSSC. Working with FCSSC and UNOSSC, the Co-Editors-in-Chief joined hands to select the topics of this report and recommended and organized accomplished experts as chapter authors, which, by their joint efforts, has materialized and is presented here to our readers. Particular thanks are due to Professor Zhang Laiwu, President of the Institute for Six-Sector Economy, Fudan University, and his team for their support in conducting the present research project.

The theme of this report is prospective, and its content is challenging. In writing it, our group of experts overcame many difficulties, especially the impact imposed by the COVID-19 epidemic. Though the report still leaves some aspects to be desired, it includes abundant South-South digital technology cooperation cases, which gives it added value to the knowledge of South-South Cooperation. Members of our report writing group are: Dr. Hany Besada, Professor Wang Xiaolin, Dr. Liu Qianqian, Dr. Zhang Xiaoying (post-doctoral researcher at the Institute for Six-Sector Economy, Fudan University), Ms. Wu Yifei (Ph.D. candidate at Harvard Business School), Professor Nir Kshetri (University of North Carolina at Greensboro), Dr. Fatima Denton (The United Nations University, Institute for Natural Resources in Africa), Dr. Mousumi Bhattacharjee (National Council of Applied Economic Research, India), Dr. Manuel Montes (Society for International Development), Dr. Bai Chengyu (China Center for International Economic and Technological Exchanges), Professor Li Jing (Beijing Normal University), Professor Olalekan Uthman (The University of Warwick), Professor Kelley Lee (Simon Fraser University) and Dr. André de Mello e Souza (The Institute for Applied Economic Research).

To perform better in organizing the writing of this report, we held a seminar at Fudan University, and many scholars, including some experts who engaged in writing this report and Ms. Maria F. Latorre of FCSSC, took part in its discussion. Though the COVID-19 outbreak made it impossible to hold our mid-term seminar offline in Hong Kong, China, as scheduled, the report project execution unit organized many rounds of online discussions, which ensured the quality of this report. The report benefited greatly from anonymous comments and feedback provided by peer-reviewers. Particular words of thanks and gratitude go to Dr. Cristina D'Alessandro and Dr. George Kararach, our international peer reviewers. We are also grateful to our colleagues Ms. Sun Dingding and Wang Yongjie at UNOSSC, Ms. Yao Zhen, Ms. Zhang Jirong, Mr. Pan Zhanfeng and Mr. Lv Rongcan at FCSSC and the South-South Education Foundation. Finally, but far from least, thanks to our translators, who contributed much to being able to publish this report in English and Chinese.

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Acronyms and abbreviations

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
AIIB	Asian Infrastructure Investment Bank
ASEAN	Association of Southeast Asian Nations
BRI	Belt and Road Initiative
BRICS	Brazil, Russia, India, China and South Africa
CBERS	China-Brazil Earth Resources Satellite
CGIAR	Consultative Group on International Agricultural Research
COVID-19	Coronavirus Disease 2019
CTA	Technical Centre for Agricultural and Rural Cooperation
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FinTech	Financial Technologies
FOCAC	Forum on China-Africa Cooperation
GCPC	Global Consultation and Prevention Center
GDP	Gross Domestic Product
GMCC	Global MediXchange for Combating COVID-19
ICT	Information and Communication Technology
IoT	Internet of Things
ITU	International Telecommunication Union
LDC	Least Developed Country
MoU	Memorandum of Understanding
MRV	Measuring, Reporting and Verification
MSME	Micro-, Small- and Medium-sized Enterprise
NDRCC	Natural Disaster Reduction Centre of China

NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organization
OECD	The Organization for Economic Cooperation and Development
SADC	Southern African Development Community
SDG	Sustainable Development Goal
SME	Small- and Medium-sized Enterprise
SMS	Short Messaging Service
SSC	South-South Cooperation
SSDC	South-South Digital Cooperation
SS&TrC	South-South and Triangular Cooperation
TrC	Triangular Cooperation
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOSSC	United Nations Office for South-South Cooperation
WHO	World Health Organization

Executive summary

Undoubtedly, digital technology is drastically transforming the global economic and social landscape. It not only offers structural change, but also opens the door for inclusive development. Although, the North is recognized for advanced digital infrastructures, various countries across the global South have also demonstrated tremendous progress in the use of digital technology and digitalization has been used to upscale some economic activities in the global South. However, some countries in the global South still lack the necessary infrastructure and strategies to mainstream digital technologies for national development and better integration into global value chains. This report sheds light on the possibilities of leveraging South-South and Triangular Cooperation (SS&TrC) to accelerate digital technology and services transformations for countries in the global South and to diversify their export portfolios, to build digital infrastructure for industrialization, to establish and manage data policies and to improve capacities and transform economies in a sustainable way.

The report first presents an overview and conceptual framework of South-South Digital Cooperation (SSDC) and describes factors that might impact the digitization of economic activities in the global South. Using case studies, this report successfully demonstrates the powerful impact that global South digitization efforts have had on smaller disadvantaged firms, along with big companies, despite the number of challenges that Southern economies face.

The report focuses on the role digital technologies have played in the progression of agricultural productivity and food security in developing nations. The report analyzes financial transformations due to digitalization and the challenges created by financial technologies (FinTech) for developing countries. It advocates for Southern governments and practitioners to integrate Fintech's role strategically into policies for enhanced SS&TrC digital cooperation, which is being shaped worldwide by individual actions of sovereign states and large international private companies.

Next, the publication assesses the potential role of SS&TrC in mitigating the negative impacts of digitization and advancing its potential in combatting climate change. This section emphasizes the role of Triangular Cooperation, in particular, to complement the potential limitations of South-South Cooperation for digitization and climate change strategies.

In the area of health care, the report evaluates the key opportunities digital technolgies offer to advance health-related Sustainable Development Goals, particularly SDG3, along with commitments to Universal Health Coverage, which is a major goal for health reform in many Southern countries. It also stresses the importance of South-South Cooperation in the digitalization of health care to promote equity and access in the global South, as digital solutions are often homegrown and culturally appropriate, further contributing to sustainable health care.

Additionally, by presenting a range of successful examples of South-South Cooperation, including examples from least-developed countries to upper-middle-income countries, this report evidences the successful efforts of SSC beyond Brazil, Russia, India, China, and South Africa (known as the BRICS countries). Finally, the report concludes by exploring the main pillars that drive the progress of South-South Digital Cooperation. It offers several recommendations, such as the need for multi-stakeholder partnerships emphasizing the role of United Nations organizations and the requirement for knowledge sharing between and among Southern countries as well as between the South and the North to scale up best practices. There is also a call for creating effective regional agreements to facilitate digital cooperation, highlighting innovation aspects in South-South and Triangular Cooperation. Lastly, there is a reminder to implement effective inclusion policies and monitoring and evaluation strategies to scale up global South innovations.

Chapter 1

Introduction

There are many things in today's social and economic sphere that the majority of people would agree are considered a luxury – access to technology should not be one. Digital advancements are an integral part of the inevitable economic transformations Southern economies are embarking upon. Despite the significant challenges developing economies undergo, their resilient growth must be anchored in strategic priorities, many of which they share with neighboring counterparts. However, a digital information gap in development cooperation is emerging that requires attention in the global South. Without cooperative efforts, this gap will continue to feed on the vulnerabilities of developing economies and communities and generate regressive implications for future generations. Although technology is credited with the ability to increase global connectivity, it requires appropriate and substantial modalities to effectively harness its powers – modalities which many countries have not yet successfully incorporated into their economies.

Reaching across every industry platform, technology has the potential to unlock developmental capacities essential to the expansion of trade and regional integration. It has the potential to increase accessibility and inclusion of various vulnerable groups in society, including poor communities, women, and youth. Thus, increasing the volume and depth of conversations on digital development taking place in the global South will not only support the formation of vital cooperation frameworks, but will also give much needed opportunities for Southern actors to take the lead on discussions pertaining to their digital development experiences. This report thus provides a comprehensive context of the role of South-South and Triangular Cooperation in facilitating the integration of Southern economies into the global digital economy.

Digital technology is transforming the global economy on a grand scale. It offers great opportunities for structural transformation and fostering of inclusive development. While countries in the North reap the benefits of developed infrastructures enabling them to derive maximum benefits from the evolving global digital economy, many countries in the global South have also made significant progress by taking advantage of the opportunities that digital technology provides for upscaling economic activities, participating in global value chains and leading on digitalization and innovation. Some countries in Africa (such as Kenya and Nigeria) and India and the Philippines have long used digital services for money transfers; these countries were among the first in the world to use mobile money transfers. Yet, many of their counterparts in the global South lack the appropriate infrastructure and capacity to mainstream digital technologies and services in efforts toward contributing to global value chains and even within the success story Southern countries these factors may be lacking in other sectors of the economy.

Against this background of differences in the initial conditions and preparedness for the emerging change in the composition and structure of the global economy, only countries that are prepared can derive the most benefits. South-South and Triangular Cooperation (SS&TrC) opens greater possibilities for countries in the global South to leverage digital technology and services in order to diversify their export portfolios, build digital infrastructures for industrialization, establish and manage data policies, improve capacities and transform economies in a sustainable way. The potential of SS&TrC to help these countries tackle the challenges posed by the digitalization of the global economy is enormous.

Digital technology has multi-sectoral implications – it affects education, health, finance, agriculture, and climate change, among others. The relative success of countries across the global South in promoting their digital economies underscores the imperative of, and the possibilities for, SS&TrC to support developing countries to take advantage of the changes associated with digital technologies.

This chapter engages with the myriad of ways in which digital technologies are shaping the global economy and the role of SS&TrC in ensuring that countries in the global South become active participants in the process. By doing so, they will be more prepared to benefit in a productive way from global value chains and to achieve the 2030 agenda for Sustainable Development. The following presents a general overview of the digital economy and the changes it is bringing to the global economy.

1. An overview of the development of the global digital economy

The current wave of technological innovation has been described as the Fourth Industrial Revolution, meaning the fourth phase of the industrial era since the first phase of major industrialization in the eighteenth century.[1] Schwab (2016) portrays it as a remarkable synergy of breakthroughs that is pervading every aspect of life. According to Schwab (2017:1), "the fourth industrial revolution is fundamentally different from the previous revolutions as it is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries." The new era of technological advancement is characterized by the spread of artificial intelligence, robotics, animation, material sciences, the Internet of Things, blockchain and nanotechnology to traditional and new industries. The Fourth Industrial Revolution, with its massive digital transformation, is changing the whole world's way of life (World Economic Forum, 2016). The current era has the potential to significantly change the global economy and impact the way future industrial designs and strategies are operated (Schwab, 2017), as well as bring massive social upheaval.

Several interesting trends and processes are features of the Fourth Industrial Revolution. The first feature is the change from manufacturing goods to fit a large demand volume to the customization of products in an efficient, flexible, and cost-effective way. For example, rapid advancements in 3D printing (additive manufacturing), digitalized manufacturing techniques and smarter customization all fuel this trend. The second feature associated with this phase is mass personalization, which is the integration of individual customer preferences into purchasing, production and logistics enabled by social technologies and better data processing capabilities. A third feature of this era is the increased adoption of machine learning (artificial intelligence) to replace human thinking based on programmed data and the utilization of growth in technology, such as sensors, to execute it. The pervasive use of information processing capabilities in various aspects of computing, platform integration, connectivity and automation support these new trends of the Fourth Industrial Revolution. Previously independent technological domains, like power generation, production, and agriculture, are now becoming interdependent with regards to connectivity, integrated supply chain management, energy and a direct interface with end users (customers) (Xiong, 2012).

Defined as "that part of economic output derived solely or primarily from digital technologies with a business model based on digital goods or services", the digital economy is estimated to make up around 5 percent of the global Gross Domestic Product (GDP) and 3 percent of global employment (Bukht and Heeks, 2017: 1). More importantly, the internet has led to 10 percent growth in the GDP of BRICS economies and 5 percent growth in the economies of other Southern states (Bughin and Manyika, 2012). In addition, the internet economies of Southern states are growing at a rate of 15 to 25 percent annually (UNCTAD, 2019). E-commerce is growing at a faster rate in the global South than elsewhere in the world. For Southern economies in particular, digital technology can foster higher levels of economic growth through lowered cost of transactions and increased productivity of labour and capital, coupled with free entry into global markets.

1 The first phase of the Industrial Revolution between the years 1760 and 1840 was characterized by widespread use of steam engines for mechanized production. The second phase saw the advent of electric power and the idea of dividing labor to ensure mass production of goods. The third phase started in the early 1980s and was defined by the rise of information technology and the automated production of goods and services (Tattrie, 2019).

Several scholars, such as Tattrie (2019) and Graham (2019), have come to identify the effect that digital technology is having on the economy and society in general through a higher level of connectivity and internet penetration. These authors note that individuals have become more connected digitally, though they have become socially distant at the same time. According to Tattrie (2019:3), "globally, about 4.39 billion people use the internet, or more than half of the world's population. That is compared to about 2.5 million in 1990 and about 44 million in 1995. Southern countries are among the fastest growing internet users." India, for example, added about 100 million in 2018 (Tattrie, 2019). What is of importance, is the fact that the internet has contributed to the GDP of emerging economies. In 2009, the internet's contribution to Brazil's GDP was 1.5 percent, while it was 2.6 percent in China and 3.2 percent in India (Du Rausas et al., 2011). A report that was prepared for the World Bank's *World Development Report 2016: Digital Dividends* states that from 1980 to 2011, a 10 percentage-point increase in internet usage in low- and middle-income states leads to a 0.93 percent increase in per capita GDP (Minges, 2015). This shows the high potential that a well-harnessed digital technology regime possesses to contribute to improved economic performance in both Northern and Southern countries.

More succinctly, the digital economy has been described as having the highest potential to facilitate commercial transactions with the aid of the internet (Osiakwan, 2017). The digital economy is moving rapidly and contributing to the growth of various economies, such as Brazil, China, India, Mexico, South Korea, South Africa, and others in the global South.

According to Miura (2018), figures from a think tank associated with the Chinese Ministry of Industry and Technology show that the Chinese digital economy accounted for 32.9 percent of the country's total GDP in 2017. In the case of India, a report by the McKinsey global Institute (2019) shows that India's digital economy accounted for 8 percent of the nominal GDP, or about US$200 billion in 2017-2018. Countries such as Kenya, Nigeria, the Philippines, and South Africa pioneered mainstreaming digital services for transferring money. Examples of digital platforms for transferring money include M-Pesa, Wari, Simba Pay, RemitONE and MFS. According to McKinsey (2018), Mexico's digital efforts have so far been laudable. For example, the country has made significant progress in its efforts to offer mobile and web access to public services and to make government more efficient by automating internal processes. One important measure taken by the government is to create the role of national digital strategy coordinator within the president's office and has established a national digital strategy. The country is ranked 55th in the company's analysis of digital maturity of 151 countries. However, it still found that higher ambitions could fuel productivity and economic growth and boost the country's GDP by 7–15 percent (or $115 billion to $240 billion) by 2025. The report also notes that the growth would come from greater productivity and employment in existing sectors, the creation of new digital (or digitally powered) businesses, the expansion of the information-and-communication-technology (ICT) sector and a successful labor force transition to these new digital industries.

Common economic activities, such as transportation and shopping, have changed dramatically, leading to the growth of new products and services, often at the cost of already-known ones. Examples of such new products include eBooks, software, videos, audio and music, photography, graphics, and digital art. Digital services include online training, legal and medical consultancies, travel booking, etc. The revolution in digital technology is causing changes in social dynamics and structures and even physiologies (Richtel, 2010). The digital revolution has assisted in the setting up of new groups, personalization, and content. These are all connected to information and communications technologies, for example thematic discussion groups on Facebook and dating apps. Currently, the internet offers a platform that safeguards existing cultures, such as diversity in languages by using digital technology to preserve languages, interviews, and art, as well allowing future generations to have access to these cultural products (Strochlic, 2018). According to Henry-Nickie, Frimpong and Sun (2019), "digital technologies have risen to prominence as a critical determinant of economic growth, national security and international competitiveness." They further note that researchers estimate that "the digital economy is worth $11.5 trillion globally, [an] equivalent [of up] to 15.5 [%] of global GDP and has grown two and a half times faster than the global GDP over the past 15 years (Huawei and Oxford Economics, 2017).

The adoption of digital technology is helping less obviously related sectors too. Digital technology is allowing Southern countries to increase quick delivery of broad-based, high-quality health care, education, and other public services at any stage of their development trajectory (OECD, 2018). In Kenya and Tanzania, farmers have gained experience in the effective usage of ICT in their sector to access commercial markets and value chains. Within low-income countries, an increasing number of small-scale businesses and enterprises in the informal sectors are utilizing digital technologies. Several start-up companies in the agricultural, creative, and advertising sectors in Africa are using digital technologies to boost the quality of their products and services. According to Bolat and Taura (2019), agri-tech companies like Farmable, Farmerline and Esoko in Ghana support farmers with pricing data, crowdfunding and communication activities. They are also connecting farmers with buyers and helping them to work out what differentiates them from competitors. The benefits became more amplified when these farmers needed to get more complex information than what was available locally, such as procedures in maintaining standard requirements in Ghana. This helped increase their agricultural productivity and levels of income (Aker and Mbiti, 2010). Access to sophisticated distribution chains, such as direct sales to exporters, through using digital technology point toward higher rewards for farmers.

The proportion of growth of the digital economy is quite fast-paced compared to total economic growth – even though the digital economy is only growing as a portion of a nation's economic growth. The present economic growth rate in the global South is relatively high, signifying the rapid adoption of digital technology in all spheres of life compared to the rest of the world. This shows that every area of human endeavor, including productivity, growth, and human development, will be determined by more integration into the global digital economy. Despite the above benefits and the effect of the internet on accessing complex knowledge as a more sophisticated means of distribution and fulfilling export standards, the formalization needed to enter the channels remains low. This is due to limited access to the internet by those who need it. Additionally, even though digital technology offers opportunities for farmers, for example, the demand of using digital tools to relate with exporters, intermediaries and traders increases the risk of exclusion for those farmers who do not use digital technologies. In the long term, this could lead to a further divide and marginalization for these population groups and economies. This can also result in a loss of their access to commercial markets and ultimately their livelihoods (Carmody, 2012).

Moreover, while digital technologies have the capacity to restructure the value chain and channels of distribution in these economies by creating new actors and eliminating intermediaries (Donner and Escobari, 2010), increasingly evidence shows that they have had had limited impact thus far in restructuring or transforming existing distribution channels. So far, new actors in the chain are not visible and intermediate farmers continue to relate with buyers (Donner and Escobari, 2010). Furthermore, the authors show that even though the adoption of digital technology by Tanzanian farmers could close the bridge between farmers and exporters, exporters still prefer to relate with intermediaries that could supply large volumes of bulk products to them, which farmers are unable to do (Donner and Escobari, 2010). Digital technology for development is concerned with technology for improving lives at the individual level rather than the total restructuring of processes. Without this, digital technology could fall short of its goal of improving livelihoods, fostering equality and poverty reduction (Murphy and Carmody, 2015). Experiences in other countries in the global South that have better infrastructures to utilize digital technologies and technological innovation, such as China Brazil, India and Mexico, pose better optimal outcomes.

2. A changing digital landscape and implications of the digital revolution for the global economy

Digital technology has brought about transformational changes to the global economy, including in the global South (Tattrie, 2019). However, concerns are centered around the fact that these changes create a further divide between the Northern states and the global South. While the North has recorded a breakthrough in bringing humans and machines together to augment and support one another with skills and knowledge, the global South, meanwhile, still has four billion people living without access to mobile internet (GSM Association, 2020).

However, the number of people with access to the internet in the global South has grown significantly over the past four years, with internet access increasing to over 500 million people in Africa alone (Internet World Stats, 2021). This has implications for profitable participation in the evolving changes in the global economy. Industrialization in Africa has been hampered by insufficient and poor quality of critical infrastructures, such as rail systems, electricity and road transport networks and inadequate human capital (Page, 2016). This raise concerns as to how the Fourth Industrial Revolution will address issues surrounding power asymmetry, security, disempowerment, exploitation, and inequality, without building on the pretense of the failure of the global South to catch up with the revolution (Wettersand, 2019). This report will unpack some of the different opinions regarding digital technology and the transformation of the global economy.

Technological transformation has led to a situation in which many aspects of human life has become digitalized. In no other area of human living has this been more profound than in economic activities, especially with the emergence of the digital economy. The organization and conduct of economic activities through digital technologies has become the new normal. Leading countries in the global South, such as Brazil, China, India, Mexico, and South Korea, have demonstrated that the digital economy can foster economic diversification and elicit growth. Several African countries are not far behind. Côte D'Ivoire, Ghana, Kenya, Nigeria, and South Africa have recorded a form of revolution in their economies through digital technology. As Osiakwan (2017:58) argues, in monetary terms, the mobile ecosystem contributed $102 billion to the GDP of the sub-Saharan Africa region in 2014, a figure projected to rise to $160 billion by 2020.

The digital economy is already showing evidence of its ability to alter economic inequalities and increase the average local wage for digital workers, leading to a global equilibrium of income (Beerepoot and Lambregts, 2015). It is also creating new local markets for digital start-ups (Quinones et al., 2015) as well as combatting unproductive, corrupt market and labour institutions through digital platforms (Lehdonvirta, et. al., 2015). In Africa for instance, the youth bulge is being increasingly converted into assets rather than liabilities as many young university graduates are leveraging an increased availability of digital infrastructures, such as broadband and commercial platforms like Jumia, adding creative value to their economies.

Apart from creating jobs (often creating their own jobs as well as jobs for employees), youth are contributing to economic growth through the payment of taxes. Osiakwan (2017:58) provides more insight into the increased activities of the millennial generation in Africa who are using digital technology to foster economic development. What remains is for countries that are already benefitting from digital technology to share their learning experiences and resources with less developed countries, and communities within countries, that have been left behind. These assets must be shared in ways that can further enhance the contribution of digital technology to the economies of the global South.

As previously mentioned, despite this impressive adaptation to digital technology, not all countries in the global South have successfully taken advantage of the immense benefits that digital technology provides. Those countries that require greater attention will need support to improve limited infrastructures, to utilize their human capital and to adopt appropriate policies to take advantage of the opportunities that the digital economy provides to stimulate economic growth. It is within this context of disparity and gaps in access that South-South and Triangular Cooperation become extremely important.

Fast-rising developments within the digital economy pose enormous challenges, costs, and risks to the global South, especially because many Southern countries have underdeveloped capacity to operate fully in a digitalized manner. A significant portion of the population of countries in the global South lacks access, or has inadequate access, to connection capabilities and may not have the required literacy level to fully benefit from the digital economy. This unequal access to low-cost and emergent digital technologies and a reduced capacity to make use of these technologies has created a structure of uneven circulation of benefits. This means that micro-, small- and medium-sized enterprises, including individuals with little or no education and especially those in rural areas with a limited capacity to connect, are most likely to be left behind in this digital economy (Osiakwan, 2017).

According to Phillip and Williams (2019), territorial digital divides underpin and further compound digital inequalities in many remote rural areas. They also note that ignoring remote rural areas with digital infrastructure programmes brings serious economic and wider sustainability implications. These observations are born of examining the experiences of many countries in the global South, where attention has largely focused on urban areas. Although digital technology can foster economic growth in rural areas, such as through the creation of opportunities for online sales and the marketing of agricultural products, the absence of critical infrastructures, such as broadband, limits such possibilities. Apart from the absence of broadband, the use of digital technology in many Southern countries is hampered by a lack or inconsistency of electricity supplies. This challenge creates opportunities for large companies from more advanced countries in the global South to invest in the electricity sector.

Another interesting opportunity that arises with efforts to bridge the digital divide between cities and rural areas is the potential to unleash the creative capacity of the youth population through micro-, small- and medium-scale enterprises, especially in the agricultural sector. But this depends on the depth and quality of access to broadband. In the case of Nigeria for example, the World Bank (2019:2) notes that: "Furthermore, fixed broadband penetration in Nigeria is very low, with a household penetration rate of 0.04 percent at the end of 2018, below the African regional average (0.6 percent), and well below the world average (13.6 percent). This is due to backbone investment in Nigeria having focused primarily on major urban areas and inter-city routes."

The digital revolution is having, and will continue to have, a massive impact on governments and businesses. Increased digitalization and the adoption of modern technology is producing innovations, especially in relation to the production of new goods and services and adjustments to the production of existing products and services. According to the World Economic Forum, the Fourth Industrial Revolution will spur new techniques as well as new business models, which will have a huge effect on production processes and society at large (WEF, 2018). Digital technologies will provide more entry for new customers to businesses in both domestic and foreign markets in a more nuanced way. For instance, through the adoption of e-commerce platforms, suppliers can reach a wide range of customers both locally and internationally while also cutting the cost of delivery, especially for digitally required content (UNCTAD, 2019). This has altered the concept of face-to-face delivery of services, as was necessary in the previous industrial revolutions.

Digital technology is enabling businesses, such as micro-, small- and medium-sized enterprises, to deal with the hurdle of expansion, enabling shared collaboration in innovative practices and allowing the adoption of new approaches for raising funds, such as crowdfunding. This growing shared economy represents an economic approach based on peer-to-peer activity for providing services and providing access to goods and services. It is promoted through the use of online platforms and allows products that are not in full usage by businesses to reach a wider target audience. E-products, such as music, movies, and online education, may have value-added in that they are less exploitative of the earth's resources.

Through countries such as China, India, South Korea, South Africa, Mexico and Brazil, the global South is increasingly becoming a major player in the evolving digital economy. Africa has posed an impressive performance in terms of internet penetration and usage, the birth of technology and innovation hubs and the deployment of e-commerce for economic activities and growth.

According to the World Bank (2018), the entrepreneurship ecosystem has grown ten-fold in Africa over the past five years through incubators, accelerators, and tech hubs. In particular, sub-Saharan Africa has the highest percentage of mobile money use in any region. Hruby (2018) found that of the 690 million registered mobile-money accounts worldwide, 50 percent are in Africa. This has increased the level of financial inclusion, access, and job creation.

Africa's success with mobile money shows that opportunities existed for leapfrogging using new financial technology and such opportunities may also exist in other economic sectors. Manyika et al. (2013) and Osiakwan (2017) used McKinsey figures to project that the internet will contribute $300 billion to Africa's GDP by 2025. Other countries in the global South, such as Brazil and Mexico in Latin America, are also creating strategies to leverage digital technology to facilitate a higher level of economic development. A 2019 report by Deloitte entitled "Insights about Digital Transformation and ICT Opportunities for Brazil, Reports and Recommendations" notes that among other things, the government has already conducted several studies and generated reports highlighting challenges and gaps that need to be addressed to improve Brazil's ICT market and to drive the country toward a digital strategy.

As noted above, countries of the global South that successfully adopt and spread the use of digital technology have the potential to unlock their economic systems. Not only are these countries leveraging digital technology for commercial means, but they are also adopting it to simplify the provision of services and foster delivery of social welfare programmes, tax collection, data management, policy formulation and execution. Engaging digital technology to foster transparency and accountability is being applied in India, where the government has invested in giving each of its 1.3 billion citizens a unique digital identification signature (Mckinsey Report, 2019). Through this project, Indian governments should be able to use data from this tool not only to introduce productive social programmes but also to gather more knowledge about the root causes of poverty in the country.

Despite the enormous opportunities for Southern countries with the digital economy, most research has studied the impact of digital technologies on high-income economies. What the digital revolution means for low and middle-income countries in the global South, especially at the level of government, business, and labour, is still relatively unknown. More crucial than this is the fact that most countries, especially in the global South and in particular in sub-Saharan Africa, still battle with what the digital economy really entails. Part of this struggle is meeting the required basic infrastructure needs, how to tap into the massive opportunities inherent in it and how it can be mainstreamed into economic planning. Thus, the huge opportunities presented by the successful adoption of the digital economy remain untapped and underutilized in many parts of the global South, consequently impeding economies from reaching their full growth potential (Arbache, 2018). It is important to recognize that the rate of the spread of information technology is dependent on a nation's legal, institutional, and political environments. Considering this, the digital economy poses an issue for policymakers that are challenged with drafting effective policies to tap into the many advantages of a digital economy.

Favorable institutional and political settings are required for Southern countries to carve a niche in the global digital economy. Central to enabling innovation and ensuring technological progress are conducive structures and institutions of governance. Algeria, Ukraine, Bangladesh, and South Africa are cases in point of creating conducive environments and consequently these countries are becoming emerging powerhouses of the digital revolution. They symbolize that all economies, whether developed or emerging, can adapt to global digital technology and become global leaders themselves.

A complexity is that powerful groups in societies in the global South that have the power of information concentrated in their hands may attempt to restrict the use of digital technology, since digital technology allows for an easy transmission of knowledge and information. However, given the rapid pace of technological change, Southern countries cannot afford to ignore the digital economy, even in the near future.

Those countries in the global South that do not proactively exploit the opportunities that abound in the digital revolution may face serious consequences in terms of growth potential, regional competitiveness, and integration into worldwide high-value production chains, among other areas.

For governments of the global South, with the help of non-state actors and in particular the private sector, the changing digital landscape presents enormous potential to leapfrog along their development trajectories. Technology-specific analysis informed and shaped by realities on the ground presents a more nuanced picture. For Southern countries to be able to take advantage of the opportunities presented by the Fourth Industrial Revolution they will need to put in place certain measures to tackle issues around affordability, accessibility, and application of technologies. At the heart of this, Southern governments need to harness the potential of partnerships at the national, region and international levels. At the regional and international levels, mechanisms for South-South and Triangular Cooperation could be instrumental in overcoming many of the above-mentioned challenges.

3. New trends in South-South Cooperation and Triangular Cooperation in the digital era

South-South and Triangular Cooperation offer countries and regions of the global South potential solutions for tackling the challenges posed by the digitalization of the global economy. SS&TrC can help build the capacities, connections and experiences nations need to leverage digital technology and services allowing them to diversify export portfolios, build digital infrastructure for industrialization, enhance trade in services and establish and manage data policies, thereby transforming their economies in a sustainable way. Achieving these objectives will require that Southern countries with the necessary technical and financial capacity support counterparts that lack these resources. It will also require Northern countries to channel more of their interventions and development assistance toward boosting digital technology in the global South.

As digitalization of the global economy continues to evolve, Southern countries have leveraged South-South Cooperation to promote economic and social development in various sectors, such as infrastructure, foreign direct investment development projects, mining, finance, and climate change. From China to Mexico and from Kenya to Nigeria, countries in the global South are collaborating to harness digital technology to advance socio-economic development. Several papers in this report provide practical examples of this trend. While some take place at a bilateral level, others, like the China Belt and Road Initiative, are being implemented through collaborative multi-country arrangements (Chatzky and McBride, 2020). A primary example of this being the Belt and Road Initiative's Digital Economy International Economy Cooperation Initiative launched on 3 December 2017 during the Fourth World Internet Conference. This initiative aims to connect eight countries (China, Egypt, Laos, Serbia, Thailand, Turkey, Saudi Arabia and United Arab Emirates) and extend their cooperation in the digital economy to build an interconnected 'digital silk road' (also called the 'information silk road').

The proliferation of agreements, initiatives, and cooperative arrangements between and among Southern countries in recent years reflects an increasing desire of both government and private stakeholders in the region to leverage digital opportunities and in particular to enhance connectivity. For example, in 2015, China's Baidu bought control of the Brazilian online discount company Peixe Urbano (Parra-Bernal, 2014). In 2019, Chinese direct investment (FDI) in Ethiopia amounted to $2.5 billion and bilateral trade grew to $5.4 billion by end of 2016 (Xinhua, 2020 & New China, 2018). About 60 percent of Ethiopia's FDI was obtained from Chinese investors (UNCTAD, 2020), within various sectors, including digital technology. Again, the digital silk road is bringing advanced IT infrastructure, such as broadband networks, e-commerce hubs and smart cities, to Belt and Road Initiative countries. Driven by China's tech giants, most notably Huawei and ZTE, the project can deliver high-quality fibre optic cables at much lower costs than competitors from European and the United States.

Multilateral agencies have also been involved in fostering Triangular Cooperation in the digitalization of African economies. The United Nations Educational, Scientific and Cultural Organization (UNESCO), for instance, is committed to fostering SS&TrC in the area of digital technology and its diffusion throughout the global South. UNESCO supports research centers in the global South to train people in science, technology and innovation, including the International Centre for South-South Cooperation in Science, Technology and Innovation (Malaysia)[2], the International Research and Training Centre for Science and Technology Strategy in Beijing (China), The World Academy of Sciences, the Abdus Salam International Centre for Theoretical Physics and the Organization for Women in Science for the Developing World (UNESCO, 2018).

One of the many challenges of the digital revolution for Southern economies is the adoption of a viable infrastructure that allows the digital economy to be accessible to everyone both in urban and rural areas. Southern countries need to address the infrastructural gaps as this will affect their ability to leverage the digital economy successfully. Certain countries are already taking advantage of donor collaboration opportunities to tackle this challenge.

Digital technology transfer from China to the African continent has been quite significant in the telecommunications sector, although China-Africa cooperation is not limited to any one sector and cuts across the length and the breadth of the continent. Tecno, a smartphone manufacturer under the parent company Transsion Holdings based in Hong Kong, introduced smartphones specifically geared toward the African market. In Ethiopia, Chinese companies invested as much as $3 billion in the technology sector as of 2012 (Crabtee, 2017). Over the past five years, the tempo of Chinese engagement with Africa in digital technology has increased significantly. According to Roy (2019), Huawei and ZTE are capturing the African digital market in a major fashion. Roy (2019) further notes that China has been promoting the use of BeiDou, often called the "digital glue" that would weave all Chinese technologies into a single thread. BeiDou is an alternative to the global Positioning System (GPS) of the United States. BeiDou will most likely become an essential tool for smart phone users across Belt and Road Initiative economies.

African governments are investing in digital technologies made in China, such as cameras and artificial intelligence. For example, Zambia is spending $1 billion on Chinese-built surveillance, telecommunications, and broadcasting equipment (Prasso, 2019). Zimbabwe signed a contract with a Chinese company named CloudWalk Technology to implement facial recognition across the country, with the expectation that cameras will be installed in city streets, airports, and other transit facilities by Hikvision, another Chinese firm (Roy, 2019). Additionally, the influence of Chinese companies on the continent has diversified. It now includes broadcasting networks, data centers and smartphone sales. In this regard, the Chinese broadcaster, StarTimes, has become a cheaper alternative to costly DSTV and other satellite cables. The broadcaster focuses on the local market and has taken television viewing from an occasional luxury to a daily routine for many rural and poor urban people in Africa (Crabtree, 2017).

2 The International Centre for South-South Cooperation in Science, Technology and Innovation (Malaysia) has five regional offices across the countries of the global South, including Brazil, Egypt, South Africa, China and India.

Similarly, Modi, Desai, and Venkatachalam (2019) provide insights into South-South Cooperation between Africa and India through a partnership in agriculture. The partnership is not only geared toward exports and investment but also toward training, capacity building and innovation using digital technologies and innovation. The Pan-African e-Network joint project between the African Union and India is another example of South-South Cooperation. Part of India's aid to Africa programme, the project connects nodal centers in India with 54 nations in Africa using electronic information and technology (ICT) and provides telemedicine and tele-education to its African counterparts. The pilot project was launched in Ethiopia in 2007. The project creates connectivity between the educational and medical centers that are of excellence in India and Ethiopia (Panbazuka News, 2009).

Given the diversity of capabilities of countries in the global South, SS&TrC can foster entrepreneurship as a means of driving innovation. Those countries that have created a niche for themselves globally are usually those in which governments have invested to ensure entrepreneurship thrives and innovation is sustained. Notable leading economies in the global South that have grasped the successful methods for innovation in today's digital age, as mentioned earlier, include China[3] and India. From around 2009, the Chinese government invested massively in small- and medium-scale enterprises with a focus on digital innovation and entrepreneurship. According to Reshetnikova (2018:507), this was anchored in a government programme on "mass entrepreneurship, universal investments," with annual financing of $6.5 billion. According to this author, by 2016 the Chinese government spent more than $56 billion to stimulate mass innovation entrepreneurship (2018: 508). The type of success that China has experienced in the scaling up of economic growth, job creation and shared prosperity through digital innovation and entrepreneurship can be replicated in other regions of the global South through SS&TrC.

Brazil has made significant inroads into cooperation with African countries through SS&TrC since the start of the century (Hubner, 2012: 2). For instance, in 2010 a Triangular Cooperation project involving Brazil, Germany and Peru was launched to develop the Centre for Environmental Technology in Peru, which offers environmental digital technology companies' market-oriented training and professional development, along with various other services (GIZ, 2014). This type of combination of efforts enables two or more external partners to optimize the use of digital infrastructure as well as financial and human resources. Many established donors are currently engaged in Triangular Cooperation with Brazil and Mozambique, including Australia, Britain, France, Germany, Italy, Japan, Norway, Spain, and the United States. Brazil, Germany, and Mozambique have been cooperating since 2010 on an institutional development project with the Maputo-based National Institute of Metrology, Standardization and Industrial Quality. Implemented by Brazil's National Institute of Metrology, Standardization and Industrial Quality, Germany's Agency for International Cooperation (GIZ) and the Physikalisch-Technische Bundesanstalt (Germany's national metrology institute). The project encompasses the traceability of complex high frequency measurands for 5G networks, nonlinear and statistical measurands in high frequency, derived measurands in digital communication systems and complex antenna systems and uses digital technologies to analyze large quantities of data.

3 As discussed in more detail later in this report, the Digital Silk Road as part of the Belt and Road Initiative, has played a great role in increasing investment in hard infrastructure by promoting e-commerce through digital free trade zones, which increases international e-commerce by reducing cross-border trade barriers and by establishing regional logistics centres (Cheney, 2019). The international aspect of the Digital Silk Road, such as the Free Trade Zone, will promote digital technology transfer between China and other countries in the global South. Several countries in the global South (Egypt, Laos, Serbia, Thailand, Turkey, Saudi Arabia, and United Arab Emirates) have agreed to become interconnected through expanding broadband access, promoting digital transformation and fostering e-commerce cooperation (Viney et al., 2017).

Despite the challenges facing start-up companies in Africa, innovation hubs have risen in different parts of the continent, such as Ghana, Kenya, Nigeria, Rwanda and South Africa. Innovation companies in South Africa include InvoTECH, ALPHACODE, JoziHub and Impact Hub. Similarly, Kenya boasts iHub, Silicon Savannah, Swahilibud, Lake Hub, DlabHub and Sote Hub (Dahir, 2018). In Rwanda, Kigali Innovation City will house innovation labs and provide training and funding for technology companies (Giokos and Parke, 2018). Positivo BGH, a joint venture between the technology companies Positivo Informática from Brazil and BGH from Argentina, has reportedly secured a deal to sell the Rwandan government 150,000 computers each year, most of which will be used for the education sector. A great example of a Southern business leading in technology knowledge transfer is the Cameroon Business Blockchain Council which focuses on bringing awareness and delivering certified training in blockchain technology for individuals, governments, entrepreneurs, and institutions across a variety of sectors.

These forms of South-South Cooperation cited above are contributing to socio-economic development in the global South. These initiatives can be strengthened even more through deeper SS&TrC. Some African start-ups are involved in promoting SSC through mergers and acquisitions. For instance, in 2019 Nigeria's CcHub acquired Kenya's iHub to create a mega African incubator. CcHub also collaborated with the government of Rwanda early in 2019 to open its Design Lab in Kigali, focused on innovating impact solutions in health, education, and governance (CcHub, 2019). It is illustrative that although these two innovation hubs had previously been healthy rivals, through collaboration they are able to connect East and the West Africa and expand their market, among other business improvements (CcHub, 2019).

According to Brennan (2019), Alibaba has been working with organizations such as the United Nations Conference on Trade and Development on capacity building initiatives to give governments, educators, and entrepreneurs a deeper understanding of best practices and policies in the digital economy. Since 2018, Rwandan educators have participated in the Alibaba Business School's global E-commerce Talent – Train the Trainers programme, which seeks to deepen teacher understanding of the e-commerce industry, while Rwandan Startup founders visited Hangzhou for training under the school's Entrepreneur Training Program. Rwandan government officials have also visited the Alibaba headquarters to learn how to build and sustain economic growth in the digital era (Brennan, 2019). The eFounders Fellowship, another UNCTAD-Alibaba partnership, is designed to bridge the digital gap faced by young entrepreneurs in the global South. Available to entrepreneurs in the digital and technology space who operate open platforms based in e-commerce, logistics, FinTech, Big Data and tourism, the fellowship will select 1,000 entrepreneurs from developing countries (200 of them from Africa) to receive training related to the digital economy (Brennan, 2019).

4. Highlights of the 2018 report

The Finance Center for South-South Cooperation (FCSSC) and United Nations Office for South-South Cooperation (UNOSSC) jointly publish the South-South Cooperation Report annually. The 2018 report *South-South Cooperation in a Digital World* was successfully launched at BAPA+40 in Argentina in March 2019. The report provided a context to the current wave of technological innovation that has been described by many scholars as the Fourth Industrial Revolution. According to the report, this revolution opened new opportunities for global economic change, especially due to the rise of the digital economy.

An important achievement of the 2018 report was its exposition on the 'platform economy.' The report showed that the digital revolution taking effect across the globe was leading to the rise of many economic models, one of which is the platform economy, a model heavily dependent on digital technologies and intelligent technologies. The pace of acquisition of the platform economy was leading to a deepening of the North-South divide due to the inability of many Southern economies to fully take advantage of the digital economy as a result of a lack of a fully developed digital infrastructure. However, the report highlighted that, despite this economic divide, some African countries, especially those in sub-Saharan Africa, had

found a way of leveraging the platform economy with the innovative establishment of mobile e-commerce and financial services, such as Jumia, Konga and M-Pesa. Due to this, a lot of platform companies are able to establish network effects in the emerging regions of the world by offering trading that is convenient.

The report further highlighted that many low-income economies were being excluded from the digital economy. Given a wide range in capacities of countries in the global South to leverage the emerging digital economy, the report called for intensified South-South Cooperation to ensure that emerging countries provided support to less developed countries in the region. This was seen as necessary so that the latter could join the leagues of countries transitioning from traditional economies to platform economies to benefit from the global economic growth.

The 2018 report reflected on some of the changes and transformations that digital technologies were having on lives, for example through the creation of smart cities, smart people, and smart businesses. It noted that common activities, such as transportation and shopping, were changing dramatically leading to the growth of new products and services at the cost of already known ones. It found the revolution causing changes in social dynamics and structures and even physiologies (Richtel, 2010). The digital revolution process was assisting in the setting up of new groups, personalization, and content, all connected to information and communications technologies. It further established that usage of digital technology in the social sector, such as social services, social governance, and social contracts, had created a digital society, with an integration and connection of digital technology and intelligent technology. Society was gradually moving toward becoming a smart society, driven by the industrialization of the new generation of digital technology, the digitalization of traditional industries, the modernization of information infrastructure and the intellectualization of economic activities.

The report contended that digital technologies were providing entry for new customers to businesses both in the domestic and foreign markets. For instance, through the adoption of cross border e-commerce platforms, suppliers were able to reach a wide range of customers both locally and internationally, while also cutting the cost of delivery, especially for digitally required content (UNCTAD, 2019). This was altering face-to-face delivery of services, as was the case in previous industrial revolutions. Digital technology in this phase was found to be allowing businesses, such as micro-, small- and medium-sized enterprises to deal with the hurdle of expansion, enabling shared collaboration in innovative practices and the adoption of other approaches for raising funds, such as crowdfunding, and was catering for the transfer of such funds through digital finance systems.

5. What this report aims to achieve

This follow-up report for 2020/2021, *South-South and Triangular Cooperation in a Digital World: New Impetus and New Approaches*, is a further exploration of mechanisms and approaches that can strengthening South-South and Triangular Cooperation in the context of the Fourth Industrial Revolution, with increased focus and attention given to how the digital revolution is transforming the global economy, including in the global South. The 2020/2021 report underscores the imperative of fostering closer levels of SS&TrC as a way of ensuring that countries in the global South are not left out of the digital transformation era. The report highlights inter-linkages between the economies of countries in the global South and how SS&TrC can foster Pareto-optimality.

Secondly, the report draws attention to the retreat of globalization and the rising tide of protectionism, the continuing wide inequality within and between countries and the imperative of promoting South-South Cooperation as a safeguard against these impediments. Relatedly, the achievement of the of United Nations Sustainable Development Goals in 2030 in the global South will depend so much on the extent to which Southern countries can cooperate to leverage the opportunities that come with this digital revolution in the global economy.

The chapters that follow address the above-mentioned overarching issues from various perspectives. These include: South-South Digital Cooperation: Developing and Operationalizing a Conceptual Framework; Digital Economic Transformations in the global South; Agricultural Productivity and Food Security Using Digital Technologies; Digital Financial Services Transformation and New Approaches in South-South and Triangular Cooperation Case Studies; Digital Health and South-South and Triangular Cooperation; Digitalization and Climate Change Strategies; and Collaborative Mechanisms for South-South and Triangular Digital Cooperation.

Following this introduction, Chapter II presents an overview and conceptual framework of digital South-South Cooperation and highlights the new impetus and approaches of digital SSC. It reviews the concepts and guidelines of South-South Cooperation, new partnerships formed with Triangular Cooperation, innovative practices in the South, the goals and approaches of the Buenos Aires Action Plan, the Belt and Road Initiative and the Asian Infrastructure Investment Bank. It illuminates the role of SSC and TrC in promoting humanity by discussing the digital Silk Road initiative, case studies such as global MediXchange for combating COVID-19 and the global Consultation and Prevention Center. The chapter recommends actions for stakeholders at global, regional, sub-regional and country level to achieve the overall goal of uplifting Southern countries.

Chapter III describes the factors that might impact digitization of economic activities in the global South. Using evidence from successful digitization programmes and practices under the Fourth Industrial Revolution, such as artificial intelligence, Big Data, smart cities and so forth, the chapter demonstrates the global South's deep capabilities across diverse economic sectors for locally generating digital technologies that are bringing political, economic, and social transformation. It finds that global South economies are less dependent on digital technologies created in the Northern economies and points to initiatives such as the Belt and Road Initiative and the trends in Foreign Direct Investment to reveal the influence of SS&TrC on digitization, specifically digital connectivity, and technology transfer. Despite the number of challenges that economies of the global South face, cases successfully demonstrate the powerful impact that the global South digitization efforts have had on smaller disadvantaged firms, alongside big companies.

Chapter IV focuses on the role digital technologies play in progression of agricultural productivity and food security in developing nations, as highlighted in the 2030 Sustainable Development Agenda by the United Nations General Assembly in 2015. The chapter provides rich literature on the intersection between agricultural productivity, food security and digital technologies, with several examples, such as: the use of SMS-based services to share information on prices, offers, transportation and to reduce post-harvest losses; the role of robots to prune vines, move cattle, mix feed and milk cows; and how Augmented Reality and augmented virtuality are utilized to identify pathogenic bacteria in the food chain. The chapter also shares United Nations initiatives for creating a global digital platform for agriculture along with its challenges and future implications and broadens the understanding from regulatory and governance perspectives as to how these challenges can be overcome via different mechanisms.

Chapter V presents case studies on digital financial transformation and the challenges created by financial technologies (FINTECH) for developing countries. Specifically: the first case explores a smart payment platform that transformed from a social networking site; the second case unveils efforts of Chengdu Branch of People's Bank of China to promote inclusive basic payment services for remote ethnic minority areas; the third case sheds light on a social enterprise engaged in rural financial services; and, finally, the last case illuminates an online microcredit service available for micro- and small enterprises based on e-commerce. The chapter acknowledges the tremendous growth of digital finance in the global South and argues that FINTECH's role in development strategies is unexplored and untheorized. Furthermore, as the digital economy is being shaped worldwide by individual actions of sovereign states and large international private companies, it advocates for Southern governments and practitioners to simultaneously integrate FINTECH strategically into policies.

Chapter VI on Digital Health analyses the key opportunities digitalization holds to advance health-related Sustainable Development Goals (SDG3) along with commitments to Universal Health Coverage, which is a major goal for health reform in many Southern countries. By weighing the opportunities and challenges, and the potential of South-South and Triangular Cooperation through numerous examples, the chapter concludes that if digitalized health care is to effectively advance sustainable health, then it is crucial for Southern countries to: formulate a national digital health strategy that is integrated in current health policies; organize training programmes and capacity building specifically for the global South; and increase financing for digital-based health. It emphasizes South-South collaborations in digital health to promote equity and access as the solutions are homegrown and culturally appropriate further contributing to sustainable health outcomes.

Chapter VII on Digitization and Climate Change Strategies details the potential of SSC to help mitigate the negative impacts of digitization and advancing SSC's role in combatting climate change. Specifically, it examines digital technologies, such as block chain, and looks at remote sensing, geographic information science technology and sustainable energy generation and storage. A range of successful examples of SSC that have taken place in least-developed to upper-middle-income countries are presented. The chapter also discusses how Triangular Cooperation can lessen the potential limitations of South-South Cooperation for digitization and climate change strategies.

Chapter VIII analyses the driving forces and mechanisms of South-South Digital Cooperation. It argues that many digital innovations, as discussed in previous chapters, are merely focused on local experiences, hence they are limited in scale. Rather than looking at digitization for promoting sustainable development by sector, this chapter calls for these initiatives to be scaled up through collaborative efforts. By exploring the key pillars that drive progress with South-South Digital Cooperation, this chapter offers several recommendations, such as the need for multi-stakeholder partnerships (emphasizing the role of United Nations organizations), knowledge sharing between Southern countries and the South and the North to scale up best practices, effective regional agreements that facilitate digital cooperation (highlighting innovation aspects of South-South and Triangular Cooperation) and effective inclusion and monitoring and evaluation strategies.

The concluding chapter, Chapter VIIII, summarizes the key findings and analysis found in the various chapters and shows how they helped support the key analytical framework of the report and its central aims and objectives. The chapter presents an agenda for future research needed to strengthen and fill policy and research gaps that were identified in the various chapters. Finally, the chapter provides policy recommendations to strengthen and promote SS&TrC in a digital world.

Chapter 2

Overview and conceptual framework of South-South Digital Cooperation

1. Introduction

Business platform models and digital technologies have been significantly transforming the way businesses create value. Over the last decade, one of the main changes in the business value creation model has been the shift from a linear business model to a platform model. Prior to this, the dominant value creation model remained the linear business model that created value through the sale of products down the supply chain. The post-industrial revolution period, with its advanced technologies, such as steam engines and railways, gave rise to extensive, vertically integrated industrial organizations. In the early twenty-first century, all industry giants were linear companies, such as Standard Oil, General Motors, Toyota, etc. (Moazed and Johnson, 2016). Major companies selling agricultural products, such as Walmart and Carrefour, also leveraged a vertically integrated supply chain to control the linear value chain of channels or pipelines and to achieve the scale effect.

The platform model is an emerging business model that leverages digital technology to connect people, institutions and resources that are interacting in the digital ecosystem to create unexpected value and to exchange value (Parker et al., 2017). A social platform made up of two or multiple users at its essence, this data-driven business model pursues the "network effect." The network effect occurs when value is indirectly created by enabling exchanges and interactions among consumers and participants. The world's most valuable public companies and the first trillion-dollar businesses were built on digital platforms that brought together two or more market actors and grew through network effects (Cusumano et al., 2020). As an example, the network effect of the two-sided market has service providers on one end and customers on the other end, thus the value of the platform to any user depends mostly on the number of users at the other end of the network. Since the platform satisfies the needs of both parties, the value continues to grow (Eisenmann et al., 2006). The platform can generate new revenue streams and create new value in the form of data-driven "smart" services even after the product is sold. For example, customers purchase books on a digital platform, which later calculates and analyses customers' preferences and suggest new purchases.

Digital technologies, such as Big Data, artificial intelligence (AI), the Internet of Things (IoT) and block chain, have provided a technical foundation for value creation using the platform business model. Since the 1990s, digital technology and traditional industries have been integrating and evolving. An example is the large-scale integration of information and communication technology (ICT) with news, publishing and media industries which now is in full swing. The integration of digital technology with primary industries has formed e-agriculture and smart agriculture. The integration of digital technology with secondary industries has formed Industry 4.0 and intelligent manufacturing.[4] In the same vein, digital technology and platform business models are being integrated with tertiary industries to create new industry formats, such as digital finance, smart transportation, digital education, and digital healthcare. In short, driven by digital technology and the platform business model, the model of value creation in human economic and social activities has been undergoing significant transformation.

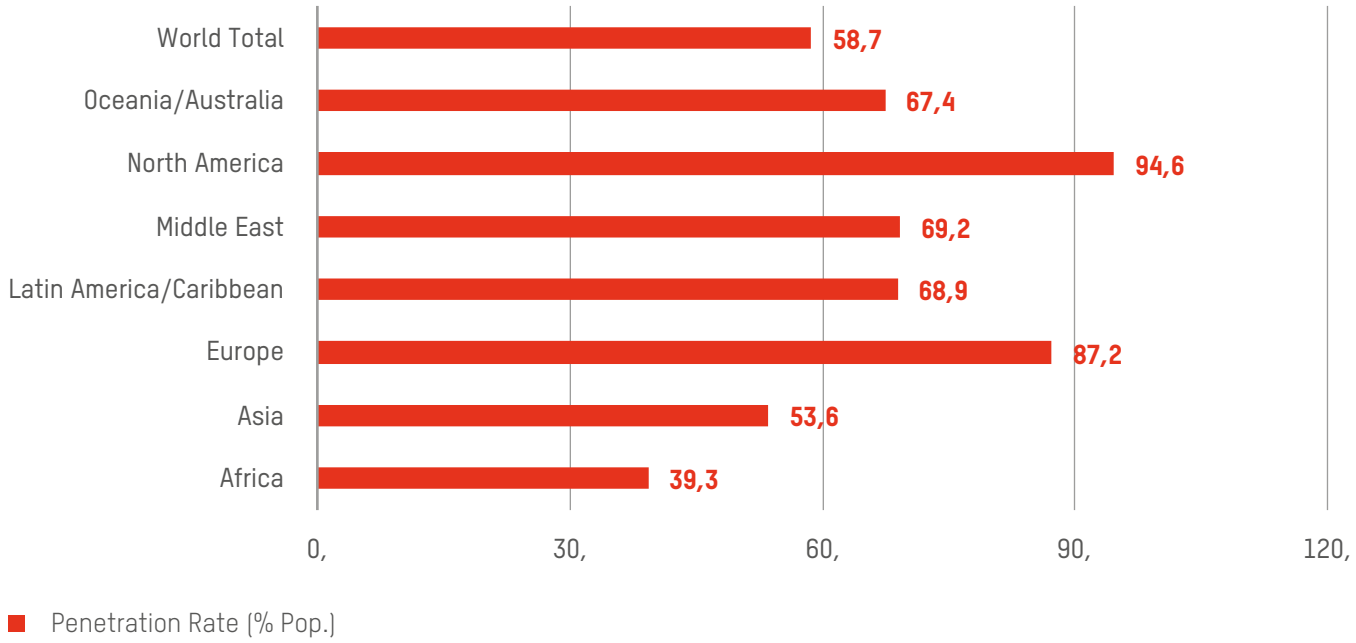
Global value chains and platforms are reshaping the landscape of global manufacturing, trade, and services. The global value chain, as opposed to traditional products and services production, allows different production steps to be carried out in various countries and regions (Dollar and Reis, 2017). With the existence of global value chains, developing countries can become exporters of manufactured products by embedding themselves into one or more steps in the production process of products. Nonetheless, only very few developing countries can truly participate deeply in the global value chain. Many factors, such as unit labour costs, transaction costs, infrastructure, and trading systems, may affect and constrain

4 Intelligent manufacturing (also known as smart manufacturing) is a broad concept of manufacturing with the purpose of optimizing production and product transactions by making full use of advanced information and manufacturing technologies (Zhong, R. Y., XU, X., Klotz, E. and Newman, S. T. 2017, Intelligent Manufacturing in the Context of Industry 4.0: A Review. *Engineering*, 3, 616-630).

the ability of developing countries to participate. Recently, digital technology and business platform capabilities have become another key factor that affect a country's ability to participate in the global value chain. China, Germany and the United States are three production centers deeply integrated in the global value chain, while the majority of other Southern countries are at the peripheral (Dollar and Reis, 2017). For the global South to participate more deeply in the global value chain of smart manufacturing and services, it must catch up with the North on digital technologies and business platforms.

According to data from the Miniwatts Marketing Group, the internet penetration rate has increased globally over the past 20 years. In 2020, 58.7 percent of the world's total population was covered by the internet, a penetration rate 11.7 times larger than the rate two decades ago (*Figure 1*). Today, approximately 4.6 billion people in the world have access to the internet. In North America, the internet penetration rate is as high as 94.6 percent. Even in Africa it is close to 40 percent (IWS, 2020). This increasing internet penetration laid the foundation for the broad application of digital technologies in production and everyday life. Digital technologies are driving the digital transformation of the global economy and societies. These transformations are reflected not only in manufacturing and production industries, such as farms and agriculture, but also in smart cities, finance, health, e-commerce, and other service industries. (Chapter 3 provides an overview of the leading technologies involved in and exhibited in the fourth industrial revolution.)

Figure 1: Internet world penetration rates by geographic regions - 2020 Q1



Source: https://internetworldstats.com/stats.htm.

The combined effect of digital technology and the ongoing restructuring of the global value chain has injected new impetus into South-South Cooperation (SSC). As digital technologies and platform business models expand across the globe, a more specific form of SSC, South-South Digital Cooperation (SSDC), has been infiltrating all areas of technical cooperation, knowledge sharing, policy dialogue, experience exchange, mutual learning, investment, and trade. New driving forces in SSC combined with some innovative models of SSC that emerged in recent years is bringing fresh impetus and new approaches to South-South Cooperation.

Accordingly, this chapter is structured as follows. First, fresh impetus and new approaches for SSDC are introduced. New partnerships, frameworks, ideas, and financing platforms for SSC brought on by digital technologies and platform business models are discussed. Guidelines for SSDC are presented, including exploring global, regional, and sub-regional actions that promote South-South Digital Cooperation and Triangular Cooperation (SSDC/TrC), and recommendations for national action are offered. The subsequent section proposes global governance for promoting SSDC/TrC. The final section summarizes the main findings.

2. South-South Cooperation: Fresh impetus and new approaches

In recent years, the scope of South-South Cooperation has gone far beyond technical cooperation and knowledge exchange and has expanded to include trade, investment, infrastructure, and connectivity aspects. South-South initiatives have become an essential means of cooperation and a financing channel for the realization of the 2030 Agenda. To commemorate the 40th anniversary of the Buenos Aires Plan of Action, the 71st Session of the United Nations Assembly reiterated the Buenos Aires Plan of Action, stressing that SSC is complementary to North-South Cooperation, not a substitute. The United Nations Office for South-South Cooperation's *Cooperation Beyond Convention–Independent Report on South-South and Triangular Cooperation* (UNOSSC, 2019) points out that the Buenos Aires Plan of Action is the world's roadmap for defining and promoting SS&TrC and development. SSC is regarded as a means of cooperation, collaboration, and mutual participation in the political, economic, social, cultural, environmental and technological spheres for nations in the global South. Occurring at regional and international levels, today SSC is recognized as an important tool for developing countries to achieve sustainable development goals (SDGs), both on the individual and collective level, through compound capabilities (UNOSSC, 2019). This section outlines five new dimensions of SSC that have taken place in recent years.

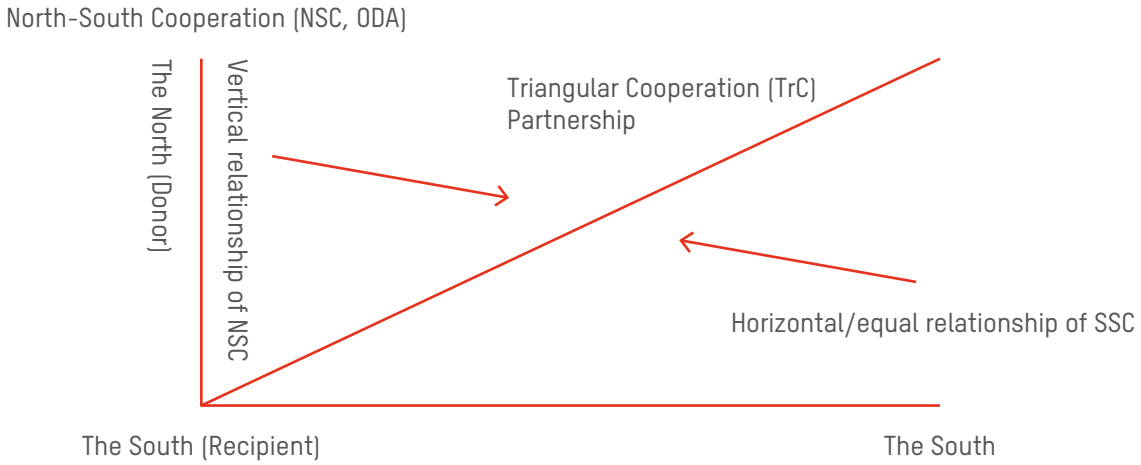
2.1 AN EVOLVING FORM OF PARTNERSHIP: TRIANGULAR COOPERATION

After World War II the Marshall Plan, which started in 1947, saw Western European countries join the Organization for Economic Cooperation and Development (OECD) to receive economic assistance from the United States to revitalize their economies. Subsequently, OECD established an Official Development Assistance (ODA) system from 1969 to 1972 to promote the economic welfare of developing countries and provided funding to these countries and multilateral institutions through national and local governments and their executing agencies. The OECD Development Assistance Committee established a series of rules for international development assistance and laid the groundwork for a vertical North-South development cooperation relationship between developed countries (donors) and developing countries (recipients). Such international development cooperation did not include trade, investment, and military assistance. It was hoped that after a period of assistance, the recipients would "graduate" (Esteves and Assunção, 2014).

Through solidarity and mutual assistance among countries of the global South, another pattern of international development cooperation was formed – South-South Cooperation. SSC is a parallel or horizontal relationship, which embodies the basic principles of equality, mutual assistance, solidarity, and non-interference in internal affairs. With the economic rise of countries in the South, the outstanding performance of emerging economies and innovations in digital technology and platform business models, new impetus and new approaches are emerging in international development on a continuous basis, much of which is being supported by South-South Cooperation.

A third form of cooperation, Triangular Cooperation (*Figure 2*), is linking the often-fragmented North-South assistance with South-South Cooperation to form an emerging cooperative relationship led by the South, but also involving international organizations and donors. This more inclusive cooperation framework transcends North-South Cooperation and has especially increased the flow of financial assistance and knowledge. TrC is building on SSC in support of the priorities of developing countries. This is not to be mistaken as a replacement for North-South Cooperation or South-South Cooperation, but instead as a framework for expanding on SSC to leverage the comparative advantages of Northern partners and international organizations, paving the way for Southern countries to form more equal cooperation platforms, that can balance historically unequal economic relations with the global North. This distinguishing clarification is significant and presents an opportunity for the engagement of Northern counterparts in international conversations encouraging SSC models, rather than creating barriers between the two frameworks and leaving room for pushback. As an evolving form of partnership, the way in which North-South Cooperation and SSC are linked through TrC enriches the framework of international development cooperation.

Figure 2: New international development cooperation frameworks

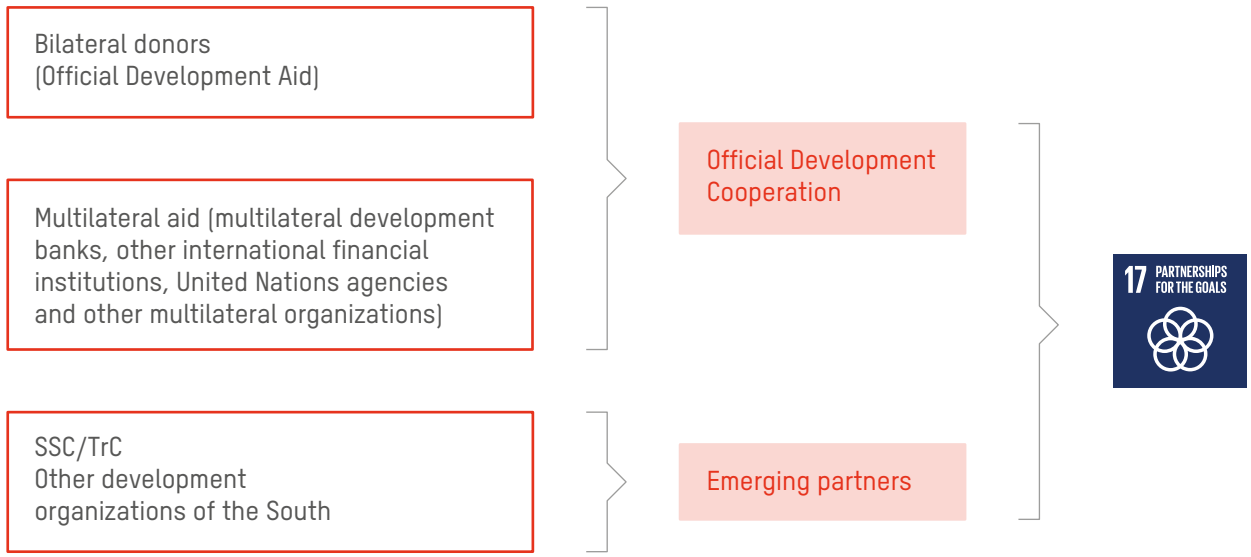


Source : Author's compilation.

The effectiveness of SSC, including technical cooperation, investment, trade and aid, has promoted the reform of Official Development Assistance (ODA). The Fourth High Level Forum on Aid Effectiveness held in Busan, Korea, in 2011 was a milestone in the field of international development as it signaled a shift in focus on aid effectiveness to development effectiveness. Due to the impact of the 2008 financial crisis, necessary funding contributed by member countries of the Development Assistance Committee (DAC) has become difficult to meet. Therefore, the international community encourages greater access to development financing through SSC. However, SSC is not characterized by aid; instead, it is a combination of technical cooperation, foreign direct investment, and trade facilitation.

In recent years, the development experience of emerging economies has proven that market-oriented financing tools have played a role in leveraging public and private sector funds to fill a growing gap in international development financing. Thus, international development financing has evolved from ODA to a concept of Total Official Support for Sustainable Development. This broader view of support includes bilateral providers (including the DAC, other bilateral providers and SS&TrC) and multilateral providers (including multilateral development banks, other international financial institutions (IFIs), United Nations agencies and other multilateral organizations) (OECD, 2020). SS&TrC and North-South Cooperation have jointly built an international development cooperation system better equipped to promote sustainable development (*Figure 3*). Hence, the DAC has shifted from adhering to ODA to supporting broader development cooperation, more importantly support for SS&TrC.

Figure 3: Partnership and international development cooperation system for sustainable development



Source : Author's compilation.

In 2015, the international community adopted the ambitious 2030 Agenda for Sustainable Development, which recognized the significant role of SSC in achieving the SDGs and specific targets of the agenda. The 2030 Agenda summarized lessons learned from SS&TrC and clarified the new opportunities that these cooperation models provide for achieving the 2030 Agenda and other internationally agreed development goals. Major frameworks, such as the Addis Ababa Action Agenda, the Paris Accord, and the Sendai Framework, also provide international consensus and support for SS&TrC. The second United Nations High-level Meeting on South-South Cooperation (BAPA +40), held in 2019, was a milestone event taking place 40 years after agreement was reached on the Buenos Aires Plan of Action. The global community reiterated the Buenos Aires Plan of Action and made SS&TrC a central element of international cooperation, instead of a "niche" model (OECD, 2019).

2.2 AN ENHANCED VISION FOR DEVELOPMENT: THE AGENDA FOR SUSTAINABLE DEVELOPMENT AND A COMMUNITY WITH SHARED FUTURE FOR MANKIND

The 2030 Agenda for Sustainable Development provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its core are the 17 Sustainable Development Goals (SDGs), presenting an urgent call for action by all countries – developed and developing – in a global partnership. The SDGs recognize that ending poverty and other deprivations must go together with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

The adoption of the 2030 Agenda for Sustainable Development and the Addis Ababa Action of the Third International Conference on Financing for Development singled out SS&TrC as a vital means and modality for achieving the 2030 Agenda. The newly adopted BAPA+40 Outcome Document helps increase the scope of SSC by laying out the principles of SSC and recognizing critical areas, such as trade, investments, finance, and technology transfer, with further importance, clarity, and diction. The United Nations advocates that all countries should incorporate the 2030 Agenda for sustainable development and its 17 SDGs into national contexts, although countries do not necessarily label them as "national sustainable development strategies," all underlying core principles are deeply embedded in the national implementation of SDGs worldwide.

Adhering to the SDGs and principles of SSC, China has proposed and committed to promoting a new development vision called Community with Shared Future for Mankind. The vision was advocated by the leader of China in his discussing with leaders from other countries on global issues, such as poverty, food security, climate change, resource shortages, environmental pollution, disease and epidemics. The vision of the Community with Shared Future for Mankind acknowledges that the development of one country is closely intertwined with that of other countries and that human society lives in the same 'global village.' It recognizes that globalization has brought tremendous development opportunities, not only to the global North but also to the global South, and that profound economic globalization, the high-speed operation of the international market and the optimal allocation and use of global resources allows diverse countries to share advanced science and technology and development knowledge in many fields.

The Community with Shared Future for Mankind is in line with the United Nations Charter, the latter of which promotes international arrangements that are centered on win-win cooperation, peace, global development, and a common prosperity that hinges on exchanges and mutual learning, openness and inclusiveness and care for the environment. As such, in 2017, the vision was incorporated in several United Nations resolutions on economic, social and cultural rights and the right to food.

As the COVID-19 pandemic unfolds to be one of the greatest threats to humanity in a century and brings with it massive challenges to global public health, economics and security, more people and governments have highlighted the interdependency of countries and the shared global future. A wide range of SS&TrC modalities have been formed during the pandemic, most focusing on the immediate response to COVID-19 Partnerships providing financial support and technical assistance.

2.3 NEW DEVELOPMENT OPPORTUNITIES

In recent years, a number of SSC efforts have been launched by the global South including the Belt and Road Initiative (BRI), the Digital Silk Road and the India-UN Development Partnership Fund. This report looks at the Digital Silk Road and the India-UN Development Partnership Fund as examples for exploring new development opportunities in the global South.

THE DIGITAL SILK ROAD

The Digital Silk Road, or Digital Belt and Road, a component of the Belt and Road Initiative, has been implemented by China and partners since 2015. The project promotes digital and new infrastructure, e-commerce and smart city projects. In contrast with traditional infrastructure, such as roads, railways and bridges, the Digital Silk Road projects utilize advanced technology and digitization to build data-driven infrastructures, such as 5G networks, artificial intelligence, the Internet of Things and data centers, and use technology to make existing infrastructures more intelligent and connected (CGTN, 2020).

The Digital Silk Road is expected to bring green transformation to both economic models and infrastructure in emerging markets. The Digital Silk Road is envisioned to play an important role in making infrastructure development more sustainable, efficient and viable, in both in the medium and long run. It is expected to bring about advanced IT infrastructure, such as e-commerce hubs, smart cities and broadband networks to the BRI countries. As an increasing number of small and medium merchants get connected to global trading via digital networks, the Digital Silk Road can also support them with a smart cross-border logistics system. The Digital Silk Road promotes sustainable broad-based development through the harnessing and application of Big Data to address competing environmental challenges directly.

The Digital Silk Road is meeting the demands for digital innovation and digital strategy in participating countries. According to statistics obtained by the Digital Belt and Road Research Center, China Institute, Fudan University, a total of 201 major Chinese companies in digital transformation-related fields have implemented 1,334 overseas investment and cooperation projects since the Digital Belt and Road programme was initially proposed at the First Belt and Road Forum for International Cooperation in Beijing in 2017 as part of the Belt and Road Initiative. Projects have focused in eight major sectors, namely e-commerce, communication infrastructure/5G networks, digital finance/FinTech, smart cities, the industrial internet, intelligent terminals, information technology services and pan-entertainment/media. Among them, 57 percent are associated with the Digital Belt and Road. Regarding their regional distribution, 490 projects are taking place in Asia accounting for 37 percent of the total, 12 percent are taking place in Central and Eastern European and Russia and 7.7 percent are in Africa (Li, 2020).

Across Asia, ambitious technological advancement is faced with a middle-income trap. Thus, governments in this region strongly advocate digital innovation as one pillar of growth strategies (Kayama, 2019). Start-ups and cost-sharing businesses have been on the rise in China since 2016 and more recently a similar boom is taking place in ASEAN countries and India. These entrepreneurs are seizing business opportunities by finding challenges that society and corporations face and resolving them using digital technologies.

The establishment of a China-Africa Digital Silk Road likewise provides new opportunities for African nations to integrate into global industries and value chains on a more equal basis. The Beijing Action Plan (2019-2021) of the China-Africa Cooperation Forum proposed to leverage the Forum's strengths in support of the Belt and Road Initiative and for China and Africa to share experiences in information and communication development and to seize opportunities of the digital economy and encourage enterprises to cooperate in the development of digital infrastructures (Huang, 2019). The Digital Silk Road has been promoting African small- and medium-sized enterprises (SMEs) to join global digital trading networks through cross-border e-commerce (AliResearch, 2019).

As COVID-19 prevention and control become the new normal, Digital Silk Road projects have offered a new development direction by using digital technologies to facilitate the resumption of production and social activities. The digital QR health code system used in China and other countries, for instance, played a positive role in identifying those who were in close contact with COVID-19 patients for tracking suspected cases. To guarantee safe travel among regions, countries can provide access to data exchanges among different digital platforms and promote the process of cross verification. It will be crucial to achieve interoperability among regional platforms and to realize real-time cross inquiry (Li, 2020). The Data Silk Road presents a new opportunity for South-South digital collaboration. Providing digital solutions for achieving SDGs will be an important area of SS&TrC in the future.

THE INDIA-UN DEVELOPMENT PARTNERSHIP FUND

The government of India has recently announced several SSC efforts, establishing an important and positive path to Southern partnership for development. More specifically, the India-UN Development Partnership Fund was created in 2017 as a dedicated facility within the United Nations Fund for South-South Cooperation. India has committed a total of $150 million over ten years to the India-UN Development Partnership Fund, managed by UNOSSC and implemented in collaboration with the United Nations system. (UNOSSC, n.d). The India-UN Development Partnership Fund supports Southern-owned and led, demand-driven and transformational sustainable development projects across the developing world, with a focus on least developed countries and small island developing states. United Nations agencies implement the Fund's projects in close collaboration with partnering governments.

India and UNOSSC agree that South-South cooperation should be demand-driven. In line with this approach, the India-UN Development Partnership Fund responds directly to the national priorities and development objectives of partner countries, contributing financial resources and technical knowledge to support partner governments in achieving the SDGs. Under the umbrella of the 2030 Agenda for Sustainable Development, the Fund's focus is on helping development partners in areas of their choice (UNDP/UNOSSC, 2020).

2.4 NEW FINANCING PLATFORMS FOR SOUTHERN COUNTRIES

Over the past decade, the strengthened proliferation of Southern development banks and other financial institutions, such as the Asian Infrastructure Investment Bank (AIIB), New Development Bank, African Development Bank (AfDB) and Silk Road Fund, have supported significant advancements across Southern economies. This section proposes the Asian Infrastructure Investment Bank and African Development Bank as examples to illustrate rising and notable SS&TrC financing platforms.

THE ASIAN INFRASTRUCTURE INVESTMENT BANK

The Asian Infrastructure Investment Bank (AIIB) is an intergovernmental multilateral development agency based in the Asia region which was established to support infrastructure across the continent. The authorized share capital of AIIB is $100 billion and the ratio of capital contribution of members in Asia versus those outside the region is 75:25. AIIB began operations in 2016 with 57 funding members (37 regional and 20 nonregional). By the end of 2020, AIIB had 103 approved members covering Africa, Asia, Europe, North America, Oceania and South America (AIIB, 2021). As it had been difficult for existing multilateral financial institutions to meet Asia's infrastructure financing needs, AIIB has made it possible to invest in infrastructure facilities and other sectors of production, facilitates sustainable economic development and creates wealth and improves the connectivity of infrastructure facilities in Asia. It also works closely with other multilateral and bilateral development agencies to promote regional cooperation and partnerships that respond to development challenges.

AIIB's vision is a of a prosperous Asia built on sustainable economic development and regional cooperation. Since it began operations in 2016, AIIB has approved 134 infrastructure projects with a total investment of $26.45 billion. As shown in *Table 1*, AIIB's infrastructure projects include energy, transport, water, finance, urban, ICT, rural infrastructure, and agricultural development.

Table 1: AIIB's projects by sector (2016-2020)

	Energy	Transport	Water	Fiance	Urban	ICT	Rural infrastructure and agricultural development	Others	Total
2016	4	3	0	0	1	0	0	0	8
2017	6	3	2	3	0	1	0	0	15
2018	2	3	3	3	1	0	0	0	12
2019	7	4	3	9	2	1	1	1*	28
2020	3	5	3	3	1	3	0	27**	45
Total	22	18	11	18	5	5	1	28	108

* Sri Lanka: Reduction of Landslide Vulnerability by Mitigation Measures.

** Projects under the COVID-19 Crisis Recovery Facility: public health (8), finance and liquidity (7) and economic resilience (12).

Source: AIIB (2020a&b).

It is worth noting that in response to the spirit of the G20 Leaders' Summit on 26 March 2020, to work together to respond to the global pandemic, an emergency $5 billion COVID-19 Crisis Recovery Fund was approved. *Table 1* shows that 27 projects were implemented in 2020 under the COVID-19 Crisis Recovery. This rapid crisis response mechanism and its accompanying funding capabilities injected new momentum into global health governance in the event of a major public health emergency.

THE AFRICAN DEVELOPMENT BANK AND AFRICA DIGITAL FINANCIAL INCLUSION FACILITY (ADFI)

The African Development Bank (AfDB) started operations in 1964 to support infrastructure development and the private sector in Africa through selected programmes and projects. Acting as a facilitator and finance provider, the AfDB contributes to the implementation of the SDGs and creates capacities that can foster SSC between developing countries. More generally, the AfDB 2013-2017 strategy identified private sector development as a core operational priority, placing it at the centre of Africa's transformation into a more stable, integrated, and prosperous continent. The strategy prioritizes African businesses, local entrepreneurship, and an efficient integration into global value chains for the promotion of cooperative sustainable growth.

The Africa Digital Financial Inclusion Facility (ADFI) is an innovative financing vehicle of the AfDB designed to catalyse digital inclusion across Africa. ADFI works to address systemic barriers to the growth and uptake of digital financial services by making strategic and catalytic investments in the ecosystem throughout Africa. ADFI's goal is to ensure that 332 million more Africans, of which 60 percent are women, have access to the formal economy (AfDB, 2021).[5] In 2020, the AfDB Board of Directors approved a grant of $2.33 million to EthSwitch Share Company, an initiative led by the National Bank of Ethiopia for the modernization of its payment infrastructure. In 2021, the Board of Directors approved a grant of $1.024 million for artificial intelligence-enabled systems to process customer complaints on behalf of the national banks of Ghana and Rwanda and the Competition and Consumer Protection Commission of Zambia.

5 WeDoctor is a leading digital medical and health service platform in China founded by Jieyuan Liao and his team in 2010. It has four main businesses. (1) WeDoctor HealthCare has two disease diagnoses systems for Western (RealDoctor) and Chinese medicine (Huatuo AI Doctor), both of which are facilitated by AI. (2) WeDoctor Insurance offers insurance options for users based on gender and concerns (cancer, leukemia, children, etc.) at different price points. (3) WeDoctor Cloud allows partnering hospitals, clinics, government and businesses to use tools, such as data processing, record management, AI diagnosis, pension management and remote consultation. (4) WeDoctor Pharma integrates healthcare services to provide patients with a 'one-stop shop' to receive a virtual consultation and receive an electronic prescription that can be filled immediately. (VO, H. 2019. *China's Healthcare Revolution: WeDoctor* [Online]. Harvard Business School Digital Initiative. (https://digital.hbs.edu/platform-digit/submission/chinas-healthcare-revolution-wedoctor/, accessed 26 June 2020).

2.5 EMERGING COOPERATION APPROACHES BASED ON PLATFORM BUSINESS MODELS

Accompanied by global South digital innovations in technology and platform business models, certain SS&TrC approaches based on digital technology platforms, such as Big Data, the Internet of Things and artificial intelligence, are sprouting and developing. Examples include, the BRI Digital Economy International Cooperation Initiative and the Digital Silk Road that aim to enhance digital connectivity and provide advanced IT infrastructures, such as broadband networks, e-commerce platforms and smart cities, to BRI countries. Such projects provide new impetus and new approaches to realizing the 2030 Agenda and longer-term development prospects. While the 2018 *South-South Cooperation in a Digital World* report reviewed some new forms of SSC, such as the platform economy, cross-border e-commerce, digital finance, smart societies and internet and business process outsourcing, in this report additional emerging approaches of South-South Digital Cooperation are discussed below.

A NEW FORM OF SYNERGY BETWEEN HUMANS AND MACHINES

International development cooperation is a basic framework composed of ODA, or North-South cooperation, and SS&TrC. These cooperation frameworks are based on the cooperation of sovereign states on a political level and then extended to the cooperation of specific economic and social sectors. As noted earlier, a new type of cooperation framework and approach based on digital technology and business platforms has been born with the advent of a digital world — South-South Digital Cooperation (SSDC). SSDC can serve both SS&TrC, as well as Northern countries.

Case Study 1 presents an example of a new model of improving the efficiency of South-South cooperation by linking multiple resources through a digital platform. In response to the COVID-19 pandemic that created an unprecedented collective threat to human life, social cohesion and economies, a public welfare platform, the global MediXchange for Combating COVID-19, was launched based on Big Data and AI. The platform went online in a very short time, providing services across the world (*Case Study 1*).

CASE STUDY 1

GLOBAL MEDIXCHANGE FOR COMBATING COVID-19: PLATFORM-BASED INNOVATION IN PUBLIC WELFARE

The global MediXchange for Combating COVID-19 (GMCC was launched in early 2020 by the Jack Ma Foundation and Alibaba Foundation as a shared platform of Alibaba Cloud Intelligence and Alibaba Health. In the face of the global COVID-19 outbreak, the need for innovative solutions to inadequate public welfare financing and the need to match public donations with demand was urgent.

Based on Big Data and AI, GMCC went online (https://covid-19.alibabacloud.com) on 18 March 2020. Within several weeks, the platform was available in 229 nations, had 3,211 million page views and was providing innovative solutions to global pandemic relief efforts (Jack Ma Foundation, 2020).

The four major components of the GMCC platform are described below.

1. *Resource sharing center*. A manual, *COVID-19 Prevention and Treatment Manual: Clinical Experience of the first affiliated hospital of Zhejiang University's School of Medicine*, was made available online and, as of 31 March, had been downloaded 535,000 times, with online views reaching 401,000 in 227 nations. In addition to the Chinese and English versions, by June 2020 the manual was published on the platform in 23 languages.

2. *International doctor exchange center*. Six hospitals with the participation of 1,107 doctors shared 13 live broadcasts. The topics included: (1) hospital strategies for COVID-19, prevention and treatment; (2) treatment, prevention and control of COVID-19; (3) prevention, screening, diagnosis, prediction and management experiences with COVID-19 in Shanghai and Wuhan; and (5) research and development updates on COVID-19 (Alibaba, 2020b).

3. *Overseas Chinese COVID-19 counseling center*. As of 31 March 2020, 693 doctors had participated, offering free consultations to 19,509 people. Also, a session on "Fighting COVID19: The China-Africa Experience Exchange" on 28 April 2020 was seen by 1,600 CDC staff and doctors.

4. *Science and technology aiding anti-epidemic center*. Technological support to counter the global pandemic was requested from 16 nations. Assistance in CT, artificial intelligence, Big Data and Cloud Computing was made available 258 times (91 times for Tokyo, Japan, 77 times for Frankfurt, Germany, and 90 times for Jakarta, Indonesia). Also, Alibaba delivers free Elastic High-Performance Computing (E-HPC) for public research institutes around the globe, offering high performance computing and AI technologies to help institutions sequence viral genes, develop new drugs, and shorten the development cycle. Alibaba's CT Image Analytics for COVID-19 assists in realizing quantitative analysis and speeding up CT image analytics, avoiding errors caused by fatigue and adjusting treatment plans in time. The Free Computational and AI Platforms to Help Research, Analyze and Combat COVID-19 support public research institutions worldwide to analyze research and prevent COVID-19 (Alibaba, 2020a).

The GMCC platform allowed a rapid and effective sharing of the knowledge and experience of China, which, being the first country impacted by COVID-19, had already spent two months controlling its spread before the disease took hold worldwide. Live broadcasting was an important channel for knowledge sharing and was supported by the platform. Efficient allocation of anti-epidemic materials, particularly effective matching of supply and demand and efficient logistics delivery, was also supported by the platform. In March 2020, the Alibaba Foundation and the Jack Ma Foundation donated nearly 100 million pieces

and dozens of types of anti-epidemic materials to domestic frontline hospitals to counter the epidemic in more than 140 countries and regions, thus fully leveraging Alibaba's powerful platform resources to implement innovative platform-based charitable efforts.

The GMCC platform not only quickly aggregated professional resources, such as hospitals and doctors, but also gathered volunteers from all over the world. The platform proved to be convenient for individuals to realize their desire to do charity work. A total of 100 volunteers participated in the translation of the *COVID-19 Prevention and Treatment Manual* (Alibaba, 2020).

In the process of promoting the connection between supply and demand, valuable official connections were made between developing and developed countries and participation of social organizations and individual citizens took place with the support of the platform.

Source: Author's compilation from information on https://gmcc.alibabadoctor.com.

HEALTHCARE COOPERATION BASED ON AN INTERNET HOSPITAL PLATFORM

Digital technology and cross-sector integration have already had many successes with SSC. One such success has been using digital technology for healthcare. (Chapter 6 of this report specifically discusses opportunities for improving health systems and services through digital technology.)

WeDoctor's[6] global Consultation and Prevention Center (*Case Study 2*) illustrates a global health cooperation mechanism based on a digital hospital platform. Case Study 2 has similar characteristics to Case Study 1 but differs in that it is dominated entirely by a private global digital health company, serving both developing and developed countries. However, the concept has demonstrated huge potential for global health governance, a potential that could be leveraged through SS&TrC.

6 WeDoctor is a leading digital medical and health service platform in China founded by Jieyuan Liao and his team in 2010. It has four main businesses. (1) WeDoctor HealthCare has two disease diagnoses systems for Western (RealDoctor) and Chinese medicine (Huatuo AI Doctor), both of which are facilitated by AI. (2) WeDoctor Insurance offers insurance options for users based on gender and concerns (cancer, leukemia, children, etc.) at different price points. (3) WeDoctor Cloud allows partnering hospitals, clinics, government and businesses to use tools, such as data processing, record management, AI diagnosis, pension management and remote consultation. (4) WeDoctor Pharma integrates healthcare services to provide patients with a 'one-stop shop' to receive a virtual consultation and receive an electronic prescription that can be filled immediately. (VO, H. 2019. *China's Healthcare Revolution: WeDoctor* [Online]. Harvard Business School Digital Initiative. (https://digital.hbs.edu/platform-digit/submission/chinas-healthcare-revolution-wedoctor/, accessed 26 June 2020).

CASE STUDY 2

PLATFORM-BASED HEALTHCARE INNOVATION: WEDOCTOR'S GLOBAL CONSULTATION AND PREVENTION CENTER

With the spread of COVID-19 around the world in early 2020, an acute shortage of healthcare and protection resources became evident. Hospitals grappled with how to provide consultation services for a public that was full of fear and anxiety and how to provide online diagnosis and treatment services for many patients with chronic illnesses.

The Global Consultation and Prevention Center (GCPC) was launched by WeDoctor in March 2020 to help with this dilemma. GCPC provides real-time assistance, such as online consultations, psychological assistance, Traditional Chinese Medicine, consultations and prevention guidelines (BookDoc, 2020). Three months after its launch, the platform had received over 14,865,000 visits.

Within one year,[7] more than 23,000 doctors had volunteered on the platform, from departments such as respiratory medicine, internal medicine, infectious diseases, and general practice, to provide health service support globally. Nearly 73,000 people had been helped. Anti-epidemic experts were organized to share their experiences with overseas counterparts on the platform.

The core value of GCPC lies in value innovation brought by a two-sided market based on the platform. The platform brings doctors and patients together to create and exchange value. On the supply side, thousands of doctor volunteers to deliver online consultant services, on the demand side, thousands of sufferers seek help.

In past instances of SS&TrC, knowledge exchange and knowledge sharing were supported, such as in the case of the South-South Facility[8] established by the World Bank in 2008. However, these cooperation projects mainly used one-way value transfer in the process of knowledge exchange and the sharing of projects, specifically based on demand expressed by the knowledge-recipient countries. The two-sided market function demonstrated by GCPC could aggregate many suppliers and many demanders on one platform to form a cooperative ecosystem, generating 'network effects' and achieving value creation for both parties.

WeDoctor's global anti-epidemic platform fully leveraged the resources of doctors, artificial intelligence and Big Data that had already been aggregated on WeDoctor's platform. Hence, the global anti-epidemic platform could be launched in a short period of time. This points to the potentially powerful role of digital technology using a platform model for global health governance. Online provision of emergency medical and healthcare services for the global South, and even for developed nations, is an area to explore further for South-South and Triangular Cooperation.

Source: WeDoctor (2020), accessed 7 April 2020 (compiled by the author).

7 WeDoctor website: https://promo.guahao.com/en/global/pneumonia?_cp=yxzj_en&cs=share.

8 The South-South Experience Exchange Facility was launched in October 2008 as a multi-donor trust fund. The Facility enables the sharing of development experiences and knowledge among members of the World Bank Group by funding knowledge exchange activities based on demand expressed by the knowledge-recipient countries. The knowledge exchanges are designed with a focus on achieving results. (www.southsouthfacility.org, accessed 27 June 2020).

Since the launch of the Buenos Aires Action Plan in 1978, many SSC networks have been formed in the global South, for instance, the Human Milk Bank Network of Brazil and Latin American countries and the Networks of National Institutes of Health of the Association of Southeast Asian Nations and the Union of South American Nations.[9] These SSC networks are part of a broader regional political and economic agenda and, as long-term networks, focus on strengthening national institutions, sharing experience and expertise and working together to achieve national and regional priorities (WHO and World Bank, 2014). Nevertheless, the two case studies, GMCC and GCPC, are global health cooperation platforms that were formed within a month to combat the COVID-19 epidemic. These platforms were able to ramp up rapidly and serve policymakers, communicable disease control professionals, doctors, and individuals directly.

3. Guidelines for South-South Digital Cooperation and Triangular Cooperation

Based on the Buenos Aires Action Plan and existing South-South and Triangular Cooperation guidelines, South-South Digital Cooperation (SSDC) is cooperation that emphasizes the support of digital technology and platform models to promote sector integration and achieve cooperation goals. To be successful, SSDC needs to follow certain cooperation guidelines. The joint report by the United Nations Office for South-South Cooperation and the Finance Centre for South-South Cooperation titled *South-South Cooperation in a Digital World: 2018 Annual Report in South-South Cooperation* summarized some of the challenges faced by SSDC, such as the fact that the global South is largely confronted with weak digital infrastructures and insufficient human capital. Further complications noted are inadequate technology transfer and independent innovation capabilities, which exacerbate challenges, such as inequality in digital technology, restrictions on cross-border data flow, violations of personal privacy and the risk of fraud (FCSSC and UNOSSC, 2019). To address some of these hurdles, several recommendations for SSDC are described below.

3.1 PROMOTE COMMON INTERESTS OF THE GLOBAL SOUTH AND HUMANITY

South-South Cooperation promotes collective self-reliance, common prosperity, unity, and stability in the global South. SSDC also requires adherence to the basic principles of SSC. The large-scale innovation brought about by digital technology, especially artificial intelligence, while beneficial, can also potentially be disruptive: certain countries, regions, enterprises, or individuals may benefit, while others may be left behind by such interests. The digital divide refers to differences in access to digital services, such as the internet and digital infrastructures; it describes the uneven distribution of information and communication technologies in society. A lack of access to digital mobile services, for instance, is understood to be harmful to those on the disadvantaged side of the digital divide because of the huge knowledge base, data and services that can only be found online. The goal of SSDC is to provide universal access to digital services and share digital dividends with everyone in the global South.

9 For more on the role of the Union of South American Nations (UNASUR) since the early 20th century, see Rosenberg, F., Tobar, S. and Buss, 2015: "Role of the UNASUR national institutes of health in generating evidence on the social determinants of health," *Revista panamericana de salud publica* (*Pan American Journal of Public Health*), 38, 152-156.

It is necessary to insist on sharing and transparency in SSDC so that everyone can access digital services. The huge opportunities that the opening up of digital services brings, notably greater consumer choices, the potential for increased productivity and better quality of services, all contribute toward economic growth and social development. Good and open data should be easy to find, free to access and made available in a format that promotes its use. When adhering to the guidelines of sharing and a transparent common interest, certain technical measures can be adopted, such as blockchain and smart contracts that can promote trade information sharing, enhance transparency and respond to fraud risks (FCSSC and UNOSSC, 2019).

3.2 PROMOTE THE FAIR USE OF DIGITAL TECHNOLOGY IN THE GLOBAL SOUTH

Digital technology innovation and transformation will bring about the extension and reorganization of the global industrial chain, an upgrade of the value chain and a redistribution of the chain of interests. During that process, SSDC should promote fair access to digital services in the global South for everyone and adhere to the cooperation and development concept of "no one left behind." SSDC should enhance the production efficiency of industries and improve people's welfare through more convenient services. This requires a 'top-level plan' at global, regional, and national levels. Top-level design needs to consider the best ways to share data across regions, especially with the aim of making digital services more accessible to low-income, rural, and other marginalized communities.

Employing SSDC, economic cooperation needs to promote global investment and the facilitation of trade in the global South, supporting pro-poor economic growth. Social development cooperation via SSDC should improve the availability and accessibility of basic public services in the global South, such as education and health, and boost inclusive social development.

3.3 PROMOTE ECO-APPROPRIATE DIGITAL TECHNOLOGY IN THE GLOBAL SOUTH

It is necessary to make full use of the advantages of data technology to create an eco-friendly cooperative development path in the global South, including within disaster management, ecological protection, and low-carbon initiatives. Establishing a proper digital infrastructure for the coming decades in the global south will require SSDC that incentivizes digital innovation cooperation among developing countries. Such a development path will demand using and scaling up digital solutions for deep decarbonization and all kinds of low-carbon solutions, providing cooperative roadmaps for new solutions and infrastructure and dismantling barriers to their implementation.

Another important step will be to build low-carbon development knowledge on a global level through Triangular Cooperation, ensuring that the global South has equal access to data, technology, and financing. This requires reaching across traditional development assistance barriers and focusing on overall system benefits of sustainable development.

4. Global governance for promoting South-South Digital Cooperation and Triangular Cooperation

The 2030 Agenda and other major development frameworks, including the Addis Ababa Action Agenda,[10] the Paris Agreement[11] and the Sendai Framework,[12] emphasize the importance of South-South and Triangular Cooperation. SSC continues to show steady expansion, diversification, and resilience. It is reducing the asymmetry in access to development opportunities and responds directly to local demands. In recent years, new actors, such as the Jack Ma Foundation and the Alibaba Foundation, more inclusive partnerships and innovative development cooperation models have emerged. These changes have strengthened development efforts at all levels to eliminate poverty and hunger, respond to climate change, support infrastructure development and advance humanitarian aid (Economic and Social Council, 2018). While accelerating the construction of a digital South, the global South must be positioned as an important partner in global governance in the digital world. To promote the global South's participation in global digital governance, the following recommendations for action at global, regional, sub-regional and country levels are proposed.

4.1 GLOBAL ACTION

In the spirit of the Buenos Aires Action Plan, global governance requires action at national, sub-regional, regional, interregional, and global levels in response to the goals of South-South technical cooperation. Governance of SSDC at the level of the United Nations and more generally on a global scale can accelerate the spread of digital technologies and services in the global South and a series of action plans should be formulated for this purpose. For instance, the large-scale network platform, South-South Galaxy,[13]

10 The Addis Ababa Action Agenda was adopted at the Third International Conference on Financing for Development (Addis Ababa, Ethiopia, 13-16 July 2015) and subsequently endorsed by the United Nations General Assembly in its resolution 69/313 of 27 July 2015. The Action Agenda establishes a strong foundation to support implementation of the 2030 Agenda for Sustainable Development. It provides a global framework for financing sustainable development by aligning the flow of all financing and policies with economic, social and environmental priorities. It includes a comprehensive set of policy actions, with over 100 concrete measures that draw upon all sources of finance, technology, innovation, trade, debt and data to support the achievement of the SDGs.

11 The Paris Agreement Under the United Nations Framework Convention on Climate Change was adopted in December 2015 to reduce the emission of gasses that contribute to global warming. The Paris Agreement set out to improve upon and replace the Kyoto Protocol, an earlier international treaty designed to curb the release of greenhouse gasses. It entered into force on 4 November 2016 and has been signed by 197 countries and ratified by 187 as of November 2019.

12 The Sendai Framework on Disaster Risk Reduction (2015-2030) is an ambitious agreement that sets out the overall objective to substantially reduce disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

13 South-South Galaxy is a global knowledge sharing and partnership brokering platform, supported by UNOSSC, United Nations agencies and development partners. It serves as a consolidated South-South solutions platform for Southern partners and the United Nations system and acts as a one-stop-shop for all partners to utilize. South-South Galaxy connects and links existing South-South knowledge sharing platforms, making it easier for Southern partners to access, navigate and use. It gives users access to a broad range of knowledge, solutions, research, partners and capacity development initiatives. For more information see: www.southsouth-galaxy.org/about/.

spearheaded by the United Nations Office for South-South Cooperation was launched in 2019 to enable partners of the global South to share their development experiences, solutions and needs and to promote and build new partnerships more effectively (Li, 2019).

Other global actions that can promote SSDC include, but are not limited to, the following:

- → strengthen those digital technologies, innovations and applications that promote national and collective self-reliance;
- → exchange development experiences and promote joint learning specifically for digital technologies and platforms;
- → fully leverage the advantages of TrC and global digital technology cooperation;
- → strengthen the interconnection of digital infrastructures among developing countries;
- → strengthen the use of digital technologies in developing countries to achieve cross-region and cross-sector integration; and
- → support global South digital talent and increase capacity building efforts.

4.2 REGIONAL AND SUB-REGIONAL ACTIONS

Since the implementation of the Buenos Aires Action Plan, regional and sub-regional SSC organizations have continued to emerge, thus greatly enriching SSC. The existing SSC regional and sub-regional organizations have realized the importance of digital economic and technological cooperation to varying degrees.

Latin America and the Caribbean have historically had many regional and sub-regional multilateral organizations and platforms, which provide dialogue, learning, consensus building and technical support for development, including healthcare. Argentina played a leading role in hosting the first United Nations Technical Cooperation Conference in 1978 (from which the Buenos Aires Action Plan for Strengthening South-South Cooperation emerged). In the 1980s, the Pan American Health Organization launched the Inter-Country Technical Cooperation Program to utilize member state capabilities to promote knowledge sharing and networking cooperation to accelerate health development (WHO and World Bank, 2014).

Meanwhile in Asia, the Association of Southeast Asian Nations (ASEAN), a political, economic and security cooperation organization, established a series of cooperation mechanisms. At the 16th China-ASEAN Expo in 2019 (with the theme "Co-drive AI to Empower the Future"), the China-ASEAN E-Commerce Forum and the first China-ASEAN Artificial Intelligence Summit were held.

Various regional and sub-regional organizations in Africa are also active, such as the African Union, the African Renaissance and International Cooperation Fund, the New Partnership for Africa's Development (NEPAD), the Southern African Development Community (SADC) and the Eastern African Community (EAC). In 2017, the African Union issued Africa's exclusive domain name (.africa) with its own digital identity. In 2019, the European Commission and the African Union Commission launched the European Union-African Union Digital Economy Task Force. The Task Force prepared a report containing concrete recommendations for future digital cooperation between the two continents (European Commission, 2019). Certain new inter-regional mechanisms, such as the China-Africa Digital Silk Road, have been established as well.

Additional regional and sub-regional actions that can be taken to promote South-South Digital Cooperation include, but are not limited to, the following:

- → strengthen capacity building of regional and sub-regional institutions and organizations in SSDC;
- → attract leading digital technology companies from the South to participate in the regional and sub-regional SSC framework and to formulate actions;
- → in view of the regional nature of digital infrastructure, promote the sharing of co-built infrastructures at regional and sub-regional levels;
- → improve the standards of digital technology cooperation among developing nations and the promotion of seamless connections;
- → support regional knowledge and experience via digital exchange platforms and the fostering of talent; and
- → strengthen inter-regional SSDC.

4.3 NATIONAL ACTIONS

Many individual countries in sub-regions of the global South have actively adopted SSC measures that have laid the foundation for country actions under SSDC. Argentina, Brazil, and Mexico are conducting technical cooperation and capacity advisory initiatives. Brazil, certain Latin American nations, and African countries are active in agricultural technology cooperation. Cuba and Venezuela have promoted human resource cooperation and Brazil and Venezuela have cooperated in healthcare infrastructure (WHO and World Bank, 2014). Brazil's technical assistance, which is mainly focused on Latin America and Africa, concentrates on education, healthcare, and agriculture. Brazil's SSC emphasizes "equal relations" rather than "aid relations" and is driven by demand (FCSSC, 2017). India has provided scholarships to nations in Africa and Asia to facilitate capacity building and promote cultural and educational development. South Africa has played an important leadership role in promoting closer economic relations between Africa and the Gulf Cooperation Council. South Africa's SSC projects are mainly dominated by the African Renaissance and International Cooperation Fund (FCSSC, 2017). Despite these crucial improvements, there is still a significant way to go in realizing the 2030 Agenda.

Further South-South Digital Cooperation actions that countries can undertake include, but are not limited to, the following:

- → formulate national plans for digital technology cooperation among developing countries;
- → adopt policies, regulations and systems that are conducive to digital technology cooperation among developing countries;
- → prioritize integration and development of digital technology in technical cooperation projects among developing countries;
- → strengthen capacity building and knowledge sharing of digital technology cooperation among developing countries;
- → promote greater dissemination and inclusion of digital services in developing countries;
- → enhance integration and international cooperation of applying digital technology in health, agricultural and industrial sectors, among others;

- → improve the efficiency of public services, knowledge exchange and knowledge sharing through digital technology cooperation among developing countries; and

- → strengthen data sharing, paying close attention to digital security and protection, among developing countries.

5. Conclusion

Since the Bandung Conference and the Buenos Aires Action Plan, South-South Cooperation has reaped fruitful results. South-South and Triangular Cooperation are now important components of international development and global partnerships are creating new momentum and new approaches to achieve the goal of sustainable development. Over the past decade, new development concepts, cooperation frameworks and cooperation models have emerged on a continual basis. For instance, Triangular Cooperation is taking hold that links North-South Cooperation with South-South Cooperation. The Community with Shared Future for Mankind provides a new concept for consolidating the consensus of global partnership cooperation, while the Belt and Road initiative and the Digital Silk Road advocate a new international development framework and cooperation-based banks, such as the Asian Infrastructure Investment Bank and the New Development Bank, offer new channels for development financing.

South-South Digital Cooperation is not simply SSC involving digital technologies, but is a cross-border, cross-regional and cross-sector integration development model based on digital technology. This cross-border integration leverages data as the key production factor and platform business models as the key industrial organization model. The two-sided market has changed the traditional one-way delivery method of the value chain by promoting two-way interactions and even network interactions in the global value chain, thereby innovating new values. This latest approach to value creation, like SS&TrC, provides fresh impetus and new methods for sustainable development goals. Several case studies of platforms generated in response to the COVID-19 pandemic have illustrated the prospects of digital technology and platforms under SS&TrC.

To accelerate the dissemination and inclusiveness of digital technologies and services in the global South, a series of actions to promote SSDC should be adopted at global, regional, sub-regional, national, and even city levels. At the global level, strategies, and actions to encourage SSDC should be adopted under the United Nations system to promote digital infrastructure, talent training and capacity building in the global South. The strengthening of capacity building of regional and sub-regional institutions and organizations, the promotion of cross-regional interoperability of digital infrastructures and public services, the improvement of standards for digital technology cooperation among developing countries, the facilitation of seamless connectivity and the strengthening of inter-regional SSDC are all actions that should be adopted at regional and sub-regional levels. At the national level, SSDC requires national planning, policy adoption, regulations and systems that are conducive to digital technology cooperation among developing nations and which promote cross-border and cross-sector integration of digital technology development to contribute to the shared development achievements of human society.

The platform model is a new model in business that uses digital networks to connect people, institutions, and resources in a digital environment to generate and trade value. Platforms, when properly constructed, can act as potent catalysts for rich ecosystems of resources and individuals. The results of such ecosystems vary based on the platform design and the actors it brings together. As such, this model has the potential to play a significant role in expanding SSDC and using digital technology for significantly more inclusive SS&TrC modalities. Platform-based approaches can be used to leverage digital technologies and capabilities in the context of strengthening SSC frameworks for inclusive digital development. Essentially, it provides an opportunity to expand the scope of SS&TrC frameworks and prioritize models that bring

together human and digital resources for a comprehensive sustainable future. Despite this potential, it is crucial to reflect on the challenges of shifting priorities within existing SS&TrC frameworks to ensure that the modalities support inclusive SSDC and development. Just as it would require a change in processes and technological systems for a business shifting to the platform model, it will require certain adjustments along the way to adopt SSDC frameworks at the various governance levels.

This report notes that digital technologies, platform models and cross-sector integration can bring broad and exciting improvements to human society. Nonetheless, the report is also aware that the sustainable development of human society faces many challenges, COVID-19 being a glaring example, and a global economic recession is possible. Certain new development concepts, frameworks, motivations, and approaches mentioned in this report have the prospect of introducing valuable strategies for responding to new challenges. That said, these concepts, frameworks, impetus, and methods are still under development and have not been perfected. Summing up collective experiences and lessons learned and improving these knowledge systems should be an ongoing study.

Chapter 3

Digital economic transformation in the global South

1. Introduction

The global South is undergoing a rapid digital transformation. Digitalization has affected virtually every economic sector and activity in global South economies. These technologies are providing several benefits, such as increasing food production, reducing the consumption of water and resources, redirecting food waste, and lowering food prices (Walla, 2019).

More broadly, the global South is rapidly embracing what is referred to as the Fourth Industrial Revolution (4IR) technologies, including blockchain, Big Data, the Internet of Things (IoT), artificial intelligence, remote sensing (satellite imagery and drones), genome editing, virtual reality, augmented reality and 3D printing, among others (*Table 2*). The 4IR has some key differences compared to past industrial revolutions. First, while technologies related to previous revolutions took a long time to have meaningful impacts on economies and societies, the 4IR technologies are impacting society rapidly. Consequently, rapid action and responses from governments and the private sector are required to make productive utilization of these technologies. Second, the 4IR is more complex due to the involvement of diverse technologies, materials, new discoveries, and tools. Third, the 4IR technologies have the potential to significantly impact all systems and economic sectors, not only one product or one industry (Silva, 2018).

What is an even more impressive feature of the 4IR is that some global South economies have surpassed their Northern counterparts in the development and deployment of some of the latest digital technologies. In a 2016 report, the United States noted that China had overtaken the United States in the number of published journal articles on deep learning,[14] which is used to develop AI *(The Economist, 2017). In 2017, Chinese firms accounted for 99 of the 314 blockchain patents and 473 of the 649 AI patents filed with the World Intellectual* Property Organization (WIPO) (Peyton, 2019). The numbers of patents related to the two technologies filed by United States companies were 92 and 65, respectively. According to WIPO (2019), Chinese organizations accounted for 17 of the top 20 academic institutions in AI patenting and 10 of the top 20 in AI-related publications.

China has also demonstrated achievement on the investment front. In 2017, worldwide investments in AI start-ups grew by 141 percent to reach $15.2 billion and 1,100 new start-ups were founded. According to CB Insights (previously known as ChubbyBrain), investments in China surpassed those of the United States. China attracted about half of all investments, compared to 38 percent for the United States. In 2016, China attracted 11.3 percent of all global funding for AI (Robert, 2018).

In another example of global South economies embracing digital technologies, a recent study published by UNECA regarding efforts to decrease gaps in ICT found that the Economic Community of Central African States (ECCAS) zone registered one of the highest growth rates in telecommunications in Africa, with 81 million subscribers (45 percent penetration) and more than 25 mobile operators. ECCAS maintains an intra-trade exchange rate of 1.8 percent with a market of 180 million people, or approximately 15 percent of the population of Africa. These statistics portray immense potential in this region for the creation of strong digital value chains.

Moreover, according to the 2019 report of the Global System for Mobile Communications Association (GSMA), strong efforts have been made to increase 4G adoption across sub-Saharan Africa to integrate the region into the global digital economy. However, several variables have been challenges to digital growth in sub-Saharan Africa, including the high cost of 4G-enabled devices and consistent delays in assigning 4G spectrum to established service providers in some markets. As such, as of 2018, the region's 4G accounted for 7 percent of total connections, compared to the global average of 44 percent. In 2019, new 4G spectrum assignments across sub-Saharan Africa combined with an increase in network

14 Deep learning uses algorithms, which teach computers to learn by examples and perform tasks based on classifying structured as well as unstructured data, such as images, sound and text.

deployment have proven to be exemplary steps forward for the region's economic growth. As of 2019, seven Long-Term Evolution (LTE) networks had been launched in the region, including in Burkina Faso and Ghana (GSMA, 2019).

Table 2: Key 4IR technologies

4IR technology	Explanation
3D Printing	Use of a computer-aided design (CAD) model to build a three-dimensional object. This is usually done by adding material layer by layer. It is also referred to as additive manufacturing (The Economist, 2013). Advantages of this process include less waste and the ability to print a custom design (Zastrow, 2020).
Artificial Intelligence	Simulating human intelligence by machines. The key processes involved are learning (acquiring information and understanding the rules for using the information), reasoning (applying the rules to reach conclusions) and self-correction.
Augmented Reality	With the help of sensors and algorithms, the computer determines the position and orientation of a camera. Then 3D graphics are made available from the camera's viewpoint and computer-generated images are superimposed into a user's view of the real world (Bardi, 2019). Alibaba's Taobao Buy uses AR to create 3D versions of products (Carlton, 2018).
Big Data	Technology research company Gartner defines Big Data as "high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making."
Cloud Computing	Involves hosting applications on servers and delivering services via the internet (software, platforms, and infrastructure). Users can access computing power and resources on the cloud and pay for services based on usage.
Genome Editing	Making changes to the DNA of a cell or an organism. By doing so, scientists can test the way in which specific genetic variations generate particular traits and diseases. Looking at the patterns in huge datasets of genetic information and medical records, scientists can examine mutations and linkages in diseases. They can then personalize treatment and process protocols for a patient. In chronic disease, this will play a critical role in increasing the efficacy of treatment.
Internet of Things (IoT)	The network of physical objects or 'things' (e.g. machines, devices, appliances, animals or people) embedded with electronics, software and sensors, which are provided with unique identifiers and possess the ability to transfer data across the web with minimal human intervention.
Remote Sensing	Detecting and monitoring an area's physical characteristics with radiation that is reflected and emitted from the area. Typically, cameras are installed in satellites or aircrafts for this purpose (USGS, 2019).
Virtual Reality	Use of computer technology to create a simulated environment or experience, which could be similar to or different from the real world. Virtual Reality places the user inside an experience with the simulation of senses such as vision, hearing, touch and smell (Bardi, 2019). Whereas Augmented Reality involves locating a real camera within a physical environment, in Virtual Reality the user's eyes are positioned within a simulated environment to create a convincing and interactive world. For instance, it is possible to use Virtual Reality to create a 3D fashion show (Appsynth, 2019).

The objective of this chapter is to examine the nature of transforming digitalization economic activities in global South economies and various factors influencing the digitalization process. First, illustrative sectoral examples of digital transformation in global South economies are provided. Next, transformations associated with AI, which is arguably the most revolutionary technology, are discussed. The effects of South-South Cooperation and Triangular Cooperation on digital transformation in global South economies is examined. This is followed by discussion on the opportunities and then the barriers for digital economic transformations in the global South. The final section provides concluding remarks and recommendations.

2. Sectoral examples of digital transformation

To illustrate the above phenomenon, specific examples from diverse economic sectors are provided in this section to show the nature and impact of digital economic transformations in the global South.

2.1 MANUFACTURING AND PRODUCTION

The implication of the 4IR's effect on the manufacturing and production sector can be best demonstrated by considering what the World Economic Forum and McKinsey have recognized as the 4IR 'lighthouses.' Lighthouses are model factories that possess all the essential characteristics of the 4IR and demonstrate the potential to generate new economic value (Leurent and Boer, 2019). China has a large number of lighthouses. Several such lighthouses are also located in other global South economies, such as Indonesia and the Middle East (Cronin, Wider and Hernandez Diaz, 2019). The French *company* Schneider Electric's smart factory in Batam, Indonesia, and its plant in *Wuhan,* China, for example, have been recognized by the World Economic Forum *as lighthouses* (Estopace, 2019).

Lighthouses are transforming production systems, bringing innovations in value chains, and introducing disruptive business models to create value (Estopace, 2019). A key characteristic of a lighthouse is that technologies work together with humans rather than replacing them (Edmond, 2019). *Schneider Electric's Batam* Smart Factory in Indonesia is highly automated but employs 2,900 workers. A smart factory utilizes many advanced technologies, such as augmented reality. For instance, with augmented reality, when an alert *about a machine* failure is received, a maintenance worker can refer to a dedicated tablet to identify the point of interest and fix the problem without even coming into contact with the machine (Lim, 2019).

Another characteristic of lighthouses is that the improvements they bring fundamentally reset benchmarks for the entire industry rather than making only incremental changes. Schneider Electric's next generation *EcoStruxure* architecture and platform has been a game changer. *EcoStruxure* is IoT-enabled and *can be plugged and played*. Its suite of tools is open and interoperable and can be used in diverse settings, such as homes, buildings, data centers and infrastructure. It simplifies data collection from intelligent devices using standard communications protocols. The data can be analyzed locally using edge computing or in a central location in the cloud (BPX, 2018). EcoStruxure exhibits high performance in terms of key indicators related to security, reliability, efficiency, durability, and connectivity (Lim, 2019). Schneider Electric reported that implementation of the EcoStruxure solutions in its Batam plants led to a 5 to 7 percent increase in energy efficiency, 46 percent reduction in production scrap and 17 percent increase in productivity (Lim, 2019).

Lighthouses are also characterized by a high degree of collaboration and knowledge sharing. Schneider Electric's base in Batam has shared many of its technology solutions with its customers and partners, which has led to the improvement of the local ecosystem (Edmond, 2019).

2.2 FARMING AND AGRICULTURE

Digital technologies have also brought about a transformation in farming practices. Advanced digitized agricultural systems utilize data collection technologies connecting them to the Internet of Things (IoT), uploading data in real time. This process makes use of AI and machine learning capabilities to provide recommendations and transfer solutions to fully automated mechanization devices connected to the IoT (Hinson et al., 2019).

The first example is a modern Big Data center at the Qixing farm in northeast China's Heilongjiang Province. The Big Data center has transformed the farm, which is the largest paddy farm in the province, covering 81,300 hectares. The Big Data center uses data collected from high-resolution Gaofen-1 satellites and data obtained from meteorological machines and those related to land and environment (underground water-level monitoring equipment and other sources) (Xinhua, 2018). Farming decisions are made based on real-time data related to temperature, humidity, wind direction, soil temperature and humidity. To access the real time data, farmers install a mobile app called the Modern Agriculture Platform (MAP), which was developed by a state-owned enterprise, the Sinochem Group (cgtn.com, 2019). If farmers find problems, such as pests, they can take photos and upload them. Experts can provide help, such as the best time to sow and harvest different crops and when to spray insecticide and to water crops (Xinhua, 2018).

The second example is Indonesia's CI-Agriculture startup which promotes precision farming techniques using Big Data, the IoT and other technologies. For instance, using aerial photographs, sensors, drones, and weather data obtained from satellite imagery, data on soil conditions can be created and analyzed. The technology can advise when the best time is to plant, fertilize and use pest control, resulting in more efficient use of fertilizer and pesticides. Data from diverse sources are used to calculate a field's production potential with a higher level of accuracy. CI-Agriculture also offers insurance to Indonesian farmers, based on calculations and schemes using smart farming technology, sensor systems and analysis of other categories of data (E27, 2020). Insurance models are based on an analysis of weather data for up to 10 years. These technological solutions are expected to reduce loan costs for small-holder farmers. The technology is likewise scalable, which means it is possible to use for large areas as well.

A third example is the iCow app, which was developed by Kenya's largest cell phone service provider Safaricom and a local organization called Green Dreams (Kshetri, 2016). The app helps small-scale dairy farmers track and manage cow fertility cycles. It informs farmers about important days of a cow's gestation period. Based on milk production and breeding records and other information, the app sends best practices instructions to farmers. It also provides advice regarding the diagnosis of pest problems, prevention of infection and selection of the types of grass that are appropriate to *feed livestock (Glickman, 2015)*. In addition, the app helps farmers find the nearest vet and other service providers. Green Dreams has developed a simple system involving Google Docs to find virtual vets to answer farmers' questions. If Green Dreams and a vet contacted by a farmer are unable to answer the farmer's question, it is uploaded on the system. The vets send messages among themselves and come up with the best answer, which is forwarded to the farmer. A *National Geographic* article told the story of a farmer named Thuo who reported that iCow led to a substantial increase in his yields and improvement of his animals' health (Glickman, 2015). By implementing the knowledge, he received from iCow, the farmer doubled milk production (Kshetri, 2016a).

The final example of a successfully digitized agricultural system is Illuminum Greenhouses in Kenya. This innovative agri-tech company works with smallholder farmers to improve greenhouse production and efficiency through technological advancements. The programme uses solar-powered sensors, data analytics and automated drip irrigation systems which can be controlled via texting with a phone by the end user (Hinson et al., 2019). The company goes a step further by offering knowledge sharing through frequent visits to farmers to share recommendations on pest and disease control and management activities.

2.3 SMART CITIES

Smart cities use technology, such as the IoT and sensors, to collect data and use the insights gained from the data to manage resources and deliver services efficiently. Smart cities are rapidly developing in global South economies. Notably, China has emerged as a global leader in smart city technology. The country has 500 smart cities under construction, which is 50 percent of the world's total (PTI, 2018). This compares with 90 in Europe, 40 in North America and 30 in India (Chou et al., 2019).

Smart city technologies, as one example of their benefits, have increased the efficiency of traffic systems. Using smart city technologies, Hangzhou's Xiaoshan District has increased traffic speeds by 15 percent. The district has also reduced ambulance arrival time by 50 percent (Allison, 2019). The AI platform of the Hangzhou government's Statistics Resource Management Bureau utilizes more than 23 billion pieces of data from 59 departments (Huixin, 2017). Following their success in China, China-developed smart city technologies are rapidly making inroads into other global South economies. Chinese companies, such as Huawei and ZTE, are building smart cities in Kenya (Mutethya, 2017), Pakistan (Husain, 2017) and the Philippines (huawei.com, 2017).

In 2016, Pakistan's Lahore city awarded Huawei a $84.7 million contract under its Smart City project. The project, overseen by the Punjab Safe City Authority, involved installing 10,000 surveillance cameras. The goals of the project are to enhance people's security, reduce crime, carry out anti-terrorism monitoring more effectively, implement intelligent traffic management systems and increase the effectiveness of emergency response operations (thenews.com.pk, 2018). Huawei is implementing another similar project in Islamabad, the country's capital (Moss, 2019).

In Kenya's[15] capital Nairobi, Huawei's communications network has linked 1,800 cameras with 195 police bureaus (bbc.com, 2015). Likewise, in the port city of Mombasa, Safe City equipment was installed in 2014 (Hillman and McCalpin, 2019). A more recent high-profile smart city project is being undertaken in the small town of Konza in Machakos County, located 70 kilometers southeast of Nairobi (rt.com, 2019). The Konza Technology City (also referred to as Konza Technopolis) project was started in 2008 as a component of the Kenya Vision 2030 initiative. The Konza Technology City's plan is to gather data from smart devices and sensors embedded in *devices, machines*, and infrastructures, such as roadways and buildings, and analyze them to deliver valuable information and provide better services to citizens (konza.go.ke, 2019).

Alibaba has partnered with the Malaysian government to launch a digital free trade zone and Smart City projects (Soo, 2018). Alibaba Cloud's Smart City initiative called Malaysia City Brain, uses AI, Big Data and Cloud Computing to help Malaysian cities run more efficiently and optimize their use of resources. Kuala Lumpur will be the first Malaysian city to deploy City Brain. City Brain will be used first for traffic management (Soo, 2018), with such activities as detecting accidents, reducing illegal parking, and changing traffic lights to allow ambulances to move faster (Marr, 2019).

Likewise, Nur-Sultan, Kazakhstan, had over 2,000 cameras installed by Huawei working with Kazakhtelecom, Kcell, Beeline and Tele2. The Tajik government implemented Huawei's Safe Cities system in Dushanbe in 2013, with over 800 cameras watching monuments, parks, and other public spaces (Yan, 2019). Huawei provided the Dubai Municipality with equipment for smart services in 2019 and is developing a Centre of the Future. The Centre of the Future will be powered by Huawei's Wi-Fi 6[16] technology and AI solutions, enabling the Dubai Municipality to deliver a superior level of automated experience to residents (Abubaker, 2019).

15 Kenya's central role in the growth of digital technologies in Africa has earned it the moniker 'Silicon Savannah.'

16 Wi-Fi 6 (technically known as 802.11ax) promises higher data rates, better performance and higher power efficiency. Wi-Fi 6 provides up to four times faster download speeds compared to Wi-Fi 5 and twice as many simultaneous users to get steady connections (Wolpin, 2019). It lowers transmission latency by 60 percent (Rizvi, 2019). Wi-Fi 6 is more appropriate communications method for Internet-of-Things (IoT) devices with low power capabilities and limited battery life. Due to its feature known as target wake time, it is possible for IoT devices to shut down their Wi-Fi connections most of the time.

Lastly, to "smartize" its cities, Rwanda is taking measures such as making Wi-Fi and cashless payment available on public transportation and delivering public services online through the e-government platform called Irembo (Mwai, 2019). Irembo supports e-transactions and communication across various sectors to facilitate government to public transactions. For instance, it allows e-payments for various permits, transportation licensing, authorization applications and immigration applications.

2.4 FINANCE AND BANKING

Digital technologies have transformed finance and banking. For instance, Big Data solutions have increased low-income people's access to basic financial services, such as loans, savings and micro insurance. One example is Safaricom's Fuliza. In early 2019, Safaricom launched an M-Pesa overdraft service, Fuliza, which allows users to borrow small, short-term loans. The service was launched in a partnership between Safaricom, the Commercial Bank of Africa and the Nairobi-based financial services company KCB Group (Njanja, 2019). The launch of Fuliza was based on Big Data analysis, which indicated that users cancelled millions of transactions every day due to insufficient funds. The reason, however, was not that the users lacked money. The analysis showed that while the users lacked funds when they started the transactions, most of them got the required money in a short period. Indeed, most users were able to get the required funds and complete the transactions within two days. Fuliza was launched to close this gap (Saigal, 2019).

Another example, the Kenya-based social enterprise FarmDrive's Big Data solution DigiFarm, aims to improve access of micro-, small- and medium-sized enterprises to key resources. Access to credit is extremely difficult for smallholder farmers in the global South. For instance, less than one percent of farmers in Kenya are reported to have access to formal credit (Maina, 2018). DigiFarm helps unbanked and underbanked smallholder farmers to receive credit. The process is simple. Smallholder farmers can download an app developed by DigiFarm through an app marketplace *such as Google Play*. The records of revenues and expenses entered in their phones are tracked by the app. This information is combined with data generated from other sources, such as satellite agronomic data like crop yields, pests, diseases, and local economic data (Burwood, 2017). In addition to agriculturally relevant data, DigiFarm also uses Know Your Customer data to identify and verify the identity of the farmer as well as advanced behavioural analytics (Jackson, 2019a). The information is used to generate credit scores and assess their creditworthiness for loans (SAP News, 2017). Banks can use this information to provide loans to farmers and customize a farmer's payback timeline to match with harvests. As of 2018, over 700,000 farmers across nine counties in Kenya were using DigiFarm (Maina, 2018). 7,000 had successfully received loans to buy seeds, fertilizers, and pesticides (Capital Business, 2019). Farmers applying for a loan know within three minutes how much they can receive (Obi, 2018).

2.5 MINING

Digital technologies are also transforming the mining sector. The South African producer and distributor of diamonds, De Beers, has implemented a blockchain pilot project to track diamonds *produced by small-scale* African miners (De Beers Group, 2018; Stoddard, 2018). Launched by De Beers in early 2018, the platform Tracr was developed with Boston Consulting Group's Digital Ventures using the Ethereum blockchain framework. Tracr assigns each diamond a unique ID and uses 200 different characteristics to identify each stone, such as weight, color, clarity, and photos. Tracr started with tracking bigger diamonds, being rough stones of two carats and above (Bates, 2019). In the early test, most of its supply chain activities were owned or controlled by De Beers, which made compliance relatively easy to achieve (Hill, 2018).

De Beers has also launched a GemFair programme to log diamonds produced by small-scale African miners. The programme started with artisanal and small-scale diamond miners in Sierra Leone at 16 sites. De Beers trained the miners on digitally tracking diamonds throughout the supply chain. By April 2019, De Beers extended the pilot to 38 additional sites. The goal is to make sure that diamonds tracked by the platform do not originate in conflict zones. This will help small-scale African miners gain access to the global market and ensure that they get their fair share of the profit (Henderson, 2018).

3. Artificial intelligence and digital transformation

Among the 4IR technologies facilitating digital transformation, artificial intelligence (AI) is arguably the most revolutionary (bbc.com, 2019). In this section, the ways in which AI is transforming economic activities in global South economies is examined. *Table 3* provides illustrative examples of AI being used in diverse economic sectors and industries in global South economies.

Table 3: Artificial intelligence use in diverse industries in global South economies

Sector/industry	Company/app	Use of AI	Outcome
Farming and agriculture	PlantVillage Nuru (Africa)	A free smartphone app to diagnose diseases in crops, such as cassava and potato.	In a test, the app outperformed human experts by a factor of two in making accurate diagnoses.
Mining and energy	IBM's AI-based adviser (Brazil)	Provides information for better interpretation and explanation of seismic information.	Used to improve the performance of geological models. It can also provide a better risk assessment of new prospects.
Telecommunications	Safaricom Chatbot assistant ZURI (Kenya)	Provides services, such as managing subscriptions, cancelling SMS services, reversal of money sent to a wrong recipient, airtime top up and checking M-Pesa and airtime balances.	To reverse pay, a M-Pesa user no longer needs to contact a customer service team, which takes a long time.
Healthcare	Viettel Military Industry and Telecoms Group (Viet Nam)	Endoscopy: identify, locate, and assess digestive system damage.	Five times faster than traditional methods with an accuracy of up to 90 percent.
	L'Oreal (China and other countries)	Diagnose hair loss.	
E-commerce	Lazada (Southeast Asia)	App to show products to users based on purchase and viewing history. Also, an image search function.	When users take pictures of items they want, Lazada will suggest similar items available.

Insurance	Jubilee Insurance (Kenya)	A chatbot JULIE (Jubilee Live Intelligent Expert) helps customers with insurance queries. JULIE can be accessed through Facebook Messenger.	Customers can access policy data in real-time and geo-locate Jubilee Insurance medical providers.
	Ping An Insurance (China)	A driver in a car accident can electronically send a photo of the damaged cars. Ping An uses AI-backed solutions to review the damage and suggest compensation.	Responds with a repair estimate in less than three minutes. If the customer accepts, funds are transferred immediately. Prevents fraudulent claims.
	Ant Group (China)	AI-driven, image-recognition system to process vehicle insurance claims launched in 2017.	Assessed damages in 12 different cases in six seconds. Human investigators: > 6 minutes to assess a claim.
Finance and banking	United Bank for Africa (Nigeria)	A banking chatbot LEO helps customers transfer money, pay bills, buy airtime, check account balances and other functions.	Available 24 hours a day and faster than human agents.
	Ant Group's AI-based customer service chatbot	Uses deep-learning technology to detect fraud.	Losses related to fraud: one in one million. Handles 2-3 million queries per day. Outperformed human agents in customer satisfaction.

3.1 AI AND FARMING AND AGRICULTURE

AI tools are available to help predict near-term crop productivity for farmers. For instance, PlantVillage is a free smartphone app used in Kenya and other African countries to diagnose diseases in crops, such as cassava and potato (Pennsylvania State University, 2019). The app provides a diagnosis with a high level of accuracy using an AI assistant, NURU (*nuru* means "light" in Kiswahili) (Kreuze, 2019). In a test of Machine Learning models in the typical high light and temperature settings of an African farm, the app was found to perform twice as well as human experts in making accurate diagnoses.

PlantVillage uses Tensorflow, Google's open-source AI (Oranye and Peter, 2019). Not much technical knowledge or literacy is needed to use the app and NURU runs on standard Android phones. An early application of the app has been to help farmers in Africa identify Fall Armyworm infections (Walla, 2019). A farmer points a phone at the crop with disease and NURU uses Machine Learning and AI to tell the farmer if a worm is damaging crops. It also provides information to stop the pest. (Gill, 2018).

PlantVillage has been adopted by FAO, which monitors the spread of Fall Armyworm in around 70 countries. When farmers connect their devices online, FAO's Fall Armyworm Monitoring and Early Warning System (FAMEWS) mobile app uploads the collected data. As of early 2019, about 10,000 users had registered on the FAMEWS system, which is available in 13 languages (fao.org, 2019). The data is validated by national fall armyworm focal points and added to a global database (Gill, 2018). Anyone can freely access the

database from the FAO Fall Armyworm home page (fao.org, 2020). In this way, the app provides a real-time view of infestations across maps of Africa to help other app subscribers (Kreuze, 2019). In Kenya, the PlantVillage AI tool is used to send SMS messages to farmers across the country (Penn State, 2019).

As another example, Aerobotics uses drone imagery and AI to help farming consultants in South Africa and other countries to analyze processed maps. Actionable information can be extracted to identify problem areas in crops, such as wheat, macadamia nuts, citrus and sugar cane, and pest and disease can be identified when they are in early phases (Al-Beity, 2019). The information can be used to develop variable rate fertilization application maps and forecast crops yields (Timm, 2019).

Farmers and service providers fly drones equipped with Aerobotics multispectral and visual cameras. The imagery from the flights is uploaded to the Aerobotics AI platform. The imagery can identify individual trees down to the canopy level. Aerobotics AI determines each tree's stress level relative to the part of the farm that the drone covered, pinpointing each tree on a map of the farm. That data is sent to Aerobotics Aeroview, a pest and disease identification software that generates a "scout map" for the farmers. The farmers then can physically visit the trees to determine the nature and causes of stress or they can further use the scout map to fly drone scouting missions, sending the drones within five meters of the trees to take images and send them to Aerobotics Aeroview (Steyn, 2018). Aerobotics was included in *Fast Company*'s Most Innovative Companies list in 2019. By that year, the technology had been used by hundreds of farms in 11 countries, including Australia and the United States. It is used by 40 percent of South Africa's macadamia nut farms and 20 percent of citrus farms (Fast Company, 2019).

3.2 AI AND MINING AND ENERGY

IBM's AI Adviser provides information for better interpretation and explanation of seismic information to increase the performance of reservoir modeling processes. A *computer model* of a petroleum reservoir is created to improve the estimation of reserves and help make decisions regarding the development of a field and adding new wells. Such models can predict future production and evaluate effectiveness of reservoir management scenarios and helps improve the performance of geological models. The models can also offer better risk assessment of new oil field projects (Milam, 2018). In April 2019, Russian oil and gas company Gazprom Neft teamed up with IBM Research Brazil to use AI in geological information processing to automate routine operations and improve the analyses of geological and geophysical data related to oil exploration and production activities (offshore-technology.com, 2019).

3.3 AI AND DISASTER RESPONSE

AI helps emergency responders make decisions and act faster. The Argentinian start-up *Dymaxion Labs uses advanced Machine Learning*, AI-powered geospatial analytics, and computer vision techniques to do surveying faster and at a lower cost (Mapbox, 2018). Cameras installed in satellites detect and monitor physical characteristics of cities and settlements, which means that human surveyors do not need to visit the sites. Moreover, machines can observe features the human eye cannot and can process information faster. Dymaxion's AP LatAm tool uses satellite imagery algorithms and Machine Learning techniques to monitor informal settlements in Latin America (including in Argentina and the capital cities of Guatemala, Honduras, and Paraguay), providing information about community locations and changes in movements on a real-time basis (Mapbox, 2018). The goal is to improve decision-making and prepare for rapid disaster responses (Kumpf, 2018).

3.4 AI AND TELECOMMUNICATIONS

Telecommunications is another sector benefiting from AI, with particular advances having been made in sub-Saharan Africa. In that region, in 2018, mobile technologies and services amounted to 8.6 percent of GDP and over $144 billions of economic value added. The mobile industry has resulted in a significant increase in job opportunities across the region, generating almost 3.5 million jobs (directly and indirectly) and contributing to public sector funding, with almost $15.6 billion raised through taxation. Furthermore, as of 2018, 395.7 million registered mobile money accounts existed across sub-Saharan Africa, making up nearly half of the total global mobile money accounts. More than 130 live mobile money services are now operating in the region, many of whom are led by a combination of mobile operators and a network of more than 1.4 million active agents. It is estimated that as of 2023, increased mobile services will result in the industry contributing nearly $185 billion (9.1 percent of GDP) to economies, substantially raising regional digital productivity and efficiency (GSMA, 2019).

One specific example of innovative use of digital technology in telecommunications in Africa is the AI-based chatbot assistant ZURI, a product of Kenyan mobile network operator Safaricom. Available on Telegram and Facebook Messenger, ZURI provides Safaricom mobile data users in Kenya a wide range of services, such as managing subscriptions, unsubscribing from chargeable SMS services, reversal of money sent to a wrong recipient, airtime top up and checking M-pesa and airtime balances (cio.co.ke, 2018). ZURI had 40,000 users in November 2018, which increased to 150,000 in mid-2019 (Ombogo, 2019). The goal is to reach Safaricom's entire customer base of over 33 million people (Reuters, 2019). Before ZURI was launched, to reverse a payment, an M-Pesa user needed to contact a customer service team, which was time consuming and may have allowed the wrong recipient to withdraw the money (Chenez, 2019).

3.5 AI AND HEALTHCARE

A wide range of innovative AI technology healthcare applications have been developed and used in global South economies. For instance, the Chinese company Ping An's AI-powered system can predict chronic illnesses and infectious diseases with a high level of accuracy and can predict the likelihood that a patient may suffer from an illness even before physical symptoms appear. It can also quickly scan large numbers of medical images for abnormalities (Choudhury, 2019). In 2018, an AI-based system developed by Ping An Technology detected pulmonary nodules, known as "coin lesions," which are small round/oval-shaped growths in the lung, with a 95.1 percent accuracy level (PR Newswire, 2018).

As another example, Viet Nam's Viettel Military Industry and Telecoms Group uses AI in endoscopy. Its AI-based solutions can identify, locate, and assess damages in digestive systems. It was reported that AI diagnosed problems related to digestive systems five times as fast compared to traditional methods with an accuracy level of 90 percent (vietnamnews.vn, 2019). While AI's use in endoscopy is a growing trend in Northern countries (Togashi, 2019), what is encouraging is that global South economies, like Viet Nam, are developing such solutions locally.

Likewise, the Madurai, India-based Aravind Eye Hospital uses AI to diagnose the risk of blindness known as diabetic retinopathy, which is among the leading causes of blindness worldwide. According to the World Health Organization, about 70 million Indians suffer from diabetes, thus also face this blindness risk. But the country has a severe shortage of eye doctors, with only 11 eye doctors for every one million people. Aravind Eye Hospitals, an Indian hospital chain, has adopted a new screening method called neural networks, which uses complex mathematical systems and learns tasks by analyzing large amounts of data. Neural networks have been used to improve tasks, such as face recognition services, digital assistants, self-driving cars and instant translation services (e.g., Google Translate). By analyzing millions of retinal scans with signs of diabetic blindness, the neural network learns to identify the blindness conditions (Metz, 2019). Starting in 2014, in a pilot project sponsored by Google and working with Aravind Eye Hospitals, an algorithm was trained to recognize signs of diabetic retinopathy, which include distinctive spots and bleeding in the eye's retina. The Machine Learning algorithm can detect problems that eye doctors could not (Lydgate, 2018). Nurses in Aravind Eye Hospital's 70 satellite clinics, known as rural

teleconsultation centers, captured images of patient retinas. The photos were uploaded on to the cloud where Google's Machine Learning algorithm worked in combination with the specialists to detect and diagnose the disease (Ganjoo, 2019). The algorithm can diagnose the problem in a few seconds. As of 2018, about 2,000 patients were benefitting from the service.

3.6 AI AND E-COMMERCE

Several innovative applications of AI are found in the e-commerce sector. Thai start-up Pomelo plans to use Big Data and AI for a pricing, design, e-commerce personalization and supply chain automation platform (Jye, 2019). Likewise, in 2018, the Southeast Asian e-commerce firm Lazada launched an AI-driven app that uses Machine Learning algorithms to show products to users based on purchase and viewing history (Trueman, 2019). Lazada's mobile app has an AI-powered image search function that allows users to take pictures of items they want and Lazada will suggest similar items available (Vernon, 2018).

Northern-based firms have also teamed up with global South companies to introduce new technologies in global South economies. For instance, L'Oréal teamed up with China's multi-purpose messaging, social media, and mobile payment app WeChat to launch its 3D Augmented Reality make-up try-on facility. L'Oreal found that when the Augmented Reality feature was used on a website or app, customer engagement time doubled, and conversion rates tripled. In 2020, e-commerce accounted for 50 percent of L'Oreal's Chinese sales, compared to two percent in 2012 (Yining, 2020). L'Oreal is also using AI to diagnose such problems as hair loss, which an increasing number of women are suffering from in China and other countries (Faull, 2019).

3.7 AI AND INSURANCE

Insurance is another important sector being transformed by AI technologies. In 2017, Ant Group, the financial affiliate of Alibaba Group Holding, launched an AI-driven image-recognition system to process vehicle insurance claims. Ant Group's algorithm assessed damages in 12 different cases in six seconds. Human investigators take longer than six minutes to assess a claim (Liu, 2018).

Likewise, if Ping An insurance holder have a car accident, they can electronically send a photo of the damaged cars to the insurer. Ping An uses AI-backed solutions to review the damage and suggest compensation. The policyholder is required to provide a 360-degree video of the car and submit it through the app. AI then evaluates the damage based on a database consisting of more than 50,000 cars and 60 million parts. The AI system responds with a repair estimate in 168 seconds on average (AAN, 2019). If the customer accepts the estimate, funds are transferred immediately (Chandler, 2019). This is helping to prevent fraudulent claims (Yiu, 2019).

Similarly, in 2018, Kenya's Jubilee Insurance launched a chatbot JULIE (Jubilee Live Intelligent Expert) to help customers with insurance queries. Using the JubiCare app, customers can access policy data in real-time and geo-locate Jubilee Insurance medical providers (Ngunjiri, 2018). JULIE can be accessed through Facebook Messenger (businessdailyafrica.com, 2018).

3.8 AI AND FINANCE AND BANKING

AI has made it significantly easier to support financial inclusion, especially female financial empowerment. Pre-existing challenges related to financing access, such as commuting costs, minimum balance requirements and low-income flows, are easier to facilitate. Global South-based firms have successfully incorporated AI in financial services, which are appealing to consumers and have increased the performance and efficiency of such services. A notable FinTech initiative slowly gaining traction in Southern countries allows households that lack access to electric grids to use mobile money accounts to finance pay-as-you-go solar-powered energy. With more than 600 million people living without access to electricity, sub-Saharan Africa is an ideal region to benefit from such an opportunity, which can also improve agribusiness efficiency through utilization of solar-powered monitoring and mechanization devices. Examples of such services include M-KOPA in Kenya and Fenix in Benin, Nigeria, Uganda, and Zambia that both offer digital financing plans for solar units.

Chinese FinTech companies, such as Ant Group, have learned how to collect and analyze financial-related data effectively as well as use Big Data to detect fraud (Zoo, 2019). Ant Group's payment platform, Alipay, offers AI-based customer service that handles two to three million queries per day. As of 2018, the system completed five rounds of queries in one second (Lingqing, 2018). Ant Group's chatbot system outperformed human agents in delivering customer satisfaction (Knight, 2017). Ant Group uses deep-learning technology to detect fraud (Perez and Soo, 2017); thus, the company's losses related to fraud are one in one million (Perez and Soo, 2017).

Another example is Nigeria's United Bank for Africa which launched a banking chatbot called LEO. LEO helps customers with a number of transactions, such as transferring money, paying bills, buying airtime, and checking account balances (mTransfersHQ, 2018). Customers can chat with LEO on WhatsApp, Facebook Messenger, Apple Business Chat and the chatbot and LEO responds immediately.

4. South-South Cooperation and Triangular Cooperation in the digital transformation of global South economies

Many of the digital innovations discussed in the previous sections originated in the global South and subsequently are used in other global South economies. This process is facilitated by South-South Cooperation through the exchange of resources, technology, and knowledge. SSC and Triangular Cooperation have played a key role in global South digitalization initiatives.

4.1 SOUTH-SOUTH COOPERATION AND CHINA'S BELT AND ROAD INITIATIVE

China has emerged as a major player in South-South Cooperation-related initiatives, especially its Belt and Road Initiative, which was mentioned in the previous chapter. The Belt and Road Initiative is emerging as a key force shaping many SSC arrangements by developing infrastructure and increasing investment in the global South. The BRI is viewed as one of the world's most ambitious infrastructure projects, promising over $1 trillion in infrastructure in more than 70 countries that account for two-thirds of the world's population (World Bank, 2018; Chatzky and McBride, 2020; Perlez and Huang, 2017).

Digital infrastructure projects carried out as a part of the BRI are among the most high-profile digital economy initiatives. Substantial progress has already been made with digital components of the BRI, specifically the Digital Silk Road (also known as the Information Silk Road). The Digital Silk Road is expected to enhance digital connectivity in other global South economies. Benefits to China include further expansion and internationalization of Chinese technology companies, access to large data pools and creation of China-centric digital infrastructures (Cheney, 2019). By August 2019, an estimated $79 billion had been invested around the world in Digital Silk Road projects (Deeks, 2018). Observers have noted that the Digital Silk Road has the potential to support and supplement, as well as compete with Germany's Industry 4.0 initiative[17] and cloud-based business models in which the United States-based companies are the dominant global players (Wijeratne, Rathbone and Wong, 2018).

The Digital Silk Road is stimulating the development of advanced ICT infrastructures, such as broadband networks, e-commerce hubs and smart cities in Belt and Road Initiative countries. For instance, at the fourth World Internet Conference held in Wuzhen, China, in 2017, many global South economies, including Egypt, Laos, Saudi Arabia, Serbia, Thailand, Turkey and the United Arab Emirates, agreed to work with China to build an interconnected Digital Silk Road by expanding broadband access, promoting digital transformation, and encouraging e-commerce cooperation (Viney et al., 2017). Chinese technology companies, such as Huawei and ZTE, are key players in this initiative. These companies are able to deliver high-quality fiber optic cables (among the fastest forms of broadband) and other technologies at much lower costs than their European and United States counterparts (Kadi, 2019).

A large number of projects have been carried out in upgrading internet connections by installing new undersea cables serving dozens of global South countries that lacked or had low quality broadband infrastructure. As of 2019, Huawei Marine, a joint venture between Huawei Technologies and the UK-based submarine communications company Global Marine Systems Limited, completed over a dozen undersea cable projects in Southeast Asia and about 20 more were under construction (beltandroad.new, 2019). In October 2016, Huawei and PT.LEN Telekomunikasi Indonesia signed an agreement to design and construct a broadband network as a part of the Palapa Ring project in Indonesia. The project was sponsored by the Indonesian government to increase broadband penetration in the country's remote areas (Qiu, 2016). A key project undertaken under the Belt and Road Initiative was the 13,000-kilometre Pakistan-East African Cable, connecting Pakistan to Kenya via Djibouti. The project was built by Huawei Marine in 2017. Its northern expansion will connect Egypt and the southern expansion will connect South Africa with other parts of the world (Hao, 2019; Huawei Marine, 2017).

Countries involved in the Belt and Road Initiative have agreed to strengthen cooperation in *advanced cellular networks*, such as 4G LTE and 5G (Desheng, 2019). Mexico is working with Huawei to build out its telecom system. In 2017, Mexico awarded Huawei a contract to supply equipment for the country's Red Compartida, a national 4G-LTE network launched in March 2018 to deliver the latest technology (Wedell, 2019; Love, 2019). Red Compartida's goal is to lower prices and advance its 5G readiness, covering up to 92.2 percent of the country's population by 2024 (Yucatan Times, 2020). In April 2019, Cambodia's mobile telecommunications company, Smart Axiata, announced a partnership with Huawei to develop its 5G networks. Likewise, the Philippines' Globe Telecom has partnered with Huawei to develop its 5G solutions (Thu, 2019).

In some cases, these technologies are providing catch-up opportunities in the digital development of global South economies. To take an example, in 2012, less than one percent of Myanmar's population had broadband access. The country's Ministry of Transport and Communications is working with Huawei to launch 5G broadband services by 2025 (Hao, 2019b). In August 2019, Myanmar's telecom operator, Mytel,

17 Through the Industry 4.0 initiative, German manufacturing and technology companies expect to gain significant influence over global manufacturing, production equipment and information technology systems (Earls, 2015). For instance, by ensuring interoperability with other systems, German companies, such as Robert Bosch, hope to shape the future of new technologies and products used worldwide.

tested 5G service using Huawei's technology. Mytel reported that Huawei's 5G New Radio technology provided increased capacity, lower latency, and faster speeds (Myint, 2019). According to the International Telecommunication Union, Myanmar's mobile broadband subscription was 49.8 million in 2018, or about 91 percent of the country's population.

Chinese firms have launched diverse digitalization projects in Africa, where most of the Belt and Road Initiative countries are located,[18] in areas such as cloud data centers, satellite launches, smart cities and 5G connectivity solutions. The Chinese government and African countries have provided financial assistance, technology, and equipment to develop ICT infrastructures on the continent.

For instance, China's space agency gave $6 million to help Ethiopia launch its first satellite (Roussi, 2019), which took place in December 2019. Ethiopia plans to use the satellite to monitor crops and weather-related phenomena (Adegoke, 2019). In April 2019, Kenya received $666 million in loans at low interest rates from China. A large proportion of the funding was earmarked to build a data center in the Konza Technology City (Mohammed, 2019). Likewise, in early 2018, Huawei and Algeria's customs agency signed a contract to build a data center (aps.dz, 2018). The Huawei cloud data center opened in Egypt in February 2019 and was its first in Africa. Huawei is also a dominant handset seller in Egypt (phys.org, 2019).

African nations have shown an interest in the transfer of Chinese technologies (e.g., new *connectivity technologies*) and know-how (e.g., workshops to provide training to African workers) under the Belt and Road Initiative (straitstimes.com, 2018; El Kadi, 2019). Such collaborations are taking place in Tunisia, where Chinese technology companies are participating in the 'Digital Tunisia 2020' national strategy. Huawei has trained over 1,000 ICT professionals in Tunisia (huawei.com, 2019).

China-Africa cooperation has also emerged in advanced technology projects, such as those involving AI. An AI project that has attracted much attention and publicity is the work that a Chinese company called CloudWalk is conducting with the Zimbabwean government. The project involves developing a facial recognition programme that improves the ability of AI algorithms to detect faces with dark complexions (Roussi, 2019).

4.2 FOREIGN DIRECT INVESTMENT AND SOUTH-SOUTH COOPERATION

Another key mechanism for technology transfer in South-South Cooperation is Foreign Direct Investment (FDI). China's outbound FDI as a proportion of the global total increased from about 4 percent in 2007 to 17 percent in 2016. One of the key goals for China's outbound FDI is to facilitate technology transfers (McCaffrey, 2017). As of 2017, over 10,000 Chinese firms operated in Africa, one-third of which had introduced a new technology (Jayaram et al., 2017). According to the United Nations Economic Commission for Latin America and the Caribbean, China invested $90 billion in the Latin America and Caribbean region between 2005 and 2016 (Guzman, 2019). In 2017, China's FDI in Latin America was $25 billion (Wedell, 2019). A main investment emphasis of Chinese firms has been in the telecommunications sector (Guzman, 2019).

A number of high-profile FDI deals have occurred in ICT sectors. For instance, during 2015-2017, Tencent, China Investment Corporation and *Didi Chuxing* Technology invested in Southeast Asia's leading ride-hailing service, Grab (Hao, 2019a). In 2018, Didi also acquired 99, a Brazilian competitor to Uber, for $1 billion (Woetze et al., 2019). Likewise, between 2015 and 2017, Alibaba Group invested more than $620 million in India's e-commerce players, such as Snapdeal, Big Basket, Ticket New and One 97 (Hao, 2019a). In 2015, China's Baidu bought control of the Brazilian online-discount company Peixe Urbano (Parra-Bernal, 2014), which as of 2017 had more than 28 million registered users and worked with over 70,000 companies (Portada, 2017).

18 As of May 2019, the Belt and Road Initiative had been endorsed by 39 African countries and the African Union Commission (Roussi, 2019).

4.3 SOUTH-SOUTH COOPERATION INVOLVING OTHER GLOBAL SOUTH COUNTRIES

While much of the discussion so far has focused on China, firms from other countries have also facilitated South-South Cooperation. In this section, other representative examples are provided of SSC involving governments and the private sector from other global South economies that have brought digital transformation or have the potential to do so.

THE AFRICAN CONTINENTAL FREE TRADE AGREEMENT

As the first example, the 55-member African Continental Free Trade Agreement (AfCFTA), which officially went into force on 30 May 2019, is likely to play a key role in facilitating digitalization and promoting Africa's economic development. The goal of AfCFTA is to create a single African market for goods and services and to promote freer movement of capital and people (Hartzenberg, 2019). As of 9 February 2020, 28 of the 55 African Union member states had ratified and deposited the ratification of AfCFTA with the African Union (tvcnews.tv, 2020). Trading activities under AfCFTA started on 1 January 2021 (Baker McKenzie, 2021). African, as well as foreign, investors stand to benefit from the agreement as it is likely to facilitate business expansion in the region. China is positioned to be one of the main beneficiaries of AfCFTA, as China-Africa trade had already reached about $150 billion in 2017 (Shao, 2019).

Several benefits are expected to accrue to the African business community from AfCFTA. The private sector will benefit from higher economies of scale related to access to bigger markets and larger production units. Firms can gain easier access to cheaper raw materials and intermediate inputs. One of the key objectives of AfCFTA has been to promote research and technological advancement to improve the continent's economic and social development. In the context of today's fast-paced technological developments across the continent, improvements in dynamic information infrastructure can significantly support much-needed socio-economic growth. As a result, AfCFTA can play a critical role in emphasizing development in digital policy frameworks among African countries to facilitate cross-country and regional trade and to overcome challenges of weak digital infrastructures. AfCFTA is thus likely to stimulate the utilization of technology and knowledge and accelerate digitalization (International Trade Centre, 2018).

RXALL'S AI-BASED HANDHELD DEVICE TO FIGHT FAKE DRUGS (NIGERIA)

The Nigerian start-up RxAll developed an AI-based handheld device to fight fake drugs, which according to the World Health Organization is a $200 billion industry (Christensen, 2018). The devise assesses a drug's compounds by connecting to a cloud-based database.

The database contains information related to what the drug should contain, and the information is sent back to an app on the phone. The database is updated using AI. The product has been used in Myanmar and the company plans to enter other developing countries, such as Cambodia, Ghana, and Kenya (Lock, 2019).

FLUTTERWAVE'S DIGITAL PAYMENT PROCESSING (NIGERIA)

Another example of a Nigerian firm providing digital solutions in other global South countries is the payment processor Flutterwave. Flutterwave's application programming interface integrates different payment systems and methods and makes it easy to process payments for banks and merchants in Africa (Jackson, 2019b). As of August 2019, the payment platform had processed over 100 million transactions valued at over $3 billion. As of December 2019, it served over 60,000 merchants in six African countries and the United Kingdom (Onaleye, 2019), supported over 150 currencies and facilitated payment services from over 68 gateways, such as MasterCard, Visa, PayPal and AliPay (Olowogboyega, 2019). Its clients include Uber, Wakanow and Arik Air (Techcabal, 2019). Flutterwave plans to enter additional African economies, such as Cameroon, Egypt, Ethiopia, and Morocco, as well as Asian economies, such as China and India (Kene-Okafor, 2019).

ARTIFICIAL INTELLIGENCE RECRUITMENT ASSISTANT'S HUMAN RESOURCE MANAGEMENT SOLUTION (CHILE)

Digital solutions have been used to improve human resource management-related activities in global South economies. The Chilean company Artificial Intelligence Recruitment Assistant publishes vacancy announcements on recruitment websites. Its AI system reads, and ranks resumes, uses psychometric tests and conducts video interviews with applicants. An applicant's performance is measured with indicators related to emotion analytics, incorporating and grading factors such as attention levels and facial expressions. After all these processes are completed, human recruiters conduct in-depth interviews with the highest-ranked candidates (Ovanessoff and Plastino, 2017). As of June 2018, it was being used by 30 Chilean companies and in Mexico and Peru (Fajardo, 2018).

SUPAHANDS' DIGITAL TRANSFORMATION OF THE WORKPLACE (MALAYSIA)

The Malaysian outsourcing company Supahands has a Digital Innovation Assistant for Knowledge Engineering called DIANE. DIANE is a predictive routing system to match agents and projects based on timing and relevance (Moe, 2018). The projects undertaken by Supahands are mainly in the area of data labelling or date annotation to train artificial intelligence programmes. The company's number of employees (known as SupaAgents) increased from more than 200 in early 2017 to about 3,000 in mid-2019 (Pradhan, 2019) and more than 5,000 in November 2019. The company has SupaAgents in Indonesia, Malaysia, and the Philippines (Pradhan, 2019). SupaAgents handle over one million units of data each month. The company collects and aggregates data related to skills, availability, and past performance of each SupaAgent and then DIANE utilizes the information to pair a project with the most appropriate team of SupaAgents. Projects are broken down into small units of micro tasks. The tasks are divided between humans and machine so that multiple people and machines can work on a project to improve speed, efficiency, and accuracy. They can also be aggregated into larger projects which require multiple workers and machines. The goal is to ensure that SupaAgents complete the project at high levels of accuracy and that the right sets of skills are assigned to each project (Moe, 2018).

SOLINFTEC'S AI ASSISTANT ALICE (BRAZIL)

Brazil has emerged as a global power in agricultural technology. According to the study "Radar Agtechs Brasil 2019," the country had 1,125 agricultural technology companies (Azevedo, 2019).

The Brazilian start-up Solinftec uses an AI assistant ALICE to integrate and process data from machines, people, climate stations and other sources to improve agriculture outcomes (nanalyze.com, 2019). To use ALICE, farmers embed smart black boxes in their machinery and deploy IoT devices in fields. ALICE calculates farmers' needs and provides real-time recommendations (CropLife, 2019). Initially, the technology was developed for the sugarcane industry, but since has been used as a digital solution for other crops. As of August 2019, Solinftec was being used on more than 6.5 million hectares, had monitored 20,000 pieces of equipment, and managed 100,000 active daily users (nanalyze.com, 2019). Solinftec has opened North American offices in West Lafayette, Indiana (Indianapolis Business Journal, 2019) and is expanding to other South American countries, as well as Russia and Ukraine (Leclerc, 2019).

5. Triangular Cooperation in digital technologies

Triangular Cooperation in digital technologies is a recently evolved paradigm. Donor countries and multilateral organizations have facilitated South-South initiatives on the digital front through various forms of support, such as funding, training, and technological systems. As an example, the Chinese e-commerce and payments company Alibaba Group teamed up with UNCTAD to launch the eFounders programme to train over 100 African entrepreneurs. Twenty-nine entrepreneurs from 11 African countries participated at the Alibaba campus in Hangzhou, China, for the third eFounders Fellowship cohort in July 2019 (newbusinessethiopia.com, 2018). The training programme focuses on teaching participants key aspects of e-commerce and digital innovations to prepare entrepreneurs for the challenges of launching and sustaining e-commerce ventures (alibaba.com, 2019).

In 2018, Alibaba Group also announced a $10 million investment plan in Africa over the next 10 years (Zoo, 2018). The focus of the investment programme is digital solutions that address technological and human resources-related challenges facing the continent (Nganga, 2018). Some of the digital *solutions planned* included those related to internet technology, e-commerce and artificial intelligence (Jackson, 2017).

Ant Group has collaborated with UNECA and the International Financial Corporation (IFC) to promote financial inclusion in Africa using digital technologies (Ababa, 2018). Promoting financial inclusion is important because, according to the World Bank's Global Findex database, about 1.7 billion adults were unbanked in 2017, meaning they lacked an account with a formal financial institution or a mobile money provider. Chinese FinTech companies, such as Ant Group, have been successful in promoting financial inclusion in their home country and can replicate that success in other global South economies, such as those in Africa. The solutions developed by Chinese FinTech companies, such as credit scores based on social media behaviors, are likely to be attractive to Africa (Kshetri, 2020a).

A lack of formal identity documents is among the main reasons why many people in global South economies lack access to financial services (Kshetri, 2020b). According to the World Bank's ID4D database, one billion people lack any form of identification. An additional 3.4 billion people have some type of identification but lack the ability to use it in the digital world (White et al., 2019). One of the key focus areas of TrC among Ant Group, UNECA and IFC has been digital IDs (Ababa, 2018).

Information sharing initiatives have also evolved to become an integral part of TrC. In April 2018, UNDP and the Chinese Academy of Governance organized a workshop, 'China's South-South Assistance to Disaster Recovery Efforts,' under the Belt and Road Initiative. A main goal of the workshop was to share China's expertise and technology in disaster recovery with global South economies (undp.org, 2018).

As a final example of TrC, in 2003, a team of programmers in Kenya created the Magpi software company which is a leading provider of configurable, cloud-based mobile data collections and data visualization tools. Magpi has thousands of users in over 170 *countries, including many in the global South*. The software allows organizations to improve the effectiveness of their mobile workforce and field operations. In the beginning of their journey, the team received grants from the World Bank, the United Nation Foundation and the Vodafone Foundation (Kshetri, 2016b). Today, the software is being used by multilateral organizations, such as the World Health Organization and the International Federation of the Red Cross.

6. Opportunities and challenges for digital transformation of global South economies

Digital transformation initiatives present a range of opportunities and challenges. This section discusses both the favorable circumstances that increase the chances of success, as well as the obstacles faced, for digital transformation initiatives in global South economies.

6.1 OPPORTUNITIES

From the above discussion a number of opportunities exist to bring digital economic transformations in the global South. Some of the primary ones are examined below.

IMPROVED CONNECTIVITY

Many encouraging developments are being achieved in digital connectivity, both in terms of quantity and quality. According to the International Data Corporation, feature phones accounted for 60 percent of phones sold in Africa in 2017 (Ekwealor, 2019). According to the trade body GSM Association (GSMA), only around a third of mobile users in sub-Saharan Africa (250 million people) had a smartphone in 2018 (Radcliffe, 2018). The GSMA has predicted that mobile broadband connections in sub-Saharan Africa economies will increase to 87 percent of total connections in 2025, compared to 38 percent in 2018. 3G is expected to account for 60 percent of all mobile connections in the region by 2025. The GSMA's study also estimated that about 300 million new subscribers will access the mobile internet and there will be 690 million active smartphones by 2025 (Radcliffe, 2018).

LOCAL TECHNOLOGY HUBS CREATE DIGITAL INNOVATIONS

Local technology hubs are rapidly evolving in many global South economies. As of October 2019, Africa had 643 tech hubs in places such as Cairo, Cape Town, Dakar, Lagos and Nairobi, which provide a foundation for digital transformation. Of these, 24 percent were innovation hubs (Shapshak, 2019). As of August 2019, Brazil had 134 AI start-ups (racxn.com, 2019). Innovation hubs in the global South are developing digital solutions for local problems. For instance, Lagos's Co-Creation Hub organizes a quarterly two-day event called Tech-In Series at which software developers and designers create new solutions to address economic development challenges facing Nigerians.

Digital innovations created by global South-based technology companies have high degrees of adaptability to local circumstances. Apps for feature phones which can be used to access the internet and perform other functions, such as storing and playing music, but lack the advanced functionalities smartphones offer are illustrative of this phenomenon. The availability of such apps has stimulated the digitalization of sectors such as farming and agriculture, which are vital for the livelihood and well-being of large proportions of populations in many global South economies. About 400 different digital agtech solutions, such as iCow, are being used in Africa. Most of them were designed for feature phones (Majid, 2019). The importance of this issue becomes significant when considering the fact that smallholder farmers play a key role in the agricultural sector of many global South economies. For instance, 80 percent of Africa's food is produced by smallholders (Majid, 2019). Many of these farmers often are not able to afford smartphones.

An encouraging trend is that several high-profile digital innovations have been created in global South economies, such as those in sub-Saharan Africa economies (Kshetri, 2016b). As noted above, Kenya's Safaricom and the local organization Green Dreams teamed up to develop the iCow system. Some other digital innovations that originated in sub-Saharan Africa economies include M-Pesa which allows users to send and receive money using cell phones, the social enterprise Kilimo Salama's completely automatized micro-insurance programme for smallholder farmers which mainly relies on solar-powered weather stations and cellphones, and Magpi which uses *cloud and mobile phones for collecting and analyzing data (Kshetri, 2016b).*

NATIONAL CAPACITY BUILDING

Many global South economies have launched national capacity building efforts and initiatives in ICT. They are taking measures to increase R&D investments and build relevant skills in major ICT sectors. For instance, China's R&D expenditure as a proportion of GDP increased from 1.3 percent in 2005 to 2.1 percent in 2016 (UNESCO Institute for Statistics, 2019). Specifically, China's R&D performance has greatly improved in the latest technologies, such as AI and blockchain.

Universities and research institutions have established programmes to focus on AI and other emerging technologies. South Africa's Center for Artificial Intelligence Research (CAIR) operates a research network with five universities. Kenya's Strathmore University has established the @iLabAfrica Research Center to promote research in AI and other emerging technologies. The University of Lagos's AI Hub in Nigeria focuses on deep learning and other AI areas (Snow, 2019). Most big universities in China have launched AI programmes (The Economist, 2017). In many African economies, educational institutions have started programmes to train data scientists (Maritz, 2019). For instance, South Africa's plan is to train one million people in data science and related skills, such as digital content production, 3D printing, cybersecurity, drone piloting, software development and Cloud Computing (It-online.co.za, 2019). Most of Ethiopia's more than 30 state-recognized universities and 130 polytechnics emphasize technology. In 2012, Ethiopia's Ministry of Science and Technology established its own university and invested $250 million to create a technology park (Galbraith, 2015).

Several initiatives have also been launched at the international level. An early example is the African Capacity Building Foundation established in 1991 to facilitate capacity development for overall development in Africa. Headquartered in Harare, Zimbabwe, the Foundation works with governments and the private sector in 45 African countries to enhance research, human and institutional capacity and develop policy initiatives (Nnadozie, 2016). The Foundation forms strategic partnerships with member country governments and international agencies and mobilizes resources. The Foundation has asked African governments, the African Union Commission and other organizations, such as UNECA, NEPAD and AfDB, for support to conduct a skills audit to identify skills gaps in African economies (Ankomah, 2020). Such an audit could be used for setting priorities in the development of manpower to promote digital transformations and other strategic initiatives.

As a more recent example, in March 2021, the African Development Bank approved a grant to develop AI-based multi-lingual chatbot systems to process customer complaints on behalf of the national banks of Ghana and Rwanda and the Competition and Consumer Protection Commission of Zambia. The systems will record customer complaints and track their resolution. The plan is to use audio complaints for consumers that are unable to read and write. The solution will be deployed in the following languages: Kinyarwanda, Kiswahili, French and English in Rwanda; English and Chewa (also called Nyanja) in Zambia; and English and Twi in Ghana (Ivudria, 2021).

Global South economies are accelerating the process of establishing new strategies, policies and practices for the utilization of modern ICTs. Over 40 countries and territories have developed strategies and action programmes related to 4IR. Many of them have also formulated and implemented national digital transformation strategies (Thai News Service, 2019). For instance, Botswana's vision is to "transform from a resource-based to a knowledge-based economy through digitization and embracing the 4IR" (Preuss, 2019). Kenya's Ministry of Information and Communications Technology released a Digital Economy Blueprint in 2019 (ict.go.ke, 2019), which identified five pillars in the digital economy: digital government, digital business, infrastructure, innovation-driven entrepreneurship and digital skills and values.

New regulations are being enacted to benefit from the 4IR. In 2016, the government of Rwanda approved regulations on drones, which made commercial drone delivery services for medical supplies possible (Toor, 2016). In that same year, the United States start-up Zipline partnered with the Rwandan government to develop commercial drone delivery services for medical supplies, such as red blood cells, platelets and plasma, to hospitals in remote areas (Baker, 2017). By September 2019, more than 13,000 deliveries of blood products had been made, providing access to life-saving treatments (Coulibaly, 2019). In September 2019, the South African Civil Aviation Authority (SACAA) established regulations related to crop spraying drones. Drones can spray in lands with challenging terrain that traditional aircraft cannot reach. Drones can get closer to the crops (1-3 metres above them) and can be programmed to follow mapped routes via GPS (Business Insider, 2019).

NORTHERN-BASED MULTINATIONAL ENTERPRISES CREATE DIGITAL INNOVATIONS IN GLOBAL SOUTH ECONOMIES

Northern-based multinational enterprises have intensified their activities to create digital innovations in global South economies. Google has opened an AI Research Lab in Accra, Ghana. Focus areas include fairness in Machine Learning (i.e., understanding and addressing discriminatory practices that are based on gender, race, religion, physical ability and sexual orientation and other sensitive characteristics), interpretability of Machine Learning models and AI use in medical diagnosis and treatment (Kennedy, 2019). A Google Launchpad Africa accelerator in Lagos, Nigeria, helped more than 60 start-ups by early 2019. Similar hubs are located in Ghana, Kenya and South Africa (Kennedy, 2019). In September 2019, Google announced the establishment of Google Research, an AI lab, in Bangalore, India. The lab will focus on areas such as healthcare, agriculture and education (Yagnik, 2019). Google Assistant is available in nine Indian languages (thenewsminute.com, 2019).

In early 2019, IBM announced a plan to start an AI center in Brazil to create solutions for problems unique to the Brazilian economy, such as those related to natural resources, agribusiness and health (brazilmonitor.com, 2019). In the same vein, the AI firm SingularityNET opened an office in Ethiopia. The International Conference on Learning Representations, a major global deep learning AI conference, was scheduled to be held in Addis Ababa, Ethiopia, in 2020 (Snow, 2019), however, due to COVID19, it was held virtually.

MULTILATERAL AGENCY TECHNICAL ASSISTANCE AND CAPACITY BUILDING

Multilateral agency technical assistance and capacity building efforts have been key enabling factors in digital transformations of global South economies. For instance, the person-to-person micro-lending site Kiva (which over the past 15 years facilitated 1.6 million people to provide small loans totaling more than $1 billion to more than two million needy entrepreneurs in global South economies) worked with the United Nations Capital Development Fund (UNCDF) and UNDP to develop a blockchain-based ID system in Sierra Leone (Kshetri, 2019). As a part of these initiatives, in August 2019, the government of Sierra Leone launched a blockchain-based National Digital Identity Platform (Inveen, 2019).

In some cases, technical assistance and capacity building efforts of multilateral agencies are directed at facilitating access to key data and information. The FAO developed a new open-access database called Water Productivity Through Open Access of Remotely Senses Derived Data Portal (WaPOR). It is the main data source for the PlantVillage Nuru app, discussed earlier (WaPOR, 2018). The WaPOR database uses NASA's satellite-derived data and computes relevant metrics for crop productivity. Other databases incorporated in PlantVillage Nuru include weather forecast data, a soil dataset for Africa and the FAO Crop Calendar, which is a series of algorithms on adaptive measures that can be taken under certain conditions (Penn State, 2019). By integrating diverse data, the AI assistant can provide information about crop drought tolerance and suitability of crops in different areas (IANS, 2019).

6.2 CHALLENGES

Researchers have identified several barriers and challenges those Southern economies encounter in their digitalization initiatives. First, only certain geographical areas and social groups are connected to the internet, making the economic and social impacts of digital connectivity uneven (Friedericie, Ojanpera and Graham, 2017). According to the International Telecommunication Union (ITU), Least Developed Countries had a cellphone penetration of 72.4 percent and an internet penetration of 19.5 percent in 2018 (ITU, 2019). Only 15 percent of Sierra Leone's population has internet access. This situation has resulted in a lack of participation of a significant proportion of the workforce in Africa, and many other global South economies, in the global economy and has hindered the continent's industrialization progress (Gonçalves, Oliveira and Cruz-Jesus, 2018).

Second, 4IR technologies may lead to labour displacement, wage stagnation and deepening inequalities between the privileged and the disadvantaged (Mehta, 2019). The inequalities and discriminatory social norms that force disadvantaged groups to work in low-paid, poor-quality jobs may be further magnified by the 4IR if measures are not put in place to prevent its continuation (Cliff, 2018). These technologies have challenged the conventional wisdom on the path of development. In the past, low-cost jobs, such as those in apparel and assembly lines, provided the path to industrialization. These types of jobs are being replaced by robots and AI systems. Low-income countries are no longer able to take advantage of lower wages and labor-intensive exports. Thus, they may lack the foreign exchange needed to import infrastructure capital and to generate the domestic savings required to invest in human capital. While the 4IR creates new types of jobs with new skillsets, education systems in low-income countries are mostly unprepared. Without the development of basic digital skills in the workforce, global South economies cannot compete in global markets (Milano, 2019) and even the middle class may not enjoy the gains of the 4IR (Bughin et al., 2018). A survey conducted by the African Capacity Building Foundation revealed that the limited human and institutional capacities of African economies has posed serious obstacles to the implementation of national development goals, as well as the Sustainable Development Goals (Ankomah, 2020).

Third, private ownership and development in AI may mean that entrepreneurs, innovators and companies with access to such technologies may control who owns, uses and benefits from these technologies (Glaros, 2019). Technologies, such as AI and Big Data, may also pose new challenges and risks to users, for example in the case of smallholder farmers, it is possible that only certain farmers will have the connectivity and funding to benefit from such technologies.

Fourth, most global South economies have an extremely low intensity of R&D. For instance, Africa's share in the world's scientific research output is less than one percent (OECD, 2017). A major upshot of this is that global South economies have often been forced to rely on technology systems developed by their Northern counterparts, which tend to perform poorly in the global South. For instance, the algorithms used by North-based AI players find it difficult to work with Africa's unstructured and "unclean" data. In Africa, 2,000 languages are spoken daily (Russon, 2019), thus solutions developed in foreign languages have limited usability for a majority of the population. Likewise, facial recognition systems have lower performance levels for African faces than for Caucasian faces. Facial recognition software can identify the photo of a white man with 99 percent accuracy, but the error rates are as high as 35 percent for images of darker skinned women (Lohr, 2018). This is mainly because the training datasets in Machine Learning systems are from the West and tend to use white males for training (Sallstrom et al., 2019).

Finally, some global South economies do not have the regulations, national standards and policies required to facilitate digitalization and benefit from digital technologies. A study conducted in the context of global South economies revealed that barriers, such as a lack of proper legal frameworks and the failure to implement policy in this area, act as obstacles and hindrances to digitalization (Touray et al., 2013). Some specific barriers that have been reported are an absence of political will and excessive bureaucratic red tape (Touray et al., 2013). Another concern is missing, or inadequate regulations related to the protection of personal data. Also, ethical standards to apply AI have not been developed and adopted (TendersInfo, 2019).

It is worth noting that strict data privacy laws (e.g., the European Union's General Data Protection Regulation and regulations requiring direct control and scrutiny of inbound foreign investments and the Foreign Investment Risk and Review Act of the United States) may prevent global South-based firms from entering West-based initiatives. According to *UNCTAD*, as of April 2020, 98 percent of economies in Europe had data protection and privacy legislation compared to 52 percent in Africa and 43 percent in Least Developed Countries. A study by the United States-based data management company Veritas (2017) found that organizations in some Asian economies had the lowest General Data Protection Regulation readiness among the countries surveyed. By the same token, due to the absence of these constraints in the global South region, global South-based technology firms are likely to emerge as major players in other global South economies.

7. Conclusion and recommendations

This chapter presented compelling case studies and examples of successful digitalization programmes and practices from global South economies and discussed challenges that arise with digitalization initiatives in these economies. 4IR-related digital technologies, such as AI, Big Data, Cloud Computing, blockchain and the IoT, are rapidly developing and are bringing political, economic, and social transformation in global South economies. These technologies have the potential to create powerful impacts not only for big companies but also for disadvantaged groups in global South economies, such as smallholder farmers. An encouraging trend is that locally developed solutions have been driving forces behind digital economic transformations in global South economies.

Organizations in global South economies are making data-driven decisions, which have important consequences for economic and social well-being. For instance, digital technologies have increased farmer access to credits, inputs, and markets. *Chatbots have been useful in cases in which human agents are too expensive and take too long*. Digital technologies are also being used to discourage socially undesirable activities and encourage socially desirable ones. For instance, smart city technologies have several positive societal impacts, such as improving safety.

The degree of digital economic transformation varies widely across global South economies. Some global South economies, such as China, are already at the forefront of digital technologies, including AI and blockchain. While China is the clear leader among global South economies, other global South economies have also gained prominence in specific sectors. For instance, AI has gained popularity in the farming and agricultural sectors in Brazil, especially among large-scale agriculture firms in which AI has been widely used to improve the speed and accuracy of planting and crop management techniques. Thanks to solutions provided by innovative firms, such as Solinftec, 4IR technologies, like AI, are diffusing rapidly among smaller firms.

The above discussion also shows that some innovative firms from global South economies, such as those in Argentina, Indonesia and Kenya, are leading strategic initiatives to capitalize on big opportunities presented by the 4IR. For many other global South economies, much space and potential exist to further advance digitalization. Too many global South economies have failed to take advantage of these technologies to improve economic, social and environmental performance. These economies need to prepare for and embrace 4IR-related changes, which will be the key to their economic success.

South-South and Triangular Cooperation, as well as other collaborations, can help Southern economies prepare and adapt to the challenges brought on by the digital economy. Several areas of collaboration can be proposed. As noted above, due to their low research output, most Southern economies rely on technology systems developed by countries in the North. Such technologies often perform poorly in the global South. Southern economies can pool together research resources and teams to develop solutions based on latest technologies to tackle important challenges facing their economies. Multilateral

agencies and Northern economies also can help their Southern counterparts in such initiatives, paying particular attention to supporting local innovative solutions to local challenges.

A well-developed national digital technology strategy is crucial to benefit from the latest technological innovations. As mentioned, whereas some Southern economies, for instance Tunisia, have developed national digital strategies, most others lack such instruments. Southern economies that lack such strategies can refer to other successful strategies from the region as a model to domesticate and develop their own national digital strategies.

Lastly, many of the innovative digital solutions developed in Southern economies discussed above, such as Safaricom's Chatbot assistant ZURI, Jubilee Insurance's chatbot JULIE and United Bank for Africa's chatbot LEO, are being used only in their home countries. It is likely that these solutions without, or only with slight modifications, could be replicated in other Southern economies to address diverse challenges facing these economies. A main reason why these solutions have not been internationalized is the lack of internationalization of the companies that developed these solutions. Governments in the global South as well as the Southern and multilateral agencies can help these companies internationalize their solutions throughout the region.

Chapter 4

Agricultural productivity and food security using digital technologies

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1. Introduction[19]

The current health pandemic raises alarm bells for those Southern leaders whose countries are dependent on agriculture as their economic mainstay.[20] COVID 19 serves as an alert to developing countries that without due protection and safeguards, growth in the agricultural sector can become stunted. Thus, there is a need to promote new forms of buffers that can enable food systems to become more resilient to such exogenous shocks. Digital agriculture can be a tool to help improve buffers and resilience of the agricultural sector and is a mainstay for attaining the SDG 2 goals and sub-goals related to food security (FAO, 2019).

The world witnessed the "rise of the South" following the financial turmoil that hit developed countries in 2008-2009. More than 40 countries of the South, notably Brazil, China, India, Indonesia, Mexico, South Africa and Turkey, experienced remarkable growth (UNDP, 2013). Some smaller economies out of these 40 also followed the growth and development trajectory of the high growth countries, like Bangladesh, Chile, Ghana, Mauritius, Rwanda and Tunisia. By 2050, the global output share of Brazil, China and India will be 40 percent. Some of the critical drivers for this sustained growth momentum are: the presence of an active developmental state which has supported both the public and private sectors; vibrant global markets; South-South trade more than tripling as compared to North-North trade between 1980 and 2011; and social policy undertakings in the space of education, health care, social protection, law and institutions (UNDP, 2013). The agricultural sector also played a vital role in the transformation and economic growth of these global South countries.

Agricultural research, underpinned by the private sector, has been heavily invested in African, Asian and Latin American nations (UNDP, 2013). China houses the world's most extensive agricultural research and development system, and China has played a leading role in South-South cooperation in agriculture with African nations (UNDP, 2013). India proposed an Agriculture Research Platform among the BRICS countries (Brazil, Russia, India, China and South Africa) (Economic Times, 2017).[21] Brazil, where the use of technology in agriculture is advanced, accounted for 41 percent of total Latin American agricultural research spending in 2006. Agricultural efficiency per worker improved by four times due to the System for Agricultural Research and Innovation in Brazil (UNDP, 2013). Agricultural technologies helped transform the Brazilian savannah (the Cerrado) into one of the world's prominent grain and beef-producing regions. Technological innovations helped improve soil quality, allowed for growing new crop and grassland varieties and improved the productivity of farm animals (Periera et al., 2012). According to the Report on South-South Cooperation in Ibero-American countries, the leading collaborating nations are Argentina, Brazil, Chile and Mexico.

African agriculture is primarily subsistence-driven and poorly integrated with other sectors, such as manufacturing. Agricultural producers on the continent remain on the lower rungs of global value chains. Today, the continent imports one-third of its grain. According to recent figures by the African Development Bank, food imports have increased to a staggering $80 billion annually and are set to increase further

19 The CGIAR Big Data Platform 2019 was crucial to understanding real-life challenges for this chapter. The following source provides useful information: www.youtube.com/watch?v=__q00tTl1D0.

20 According to the World Atlas online, the top ten countries in terms of reliance on agriculture as a percentage of GDP are all in Africa: www.worldatlas.com/articles/countries-most-dependent-on-agriculture.html.

21 The Agriculture Research Platform was proposed by Shri Narendra Modi, Prime Minister of India: "We are quite strong and well equipped in the field of agriculture and we are also at the top position in many fields across the world. I would like to propose to establish BRICS Agriculture Research Centre which will be a gift to the entire world. In a similar way, we can work on creating a system wherein we can invest in augmenting production and infrastructure in agriculturally rich or land rich countries. We can send the extra production to less productive countries. This will be a significant next step" (Economic Times, 2017).

to $110 billion by 2025 (AfDB, 2020). This dependence will significantly increase Africa's vulnerability to fluctuating terms of trade and variations in the availability of imported foodstuffs. Africa is also battling climate change impacts, resulting in agricultural losses amounting to 2 to 7 percent of GDP. Given the importance of agriculture as a revenue earner and as the biggest employer in most African countries, the livelihoods of millions are at stake. Africa's population will rise to 2.5 billion by 2050, and for Africa to feed itself, agriculture must become a high-performing sector. This means the agriculture sector must utilize critical factors, such as energy and water, and become the basis for industrialization. It also means the industry must realize the potential from the wealth of raw materials available and, importantly, must take advantage of new technologies across the agricultural value chain.

African countries are working toward safeguarding their economies, and since many are agrarian based, they are largely reliant on predictable rainfall. Adverse impacts of climate change and increasing severe weather events are constraining national development agendas and progress and have implications for sustainable development as well as the achievement of Agenda 2030 and the African Union's Agenda 2063 goals. The region's ambition to industrialize will rely on its agricultural production base, especially on the ability to achieve food security to address the well-being of its population, as well as to create surplus for export. Despite structural problems, some mega-trends in digital technologies have been superimposed on existing problem areas in agriculture. Africa's management of these mega-trends will largely determine the region's ability to take advantage of its agricultural sector, which is largely seen as a gateway to capitalizing on green economy opportunities.

Digital innovations can overcome challenges and transform agri-food systems for food security achievement. Digital technologies sit at the core of the agribusiness value chain (*Figure 4).* Disruptive technologies, such as blockchain, the Internet of Things, artificial intelligence, 3-D printing, Virtual Reality, Augmented Reality, sensors and drones, are ushering in the Fourth Industrial Revolution in the agricultural sector as well as all others. The Internet of Things and Cloud Computing are pillars of support for Smart Farming. Smart Farming is the use of intelligent devices connected to the internet for managing farm systems. Big Data is all about high volume, velocity and variety (the 3Vs), and related technologies play a significant role in managing Smart Farms (Wolfert et al., 2018). Venture capitalists spend large sums on e-commerce and biotechnology. Almost 32 percent of that expenditure is on food e-commerce, nine percent is on soil and crop technology and four percent on drones, robotics and decision support technology (GSB, 2017). The proliferation of mobile technologies is aiding increasing digitization and development of digital platforms along all major agri-food value chains. To increase agricultural productivity and ensure food security in developing countries, digital technologies must be adopted and promoted along all value chains, including reaching predominantly smallholder farmers. Digital technologies hold the key for smallholders to maximize their small farms for livelihood improvement, economic growth and global goals.

The evolution of dynamic digital platforms for agriculture primarily rests on the new market for improved data and subsequent global policies. The United Nations has adopted significant initiatives to create global digital media, devise digital governance plans and be the nodal point for cooperation among nations, institutions and participants. An inter-agency mechanism established by UNOSSC coordinates the United Nations system-wide strategy formulation. Designated South-South focal points administer the flow of information, best practices, legal frameworks and funding channels across different agencies related to digital agriculture and Sustainable Development Goals. Triangular Cooperation permits traditional donors and outside partners to get involved in South-South initiatives as an alternate channel for financial and technical support (UNGA, 2018). For example, an IFAD grant involves three African nations, Ethiopia, Madagascar and the United Republic of Tanzania, with India as the technical partner. The Center for Indian Bamboo Resources and Technology (CIBART) aided the Madagascar Ministry of Environment, Ecology and Forests in formulating a national bamboo policy (IFAD, 2017).

This Chapter will draw on such examples in detail. It will explore existing public-private partnerships, recognize the challenges faced in South-South cooperation, identify the fundamental values and ethics for building trust among digital agriculture partners and discuss adoption strategies for enhanced collaboration.

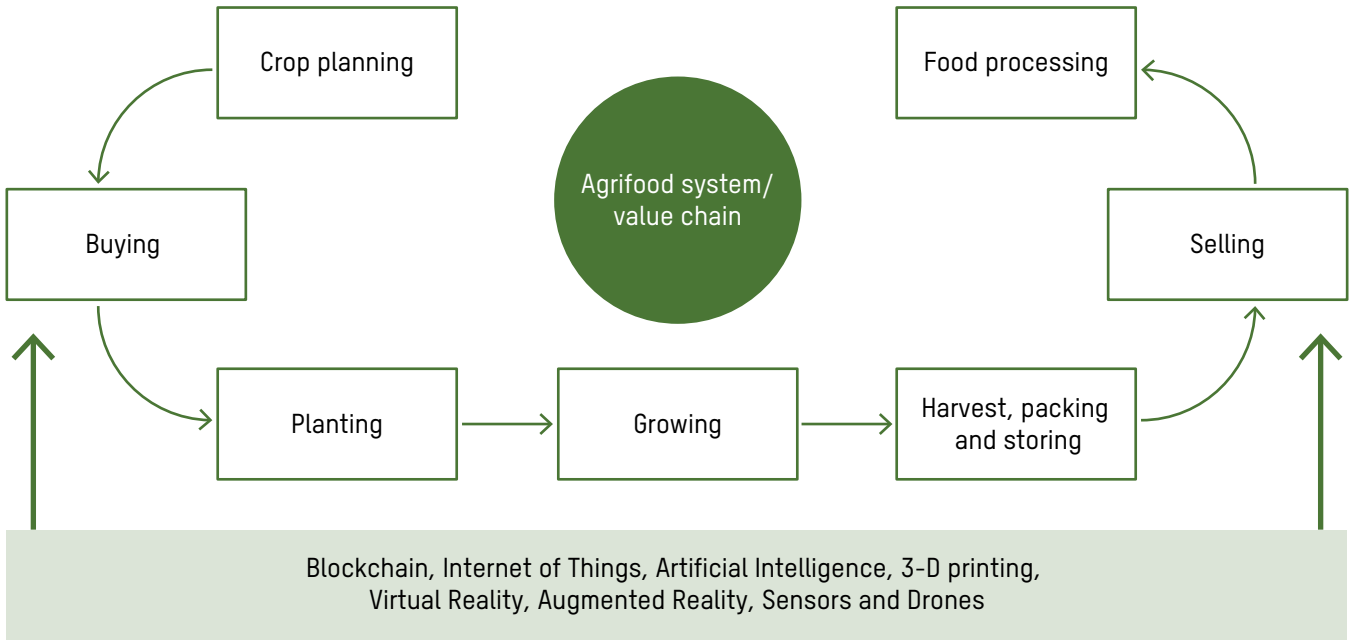
The Chapter is structured as follows: Section 2 provides a literature review of the intersection between agriculture productivity, food security and digital technologies; Section 3 comprises two parts — part one discusses the enablers of digital technologies, while part two gives examples of recent technologies in agri-food systems; Section 4 focuses on United Nations initiatives for creating global digital platforms, public-private partnerships and capacity building in the use and advent of digital technologies and challenges and future implications; and Section 5 explores regulatory and governance perspectives and the challenges facing the digital agriculture sector and how it can overcome them through various mechanisms. The final section is devoted to the conclusion and recommendations.

2. The intersection between agriculture productivity, food security and digital technologies

Agriculture has evolved through various developmental stages: early domestication and efficient farming systems; mechanization and fertilizer; the green revolution of crop genetics and fertilization practices; to the present age of technological revolution.

In the 4IR, digital innovations and disruptive technologies, like blockchain, the IoT, AI, 3-D printing, Virtual Reality, Augmented Reality, sensors and drones, are increasingly crucial for providing solutions to tackle the multiple challenges facing agriculture and the food security sector. For example, digital technologies are processing weather-related data and helping with crop planning, seed variety selection, fertilizer application and crop growth. Digital innovations are providing timely information flows that are necessary for harvesting, packing and storing.

Figure 4: Agrifood system/value chain



Source: Mittal, Gandhi and Tripathi (2010).

Raghu (an old farmer):
"Alexa, will it rain today? Should I go ahead and plant the seeds?"

Alexa:
"I predict a bumper harvest definitely for the next three years."

Through mobile technologies, IoT, sensors, AI, remote sensing, etc., a wide range of advisory services are now available. These technologies support agricultural productivity increases, reduce post-harvest losses, provide accurate market data linking farmers to buyers and serve as a transaction platform in a digital economy. A study by Deichmann et al. (2016) shows that improved market transparency resulted in better arbitrage opportunities, a lower rate of wastage, increased consumer and producer welfare and reduced variation of spatial prices. In rainfed dominant agricultural systems (e.g., sub-Saharan Africa), due to climate-induced erratic rainfall patterns, even smallholder farmers with significant knowledge of traditional weather systems increasingly realize the value of advisory services powered by digital technologies.

One such channel of obtaining information on different stages of the agricultural process is the use of mobile phones. Mobile phone adoption by rural farmers is on the rise. Mobile phones present farmers with opportunities to access information on farming technologies, extension services, market prices, weather and agricultural techniques. This trend is supported by a substantial rise in mobile phone subscribers by both rural and urban populations worldwide. More than 40 percent of the global population has internet access and significant initiatives connect more people in rural areas of the global South (World Bank, 2016).[22]

New technologies that enable farmers to connect with information and ag-related institutions are minimizing uncertainty and mitigating risk. Most of the promising innovations in agriculture and food security are technology- and service-based (Dinesh et al., 2017). Mobile network connections and apps designed to collect and share agricultural information are becoming increasingly accessible. With access to data, markets and financial services, farmers can plant, fertilize, harvest and sell products more effectively, with benefits for natural resources and household income and nutrition. Connectivity further enhances the functioning of markets by allowing farmers and herders to access timely and accurate price information, coordinate transport and other logistics and facilitate more direct exchange of perishable but nutritious foods, such as animal products and vegetables.

E-agriculture applications (like e-Cow in Kenya) are improving information sharing across agricultural and food value chains, resulting in improved productivity and service delivery. While some governments may have failed to provide adequate consultations with farmers, agricultural research and extension services have seen a revolution with the advent of digital technologies. Babu et al. (2012) provide a thorough analysis of farmers' needs, how they can improve their information search strategies and the willingness for smallholder farmers in the southern part of India to pay for services. Even though interpersonal contacts are essential, farmers preferred to use mobile phones as a communication channel, relying more on voice messages than SMS services. Aker (2011) found that small-scale farmers in Africa benefited from reduced time and increased savings due to ICT usage for extension services. With the use of advanced technology, agricultural extension officers who advise farmers on improving crop productivity can now reach out to more farmers than individual field visits.

In Uganda, Svensson and Yanagizawa (2008) showed how the dissemination of information by radio services on the prices of essential agricultural products led to an increase in the farm gate price for farmers. Beuermann et al. (2012) corroborate this finding for Peru, Aker (2016) for Niger and Labonne and Chase (2009) for the Philippines. The French Consultancy firm Capgemini, in collaboration with the East African social enterprise Agrics, conceptualized Project FARM (Financial and Agricultural Recommendation Models) for rendering AI-based farming solutions, through which Kenyan farmers receive SMS alerts on appropriate steps to adopt on their farms (Wight 2019). Maize production of farmers in Western Kenya rose from six to nine bags per farmer.

22 Internet penetration in Asia and Africa is 54.2 and 39.6 percent respectively, with the global average being 58.8 percent. Source: www.internetworldstats.com/stats.htm (accessed 7 January 2020).

A recent study by Samberg (2018) found that in Egypt, Ethiopia and Sudan, local extension services deliver real-time weather-related data to vegetable farmers through text messaging. In West Africa, private companies, such as Ignitia, are promoting the accuracy and precision of text messaging weather alerts to remote farmers. In Mongolia, rural herders receive information about disease outbreaks to help them maintain the health of their livestock. Mittal and Mehar (2012) note that Indian farmers are using mobile phones to obtain agricultural information and better connect to markets to fetch a better price for their produce and experience positive yields. At the all-India level, farmers used mobile phones for farming purposes (41 percent) and achieved better access to markets (87.2 percent), better farm gate prices (the market price less the selling cost) (71.7 percent) and positive yields (35 percent) (Mittal and Mehar, 2012). This study also found that large-sized farm holders fared the best to access markets and realize favorable prices through mobile phone access. Akter and Fu (2012) documented the positive impact of the project Knowledge Help Extension Technology Initiative (KHETI), which provided mobile phone-based agriculture extension services to smallholder farmers in Madhya Pradesh State, India. Almost 75 percent of farmers benefitted from the mobile phone services. 86 percent found KHETI improved extension services and 13 percent found KHETI-based services were faster than those used earlier. As Babu et al. (2012) discussed, the willingness to pay for availing technology-based information is not relatively proportional to the need for information. In search of the highest amount of data, farmers were willing to pay the highest and the medium searchers the least.

An increasing dependency on mobile phones is arising among farmers in remote areas to transport their produce (Site and Salucci, 2006; van Rensburg, 2004). For example, the Zambian National Farmers Union, Moroccan farmers and a Kenyan-based agri-business company, M-Farm Ltd, use SMS-based services to share prices and special transportation offers and to reduce post-harvest losses (Deichmann et al. 2016). TATA Consultancy Services, based in Mumbai, India, has developed an app named mKrishi to assist farmers. This mobile agro-advisory system is available in local languages and includes a voice messaging system which has helped illiterate farmers greatly. The app allows farmers to connect with stakeholders, better negotiate prices and spend less on fertilizer and pesticides. Farmers subscribe to mKrishi platform cooperatives, called Progressive Rural Integrated Digital Enterprise or PRIDE. The platform registered more than one million users in 2017, 40 percent of users reported an increase in yield and another 10 percent had a reduction in pesticide and fertilizer usage (TCS, 2021).

The mobile-based application DigiCow connects small-scale livestock owners in Kenya with veterinary and artificial insemination services and feeds suppliers. Farmers register their cows, calves, customers, cooperatives, staff and farm help using the app and register, record, maintain and generate reports and obtain training (Farmingtech, 2020). IFDAP trained around 48 female cassava root growers in the Uvira region of the Democratic Republic of the Congo to access the internet to learn more about pests destroying their crops. IFDAP also provided the women farmers with mobile phones to contact potential buyers leading to lower transportation costs (APC, 2010).

Global organizations like the Grameen Foundation, Reuters Market Light and Technoserve are delivering timely and valuable information on the price of produce, market demand, weather details, etc., at a reduced cost to farmers in South Asia, Latin America and sub-Saharan Africa (Nakasone et al., 2014). Digital Green, a global agricultural development initiative, provides video-based agricultural advisory solutions to small-scale farmers in the most cost-effective way possible. Videos available online (Video Kheti) provide step-by-step guidance for illiterate farmers to sow and harvest seeds of different vegetables and crops. Validation exercises are ongoing to estimate the difference in yield estimation based on satellite imagery techniques and personal verification.

Many other new ventures have sprung up, improving agricultural productivity using digital technologies. Precision agriculture reduces greenhouse gas emissions (Future Farming, 2019; Soto et al., 2019) by providing personalized solutions specific to each farm and farmer. Hello Tractor provides remote asset tracking and virtual monitoring services to tractor owners and connects them with farmers in remote locations of Africa, mainly in Nigeria. It has helped farmers sow seeds 40 times the existing speed and reduced costs by 33 percent (Foote, 2018). Plantix uses AI-based images to warn farmers of plant diseases. Planet Lab captures daily photos of the Earth's surface to provide farmers with information for adopting

protective measures against crop stress-related issues. This satellite imaging company computes a vitality index based on the satellite images of vegetation cover, which helps to detect field-level anomalies.

However, the mere existence of digital technologies and innovations will not eliminate the challenges of agriculture productivity and food security. For example, an intelligent tractor commissioned by Reliance Jio (based in India) and Microsoft and Escorts (based in India) can talk to farmers and provide necessary guidance (Gadgets Now Bureau, 2018). But the challenge is to broaden access to such tools and ensure they meet the needs of as many farmers and other stakeholders as possible along the value chain (Samberg, 2018). For this to be successful digital technologies should consider differences among farmers in resources, gender and education levels and be responsive to changing circumstances.

Nigeria's pioneer digital agriculture platform Farm-crowdy connects farm sponsors with farmers to augment food production and promote youth participation in digital agriculture. In Nigeria, Kitovu, a web and mobile-based application system, connects warehouses storing fertilizer and seedlings with smallholder farmers in remote locations. Kitovu helps meet the input requirements of farmers using geographic location and information on soil conditions. In Kenya, Apollo Agriculture uses a combination of agronomic machine learning, remote sensing and mobile technology to provide customized inputs, credit and solutions to farmers. AMIntegrated Aerial provides a precise spread of agrochemicals for environmental protection across Africa. Pula is a data-driven agricultural insurance company for small-scale farmers across six African countries. Syecomp analyses data collected by drones to help mitigate crop disease in Ghana and other parts of sub-Saharan Africa (Balachandran, 2018).

In India, one of the largest producers of fruits and vegetables globally, perishable produce value chains are a lucrative business venture. CroFarm in India is a Farm to Business venture connecting farmers with retail chains, like Reliance Retail, Grofers, Big Basket, Jubilant Foodworks, Big Bazar and Metro Foods. CroFarm helps reduce agricultural wastage by providing digitized agri-supply chain solutions, increasing the profits of both farmers and local retailers. Intello Labs, based in Bengaluru, uses a computer vision algorithm to examine the finest details on every plant for grading agricultural produce. Tessol, based in Mumbai, provides a heat exchange unit solution for charging refrigerator trucks in six hours for a full day's operation. Companies use the fuel-free technology across poultry, horticulture, dairy, seafood and frozen food sectors, like Godrej Tyson, Fortis, Mother Dairy, Abad Fisheries and Fortis Hospitals (Modgil, 2017).

Meicai, based in Beijing, China, provides efficient supply chain management and improved food safety control by providing fresh fruits and vegetables to small- and medium-sized chain restaurants. Dfs168.com is a Chinese e-commerce platform that helps lower procurement costs for farmers by delivering fertilizers and pesticides without the interference of intermediaries. Maifei Technology, based in Chaoyang, helps gather aerial farming data using McVision AgriDetector and hyperspectral cameras and provides controlled spraying solutions for crop protection. Shanghai firm Gfresh is a global platform for seafood traders in China. The company provides logistics, customs clearance and inspection services to almost 400 sellers and 450 buyers, with a turnover of $150 million. The P2P agri-loan platform KesuCorp, based in Hangzhou, helps loan seekers with financial solutions for digital agriculture-related activities.

In a South-South example, the Chinese government has significantly supported Chinese private companies to set up Agricultural Technology Demonstration Centres in Africa. These centres offer seeds for cultivating rice and other crops, technology transfer and training to grow all varieties of crops and rear livestock, such as cows and poultry (Tracxn Technologies, 2020).

3. Recent disruptive innovations and digitization in agriculture

Advances in applying digital technologies in multiple economic sectors, including agriculture, can be attributed to recent innovations in data capture and collection, data processing and analysis, data transfer, information systems and sharing platforms. Artificial intelligence (including robotics and machine learning), the IoT and digital platforms (including the web and mobile technology) are digital technologies that enable the development of services for improving agricultural productivity, food processing and marketing. Brief overviews of these technologies are provided in the sections below, followed by details on their application in various agri-food value chains in the global South.

The digital transformation of the agriculture and food sector requires establishing a 'digital agriculture ecosystem' that can create an enabling environment for innovation by farmers and agripreneurs. Such a transformation has the potential to deliver significant economic, social and environmental benefits.

Table 4 summarizes the main innovative technologies and the agricultural tasks they facilitate. These technologies will be discussed in more detail in the subsequent sections.

Table 4: Technology type and agricultural application

Technology type	Type of agricultural ask
Robots	→ Reduce labour costs and perform repetitive, monotonous tasks, like planting and weeding → Wine bots can prune vines, remove young shoots and monitor soil quality → Nursery bots can relocate potted plants → Herder bots can move cattle and mix feed → Rotary bots are used for milking machines and can let cows decide when to be milked → Soft robotic modular gripping system can pluck raspberries → Robots can harvest coconuts using a steady-state genetic algorithm and an extendable arm fitted with a saw → Personalize dairy farming to create more accuracy and profitability → Detect changes in cow's health
Drones and sensors	→ Produce aerial images to help farmers apply fertilizer and to make irrigation choices → Soil and field analysis, planting, crop spraying, monitoring, irrigation and assessment of crop health → Implementation of precision agriculture → Measure chlorophyll activity and vegetation health of pilot farms → Examine each stalk in a wheat field to detect the onset of fungal infections → Provide solutions based on data collected from the farm, farmer, machinery, climate stations and other Big Data sources
Machine Learning	→ Predict yield, detect diseases, weeds and crop quality, species recognition, livestock management, animal welfare, livestock production and soil and water management → Improve agricultural productivity across different pathways across the value chain → Detect cassava pests and diseases in African farms → Advise when to prepare land for cultivation, sow, treat and select seeds → Facilitate farmers to take and execute optimum decisions by providing geo-mapping, crop planning, individual farm plans and farm automation customized for each farmer based on weather, soil, pest and crop data on an almost real-time basis

Mixed Reality	→ Detect a spectrum of light that is not visible to the naked eye; smart glasses are used in livestock farming to identify pathogenic bacteria in the food chain → Aid in cultivation optimization by understanding the impact of fertilizer usage on crop production in a specific environment → Visualize the microclimate of greenhouses to determine the factors conducive for fungus growth
Internet of Things (IoT)	→ Provide real-time views of farms → Track growth of grapes for wineries → Trace movement of products from the field to the final consumers → Gauge the freshness of fruits in e-commerce deliveries → Long-term solution for collecting information on vegetable crops and environmental statistics using sensors on soil moisture, air humidity and temperature → Agricultural greenhouse monitoring system → Agricultural advisory call centre for providing value-added services → Online monitoring system based on Cloud Computing to facilitate data mining exercises → Precision farming
Blockchain technology	→ Improve the traceability of crops and deliver better outcomes → Help farmers know the status of their crops from planting to delivery through secure and real-time information → Allow farmers to provide proper documentation of their food supply chain, thereby meeting consumer expectations and ensuring food safety → Monitor food procurement and sales for understanding and implementation of these food chains → Prevent food poisoning → Identify defects in products along the value chain → Transparency and security along the entire process of production, transportation and distribution of food in the market → Provide certifications during the process, simplifying the task of stakeholders and making transactions more transparent, leading to overall better management

3.1 ENABLERS OF DIGITAL TECHNOLOGIES

3.1.1 ARTIFICIAL INTELLIGENCE

Artificial intelligence systems have three essential qualities: intentionality; intelligence; and adaptability (West, 2018). Four AI technologies, in particular, are being employed in the agricultural sector: (1) robots; (2) drones and sensors; (3) machine learning; and (4) augmented reality. Already widely used in the agricultural sector, the market for farm robots may rise from $1 billion to $16 billion by 2020 (Shaw, 2019). Robots reduce labour costs and perform repetitive, monotonous tasks, like planting and weeding. Robots function autonomously based on AI techniques or follow pre-set instructions. Wine bots can prune vines, remove young shoots and monitor soil quality; nursery bots can relocate potted plants; herder bots can move cattle and mix feed; and rotary bots are used as milking machines and can let cows decide when to be milked.

ROBOTICS

New generation soft robots use compressed air for more delicate tasks in fields in recent years. Soft robotics is cheaper to develop and can perform delicate tasks using programmed motor skills. Companies like Soft Robotics Inc. introduced soft elements into their robotic grippers. mGrip is one such soft robotic modular gripping system (DeMaitre, 2019). A challenge in this context was to help pluck raspberries. A tube-like structure moves up the bush, separates a raspberry from others, inflates the soft robotic sacks and tears off the soft stem of the connector between the plant and the raspberry (*Figure 5*). This process is similar to a human plucking a berry (Chin, 2018). Wibowo, Sulistijono and Risnumawan have developed a coconut harvesting robot that detects a coconut using a steady-state genetic algorithm and an extendable arm fitted with a saw. Farmers conducted initial experiments in large coconut farms in Indonesia (Wibowo et al., 2016).

Integrated robotic solutions are available for improving the productivity of the livestock sector. For example, the DeLaval VMS milking system, V300, personalizes dairy farming to create more accuracy and profitability. The milking system can detect changes in the cow's health, such as elevated temperatures, early-stage mastitis and ketosis and check urea content, which can help balance feed protein (DeLaval Inc., 2020). The system treats each farmer, farm, cow and teat individually, and thus productivity improves, more milk is extracted per labour, cows are healthier, and the milk produced is of the highest quality. Tetra Laval Group, the parent company, has initiated support for 30,000 smallholder farmers in Kenya to improve the quality and production of milk. DeLaval has entered the Chinese market to provide automatic milking solutions specific to their needs by collaborating with Chinese Universities, the government and other stakeholders. DeLaval renders sustainable solutions by being more energy-efficient, consuming less water and raising feed efficiency. DeLaval, Tetra Pak and China Agricultural University signed a deal in 2019 to continue to foster their commitment to a Sino-Swedish Dairy Cooperation programme (DeLaval, 2019a, b).

DRONES AND SENSORS

> **The drone makes work easier for farmers because it can operate over a wide range of land. Also, the children can stay at home with their families, do homework instead of being on the farm.**
> – George Madjitey, CEO of GEM Industrial Solutions, Accra, Ghana (Njagi 2019).

Unmanned aerial vehicles (UAVs), known as drones, can be considered flying robots. Drones collect essential environmental data for multiple applications in a wide variety of sectors, including agriculture, forestry, health, disaster risk reduction, water resource management, etc. For agricultural applications, UAVs enable remote observation and data collection from fields (crops and pasture) at a scale larger than can generally be physically observed by farmers. Sensors are mounted on UAVs to collect information in different spectrums of the electromagnetic spectrum. The data is used for soil and field analysis, planting, crop spraying, monitoring, irrigation and assessment of crop health (Sentera, Inc.). Syngenta and DuPont Pioneer developed drone technology that produces aerial images to help farmers apply fertilizer and make irrigation choices.

The Executive Council of the African Union, on 26 January 2018, noted the importance of drones for driving agricultural transformation in Africa (Choake, 2019). The African Union High-Level Panel on Emerging Technologies and NEPAD jointly published the report, "Drones on the horizon: Transforming Africa's Agriculture," which confirmed the importance of drones to implement precision agriculture on the continent. Drones for Agriculture (UAV4Ag), a community of the Technical Centre for Agricultural and Rural Cooperation (CTA), initiated a project called Eyes in the Sky (in full, Transforming Africa's Agriculture: Eyes in the Sky, Smart Techs on the Ground). Eyes in the Sky has facilitated African drone operators to build on existing stock, share costs and procure drones and software. Working sessions on using the Agisoft software involved the first phase of the project launched in Lusaka, Zambia. It significantly improved participant knowledge of drones.

Launched in Ghana, the second phase was in collaboration with Parrot, a drone manufacturing company. This phase successfully tested Parrot, Bluegrass and Disco-Pro AG drones and data captured using the drone's multispectral sensors. The last stage of the project involved analyzing the data for better decision-making, such as the Normalized Difference Vegetation Index that assisted in measuring chlorophyll activity and vegetation health. The knowledge base of all the participants improved due to active participation and intense discussion by all the different stakeholders.

Taranis, a precision agriculture company, works with farmers in Argentina, Brazil and Ukraine, using drones fitted with high-definition cameras that fly close enough to wheat fields to examine each stalk to detect the onset of any fungal infection (Stickles, 2019). Solinftec is a São Paulo, Brazil, based start-up providing precision agriculture solutions to farmers. A Solinftec product works along similar lines as that of Alexa. It provides solutions based on data collected from the farm, farmer, machinery, climate stations and other Big Data sources. Initially developed to cater to the needs of sugarcane farmers, it was later extended to meet the needs of soy, corn and cotton farmers (Solinftec, 2020).

MACHINE LEARNING AND AUGMENTED REALITY

Recent applications of machine learning techniques are for predicting yields, disease detection, weed detection, crop quality, species recognition, livestock management, animal welfare, livestock production and soil and water management. Using the technology can take different pathways across the value chain to improve agricultural productivity (Liakos et al., 2018).

Mixed reality is an understanding of the real environment by using Augmented Reality, Augmented Virtuality and Virtual Environment. For example, a computer can detect a spectrum of light that is not visible to the naked eye. It enables smart glasses usage in livestock farming (Caria et al., 2019) to identify pathogenic bacteria in the food chain. Augmented Reality can aid in cultivation optimization by understanding what impact fertilizer usage can have on crop production in a specific environment.

Neto and Cardoso (2013) provide an exciting application of Augmented Reality related to the ecosystem of greenhouses. It can gather information from humidity and temperature sensors to detect the conditions that allow the botrytis cinerea fungus to grow on tomato plants, thus warning farmers. The application used the Layar SDK augmented reality framework to visualize the microclimate of the greenhouse and determine the factors conducive to the growth of the fungus. The MIT Institute for Data, Systems, and Society provides digital solutions to improve productivity in hi-tech African farms. Advanced tools like predictive analytics, machine learning, reinforcement learning and data sharing markets help process farm data. The main objective is to share data among stakeholders like farmers, lenders, insurers and machine manufacturers (Murray, 2019).

The three data quality challenges that Africa and probably all countries in the global South are grappling with include availability, reliability and accuracy (King, 2019). Several Southern-based projects are tackling these challenges. The Consultative Group on International Agricultural Research (CGIAR) platform Global Agricultural Research Data Innovation and Acceleration Network (GARDIAN) aggregates data from fifteen global agricultural research centres in Africa. The research centres and African public, private and non-profit partners are well connected. The International Livestock Research Institute (ILRI) and Farm.ink use natural language processing to track animal health and livestock productivity. Based on the analysis of millions of farmers in East Africa, they provide advisory services. Farm.ink, is a Kenya-based start-up specializing in agritech digital solutions that tackle predatory attacks by the fall armyworm (Jackson, 2018). The International Food Policy Research Institute (IFPRI) conducted a pilot in India using images from wheat farms to devise insurance products. IFPRI rolled out a similar experiment in Ethiopia.

Penn State University developed the NURU app to collaborate between CGIAR and Google using open-source software for TensorFlow's object recognition. Many images collated and used machine learning techniques to detect cassava pests and diseases in African farms. This app used offline is handy for farmers in remote locations of Africa and other parts of the South (Voegele, 2018). Farm Beats, a Microsoft initiative utilizing the Internet of Things (IoT), is a data-driven farming technique for farmers to improve their yields and lower costs. Broadband connectivity using TV whitespace linked with IoT sensors provides real-time views of farms. Following a pilot

experiment in Nairobi, Kenya, the larger goal is to double yields by 2050 across African farms (Addo, 2019). Mobile-based digital platform DigiFarm launched by Safaricom in Kenya renders a whole range of services. Discounted e-vouchers for inputs, agricultural advice using a training manual, precise usage of seeds and fertilizers, mobile phones to procure agricultural inputs, M-Shwari mobile microloans for Safaricom customers, etc. (Roy and Heinz-Wilhelm, 2018).

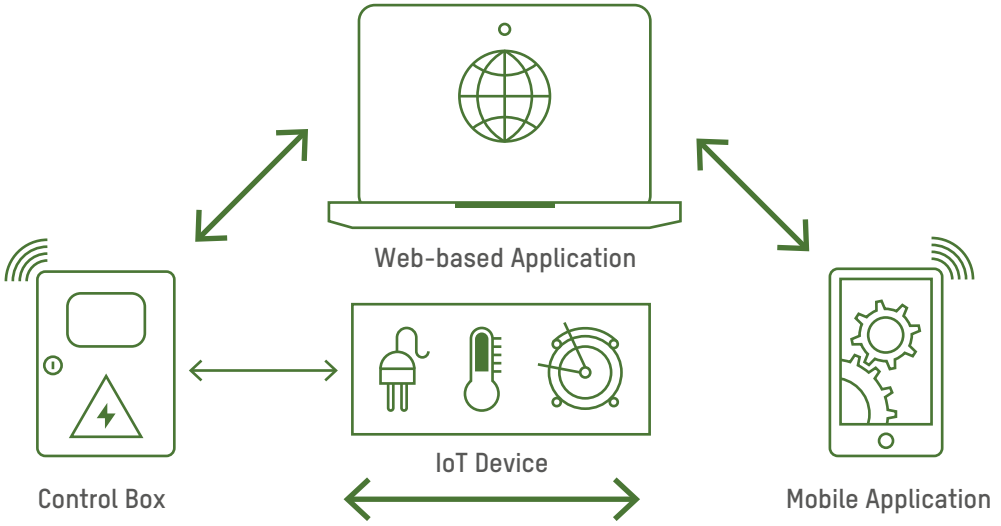
3.1.2 THE INTERNET OF THINGS

The Internet of Things (IoT) is central to the application of digital technologies in multiple sectors, including agriculture. An IoT platform integrates data from devices and objects with in-built sensors (for data collection). It performs analysis on such data (e.g., using machine learning algorithms) to deliver information or results to specific problems and needs. Increasing access to the internet in developing regions such as Africa provides compelling evidence of its use in problem-solving, not least in agriculture. Muangprathub et al. (2019), Khanna and Kaur (2019), Elijah et al. (2018) and Tzounis et al. (2017) provide comprehensive overviews of the application of IoT for agricultural data analysis in smart farms. Lalitha et al. (2018) provide a review of IoT implementation in the agriculture sector in developed and developing countries.

The Microsoft product FarmBeats has captured global South markets in Africa, China and India. Solar pumps drive this IoT solution used by thousands of small-scale farmers in Africa to detect the stock of freshwater reserves. The pumps are fitted with sensors to record energy usage and pump speed, which is then shared with the International Water Management Institute to compute the rate of extraction of groundwater and the reserves (Bhalla, 2019).

Muangprathub et al. (2019) lay out illustrative evidence of how IoT works in village systems. The experiment was to install IoT systems in three villages with different agricultural practices. Limes and home-grown vegetables were grown in the first, salad greens and home-grown vegetables in the second and salad greens, mushrooms, herbs and chickens in the third. *Figure 5* provides a graphical overview of the system components: hardware, web applications and mobile applications. On a real-time basis, the system switches the water sprinklers on and off automatically. For five months, the IoT collected data on yield analysis of limes and vegetables and helped understand the association between IoT information and agricultural produce. The IoT was a low-cost investment to the tune of $93.27 per field. Increased productivity was observed across mixed farms and the experiment helped farmers explore other employment opportunities.

Figure 5: Example of the Internet of Things



Source: Muangprathub et al. (2019).

Comprehensive studies are available that discuss the application of IoT in the agro-industrial production chain. For tracking the growth of grapes for wineries, Medela et al. (2013) proposed a system of combining IoT, wireless and sensor devices, simulating climatic conditions. A real-time monitoring service uses the IoTs for tracing the movement of products from the field to final consumers (Capello et al., 2016). The entire agricultural production process can be tracked using distributed IoT servers to implement, capture, standardize, manage, locate and query business data from existing agricultural production (Li et al., 2013). Transporting fruit is expensive as it is easily perishable, thus Ruan and Shi (2016) developed an IoT framework for gauging the freshness of fruit in e-commerce deliveries. Kaewmard and Saiyod (2014) proposed a long-term solution for collecting information on vegetable crops and environmental statistics using sensors to detect soil moisture, air humidity and temperature. An agricultural greenhouse monitoring system was conceptualized by Li et al. (2012) based on IoT, collating information on the internet, wireless and mobile networks. Sarangi et al. (2016) suggested an agricultural advisory call centre (2016) for providing value-added services based on IoT. Xian (2017) conceptualizes an online monitoring system based on Cloud Computing to facilitate data mining exercises based on IoT. EZ Farm, an IBM trial project in Nairobi, Kenya, uses IoT for precision farming. Sensors collect and store data in the IBM cloud storage and data is updated every minute. Water tanks, soil monitors and infrared light sensors monitor plant health regularly for raising yields and lowering costs (Kariuki, 2016).

IoT platforms deliver results and services to end-users through digital platforms and channels. Ample evidence in the context of Southern countries illustrates the beneficial impact of technology, such as IoT, on growth and welfare. *The Digitalisation of African Agriculture Report 2018-2019*, launched by the Technical Centre for Agriculture and Rural Cooperation (CTA), examines the impact of agricultural technologies on smallholder farmers in Africa (CTA, 2019). Almost 33 million smallholder farmers and pastoralists registered for Digitalization for Agriculture (D4Ag) solutions in 2019. The figure may rise to 200 million by 2030. Twenty-five percent of women and more than 71 percent of youth are expected to benefit from digital solutions. Of the 33 million farmers, 68 percent registered for advisory and information services, 17 percent for financial access, 8 percent for market linkages and 7 percent for supply chain management services. While 41 digital solutions were reported to be available in 2012, that number rose to 390 by 2019. Bundling of services (market linkages, financial access, advisory and information services and supply-chain management) can increase income by 57 percent and yields by 168 percent. Digital advisory services can also increase the revenue and productivity of smallholder farmers by 30 and 23 percent, digital market linkages by 37 and 73 percent and digital financial services by 18 and 38 percent, respectively.

Agricultural services delivered via smartphones have become an essential tool for farmers and are helping boost production, combat pests and get agricultural products to market, among other uses (World Bank, 2017; Mitchell, 2018; Ritchie and Roser, 2019). An estimation suggests there will be more than 700 million smartphone connections in Africa by 2020 — more than twice the number in North America (GSMA, 2017). In developing countries, smartphone adoption is expected to rise to 64 percent (GSMA, 2017), which will also widen access to the internet. Internet penetration in January 2018 (in percent) is around: North Africa (49), West Africa (39), East Africa (27), South Africa (51), Central Africa (12), Southern Asia (36) and South-East Asia (58). Though internet penetration is low in much of Central Africa, East Africa and Southern Asia, internet adoption is multiplying. With smart phone and internet adoption rates growing fast in Africa, inclusive agricultural technologies for growth and employment hold considerable promise (McDonald, 2018).

3.2 APPLICATION AND IMPACT OF DIGITAL TECHNOLOGIES ON AGRI-FOOD SYSTEMS

Using machine learning and Power BI, Microsoft Corporation and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) engaged with farmers in the southern Indian state of Andhra Pradesh to provide farm advisory services. AI-based sowing techniques advise when to prepare land for cultivation, sow, treat and select seeds and other actions, which has increased crop yields per hectare by 30 percent (Trendov et al., 2019). Tomatoes were detected using drones that captured red-green-blue (RGB) images in a study by Senthilnath et al. (2016).

EMA-I is an early warning app developed by FAO to facilitate quality and real-time livestock disease reporting. EMA-i is integrated with the FAO Global Animal Disease Information System (EMPRES-i) and is easily adaptable to existing livestock disease reporting systems in countries. EMA-i is in usage in six countries in Africa (Côte d'Ivoire, Ghana, Guinea, Lesotho, Tanzania and Zimbabwe). It supports surveillance and real-time reporting capacities and response to animal disease occurrence, with high impacts on food security and livelihoods. Image processing techniques help identify thrips in greenhouse strawberry farms (Ebrahimi et al., 2017). Drones using counter propagation (CP)-ANN and multispectral images help in weed detection (Pantazi et al., 2017). The DINO weeding robot allows vegetable farmers to manage crop weeding with a high level of precision while helping save time. DINO is highly effective in weeding vegetables grown in the field, both in raised vegetable beds and in rows, such as lettuce, carrots, onions, etc.

> **Our collaboration with Microsoft to create a Pest Risk Prediction API enables farmers to get predictive insights on the possibility of pest infestation. The app empowers them to plan, reducing crop loss due to pests and thereby helping them to double the farm income.**
> – Vikram Shroff, Executive Director, United Phosphorus Limited

Microsoft Corporation worked with United Phosphorus Limited, India's leading agrochemical producer, to develop a Pest Risk Prediction Application Programming Interface (API) to forecast pest attacks. The app classifies pest attacks into low, medium, and high based on weather conditions and the growth of crops in the field. Three thousand smallholder farmers in 50 villages across Telangana, Maharashtra and Madhya Pradesh received alerts for pest attacks on cotton crops (Microsoft News Center India, 2017). AgrixTech, a Cameroon-based start-up, provides technological solutions to farmers to detect plant diseases, physical and chemical treatment, and prevention measures. The facilities are available in local languages, like Fang, Pidgin and Wolof, as well as French and English, for its customers based in Benin, Cameroon, Morocco and Senegal. The start-up is timely given that farmers experimented with a mix of chemicals to reduce plant diseases, which could be deadly for humans and bad for the environment (Atabong, 2019).

Aerial images from satellites and drones, weather forecasts and soil sensors make it possible to manage crop growth in real-time. Automated systems provide early warnings of deviations from average growth and other factors using support vector machines (SVM), Deep Learning and Convolutional Neural Network techniques (Grinblat et al., 2016; Maione et al., 2016; Hu et al., 2017; Zhang et al., 2017).

CGIAR researchers, as part of a pilot project for the Platform for Big Data in Agriculture, using a climate model that predicated weather changes, were able to advise rice farmers in Colombia to delay the sowing of seeds due to climate variability. Indeed, it rained very heavily that year and would have destroyed saplings (Ramirez-Villegas et al., 2018). IBM combines AI with remote sensing data to improve farm crop yield. IBM pools data from multiple global satellites to provide agronomic advice on stress levels of crop health, water levels, pest attacks, etc. IB''s Big Data platform, the Physical Analytics Integrated Data Repository and Services (PAIRS-- Geoscope), is used to process 15-20 petabytes of collated agricultural data per day. IBM has invented a''Digital Twi'' of a farming field containing information on three layers of the field: under the soil, on the field and just above the ground. Such solutions are available for smartphones at the cost of approximately $50. Pilot experiments are ongoing in ASEAN countries, Brazil and India (Periera, 2019).

MyCrop is a collaborative platform that strives to combine cutting edge technology (Big Data, machine learning, smartphones, tablets, etc.), an innovative business model (agriculture platform as a service) and focused human efforts (agriculture insights, products and services) to serve smallholder farmers (Trendov et al., 2019). Jointly based in India and the Philippines, MyCrop facilitates smallholder farmers to execute optimum decisions by providing geo-mapping, crop planning, individual farm plans and farm automation customized for each farmer based on weather, soil, pest and crop data on an almost real-time basis.[23] MyCrop is a sustainable data-driven, scalable, intelligent, self-learning, real-time collaborative agri-food system. It provides farmers with management solutions, predictive analytics and monitoring tools, a decision support system and an agriculture e-commerce platform (buy and sales side) (Trendov et al., 2019).

> **Smartphone penetration is less than three percent in rural areas of South Asia, thus posing a challenge for promoting technology solutions. We faced this challenge and came with an innovative solution to reach more farmers by delivering our services to farmers in two modes. First, using a mobile application for farmers for those having smartphones. Second, through a village-level entrepreneur called Farmer Mitra, who acts as a community manager in the village we operate in, and he becomes the gatekeeper to deliver MyCrop to enrolled farmers.**
> – Deepak Pareek, CEO, MyCrop (Nair, 2018)

For the design and operation of irrigation systems and resource management for crop production, accurate estimations of evapotranspiration are essential. Data limitation is a big challenge when making exact evapotranspiration estimates for crop water management. For arid regions of India, extreme learning machine (ELM) models used temperature data from two weather stations to run models for weekly estimations of evapotranspiration (Patil et al., 2016). In Iran, machine learning techniques estimated the daily dew point temperature from two weather stations to estimate evapotranspiration and evaporation for weather forecasts (Mohammadi et al., 2015). UjuziKilimo, a Kenyan start-up, helps farmers adjust irrigation and determine the needs of individual plants by using Big Data and analytic capabilities; this is transforming farmers into a knowledge-based community and improving productivity through precision insights. This innovation, along with SunCulture, which sells drip irrigation kits that use solar energy to pump water from any source, has made irrigation affordable. Drip-irrigation systems raise crop yields by 300 percent and save water usage by almost 80 percent. The pay-as-you-go solar irrigation packages cost only $2 per day (Raval, 2016).

23 For more information: http://mycroptech.in/ (accessed 26 February 2020).

Accurate estimation of soil moisture is essential for predicting variations in crop yields. Usually, such measurement is time-consuming and expensive. Zenyus is a Nigerian precision farming start-up that measures and analyzes soil data, like temperature, nutrients, and vegetative health, to help farmers apply the right fertilizer and optimally irrigate their farms. The process reduces input waste by using analytics to facilitate data-driven farming practices for small-scale farmers, improving farm productivity. The Smart Farm technology developed is used by half a million farming units in Botswana, Ghana, Nigeria and Rwanda (Alawode and Reeve, 2019).

> **I was initially skeptical [of the Zenvus sensor] but later decided to try it. I got a significant crop yield and harvested so much. The good thing is that the device is so easy to use.**
> – Cyracus Obiah, a farmer from Imo State, Nigeria

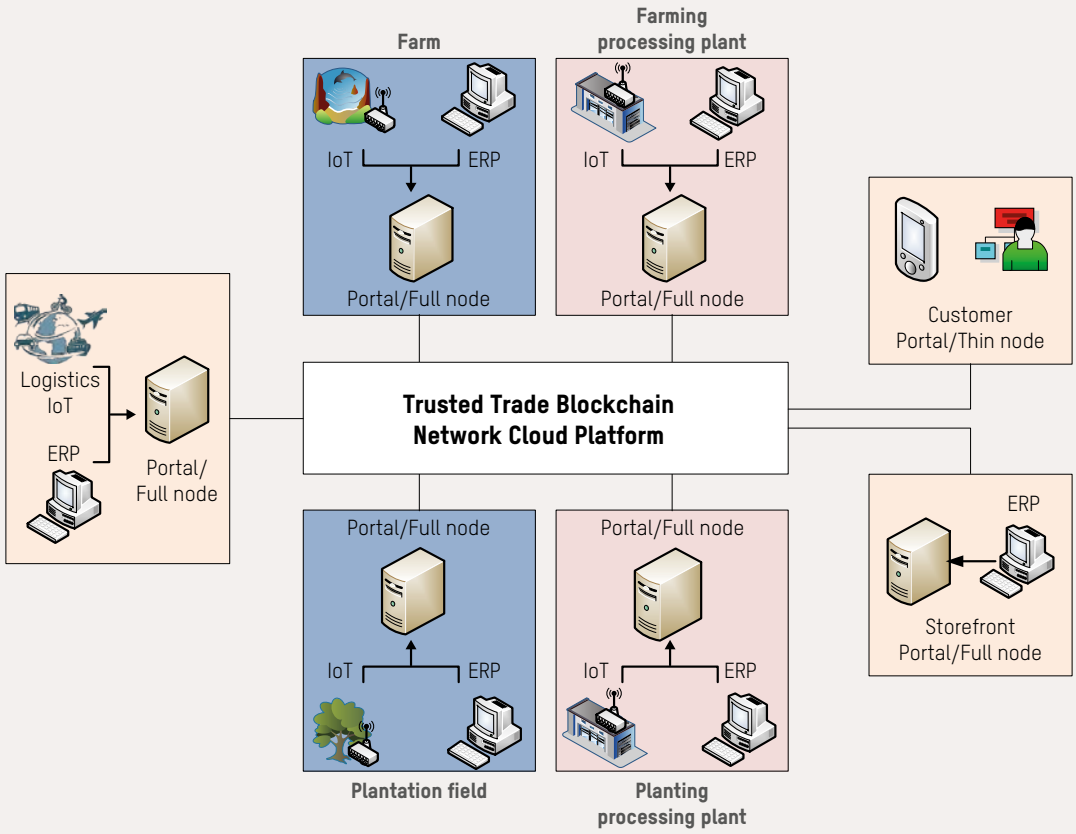
BLOCKCHAIN AND IMPLICATIONS FOR VALUE CHAIN DEVELOPMENT

Blockchain is a distributed ledger technology that allows all members to record transactions in a decentralized data log maintained on a computer network. Approval of transactions is usually through consensus and secured through cryptography. For agriculture applications, the electronic ledger provides information on how food moves through the supply chain. Information on the location where food is grown, processing, storage and transportation and the entity controlling distribution is collected. Recording of data with complete transparency and a third party maintains integrity and security. FAO and the International Telecommunication Union, in their 2019 report *E-agriculture in Action: Big Data for Agriculture*, provide a comprehensive overview of the application of blockchain technology in agriculture, challenges in adoption, best practices and possible future steps. The report is a timely one, with details on technical and application-based challenges, and is a valuable handbook for Southern countries.

The disconnect between suppliers and retailers is one of the biggest challenges of the digital agriculture sector. Blockchain can improve the traceability of crops and deliver better outcomes. Blockchain ledgers help farmers know the status of their produce from planting to delivery through secure and real-time information. With increasing consumer interest in organic foods, for example, blockchain allows farmers to provide proper documentation of their food supply chain, thereby meeting consumer expectations and ensuring food safety. Some significant factors holding back blockchain adoption are uncertain regulation, lack of trust, lack of coordination among stakeholders and blockchains working in silos (FAO and ITU, 2019).

Lin et al. (2018) provide a graphical illustration of a blockchain developed for a trustworthy food traceability system *(Figure 6)*. Farm companies, farming processing plants, plantation companies, planting processing plants, logistics companies, food retail storefronts and customers can use their smartphones to access information stored in the chain. Enterprise Resource Planning and new IoT-based systems facilitate the same.

Figure 6: Blockchain network cloud platform



Source: Lin et al. (2018).

Many companies and farmers are adopting blockchain solutions. Walmart uses blockchain technology to monitor food procurement and sales of Mexican mango farmers and Chinese pig producers to understand and implement these food chains (Kamath, 2018). Blockchain technology is instrumental in preventing food poisoning too. India's policy-making body, the National Institute of Transforming India (NITI Aayog) is collaborating with Gujarat Narmada Valley Fertilizers and Chemicals Limited to build a blockchain solution for doling out subsidies to fertilizer companies (FAO and ITU, 2019).

Kamilaris et al. (2019), Bermeo-Almeida et al. (2018), Tse et al. (2017) and Lin et al. (2017) provide a comprehensive overview of the application of blockchain techniques in agriculture. Tian (2016) traces the agri-food supply chain by detecting radiofrequency and blockchain technology. This process can help to identify defects in products along the value chain. Full transparency in the movement of agricultural produce across the supply chain is essential for the functioning of markets. Xie et al. (2017) develop a double-chain storage structure for tracking agricultural data, ensuring the safety of both the data and food. Tse et al. (2017) establish food safety across the supply chain system for China for ensuring transparency among the processors, brokers and consumers. Patil et al. (2017) create a framework for greenhouse farming, providing decentralization, anonymity and security. An intelligent system based on blockchain and IoT offers reliability and is faster, efficient and scalable. Agricultural supply chain systems developed using double chain architecture are proposed by Leng et al. (2018) for ensuring transparency, security, privacy, efficiency and overall credibility. Blockchain technology helps to collect agricultural and environmental data (Lin et al., 2017). The data gathered helps improve export competitiveness, as compliance with international standards requires transparency.

A supply chain based on blockchain and IoT techniques ensures grain quality. Members of the Grain Exporters Business Network, Brazil, shared data and reduced misunderstanding among business partners by removing asymmetry in information, leading to better governance of the overall system (Lucena et al., 2018). Carbone et al. (2018) provide IoT in supply chain management by constructing a decentralized hyper ledger platform. The

platform provides transparency and security throughout the production, transportation and distribution of food in the market. Papa (2017) suggests applying blockchain technology in agricultural trade by providing certifications during the process, simplifying stakeholder'' tasks and making transactions more transparent, leading to overall better management.

Bext360 provides a combination of mobile robots and blockchain technology for small-scale farmers in Africa. Bext360 helps bring complete transparency to the coffee supply chain by proper weighing, sorting, quality assessment and price discovery. Among its other initiatives in the agriculture supply chain, the Provenance project offers solutions to track yellowfin and skipjack tuna produced in Indonesia from the waterbed to the plate. The objective is to improve robustness in the certifications issued. This pilot project is a breakthrough for the Southeast Asian fishing industry, where 200 retailers who are part of the project supply markets in Japan, the United States and the United Kingdom (Provenance, 2016).

Blockchain technology can efficiently help the process of verifying a product's certification. Pipeline Foods uses blockchain technology to increase the supply of organic foods that can pay the grower well; it provides organic farmers the opportunity to capture comprehensive production data, sign on its accuracy and share the information with relevant certifying agencies. Ripe.io uses blockchain technology to track crops, yield higher quality crops and put trusted knowledge in the hands of farmers, distributors and consumers. Traceability can help growers deliver quality products to food processors and grain buyers. The presence of IBM Technologies in the blockchain market helps precision agriculture data move across the food supply chain. It connects producers, processors, distributors and retailers through a reliable and trustworthy network. A vegetation index computes the value to decipher whether the output will be low in volume or quality. Based on predicting the onset of crop diseases, the impact on farm yield can be estimated (Periera, 2019).

Blockchain helps farmers stay on top of asset exchange and enjoy real-time transactions and instant payments. A system can configure to spread out payments to farmers throughout the year instead of paying them seasonally. Bart Digital is a Sao Paulo, Brazil, start-up that uses blockchain technology for providing agricultural credit-related solutions to farmers. Participants using the digital platform can access information and online documentation, digital signatures, and document analysis (Bart Digital, 2021). Agrikore, based in Nigeria, was developed using blockchain technology for providing digital payment and customer relationship management solutions to farmers. Powered by Cellulant, Agrikore connects farmers, agro-dealers, input manufacturers, produce off-takers, bankers, commodity exchanges, warehouse receipt operators and logistic companies in one platform (Wangari, 2018).

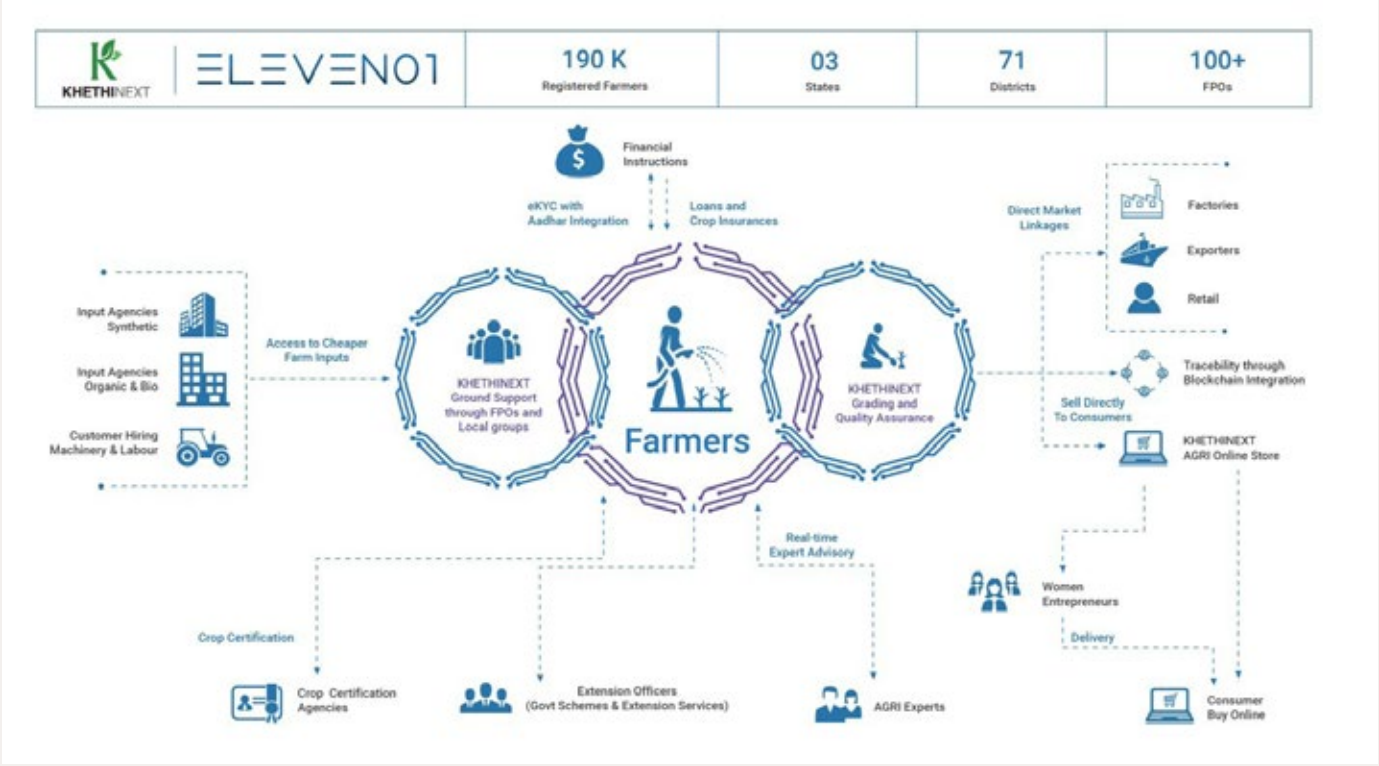
Implementing blockchain into logistics can simplify deliveries in the agricultural supply chain. With smart contracts, farmers are free from the long chains of intermediaries, unnecessary delays and can be confident that they will get paid for their product on time. WOWTRACE is a leading blockchain solution provider to Vietnamese mango, chocolate and organic vegetable producers. It helps overcome the obstacles in the agricultural supply chain, like food safety, transparency and trust between supply chain actors and consumers (WOWTRACE, 2019). IoT harnesses blockchain technology to monitor soil quality, irrigation and pests precisely and efficiently in terms of quality control. It can also leverage sensors to track the quality of stored crops.

Ghoorcom is the Middle East's pioneer in implementing blockchain for tracing fruit and vegetables from the field to the plate. Based in Jordan, the company has 200 farmers signed up for the programme. Normally, farmers pay high interest rates on microloans during the growing season and late payments become a problem. The Ghoorcom platform ensures that farmers pay on time. Ant Financial, based out of Hangzhou, China, works with Bayer Crop Science on a blockchain system for tracing agricultural products (Meyer, 2019). HARA, a blockchain start-up based out of Jakarta, Indonesia, collects and analyses farm data on soil and crop health, pest diseases, cultivation, land ownership and grains exchange. Sero.ai is a firm in Vietnam using AI for the agricultural sector. Sero.ai connects farmers with agriculture experts using mobile data connectivity and images are shared to detect plant diseases instantaneously (Misal, 2019).

ICRISAT, in collaboration with Eleven01, an Indian blockchain ledger, and KHETINEXT, a mobile-based agro advisory, is working on improving the productivity and income of smallholder agriculturalists (Kumar, 2019) (*Figure 7)*.

> **We will be focusing on providing a transparent and more reliable solution for issues such as funds, supply chain, post-harvest equity and land holding through the blockchain.**
> – Ausaf Ahmad, CEO of Eleven01 (Kumar, 2019).

Figure 7: Blockchain for Indian farmers



Source: Kumar, 2019.

GENDER DIGITAL DIVIDE

As discussed earlier, access to technologies, computers, mobile phones and ICT-related climate information services has important implications for the agricultural sector. However, a notable gender gap exists in access to technology. The usage of digital technologies by women in Southern countries is lower than that of men by almost 250 million (OECD, 2018). In Africa and Asia, the gender gap in internet usage is around 25 and 17 percent, respectively (OECD, 2018). The lower education levels of women in these regions put them in a heightened vulnerability category and is one of the primary reasons for the low uptake of digital skills among women. Giving women access to ICT and digital technologies and supporting equality creates more space for new business ventures. Ample studies support the importance of including gender dimensions in ICT policies (World Bank 2017; OECD 2018; USAID 2018; Yonazi et al., 2012).

Not only is there a digital gap, but women face a triple divide: digital, rural and gender. In Southern countries, women constitute a large agricultural labour force and are heavily involved in agricultural value chains. Agriculture is often women's sole source of income. Women make up 43 percent of the labour force in all Southern countries (20 percent in Latin America and almost 50 percent in East and Southeast Asia and sub-Saharan Africa) (FAO, 2018). An FAO study finds that investment in rural women improves food security for the entire household, thus increasing a nation's food security situation (FAO, 2018). FAO (2018) estimates that empowering women in agriculture could raise farm productivity by 20 to 30 percent and eliminate hunger for 100 to 150 million people.

ICT-enabled platforms across the agricultural value chain would be immensely useful to female agripreneurs, farmers and laborers. Some suggestions put forward by researchers for closing the digital gender gap in agribusiness are:

- cheap and easy access to ICT tools and services;
- a systematic application of ICT across the agricultural value chain; and
- skills acquisition by women and youth, as both suppliers and producers of ICT products for agribusiness.

FAO (2018), APC (2010) and Sey and Hafkin (2019) discuss in detail challenges faced by women farmers and entrepreneurs in accessing and using ICT services. Some of the many hurdles women have for accessing ICT services and mobile phones in the global South include lower earnings than men, making phones and ICT equipment unaffordable, and social constraints, such as males fearing access to phones might increase women's proximity to men outside the family.

In the Baray District of central Cambodia, Women for Prosperity, a partner of Oxfam in Cambodia, gave women pink mobile phones as part of a women's empowerment initiative. The idea was to keep men from using the phones doled out to women. The Gender, Agriculture and Rural Development in the Information Society (GenARDIS) is a resource programme supporting work on gender-related issues in ICT for sustainable digital agriculture in African, Caribbean and Pacific regions. GenARDIS has commissioned many initiatives promoting women's access to digital technology for managing their farmlands. Info-ladies are women knowledge bearers equipped with laptops, headphones and USB sticks who roam rural Bangladesh to give internet access and information to farmers, especially women. Launched by the local NGO Dnet, the Info-ladies project trains women on operating laptops, surfing the internet and other related services. Other Dnet grassroots interventions, like the Pallitathya Model, Oparajitar Ovijatra and Tara, have improved access to information for female participants.[24] The SB Mathur Foundation in Cameroon works with women producers in rural communities to provide increased mobile access, information files and other ICT tools for women for promoting sustainable agriculture. Women were able to access offline content on crop-specific farming techniques and revenue increased by almost three percent as compared to the previous year (APC, 2010).

Networking and access to information and markets are also challenges faced by women farmers. The Women of Uganda Network project provides a platform for shared best practices, problems faced, ideas and solutions provided by other women's organizations working in related fields. In collaboration with the M. S. Swaminathan Research Foundation based in Chennai, India, Digital Green trains women farmers to adopt best practices and use clean technology in rural areas of Maharashtra State in the western part of India. As radio remains one of the most used technologies for small-scale farmers in Malawi, Her Farm Radio by Farm Radio International, a Malawian NGO, works with 200,000 farmers in two districts of Malawi. It provides a platform for female farmers to raise their concerns on forest landscape restoration. The platform has reached out to two million female farmers in Burkina Faso, Ethiopia, Ghana, Malawi, Mali, Tanzania and Uganda (IUCN, 2018). Women use the internet to procure high quality seeds from other African countries, like Burundi and Rwanda, thus enlarging networks and the market base.

Programmes are also tackling education and technology training for women farmers to help them become part of the digital agriculture trend. Initiatives des Femmes pour le Développement, l'Auto Promotion et la Paix/Women's initiatives for development, self-promotion, and peace (IFDAP) trained women with low levels of literacy in the Uvira region on ICT skills. Earlier it was taboo for women to use ICT, but the project transformed people's opinions (GenARDIS). Women Advancing Agriculture is an initiative in Ghana that provides information to women farmers on their mobile phones on financial literacy, family planning, maternal health and agricultural planning. With only 29 percent of women residing in the northern rural regions of Ghana being literate, Women Advancing Agriculture is a timely intervention to uplift the welfare of female agricultural workers. They hold regular workshops to keep female farmers well-informed and around 180 women attended the same in May 2015 (Farmerline, 2015).

Solutions for access to finance for women farmers are important. Mobile financial services have been a great success among farmers and fishers in Kenya (FAO, 2018). Almost 70 percent of the adult Kenyan population receives services from Safaricom Ltd's M-Pesa. Women can save more with little interference by men and explore better business opportunities (Ndiaye, 2015). In a gender study of the fishing industry in Lake Victoria (White 2012), the authors witnessed significant positive changes in women's lives. Women were better able to save money to process fish and undertake expensive expenditures for their business. Around 81 percent of women became more independent. The payment mechanism has improved trust among community members (White 2012; Ndiaye 2015).

24 Source: https://dnet.org.bd/page/programs (accessed 22 January 2020).

4. Improve agricultural productivity through public-private partnerships, policies and South-South and Triangular Digital Cooperation

As noted in this chapter, digital technologies drive innovative research and development to solve complex problems in the agrifood value chain. Climate change impacts, pests and disease, postharvest losses, poor product quality, inadequate food safety and low-value addition are some of these problems (FAO, 2016). Countries in the global South can only achieve sustainable agricultural development and food security by improving their agricultural innovation systems and approaches to technology transfer and adoption. With limited government resources and expertise in most of these countries, especially in Africa, innovative public-private partnerships have emerged as a mechanism with the potential to modernize the agricultural sector so that sustainable development can be smallholder inclusive.

South-South and Triangular Cooperation digital technology initiatives can further boost this push toward modernization of the agricultural sector in the global South. Some of the significant challenges faced by Southern countries in this sector are insufficient knowledge of Southern adaptation technologies and actions, inadequate funding, limited access to financial resources, deficient legal and regulatory frameworks and reduced organizational and technical capacity.

> **We … recently embarked on an exciting new public-private partnership with John Deere and the Nigerian Federal Ministry of Agriculture and Rural Development to deploy 10,000 tractors over the next five years. The government will implement a pay-as-you-go model that allows tractors to be leased to new owners over a defined period before resold to them at a discount. Hello Tractor will serve as an implementation partner, providing tractor monitoring, security and valuation support.**
> – Jehiel Oliver, Founder of Hello Tractor (Foote, 2018)

IMPROVE AGRICULTURAL PRODUCTIVITY THROUGH PUBLIC-PRIVATE PARTNERSHIPS

Hartwich et al. (2007) describe public-private partnerships in agricultural research and innovation as a "collaborative mechanism in which actors in research fields and in the private sector share resources and risks and generate innovation for the development of the agricultural sector, including the livestock, forestry and fisheries sectors." Public-private partnerships for digital agriculture involve various stakeholders — government agencies, education institutions, upstream and downstream industries, non-governmental organizations, consultants and farmer organizations. These stakeholders all possess different skill sets, varying capacities, infrastructure and financial resources (Moreddu, 2016).

In an analysis of the potential demand for South-South and Triangular Cooperation on adapting technologies in the agriculture sector, 16 percent of the countries demand other farming systems, 22 percent require resilient crop varieties, 22 percent demand seasonal forecasts, 16 percent demand farmer-led sustainable agriculture and 24 percent water-saving irrigation (UNFCC, 2017). Of the initiatives on water, climate change and agriculture, UNFCC found 46 percent of the engagements focused on agriculture (UNFCC, 2017).

FAO (2016) provides a comprehensive overview of public-private partnerships for innovation and technology transfer in agriculture, using various case studies worldwide. The review differentiates four types of public-private partnerships designed to address specific national problems and related economic, social and environmental concerns. These are:

- public-private partnerships to develop and commercialize agricultural inputs, such as improved seeds and plant varieties for pest and disease resistance and climate change adaptation;

- → public-private partnerships for the development and commercialization of new small-scale, value-adding technologies for adoption by small and medium agribusiness enterprises;
- → public-private partnerships that demonstrate and stimulate demand for new technologies, including agricultural machinery and adoption of integrated and sustainable farming practices; and
- → public-private-producer partnerships (4P), which enhance the demand-driven nature of research for agro-industry development.

These categories all emphasize the critical advantage of public-private partnerships in complementing the relative strengths and weaknesses of the partners to reduce risks in developing or adopting new technologies along the agri-food value chain.

For example, public-private partnerships that focus on developing and commercializing improved agricultural inputs, such as seeds, usually include a public research institution, a private seed company and contract farmers (FAO, 2016). Typically, the public research institute provides the foundation seed or improved technology. The private seed company has the responsibility of multiplying and commercializing its distribution under an exclusive licensing agreement. At the same time, contract farmers produce the seeds under buy-back agreements with the private partner. Whereas none of these partners may have the capacity to perform all these roles, public-private partnerships make it possible, eventually resulting in the availability of improved and affordable seeds, increased productivity and income as well as employment opportunities. Public-private partnerships like this, or its variants, in Indonesia, Kenya, Pakistan, Thailand and Uganda have resulted in employment of 450 farmer groups (Indonesia), production of an additional $17 million tonnes of maize (Kenya) and production of over 90,000 kilograms of seed grains made available locally at affordable rates (Pakistan) (FAO, 2016).

Public-private partnership models work toward developing and commercializing new, small-scale, value-adding technologies for adoption by small- and medium-sized agro-enterprises (SMAEs). This type of model involves a national research institution that develops partnerships with the SMAEs to solve a specific technology constraint inhibiting agricultural productivity and limiting competitiveness in the agricultural sector. FAO (2016) presents a case study in Chile where new varieties of olive trees adapted to the climatic conditions of a marginal region grew while working with SMAEs to introduce small-scale olive oil processing technology in the region. This public-private partnership stimulated both the production and value-addition aspects of a new value chain for improved economic benefits to a marginalized region. Three companies initially adopted the processing technology, increasing to 47 companies (FAO, 2016). Additionally, the technical and commercial skills of farmers and entrepreneurs improved along with an increase in employment opportunities.

An interesting case of a 4P model took place in the sugarcane industry of Tanzania (FAO, 2016). A public-private partnership arrangement was made between the Sugarcane Research Institute of Tanzania (government) and sugar industries and the association of millers and growers (private) to obtain new, high yielding and improved varieties of sugar cane that could thrive in different cane growing areas. A goal was to help overcome difficulties with poor sugar cane husbandry, improper irrigation systems and weak pest management and control. Through the partnership, the government provided research infrastructure and logistical and manpower support (salaries) to enable the Sugarcane Research Institute to conduct research. The private partners provided research funds through a special arrangement in which a fixed amount, Tsh 1,000 (about 43 US cents), is deducted from the price of every tone of sugar produced. Through this arrangement, approximately $150,000 is available for research annually (FAO, 2016).

Strong institutions, good governance and robust policy regulatory frameworks are prerequisites for successfully designing and implementing public-private partnerships in promoting digital technologies, especially in developing regions like Africa. Weak human and institutional capacity, which persists in many southern countries, must be addressed through comprehensive capacity development efforts. These include improving the data and research infrastructure of national and civil service institutions, enhancing the scientific knowledge and capacity of public sector institutions and agri-tech entrepreneurs through knowledge platforms and training programmes to equip smallholders and increase participation in modern technologies. Syngenta, for example, launched a United Nations Soil Leadership Academy for the design and implementation of policies for sustainable soil management. In 2010, MasAgro provided advice on conservation agriculture to smallholder farmers in Mexico in partnership with Mexico's Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) and the International Maize and Wheat Improvement Center (CIMMYT) (Martínez-Cruz et al., 2019). A partnership between the International Rice Research Institute (IRRI) and Intertek developed genetic markers for rice breeding (IRRI, 2018). The partnership allowed for a broader outreach to other stakeholders, speeding up the development of new varieties of rice.

IMPROVE AGRICULTURAL PRODUCTIVITY THROUGH SOUND POLICIES AND REGULATORY FRAMEWORKS

Countries in the developing world must increasingly pursue sound policies and regulatory frameworks that create an enabling environment for the development, deployment and large-scale adoption of digital technologies in the agri-food industry. For example, policies that encourage innovation by providing incentives to agri-business start-ups like tax exemptions, access to land and tenure security, subsidized interest rates, marketing opportunities, etc., can accelerate food security targets (e.g., SDG 2). However, insufficient data availability in parts of the global South remains a significant challenge for designing practical policy solutions.

In the case of Africa, sound policies and favorable regulatory frameworks in the entrepreneurial space can be a powerful solution to the youth bulge and increasing unemployment on the continent. African governments must take advantage of the proliferation of mobile technologies and digital platforms by improving the rate of internet penetration and increasing the availability of open access data to design strategic policies and programmes to harness the youth dividend and develop innovative technologies along the agri-food value chain.

IMPROVE AGRICULTURAL PRODUCTIVITY THROUGH SOUTH-SOUTH AND TRIANGULAR COOPERATION

The process of sharing technology developed for use in the global South with other nations in the South is imperative and efforts for better South-South Cooperation among these countries is needed, along with intentional sharing of best practices. Many farms in the global South are smallholdings. Farms under two hectares produce about 30 to 34 percent of the food in this region and span across 24 percent of the gross agricultural area (Ricciardi et al., 2018). With an increase in farm size, crop diversity declines, and post-harvest losses rise.

Africa and India have similar farming systems (Khoury et al., 2016; Ricciardi et al., 2018) with considerable potential to tap into sharing the application of digital technologies (IRRI, 2014). China and Africa have signed many well-defined contracts to learn from each other's digitization experiences in agriculture (IFPRI, 2018, MMP, 2019). The aim is to support Africa to achieve food security by 2030. China's experience is essential to share with African smallholder farmers to boost farm productivity, which has been key to China's agricultural growth.

Key recommendations for South-South Cooperation related to agriculture include (IFPRI, 2018, MMP, 2019):

- → create an online knowledge house of technologies for climate change adaptation;
- → increase awareness of existing technologies for agriculture;
- → match existing and new sources of funding for sustaining South-South Cooperation and Triangular Cooperation partnerships in digital agriculture;
- → initiate mechanisms of the private sector and NGOs for digital cooperation and be sure they are supported by governments and international bodies.

SS&TrC is a crucial tool to achieve sustainable agriculture. The United States Agency for International Development (USAID) and the United Kingdom's Department for International Development Supporting Indian Trade and Investment for Africa[25] (DFID SITA) are some of the significant Northern-based organizations partnering with companies in the global South. CGIAR is committed to sharing learning experiences across partners from different countries over one platform. A recent workshop held at Montpellier, France, gathered participants from both the North and South to discuss improving the use of machine learning techniques in digital agriculture (CGIAR 2019). The Internet Governance Forum established in 2005 by the World Summit on the Information Society (Tunis Agenda for the Information Society 2005) is another platform for involving a variety of stakeholders in important digital discussions (United Nations, 2019a).

25 SITA is an initiative undertaken by the International Trade Centre in the five African countries of Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

5. Challenges and way forward

Global digital cooperation mechanisms are the need of the hour (United Nations, 2019a, 2019b), including in the agricultural sector. Local, regional and national cooperative mechanisms cannot alone address global needs. Digital technologies have their own set of challenges and risks (Jakku et al., 2018). Concern is growing about the accuracy of data collected and reliability and transferability options. Storing and handling large volumes of data is a very demanding exercise. Interoperability poses new threats and challenges given that profit-making strategies are in the public domain. Insufficient data availability in parts of the global South remains a significant challenge for designing practical policy solutions. Existing digital infrastructures have limitations and need constant updating. Acquisition of new skills at a fast rate and capacity building strengthening are also challenges.

Participants with a lesser voice and participation, like those from small and developing nations, local communities, small companies, women, youth, the elderly and disabled, need to be heard. Digital policy solutions filled with complex mechanisms are often not that effective. Considerable time and effort are required to make the voices of minor stakeholders heard. Different bodies are involved in managing various aspects of the digital world, from developing technology to managing data. Institutions may find it challenging to function in an integrated fashion for effective cooperation.

Instilling ethics can help resolve many of the complications arising with digital technology adoption and scaling up. A 2018 report by United Nations Global Pulse and the International Association of Privacy Professionals (IAPP), *Building Ethics into Privacy Frameworks for Big Data and AI*, identifies three pillars for building up an ethics framework: a) conceptualization of a workable approach adhering to a privacy and ethics framework; b) development of a data ethics leadership in the organization; and c) and adoption of tools for ethics impact or risk assessments for assessing different ethics approach.

In the agriculture sector, particular concerns exist related to the easy availability of private on-farm data. Another problem is giving drone access to smallholder farmers. Operating drones for non-recreational use requires special permission from the Ministry of Civil Aviation in every country. Relevant laws are needed so that smallholder farmers can implement drone operations solely or in groups at a reasonable cost.

Poorly trained human capacity is a significant hindrance to adopting digital technologies in agriculture, as expressed by 49 percent of the D4Ag enterprises in Africa. Digital literacy is also a significant bottleneck, according to 28 percent of the enterprises (CTA, 2019). Bardhan and Mookherjee (2011) note that farmers must have information on recent technologies, believe in their usefulness and use them efficiently. Technologies that function in foreign languages add to difficulties in adoption (Misaki et al., 2018). Public extension officers usually try to eliminate the hurdles in adopting digital technologies. However, scale, sustainability and overall impact remain significant challenges (Rivera, Qamar and Crowder, 2001).

Profitable and sustainable business models need to be drafted by entrepreneurs and remain a daunting task in the face of rapidly changing circumstances. Companies are still risk averse. Digitalization of African experience suggests a diverse set of challenges in functioning in countries like Côte d'Ivoire, Ghana, Kenya, Rwanda, Senegal and elsewhere (CTA, 2019). Agricultural and Rural Cooperation (CTA) conducted a survey of 439 D4Ag enterprises, a database that tracks 390 active D4Ag solutions and 120 agribusiness leaders in the above-mentioned countries. The key findings are it is a relatively young sector; the reach is growing; 70 percent of the enterprises are revenue generating and, of those, 80 percent possess multiple revenue streams; market penetration is 6 percent; it is a net job creator in agricultural technology, D4Ag support, agricultural processing and agricultural manufacturing; and finally, there is low uptake by women farmers (25 percent) (CTA, 2019).

A limitation on the ability of farmers to use the information on wholesale prices is that the buyers are themselves the creditors; this may mar the well-established relationship between buyer and seller. Large farmers who are digitally connected have access to markets across the globe. In this age of technology, global access to smallholder farmers can make digital innovations in agriculture more inclusive (Karippacheril, Rios and Srivastava, 2011). Smallholder farmers are increasingly approaching organizations to support them to help improve the traceability and quality of their products. For example, the National Coffee Growers Association in Colombia uses Radio Frequency Identification (RFID) chips for traceability and developing coffee quality standards.

Trust, transparency and benefit-sharing pose the 'trilemma' in adopting and scaling up digital technologies (Jakku et al., 2018). Trust, in particular, stands out as a barrier.[26] Worries are increasing about data privacy and security. As the Internet of Things and Blockchain platforms, major digital initiatives cannot function if trust is lacking among the participants spread across the globe. Uncertainty exists regarding principles, rights and compliance issues in data sharing, ownership of data and usage. Different stakeholders may have other profit motives and the most powerful one may reap all the benefits. A growing concern among farmers is the sharing of farm data and how a third party could tweak the rules in favor of its interests. The value proposition for sharing farm data is ambiguous for most farmers. Complete openness of data jeopardizes international cooperation. The proposed IGF Plus addresses these issues by formulating appropriate regulatory policies and norms.

Ezezika and Oh (2012) discuss the perspective of trust as envisaged by stakeholders in the context of ag-biotech public-private partnerships in Africa. The authors conducted a survey of stakeholders across eight agrobiotech projects in Burkina Faso, Egypt, Kenya, Nigeria, South Africa, Tanzania and Uganda. Six themes emerged from interviews in defining trust: integrity, delivery, capability, mutuality, transparency and humanitarianism (*Table 5*). The critical message appeared that trust is the solution to public-private partnerships in the space of digital agriculture. Almost 31 percent of interviewees agreed that honesty is still the best policy.

Table 5: Trust among agri-stakeholders in Africa

Theme		**Interviewee responses per theme (%)**
Integrity	No harm and mischief to others	31
	Partners must behave with integrity	
	Help others, especially in times of difficulty	
	Truthful and honest in dealings with others	
	Show sincerity in interactions with others	
	Have long-established credibility	
Delivery	Deliver results that are expected of you	21
	Follow through on agreed-upon outputs	
	Meet appropriate deadlines	
	Good results stemming from the product and producer [of technology]	
	Agreements in place to ensure accountability	

26 Trust was the main focus of 2019 CGIAR's Big Data in Agriculture Convention. See: https://bigdata.cgiar.org/hyderabad-2019/ (accessed 20 December 2019).

Capability	Confidence in the competency of the individual or institution	19
	Have the capacity to perform the role(s) effectively	
	Data provided by researchers must be science-based	
	The technology must prove effective to the end-user	14
Mutuality	Partners must have uniform vision and objectives	
	Partnership mutually beneficial to both parties	
	Work together cooperatively	
	Equal advantage and understanding in the partnership	
Transparency	Full disclosure and discussion of issues pertaining to partnership	13
	Not keeping secrets (i.e., doing everything on the table)	
	Regular dissemination of information	
Humanitarianism	Provide services on behalf of a target community	2

Source: Ezezika and Oh (2012).

Some challenges identified in the literature for adopting public-private partnerships in the sanitary and phyto-sanitary agricultural sector are: economic (unequal contribution by partners, restricted funding and poor governance in the monitoring of the use of funds); vision (unable to agree on a shared vision, unclear objectives leading to a weaker commitment from different stakeholders, political incentives, corruption, conflicts of interest and additional burdens on those involved in the process of ensuring successful implementation of the deal); and performance (complicated functioning mechanisms, delay in implementation of the process, difficulty in resolving issues and finding common ground and poor communication among stakeholders) (Moreddu, 2016).

The United Nations Secretary-General's High-Level Panel on Digital Cooperation identified similar values and principles as the Ezezika and Oh (2012) research for global digital cooperation; these being cooperation that is inclusive, respectful, human-centered, conducive to human flourishing, transparent, collaborative, accessible, sustainable, and harmonious (United Nations, 2019a). Keeping these values in mind, governments, the private sector, and NGOs should devise mechanisms that balance overregulation and laissez-faire. Some proposed solutions for framing global digital architectures are in the public domain. The proposed internet Governance Forum Plus (or IGF Plus) of the United Nations would constitute an Advisory Group, Accelerator, Policy Incubator, Observatory, and Help Desk. As the name suggests, the Advisory Group would consist of members from various backgrounds and oversee the overall functioning of the IGF Plus (United Nations, 2019a). The Cooperation Accelerator would coordinate actions on common interests across institutions. The Policy Incubator would be the cradle for policies and identify if existing norms and regulations can fill gaps. The Observatory and Help Desk would entertain requests on digital policy and related issues and identify future ones. The United Nations Secretary-General is the overarching body to coordinate the actions and set rules for the multi-stakeholders involved, acting as a convenor, and providing scope for debates and discussion. It will set norms, foster the growth potential of member states and rank and map the performance of members on cybersecurity and arbitration and dispute-resolution (United Nations, 2019a). The Internet Governance Forum Trust will be providing funds for the overall functioning of the United Nations Tech Envoy and related groups.

Lesson from the European Union's Digital Agriculture Platform experiences under the broad umbrella of the European Common Agricultural Policy is valuable (EU, 2021). The platform comprises a team of multicultural staff coordinating the actions of global stakeholders. One of its prime tasks is the formulation of a digital single market strategy. A single platform is being developed to provide access to technology like AI, robotics, blockchain, High Performance Computing, IoT and 5G to European farmers in rural areas to improve their livelihoods and competitiveness of the agriculture sector. Some of the actions taken under the digital market strategy are establishing a cybersecurity contractual public-private partnership, creating a European research cloud, formulating a priority ICT standard plan and European interoperability framework to be compulsory for public services, restricting unjustified geo-blocking of products and others.[27]

6. Conclusion

Ensuring global food security remains a challenge for Southern countries. The current COVID 19 pandemic has made more evident the vulnerability of the global South, particularly concerning the disruption in food supply chains triggered by lockdown restrictions. Equally, COVID has elevated digital technologies and revealed that countries with marginal access to digital technologies will be more exposed to the resultant economic hardship and turbulence that is still evolving. Indeed, the rapid advent of digital technologies has led to increased agricultural production and productivity over recent years for the global South. Present-day digital innovations play a transformative role in agri-food systems in the global South and across the globe. Disruptive technologies, such as Blockchain, the Internet of Things, artificial intelligence, 3-D printing, Virtual Reality, Augmented Reality, sensors and drones, are ushering in the Fourth Industrial Revolution.

This chapter examined the application in agriculture in the global South of machine learning techniques and various other technologies. Good practices are highlighted and some of the complex situations requiring solutions in the future are noted. All the technologies discussed bring their benefits and advantages and have their own set of challenges. One crucial hurdle is establishing trust in technology, particularly when sharing private information is taking place.

Advancements are required in existing technologies and upgrading digital infrastructures to hold such vast volumes of data. Public-private partnerships have been identified as one solution to meet the growing demand for technology adoption in the agriculture sector. South-South and Triangular Cooperation also offer solutions and are essential for learning, sharing and financing sustainable changes to agricultural systems. Indian and Chinese companies, as was noted, have heavily invested in Africa for knowledge and technology transfer. However, much more of this type of cooperation is needed, including making more significant efforts in outreach and revamping and formalizing existing contracts.

It is important to reiterate that capacity building must simultaneously accompany technological growth to create new skill sets and update the skills of existing workforces. Furthermore, to improve agricultural productivity enough to meet the food security challenges of the global South, countries will need to adopt frameworks based on the pillars of supportive policies, strong institutions, advanced technology, modernized capacities and good governance. This has to be accompanied by an increased and sustained focus on digital innovations and shared innovations across countries and regions of global South countries.

27 A plethora of resources related to this topic are available at: https://ec.europa.eu/digital-single-market/en (accessed 2 April 2020).

Chapter 5

Digital financial services transformation and new approaches in South-South Cooperation and Triangular Cooperation

Within the last decade, financial technologies, or FinTech, have emerged rapidly as an issue for developing countries. This paper explores the challenges related to FinTech for developing countries and the extent to which FinTech is a vitally important area for South-South and Triangular Cooperation.

1. Introduction

Financial technologies refer to the space in which technology and financial services intersect. In recent years, FinTech has been expanding so rapidly that it is almost impossible to provide a comprehensive listing of technologies involved in this sector. These technologies not only are applied to existing financial sectors of economies, but also are being applied by actors and agencies outside of the traditional financial sector, in parallel to it, if not in competition. The traditional banking industry has heavy off-line assets and high transaction costs that make business difficult and unprofitable, particularly in remote locations. And because unbanked people at the bottom of the financial market do not have credit records in the system, it can be difficult for traditional banks to analyze these potential clients' risk and to deliver services to them. The ability of FinTech to accumulate information on the credit worthiness[28] of potential borrowers in the course of the provision of their services breaks through the information wall which usually excludes these borrowers from access to finance. The information gathered in the course of business provides FinTech firms with improved risk management and lower costs. By moving the trading place from physical branches to online platforms, digital finance greatly reduces transaction costs. In addition, Fintech and Big Data are also breaking through information asymmetry by changing the model of data collection and analysis for risk control, thus, expanding the scope of financial services and making more remote clients reachable. The most direct examples are financing services for consumption and supply chains. The Big Data analysis system can help financial institutions carry out risk judgment and credit assessment for clients who in the past lacked financial credit information. Supply chain operations require timely financing for working capital to meet the needs of operations, thus FinTech, takes advantage of the information already gathered on these operations, giving it a clear lead over traditional banks to support credit needs.

As Fintech enterprises and decentralized financial platforms have made it possible for financial transactions to be independent of traditional financial institutions, they are challenging traditional banks and stock exchanges. The digitization of financial transactions encourages information sharing and embeds credit investigation systems. Rapid and open information processing promotes the process of interest rate liberalization and competition. Challenges are present in FinTech as well, in particular in relation to traditional financial regulations, bringing new risks and hidden dangers. The usage of Big Data, for example, has led to excessive collection and sale of customer data and raised concerns about individual privacy and security.

This chapter will cover some of these innovative and disruptive advancements that are beyond the traditional financial sectors.

28 Using data gathered from U.S. FinTech firms, Agarwal et al. (2020) analyze the informational advantages of these kinds of firms. Agarwal, Sumit, John Grigsby, Ali Hortaçsu, Gregor Matvos, Amit Seru and Vincent Yao (2020). "Searching for Approval." Working Paper 27341. National Bureau of Economic Research. Cambridge, Massachusetts, June 2020 (retrieved 30 March 2021 from www.nber.org/papers/w27341).

FINTECH INNOVATION IS TAKING OFF IN THE GLOBAL SOUTH

The application of financial technologies, and the market and social changes brought with them, have been far-reaching and extensive in the global South. In fact, the scale of FinTech introductions and applications in Asia, a region dominated by developing countries, has led observers to suggest that Asia is setting the pace for financial services innovation, outstripping advances in the global North (Ruehl and Kynge, 2019).

Non-FinTech businesses are generally dependent on brick-and-mortar infrastructure. FinTech businesses do not require land line telephony or local area networks for computers and instead operate using mobile phones whose infrastructure requirements can be installed with much smaller investments. FinTech is being propelled in developing countries by the fact that the technology is able to serve remote suppliers and consumers. The growth of FinTech in the global South is also fueled by the fact that the technologies – because of the lower cost and reduced demands on infrastructure – can easily be directed at serving individuals and small markets at retail quantities. For example, India, a large emerging economy, is home to millions of consumers with miniscule requirements for finance and retail services. These consumers and users normally may not offer economies of scale to suppliers and producers, but through FinTech-enabled sellers and finance companies, their small quantity needs can be served.

FINTECH'S POTENTIAL ROLE IN POVERTY ALLEVIATION

Because of the nature of its growth dynamic, FinTech has been touted as having the promise of addressing dimensions of widespread poverty in Southern countries – in the same way that microfinance was predicted to alleviate poverty more than two decades ago – thereby mobilizing and consuming an enormous amount of policy and donor attention and resource redirection. While the possibility to impact poverty does exist, it is probably premature to promote FinTech as a miracle poverty alleviation methodology. Long-term research on the impact of microfinance experience indicates that the potency of the approach depends much on the existence of a "vibrant and stable formal sector" (Vasudevan and Raghavendran, 2019: 26) and thus microfinance could not have succeeded as a stand-alone anti-poverty intervention (Cull et al., 2009; Bateman and Chang, 2012).

Thus, interventions centered on expanding financial services to the asset-poor require a steadily growing overall (formal) sector. While the informal sector in many countries of the South is quite large, at the level of the household, the sector is essentially a coping mechanism to the problem that the formal economy is not creating enough new jobs to absorb entrants into the labour force. Introducing new financial services to this sector is conditioned on the possibility of creating new businesses which create livelihoods and profits from which to pay back microfinance loans, for example. If the formal sector is growing, new businesses are able to grow on the basis of increasing incomes in the overall economy. If a robust formal economy does not exist, microfinance and new financial services are less successful and, in many cases, create debt burdens. Introducing micro-financial services in the past often became an additional coping tool of the asset-poor, with loans directed toward consumption maintenance in response to family emergencies, rather than being applied to the startup of new economic activities which generate additional income to repay the loans (for which they were intended). When used for emergency expenses, loans are redirected to expenses that do not generate additional income; finding resources for repayment becomes a matter of selling other liquid assets or borrowing the debt service amounts due.

When the mobile phone was introduced and mobile phone money transfer became possible (as well as other new possibilities, like helping farmers observe urban prices for produce), numerous forecasts predicted that Southern countries could move directly into industries centred on the fourth industrial revolution. In Kenya, as a primary example, the mobile phone's main contribution to financial services was the introduction of a payments system in a society where a great majority of consumers were unbanked. According to the World Bank's Global Findex, approximately 34 percent of adults in sub-Saharan Africa have bank accounts, and of those with bank accounts, only 12 percent used mobile money services in 2016. Financial exclusion was pervasive in Kenya. Banks

were not accessible in remote areas and had done little to bring financial services to the inhabitants of these areas. Because a significant majority of Kenyans, mainly from lowly penetrated rural areas and low-income earners, were not captured by the incumbent banking institutions, micro-finance institutions and micro-credit savings unions prevailed. Thus, when the mobile phone money transfer company M-Pesa was introduced in Kenya, making it possible to bank without phone lines, banking in the country was revolutionized.

BOX 1 FINTECH AND ACCESS TO FINANCIAL SERVICES IN LATIN AMERICA

Studies in Latin America opened a window on why both the traditional financial sector and microfinance sector have been slow to make headway in solving the unbanked consumer problem. The Inter-American Development Bank (IADB) cites surveys in Latin America that found that "the high costs of access, high interest rates, lack of products and services that provide value to users and the confusing user experience are among the main factors which make the financial industry one of the least appreciated by users" (IADB, 2018: 1).

Small- and medium-sized companies in the region, which account for 90 percent of all companies, have difficulty accessing credit, mainly due to lack of credit history or liquidity. IADB also reported that in fact, 71 percent of millennials prefer to go to the dentist rather than interact with their bank and most do not know how to identify the differences between their bank and another. As a consequence, IADB estimates that around 46 percent of the adult population, or 210 million people in Latin America and the Caribbean, do not have a bank account. These operations are characterized by high costs and restrictive user access because every client attended to has a financial impact on business operations. As private operations, they cannot turn a profit without restricting access and imposing high fees and interest costs.

THE ROLE OF FINANCE AND FINTECH IN DEVELOPMENT STRATEGIES

FinTech is a new tool that can be used within development programmes, although it is important to avoid looking at FinTech as a development strategy in itself. FinTech has made it possible for some Southern countries, such as Afghanistan, Kenya, Nigeria and South Africa, to take significant and likely permanent strides toward labor mobilization participation in the formal economy and increasing access to financial services, markets, equipment and technology in poorer areas of the economy. These are essential development objectives that are regarded as natural outcomes of development success. Up to recently, governments have not been considered responsible for creating domestic and external markets as part of development policy; creating markets was considered the province of a vigorous private sector (Mazzucato, 2014).[29] What recent experience in FinTech has shown is that it is possible to promote these development outcomes directly with a sturdy expansion of the application of FinTech.

The growth of FinTech and its impact depends logically on the overall economic ground on which it is planted. The technology can easily reproduce and expand the existing economic structure without introducing any transformational developmental changes, at times even adding some problems, like reducing housing availability and formal sector jobs. A recent example is the business of delivering food from restaurants to homes in New York, possibly the largest of its kind in the world. Characterizing the sector as possibly a "new hunger game," Bromwich (2019) describes how New York home delivered food is mostly cooked in "ghost" kitchens, not in

29 A modern, contrary view is Mazzucato's (2014) "entrepreneurial state," which says that governments have the duty to create markets to promote economic growth and diversification.

actual restaurants. This new business model could mean a reduction in the number of highly paid jobs in actual restaurants. This model is being reproduced in the West Coast of the United States and the founder of Uber is one of the more prominent investors. The shared cooking and delivery of food results in lower costs for consumers and food producers but otherwise cannot be associated with transformational and developmental change.

ILO suggests that in the case of the gig economy "most platforms do not apply employee protection under existing labour laws to the work being done, as workers are primarily hired as independent contractors. While some of these workers may be legitimately self-employed, in other instances they may be misclassified to avoid employment law obligations" (ILO 2018). When large corporations invade FinTech activities, similar kinds of policy and regulatory dilemmas have arisen, for example the way that in Northern urban areas Airbnb is impacting access to affordable local housing by local residents.

In contrast, in Indonesia, businesses providing lunch to workers (Ruehl and Kynge, 2019) has made possible the expansion of the business and access to credit. In a suburb of Jakarta, Rice Basket Queen is a stall serving fish and vegetable dishes on banana leaves to walk-in customers. The owner of the stall decided to sign up with Grab (an Uber-like food delivery company headquartered in Singapore) to deliver her lunches on the back of motorcycles through traffic-snarled streets to clients who order over a mobile phone app. Through the process, Grab accumulated information on the expansion of this small business. Grab's financial partner, a company called Ovo, offered the owner a $3,562 loan to open a new stall the following year. This kind of evolution that is associated with the transformational and developmental impact of FinTech is proliferating in the small business sector in many parts of Asia.

In earlier reactions to the wildfire growth pattern of Kenya's M-Pesa, FinTech had been seen as providing a path through which developing countries could bypass the need to industrialize and avoid wrestling with making progress in the first three industrial revolutions, including manufacturing. Juma discusses why, in the case of the mobile phone path, "the promise of leapfrogging remains largely unfulfilled" (Juma, 2017: 1). The mobile revolution has hardly provided a stimulus for broader industrial development and has had little impact on African innovation policy. Juma suggests that the reason for failed hopes from the mobile phone is the fact that this technology is in the service sector of the economy and that this transition is not possible without a corresponding manufacturing sector to support the growth in demand and supply in the service sector. If every increase in the domestic use of imported mobile phones involves some proportion of foreign exchange payments, then Southern countries still have to find a way to earn additional foreign exchange from their domestically produced exports. M-Pesa provides consumers and small business owners with a tool to facilitate and lower the cost of their economic activities. But M-Pesa does not create the activities from whose return loans obtained can be repaid. The growth of M-Pesa enables faster growth of such activities, but it has not caused it. The drivers of growth, especially for small businesses, is not M-Pesa – conceding that M-Pesa enables a faster rate of growth – but is the overall growth of the economy. As the record of periodic crises in economies like Kenya has shown, an overall economic downturn will be felt most deeply, and often permanently, in the consumer and small business sector. In non-crisis times, if the cost of M-Pesa's financial services exceeds those available elsewhere, then its financial facilities will instead serve as an inhibitor, not a promoter, of economic growth.

While there could be much confusion over the role of finance in policy circles and structural changes have repositioned the financial system to a position of dominance over the real sector in a process called "financialization," the sustainable and productive location of finance is in the service of the real sector. Otherwise, growth will be insufficient to sustain the internal growth of financial sector expansion (Montes, 2019a).

Montes (2019a) explains that decades of deregulation of traditional finance has not resulted in the expansion of financing for physical investment and new economic activities. Instead, deregulation of the traditional sector has created financial sectors mostly oriented toward short-term capital gains on other financial assets. This has meant that proposals for financing for physical investments and expanded operations must pay high interest rates to compete with financial investments. International financialization has put the cost of loans beyond the reach of the mass of those unable to securitize their future income streams, such as entrepreneurs in new production and service proposals in the real sector, small domestic borrowers and those without a credit record. As a sector outside the traditional sector in most countries, Fintech provides access to financial services, including unsecured lending, to these non-mainstream businesses.[30]

30 The China experience discussed in this paper is proof itself of this role. For a study on the same role in the U.S., see Jagtiani, Julapa and Catharine Lemieux (2018), "Do Fintech Lenders Penetrate Areas That Are Underserved by Traditional Banks?" *Journal of Economics and Business*. doi:10.1016/j.jeconbus.2018.03.001.

In the global South, it is important to recognize FinTech's role in development and how governments can promote this role in the overall context of development challenges being faced. South-South and Triangular Cooperation promises enormous possibilities to assist in this effort. While commonalities exist in the basic technology involved, Southern countries are often at different stages of application. These differences in the FinTech experiences stem from differences in many areas, including:

- → inherited contractual rules on entry and exit of enterprises, particularly from new entrepreneurs from non-elite families;
- → recent records of government support and regulation and the dominance of the formal financial sector;
- → aside from other purely economic factors, such as income distribution, the range of livelihoods and work status (whether workers are the entrepreneurs themselves, contactors, employees, part-time, full time, from minorities or have legal permission to work); and
- → underlying economic growth.

These differences have in turn provided a variety of lessons in each country which can be distilled, analyzed and shared among developing countries to promote the FinTech sector. One thing that must be repeated at this point is that, as mentioned above, Southern countries are setting the pace for FinTech innovation and growth – a pace that could be inhibited in the future by new international obligations introduced in free trade agreements with countries of the global North, such as the Comprehensive and Progressive Trans-Pacific Partnership agreement (CPTPP) (New Zealand Foreign Affairs and Trade (2018) (to be discussed below).

FinTech does provide an open and productive arena where activities in South-South Cooperation can be expanded and intensified. Chapter 14 of the CPTPP introduces two new international obligations: 1) prohibiting governments from requiring data gathered from the local economy to be located in domestic servers; and 2) prohibiting requiring the disclosure of source codes specific to goods and services internationally traded among private parties. These restrictions fortify enormous technical and commercial advantages of incumbent international platform companies and suppliers from advanced countries compared to potential competitors and startups in Southern countries.

The rest of the paper is composed of the following sections. Section 2 examines China's FinTech adventure as an exemplary illustration of how FinTech can be introduced in a steadily growing economy, grow organically, contribute numerous positive impulses to the macro-economy and raise the living conditions of marginalized groups, including those who are marginalized in the business sector. Section 3 discusses the developmental challenges presented with the rise of FinTech. Section 4 examines the potential for South-South Cooperation to address the developmental challenges posed by FinTech. The chapter concludes with recommendations.

2. Digital financial innovation in China

If you travel to a remote mountain village in a poor area of western China, when you need a drink, you can walk into the e-commerce site of a village and scan the "QR" code with your mobile phone to buy drinks and food. You will find fresh local specialty agricultural products on sale in the outlets. You are eager to buy some to take home, but you don't want to carry the products on the road and don't have enough cash on hand, so you scan QR codes on your mobile phone to place a delivery order and pay. A few days later, when you get home, the product will be delivered to your doorstep. This is a modern scene in China and made possible by the innovations and development uses of e-commerce and digital finance in China.

Digital finance is changing the financial ecology in China and affecting economic development and social life. It not only improves the efficiency and convenience of traditional financial institutions and businesses, but also is improving services. The innovations and development of digital finance in China, also known as internet finance (Xie, 2012), are mainly taking place in digital payment systems, internet credit, digital insurance, digital wealth management, P2P, crowd funding, Big Data credit record systems and sovereign digital currency.

New FinTech has expanded the reach of effective financial services and promoted financial inclusion in China, an important social objective, and has made a huge impact on the financial system. In the past, it was difficult to provide financial access to poor smallholders and micro enterprise groups because of geographical and economic barriers. The traditional banking system requires physical branches to deliver the services and it is not feasible for banks to open branches in remote areas for scattered households. It is also difficult for traditional banks to provide downscaling services to the lower layer in the financial market because of the diseconomies of scale that come with small and even micro-lending. And the more important fact is there were no tools for batch processing of large-scale transactions and risk analysis for huge numbers of customers. While traditional banks are stymied from giving small loans, FinTech companies accumulate the needed information about behavior – from the transactions in their electronic wallets, for example – as a matter of daily operations, and thus are already poised to dole out small loans.

2.1 INNOVATIONS ARISING FROM DIGITAL PAYMENTS IN CHINA

Digital payment and credit systems have been successfully established on a large scale in China. Digital payment provides access to financial services online without physical branches. The rapid development of internet and mobile payment systems has increased the convenience of micro-payment. It has improved payment infrastructures for microfinance development and encouraged the development of micro-savings, micro-credit, micro-wealth management and micro-insurance. Today in China, people can easily apply for micro-credit of several hundred yuan to tens of thousands of yuan online, based on meeting credit standards. Payment services are the starting point and door to other financial activities, thus third-party payment institutions take the opportunity to enter the fields of credit, insurance, wealth management and other financial businesses with the leverage of users and their transaction data obtained through payment systems.

Third-party payment agencies and QR code technology based on mobile payment are the most innovative digital payment methods in China. Third-party payment refers to a payment platform created by a non-banking institution independently or in cooperation with banks with the guarantee of their own reputation and ability. The earliest third-party payment platform in China was Shouxinyi, an online platform launched by Capital Information Development Co., Ltd. in 1999 (Bei, 2017). In 2002, China UnionPay, the bank card association of China, solved the problem of multi-bank interface and made possible inter-bank online payment. Currently, the most successful third-party payment platforms in China are Alipay and WeChat.

As offshoot of Alibaba's e-commerce business, Alipay was created in 2003 to solve the trust problem between unfamiliar buyers and sellers on the Taobao e-commerce platform, similar to the service that would be provided by a letter of credit. At that time, the bank was not willing to provide letters of credit for online small transactions. Moreover, if the two parties of the transaction did not open an account in the same bank, the inter-bank payment would be troublesome. To increase the convenience of online transactions and improve the user experience online, Alibaba set up a prepayment virtual account for users, launched a credit intermediary mode of payment that realized the interbank settlement through the prepayment capital pool and developed a set of payment and settlement systems for fragmented small transactions. The Alipay system greatly improved the security and convenience of transactions online. This innovation was quickly recognized by users, which fueled rapid growth of the Taobao platform and further expanded the flow and the capital pool of the Alipay system.

To promote healthy growth in the payment service market, regulate the payment service behaviour of third-party institutions, prevent payment risks and protect the legitimate rights and interests of the parties concerned, the People's Bank of China formulated the Regulation on Payment Service of Non-financial Institutions, which came into force on 1 September 2010. By the end of 2015, the People's Bank of China had issued 270 third-party payment licenses. The license allowed third-party payment institutes to conduct internet payments, prepaid card issuance and acceptance and bank card receipts. But due to irregularity in behavior that caused risks, the bank paused issuing licenses.

Following the widespread popularity of smartphones, in 2012 Alibaba launched Alipay wallet, the mobile application of Alipay. In the same year, another giant third-party payment platform WeChat was born, thus mobile payment had firmly taken hold in China. WeChat payment relied on powerful social networking platform attributes and is based on the dense interconnectedness of people. WeChat launched services for credit, consumption, wealth management and other aspects of daily life. Users were able to turn a smartphone into a universal wallet by simply associating a bank card with WeChat and completing identity authentication.[31]

QR code payment is a contactless form of digital payment that has had a huge impact on economies and societies, including China. Under QR payment schemes, merchants can compile transaction information, such as account number and commodity price, into a QR code and publish it in various places. By scanning the QR code on their mobile phone, a client can realize payment and settlement with the merchant account. The merchant can carry out goods distribution and complete the transaction according to the payment transaction information, such as client address and contact information. QR code payment technology has established a very convenient and fast connection between online payment and offline real economy, allowing QR code payment to penetrate all aspects of social and economic activities, such as administrative affairs, medical services, transportation, meteorological and environmental information, recharging payment balances, cultural life and other fields. The application scenarios of mobile payments are expanding rapidly and quickly becoming common place in consumption, tourism, e-commerce, finance, entertainment and other sectors. In China, as in many other parts of the world, people can leave home without their wallet, as long as they are carrying a mobile phone with payment applications installed.

The combination of traditional financial institution outlets and mobile payment methods can significantly improve the accessibility of financial services in remote areas and close the geographical gap in financial service, thereby promoting financial inclusion in the global South, as it has in China. Below are two case studies in internet payments in China. Distilling the key elements of China's experience, and in other countries of the South should give impetus for greater South-South Cooperation.

31 o2o stands for "online to offline and offline to online" and basically means any technology that allows consumers to use online payments to purchase goods and services offline in physical stores.

CASE STUDY 3

GAINING CUSTOMERS THROUGH APPLICATION SERVICES — WECHAT PAY

WeChat Pay is the second largest digital e-commerce payment platform in China after Alipay. WeChat Pay was launched by Tencent in 2005, but in its early stages it was called Tenpay. In 2013, Tenpay cooperated with WeChat, China's largest mobile social networking service platform (developed by Tencent also), to launch a new mobile payment system, WeChat Pay.

In the early days of the launch, even though WeChat had 270 million monthly live users, WeChat Pay could not effectively convert users due to insufficient scenarios. In January 2014, DiDi Taxi (an online car hailing platform like Uber) connected to WeChat Pay, following which a large number of other online and offline merchants connected to WeChat Pay, finally giving users a reason to use the service. But signing up with merchants was not enough to make WeChat Pay go mainstream. The real turning point was the 2015 Spring Festival for which WeChat created an app called the Red Envelope to send 'lucky money,' a Chinese tradition, through WeChat Pay. During the New Year's festival in 2018, 668 million people used the Red Envelope app to send and receive lucky money and many more people were enticed to open digital wallets, leading to explosive growth of mobile payments in China in a short time.

Previously, digital enterprises faced the dilemma called the "cold start," which meant figuring out how to persuade customers to go through the process of binding their bank cards to an app. WeChat Red Envelope neatly solved the problem by automatically binding user bank cards when they withdrew cash using the Red Envelope app. After the Spring Festival of 2015, WeChat bank card-tied accounts successfully broke 100 million (a far shorter timeframe than Alipay was able to accumulate users).

CASE STUDY 4

THE INNOVATIVE EVOLUTION OF PAYMENT AND SETTLEMENT IN POVERTY STRICKEN RURAL AREAS OF SICHUAN PROVINCE

To support the poverty elimination programme of China, the Chengdu Branch of the People's Bank of China is promoting inclusive coverage of basic payment services in Sichuan Province, especially in three remote areas. The bank began by making traditional facilities more accessible, such as ATMs and point of service, eventually adding mobile payment platforms.

In the past, residents of Mianchi Town and surrounding villages had to travel to a bank branch in another town, at a cost of about 30 yuan and taking more than one hour. In 2011, the People's Bank of China helped the Wenchuan County Branch of the Agricultural Bank of China to set up a service point in a local store for withdrawing money. That service point has since been upgraded into a comprehensive financial service station, equipped with a monitoring TV camera, safe box, money detector and other equipment. The service station also offers mobile payment and a small merchant penetration mode (now available in all the townships of Sichuan Province). On the platform, small merchants can access other mobile payment systems, such as UnionPay, WeChat Pay, Alipay, etc. To encourage more use, the Aba Branch of the People's Bank of China carried out a remote inspection programme, after which operation and maintenance costs were reduced, service efficiency improved, and enthusiasm promoted of the remote agent merchants through financial subsidies and awards. These measures stimulated the platform's sustainable and effective operation.

Mr. Dai Yuhong, owner of The Yuhong Store, said: "The villagers come to my store to buy things, at the same time, they can also handle cash withdrawals, remittances and other business. In a month, the system handles more than 150 transactions, not only providing convenience for the villagers, but also helping my shop business stay stable." According to the officer in charge of the Aba Branch of the People's Bank of China, the service station handled a total of 13,000 transactions and saved about 200,000 yuan for farmers since 2012.

Over a decade, the Chengdu Branch of the People's Bank of China invested 100 million yuan to build more than 80,000 such service points, covering all the administrative villages in Sichuan Province, effectively making up for the shortage of financial outlets in rural areas. Nearby and convenient payments for social security, health care, water, electricity, gas and other public services has made banking in this part of China more inclusive.

Source: The *Financial News* (2020) was the main source for this case study.

2.2 OVERVIEW OF THE INTERNET CREDIT BUSINESS

For low-income people and small- and micro-enterprises, the scale of individual credit services is small, scattered and the transaction costs are high. From the point of view of the credit providers, the cost of information collection is high and there is information asymmetry, resulting in risk uncertainty. In addition, the adverse selection effect[32] on credit market, moral hazard[33] and lack of collateral, make it difficult for traditional financial institutions to provide effective financial services for this category of consumer. Although some successful microfinance institutions have solved these problems by, for example, group lending or collecting personal information in the community, borrowers still must bear high financing costs due to the high transaction costs as a result of the need for substantial human resources. It is not easy for microfinance institutions to achieve the dual goals of commercial viability and social performance that can achieve a win-win situation for both lenders and borrowers. To realize accessibility, affordability and business sustainability of financial inclusion, further innovation is needed to continuously reduce the costs of information acquisition and transactions.

Innovations in digital finance, promoted by digital technology, are helping resolve many of the above problems and digital financial inclusion has become a trend in global financial inclusion development. The below aspects of FinTech are supporting this trend.

1. The internet and mobile communications are closing geographic gaps in financial services, with online transactions making physical distance no longer an obstacle.

2. With the popularization of digital communications, economic and social activities are migrating online, thus information about human behavior is increasingly generated and recorded on the internet. Leaving aside any legal issues and privacy constraints, the cost of obtaining information online is extremely low and a company can obtain massive amounts of data cheaply and in a short time.

3. With continuous improvements in computer processing speeds, statistical analysis of Big Data can be done at amazingly fast speeds, which helps financial institutions carry out risk identification and assessment through artificial intelligence.

4. Computer programmes can process large numbers of small transactions, which would be difficult for handling manually.

5. Cloud Computing technology can flatten the process of information collection, storage and transmission and improve the efficiency of the internal management of information systems of financial institutions.

6. Technologies such as digital images, digital video technology, fingerprint recognition and face recognition can deal with remote identity authentication, document certification and other transaction procedures online, reducing transaction costs.

7. Combinations of the above technologies can create new financial business models and more effective risk management methods.

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32 Adverse selection effect is a problem brought about by information asymmetry. The tendency of one side of the market to enter into an agreement with the other side if it can use more information than the other side to benefit itself at the other side's expense. It is closely related to moral hazard. On the credit market, it is the process of singling out potential customers who have higher risks than the average.

33 Moral hazard is the risk that a party has not entered into a contract in good faith or has provided misleading information about its assets, liabilities, or credit capacity. In addition, moral hazard also may mean a party has an incentive to take unusual risks in a desperate attempt to earn a profit before the contract settles.

In short, digital finance can effectively reduce transaction costs and risk management costs, break through the service boundary of traditional finance, further penetrate into the bottom of the social pyramid and truly realize the dual goals of commercial sustainability and social performance advocated by financial inclusion.

2.2.1 DIGITALIZATION OF THE CREDIT BUSINESS OF BANKS

The use of digital technology to deliver credit services is known as internet lending. Categorized by clients, internet lending can be divided into micro credit and small and medium-sized enterprise loans. By the uses of funds, it can be divided into business loans, consumer loans and individual and family comprehensive loans. By providers, it can be divided into banks, non-bank financial institutions and new players, such as P2P lending platforms and crowd funding platforms. At present, almost all the banks in China have applied digital technology to deliver MSME loans to varying degrees. All kinds of banks have online banking and telephone banking services and most banks have opened mobile banking, so that customers can more easily apply for and repay loans. The application of digital technology is embodied in the whole process of loan applications, approvals, post-loan management and recovery.

These technological advances have improved banking services and enhanced competitiveness through the approaches listed below.

1. Banks open online application and approval services to shorten the process, reduce intermediaries and lessen the time cost. The approval time of many small and micro loan products has been shortened to three to ten days, or sometimes even one day.

2. Banks obtain customer behaviour information from e-commerce platforms, telecom operators, user data, supply chain financial data, bank card usage data, etc. By monitoring risks with Big Data, banks can effectively manage risks and improve loan quality.

3. Online banking and mobile banking enable most banks to provide revolving loans for customers, which can be borrowed and returned at any time, reducing customers' interest costs.

4. Some large commercial banks with strong technical capacity and large data resources created a Big Data scoring card system, which greatly improved the efficiency of loan approvals. The system also uses data analysis to build customized products for clients.

5. Banks connect with e-commerce platforms by means of shareholding or cooperation and use the e-commerce platform as channels for customer acquisition and product promotion and delivery. The data from the e-commerce platform is also used to develop and provide Scenario Consumer Finance[34] and supply chain financial services.

34 Scenario Consumer Finance combines consumer credit closely with the daily consumption of food, clothing, housing and transportation. Financial institutions directly deliver loan funds for the consumption of specific goods or services according to the withdrawal application and payment authorization of consumers.

2.2.2 DIGITAL FINANCE IN TRADITIONAL LOAN COMPANIES AND MICROFINANCE ORGANIZATIONS IN CHINA (THE NON-BANK SECTOR)

Non-bank financial institutions engaged in the lending business in China include finance companies, financial leasing companies, commercial factoring companies, pawn shops and so on. In addition, some not-for-profit microfinance organizations,[35] such as the China Foundation for Poverty Alleviation (predecessor of CD Finance), engage in lending. There are five main categories of finance companies. The first are traditional offline loan companies initiated by the private sector. Due to their weak institutional strength and lack of sufficient data, it is difficult for traditional offline loan companies to independently develop FinTech. They tend to partner with FinTech companies and e-commerce platforms to get their technology and data and even outsource some of their work to FinTech companies.

The second type of finance company is supply chain-based, which is invested in the core enterprises of the supply chain. Supply chain-based finance companies provide payments, loans, investments and other financial services for upstream and downstream enterprises and end consumers of the supply chain by virtue of their parent company's core position in the payment and settlement of the supply chain and the logistics and capital flow information on the supply chain. These companies use digital technologies, such as the internet, mobile communications and Big Data, for analysis to improve efficiency and risk management capabilities, reduce costs and provide more convenient and preferential services to enterprises and individuals on the supply chain.

The third type are online loan companies that are invested by BigTech, sometimes called "internet giants." These internet giants have large financial resources, strong technology development ability, huge data resources and natural internet business model genes. Not-for-profit microfinance organizations have not been granted formal legal status in China, resulting in their marginalization. They are mainly active in rural financial markets providing inclusive financial services to farmers; however, they offer the minimum of financial services. CD Finance is the most typical one (*Case Study 5*).

The biggest and most active group of non-bank financial institutions engaged in the lending business in China are small loan companies, a special kind of finance company registered and regulated at the provincial level. Small loan companies are vastly different from traditional loan companies in terms of business model and scale. More than 8,000 small loan companies are registered in China. These companies can only use their own capital and a limited leverage to lend, have no capacity to compete with banks and generally engage in high-risk personal subprime loans and small- and micro-business credit not yet served by banks. To survive and thrive under difficult circumstances, these small loan companies have a great incentive to use digital technology to improve their credit management, reduce costs, manage risks and expand into new markets. As individual small loan companies find it difficult to develop their own FinTech systems, third-party service providers are getting involved, making small loan companies among the most active and innovative institutions in the field of digital finance in China. For example, the Jiangsu Provincial Government established a FinTech company, Jiangsu Jinnong, which developed a free online management information system for small loan companies. The system helps the companies to conduct risk control and refinancing services are available to the small loan companies by evaluating their performance online.

35 In China, non-for-profit microfinance organizations are not legal financial institutions but have certain kinds of business permission.

CASE STUDY 5

APPLICATION OF DIGITAL TECHNOLOGY FOR RURAL MICRO-CREDIT – CD FINANCE

Zhonghenongxin Credit Project Management Company is a social enterprise that provides rural financial services. Its predecessor was the microcredit project department of the China Foundation for Poverty Alleviation, a charitable foundation. In 2018, Zhonghenongxin was renamed CD Finance. Its customers are mainly low- and middle-income households in rural areas that have difficulty getting loans from banking institutions. CD Finance has not obtained a financial license so far, relying on concessionary financial rights provided by the People's Bank of China. After securing financing from IFC, TGP, Sequoia Capital and Ant Finance, CD Finance invested in eight small loan companies with lending licenses across the country. By October 2019, CD Finance covered 20 provinces in China, had more than 440,000 customers and loan balances of more than $1.58 billion, with an average balance of about $3,500 per client.

Prior to 2013, CD Finance operated its credit business in the traditional ways, including door-to-door cash services (which brings significant risks and operating costs) and PC-based credit management systems in which loan officers traveled to the field and returned to a base to upload data acquired (which created information lags). The control of risk was placed on the branch, and headquarters was not involved in loan approvals. CD Finance started a pilot reform of information management in 2013 with the goal of more standardized operations, simplified work processes, greater work efficiency and strengthened control of risks. In 2015, CD Finance completed an overall information system upgrade of all branches nationwide.

In 2018, CD finance launched the Zhonghe financial services application that reached one million farmers in more than 300 counties across the country, marking a breakthrough in the demand side of Zhonghenongxin's digital strategy. The app was developed by Ant Financial, the biggest shareholder of CD Finance, with its top research FinTech team in China. The app makes use of Big Data risk control, machine learning, artificial intelligence and other FinTech technologies, and can effectively optimize processes, improve efficiencies and reduce costs. Meanwhile, it is complementary to CD Finance business, improving service ability and efficiency. Using ID authentication and face recognition, farmers can get loans in 10 minutes without guarantee or collateral, benefiting from a line of credit from 2,000 yuan to 30,000 yuan. Farmers can complete all the processes – from the loan application to transferring funds on smartphones, tablets and other terminals – from home.

By the end of 2019, the CD Finance app had reached two million people, of whom 1.44 million people applied for a credit line and 600,000 people successfully received a credit line, representing a success rate of 41.6 percent. The average time for use of credit was 104 days (CD Finance, 2020).

CD Finance is gradually eliminating the need for cash in business, relying instead on centralized payments through bank-enterprise direct connections and online banking systems. The mobile application used by loan officers is also innovative and can automatically identify ID cards and bank card information, enabling uploading of customer data in real time. Because the risk management department of the headquarters participates in the loan approval process, reviewing compliance of various documents in real time, risk is controlled throughout the process. For personal loans, the repayment ability of individual clients is evaluated using inter-process communication (IPC) technology.

(*Source*: CD Finance's Brief Executive Reports 2018-2020.)

2.2.3 THE FINANCIAL INNOVATIONS OF BIGTECH

Some large internet platforms for e-commerce and social networking are involved in financial businesses, taking advantage of their use of and access to technology, data, trading channels, capital, as well as lax regulatory environments. Started with digital payments, many penetrated into all kinds of financial sectors, such as savings, credit, insurance, investments, wealth management, etc. The expansion of their financial services has consolidated and strengthened their position and influence in the market, creating giant business groups that cover many commercial fields. Some separate their financial arms from the parent company and develop into a comprehensive financial syndicate. Among the most representative and influential of these companies in the global South are the Chinese companies Alibaba and Ant Finance, Tencent group and JD group.

CASE STUDY 6

MICROFINANCE FOR E-COMMERCE – ALI MICROCREDIT

Ali Microcredit is a typical example of online microcredit services for micro and small enterprises based on e-commerce. A product line developed by China's Ali Microcredit Company, Ali Microcredit was jointly invested in by Alibaba and other investors in June 2010. The Ali Microcredit Company is the first finance company in China that met the financial needs of small and micro enterprises in the field of e-commerce. In 2014, an internet bank called Mybank was established that adopted the credit service model and products of Ali Microcredit Company. It was invested in by Ant Financial Group, the financial business entity that separated from Alibaba. By December 2018, MyBank and the Ali Microcredit Company had provided more than 2 trillion yuan in loans for more than 13 million small and micro businesses (MyBank 2018 Annual Report).

Ali Microcredit provides two different types of loan services: Taobao is for peer-to-peer (C2C) and business-to-consumer (B2C) loans and Alibaba is for business-to-business (B2B) loans. This case study focuses on Taobao. Taobao loans are mainly provided to sellers on Alibaba's e-commerce platforms, Tmall, Taobao and Juhuasuan. Taobao is divided into order-based loans and credit loans, with the amount within one million yuan. Taobao order-based loans provide credit lines based on the amount of the physical transaction order that has been delivered by the seller's shop but not received by the buyer. When the loan is due, the system will automatically repay it. Taobao credit loans provide credit lines based on the comprehensive operation of the store, not limited by the present day's order volume and with no collateral or guarantee. The credit line can be used many times, making it flexible for borrowing and repayment. In addition, the Tmall platform's high-end merchants can also obtain loans of up to 10 million yuan through offline checks. Taobao has no geographical limit for loans. All the loan awards are completed online and are issued through Alipay, which basically does not involve offline checking. The shortest delivery time is only three minutes. (The Digital finance Research Center of Peking University, 2017).

The two Taobao products through Ali Microcredit

Product type	Loan condition	Advantages
Loan on credit	→ No guarantee, no collateral. → Assess the credit line by comprehensively evaluating the credit status, credit risk and credit demand of the applicant. → Quota of 50,000 to 1 million yuan; the loan term is six months. → The daily interest rate is 0.06 percent and the cumulative annual interest rate is about 21 percent.	Not subject to regional restrictions; strong replicability; great development potential.
Loan on orders	→ Based on the seller's shop having shipped the product; the buyer has not confirmed the physical transaction order amount; the system gives the credit line and due to automatic repayment, this is an order pledge loan. → The daily interest rate is 0.05 percent, and the cumulative annual interest rate is about 18 percent. → The maximum limit is 1 million yuan; the loan term is 30 days.	Improves the utilization rate of funds; reduces operational risk.

Source: Li (February 2015), "The application of Big Data financial model in the field of small and micro loans is seen from Ali small loan," China Civil and Commercial Law.

Taobao uses accumulated massive transaction data from Alibaba, Taobao and Tmall e-commerce platforms as the basis for risk control, and thus does not need collateral and guarantees. Taobao operates online, covering the whole process of loan application, approval, delivery, post-delivery management, etc. Clients who want to apply for loans can log onto the home page of Ali Microcredit and submit the loan application form online. Ali Microcredit receives the loan application, the investigation team reads the transaction records of the customer on Alibaba B2B, Taobao C2C, Tmall B2C and other platforms, as well as using credit records, peer comparisons, inventory changes, accounting information, non-financial evaluations, credit investigation reports, bank statements and other information. In some cases, Ali Microcredit Company verifies the information off-line through an outsourcing agency.

For loan approval and delivery, Ali Microcredit has adopted the Probability of Default model to evaluate the credit rating of online merchants. According to the merchant's credit score and guarantees, the credit line, interest rate and term can be determined. If the loan is approved, the customer signs a contract with Ali Microcredit online, binding the personal bank card of the legal entity and Alipay account. After personal real-name ID authentication and Alipay authentication, the loan amount for delivery is confirmed.

In post-delivery management, the use of the loan, operation efficiency of the merchants and timely collection of loan repayments are monitored by using the transaction information and financial statement information of online merchants. This is called a monitoring scoring model and loan collection scoring model. Ali Microcredit uses the equal principal amortization and interest repayment method. The client transfers the repayment to regularly pay a virtual account on Alipay through a bank card or a sufficient amount remains in the virtual account on Alipay and money is deducted automatically by the Alipay payment system. If clients repay in advance, Alibaba charges a commission of three percent of the principal. (This charge appears to reflect the additional administrative cost of an unexpected transaction, which is an administrative issue traditional financial companies have normally been able to absorb). In the case of overdue payments, interest is calculated at 1.5 times the regular interest rate during the overdue period (The Digital finance Research Center of Peking University, 2017).

On 20 February 2014, the Ali Microcredit Company disclosed its 'hydrological model,'[36] a lending model based on the internet and Big Data. The hydrological model is a database of Ali-series merchants by category and layer of small and micro enterprises. The academic definition of a hydrological model is to symbolize the natural system and simulate hydrological phenomena through mathematical models. In the hydrological management of a city, for example, the hydrological model can help the government flood control authority predict the risk of flooding and make decisions.

Ali Microcredit interprets the hydrological model within the context of the credit business to have two important meanings. One is to improve risk management based on more detailed data and reduce the influence of special factors on credit judgment. The second meaning is related to the business plan and product sales; the hydrological model can predict trends in operations and capital demands of small and micro enterprises. By computing the change of data from the shop and the data of other similar stores, the system can identify future changes of customers and judge the future financing needs of stores. For example, on 11 November 2014, a mobile phone sales shop reached 3 million yuan in sales, much higher than usual. If one only looked at this time-specific data, a wrong assessment of the business would be made, and an inappropriate credit line could be approved for this shop. However, if this data is plugged into a hydrological model, changes in the store's operations at different times and seasons and the data from similar shops in the category would be reviewed, allowing a more comprehensive picture (Economic Daily, 2014).

In summary, Ali Microcredit is fully connected with the underlying data of Alibaba, Taobao and Alipay and its microcredit business is made possible through Big Data Cloud Computing and understanding customer network behaviour and internet credit. In Alibaba's Big Data system, tens of millions of small and micro enterprise's data on cash flow, growth conditions, the condition of credit records, trading, sales growth, warehouse turnover, complaint disputes, etc. are collected. Using this data, the Ali Microcredit system calculates and analyses more than a hundred indicators of the client, combining the qualitative analysis and quantitative evaluation on financial data provided by the enterprise and finally forming a standard for credit assessment. At the same time, some external data are introduced to match with the data of clients, such as tax and electricity expenditures, to form a set of unique risk control standards and establish a purely quantitative loan delivery model.

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36 A hydrological model is a mathematical model that simulates hydrological phenomena. The hydrological data of a basin are analyzed in the laboratory to form a mathematical model that can be reappeared and predicted, which is used to detect and predict hydrological phenomena of a basin. In China, this technology is used for flood control.

3. Development issues arising from FinTech

Southern countries, particularly in Asia, have represented the leading edge of the FinTech revolution. FinTech in Asia has been described as twelve years ahead of the world (Ruehl and Kynge, 2019, quoting Jan Metzger, Asia Pacific head of banking, capital markets and advisory at Citibank), while Africa and Latin America are FinTech expansion areas.

In Africa, drawing from an initial spurt of interest in Kenya's M-Pesa, mobile-based payment systems have expanded to other countries. Kaseem (2019: 1) characterizes FinTech growth in Africa through start-ups in mobile money, online payment processing, lending and investing as not necessarily "disrupting traditional financial services" but instead as "plugging large gaps that exist in local financial service industries." Sixty-six percent of Africa's adult population is unbanked. Financial inclusion appears to constitute the main thrust of African FinTech, in contrast to Asia where growth is organically driven by the possibilities of deploying FinTech to expand retail and other services as new business opportunities. Since M-Pesa's start-up in 2007, financial inclusion in Kenya increased from 27 percent 2006 to 83 percent.

In West Africa, the mobile money sector is 13 times larger than local banks (Kaseem, 2019). In Ghana, the mobile phone company MTN raised over $200 million in its IPO in 2018. Large international credit companies have been active in Africa. Visa and Stripe invested $8 million in Nigerian online payments company Paystack, while Mastercard invested $20 million in Flutterware, another Nigerian payment start-up. The numbers are modest by international standards but reflect growing interest. Flutterware signed a partnership agreement with Alibaba which enables African exporters to receive payments from Alibaba's one billion users. This last item, the exception that proves the rule, emphasizes how in Asia the starting point is not financial inclusion *per se* but to support the growth of business activities.

Chinese companies have been active in start-up activities in Africa. Two competing companies in payments systems in Nigeria, OPay and PalmPay have received $210 million in funding mostly from Chinese investors. Chinese investors are seen to be trying either of two strategies. One is to try to implant the successes of AliPay and WeChat in Africa. The other strategy is to make a quick capital gains profit, angling for a major IPO or by being purchased by a giant global payments company. The first play is contingent on steady economic growth in the formal sector in Africa (the factor that undergirded the growth of FinTech in China); the second play for capital gains is a customary investment strategy in the dominant international financial regime.

In Africa, regulatory constraints are seen to be inhibiting FinTech growth. The traditional financial sector has been supportive of such regulations, such as the proposal to require a high minimum capital investment (of at least $275,000) in FinTech start-ups in Nigeria as a condition for a license. Traditional banks are of course subject to minimum capital requirements. The question is whether the same kinds of regulations should apply to FinTech companies. FinTech companies have presented fierce competition to traditional banks by providing access to credit quickly by using smart phone call logs, contact lists and GPS data as data inputs to determine credit worthiness. Evidence is growing of a spike in personal debt. Kaseem (2019) suggests that "as lending apps jostle for market share and revenue from interest payments, there are fears they will inadvertently nudge users toward indebtedness and poor spending choices."

Financial authorities are well advised to evaluate the potential of such trends to inflict systemic vulnerabilities. It important to point out that the China case study in the previous section indicates that the regulation of FinTech-using companies was ring-fenced into the Regulation on Payment Service of Non-financial Institution framework; of course, it is also true, that under this framework, Chinese authorities have stopped issuing new licenses. In Latin America and the Caribbean, similarly notable growth has occurred in FinTech. In 2017, a survey by the IDB and Finnovista (a FinTech industry association), identified 703 Fintech start-ups in 15 Latin American countries. A year later, 1,166 FinTech start-ups had been identified in 18 countries of the region (IADB and FINNOVISTA, 2018). The same report indicates 85 companies out of 703 start-ups stopped commercial operations; however, there were 548 new start-ups in the same period. The numbers of companies once again appear to be modest by comparison internationally.

The main activities counted in the FinTech sector by the IADB and FINNOVISTA (2018) report are the following: digital banking; crowdfunding; enterprise financial management; personal financial management; wealth management; payments and remittances; lending; scoring; identity and fraud; insurance; and enterprise technologies for financial institutions. Payments and remittances are one category that has been important in Asian FinTech growth. One would expect FinTech evolution to be contingent on inherited social structures, wealth and income inequality. Unlike in Asia, where payments and remittances led the way, the services in which growth has occurred in this region are those needed by high income groups and not those of small businesses and start-ups. Thus, FinTech in Latin America appears to be concentrated in competing to serve the region's high-income groups, whereas in Asia growth has been small businesses and consumers, many in remote locations.

Countries of the global South must recognize that the future evolution of the FinTech sector is anchored at the financial end by global mergers and acquisitions and reorganizations, dominated by Northern countries at the global level. In 2019, the largest merger and acquisition reorganization involved the United States payments companies First Data and Fiserv (Sraders, 2019). In absolute terms, this trend is expected to continue. The extent of reorganizations and restructuring in the global South have themselves intensified. Southern countries need to have policies in place that protect their interests in this growing field and to secure a growth path consistent with their external macroeconomic stability, financial development ambitions and the emergence of a set of indigenous, internationally competitive, private enterprises which are critical for the long-term development of any developing country.

As exemplified in the China experience in the previous section, FinTech involves not just business-to-consumer transactions, but also a growing business-to-business dimension. The business-to-business dimension opens channels to support start-ups and the diversification of private sector business activities. Many of these businesses are small. For example, in Asia the serving of lunch to laborers on working days has provided business opportunities for small operations.[37] By expanding this kind of operation to food delivery made possible by digital payments, these kinds of small businesses have expanded and proliferated (Ruehl and Kynge, 2019) and eventually have achieved access to loans from companies related to delivery service enterprises.

FinTech has not only expanded and provided more efficient and timely financing for the working capital needs of business enterprises and individuals, but it has also contributed infrastructure for the remote international supply of labour. Some southern countries, in particular Bangladesh, have become big players in globally exporting ICT technical services, mostly through freelancing activities of its residents (Zaman, 2019). This has of course included computer programming and web design but has also included tax preparation and search engine optimization (in the case of the latter, one example is the Wild Fusion Digital Marketing Agency in Lagos, Nigeria). A few developing countries have attained competitiveness in web design services and computer programming. In fact, Northern companies are engaging in significant outsourcing of programming to India, Nigeria, the Philippines and other countries.

While these activities are not the core of FinTech, it is another venue through which FinTech technology arising from developing countries can be disseminated internationally. The provision of easy internet access in urban areas has introduced a wide range of work opportunities for many people in the global South, such as the examples given for Bangladesh and Nigeria. The range of FinTech-using economic activities that Southern countries must oversee and promote is very wide and expected to further proliferate in the future. As illustrated in the China case, while most FinTech applications began with providing internet-based and later mobile phone-based order and delivery systems, these have quickly expanded to mobile banking services and loan processing services. The China case demonstrates how starting from a prepaid mode of e-commerce, FinTech services have quickly evolved into providing financial services for the enterprises providing the consumer goods. While at the start, e-commerce was heavily dependent on pre-paid balances, it has become possible with the personal and enterprise data gathered from clients' economic transactions to make rapid loan decisions. This is disrupting the traditional financial sector.

37 See the case of the Rice Basket Queen in Jakarta presented in Section 1.3 of this chapter.

The next stage for the disruptive impact of the information advantage of FinTech is its entry into insurance markets. Armed with personal data, FinTech companies can offer competitive insurance premia basically by discriminating between insurance buyers. In most traditional financial sectors, the insurance market is an important source of long-term finance and subject to public regulation. At the moment, most insurance from FinTech is not yet quantitatively important, but when it does become large enough, these operations will have to be incorporated into the main financial sector activities. In the traditional financial sector, insurance companies are heavily regulated with regard to where the premiums of their insurance holders are invested. These regulations must eventually apply to FinTech-based providers when they become quantitatively important because their failure could have systemic implications – such as the near-failure of AIG in the 2008 financial meltdown. The ability of FinTech-based insurers to price-discriminate also puts the traditional insurance companies at a disadvantage which could mean either those traditional insurers will increasingly rapidly lose their markets to those that are FinTech-based or that this model will become standard in traditional companies as well. The issue is whether or not the standard regulatory approaches to where insurance companies can invest their funds would apply. The potential is strong that this new insurance model will result in shrinkage of the long-term funds that insurance companies are accustomed to contributing to financial markets.

3.1 INGREDIENTS AND CONDITIONS FOR FINTECH'S GROWTH IN DEVELOPING COUNTRIES

The growth of FinTech has been spectacular in Bangladesh, China, India and Southeast Asia and uneven and halting in many other parts of the global South. In Asia, almost 800 companies have received venture capital or private equity financing since 1986, including 266 start-ups in China, 190 in India and 183 in Southeast Asia (including 44 in Indonesia and 86 in Singapore). The emergence of FinTech has been most rapid when the actors involved in start-up efforts have not been from the traditional financial sector. This is exemplified in the China experience highlighted in the previous section and in many other countries in Asia (Ruehl and Kynge, 2019). On the contrary, South Africa, for example, has found that growing a consumer base for M-Pesa-types of businesses has been slow. One explanation is that South Africa's traditional financial sector is globally competitive in terms of services and technological innovation; it is estimated that 70 percent of South Africans are already banked (Tshabalala, 2015).

Africa and Latin America are FinTech expansion areas. The main trends in this expansion are in the provision of traditional banking services, taking advantage of the faster processing and lower costs made possible by FinTech. The faster African growth path has notably involved expanding services to the currently unbanked. In Latin America, notable innovations have been in the digital distribution of insurance, the availability of automated algorithms for asset management and online mutual funds, including facilities for investing in equity markets. FinTech start-ups in wealth management provide platforms "that simplify the configuration of investment portfolios: they compare consumers' profiles to their goals and the risks associated to financial instruments" (IADB and FINNOVISTA, 2017: 65).

In reality, the core technology involved in FinTech are those that are critical for error-free and more rapid back-office operations of traditional financial companies. Incumbent financial companies have integrated these technologies but have been slow to apply these to expand their clientele and activities. The growth of FinTech, instead of building on the problem of expanding activities and access to financial services, has sought to solve the problem of expanding access to goods and services at the retail level. Internet services provide the infrastructure to widely demonstrate the availability of goods, such as furniture and appliances, and services, such as transportation and food delivery. The financial step that had to be solved was the question of how to retail these goods and services over a wider space.

Retail services are a historically important sector, yet one that development policy has tended to disregard. In the 1890s, the rise in the United States of the catalogue-order business Sears, Roebuck and Co.[38] depended on internalizing the risk of financing in delivering retail goods to remote locations (Emmet and Jeuck, 1950). In China, the comparable FinTech experience began in a less risky mode. FinTech companies in China did not internalize the risk of financing as in the Sears, Roebuck and Co. case, but began by offering pre-paid balances to users – basically taking deposits in the beginning, against which the companies could charge purchases. This then evolved into financing retail activities, then into providing consumer finance; a similar scenario is also occurring in Southeast Asian countries.

The start-up in 2005 of the M-Pesa payments system was made possible by a grant from the UK's Department for International Development as a means to expand access to financial services. M-Pesa did not start like FinTech companies in Asia that were initiated to remove obstacles to expansion of retail services, but rather was a means to expand financial inclusion. M-Pesa is based on the purchase of airtime from mobile phone providers, which in effect makes it a pre-payment service, with the added facility for users to be able to transfer balances and make cash withdrawals. Original M-Pesa target users were those involved in microfinance activities. The operators of M-Pesa did not have the legal status of banks and could not take deposits. However, by providing a money transfer and withdrawal facility, M-Pesa users could purchase airtime, deposit and withdraw money, transfer money with accounts of some banks, transfer balances to other M-Pesa users, pay bills and accumulate savings in a virtual account called Mshari. Providers collected transaction charges based on the kind of transaction and the size of the transaction.

Like its microfinance antecedent, M-Pesa was shown to reduce poverty *and* mitigate gender inequality (Suri and Jack, 2016). Suri and Jack (2016) proposed that by facilitating the movement of clients out of agriculture into business through the facilitation of mobile payments, M-Pesa lifted 194,000 Kenyans out of poverty,[39] a high proportion of these being female-headed households. However, questions have arisen as to the high costs of M-Pesa loans (and even ringtones) and similar types of systems (Bill and Melinda Gates Foundation, 2013). These higher costs of lending were attributed to various factors, but mainly to the lack of competition by mobile payments providers. In 2009, the traditional banking sector of Kenya sought an investigation into M-Pesa, no doubt prodded by the competitive pressures its operations had been exerting on incumbent companies. The investigation found the finances of M-Pesa to be sound; this is consistent with the monopoly commercial positions enjoyed by the limited number of companies involved, who can adjust their fees accordingly. This structure of regulated monopoly mimics that of the traditional financial system, in which limitations on excessive growth, entry and risk taking have also proven to be important regulatory policies in ensuring financial soundness in the banking system.

The following questions need to be asked by developing countries regarding their FinTech policies: 1) What kind of policies and public activities are needed to promote the steady and safe growth of FinTech? and 2) How shall the disruptions of financial services and expansion of related services be incorporated into the regulatory and macroeconomic responsibilities of authorities?

If FinTech principally provides payments and basic financial services for the unbanked in an economy with tepid or unstable growth as a result of a slow rate of structural change, it will basically be providing services to a subpopulation which traditional financial companies consider too expensive or too unprofitable to service. In such a situation, to secure the financial viability of FinTech firms themselves, government authorities will have to allow the price of their services to rise closer to the rates that traditional financial firms would have levied on clients with comparable credit records. This is how microfinance evolved in many slow-growing developing countries (Vasudevan and Raghavendran, 2019). On the other hand, if the overall economy is growing steadily at high rates, then the informational advantage of FinTech firms makes them highly suitable to provide financing for the startup ventures of the unbanked population in a dynamically growing economy, as it was in China.

38 Recently driven into bankruptcy through financial engineering-motivated maneuvers (Parramore, 2015).

39 Methodological questions have arisen regarding these results (Bateman, Duvendack and Loubere, 2019).

Based on elements found in recent successes, the policies below can help promote FinTech for development in global South countries.

1. Governments have the primary duty to install steadily expanding access to the internet, reliable power and other basic infrastructure services. The relative efficiency and competitive cost structure of FinTech and their ability to gather information for expansion and to coordinate across separate markets depend heavily on this overall support. Despite wonderful cases of success, Southern countries, many parts of which remain unelectrified, are at quite a disadvantage in this growing field when their consumers, producers and sellers do not have reliable power sources. Countries of the South must recognize that FinTech innovators in China could count on these basic services, including an adequate road network. Without the provision of basic infrastructure, FinTech cannot be a panacea for poverty reduction and transformational change; this is putting the FinTech cart before the horse of basic infrastructure. With basic infrastructure, FinTech provides enormous opportunities.

2. An overwhelming majority of commercial intellectual property is owned by private citizens and corporations in the North. This is also true regarding registered FinTech intellectual property, though China is catching up both in digital and non-digital registrations. Because of this imbalance, governments in the South must facilitate access of FinTech firms to software and source codes. Very often, demands are made of governments to enforce claims of private intellectual property ownership over software. For the most part, software and operating systems are not patentable and not subject to protections. Further, it has become fashionable to prohibit governments from requiring disclosure of source codes related to equipment and programmes imported from abroad, as exemplified in Article 14.13 of the Comprehensive and Progressive Trans-Pacific Partnership agreement (CPTPP).[40] Southern governments should avoid accepting these kinds of prohibitions. The inability to access source codes has commercial security dimensions; when local users lack access to such codes, external hackers can halt the operation of programmes or modify their operations at will. Thus to protect the financial system, user and consumer source codes should be accessible for programmes and equipment being used locally and governments should facilitate the access of their societies to data sets, particularly those gathered from their own populations. Large data bases gathered from consumer behavior and from data mining are often stored in the North because of the superior resources these countries have; this creates a specific challenge for the South. The status of ownership of these data sets (or whether they can even be privately owned) is still unresolved. These data sets have great commercial value in machine learning to improve software and build the competitiveness of local FinTech companies.

3. Governments can promote FinTech-building research and development activities in its universities and research institutes. Once again, Northern countries fund research activities and have a political constituency in the universities to support research. Despite their limited public finances, Southern governments have to find the means to provide research support.

4. In successful cases, governments have given FinTech-using start-ups space to introduce their services and test the sustainability of their business model in the market. There should be no need to provide start-ups with direct subsidies (beyond those indirectly provided through sound and reliable infrastructure) for their ventures. Governments should also avoid imposing regulations early, including many suggested by incumbent firms, on their financial operations. Regulations that apply to

40 The Comprehensive and Progressive Trans-Pacific Partnership agreement (CPTPP) is a free trade agreement signed by 11 countries in the Asia-Pacific region, which went into force on 30 December 2018. There were originally 12 countries, but in 2017 the United States withdrew. CPTPP is notable for encompassing 495 million consumers and 13.5 percent of global GDP; because of this, its agreed standards will be more easily importable into the WTO. CPTPP is also notable for a new chapter not seen in other free trade agreements entitled Electronic Commerce. In this chapter, Article 14.13 states "No Party shall require the transfer of, or access to, a source code of software owned by a person of another Party, as a condition for the import, distribution, sale or use of such software, or of products containing such software, in its territory." A party is any of the signatory countries. The main importance related to economic space of the prohibition is explained in the main text.

labour rights and tax liabilities are in a different category; for these categories, governments, incumbent companies and FinTech start-ups should work together to formulate effective adjustments to existing regulations. So far, no notable cases of regulatory innovation have arisen in the South. The cases are in the North, where, as an example, legal and regulatory controversies exist over whether Uber drivers are independent contractors or employees subject to labour protections.

3.2 INCORPORATING FINTECH INTO MAINSTREAM ECONOMY AND FINANCE

As has been evident from experiences over the last decade, FinTech's expansion has encroached significantly on mainstream finance. In successful areas, governments and regulators have taken a stance of forbearance which permitted FinTech applications to proliferate. Traditional financial companies have been seen to resist the competition from FinTech, requesting governments to limit their activities. The China experience discussed above is instructive. In 2010, the People's Bank of China Regulation on Payment Service of Non-financial Institutions introduced a system of licensing within which FinTech would be allowed to grow but would be separated from the regulations applied to the traditional finance sector. By the end of 2015, after issuing 270 third-party payment licenses, the People's Bank of China paused issuing licenses in response to some perceived irregularities in behavior. The expansion and proliferation of FinTech activities are a fact of life and societies must find ways to incorporate the sector productively into their economies and their development efforts. FinTech-enabled economic transactions have changed the behaviour of consumers and the nature of the operations of small private enterprises.

While financial companies in the traditional sectors have extensive experience in providing services and processing loans to operations with established accounting records and to wealthy individuals, they are at a distinct disadvantage when seeking to serve unbanked individuals and small businesses (including start-ups in this sector). The China case study in Section 1 discussed how even microfinance firms have found it too costly in terms of internal administrative procedures to provide financial services to very small operations. The China case study also demonstrated how FinTech companies are able to accumulate data at a low cost regarding the payment habits and credit worthiness of individuals and small businesses. Thus, companies in the traditional financial sectors are at a distinct disadvantage in this market segment. On the one hand, they find it too costly to service these clients. On the other hand, the financing needs of these clients represent an important and, from a policy standpoint, a key priority for most governments.

Public policy has to find a way to bridge the gap between FinTech and the incumbent financial sector. Incumbent financial sector firms have regulatory burdens stemming, for example, from their deposit insurance, know-your-customer and anti-money laundering responsibilities, which FinTech firms do not have to meet. Supervisory authorities over the financial sector must monitor the larger FinTech firms. In the case of China, notably, the granting of licenses to FinTech firms has stopped; this kind of action creates accountability on the part of the incumbent FinTech firms to supervisory activities without the legally mandated responsibilities. No guarantee exists that all (or even a big proportion) of FinTech firms will survive or prosper. But both their introduction of finance to new sectors and their technological innovations are of great value to a developing economy. Governments must in the first instance ensure effective modes of ring fencing the risks inherent in FinTech from the mainstream financial sector. While the traditional sector should be encouraged to expand their services to those not currently being served, it is important that their leverage is not unduly stretched into either serving or providing resources to the rising FinTech activities.

Public policy has to facilitate the accumulation of data on local economic activities and clientele both in the FinTech and traditional sectors to manage systemic risk. For this reason, financial supervisory authorities must require secure access to the data of all companies operating in the financial sector, even though they do not regulate these in the same manner. Making sure that the data is locally accessible is critical and public authorities should eschew international commitments that prohibit the local storing of financial data as is being proposed in the WTO and in free trade agreements.

In the South, Argentina, Brazil, China, Colombia, India, Indonesia, Iran, Malaysia, Nigeria, Viet Nam and Venezuela have various restrictions requiring the storing of data in domestic servers. This is particularly critical for financial regulation; thus, it is more notable that very few South countries have such requirements. It is also important for public policymakers to be able to protect their policy tools to enforce policy changes and regulations. FinTech, in particular, is susceptible to situations in which financial services are being provided and systemic and exchange rate vulnerabilities are being impacted, even when the service provider is not located in the public supervisory jurisdiction as a corporate entity. While this section recognizes the importance of regulating FinTech differently from the traditional sector, domestic authorities must maintain the ability to enforce policies and impose penalties on corporate actors even when located overseas. For this reason, it is critical to require FinTech firms to incorporate locally and maintain a local presence.

4. South-South Cooperation and FinTech

4.1 FINTECH OPERATIONS IN MULTIPLE COUNTRIES AND JURISDICTIONS

While FinTech has grown tremendously in the global South, FinTech's role in solving development challenges is unexplored and untheorized. FinTech's continued evolution is undisputable, but it's role as part of development policy and strategy needs to be shaped among Southern governments and practitioners in parallel with its growth worldwide and that of the digital economy in general; a growth that is currently primarily driven by the individual actions of sovereign states and large international private companies.

Having said that, cross-border business operations among developing countries do exist, as many FinTech-using corporations are operating in multiple countries, especially within subregional areas. A well-known example is Grab, a Singapore company operating in East Asia which is an Uber-style ride-sharing company. Grab is also involved in food delivery and urban transportation services. In line with the evolution of FinTech companies, Grab and its subsidiaries are rapidly becoming financial service companies too. As in other regions of the world, a variety of approaches are used to regulate public transportation in different East Asian countries, not to mention the regulation of FinTech companies themselves. Through intentional South-South Cooperation arrangements, for instance, countries in the region could establish a consultative body on these regulations which could greatly facilitate the promotion of the activities of local subsidiaries of these companies and expand access to these services. For underserved areas, South-South Cooperation consultative bodies could facilitate the emergence of local operations within the umbrella of regional investors.

4.2 GLOBAL SOUTH PARTICIPATION IN SETTING INTERNATIONAL REGULATIONS AND STANDARDS

A newly emerging and intense debate[41] is taking place about the need to regulate and ensure that digital technologies do not undermine social and democratic objectives. Initiatives in the World Trade Organization and the OECD often set rules on tariffs, regulations and trade that are more advantageous to large companies headquartered in advanced economies. Meanwhile, African countries are coordinating their

41 As an example of the elements of this debate, see United Nations, Inter-agency Task Force on Financing for Development, *Financing for Sustainable Development Report 2020*. (New York, 2020), which devoted a separate chapter, Chapter II, pp. 15-21, to the opportunities and pitfalls represented by FinTech, including questions of financial regulation (https://developmentfinance.un.org/fsdr2020).

negotiating position in dealing with proposals from the global North regarding rules about the treatment of digital businesses worldwide. The most significant of the Northern country proposals includes making permanent those temporary market access and tariff suspension agreements currently in effect. Northern proposals also aim to prohibit WTO members from requiring that data gathered from local citizens be kept in local servers and from requiring the disclosure of source codes for apps used locally.

The international legalization of these proposals could have a profound impact on the ability of Southern governments to regulate digital companies and their activities and to obtain public revenues from their operations. India and South Africa unilaterally imposed taxes on select transactions of foreign digital companies in their jurisdictions in violation of the OECD Base Erosion and Profit Shifting Project (BEPS) prohibition against unilateral measures that was in effect until 2020, when the BEPS project was scheduled to complete proposals for the tax treatment of digital companies (OECD, 2021"Action 1: Tax Challenges Arising from Digitalization.) The lack of consensus has required additional public consultation delaying progress in this effort, and participants in the consultations are working against a new deadline of July 2021. On 10 July 2021, G20 finance ministers, working within the policy boundaries set by the 13 June G7 Cornwall communique, agreed on a minimum corporate income tax and limited methods of sharing profits made by multinational companies in tax jurisdictions where they have no physical presence.[42] To operationalize these agreements, details are being worked out and the next deadline is the outline of the G20 summit, 30-31 October 2021 in Rome. A set of studies suggests that the revenue impacts of these proposals can be significant, particularly for the South (Banga, 2017; OECD 2019; Hoksu-Lee and Narayana, 2019). It is notable that both the OECD and the WTO are venues not embedded in the United Nations where the default approach is to ensure that all countries have a voice in setting rules.

In recognition of the significant progress achieved in FinTech in the global South, under the umbrella of South-South Cooperation, it is recommendable for Southern countries to organize coordination mechanisms in their negotiations and participate in fora that affect them, notably the OECD, the WTO and the United Nations. The South Centre[43] is providing technical support for developing countries negotiating in the WTO on the digital economy. The South Centre also convenes an annual forum of developing country tax officials and administrators through which developing countries have recently consulted among themselves on their policies with regard to the tax treatment of digital companies. The Intergovernmental Group of Twenty-Four on International Monetary Affairs and Development (G-24) has designed a proposal more conducive to developing country interests in the tax treatment of digital companies.

Such efforts should be expanded and subcommittees on specific topics created that are responsible for questions about developing country positions on rules affecting FinTech. Consultative events among developing countries can prepare them to coordinate their positions in other venues, such as the IMF, the World Bank and regional financial institutions, because in many instances, the outcomes of products of these institutions act against the interests of developing countries. As a matter of South-South Cooperation and in order to reduce costs, Southern countries should consider establishing expert councils populated with experts from developing countriesto give them advice about current and future questions on the digital economy (Montes, 2019).

42 For the G20 finance ministers' communique, please refer to Italian G20 Presidency (2021). For the G7 communique, please refer to White House (2021).

43 According to their website, the South Centre is an "intergovernmental organization of developing countries that helps developing countries to combine their efforts and expertise to promote their common interests in the international arena. The South Centre was established by an Intergovernmental Agreement which came into force on 31 July 1995. Its headquarters are in Geneva, Switzerland."

4.3 SOUTH-SOUTH COOPERATION TO PROMOTE FINTECH GROWTH AS A DEVELOPMENT TOOL

The most important opportunity FinTech offers the global South is that its propagation has the potential to change the nature of markets and economic transactions, which could speed up both economic growth and poverty reduction, particularly by facilitating small business start-ups (Suri and Jack, 2016). South-South Cooperation can be used to promote the more rapid growth of FinTech as a development tool. The reality is that the uptake of FinTech is very uneven among developing countries. Important lessons learned – both successes and failures – are on record. As a matter for South-South Cooperation, leading Southern countries could intensify their efforts to share their methods, software and regulatory frameworks with other developing countries through technical cooperation.

The African record, notably Kenya, highlights the potential to rapidly provide services to those without bank accounts. The Latin American experience, especially in Brazil and Uruguay, underscores the potential for FinTech to provide facilities for wealth management and to adapt digital technologies to standard banking operations (IADB and FINNOVISTA, 2017). The East and Southeast Asian experience highlights the potential of FinTech to promote the expansion of small real sector businesses and services.

Many shared experiences exist, of course, but each Southern country has a unique situation in terms of experience and possibilities in building its FinTech sector. When countries with extensive FinTech sectors share their experiences with other countries in their region and the rest of the global South, the recipient country must make appropriate decisions for their unique circumstances and design the best path forward to take full advantage of the technology and the market development that FinTech affords.

5. Conclusion

FinTech presents enormous possibilities for the expansion of business opportunities for unbanked and asset-poor segments of the population in developing countries. FinTech has grown most rapidly and robustly where it has facilitated the growth of real sector activities. As was noted in the examples, the evolution and growth of FinTech in China has been both innovative and remarkable. FinTech also continues to grow as a tool for expanding financial inclusion in China, but with a relatively lower speed than in other developing countries.

The chapter identified some challenges to promoting the growth of FinTech. First, it is important that the real sector of the economy, the formal sector, is growing steadily, considering the risk that a FinTech expansion could share many of the problems experienced with microfinance (previously considered a silver bullet for poverty reduction) including over-indebtedness. Second, governments are making policies seeking to integrate FinTech in their development toolkits. It was proposed that when FinTech is not yet quantitatively important in a country, governments forbear the imposition of standard financial regulations on FinTech. Thus, it is suggested that governments of the South assume that FinTech will eventually become significant, and authorities should enter into unmapped policy territory sooner rather than later.

As a matter for South-South and Triangular Cooperation, FinTech is a ripe area for expansion. Technical elements can be shared among countries of the South as many of the approaches are particularly suited to situations in developing countries. The international grip on the FinTech policy space in the global South, emanating from such sources as the WTO and OECD in regard to setting standards and the regulatory treatment of FinTech companies, can be loosened via closer consultation and more concerted activities among developing countries.

Chapter 6

Digital health and South-South and Triangular Cooperation

1. Introduction

Digital health is the application of digital technologies for health purposes. According to the World Health Organization (WHO), digital health is rooted in electronic health (eHealth), which is "the use of information and communications technology in support of health and health-related fields." Mobile health (mHealth), in turn, is a subset of eHealth and is described as "the use of mobile wireless technologies for health." More recently, digital health has come to be understood as "a broad umbrella term encompassing eHealth (including mHealth), as well as emerging areas, such as the use of advanced computing sciences in Big Data, genomics and artificial intelligence" (WHO, 2019). Digital health, in short, spans the entire breadth of the health sector and technologies involved.

Diverse digital technologies are being used for a wide range of health applications, spanning health research (e.g. data collection and sharing), clinical care (e.g. diagnostics, clinical procedures, post-operative follow-up), public health practice (e.g. disease surveillance, health promotion) and health systems functioning and management (e.g. information systems, financial management). For all of these areas of health application, digital technologies are potentially transformative.

Public and private sector investment in digital technologies for health purposes have grown in pace, scale and breadth over the past three decades. This has been driven, foremost, by rapid advances since the 1980s in computer technology, enabled by the invention and commercialization of the microprocessor chip (microchip) which, in turn, increased the capacity and lowered the cost of ICT. These technologies found immediate application in the health sector. Given the health sector's need to manage large amounts of diverse forms of data (e.g. research data, patient records, budgeting), digital technologies offered improved means of generating, storing and sharing such data.

The exponential growth of microprocessor capacity over time, combined with broadband technologies (e.g. cable, satellite, digital subscriber line) that could send and receive ever larger amounts of digital data, subsequently opened digital communications for additional health applications. One prominent application was the remote delivery of clinical care, known as "telehealth," which was driven by the desire to expand services in cost-effective ways (Nesbitt, 2012). The rapid development and uptake of mobile technologies, notably from the mid-2000s, led to a proliferation of other innovations in such applications as diagnostics, surveillance and health promotion, collectively known as mHealth (Waegemann, 2016). Lower costs and the expansion of mobile technology networks worldwide made it possible to overcome limited infrastructure and reach underserved populations at lower costs. Finally, since the mid-2010s, the continued expansion of the computational capacity of digital technologies has spurred health-related applications of Big Data analytics (analysis of very large volumes of data using quantitative and qualitative techniques to explore trends and patterns), informatics (application of data for improved decision-making and action), artificial intelligence (performance of tasks by computer systems normally requiring human intelligence) and cyberphysical systems (the use of computer-based algorithms to control or monitor a mechanism within a system).

Health-related applications include bioinformatics (the science of collecting and analyzing complex biological data, such as genetic codes), precision medicine (customization of health care tailored to the individual patient), smart healthcare (using new generation information technologies to transform the traditional medical system to be more efficient, convenient and personalized) and contact tracing during outbreaks using cyberphysical systems and AI (Agrawal, 2019; Tian et al., 2019; Guttman, 2020). These applications are transforming health research, clinical and public health practices and healthcare management and delivery.

While these advances, collectively known as the Fourth Industrial Revolution, have been primarily driven by public and private sector investment and application in high-income countries, many argue the greatest benefits in the health sector from digital technologies are yet to be realized in the global South. This is because many believe digital health offers unprecedented opportunities to improve access and affordability of health care for underserved populations, in particular by "leapfrogging" limitations of traditional infrastructures and allowing for lower costs (Burki, 2018; Mitchell and Kan, 2019). The relatively small differences by 2019 in the number of mobile-cellular (128.9 compared to 103.8) and mobile-broadband (121.7 compared to 75.2) subscriptions per 100 inhabitants between developed and developing countries is seen as especially promising. As a result, there has been substantial interest in extending, adapting and applying new digital technologies to address unmet health needs and advance health development goals in the global South over the next century. This interest is reflected in the proliferation of projects supporting digital health for development (WHO, 2018; Ngoc et al., 2018).

The purpose of this chapter is to review the key opportunities for digital health to advance development goals and the potential risks and challenges to be navigated to realize potential gains. For this review, the focus is specifically on health-related Sustainable Development Goals, notably the health-focused SDG 3, along with commitments to Universal Health Coverage as a major goal for health reform in many Southern countries and a priority objective of WHO (Darkoh and Sargent, 2017; WHO, 2019). The chapter starts by identifying major opportunities for health development, applying WHO's classification of digital health interventions and illustrates the topic with case studies. Next, the main risks and challenges of expanding digital health for sustainable development, as faced in the global South, are reviewed. The potential role of South-South and Triangular Cooperation in advancing potential opportunities and mitigating the risks and challenges is considered and finally conclusions are offered.

2. Opportunities for advancing health systems through digital technologies

Four decades ago, when the Declaration of Alma-Ata[44] was agreed, information and communication technologies were newly emerging. At the time, the adoption of these technologies in health services was complex, costly and limited. The commonplace technologies of today, such as smart phones, tablets and laptop computers, did not exist. However, by 1990 new technologies – notably the internet – had begun to have a revolutionary impact. As technologies became more advanced, more assimilated in all sectors and mainstreamed into society, their remarkable value for health became apparent. From technologies that allow people to manage their health more effectively, to better ways of diagnosing disease, to monitoring the impact of policies on populations, these digital technologies for health, or digital health, profoundly affected how health services were delivered and how health systems were run. The impressive trend in national policies for digital health (more than 120 countries had such policies by 2015) reflected the firm commitment to using digital technologies to advance the Sustainable Development Goals, support universal health coverage and shape the future of primary health care.

Today, digital health has become a salient field of practice and employing both routine and innovative forms of ICT to address health needs is commonplace. The World Health Assembly Resolution on Digital Health, unanimously approved by WHO Member States in May 2018, demonstrated a collective recognition of the value of digital technologies to contribute to advancing Universal Health Coverage and other health aims of the Sustainable Development Goals. This resolution urged ministries of health "to assess their

44 According to the WHO website, "the Alma-Ata Declaration of 1978 emerged as a major milestone of the twentieth century in the field of public health and it identified primary health care as the key to the attainment of the goal of Health for All."

use of digital technologies for health [...] and to prioritize, as appropriate, the development, evaluation, implementation, scale-up and greater use of digital technologies." Furthermore, the resolution tasked WHO with providing normative guidance in digital health, including through the promotion of evidence-based digital health interventions.

Amid the heightened interest in digital health, project implementations have been characterized by roll outs in the absence of careful examination of the evidence base on benefits and harms. The enthusiasm for digital health has also driven a proliferation of short-lived implementations and an overwhelming diversity of digital tools, with a limited understanding of their impact on health systems and people's well-being. This concern was highlighted most notably in the consensus statement of the WHO Bellagio eHealth Evaluation Group, which opened by stating: "to improve health and reduce health inequalities, rigorous evaluation of eHealth is necessary to generate evidence and promote the appropriate integration and use of technologies." While recognizing the innovative role those digital technologies can play in strengthening health systems, an equally important need is to evaluate their contributing effects and ensure that such investments do not inappropriately divert resources from alternative, successful, non-digital approaches.

Electronic health records, the use of smart phones and smart watches, electronic medical prescriptions, artificial intelligence, e-learning and many other existing digital technologies can play a vital role in improving patient safety, raising awareness of health education, training health care professionals and empowering patients and families. No region is better positioned to benefit from the digital revolution in healthcare than the global South, where technology can help tackle the rising burden of disease and major obstacles related to infrastructure and the operating and regulatory environments. However, realizing the promise of digital healthcare technology, while avoiding its potential pitfalls, will require a comprehensive, systematic approach based on the principles of sustainability, equity and inclusion. Public health challenges are well known in this region. Health infrastructures for preventative measures, diagnosis and treatment present their own problems, especially coupled with the limited capacity and poor state of many Southern country health systems and their inadequate ability to support the delivery of health services.

Digital technology holds enormous potential to bridge such gaps in healthcare provision by directing limited medical resources where they are most needed. While recent decades have seen major progress in the treatment of diseases, such as HIV/AIDS and malaria, the global South still suffers from a disproportionate disease burden along with a rising incidence of chronic diseases, such as diabetes, heart disease and cancer. In 2016, non-communicable diseases accounted for 41 million of the world's 57 million deaths, compared to 38 million deaths in 2014 (according to the WHO report on non-communicable diseases), marking an increase of three million deaths within a short time span. Alarmingly, 78 percent of non-communicable disease deaths occurred in low- and middle- income countries (NCD country profiles, 2018).

As it is painfully visible, a large number of Southern states lack the necessary infrastructure to provide basic health care to their citizens. Mobile phones, mobile applications, telemedicine, medical drones and other solutions that mostly by-pass traditional infrastructures and services hold the future. Telemedicine has been shown to be a cost-effective alternative for the delivery of routine care, especially among rural populations with limited access to subspecialty services (Agha et al., 2002). Cost effectiveness of telemedicine is related to three major factors: 1) cost sharing, i.e., adequate patient volume and sharing of telemedicine infrastructure among various clinical users; 2) effective patient utility and successful clinical consultations; and 3) indirect cost savings accrued by decreasing the cost of the lost productivity of patients (Agha et al., 2002).

Digital technology has had positive effects on a wide range of sectors in society, including agriculture, economics, education and socio-politics. Digital technologies have transformed the way people work, shop and socialize. Digital technologies are also changing the landscape for healthcare providers and patients at an unprecedented rate. The convergence of science and technology in the current dynamic digital era has resulted in the development of innovative digital health devices that allow easy and accurate specification of health and disease processes. It spans a vast array of technologies and applications, including patient monitoring, virtual reality rehabilitation, accurate prediction of medical outcomes,

clinical decision support, wearable medical devices and many others. Digital health has the potential to help reduce inefficiencies in healthcare delivery, improve access to healthcare, reduce healthcare costs, increase quality of care, make health services more person-centered and personalize medicine for each patient's unique needs.

This wind of revolution in health care is blowing across different parts of the world, including the global South. Digital health is offering great opportunities to strengthen and transform weak health systems and combat everything from maternal and child illness and mortality to chronic and infectious diseases. Mobile network infrastructures through cell phones and the internet are allowing remote and isolated communities to communicate in real time in ways that had not been possible before (Curioso et al., 2005). Information previously only available in specific locations or to specific populations is now widely available to physicians, health workers and patients. Diagnostic tools delivered at the point of care, perhaps through a cell phone, a personal digital assistant or a web camera, are expanding the ways in which people can receive care. In many countries, private and public organizations are working together to use social networking and other media to encourage healthy behavior, assist patients in monitoring their care, train health care workers, track disease outbreaks and improve diagnostic and treatment support (Mechael et al., 2008).

Many of the digital health innovations now emerging originated from the ingenuity of social entrepreneurs in Africa, Asia and Latin America. Collaborations throughout the global South among private sector telecommunications companies and nongovernmental organizations, academic institutions and software development groups are helping advance innovations that can improve people's health and well-being. Some technological advances have been happening, and will continue to happen, first in the developing world because there are less entrenched interests blocking the way. For example, a free software programme called EpiSurveyor allows health workers in Kenya to efficiently track disease outbreaks using web-based data-gathering tools on their mobile phones. This software has been embraced by Kenya's ministry of health, yet it is unlikely to enter developed markets quickly.

Digital health innovations that originate in the South have taken many forms. According to the WHO 2018 classification of digital health interventions, these innovations fall under four broad groups, based on the targeted primary user (WHO, 2018). The intervention groups are:

1. clients — members of the public who are potential or current users of health services, including health promotion activities and caregivers of clients receiving health services;

2. healthcare providers — members of the health workforce who deliver health services;

3. health system and resource managers — those involved in the administration and oversight of public health systems; interventions within this category reflect managerial functions related to supply chain management, health financing and human resource management;

4. data services — this consists of crosscutting functionality to support a wide range of activities related to data collection, management, use and exchange.

An example of an intervention for clients is Ghana's Mobile Technology for Community Health (MOTECH). MOTECH was designed to narrow the gap in the use of health services to reduce maternal and neonatal deaths and improve the health of pregnant women and infants. MOTECH's two interrelated mobile phone applications, Mobile Midwife and Nurse Application, reach clients and health care workers in poor rural areas. Mobile Midwife sends targeted, time-specific, evidence-based voice messages containing important health information to pregnant women and new parents in their local language. Nurse Application helps community health nurses electronically record the care given to patients and to identify clients, both mothers and infants, who are due for critical care. The innovative use of voice messages in local languages sidesteps low literacy and gives the messages more credibility. Another key innovation is that MOTECH's two applications function together to cross-enable appointment reminders for patients and nurses. Each week, nurses receive on their mobile phone lists of clients whose care is overdue, enabling

them to plan their outreach and home visit schedules to maximize coverage. The flexibility of MOTECH's core technology and its open-source license ensure that the government of Ghana can extend it into new health areas, such as inventory tracking.

Other countries and organizations also have created interventions for client-based digital health projects. In South Africa, the Praekelt Foundation (which develops innovative mobile technology solutions) and the University of Cape Town are partnering to build and deploy platforms for HIV and AIDS prevention and treatment. In India, Asia Media Labs are developing and deploying data collection support tools for community health workers and gaming systems to promote behavior change. Gamification for health promotion refers to the learning experience platform that engage, unite and upskill for a wide variety of behavior change. Gamification improves health literacy for patients, students and doctors and is being used in some tele-health programmes to educate patients, health workers and the general populace. In Peru, the Universidad Peruana Cayetano Heredia is conducting research and training in biomedical and health informatics. In Ghana, a programme called m-Pedigree is using cell phones to identify and reduce the use of counterfeit drugs. In Rwanda, a cell phone-based technology called TracNet is helping follow patients and their treatment.

The following are examples of interventions for healthcare providers. In an intervention targeting health care providers, UNICEF and the Uganda Ministry of Health are rolling out an e-health solution called mTrac, which enables real-time monitoring of disease surveillance, drug stocks and health service delivery using text messaging (SMS) built on a web-based data aggregation and analysis platform using open source RapidSMS software. mTrac takes advantage of the rapid growth in telecommunications infrastructure, network coverage and mobile phone penetration. Health facility and community health workers use their own mobile phones at no cost to submit weekly disease surveillance and ACT drug stock reports on a health management information system form. This weekly information is managed on a web-based dashboard by district health teams, the Ministry of Health and other national stakeholders who can generate reports to facilitate planning and monitoring. To strengthen community monitoring, mTrac has an anonymous, toll-free SMS-based hotline for reporting health service delivery problems.

In August 2010, WHO in Cameroon rolled out a health care worker intervention that employed a cost-effective strategy using ICT to strengthen epidemiological surveillance and speed the response to outbreaks. The network built on existing ICT systems, the growing number of mobile phone users and expanding mobile network coverage. A mobile phone reporting network was created for health workers engaged in epidemiological surveillance at all levels, including those in referral laboratories. Computers and wireless internet networks were installed to link the central and regional levels and were gradually expanded to all ten regions of the country. Phone communications within the network are free around the clock. The high-speed internet network connects five decision-making services at the central level and the ten regional health services for electronic data transmission. The mobile phone network allows higher level health staff and community health workers to mentor surveillance officers in disease case definitions for better quality case detection and investigation. The timeliness and completeness of reporting of epidemiologic data improved, as did communication between laboratories and field teams, which led to improved response times and accuracy of sample testing. Data transmission is 30 times less expensive through the phone network and internet than through land transport, the common method before the initiative. With health personnel able to transmit data electronically, it reduced the need to travel and freed up time for dealing with other health care issues. In the Philippines, mobile health technologies are being used to help rural health workers. In Cambodia, the Mekong Collaboration Program has begun using a messaging system known as GeoChat for group communications and a hotline allows citizens to report disease outbreaks (Mechael et al., 2008).

The following are interventions for health system and data services. Recently, digital health solutions are being found in countries of the South to deal with the Covid-19 pandemic. In India, high-throughput tertiary referral centres, like the All India Institute of Medical Sciences, have launched telemedicine services instead of in-person check-ins. The Ministry of Health of Sri Lanka developed a web-based District Health Information Software to capture information on passengers entering from at-risk countries for active COVID-19 surveillance; the nCoV Surveillance System captures demographics, immigration, symptoms of COVID-19 disease and possible contacts at all ports of entry for local public health officers, predicated

on their geographic region. CommCare is an open-source mobile case management platform utilized by 700,000 frontline health workers to track clients through a continuum of service delivery, commodities supply chain and patient messaging. CommCare allows non-engineers to build and adapt mobile applications for contact tracing, data collection, decision-support, client tracking, SMS-interaction and map-based visualizations. In Liberia, mHero, a two-way, mobile phone-based communication system that was established during earlier Ebola outbreaks, is now being used for Covid-19 applications. mHero connects the Ministry of Health with health workers using basic texting, or SMS, over simple talk-and-text mobile devices, meaning smartphones and tablets are not required.

3. Risks and challenges with advancing health development through digital technologies

Having described above the wide-ranging opportunities, spanning a broad array of technologies and applications, that digital health offers for advancing health development in the global South this section discusses the potential risks and existing challenges that need to be navigated to realize these opportunities. These risks and challenges are discussed under four key thematic areas: project management; financing; equity; and ethics and governance. The potential for South-South and Triangular Cooperation to help countries of the global South address these risks and challenges is great and are discussed in the next section.

3.1 PROJECT MANAGEMENT

Given their sheer size and complexity, large infrastructure projects (over $1 billion) often experience project management challenges, resulting in cost overruns and time delays (Beckers et al., 2013; Garemo et al., 2015; Shepherd, 2017). For example, the metro system in Salvador, Brazil, began construction in 2000 with plans to open its first section in 2003. After repeated delays, Line 1 was partially opened for the 2014 FIFA World Cup and Line 2 opened in sections between 2016 and 2018 (Passos, 2017). Similar risks of project management problems can be especially high for large-scale digital health projects given the task of marrying two complex systems – digital telecommunications and health systems. There are numerous reports of major digital health projects in high-income countries not being delivered on time or within budget, or even not at all, and becoming "white elephants" or "money pits" for governments (Carvel, 2010; Chadha and Llewellyn, 2019). In the global South, these risks are potentially heightened when there are multiple small-scale projects, often externally initiated (sometimes referred to as "pilotitis"), which can overburden local capacity. Donors and investors may be tempted, in the short term, to rely on external consultants and technology company representatives to design and implement digital health projects to meet agreed budgets and timelines. However, this can result in insufficient attention to building local project management capacity and dovetailing with local systems. In Latin America, Curioso (2019) identifies training and building the capacity of health care professionals in digital health as "one of the most significant public health challenges."

Another challenge arising from multiple digital health projects is fragmentation or insufficient integration of efforts within and across countries and regions. The lack of national and regional digital health strategies, in particular, can lead to numerous small-scale, usually disconnected projects, often with time-limited funding, to serve selected populations, applications or geographies within a country. The result can be simultaneous gaps and overlaps in efforts, incompatibilities in technical standards and a failure to ultimately deliver on project goals. In Uganda, for example, the proliferation of small-scale

demonstration and pilot projects during the early years of the mobile phone revolution, which were often incompatible and redundant, was quite significant. As described later in this chapter, reducing project management risks in the global South begins with strong national digital health strategies that clearly set out national digital health priorities as a blueprint for building infrastructures and the local capacity to support them (PATH, 2017).

3.2 FINANCING DIGITAL HEALTH FOR DEVELOPMENT

It is estimated that an additional $2.5 trillion is needed to achieve the Sustainable Development Goals. However, this level of financing remains far more than the global South can afford from domestic resources, meaning external funding will remain essential (Broom, 2019), including for health-related goals. Investment in infrastructure, including health facilities to achieve development gains has been supported by the donor community since the 1990s (World Bank, 1994), with the scale of investment increasing substantially since 2010. Many of these development projects have focused on further integration of the global South into the world economy, led by China's Belt and Road Initiative. With $1 trillion in financing planned from 2017-2027, the Belt and Road Initiative focuses on transportation, communications and logistics across nearly seventy countries spanning Asia, Africa and Europe (OECD, 2018) while the initiative has many implicit influences on global health. Similarly, the Japan Infrastructure Initiative is investing an additional $200 billion in infrastructure projects in emerging Asian and African markets, including Bangladesh, Cambodia, India and Turkmenistan (Shepherd, 2017). As a result, the stock of infrastructure assets has increased in the global South, although unevenly distributed across countries and sectors (Gurara et al., 2018). It is estimated that African countries still need an estimated $95 billion per annum for infrastructure investments (Asamoah, 2020).

Financing for digital health in the global South, to date, has come from a combination of domestic and external sources, spanning the public and private sectors. While countries of the global South increased spending as percentage of gross domestic product on telecommunications investment between 1995 and 2005, Negash and Patala (2006) found that the absolute amounts remain insufficient to realize economic benefits from the investments. External sources of investment for digital health, in particular, thus remain critical but have to date, as noted above, often been smaller-scale and time limited, allocated for pilot projects rather than being a component of large-scale infrastructure development projects. Where the latter are externally sourced in the form of private investments and development loans, financing is offered in exchange for the privatization of national assets, in whole or in part, leading to increased indebtedness (Doh and Teegan, 2003). The challenge for these countries in seeking to advance digital health will be to attract financing in sufficient volumes and in forms that complement rather than undermine broader development goals. This will mean addressing factors that limit the involvement of potential investors and strengthen administrative, regulatory and legal frameworks to ensure investments benefit local needs. The potential to achieve this through South-South and Triangular Cooperation is discussed in Section 4.

3.3 POTENTIAL IMPACTS ON HEALTH AND SOCIAL INEQUITIES

Much hope is placed on using digital health opportunities to overcome wide disparities in health care and reduce health and social inequities in the global South. This section again touches on the potential benefits of digital health, but also highlights the associated risks arising from wider inequities, focusing on concerns over who controls digital technologies in the global South and for what purposes these technologies are used.

The digital technology sector is composed of "manufacturing and service industries that use creativity, talent and digital skills to capture, transmit and display data and information electronically" (Canada, 2017). Globally, the sector is currently dominated by a small number of large, for-profit, privately-owned companies, with healthcare identified among emerging "lucrative new vertical markets" (Canada 2017). Available data on the world's top 100 digital companies and their market capitalization (by US$ billion),

shows that the leading publicly traded IT, hardware, media, digital retail and telecommunication companies come from 17 countries. American companies make up nearly half of the list (49 companies) and dominate the top 25 positions (19 companies) (Murphy, 2018). In this context, to date, when countries of the global South seek to invest in digital health technologies, they have been largely buyers in a marketplace dominated by private for-profit companies based in the global North. The drive by these companies to expand digital health into the global South has been to establish footholds in emerging markets ahead of competitors, to increase economies of scale and to take part in large-scale investments in infrastructure projects.

However, evidence shows that digital technology companies from the global South themselves are poised to become major global players, building on their experience of serving large domestic markets. For example, there are now more internet users in China (800 million) and India (500 million) than 37 OECD countries combined (Chakravorti, 2018). This has given rise to fast growing companies, such as China's Alibaba and Tencent Holdings and India's Tata. The governments of both countries have adopted ambitious plans to accelerate digital development. President Xi Jinping has declared a strategic goal of China's advancement in digital technologies, including AI (Segal, 2018). Prime Minister Narender Modi initiated Digital India, a national programme to transform the country into a digitally empowered society (Digital India, 2014). Digital health is a major component in the transformative plans of both countries. For example, it is believed that "[m]any issues holding back India's healthcare sector could be resolved by digital technologies that are already available or under development. Some of the innovations have the potential to fundamentally change the nature of healthcare delivery by better connecting people with services, automating routine tasks and analyzing patient data to improve care decisions" (Kaka et al., 2019: 55). Some observers contend that digital companies from the global South will be more attuned to health equity needs and be more capable of supplying appropriate digital technologies for health development in their own regions.

Regardless of ownership, or the balance between public and private investment, the risks to health and social inequities from digital health depend on which technologies are adopted, for what purposes and for whose benefit. Some critics argue that the introduction of digital technologies, more broadly, supports an industrial model which seeks to further integrate the global South into "the particular form of industrial organization that has come to underpin the contemporary global economy – one organized around the structures of global value chains and global production networks" (Phillips, 2017). These forms of industrial organization have produced "vast socio-economic disparities" due to asymmetries of market, social and political power. Kwet (2018) describes five forms of domination arising from "digital colonialism" as leading global technology companies expand into emerging markets. Focusing on South Africa, he describes "imperial control at the architecture level of the digital ecosystem: software, hardware and network connectivity" results in new forms of economic domination, direct control of political, economic and cultural life, privacy violations, mass and targeted surveillance and elitist conceptions of the digital world. In such scenarios, digital technologies are unlikely to meet the priority needs of the many and may divert scarce resources from non-digital approaches (Bellagio eHealth Evaluation Group, 2011), including in the health sector.

To contribute to the reduction, rather than reinforcement or widening, of health and social inequities in the global South, digital technologies must begin with careful attention to embedding equity-driven goals, such as increasing access to underserved populations and strengthening universal health coverage, into their design. Digital health technologies in African countries, for example, have the potential to improve health outcomes or contribute to an already widening knowledge gap in health information (Sheikh, 2014). As Brall et al. (2019) noted, "when all stakeholders, especially digital health providers and regulators, ensure that digital health interventions are designed and set up…[to] foster health equity for all population groups, there is a chance for this transformation resulting in a fair approach to digital health."

3.4 NAVIGATING THE ETHICAL GOVERNANCE OF DIGITAL HEALTH TECHNOLOGIES

Digital health ethics concerns the conduct of health-related activities using on-line and digital mediums according to agreed ethical standards, principles of professionalism and clinical soundness. While central to the expanding use of digital health, resources that set out the ethics of digital health remain scarce (Brall et al., 2019). Medical ethicists caution against allowing the "technological imperative" to take precedence over ethics. As Kluge (2011) writes, for example, "issues facing telehealth are not merely technical issues. There are value issues that go to the very nature of health care, to the nature of the health care provider-patient relationship, the role and responsibilities of the informatics professional." The author warns that "focusing mainly on pragmatic considerations will ignore fundamental ethical issues with legal implications that could undermine its success." Thus, an understanding of the ethical risks and challenges faced is emerging alongside the development and application of digital health technologies. It is important, in this context, to integrate ethics as early as possible and across all phases of digital health planning. Careful consideration of digital health ethics, within the specific contexts of the global South, must be given deeper consideration.

There are three main dimensions of digital health ethics that need to be addressed more fully from a global South perspective. First, digital health ethics span before, during and after technology use. Ethical considerations concern the safeguarding of fairness and equity of access. As noted above, how digital health technologies are designed can hinder or advance equity for specific individuals and populations based on affordability, literacy and other factors. Ethical practice means ensuring people have appropriate prior knowledge to make informed choices about the risks and benefits of using digital health technologies. Users need to understand, for example, what data will be created and how it will be used and to be empowered to give their informed consent accordingly. As Brall et al. (2019) describe it, there are "ethical issues of autonomy, informed choice and right to privacy…closely interlinked with justifiable uses of data basing on the individual's right to determine for what his or her personal information is used for." For many countries of the global South, where there has been a legacy of "exploitation, dehumanization and lack of ethical professionalism, to an extent that developed countries do not encounter" in health care (Begum, 2004), "ethics by design" is critically important. The practice by digital technology companies to commodify and commercialize health data, for instance, must be governed by clearly agreed rules on informed consent, privacy and shared benefits.

A second dimension of digital health ethics concerns the various stakeholders involved, spanning "the medical and non-medical, public and private." In the global South, in addition to patients, health care providers, researchers, charities, government bodies, insurers and private companies, stakeholders may also include health development agencies, aid donors and nongovernmental organizations. A particular risk is digital health initiatives which are externally driven. As Brall et al. (2019) describe it, this configuration of stakeholders poses governance challenges that require careful navigation to ensure sufficient understanding of local contexts and needs. Digital health governance must create trust and empowerment, sometimes in countries where there are lower levels of trust in the healthcare system (Peters and Youssef, 2016).

A third dimension of digital health ethics is the interface between technical issues (e.g. interoperability standards) and broader governance principles, notably transparency and accountability. Governance in this case concerns the agreed principles, rules and processes by which digital health technologies operate within a given society. This includes the distribution of authority to make decisions about the overall goals to achieve the design and building of digital health systems to ensure interoperability standards and regulatory mechanisms that oversee the use of such technologies.

Ethical issues around data ownership and security are especially important to address through appropriate regulatory mechanisms in the global South. Effective systems of governance are needed to ensure use of end data only for purposes consented to, and to prevent unethical data use practices, such as government surveillance or insurance company screening. The capacity for digital health technologies to collect, store and transmit large amounts of data across jurisdictions and, indeed, globally, raise particular challenges in the global South. For example, digital epidemiology (or digital disease detection) uses electronic data sources for surveillance, with the potential to increase the speed of outbreak detection

and hence response. Since 2010, India has implemented a national identification system, Aadhaar, which uses unique 12-digit identifiers and biometrics to integrate personal data across many domains, including electronic medical records and health insurance information. The Aadhaar card system enables more accurate and comprehensive health statistics to support health system planning and delivery of public health interventions for India's 1.2 billion citizens (Raul and Nair, 2019). Another example is the use of digital technologies to enable governments to improve contact tracing in the event of a pandemic, like the Covid-19 pandemic, and enforce quarantine and physical distancing requirements (Huang et al., 2020)

This points to important opportunities for digital health to be collected and combined with Big Data to address major global scale health challenges. However, concerns remain that the temporary intrusion of technology on personal privacy by governments during a public health emergency may not be rescinded once the event is over (Bell, 2020). Thus, the integration of digital health with Big Data must be governed by a clear ethical framework. How will this data be securely stored? How will individuals give informed consent on use of their personal data? Under what conditions can authorities gain access to such data and even circumvent privacy rules? To what extent might private for-profit companies, such as the pharmaceutical industry, gain access to such data for commercial purposes? The compulsory nature of the Aadhaar system has raised concerns, for example, about privacy, potential for errors (and thus denial of rights to basic services) and the increased potential for fraud (Khera, 2018).

Overall, regulatory mechanisms need to address the above questions carefully, from a global South perspective, to decide who is granted access to digital health data and for what purposes, to promote fairness of access, ensure maximum health benefits and protect vulnerable populations (Kickbusch, 2020).

4. The role of South-South and Triangular Cooperation in advancing digital health

Harnessing the opportunities offered by digital technologies for health development, reaching the Sustainable Development Goals and strengthening capacities to address the challenges associated with their adoption in the global South can be supported in several ways through South-South and Triangular Cooperation. A critical starting point is a commitment by countries to formulate national digital health strategies that are integrated with existing health systems and digital technology strategies (WHO, 2020a). While most countries have separate strategies and/or policies on health and technology, few have national digital health strategies, and most are located in the global North. As a result, the experience with digital health of most countries in the global South has largely been small-scale projects, externally driven and short-term. In Uganda in 2012, for example, frustration with "pilotitis" led the government to putting a moratorium on m-health projects, demanding that future interventions prioritize interoperability, sustainability and conformity to existing Ministry of Health cyber laws and data requirements (McCann, 2012; PATH, 2017). A national digital health strategy would go farther, ensuring that any scaling up of technology would be aligned with local contexts, needs and goals.

One useful model of a digital health strategy is the National Digital Health Strategy for South Africa (2019-2024) which aims to "strengthen digital health governance structures, create robust integrated platforms for development of information systems and establish the requisite broadband network infrastructure in conjunction with other government departments" (Republic of South Africa, 2019). The strategy builds on the earlier eHealth Strategy of South Africa which identified the role of digital technologies in addressing key health challenges (Republic of South Africa, 2012). In Rwanda, strategic planning is at an earlier, but fast-moving, stage. Large-scale health reforms have included the introduction of electronic health records (EHR) for HIV services with external partners. The government is seeking to expand EHR as part of a transformation of the health system to make it focused on digital health over the next decade. Rwanda does not yet have a national digital health strategy but is actively seeking to integrate various systems (Anon, 2018).

As countries such as Rwanda and South Africa advance their national strategies, they are gaining valuable experience that could be shared with other countries of the global South that may be seeking to follow suit. Lessons being learned across countries about the process of developing a strategy, including the key components required, the core governance arrangements needed and best practices for working with domestic and external partners, can be brought together through South-South and Triangular Cooperation (Labrique et al., 2018b). While varying in their specific content, steps in the process of formulating an integrated national digital health strategy need to be documented and shared. As a growing number of countries engage in setting national digital health strategies, opportunities may arise to explore the advantages of regional and interregional strategies to optimize infrastructure investments, economies of scale and data and technology sharing possibilities.

Another opportunity for South-South and Triangular Cooperation is joining efforts in digital health training programmes and capacity building designed specifically for the global South. Investments in digital health technologies require commensurate investments in human resources. A large-scale need exists to train health care workers, data analysts, information technology engineers and many other essential medical-facing personnel in the global South. However, studies show that attention to building local capacity through training on digital health lags behind the focus on building technological infrastructure and developing applications (Long et al., 2018). While a digital health workforce is recognized as an essential component of creating a successful digital health system, investments in training and education are often of secondary consideration. Most digital health training opportunities are provided by institutions of the North, many with limited relevance to southern countries needs and experiences. Curioso (2019), for example, writes that "a successful digital health ecosystem in Latin America requires culturally relevant and collaborative research and training programmes…responsive to the needs of all relevant regional stakeholders." A training centre located in the global South, with appropriate curriculum and delivery methods, could be essential to the expansion of digital health. Training resources may be pooled across countries to develop tools and methods, such as technology assessment, strategic planning, risk assessment, project management and data analysis. Other key subjects may include the interface between digital health and legal frameworks, ethics, data governance and health equity (Kim et al., 2017).

To support the development of national digital health strategies and training programmes, knowledge mobilization and sharing across the global South can be advanced through South-South and Triangular Cooperation. One example is the mHealth Alliance which champions the use of mobile technologies to improve health worldwide by "sharing tools, knowledge, experience and lessons learned" (Devex, n.d.; Gerber et al., 2010). Another example is the global South eHealth Observatory, initiated by the Fondation Pierre Fabre in 2016, which provides a platform for information sharing and networking (Fondation Pierre Fabre, 2020). Through closer cooperation, the potential exists, for example, to expand this platform from an annual conference and periodic project funding to a larger-scale investment in an integrated programme of training and capacity building, research, knowledge translation and evaluation. Particular benefits can arise from "more systematic evaluations and better codification of lessons learnt from existing programmes, which in turn will allow programmes that are currently struggling to employ technology to make educated decisions about when and how to implement ICT" (Lewis, 2012). The joint development and sharing of ethical guidelines, technology assessments, governance and legal frameworks are especially important as countries expand digital health investments.

Given the scale of investments needed for digital health, some countries of the global South may benefit from pooling shared resources and infrastructure to achieve greater economies of scale and other efficiencies. Small island developing states, as one example, could form regional networks to support digital health to address the health needs and circumstances of such countries. The Caribbean Public Health Agency, formed in 2013, one of only three multinational public health agencies in the world, is seeking to leverage digital health and other technologies through shared resources (Hospedales, 2019). While regional cooperation based on geographical proximity may be appropriate in some situations, in others, digital technologies may also offer opportunities to pool resources among physically distant countries which share similar attributes.

Finally, the financing of digital health for many countries in the global South will benefit from closer South-South and Triangular Cooperation. As noted previously, project funding for digital health projects in the global South have been dominated by donors, researchers and technology companies from the global North, as the financial investments needed to scale up and integrate such technologies into national health systems over time are substantial. However, more recently, financing partnerships are beginning to be formed across countries of the global South for this purpose. In the Asia Pacific region, total venture capital investments in digital health reached $6.8 billion (compared to $8.2 billion in the United States and $2 billion in Europe) in 2018, which investors described as "a very vibrant ecosystem." These investments include the Indonesia-based HealthTech platform Halodoc, China's Tencent Trusted Doctor and the HealthTech ecosystem in Vietnam (Koh, 2018).

5. Conclusion

Countries in the global South continue to face significant health development challenges. While overall progress has been made in the past two decades and continues to be made under the impetus of the Sustainable Development Goals, a closer look reveals mixed gains with continued hurdles posed by widespread poverty, marginalization, displacement and environmental degradation. Health systems in many parts of the global South remain chronically weak and under-resourced, given insufficient attention to these broader development challenges, limiting their capacity to reduce the overall burden of disease and achieve universal access to health care. Health interventions still cannot match the scale of need and health services do not equitably reach people whose needs are greatest. These immense challenges demand continued commitment to the SDGs, as a whole, but also sustained efforts to improve health systems. Digital technology, in this context, offers the potential to strengthen these health developments in resource-limited countries and areas of the global South.

The digitalization of health services offers diverse opportunities and promises more transparency and accountability in delivery. Digitalization can boost evidence-based practices, reduce errors, increase diagnostic accuracy and improve overall treatment. It can facilitate client empowerment, enabling better self-care and health decision-making. It may also be used to shift tasks down the abilities ladder, thus helping address skills shortages. Finally, it can boost cost efficiency by streamlining processes, reducing waiting times and enhancing accuracy of data. Increased use of e-health services requires a regulatory environment covering legal and ethical conditions that ensures data privacy, security and confidentiality. It is vital to build data bases for e-health by identifying what works, where and why and information on encounters and guidelines should be shared. Collecting relevant indicators, analyzing key trends and reporting on guidelines for integration of e-health into national health systems will help enhance the evidence base in countries and can guide policy and practice. Countries that adopt and promote the utilization of e-health standards are expected to achieve health sector success through interoperable and, better still, integrated systems.

Promoting partnerships in digital-related activities with key stakeholder groups — academia, government, industry and civil society — can stimulate innovative research and development in public health, and, of course, encourage sharing of resources. To avoid medical "brain drain" and ensure that medical professionals are digitally capable, continuing professional development and career support is required. Digitalization in itself can significantly enhance the way healthcare professionals are trained, through targeted e-learning programmes, and can enhance the efficiency of health services, especially in areas with small health workforces.

The spread of digital health, like the internet and mobile telephones, has a chance to reach the general public at home, school and in the workplace. These technologies may be used to provide health education and promotion, monitor chronic conditions and deliver information on demand. It can contribute to enhanced quality, safety and usage of health care. However, for digital health to advance sustainable health development, more critical analysis of the nature of emerging technologies is required, as is greater meaningful participation by the global South in their creation and use and strong and deliberate governance of digital health technologies to ensure these technologies are used for public rather than private interests.

The closer the developers of digital-based solutions are to where the problems lie, the more effective the solutions become, and the more transferable solutions will be to similar environments. South-to-South collaborations, in particular, can support the development of digital health solutions that are culturally appropriate, sustainable and offer lessons learned for similar environments. Moreover, such efforts promote both equity and equality of access at the global level.

Chapter 7

Digitalization and climate change strategies

1. Introduction

Digital technologies are recognized as powerful tools to help achieve sustainable development when created and deployed correctly. The 2019 Exponential Climate Action Roadmap highlights the transformative effects of digital technologies, particularly artificial intelligence, in helping to reduce carbon emissions by up to 15 percent by 2030.[45] However, when created and used incautiously, digital technologies could induce and accelerate climate change. Digital technologies are fundamentally unsustainable because they produce e-waste, drive electricity demand, exploit rare minerals and account for a high percentage of global C02 emissions (Unwin, 2020). Given the double-edged sword of digital technologies in terms of environmental health, South-South Cooperation could play a crucial role in mitigating the negative environmental impacts and advancing the potential of these technologies to combat climate change. This is especially important for developing states that are facing challenges of limited investment in digital infrastructure and services.

Along with an increasing use of digital technologies, massive e-waste has been shipped from Northern to Southern countries, including several African states, China and India.[46] Due to the lack of formalized e-waste recycling plants and e-waste management systems, African countries have fallen victim to colossal e-waste piling. In December 2015, China set the example of transforming a notorious e-waste dumping ground in the city of Guiyu into a large $233 million (1.5 billion yuan) industrial park (Recycling Today, 2015). The Chinese government reinforced controls over informal e-waste recycling operations and banned the entry of foreign e-waste into the Guiyu area. This experience could be transferred to African countries that need to establish e-waste recycling regulations and technological know-how.

Moreover, these regions can learn from one another and build cohesive regional recycling networks and scrap metal trades, for example among countries in Africa, to achieve an economy-of-scale refinery industry. Nigeria is potentially a leading country to host e-waste refineries and smelting facilities, particularly after the kick-start of the Global Environment Facility project, "Circular Economy Approach for the Electronics Sector," that supports implementation of Extended Producer Responsibility legislation (UNEP, 2019). South Africa, with one of the few and first e-waste recycling plants on the continent, is also regarded as a potential leading country to construct a collaborative multilateral recycling cooperation system among African countries (Zhang, 2016). As such, South-South Cooperation could be leveraged to address e-waste problems, a common challenge derived from digital technologies as well as a collective action problem for Africa.

Another example of successful SSC practices in preventing digital technology's negative effects on climate change can be found in rare minerals mining, which is unfortunately essential for most digital technologies (a mobile phone contains more than a third of the elements in the Periodic Table; Jones, 2018). Chile has successfully built a vibrant mining sector by setting up a national mining utility, COCHILCO,

45 The 2019 Exponential Climate Roadmap Report is a flagship report of the Exponential Roadmap Initiative that outlines 36 solutions in how to boost efforts to reduce greenhouse gas emissions by 50 percent at by 2030. The Exponential Roadmap Initiative is a platform that gathers together technology innovators, scientists, companies and NGOs (https://exponentialroadmap.org/about-us/).

46 In 2016, UNEP reported that up nearly 60 million metric tons of e-waste is disposed annually, most of which is generated in developed countries and shipped to developing countries. Up to 90 percent of the world's e-waste is illegally dumped as no current international system exists for tracking legal or illegal shipments of e-waste. Some of the e-waste is shipped internationally under "working equipment" intended to be disposed of upon arrival. This issue is exasperated by the lack of adequate policies to support the environmental sound management of e-waste in developing countries. For instance, African countries are severely impacted by the lack of formalized e-waste recycling plants and processing businesses which has resulted in a burden to environmental conditions across the continent (Zhang, Y., 2016).

and receiving many foreign private operators. A Memorandum of Understanding between Chile and South Africa in 2017 allowed South Africa to learn from Chile not only about small-scale mining technologies and skills, but also regarding environmental regulations and best practices related to inclusion of women in the mining industry (International Mining, 2017). More such arrangements could be beneficial to African countries, as many African countries are struggling with dependency on one commodity (UNECA, 2017) and child labour in mining rare minerals is a grave problem, particularly in the Democratic Republic of the Congo (Kara, 2018).

In unlocking the great potential of digital technologies to tackle climate change, the positive impacts of South-South Cooperation are expected to expand. Southern countries, whether in rural areas or in cities, face the harshest impacts of climate change. Crop production is strongly affected by climate change, which in turn aggravates food insecurity, malnutrition and poverty. By 2050, approximately 350 to 600 million people in Africa are expected to struggle with water shortages due to climate change. More than 90 percent of all urban areas in the global South are coastal, thus vulnerable to rising sea levels and devastating storms (Eco-Business, 2016).

Ironically, the vulnerable position of Southern countries to climate change has provided them with opportunities to step up their climate mitigation and adaptation practices and gain experiences that highlight the importance of South-South Cooperation. Countries like Fiji and Papua New Guinea, for example, actively participated in international workshops on enhancing South-South Cooperation on Disaster Risk Management in the Asia Pacific region. Participation of disaster management practitioners from both countries have led to successful maintenance of coastal wetlands while strengthening both the natural and the built infrastructure, as well as educating people about sustainable management. Costa Rica's National Climate Change Metrics System aims to build an international community of practice by sharing its knowledge and experiences with other global South countries, particularly in enhancing measuring, reporting and verification (MRV) capabilities that successfully helped the country's transition to the Enhanced Transparency Framework reporting process. The Enhanced Transparency Framework is an open-source software platform with the explicit goal of improving SSC practices in strengthening climate mitigation. It entails automatization and process improvements for greenhouse gas inventory data collection and a registry for mitigation actions. The platform also includes a national carbon asset registry to be used with blockchain technology, a climate finance registry and modelling and scenario-building tools (Mora, 2019). Other Southern countries could benefit from sharing such platforms that combine data management climate reporting, decision making and open data.

This chapter further examines how South-South Cooperation has been and can continue to be leveraged to unlock the full potential of digital technologies in fighting climate change. It is organized into four sections: 1) remote sensing and GIS; 2) climate mitigation and adaptation; 3) sustainable energy generation and storage; and 4) blockchain application. The significance of these four distinct areas of study is rooted in their ability to support feasible strategies for facing risks and challenges and to optimize the various opportunities provided by digitalization in support of climate change adaptation initiatives across the global South. These technical areas can fast-track implementation of the Paris Climate Change Agreement through increased stakeholder involvement, transparency and engagement in innovative solutions for tackling climate change.

Throughout this chapter, a wide range of successful examples of South-South Cooperation taking place in least developed countries to upper-middle-income countries support the belief that South-South Cooperation is a successful framework for climate initiatives and that SSC should be further encouraged beyond the BRICS countries, which admittedly are prominent investors in climate action. Furthermore, the benefits of Triangular Cooperation for addressing climate change is discussed and how TrC can complement the potential limitations of South-South Cooperation.

2. Remote sensing and Geographic Information Systems

In a 2013 *Nature* article about climate change, Satellite Remote Sensing (SRS) was featured as an important component of climate system observations. It "acquires information about the Earth's surface, subsurface and atmosphere remotely from sensors on board satellites." It allows humans to observe and monitor the atmosphere, the land and ocean at various spatial-temporal scales. Compared to traditionally land-based observations in which data collection is limited to fixed intervals and confined spatial coverage, continual monitoring with unbounded scope through SRS helps humans to understand climate systems and improve climate projections. SRS data are also critical in improving meteorological reanalysis products as part of climate change research. According to the Global Climate Observing System, 26 out of 50 essential climate variables (ECVs) are deemed significantly dependent on satellite observations.

Along with SRS, continuous advances in Geographic Information System (GIS) technology have contributed to improved climate change research, disaster response, urban planning, agriculture development and ecological protection, among many other benefits. For example, researchers use GIS to show areas in which temperatures are particularly high due to global warming, can visualize factors that affect crop growth and can examine the relevance of shifts in land surface due to climate change. GIS is a useful tool to effectively visualize the correlation between climate status and its impact and allows the presentation of climate change to non-experts as well as scientists in ways that both can understand. Climate change mitigation also benefits from GIS, as geospatial tools and analyses enhance monitoring systems. GIS technologies can likewise be used to harness green energy, for instance evaluating which building is suited for solar panel installation and finding the best locations for raising sustainable crops.

In the context of developing countries, the need for geospatial information technologies is a consistent concern for the implementation of sustainable development agendas. The limited utilization and legal protection of natural resources in developing nations has created multiple barriers and disadvantages along their path to effective natural resource exploitation capabilities. Moreover, limited investment in technological advancements and infrastructures in the global South has prevented effective leveraging of this sector for future development strategies on both national and regional scales. South-South Cooperation can play a prominent role in enhancing existing and new mechanisms to promote cooperative development initiatives for the advancement of capacities to address these concerns (Mohamed, Muhammad and Plante, R., 2002).

South-South Cooperation can be more active in the area of remote sensing and GIS technology. For example, China's development in hyperspectral remote sensing technology has made new applications possible, such as the ability to monitor and find wheat stripe rust as soon as possible. A small hyperspectral digital camera system has been implemented for environmental and agricultural monitoring. This technology supports the harvesting and processing of crops for different land parcels based on their different qualities and ensures quality and price for crop production. Through monitoring and estimating pasture quality, it will also ensure quality and price for livestock products (Jiang, 2016). Based on the relationships that China has already established with other global South countries, it is highly encouraging that China is expanding in this area of South-South cooperation.

2.1 SOUTH-SOUTH COOPERATION IN THE USE OF REMOTE SENSING SATELLITES

In the global South, China and India are the fastest growing countries in terms of remote sensing technology, applications and satellites. China and India have built and launched dozens of remote sensing satellites, include land, sea and weather satellites. Among them are the most advanced satellites in the world, such as the GF-4 satellite launched in 2015 that can obtain remote sensing images with a spatial resolution of 50 meters, which is until now the highest resolution for geostationary satellites (Cresda, 2019). These satellites enhance the capacity for countries in the global South to obtain and apply remote sensing data, including enhancing emergency response for natural disasters.

South-South Cooperation has made good progress in the field of development of remote sensing technology and applications. An example is the July 1988 protocol between China and Brazil that approved development of an earth resources satellite, opening a prelude to China-Brazil space cooperation. In October 1999, the jointly developed China-Brazil Earth Resources Satellite (CBERS-01) was successfully launched. This was the first transmission remote sensing satellite for both countries. It broke through many key technologies and formed a modular remote-sensing satellite platform that was autonomous, controllable and scalable, laying a foundation for the strong development of more Chinese and Brazilian remote sensing satellites. Four subsequent CBERS satellites were launched (in 2003, 2007, 2011 and 2014) and put into operation, providing more than six million images for China and Brazil. These images are used widely in agriculture, forestry, geology, water resources, urban planning, environmental protection and disaster prevention and reduction.

Follow-up on the CBERS-05 and CBERS-06 satellites is actively continuing to promote cooperation. In 2003, after CBERS-02 was successfully launched, China and Brazil jointly announced that the 20-metre resolution data obtained by the CBERS satellite would be freely available to all countries in the world, benefitting countries in the global South. Now that the CBERS satellite platform is fully developed, it has established ground data receiving stations in not only China and Brazil, but also in Singapore and South Africa. It has provided more than 500,000 CBERS images for Southern countries in Africa, Asia and Latin America.

China and Brazil plan to strengthen their cooperation and continue to enhance and expand the international influence of the CBERS, including expanding cooperation with more countries, for example the BRICS countries, so that more countries can share the fruits of the cooperation. China and Brazil are cooperating to advance the BRICS countries remote sensing satellite constellation project and plan to establish a virtual constellation. The constellation will include the CBERS satellite and other remote sensing satellites, which can meet the needs of the BRICS countries and other countries in a much better way (China News Agency, 2018).

2.2 SOUTH-SOUTH COOPERATION IN PROMOTING REMOTE SENSING AND GIS TECHNOLOGICAL COLLABORATION

To accelerate remote sensing data applications for more countries, especially the Southern countries that don't have remote sensing satellites, mechanisms and platforms of remote sensing data sharing have been established. The Asia-Pacific Space Cooperation Organization (APSCO), established in 2008, has eight member states (Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey), one signatory state (Indonesia) and one observer state (Mexico). It provides a cooperative mechanism for Southern countries in and beyond the region to be able to share resources (including data resources) as a way of promoting the development of space, science, technology and applications (APSCOa, 2020). The project promotes joint development and research and optimizes cooperative activities among its members using their tremendous geographical distribution advantage. APSCO established a variety of resource sharing platforms for the Asia-Pacific region, including a data sharing network, a space segment network-ground system interconnection, a ground-based space object observation network, a disaster monitoring network, a space application network and an education and training network.

APSCO has also set up a platform for technology, policy and legal exchange and knowledge sharing in science, technology and personnel management in the space field. The Data Sharing Service Platform (DSSP) project, one of the most important projects, was approved at the First Meeting of the Council of APSCO in 2008 (APSCO, 2020). The objective of this project was to build the data sharing platform and provide full service for space technology and applications to maximize effectiveness to meet the demands of different levels of users from the member states, Asia-Pacific countries and regional users. Through the data sharing platform, the member states can enhance the level of spatial information application techniques and improve the utilization capacity of the space resources.

With its free data sharing launch in 2012, DSSP became fully operational in 2014. Users from member states could request images and place a request to the Secretariat for downloading the images. Member states could also place requests for image capturing of remote sensing satellites based on their specific requirements (for example, emergency response) under the framework of the agreement. In addition, two pilot projects were implemented based on data from DSSP. Over 300 people attended DSSP-related training and pilot projects. DSSP created a new method for member states not only to gain access to remote sensing data, but, more importantly, to benefit from remote sensing applications to address many unique climate change challenges of the global South.

The China- ASEAN Remote Sensing Satellite Data Sharing Service Platform is another successful example of South-South Cooperation in data sharing. This first project of the China-ASEAN Science and Technology Partnership was officially launched at the end of 2012 and made remote sensing satellite data from China available to ASEAN countries through sharing applications. The sharing service platform includes a Beijing data centre and a Singapore receiving station and data application terminal. The Singapore data receiving station, operated by the National University of Singapore, is mainly responsible for receiving satellite data and transmitting the data back to the Beijing data centre. The superior geographic location of the Singapore receiving station allows it to receive data covering most of the ASEAN region. ASEAN countries that join the platform obtain dedicated data application terminal equipment for free. By the end of 2018, the Singapore data receiving station had received and processed more than 150,000 CBERS images, supporting remote sensing applications in agriculture (such as yield estimation), water conservancy, resource survey, urban planning and disaster monitoring in ASEAN countries and promoting scientific, technological and economic development in the region (CRESDA, 2015).

Bangladesh continues to grapple with an influx of 1.1 million displaced Rohingya people in Cox's Bazar, which itself is vulnerable to harsh weather events imposing a burden on the country's limited resources. Climate-resilient multi-purpose disaster shelters are being constructed inside the displaced persons camps by the local government's engineering department. As part of the World Bank's Emergency Multi-Sector Rohingya Crisis Response Project, solar nano-grids are being constructed on the roofs of the shelters. Despite the physical restrictions imposed by the COVID-19 pandemic, the World Bank was able to continue its assistance to the engineering department to design these complicated multi-story constructions remotely using drone imagery and GIS. These technologies could be game-changers in conducting evidence-based implementation support in the broader context of project implementation, even beyond a pandemic situation (World Bank, 2021).

In addition to data sharing, South-South Cooperation in human resource development also plays an important role in remote sensing technology and applications. Many universities and agencies, such as the Asian Institute of Technology in Thailand, the Peking University and Wuhan University in China, the UNOOSA Regional Centres for Space Science and Technology Education, UNESCAP and APSCO, organized workshops in remote sensing technology and application, training numerous remote sensing experts for the global South, which also promoted remote sensing application in participating countries (Government of China, 2013). Through personnel training and sharing of data, knowledge and technology, the technological level in the remote sensing field in Southern countries has been greatly improved and the gap with Northern countries has been reduced.

3. South-South and Triangular Cooperation for disaster response

Climate change makes the climate system more unstable and the distribution of heat and water more uneven. The Inter-governmental Panel on Climate Change fourth assessment report, released in 2007, pointed out, "since the 1970s, the occurrence of drought is wider, lasts longer, is more serious, especially in tropical and subtropical regions" and "over the past 50 years, a wide range of changes have taken place in extreme high temperature[s] and low temperature cold frost becomes less frequent and high temperature heat is more common" (IPCC, 2007).

The impact of climate change is multi-scale, omni-directional and multi-layered. Both positive and negative impacts coexist, but the negative impacts are of more concern. The major negative effects of climate change include melting glaciers, rising sea levels and extreme weather events (typhoons, rainstorms, blizzards, flood, drought, etc.). The increase in frequency and intensity of extreme weather events and natural disasters have caused heavy casualties and economic losses. Natural disasters are common challenges facing mankind and a huge obstacle to sustainable development. Climate mitigation and adaptation efforts, such as disaster reduction mechanisms, are valuably strengthened through partnerships between Southern countries.

Disaster risk reduction is playing an increasingly important role for implementation of the Sendai Framework for Disaster Reduction 2015-2030, the Paris Agreement and the United Nations Sustainable Development Goals. The Sendai Framework for Disaster Reduction 2015-2030 identified increasing access to multi-hazard early warning systems and disaster reduction information and assessment as one of its seven goals. Disaster risk reduction also has become one of the most important activities to eliminate the negative effects of climate change. Disaster prevention and mitigation are considered the most successful area for remote sensing applications. Whether it is to prevent climate-related natural disasters or to attenuate the after-effects of them, digital technologies are valued as powerful disaster management tools.

No matter whether before a disaster (stages of disaster mitigation, preparedness, early warning and emergency response) or after a disaster (stages of restoration and reconstruction), data related to the disaster are indispensable. Making the right decisions, the key to reducing casualties and economic damage, depends entirely on obtaining timely and accurate information. However, even if ground monitoring systems have been set up and data sharing takes place among systems and countries, at times they may not be adequate for disaster prevention and mitigation. Natural disasters, especially catastrophes, often destroy ground systems, including monitoring, communications and traffic systems. Getting new systems to the disaster site may be difficult, which leaves the disaster relief command unable to obtain the necessary information when needed the most. Space-based technologies, like remote sensing, satellite communications and Global Navigation Satellite Systems, have the advantage of still functioning in disasters. Remote sensing satellites can offer wide observation ranges, repeatable observation unrestricted by ground conditions, a multi-star cooperative reality and multi-dimensional dynamic observation. Remote sensing is considered to be one of the most important information technologies for disaster prevention and mitigation, providing tremendous social and economic benefits.

When satellite resources depend only on one country or organization it is difficult to meet demand. International cooperation and resource sharing (including satellites, data and processing capabilities) is imperative in this area. Through satellite-based collaboration on disaster reduction, different satellite resources significantly enhance data availability and collaborative monitoring can reduce the risk of and mitigate the impacts of disasters. Such collaboration is particularly important for countries in the global South without their own satellite resources. Currently, remote sensing emergency monitoring of major disasters is the most active and mature field of satellite resource sharing. Satellite disaster reduction cooperation mechanisms are constantly being explored, created and improved.

More than a dozen satellite cooperation mechanisms are currently in operation, covering the entire world. Some specifically target satellite disaster mitigation applications, while others are important components of the satellite application cooperation framework. APSCO and the Group on Earth Observations (GEO), for example, work together on an international level in various areas of space application and designate disaster mitigation applications as an important part of their joint strategy (GEO, 2020). The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030) makes disaster risk reduction its first priority. The International Charter: Space and Major Disasters (Disasters Charter) and the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) are satellite resource sharing and information service mechanisms established for disaster monitoring (ICSMD, 2020).

The Disasters Charter, which came into force on 1 November 2000, may be considered one of the most important and successful inter-governmental disaster reduction mechanisms currently in operation. It authorizes users to provide satellite remote sensing data to disaster-affected areas free of charge, making it invaluable for disaster monitoring and assessment and the entire process of disaster emergency monitoring (*Case Study 7)*.

CASE STUDY 7

THE INTERNATIONAL CHARTER: SPACE AND MAJOR DISASTERS

The International Charter: Space and Major Disasters (the Disasters Charter) consists of 17 space agencies (10 from Northern countries and six from Southern countries) and the 17th member is the DMCii.* The members are DLR (Germany), KARI (Korea), CSA (Canada), NOAA and USGS (USA), CNES (France), UKSA (UK), EUMETSAT and ESA (Europe), ROSCOSMOS (Russia), JAXA (Japan), CNSA (China), INPE (Brazil), CONAE (Argentina), ISRO (India), UAESA (UAE) and ABAE (Venezuela) (ICSMD, 2020). As the Charter members all have remote sensing satellites resources, and with dozens of satellites in orbit, the Disasters Charter boasts the largest and most advanced remote sensing satellite resources in the world.

By early 2021, the Disasters Charter marked its 700th activation, assisting with various major disasters in countries, mostly in the global South, including storms, floods, landslides, snow disasters, earthquakes and so on. The Disasters Charter provides powerful informational support for decision-making for disaster reduction activities and in times of disaster itself and plays an important role in reducing casualties and economic losses in disaster-affected countries. For example, on 12 May 2008 a massive earthquake struck Sichuan Province in China causing serious casualties and economic losses. Through launching the Disasters Charter and other international cooperation mechanisms, the National Disaster Reduction Center of China acquired more than 1,000 satellite images from 24 satellites of 12 countries, which supported effective disaster monitoring and assessment (ICSMD, 2020). The satellite images provided by the emergency response cooperation mechanism became the main data source and created a historical record of a single disaster.

Disaster Charter satellites work in optical, infrared and radar bands. These satellites can operate and obtain images in any weather and during any time, providing an important guarantee for global disaster emergency monitoring. The Disasters Charter operates a duty office that offers non-stop 24-hour service. Authorized Users can apply for activation through Member States or the United Nations system,

then access emergency services for the entire disaster emergency monitoring process from satellite data to mapping products. For example, the African Union first makes contact with an on-duty operator; the on-duty operator confirms the demand from the African Union and sends the information to the Emergency on-Call Office; the Emergency on-Call Office makes a plan based on the demand and satellite resources, determines the most suitable satellites and most suitable imaging time and assigns tasks to corresponding members; members make their satellite data reception plan based on the Emergency on-Call Office plan, receive and process data and provide satellite data and mapping production to the final user.

Because the Disasters Charter has clear protocol content, rich satellite resources and strict operational procedures, the Disasters Charter is the world's most important inter-governmental cooperation mechanism in satellite disaster reduction.

*Note: DMC International Imaging (DMCii) is the company that manages the Disaster Monitoring Constellation for the International Charter for Space and Major Disasters. It also sells satellite imaging services under contract and manages the operations of spacecrafts, such as UK-DMC1 and UK-DMC2 (source: Wikipedia). The Disaster Monitoring Constellation is made up of five satellites from five countries: Algeria, China, Nigeria, Turkey and the UK (Zhang et al., 2006).

In addition to government agencies, many civil social organizations are actively involved in providing data services for disaster relief efforts, and they play an important role in disaster relief, even if they have limited resources. For example, Zhuoming Info Aid, created in 2010, is a Chinese civil society organization focused on providing information services for disaster relief and is devoted to addressing information asymmetry during disaster response and to improve the efficiency and quality of rescue and relief actions. The work of Zhuoming Info Aid almost entirely depends on online volunteers and their time, knowledge and expertise through a crowd-sourcing internet platform. Their analysis is based on a 'hazard-exposure-damage-need-action' framework and a deep understanding of how a decision-maker needs to make decisions, especially when time is limited, and a situation is urgent and not all that clear. The Zhuoming Info Aid team has responded to over 100 disasters in and out of China, including earthquakes, typhoons, floods, tornados, explosions and including the Nepal earthquake in 2015, the Ecuador earthquake in 2016 and the Indonesia earthquake and tsunami in 2018.

4. South-South and Triangular Cooperation and energy futures

4.1 SOUTH-SOUTH AND TRIANGULAR COOPERATION FOR RENEWABLE ENERGY TRANSITIONS

Global energy transitions are already underway yet need to be encouraged further to meet the Paris Agreement and achieve SDG 7 on sustainable energy: "ensure access to affordable, reliable, sustainable and modern energy for all." The World Economic Forum states that Southern countries are going through the first energy transition, which is focused on promoting renewable energy by requiring utilities to generate a small portion of their power from renewable sources (Tamhane, 2020). Northern countries, such as Denmark and Germany, are experiencing the second transition, in which a significant portion of their energy is from renewables. The third energy transition focuses on building decentralized electricity supply infrastructures. With a decentralized electricity supply, more circular energy systems would be created to build customized solutions for end users.

Such global renewable energy transitions could be expedited by South-South and Triangular Cooperation. Close technical cooperation between Southern countries, given their relatively similar economic status, geographic conditions and environmental challenges, could help them to acquire necessary sustainable energy technologies. Expanding access to renewable energy technologies would help them to expedite sustainable growth and development. To be specific, South-South Cooperation plays a crucial role in enhancing electricity and sustainable energy access in rural and isolated communities. For example, although Ghana's electricity access rate of 81.4 percent is far higher than the 24 percent sub-Saharan African average, many rural communities in the country still lack access to grid electricity due to difficult socio-economic challenges (South-South World, 2019).

In addition, SSC can establish more sustainable energy value chains through manufacturing, assembling, installing, maintaining and repairing renewable energy services. In global supply chains, where trade in manufacturing has expanded, big gains are enjoyed by large manufacturers and the value added from export activities remains low (UNCTAD, 2018). Southern economies with weak productive capacities often remain trapped in low value adding activities at the bottom of chains, which in turn leads to weak industrialization, slow productivity growth and growing income gaps with Northern economies. SSC practices strengthen regional value chains in the South, as it focuses on building productive capacities and structural transformation at the regional level (UNCTAD, 2019). In the long-term, SSC can generate economies of scale, create jobs and promote diversification and production upgrading in Southern economies. Such benefits in the global supply chain derived from SSC also apply to sustainable energy value chains. Southern countries with a large supply of raw materials would be able to enter the value chain, but they could add even greater value if they could produce high-tech components. For example, the manufacturing of components for wind energy, such as turbines, requires technical sophistication (ConnectAmericas, 2015). Training more local subcontractors in Southern countries with high-tech skills through SSC can help these countries create more value.

Furthermore, in the transition toward renewable energy, Southern countries that have limited fossil fuel reserves could profit from reducing their import bill for fuel. Given frequent unexpected geopolitical events, energy importing countries are vulnerable to price fluctuations. Triangular Cooperation practices have been pronounced in renewable energy transitions. A successful example was a four-year (2015-2018) programme called the China-Ghana South-South Cooperation on Renewable Energy Technology Transfer, implemented by the Ghana Energy Commission and the China Ministry of Science and Technology and funded by the government of Denmark (*Case Study 8*).

CASE STUDY 8

CHINA-GHANA SOUTH-SOUTH COOPERATION ON RENEWABLE ENERGY TECHNOLOGY TRANSFER PROGRAMME

The China-Ghana South-South Cooperation on Renewable Energy Technology Transfer programme was implemented by the Ghana Energy Commission and the China Ministry of Science and Technology and funded by the government of Denmark. UNDP Ghana facilitated the Chinese and Ghanaian governments to review Ghana's renewable energy policies and strategies and to identify capacity building gaps and potential investment opportunities. UNDP organized a series of exchange visits and business-to-business (B2B) match-making events so that Chinese and Ghanaian private companies could tap into investment opportunities. Part of the programme was to formulate a Renewable Energy Master Plan and Renewable Energy Act for Ghana.

The Government of Ghana had identified renewable energy development as a key component of its efforts to minimize the adverse effects of energy production on the environment, reduce poverty and improve socio-economic development of the country, particularly in rural areas. To have a clear roadmap for long-term renewable energy development, the Renewable Energy Master Plan identified specific goals to be achieved by 2030 (quoted from UNDP, 2019):

- → increase the proportion of renewable energy in the national energy generation mix from 42.5 MW in 2015 to 1363.63 MW (with grid connected systems totaling 1094.63 MW);
- → reduce the dependence on biomass as the main fuel for thermal energy applications;
- → provide renewable energy-based decentralized electrification options in 1,000 off-grid communities; and
- → promote local content and local participation in the renewable energy industry.

Along with creating the Renewable Energy Master Plan, the programme focused on removing technical and social barriers that hindered the widespread absorption of Renewable Energy Transfers (RETs). Ghana was able to strengthen its training facilities and improve the capacity of researchers and trainers in RETs. The programme built a network and partnership with local enterprises in China and Ghana.

The successful Renewable Energy Transfers of this programme are regarded as key drivers for the United Nations Sustainable Energy for All (SE4ALL) initiative,[47] whose main goal is to double the share of renewable energy in the global energy mix.

47 Launched by the United Nations Secretary-General in 2011, the United Nations Sustainable Energy for All (SE4ALL) initiative is an independent international organization working with governments, the private sector and civil society to achieve SDG 7.

Triangular cooperation practices in the renewable energy field are not limited to the national level but are also encouraged at the local level. The Renewable Energy and Energy Efficiency Partnership, a Vienna-based international organization that advances markets for renewable energy and energy efficiency in Southern countries, funded a South-South Cooperation project between cities in India, Indonesia and South Africa between 2011 and 2013 (ICLEI, 2013). Receiving guidance from the city of Coimbatore in India, Ekurhuleni Municipality in South Africa and Yogyakarta City in Indonesia identified and realized the high potential of renewable energy to provide more efficient municipal services. Yogyakarta built the Yogyakarta Renewable Energy and Energy Efficiency Resource Centre to help increase the transparency of electricity bill payments and disseminate knowledge on renewable energy to the general public. A workshop held in Yogyakarta in June 2013 brought 50 participants from three cities together to share experiences on how they could shorten the learning curve to reduce energy usage and greenhouse gas emissions (ICLEI, 2013). SSC and Triangular practices at city level are expected to have transformational effects, as "learning" cities, such as Ekurhhuleni and Yogyakarta, could become resource cities to roll out programmes in neighboring cities.

4.2 SOUTH-SOUTH AND TRIANGULAR COOPERATION FOR SUSTAINABLE ENERGY STORAGE

Along with renewable energy generation, South-South and Triangular Cooperation has great potential to tap into energy storage. Sustainable energy storage is a promising solution to enhance system flexibility for weak grids, isolated locations and vulnerable environments where electricity supply is not reliable, such as many locations in the global South. Renewable energy, with its available storage options, fast frequency response, reduced costs and easy deployment could make better energy storage possible. The World Bank's 2018 flagship initiative to support energy storage deployment in Southern countries shows sustainable energy storage's significance not only for expanding energy access but also for transitioning to much cleaner and more stable energy systems (IEA, 2019). With $1 billion and other funding sources on the way, the initiative aims to "finance 17.5 gigawatt hours (GWh) of battery storage by 2025, which is more than triple the 4-5 GWh currently installed in Southern countries" (World Bank, 2018).

For sustainable energy storage, in particular, the ability of lithium-ion batteries to store significant amounts of energy for hours in small packages has transformed the way people live and work in Southern countries. Lithium-ion batteries are frequently used in the global South for rural electrification (EESI, 2019). Paired with solar panels, lithium-ion batteries enable households and businesses to use limited amounts of electricity to charge cell phones, use appliances and light up buildings. Previously, off-grid users either did not have access to electricity or depended on cost-prohibitive diesel generators.

The growing demand for lithium-ion batteries, which are valued as low-cost, safe and high-energy batteries, could be met by SSC-led supply. In 2019, India and Bolivia created a development cooperation partnership under an SSC framework. India committed to provide a $100 million line of credit to Bolivia for financing development projects that Bolivia would need, such as mining, space, IT and the Bi-Oceanic Railway project. In exchange, Bolivia contributed by providing lithium carbonates, which are crucial for India's plan to have at least 30 percent of its vehicles run on electric batteries by 2030 (IamRenew, 2019).

In 2018, experts from the Argonne National Laboratory, the flagship institution for research and development of energy storage materials of the United States Department of Energy, visited the University of Limpopo to help advance South Africa's lithium-ion battery research and efficient production efforts. The collaboration benefitted from the presence of a senior researcher, Mike Thackeray, who received his doctorate from the University of Cape Town and headed the battery department at the Council for Scientific and Industrial Research in South Africa before moving to the Argonne National Laboratory in the United States in 1994. Thackeray invented the use of spinel oxides in lithium-ion batteries (Venter, 2017). Such SS&TrC could attract substantial interest and investment and help establish the presence of countries such as Bolivia and South Africa in the lithium-ion batteries industry.

5. South-South and Triangular Cooperation opportunities in blockchain applications for climate change mitigation and adaptation

The world is in the midst of precipitously declining climate change conditions, with many Southern countries in a particularly vulnerable state. South-South and Triangular Cooperation opportunities in the utilization of blockchain may help the global South to combat and adapt to climate change.

The emergence of blockchain technology (or in more general terms, Distributed Ledger Technology), has shown great potential in accelerating climate action, as acknowledged by the United Nations Climate Change Secretariat (UNFCCC, 2018). Blockchain introduces a new and innovative form of decentralized database that allows the secure exchange and storage of data and digital assets. It is primarily designed for peer-to-peer transaction platforms in trading without third parties, which brings greater transparency, stakeholder involvement and engagement. The useful application of blockchain technologies in tackling climate change can be largely summarized as follows: improved carbon emission trading, facilitated clean energy trading, enhanced climate finance flows and better tracking and reporting systems.

Firstly, blockchain technology can help tackle the challenges of carbon emissions trading. In the carbon emissions trading market, it is difficult to track emissions accurately due to lack of a standard measurement protocol. Also, since self-reporting does not require a strict verification process, there is limited transparency. A high number of intermediaries in the market complicate the trading process and incur high transaction costs. According to an Infosys report from Oracle, blockchain provides a single platform for carbon measurement, with data from multiple sources that manufacturers are already using and for a reporting network based on standardized metrics. The report further confirms that blockchain helps "every partner across the supply chain, i.e., manufacturers, suppliers and distributors to work together in a transparent and accountable manner with the original equipment manufacturer (OEM) or retailer to drive a unified carbon ecosystem with accurate measurement and credits" (Banerjee, 2018). The data is traceable, transparent and visible in real time to all stakeholders, which naturally streamlines the carbon trading process. As such, blockchain not only reduces costs but also improves transparency and security (IBM, 2018).

Blockchain technology could also facilitate clean energy trading. In Singapore, companies can buy and sell Renewable Energy Certificates that represent a unit of green energy production from wind and solar power (Goh, 2018). A similar concept to carbon trading, firms who want to offset their non-green energy production can buy Renewable Energy Certificates from others who produce excess green power. Through Renewable Energy Certificates trading on a blockchain-powered system, verification processes at a centralized entity become unnecessary, which allows for better transparency and lower transaction costs. Easier tracking of Renewable Energy Certificates and lower costs in verifying the certificates also allow small energy consumers and producers to participate, potentially contributing to larger trading volumes.

In addition, blockchain technology holds the potential for helping climate finance reach vulnerable communities which often face the hardest consequences of climate change. The International Institute for Environment and Development estimates that only 1 in 10 US dollars (a total of $60 billion) in public and private climate finance from dedicated climate funds directly reaches local level activities (Soanes et al., 2017). Because blockchain allows transparent transactions of not only money, land and identities, but also assurances of the impact created by an investment, blockchain could be a key tool to increase funds for climate finance investments and deliver them directly to local communities. Gainforest, for example, uses smart contracts to incentivize small-scale farmers in the Amazon to conserve the rainforest. Farmers receive rewards from private individuals or institutional donors through crowdfunding to preserve patches of rainforest over a three- to six-month period. When remote sensing satellites verify the status

of patches, farmers automatically receive payments through smart contracts. These transactions are highly transparent, thus trusted by donors, and nudge them to invest in a "smarter" way to support local communities. Bitland in Ghana, another example, uses blockchain technology to create a transparent record of land ownership. A transparent public record of who owns what improves local people's access to finance, as they can prove their land ownership and secure credit by borrowing against it (Greene, 2018).

Blockchain could furthermore be useful in improving climate-related monitoring, reporting and verification (MVR) applications of greenhouse gas emissions and mitigation actions. The goal of MRV of greenhouse gas emissions is to understand an entity's emissions profile and report it in the form of an emissions inventory. The MRV of mitigation actions refers to monitoring their implementation to assess greenhouse gas and other non-greenhouse gas impacts (adopted from WRI, 2016). Blockchain's potential for improving MRV applications is summarized in *Table 6* below.

Table 6: Blockchain potential for monitoring, reporting and verification of emissions and mitigation action

Challenge	Potential for blockchain
Lack of transparency	Greater transparency of how the data is collected and reported and how the combination of parameters leads to the determination of greenhouse gas reductions through the use of shared ledgers displaying relevant MRV parameters.
Costly and impractical	Coupling the benefits of a decentralized database with smart contract applications and the Internet of Things automates processes, thus lowering transaction costs and reducing complexity.
Time consuming	Blockchain technology and decision-making via smart contracts makes climate finance investments more attractive; verification can become a rolling approach where data is checked automatically or in real time.
Limited exchange of MRV frameworks (data silos)	Storage of MRV raw (primary) data on a blockchain (following a joint protocol) could lay the groundwork for connecting MRV frameworks and end the era of data silos.

Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2019), Blockchain for Mexican Climate Instruments: Emission Trading and MRV Systems, p. 34.

Due to blockchain technology's huge potential in advancing climate actions, Southern countries, as the most severely affected part of the world, are seeking more South-South and Triangular Cooperation opportunities in the utilization of blockchain to combat climate change. Southern countries, such as Chile, Brazil, India, Indonesia and Venezuela, have made large increases in their investments in blockchain technology. Through 2017, China filed more blockchain-related patents than any other country (Rogin, 2019) and in 2018, the China Development Bank signed a Memorandum of Understanding for blockchain research collaboration with BRICS countries. In 2018, the size of the blockchain market was $1.2 billion and is expected to increase up to $39.7 billion by 2025 (Statista, 2021). With such huge investments, some of the ongoing successful SSC practices can be pushed forward through the utilization of blockchain technology.

For example, South-South Cooperation between the two large cities of Beijing, China, and Lagos, Nigeria, was established to share China's successful air quality management experience and identify potential collaboration areas. In fact, this can be considered a case of triangular cooperation in that the collaboration work was supported by the Pollution Management and Environmental Health Multi-Donor Trust Fund within the World Bank's Environment and Natural Resources Global Practice. The Trust Fund supported a visit to Lagos of two Chinese delegations from the Ministry of Environmental Protection to share its air quality management experience, especially in the Jingjinji region. The Nigerian delegation, led by the governor of Lagos State, also was supported to pay a visit to Beijing and Tianjin in November 2017 to learn policy approaches with regard to air quality management at city, regional and national levels (World Bank, 2017).

China can also lead South-South Cooperation in this area because it has ten years of air quality management experience, in other words, ten years of datasets of air quality data. Launched by a Chinese non-governmental organization, the Institute of Public and Environmental Affairs, an app called Blue Sky allows the Chinese public to check real-time data on air and water quality, local sources of pollution and scrutinize emissions from 9,000 polluting companies (Chen, 2016). Not only has this app put pressure on companies to self-monitor their pollution, but it has also helped to strengthen pollution peak detection, which in turn enables more accurate early warnings for those who are vulnerable to air pollution, such as children, the elderly and people with heart and lung diseases. China sharing its successful experience in using real-time air quality data to take appropriate climate actions would be helpful for other Southern countries. For those who have a weak air quality monitoring system, learning blockchain technology, its application in improving air quality and its implications for both public and private entities could accelerate their own climate actions.

South-South and Triangular Cooperation could help to overcome some of the limitations of blockchain technology applications in climate mitigation and adaptation. Major limitations are lack of solidified legislative frameworks and data privacy. Legislative frameworks for blockchain are currently distributed all over the world, as blockchain ledgers do not have a specific or clearly identified location for each transaction (World Economic Forum, 2018). Without clarifying which jurisdiction, a blockchain falls under, it is complicated to decide which laws should be applied to conflicting regulatory and compliance demands from different entities implementing blockchain technology. Also, a careful examination should be made of how to handle personal data stored on blockchain ledgers. In the case of a public blockchain network, it would be extremely difficult to control where personal data is transferred to and who has access to it. In the worst-case scenario, a citizen's personal data collected through a blockchain-based app could be abused, misused or sold by companies working with the government (Guerrini, 2016).

South-South and Triangular Cooperation platforms and arrangements could be useful in establishing collaborative, harmonized and standardized climate governance frameworks, including those related to blockchain technology. Sharing not only successful cases but challenges faced in employing blockchain technology to tackle climate change, such as data concealment and confidentiality breach cases, would be helpful for other Southern countries when integrating new approaches into their national blockchain implementation. Learning from the experiences, both positive and negative, of other Southern countries who used blockchain technology in collecting and reporting climate data can help assure the proper flow of data between citizens and the state and can align the flow with successful transparency practices (Rough, 2019). A World Bank-commissioned report supports the belief that a collaborative governance system that enables more efficient monitoring, reporting and verification standards can help with implementation of the Paris Agreement. It can be achieved "firstly, through blockchain-enabled distributed ledgers that provide transparency and robust rule implementation via smart contracts; secondly, through collaborative governance systems that enable more efficient development of MRV standards structured as holistic systems of modular, compatible and extensible methods and rules" (Clack et al., 2016).

6. Conclusion

The impact of the global climate change, especially its associated increased risk of natural disasters, is one of the great challenges facing humankind. The 2016 Paris Agreement under the United Nations Framework Convention on Climate Change highlights the urgency of climate action. In a variety of space and time scales, climate change is becoming increasingly apparent, and the frequency of extreme weather events has increased by a record amount and threatens more and more regions and populations. This is especially true for countries of the global South that require urgent enhanced support mechanisms to undertake ambitious efforts to combat climate change.

Because of their ability to obtain and analyze huge amounts of data related to climate change, various digital technologies are being employed to support policymakers to implement appropriate mitigation and adaptation policies to address the climate challenge. These new digital technologies, such as remote sensing, Big Data, blockchain and artificial intelligence, have enhanced the ability to cope with climate change and disaster. However, digital technologies can only be beneficial when deployed and utilized correctly. Digital technologies could also be detrimental due to their own risks and limitations, such as lack of data privacy, inadequate governance and the existing digital divide. In this regard, South-South and Triangular Cooperation can be brought into full play to enlarge the positive effects of digital technologies and to minimize their risks through sharing of technologies, systems, data, knowledge and experiences.

South-South Cooperation has made significant progress in remote sensing and GIS technology collaborations, especially through sharing data. Since China and Brazil jointly developed and launched the China-Brazil Earth Resources Satellite (CBERS-01), satellite remote sensing data are not only effectively shared between two countries, but are also available to other countries, benefitting especially countries in the global South. The China-ASEAN Remote Sensing Satellite Data Sharing Service Platform Project in 2012 is a good example of a region being able to establish a satellite data sharing service platform by relying on another country's (China) remote sensing satellite data resources. The applications of remote sensing and GIS technologies are also prominent in climate mitigation and adaption efforts in the global South. Through sharing satellite remote sensing data to disaster-affected areas, Southern countries benefit from more accurate and faster disaster monitoring and assessment. The Disasters Charter whose nine out of 20 members, are from Southern countries as of 2020, shows how data, information, technology and knowledge sharing strengthens disaster reduction in disaster-affected countries.

Blockchain technology possesses the potential for facilitating carbon emissions trading and clean energy trading, assuring that climate finance investments are delivered to local communities and improving climate related MRV applications of greenhouse gas emissions and mitigation actions. Although blockchain applications are not yet in full bloom, successful SSC practices, such as China's blockchain research collaboration with BRICS countries to improve air quality, highlight their importance. In addition, South-South and Triangular Cooperation could be leveraged to overcome blockchain's limitations regarding the lack of legislative frameworks and data privacy by establishing a collaborative, harmonized and standardized climate governance framework.

The aforementioned wide range of cases of South-South and Triangular Cooperation across various geographical areas show that many countries can benefit from practices that utilize digital technology to combat climate change. Acknowledging that many of the current South-South cooperation practices are led by BRICS countries who have upper socio-economic status among global South countries, SSC should be carefully approached and practiced so that all participants can benefit from cooperation, especially those Southern countries with fewer resources to use digital technology to its fullest extent.

Chapter 8

Impetus and mechanisms of South-South and Triangular Digital Cooperation

1. Introduction

Over the past decade, the rapid expansion of digital technology has helped to transform the global economy and reshape human social activities. While South-South Cooperation and Triangular Cooperation influence digitalization, digitalization in turn also influences the practices of such cooperation. Digitalization creates new opportunities for Southern countries to address their wide-ranging development needs. As was shown in the cases in previous chapters, digitalization plays an active role in agriculture, poverty reduction, climate change, health, education, finance and many other areas of importance for broad-based sustainable development across the globe.

While digital technology enhances communication and information flows across country borders and strengthens global interconnectedness, current cooperation mechanisms for Southern countries have not been able to apply it more broadly, which is increasingly seen as key for the attainment of the 2030 Sustainable Development Agenda. Many pilot projects and innovative solutions around digitalization for sustainable development, as shown in the cases in the previous chapters, are focused on unique local experiences and conditions. These solutions are still limited in scale, either in a country or in a region, and have not been replicated elsewhere. Digital solutions aimed at eradicating poverty and influencing real change in the global South can only be effective if scaled up and transferred more broadly across Southern countries with different levels of development. To this end, South-South Digital Cooperation can help explore the possibility of applying these innovative solutions more broadly across the global South.

Many of the challenges that need to be overcome in digital technology development – related to issues such as e-commerce, cross-border payment, e-government and digital governance – cannot be tackled by countries in isolation. On the contrary, these challenges require cooperation and collaboration among countries, as well as the creation of international governance structures that set technological standards, not the least of which are standards related to security, and offer some degree of harmonization in the technologies employed globally. The needs of Southern countries in this regard are not fully addressed (United Nations Secretary-General's High-Level Panel on Digital Cooperation, 2019: 30-31). Only through cooperation involving Southern countries and other key stakeholders, including the private sector, foundations, development banks and research institutions, can effective and inclusive global governance structures and institutions be built. Those structures and the cooperation they promote will in turn be crucial for defining the role of digital technologies in the areas of trade, taxation, cross-border data flows, intellectual property rights and employment. In these areas and many others, Southern countries have their own distinctive interests and needs, which South-South Digital Cooperation can help them to voice and to address globally.

This chapter focuses on the international cooperation dimension of the digital story. Section 2 highlights the significance of South-South Digital Cooperation. Section 3 discusses some key development impetus for fashioning a global South driven by digital technology, based on a 2018 UNOSSC and FCSSC report titled "South-South Cooperation in a Digital World." Section 4 explores the mechanisms and means for promoting South-South Digital Cooperation, with some cases illustrated. Section 5 and 6 present conclusions and policy suggestions on South-South Digital Cooperation.

2. Emerging trends of digitalization in the global South

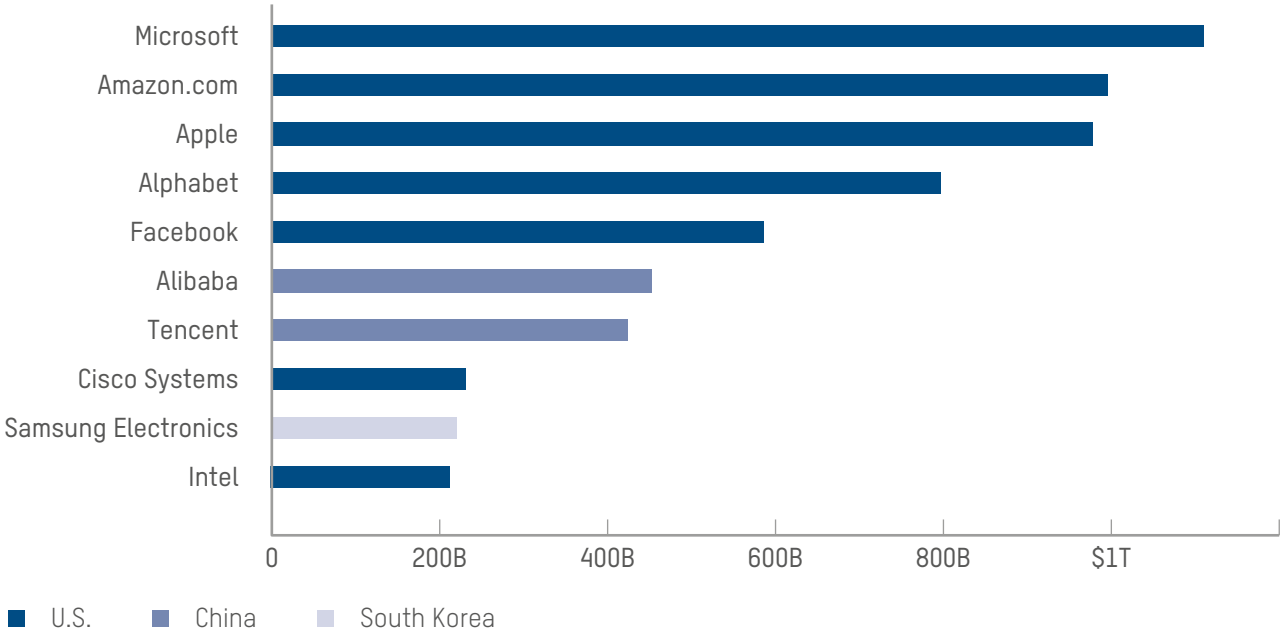
Why should South-South and Triangular Digital Cooperation be promoted? The evidence supporting a causal relation between the emergence and expansion of digital economies and innovation, on the one hand, and sustainable development, on the other, is overwhelming. Nevertheless, it is important to note that digitalization is not the answer to all development challenges, nor is it without its shortcomings, challenges and obstacles. There are four emerging trends of digitalization, discussed below, which highlight the significance of South-South Digital Cooperation as well as its limitations. These are: 1) southern countries are creating their own innovative digital solutions to development challenges; 2) the development of digital technology in Southern countries does not necessarily lead to the narrowing of wealth gaps between the rich and the poor; 3) South-South Digital Cooperation has the potential to allow technological 'leapfrogging' in Southern countries; and 4) digital technologies can be a powerful tool for monitoring and evaluating South-South Cooperation.

2.1 SOUTHERN COUNTRIES CREATE INNOVATIVE DIGITAL SOLUTIONS TO DEVELOPMENT CHALLENGES

Digitalization and the digital economy have developed rapidly not only in the North, but also in the global South, particularly in China and the emerging economies (*Figure 8*). For instance, India has become the largest exporter of IT services. The top five Indian IT companies are Tata Consultancy Services, Infosys, Wipro, Tech Mahindra and HCL Technologies (Raveendran, 2019). In Brazil, digital technology, especially blockchain technology, is witnessing unprecedented growth. In September 2019, Brazil used blockchain technology to issue the first digitally recorded birth certificate in the world (Wood, 2019). Similarly, 10.7 percent of internet users in South Africa own cryptocurrencies, ranking first in the world, according to a survey published in the *Global Digital Yearbook 2019* (Hootsuite and We Are Social, 2019: 205). Thailand and Indonesia ranked second (9.9 percent) and third (9.5 percent), respectively, in cryptocurrency use in the world. In India, 6.5 percent of internet users owned cryptocurrency. In addition, 80 percent of the population in Africa had mobile subscriptions in 2019 (Hootsuite and We Are Social, 2019: 205).

The rapid development of digitalization in the global South suggests that Southern countries also possess their own experiences and solutions on digitalization and the digital economy and that they are creating their own innovative digital solutions to development challenges. These homegrown digital innovations from Southern countries are generally more applicable and practical to other Southern countries than those from their Northern counterparts. Specifically, Southern countries share similar development contexts and needs. These Southern countries can fruitfully work together on digital technology transfer, knowledge sharing and capacity building through South-South Digital Cooperation.

Figure 8: Market valuation of top technology companies



Source: Wu, Hoenig and Dormido (2019).

Unfortunately, however, evidence shows an emerging digital divide within the South itself, as Least Developed Countries lag behind in terms of digital technology use and development. In these countries, only about one in eight people have access to the internet and less than 20 percent of the population have mobile broadband subscriptions. Internet access is largely led by mobile phone technology. Gender inequalities are also evident as just about 12.5 million women are online, as opposed to 18 million men. In addition, internet speed remains a considerable challenge in Least Developed Countries (OECD and WTO, 2017).

While some African countries are clearly innovating in the use of digital technology, Africa in general has a slower uptake of digital technologies than other world regions. Africa accounts for 13.4 percent of the global population, but only produces 1.1 percent of the scientific knowledge. Only one percent of global investment in R&D is spent in Africa and the continent holds approximately 0.1 percent of the world's patents. In the interest of ramping up innovation and solutions to development challenges, a need exists to promote and facilitate digital policies that support scientific R&D work. Through the leveraging of regional technology transfer processes and increasing open access to scientific knowledge, Africa's capacity to develop, produce, manufacture and assemble digital products and services can allow it to build a globally competitive ICT service sector and industries (African Union, 2020). Fortunately, efforts to shift the slow adaption of science and technology sectors to commercialize innovative solutions across Africa are being made through agreements, such as the decision by heads of governments and states to increase R&D investments to at least one percent of GDP and the adoption of the Science, Technology and Innovation Strategy for Africa 2024 (STISA).

BOX 2 AFRICAN DIGITAL SOLUTIONS

A notable example of homegrown digital technology development is Rwanda's Digital Transformation Center, an initiative carried out in partnership between the Government of Rwanda, through the Ministry of ICT and Innovation, and the Germany Development Agency (GIZ). This initiative created space for innovators, including 24/7 access to high-speed internet and a support ecosystem – including mentors, well-stocked hardware devices and the latest software – that enables users to prototype, commercialize and expand their cutting-edge digital solutions (Kaliisa, 2019).

The African Alliance of Digital Health Networks works to ensure that African countries have the support and resources needed to develop strong digital health systems. Its Digital Health Leadership Program improves the technical capacities of African digital health leaders, particularly in government agencies, to develop, manage and direct in-country digital health initiatives and investments. This programme is intended to build capacity systematically and coherently through training, mentorship and support, thus tying generic course content and knowledge to digital health (African Alliance).

In agriculture, several successful innovative ventures in West Africa have overcome hurdles to modernize one of the oldest industries in the region. For instance, Verdant uses mobile phones to help improve food production. The start-up provides agricultural extension, market information, managerial support and access to financial services to rural farmers with innovative, yet simple, mobile technologies. Verdant is able to bring together stakeholders and major players in the agricultural value chain under one platform, including not only the farmer, buyers and the agri-industry, but also research agencies, donor organizations, governments and financial institutions.

Similarly, the Farmerline platform targets Ghana's smallholder farmers. Farmerline links farmers to markets, finance, inputs and equipment services. It offers a range of supply chain innovation products and services that help small-scale farmers and the organizations that work with them. AgroData is an agritech company that uses digital technology in agriculture in Nigeria. Specializing in precision agriculture, AgroData supports and improves tropical farming with the creative use of spatial data, processed agricultural information and agricultural research data. Esoko is a communication tool for businesses, governments, NGOs and others to connect with farmers in Ghana and Liberia. Its product offerings include web and mobile apps, original agricultural content and on-the-ground deployment services. Such products are described as useful for client marketing, monitoring and advisory needs (Adepoju, 2016).

2.2 DIGITAL TECHNOLOGY IN SOUTHERN COUNTRIES IS NOT NECESSARILY NARROWING WEALTH GAPS

In general, inequality is more pronounced in the global South than in the global North. Emerging economies have sustained a period of strong economic growth, lifting millions of people out of absolute poverty. Yet, the benefits of growth have not been evenly distributed and high levels of income inequality have risen further. Among the largest emerging economies only Brazil managed to strongly reduce inequality, but the gap between rich and poor is still about five times that of the OECD countries (OECD, 2017a).

Hence, while such emerging countries have experienced rapid and profound digitalization, they still present some of the worst national indicators of socio-economic inequality in the world. While inequality is a concern of the 2030 Agenda for Sustainable Development, with a particular focus on SDG 10, according to Unwin (2019), "information and communication technologies are rarely mentioned in international fora relating to SDG10 on reducing inequalities, and interestingly none of the targets for this goal make any references to digital technologies." This may be the case because of the overwhelming attention paid to digitalization as a driver of economic growth and because it is generally believed that access to digital technologies will somehow beneficially trickle down to the poor (Unwin, 2019). However, the development of digital technologies in Southern countries does not necessarily lead to the narrowing of the gaps between the rich and the poor.

Understandably, digital technologies were not developed with the primary goal of tackling inequalities. Moreover, digitalization, as any technological development, tends to increase inequalities both by eliminating jobs replaced by automation and artificial intelligence and by leading to market concentration. Therefore, it can lead to heightened economic power and wealth of owners and shareholders of large global technology corporations. In 2017, Oxfam reported that eight men owned the same wealth as the poorest half of humanity; five of these men made most of their wealth directly from the technology sector (Oxfam, 2017).

Nonetheless, digital technologies have the potential to contribute to greater inclusion and to the reduction of wealth and opportunity gaps. For instance, although e-commerce platforms can benefit companies everywhere, these platforms disproportionately boost small businesses in rural and remote areas, and thus help equalize opportunity. Entrepreneurs previously unable to sell directly in sufficiently large volumes because of high intermediary charges become enabled to do so through e-commerce. For instance, the Chinese platform Taobao.com – part of the Alibaba Group and the largest online marketplace by volume among emerging economies – allows tea growers, furniture makers, suitcase manufacturers and other small producers and merchants, including those from remote villages, to reach their customers in Shanghai and Beijing, and even overseas, more easily and cheaply (Wei, 2019).

Moreover, as a World Bank report titled "E-Commerce Development: Experience from China" points out, e-commerce may promote gender equality. While the vast majority of offline entrepreneurs are men, the report offers considerable empirical support showing that online counterparts are as likely to be female as male (World Bank and Alibaba Group, 2019). The report does not explain why e-commerce would disproportionately favor female entrepreneurship. However, it notes that in Shuyang and Suining, Jiangsu Province, many young women return from the cities to develop e-commerce businesses and earn incomes similar to or higher than they did previously (World Bank and Alibaba Group, 2019).

Similarly, FinTech can help to meet the financing needs of micro and small businesses. For instance, Ant Financial, which is partly owned by the Alibaba Group, generates credit scores by using cash flow data, online customer reviews and other digital indicators. It then uses these scores to make uncollateralized loans to more than a million vendors of micro and small enterprises in China that previously could not obtain a traditional bank loan. Entrepreneurial growth after FinTech credit access is larger for younger firms and younger entrepreneurs (Wei, 2019).

Digital technology also offers the possibility of directly decreasing imbalances in educational resources between poor and rich areas. Many rural schools in the global South cannot afford to recruit and retain high-quality teachers or to provide effective, up-to-date training for the teachers they have. As a result, rural students tend to do less well than wealthier urban areas. YouChange Foundation, a non-profit organization, persuaded top primary and middle schools in Beijing and other large Chinese cities to have video cameras installed in their classrooms and to let schools in poor and remote rural areas audit their lessons via online video links. In so doing, the YouChange teaching programme helped reduce the educational gap between some of China's poor rural regions and its much richer urban areas (Wei, 2019).

Moreover, emerging economies may potentially act as a digital growth hub for smaller and low-income developing countries, which may in turn further boost growth in these emerging economies (UNOSSC and FCSSC, 2018). For instance, in 2012, the Brazilian Institute of Geography and Statistics, the Brazilian Cooperation Agency, the United Nations Population Fund (UNFPA) and the national statistical offices of Cabo Verde, Senegal and South Africa came together to establish reference centres for censuses using electronic data collection in the three African countries. The project utilized the technical knowledge and experiences of the Brazilian Institute of Geography and Statistics on data gathering and censuses. In these countries shared technical equipment, namely personal digital assistant devices – handheld devices combine computing, telephone/fax, internet and networking features, to gather data. This initiative came about in response to the need of countries for reliable data to undertake policy evaluations, monitor progress and ensure the transparency and accountability of national institutions (UNOSSC, 2016). This is also an example of Triangular Digital Cooperation, bringing together the resources of governments and international institutions and exploiting their complementarities to promote digital development in partner developing countries.

2.3 SOUTH-SOUTH DIGITAL COOPERATION AND 'LEAPFROGGING' IN SOUTHERN COUNTRIES

Digital technology creates numerous possibilities for Southern countries to 'leapfrog,' meaning because of digital technology these countries may be able to bypass some of the intermediate stages of technological development that Northern countries have gone through. Southern countries arguably have latecomer advantages regarding technology adoption. The lack of legacy infrastructure and entrenched vested interests often allows for rapid adoption of emerging digital technologies, especially compared to developed countries that need to follow more incremental transition plans. This flexibility permits developing countries to plan policies, innovation ecosystems and infrastructure with emerging technologies in mind from the outset. This approach may speed their transition to more efficient systems and provide their entrepreneurs an early opportunity to become a part of the value chain that grows around those innovations (Yayboke, 2020).

For instance, while smartphone payments are still gaining ground in the United States, mobile money has been used for over a decade in Kenya. The majority of the Kenyan population subscribes to a mobile payment service, of which the most popular choice is M-Pesa which dates from March 2007 when it was launched by Vodafone. M-Pesa (*pesa* means "money" in Kiswahili) has made a dramatic impact over time, gaining 30 million users in ten African countries and offering a range of services, including international transfers, loans and health provision. The system processed around six billion transactions in 2016 at a peak rate of 529 per second. M-Pesa is also lauded for its social value, offering opportunities for small businesses and playing a significant role in reducing poverty (Monks, 2017).

However, many Southern countries alone cannot realize leapfrogging due to a shortage of the tools needed, such as resources, infrastructure, technologies, skills and knowledge which, in themselves, cannot be leapfrogged. Moreover, it is essential that an enabling regulatory environment be created. Technologies must be examined with a view to their interconnection before adoption occurs – ad hoc, uninformed and uncoordinated decision-making that does not conform to a global standard may lead to costly, isolated and, hence, useless solutions. This reinforces the need to look beyond national boundaries

to a situation in which regional and global infrastructures are developed, permitting communication among developing countries and with the rest of the world (Davison et al., 2000).

The local context, challenges and needs must also be considered. For example, a strategy to use networked cameras to improve traffic management is totally inadequate if cities are struggling to install traffic lights or enforce basic traffic laws. Similarly, investments in autonomous vehicles or advanced robotics for manufacturing may not work for developing nations whose comparative advantages lie in low labour costs (Yayboke, 2020). Finally, to succeed, leapfrogging needs to be sustainable and applied for the long-term.

As will be shown in the next part of this chapter, current aid programmes from advanced economies cannot fully address the digital needs of Southern countries, both financially and technically. Critically, given the challenges and problems indicated above, the best way to approach leapfrogging is to start with development gaps and then ask how new technologies may be able to help solve them (Yayboke, 2020). By espousing this demand-driven principle, South-South Digital Cooperation can help bridge gaps as a complement to North-South cooperation.

2.4 DIGITAL TECHNOLOGIES FOR MONITORING AND EVALUATING SOUTH-SOUTH COOPERATION

One of the key debates in the practice and governance of international development cooperation relates to monitoring and evaluation. While this debate is strongly associated with the development effectiveness agenda pursued by Development Assistance Committee and OECD members since the 1990s and embodied in the Paris Declaration (2005), Southern providers have insisted that their development cooperation is distinctive and, accordingly, requires different monitoring and evaluation approaches from those of the Development Assistance Committee members. Digital technologies can be a powerful tool for monitoring and evaluating South-South Cooperation and may help address these concerns.

Digital technologies have made possible several innovative and more recent evaluation methods which can render SSC more participatory. For instance, through crowdsourcing, a large number of people actively report on a situation around them, frequently using mobile phone technology and open-source software platforms. It allows data collection on a scope usually not feasible through traditional evaluation methods and also allows gathering information on sensitive issues that these methods would have difficulty addressing (such as corruption). Moreover, crowdsourcing is able to gather massive, location-specific data in real-time with lower running costs than more traditional monitoring and evaluation methods. It can boost civic engagement by establishing direct channels of bottom-up communication and, if systems are set up right, crowdsourced data tends to be more difficult to manipulate and less vulnerable to biased interpretation, therefore potentially increasing independence and credibility. More structured mobile data collection systems may also be put in place to run designed surveys which collect specific information from target audiences (Winderl, 2013).

For example, the development of a crowdsourcing platform has been proposed as an essential step toward combating corruption, misuse and embezzlement of funds in Tanzania. The developed crowdsourcing platform for monitoring and evaluation provides an up-to-date status of projects based on key indicators, and from such information, any member in a particular organization can monitor and evaluate the progress of a given project. A study of this platform suggests that it promotes transparency, collaboration, accountability and has the potential to motivate actors and stakeholders in monitoring projects funded by governments and donors (Sanga et al., 2019).

Hence, digitalization not only should be a target of SSC, but can also contribute to improving SSC itself, as shown by the use of new technologies for innovation in monitoring and evaluation approaches. Thus, digital technologies become a valuable tool for improving SSC in all other sectors and modalities and, in so doing, help promote development in a more indirect and broader sense than just the development and use of these technologies themselves.

3. Development impetus for the global South in the digital era

According to the previous FCSSC and UNOSSC annual report for 2018 *South-South Cooperation in a Digital World*, four of the key driving forces for South-South Digital Cooperation are digital technological change and innovation, deregulation by governments, business model innovation and consumer demand. Understanding these driving forces behind digital development in the global South will help further explore how to promote South-South Digital Cooperation.

The first development impetus for the global South in the digital era emanates from the transformation of digital technology. As cases in the above sections show, the adoption and use of block chain, the IoT, AI and many other modern technologies increases digital interconnectedness between Southern countries and the rest of the world. These cases also suggest that, driven by digital technology, the way of social life and delivery of social services (such as education and healthcare) in many Southern countries is undergoing profound change. With the advancement of digital technologies, many social interactions and social service activities take place in cyberspace, rather than in the traditional physical space.

Due to the Covid-19 pandemic, the importance of digital technologies for work, study and access to goods, services and information has also grown significantly. Telemedicine, telework and online education is currently taking place at unprecedented levels. Digitalization has allowed the generation of data related to the virus, has helped with information exchanges for research cooperation and artificial intelligence is being used to help find a cure. A surge in teleworking and online conferencing has expanded the demand for internet conferencing software, such as Microsoft Teams, Skype, Cisco's Webex and Zoom. According to Microsoft, the number of people using its software for online collaboration climbed nearly 40 percent in one week. In China, the use of digital work applications from WeChat, Tencent and Ding took off at the end of January 2020 when lockdown measures started. Another trend has been a significant shift to e-commerce (UNCTAD, 2020). While this acceleration in the adoption of digital solutions, tools and services has sped up the entire world's transition toward a digital economy, it has also widened the chasm between the connected and the unconnected (UNCTAD, 2020). Indeed, the disadvantage of countries with less access to these technologies, as well as the inequalities between them and more digitalized countries, is expected to grow significantly in the wake of the pandemic.

The second development impetus arises from governments in Southern countries making policies that create an open and friendly atmosphere for digital development. In recent years, many governments in the global South, especially in emerging economies, have increasingly relaxed controls over the digital economy and technology. China, India, South Africa and other developing countries are even going farther by actively encouraging the development of digital technologies and digital economies and have adopted relevant policies and development strategies for such purposes.

In 2018, the Ministry of Science and Technology of South Africa issued a white paper on Technology and Innovation for the next five to fifteen years. The white paper lays out the long-term national digital strategy of South Africa, to "enable South Africa's effective participation in this new world order, which is bringing increasing automation and digitization" (South African Government, 2018). The white paper suggests strengthening research and innovation in the fields of digital and information technology. The Indian government launched Digital India, a national flagship programme to transform the country into a digitally empowered society and knowledge economy. The Indian government identified nine pillars of growth, including broadband highways, universal access to mobile connectivity, e-governance, IT for jobs and electronics manufacturing (Government of India, 2015). The 2020-2030 Digital Transformation Strategy for Africa has set impressive objectives for the successful harnessing of digital technologies and innovation across the continent. The strategy points out that, despite the weak coordination and limited policy reform among African Union member states, a great potential exists to utilize existing developed ICT frameworks and policies in most states. The comprehensive framework for the implementation of the digital strategy is grounded in the diversity of existing initiatives and the collaborative strength of institutions from across the region. A crucial part of the strategy is to build digitalization from a micro-level by pushing for implementation of policy change on national and sectoral levels.

The third driving force for the digitalization of the global South comes from innovations of business models driven by digital technologies. As the 2018 annual report on South-South Cooperation indicated, innovative digital technologies, such as block chain and the IoT, are transforming traditional business models and replacing existing product models. In particular, the platform economy has become a new type of business and industrial organization model (FCSSC and UNOSSC, 2019: 50). Many developing regions, and notably sub-Saharan Africa, have cultivated numerous innovative platform companies. Beside M-Pesa and Esoko, many other platform companies have emerged in developing countries, such as Jumia, Konga and Kilimall in Africa and Flipkar in India (FCSSC and UNOSSC, 2019:46-55). These platform companies in the global South will create network effects (FCSSC and UNOSSC, 2019: 50), which means they will lead to larger scale and greater value. In turn, they will attract more customers and even further increase their scale.

The final main driving force of digitalization in the global South is customized services based on customer needs. Extensive utilization of Big Data has led to the emergence of many customized, individualized business models and services (FCSSC and UNOSSC, 2019:48, Wang, 2019). DiDi, a Chinese mobile transportation booking platform, can provide tailored taxi hailing services based on customer needs. Customers are offered specific brands of cars and special routes according to their requests. JD.com and many other online retailers provide 'limited time services' in many areas of China to customers. Realized through robot warehouse management and logistic optimization management with the support of Big Data analysis, parcels can be delivered on the same day or on a specific day based on customer requests (FCSSC and UNOSSC, 2019: 52-53). WeDoctor, a Chinese online healthcare e-platform, provides online health services, online psychological support and real-time pandemic reports. Based on individual enquiries, customers can select specific doctors in specific hospitals or professional levels, according to their preference. Through internet consultations, health services are accessible for millions of people in the western part of China, as many high-skilled doctors in China are based in cities along the country's east coast (Yao, 2020). So far, WeDoctor has gathered more than 7,000 well-known doctors and medical experts in China and more than 50,000 users have used the online medical and healthcare services (Tencent, 2020).

4. How to promote South-South Digital Cooperation

Based on the understanding of the main development impetus for the global South in the context of digitalization, this section will explore how to promote South-South Digital Cooperation. Four aspects will be discussed: (1) prioritizing digital infrastructure connectivity; (2) strengthening digital skills and capacity building; (3) diversifying financing for South-South Digital Cooperation; and (4) providing policy support to foster a sound environment for the digital economy and e-commerce across borders.

4.1 PRIORITIZE DIGITAL INFRASTRUCTURE CONNECTIVITY

Digital infrastructure connectivity is a fundamental condition for achieving high-quality digital development. Without the necessary digital infrastructure, it is difficult to promote a digital economy. For many Southern countries, inadequate digital infrastructure for connectivity is identified as one of the most significant bottlenecks restricting the continued development of digitalization and the digital economy (United Nations Broadband Commission for Sustainable Development, ITU and UNESCO, 2019:14). Due to insufficient financial resources and capabilities domestically, many Southern countries face huge gaps in digital infrastructure construction.

Accessibility is the first fundamental challenge for digital infrastructure connectivity for many Southern countries. More than four billion people in the world still have no access to the internet and 90 percent of these come from Southern countries (UNDP, 2019). South Asia is the least connected region in the world. In 2019, only about one in five people living in the region (21 percent) could get online. *Table 7* displays percentage connectivity in selected regions from 2017 to 2019 (Bikus, 2020).

Table 7: Access to internet in selected regions, 2017-2019 (%)

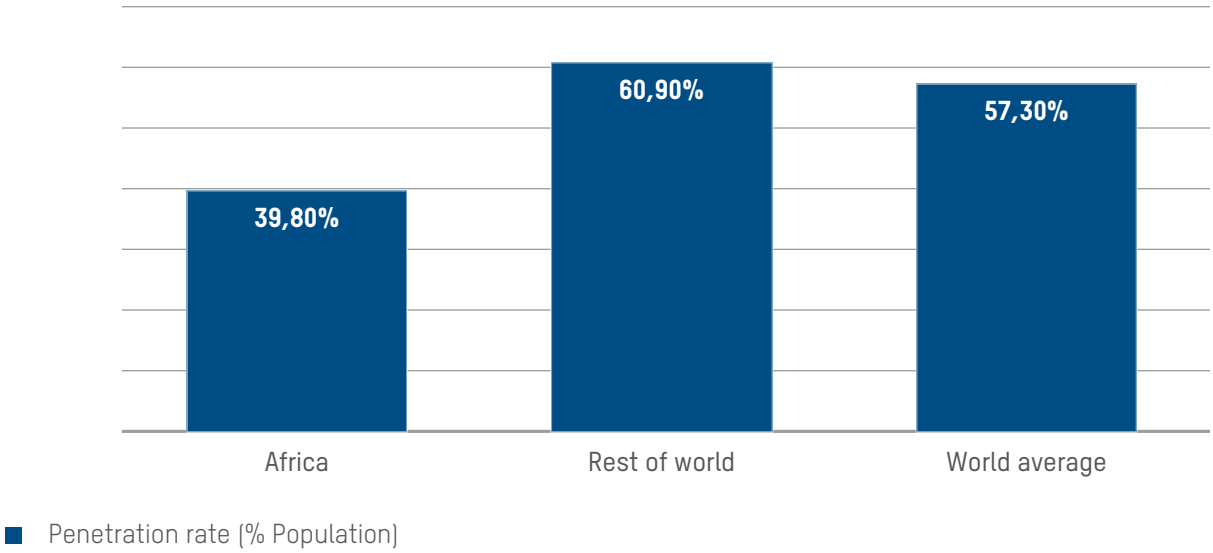
Percentage of positive answers to the following question: Do you have access to the internet in any way, whether on a mobile phone, a computer or some other device?

Region	2017	2018	2019
	%	%	%
Northern America	89	91	94
Australia-New Zealand	92	91	93
European Union	84	87	87
Europe (Other)	78	83	82
East Asia	66	67	71
Commonwealth of Independent States	66	68	70
Latin America and the Caribbean	58	60	68
Middle East and North Africa	59	62	63
Southeast Asia	42	46	55
Sub-Saharan Africa	25	30	31
South Asia	15	25	21

Source: Gallup World Poll (2019).

Internet penetration in Africa is also low, compared to other parts of the world. In June 2019, in Africa, internet users were merely 39.8 percent of the total population (*Figure 9*). In sub-Saharan Africa, only 31 percent of the population was connected to the internet (Bikus, 2020). These figures are much lower than the world average of 57.3 percent. Internet users in Africa accounted for just 11.9 percent of the world total. (Internet World Stats, 2019). According to *A Digital Infrastructure Moonshot for Africa*, a report from the United Nations Broadband Commission, the International Telecommunication Union (ITU) and UNESCO (2019:62), about 1.1 billion more people in Africa would need to be brought online and approximately $9 billion in investment required to double broadband connectivity penetration in Africa by 2021.

Figure 9: Internet penetration in Africa (by June 2019)



Source: Internet World Stats (2019).

In Latin America, an estimated 68 percent of the population was accessing the internet in 2019 (Chevalier, 2020). However, in 2017, in the two best-ranked countries in the region, only 15 percent of their connections had speeds above 15 Mbps, while in the worst ranked country only 0.2 percent of connections had this speed. As a reference, on a worldwide scale, in the ten most advanced countries in this field, more than 50 percent of the connections have speeds above 15 Mbps (ECLAC, 2018).

In all regions a significant gap exists between rural and urban infrastructure. Globally, people who live in rural areas were 40 percent less likely to use mobile internet than those in urban areas (ITU and UNESCO, 2019: 14). In Africa, the gap is particularly large, about 58 percent. In South Asia, 45 percent of those living in rural areas were less likely to use the mobile internet than those in urban areas (ITU and UNESCO, 2019: 18). Similarly, in Latin America, the average percentage point difference between internet coverage in rural and urban areas was 27 (ECLAC, 2018). Gender inequality in access to digital technology is also alarming. Females are generally left behind in terms of digital accessibility and use. Females have fewer possibilities to achieve internet access than males. Indeed, females were 24.8 percent less likely to have access to the internet in 2018 (ITU and UNESCO, 2019: 15). Hence, there is a specific need to support digital gender equality.

Beside the issue of accessibility, affordability is another key challenge. Internet access remains expensive in many Southern countries. The current affordability threshold target is five percent of monthly income, recommended by the United Nations Broadband Commission (United Nations Broadband Commission for Sustainable Development, 2018b). However, in Africa in 2018, purchasing a handset and 500MB of data cost an average of 10 percent of monthly income (Radcliffe, 2018) — twice the threshold suggested by the United Nations Broadband Commission. When focusing on low and middle-income countries, South Asia has the most affordable mobile broadband across all regions (Bikus, 2020). Many Southern countries realize the importance of building digital infrastructure. Recently, digital cooperation with an emphasis on digital infrastructure cooperation has increasingly been highlighted by many Southern governments engaged in South-South Cooperation.

One of the earlier initiatives to address the disadvantaged situation regarding digitalization in Africa is the African Union Pan African e-Network Plan, a flagship proposal of Agenda 2063, that emphasizes the construction of broadband infrastructure in African countries. This project was sponsored by the government of India in 2009 as part of its aid to Africa (Pambazuka News, 2009). The project sought to link the 55 developing member states of the African Union through a satellite network so that these countries could access and share experiences from India in tele-education and tele-medicine. It has become one of the world's geographically largest e-health and e-education initiatives (South-South Galaxy, 2020). More recently, digital infrastructure has been one of the priorities for China and the African continent and is integrated in the development strategies of both China and Africa. In particular, China's Belt and Road Initiative aligns with the African Union's Agenda 2063 on digital infrastructure development.

China is also supporting digital development in other Southern regions. In December 2017, China jointly launched the BRI Digital Economy International Cooperation Initiative with six Southern countries (Egypt, Laos, Saudi Arabia, Thailand, Turkey and the UAE). Based on this initiative, China and the six countries will cooperate on 15 major areas, of which expanding broadband access is the priority. Other main areas include promoting e-commerce cooperation, supporting internet entrepreneurship and innovation, promoting the development of small and medium-sized enterprises, strengthening digital skills training, promoting investment in the field of information and communication technology, encouraging the development of a transparent digital economic policy and advancing international standardization cooperation (Guo, 2017).

Following this initiative, China and 16 countries signed cooperation agreements to strengthen the construction of the Digital Silk Road (Office of the Leading Group for Promoting the Belt and Road Initiative, 2019). In April 2019, China held the 'Digital Silk Road' forum as part of the Second Belt and Road Forum for International Cooperation. Many enterprises were involved in the process of digital cooperation, such as the Beijing Star Times Software Technology Co., Ltd., which signed an MOU with Nigeria's National Television Station for a digital transformation project called Wan Cun Tong (*Box 3*).

BOX 3 THE WAN CUN TONG PROJECT

China's Wan Cun Tong (万村通) project was initiated in 2015 to provide access to digital satellite TV programmes to African villages. The project was an outcome of the 2015 Forum on China-Africa Cooperation (FOCAC) Johannesburg Summit. StarTimes, a Chinese electronics and media company, was contracted to deliver the project across the African countries. Prior to the commencement of this project, television in many African countries were not widely used, partially due to the high costs (initial installation fees were $200 on average and monthly viewing fees ranged from $47-100) (Zhou, 2018). Under the Wan Cun Tong project, digital satellite TV was installed in 10,112 villages in 25 African countries (Zhou, 2018).

The project installed two projection TVs and one TV in each village at no cost. The devices were placed in public areas, such as schools, hospitals, village committees and activity centres. No less than 20 sets of free programmes were offered. All the TVs were equipped with a solar system to ensure normal viewing even during power outages. In addition, a set-top box was provided for a nominal fee to 20 households in every village who had their own TV sets, with no less than 30 programme channels for home users (Zhou, 2018).

As a result, by the end of 2019, thousands of villages benefited from this project and now enjoy digital TV, according to an official announcement by the Chinese Government (Wan, 2019). Some of the Wan Cun Tong projects completed in 2019 are listed below.

Wan Cun Tong projects completed in 2019

Date	Country	Number of villages benefited
10 May	Ghana	300
24 May	Rwanda	300
13 June	Zambia	500
29 October	Nigeria	1,000
14 November	Cameroon	300

Source: Wan (2019).

The Wan Cun Tong project received high praise from local populations in the selected African countries. Côte d'Ivoire's Minister of Information and Media, Sidi Tiémoko Touré, said, "This project has effectively filled the gap in Ivorian digital TV watching and has brought the local people in my country closer to the world" (Wan, 2019). A member of the Nigerian parliament and chairman of the national parliament's committee on information, Odebunmi Dokun, commented that "The completion of the project, which we are celebrating today, is an investment to the people because it concerns the masses and enables them to connect to the digital world" (Onuoha, 2019). A traditional ruler in the Moba local government area of the southwestern state of Ekiti, Oba Sunday Adewumi, noted that "The project rekindled the hope of the locals, mostly farmers, in Igogo Ekiti [his village]" (Saliu, 2019).

The main regional cooperation mechanism between China and Africa, the Forum on China-Africa Cooperation (FOCAC), which has been viewed as a model of South-South Cooperation (Chinese Embassy in Nigeria, 2018), also attributes importance to digital infrastructure, viewing it as a key part in its cooperation on infrastructure development. Digital infrastructure building was mentioned in the FOCAC Johannesburg Action Plan (2016-2018), stating that "the two sides encourage Chinese enterprises to assist African countries' efforts to put in place digital radio and TV broadcasting systems, to promote digitalization of radio and TV services, and to benefit more people in the rural areas in Africa (3.3.10)." Four years later, the goal of building digital infrastructure was reiterated in the FOCAC Beijing Action Plan (2019-2021) in several passages, mentioning new technologies, smart cities, counter terrorism and optical fibre cable backbone networks, among other topics.

4.2 STRENGTHEN DIGITAL SKILLS AND CAPACITY BUILDING

Digital capacity determines whether a country or an individual can take advantage of digital technology and the opportunities it brings. In general, digital skills encompass two major aspects: (a) basic digital literacy to access, use and benefit from digital resources; and (b) skills for employment and digital entrepreneurship (United Nations Broadband Commission for Sustainable Development, 2018a:16).

The United Nations Broadband Commission set specific goals for digital skills to be achieved by 2025. These are:

- → 60 percent of youth and adults should have achieved at least a minimum level of proficiency in sustainable digital skills;
- → 40 percent of the world's population should be using digital financial services;
- → 50 percent, by sector, of micro-, small- and medium-sized enterprises (MSMEs) should overcome lack of connectedness; and
- → gender equality should be achieved across all targets (United Nations Broadband Commission for Sustainable Development, 2018b).

To achieve these goals and reduce the digital gap between Southern and Northern countries, capacity building on digital skills is extremely necessary and warranted. Digitalization affects the labour market in Southern countries. Due to their lack of digital capacity and competitiveness, local companies in poor Southern countries often face fierce competition from digital companies in advanced countries. Moreover, some labor-intensive jobs in Southern countries have been and will continue to gradually disappear. Many workers will lose jobs due to automation and lack of digital skills. People with limited digital skills will find themselves at a disadvantage compared to workers who are better prepared for the digital economy.

Lack of access to digital technologies also affects government policies and the quality and efficiency of public services. Public employees, citizens and businesses should be granted fast access to practical information and the capacity to fulfil their administrative, legal and social obligations online, as well as to settle taxes and other charges using the internet. In this regard, Estonia stands out as a most advanced case of e-governance: taxes are completed online in under five minutes, 99 percent of the country's public services are available on the web 24 hours a day and nearly one-third of citizens vote via the internet.

Access to Information (a2i), a special programme of the Government of Bangladesh, in partnership with the Local Government Division, set up digital centres in the lowest tier of government administration offices that act as one-stop access points for obtaining private and public services. The digital centres ensure that underserved populations, such as rural women, people with disabilities and the elderly, can access vital information and services, regardless of their general and specific ICT literacy level. A typical digital centre is about four kilometres from the average rural citizen's home, compared to a government sub-district office which is about 20 kilometres away and a district office over 35 kilometers away.

Access to these digital centres enables citizens to receive efficient and customized public and private services. To date, 5,286 digital centres are delivering over 150 types of services – both public and private – to an average of six million underserved citizens every month at a much quicker rate, cost and number of visits. Government and non-government agencies from Bhutan, Fiji and the Maldives have entered into partnerships with a2i to replicate some of its successful initiatives, including the digital centre initiative. Discussions are underway with government agencies and development agencies in other countries to replicate the model, especially developing countries, facilitated by the South-South Network for Public Service Innovation (UNOSSC, 2018).

In a programme designed to promote capacity building in information and communication technologies for public officials in Timor-Leste, a Triangular Cooperation scheme was set up between Timor-Leste, Indonesia and South Korea. After a series of discussions and careful reviews on the feasibility of the 'Information Technology Capacity Building for Central and Local Government' project, the Indonesian government, the Timor-Leste office of the Korean International Cooperation Agency, the Ministry of Communication and Information Technology of the Republic of Indonesia and the Ministry of Public Works of Timor-Leste signed a cooperation agreement. Thus, Indonesia committed to enhancing South-South Co-operation with Timor-Leste in the field of IT by mobilizing its own budget. A training programme for public officials from Timor-Leste to enhance IT capacity was reviewed for its feasibility, which was followed by a field survey and discussions for South-South Cooperation between South Korea, Indonesia and Timor-Leste conducted by the Korean International Cooperation Agency's Indonesia office in May 2016 in Dili, Timor-Leste. South Korea provided not only financial support but also its know-how and experience in e-government. The programme cost $3.7 million and was carried out between 2013 and 2017. This triangular digital cooperation project was successful in part because all partners contributed their own financial and/or in-kind resources to the project. Moreover, Indonesian and Timorese public officials made the most out of the training workshops through peer-to-peer learning as Indonesian officials shared with Timorese representatives what they had learned from previous bilateral co-operation with Korea for developing an e-government system. 30 Timorese participants were trained through this programme (GPEDC, 2019: 40).

Individuals in Southern countries who do not possess digital knowledge and skills miss out on the full benefits that accompany a digital economy. As indicated above, women are at a great disadvantage when it comes to digital literacy and digital skills. Women in many poor Southern countries do not have the same access to formal education as men, particularly in patriarchal and conservative societies, often leaving them unable to use digital technologies, even basic digital equipment, such as mobile phones and the internet. The gender digital divide remains wide (UNCTAD, 2018b: 6). According to OECD data, in 2018, globally, approximately 327 million fewer women than men had smartphones and access to mobile internet. In addition, approximately 26 percent less females had a smartphone than males. In South Asia and Africa, the ratios in 2018 were about 70 percent and 34 percent, respectively (OECD, 2018: 13).

Likewise in the job market, digitalization may affect females more than males in Southern countries. According to a 2019 ITU report (ITU and UNESCO, 2019: 118), this is largely due to the fact that female workers tend to be more involved in routine tasks and labor-intensive jobs which are affected by digitalization and automation. Furthermore, the proportion of female researchers in science, engineering and technology in most Southern countries is low, at about 10 to 40 percent (UNCTAD, 2018b: 6). Among computer graduates, women are a minority, and the proportion is declining. Furthermore, female business leaders and policymakers in science, technology and innovation are also underrepresented (UNCTAD, 2018b: 6). All these data indicate a large deficiency of females in digitalization.

As the need to prioritize capacity building in South-South Digital Cooperation is increasing, United Nations organizations can play a key role in developing digital skills and helping capacity building for Southern countries. United Nations organizations are skilled at coordinating and mobilizing resources from governments, the private sector, civil society, other international organizations, academia and technical communities. Organizations in the United Nations system have strongly supported South-South Cooperation through policy, programming and institutional initiatives. In recent years, United Nations organizations, especially ITU, UNCTAD and UNESCO, as well as the WTO, have played a leading and active role in capacity building for digital cooperation in South-South Cooperation and Triangular Cooperation.

At the policy level, for instance, the United Nations Broadband Commission for Sustainable Development set a digital connectivity goal to guide digital development worldwide by 2025. The ITU, ILO and UNESCO made a digital skills toolkit to provide policymakers and other stakeholders in the global South with practical information, examples and step-by-step guidance to build national digital skills (ITU, 2018b).

At the institutional level, in July 2018, the United Nations Secretary-General established a High-level Panel on Digital Cooperation to identify good practices and opportunities, gaps and challenges in digital cooperation. The panel, led by two co-chairs, Jack Ma and Bill Gates, consisted of 20 leaders from across the world representing governments, the private sector, academia, the technical community and civil society. In June 2019, the panel released its report, *The Age of Digital Interdependence*, calling for more and deeper collaboration to ensure that all people in the world will benefit from digital technology. The report makes five recommendations: 1) build an inclusive digital economy and society; 2) develop human and institutional capacity; 3) protect human rights and human agency; 4) promote digital trust, security and stability; and 5) foster global digital cooperation (United Nations Secretary-General's High-level Panel on Digital Cooperation, 2019).

The private sector has a crucial role to play in digital capacity building. For example, Alibaba, a top Chinese technology company, helps digital capacity building in the global South. In July 2017, Jack Ma, Alibaba's executive chairman, attended the African Youth Summit in Rwanda as a special adviser to youth entrepreneurship and small businesses at the United Nations Conference on Trade and Development. Ma announced three action plans on digital capacity building for African countries: 1) supporting 200 to 500 African entrepreneurs to study in Hangzhou, China, where Alibaba's headquarters are located; 2) collaborating with African universities and governments to provide training in digital technologies and skills for African students; and 3) setting up a $10 million African entrepreneurship fund (Hou, 2018). Thus far, Alibaba has held two training sessions for African countries, inviting young African entrepreneurs to Hangzhou to learn about the growth of the digital economy in China and the experience of e-commerce operations at Alibaba.

In August 2018, Alibaba announced the Netpreneur Prize to encourage young Africans to become digital entrepreneurs. The project announced that beginning in 2019 it would grant one million dollars annually to ten local entrepreneurs in Africa, helping a total of 100 local entrepreneurs with $10 million over ten years. In the first year, 10,000 applications were received from 50 African countries (Ifeng News, 2019). Alibaba, in cooperation with UNCTAD, also is conducting a five-year eFounders Program to provide training for 1,000 young entrepreneurs from developing countries (also starting in 2019), with at least half from Africa (Ding, 2019; Costa, 2020). By March 2020, 119 entrepreneurs from 18 African countries had participated (Costa, 2020). According to Jack Ma, through digital capacity building "100 Alibaba will emerge in Africa" (Hou, 2018).

The above-mentioned initiatives by Alibaba, among others, have already had positive effects in Africa. Many young entrepreneurs who participated in the training programmes have begun business exploration in African countries. Felix Mwaura, a young Kenyan Alibaba alum, currently runs Kopay, an online rental platform that aims to optimize the housing rental system in Kenya by opening an online payment system, online rental and sales platform and paperless signing. Using knowledge and experience from Alibaba's training programme, Mwaura set a specific target, planning to collect information on more than 1,000 vacant houses in one year and to reduce the duration of the housing registration process to less than one minute. In just three months, Mwaura successfully found 1,400 vacant houses (Hou, 2018).

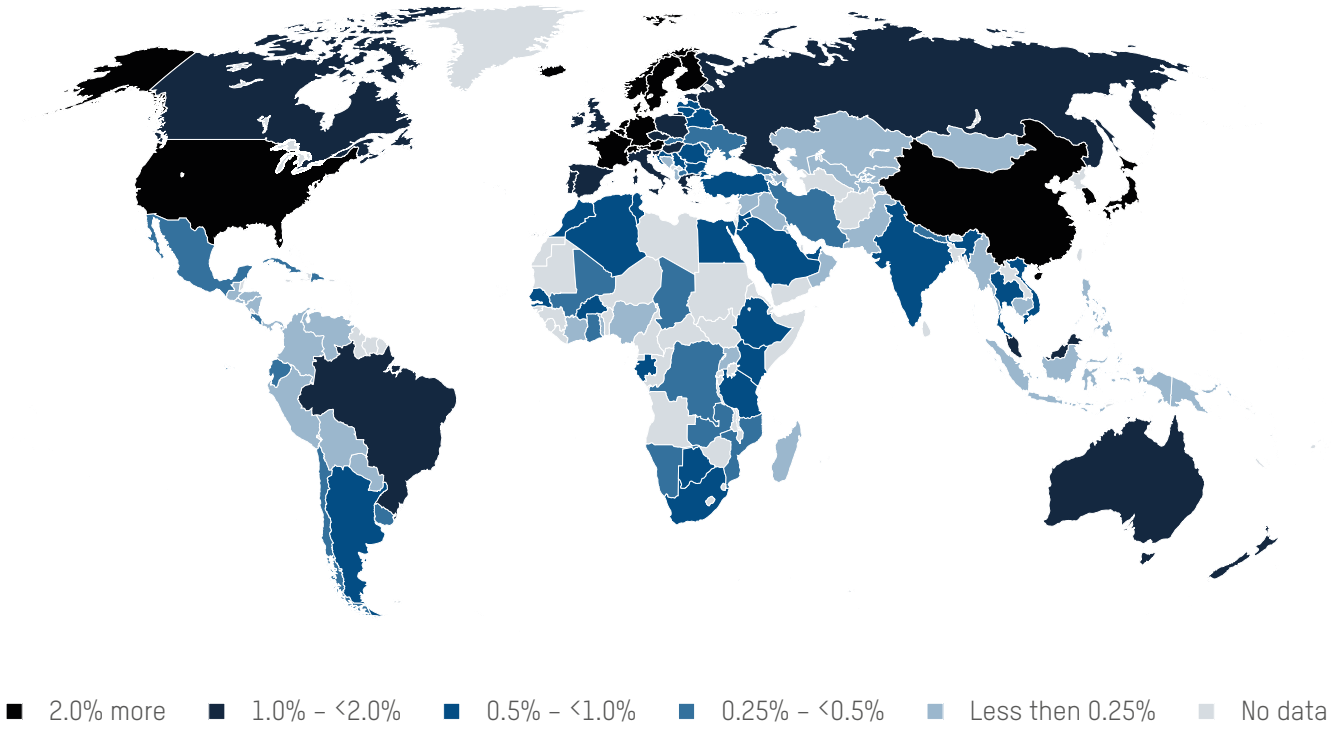
The cases above of private sector and international organization involvement in South-South Digital Cooperation for skills and capacity building indicate two key points. First, in addition to governments, the private sector and international organizations can play a crucial role in capacity building through South-South Digital Cooperation. They can supplement governments by providing expertise, financing and experience. Second, both short-term training and long-term educational programmes on digital technology are needed. Knowledge and skills will be best utilized when they are applicable to local conditions, address local challenges and meet the specific needs of Southern countries and relevant stakeholders.

4.3 DIVERSIFY FINANCING FOR SOUTH-SOUTH DIGITAL COOPERATION

Limited funding is one of the main obstacles for the digitalization of most Southern countries. A huge gap exists for financing the digital development of Southern countries. The United Nations Broadband Commission for Sustainable Development estimates that to double broadband connectivity in Africa by 2021, approximately $9 billion would be needed (United Nations Broadband Commission for Sustainable Development, 2019: 62). Meanwhile, many small digital enterprises in Southern countries struggle to raise enough financial support for their operations. According to OECD statistics, the finance gap for small enterprises in Africa that need financial support for start-up and operations is $136 billion on an annual basis (OECD, 2017a).

Research and development, science and new technology expenditures in many Southern countries are also inadequate. According to the UNESCO Institute for Statistics, the United States was the largest spender on R&D (on a dollar basis), while China and Japan ranked second and third (UNESCO, 2019). As a percentage of GDP, Israel and South Korea were the leading spenders on R&D (in 2017), both committing 4.6 percent of their GDP, against the world average of 2.3 percent. South Korea spent significantly in the ICT and electronics sectors (Investopedia, 2019; UNESCO, 2019). In contrast, even though the African Union set a target of 1 percent of GDP on R&D, most African countries spent far less than this, as shown in *Figure 10* below. Only three African countries (Kenya, Senegal and South Africa) were close to the 1 percent target, at around 0.8 percent each (UNESCO, 2019).

Figure 10: Expenditure on R&D as a percentage of GDP



Source: UNESCO (2019).

While Southern countries still rely heavily on development cooperation, foreign aid from Northern donor countries has not prioritized digital development and current levels of development cooperation on digitalization are not adequate. Between 2001 and 2013, the European Union spent around 32 billion Euros on development aid, but just 350 million Euros of this was used for digital-related activities (EU, 2016). According to OECD and WTO statistics (2017), the proportion of aid-for-trade disbursements on ICT from aid donors to Southern countries was merely 1.2 percent in 2015, significantly smaller than in any other category of aid disbursement. This number was even smaller in 2015 than the 2002-2005 period, which was 3 percent (OECD and WTO, 2017: 307).

Against the backdrop of insufficient aid assistance for digitalization from Northern donors, digital private companies, especially telecommunications and technology companies, can likewise play an important role in digital development, such as promoting inclusive cross-border e-trade, building digital infrastructure and engaging in capacity building. Recently, China's Alibaba made great efforts to build the electronic World Trade Platform (eWTP) that helps small enterprises and young people in Southern countries become involved in international trade (Alibaba Group, 2018: 68). Alibaba has invested over $100 million in Malaysia, where it started its first overseas eWTP hub (Xinhua News, 2018). To enhance the competitiveness of local digital SMEs and micro-enterprises, Alibaba cooperates with the Malaysian government and establishes infrastructure with services that integrate e-commerce, logistics, Cloud Computing, mobile payments and talent training (Business Wire, 2017).

4.4 PROVIDE POLICY SUPPORT FOR CROSS-BOUNDARY DIGITAL ECONOMIES AND E-COMMERCE

Providing policy support and engaging in policy collaboration to foster an enabling environment for cross-boundary digital economies and e-commerce is important in the process of promoting South-South Digital Cooperation for three main reasons. First, because digital technology encourages countries to be more interdependent, the development of a digital economy and e-commerce requires cross-border collaboration. Having access to regional and international markets is important for digital enterprises to exist and operate. This requires a supportive policy environment regionally and globally to facilitate e-commerce across borders. However, many start-ups digital SMEs and micro enterprises in Southern countries often face particular obstacles when expanding their businesses across borders, such as the need for mutual recognition of electronic identities and digitally signed documents across borders (United Nations Broadband Commission for Sustainable Development, 2018a: 24). Overcoming such obstacles calls for regional cooperation and close policy collaboration between governments on cross-boundary issues.

Second, many Northern countries and global multinational digital enterprises are currently the major players in the digital world. Not only do they have an absolute advantage in the development of digital technology, but also have a dominant position in the rule making processes and in the guidance of cross-border e-commerce. By contrast, the voices of small and Southern countries often cannot be heard. The interests of vulnerable groups, such as the poor, women, the elderly and the disabled, are not fully represented (United Nations Secretary-General's High-level Panel on Digital Cooperation, 2019: 30). Through global and regional policy coordination and arrangement, an enabling environment to facilitate the digital economy of Southern countries can be created. Digital policy can be made pro-poor and people-centred and the interests of vulnerable groups in poor Southern countries can become more visible.

Third, many good practices of digitalization in different sectors, such as health, poverty reduction, agriculture, microfinance, climate change, education and gender inequality, are limited to local or domestic levels. Learning how to scale up these local practices is key. Policy collaboration between countries regionally and globally can help spread and scale up local best practices to benefit more people across the global South. Policy support that can create an enabling environment for local digital enterprises in Southern countries must firstly facilitate access to regional and international markets for local digital SMEs. Furthermore, through technical assistance, marketing and matchmaking services, governments can help SMEs collaborate with large and international digital companies within potential cooperation initiatives (United Nations Broadband Commission for Sustainable Development, 2018a:30).

Governments in Southern countries need to cooperate to build a collaborative regulatory framework for e-commerce across borders. In many Southern countries, a clear legal and regulatory framework related to the digital economy and e-commerce has not been fully established. A well-established regulatory framework could reduce transactional costs and risks of digital companies when doing business across borders and protect the rights of local enterprises (United Nations Broadband Commission for Sustainable Development, 2018a:34). Close coordination on intellectual property rights and data protection is also necessary. Compliance with data protection rules is required by many countries for entry into their markets (United Nations Broadband Commission for Sustainable Development, 2018a:34).

According to a survey on e-commerce conducted by OECD and WTO (2018) regarding cross-border e-commerce, the top export obstacles faced by SMEs and micro enterprises in Southern countries included high shipping costs, high cost of small parcel shipment, issuance and acceptance of Sanitary and Phytosanitary Certificates, problems with online payments and absence of or difficulties in using electronic single windows (WTO and OECD, 2018: 11-12). Top import obstacles included delivery costs of small parcel trade, problems with online payment systems, dealing with returned goods and difficulties accessing third party payment services (WTO and OECD, 2018: 11-12). Many of these problems can only be solved through global and regional collaboration between governments.

While some 163 countries in the world have national digital strategies (ITU, 2010: 4), regional digital strategies are few. Regional digital strategies are needed to foster sound policy environments for the development of e-commerce and to establish clear rules and regulations on the digital economy. It should be stressed that regional organizations in the South and other regional mechanisms play a key role in facilitating close cross-border digital collaboration. Some suggest that regional initiatives, such as building a regional digital single market or integrating digital components into regional trade arrangements, are good ways to facilitate a supportive legal and regulatory environment regionally (United Nations Broadband Commission for Sustainable Development, 2018a:38). Such strategies could cover a broad range of policy issues, such as regional ICT development, e-commerce across borders, digital economy, telecommunications, broadband strategy and so on. Regional digital strategies should be relevant to the national digital strategy of each country in the region. An example of regional collaboration in digitalization in the South is SADC's[48] integrated bank-to-bank regional electronic settlement system (SIRESS). SIRESS facilitates intra-regional transactions for local people and companies. By 2017, 83 financial institutions in 14 SADC member countries had joined this electronic system and SIRESS had made total payments of $245 billion (UNCTAD, 2018a: 18).

48 The Southern Africa Development Community (SADC) has 15 African member countries: Angola, Botswana, Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

5. Policy suggestions to promote South-South Digital Cooperation

Policy suggestions to promote South-South Digital Cooperation are discussed below.

1. Multi-stakeholder partnerships should be viewed as crucial in the process of South-South Digital Cooperation. No country alone can achieve digital development. The cases in this chapter illustrate that, apart from development cooperation from governments, many other stakeholders should be fully involved in the process of South-South Digital Cooperation, including the private sector, international organizations, academia and civil society. Partnerships can come in many forms — multi-layered, domestic, regional, global. All these actors have their own comparative advantages and expertise and play different roles, not only in technical transfer and knowledge sharing, but also in digital infrastructure connectivity and investment, capacity building, cross-border e-commerce, financial support and so on. Crucially, many digital-related private companies in the global South are becoming more and more active in promoting digital development in Southern countries, as shown in this chapter. Through the promotion of effective public-private partnerships, the private sector should be encouraged to participate deeply in South-South Digital Cooperation.

2. United Nations organizations should continue playing their leading role in resource coordination and mobilization both regionally and globally. These organizations have always been strong supporters of South-South Cooperation and Triangular Cooperation. In recent decades, the United Nations system has continuously strengthened its policy support, programme support and institutional support for South-South Cooperation and Triangular Cooperation, for example South-South and Triangular Cooperation were incorporated in the policy framework for implementing the 2030 Agenda. United Nations organizations to be involved, in particular, are those that specialize in digital technologies, such as ITU, the United Nations Broadband Commission for Sustainable Development, those with a focus on SSC and TrC, such as UNOSSC and region-specific organizations, such as the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), among others. Many of these United Nations organizations have elaborated their digital agenda and goals. For instance, the United Nations Broadband Commission for Sustainable Development set Global 2025 targets for broadband and UNECLAC created the Digital Agenda for Latin America and the Caribbean. In future, these international organizations should prepare specific guidelines on how to implement effective digital programmes targeting Southern countries and how to scale up local practices in a wide range of countries in the South.

3. Development cooperation from emerging countries in the global South (as well as donor countries in the North) should further emphasize the digital component, including digital infrastructure, capacity building, technology transfer, digital technology R&D and innovation. Cooperation projects should focus specifically on how to promote digitalization for development in the South. In addition, aid recipient countries in the South should also call for larger aid commitments to digital development from donor countries in the North through Triangular Cooperation or working together with international organizations.

4. Knowledge sharing between Southern countries and between the South and the North is an effective tool for Southern countries to scale up the good practices of digitalization from other countries. Knowledge sharing is the most dynamic component of South-South and Triangular Cooperation (United Nations General Assembly, 2018). Due to similar development backgrounds and development paths, Southern countries should share with each other knowledge on the best practices in digital technology, digital economy and other digital solutions, and thereby facilitate the application of digital development experiences suitable for Southern countries, especially those that involve leapfrogging. The establishment of global and regional networks on digital technology and digital development should be encouraged.

5. Regional agreements and mechanisms can be effective in facilitating and catalyzing cross-border digital issues for Southern countries. As mentioned above, digital economy, e-commerce and digital trade increasingly require cross-border collaboration among countries. Southern countries in the same region should work together on regulations, legal frameworks and shared standards to facilitate cross-border e-commerce and e-trade. In addition, regional free trade agreements or regional digital integration plans, such as a digital single market, may help foster regional digital cooperation.

6. Southern countries should enhance the international connection of their digital development strategies. Many Southern countries and regional organizations have incorporated digital development into their national and regional development initiatives and strategies, such as China's Belt and Road Initiative and the African Union's 2063 Strategy, as mentioned earlier in this chapter. These plans share many common focuses and concerns on digital issues, such as the development of digital infrastructure and capacity building. The connectivity of these development plans brings mutual benefits and helps foster cooperation between Southern countries for digital development.

7. Innovation should be emphasized in South-South and Triangular digital cooperation. Innovation is the core driving force for the development of the digital economy in Southern countries. However, the potential for innovation is determined by capacities. Therefore, to strengthen the capacity building of Southern countries should become one of the key targets in digital South-South Cooperation. Capacity building should include basic scientific and technological skills, employment skills, ability of SMEs to run e-businesses, R&D and e-government.

8. Specific attention should be paid to gender equality, inclusiveness and the greater needs of rural areas when conducting digital South-South Cooperation. In terms of internet accessibility, for instance, females and rural populations are left behind. As mentioned previously, the development of digital technology risks concentrating economic power and wealth in the hands of a few large companies, creating a digital divide in which jobs are eliminated and the poorest sectors of society are even less empowered. South-South Digital Cooperation should promote the reverse scenario, through which the potential of digital technology to help reduce socio-economic inequalities is fully explored and shared in the developing world, with a view to fulfilling SDG10 and narrowing gender and rural-urban gaps in Southern countries. Gender equality, as one of the key targets of the Sustainable Development Goals, should be considered and emphasized in every aspect of South-South Digital Cooperation and specific plans and targets on gender equality should be added into every South-South Digital Cooperation project.

9. Last but not least, digital technologies can and should be put to use in promoting monitoring and evaluation initiatives to improve the quality and enhance the impact of South-South Cooperation itself. Digital technologies make possible the collection of more and better data from isolated and disenfranchised populations in the developing world, which may otherwise be difficult to collect because of geographical obstacles, communication barriers, lack of safety in conflict zones or because the data involve politically sensitive issues, among other reasosn. In so doing, digital technologies allow for more precise guidance, appraisal and prescriptions for future SSC initiatives in all sectors, not just in those that involve digital technologies.

6. Conclusion

This chapter has focused on the potential and challenges of South-South Digital Cooperation. Digitalization is key for the achievement of the 2030 Sustainable Development Agenda. In particular, it plays an important role in reducing poverty and inequalities, promoting economic growth, improving education, health and agricultural practices, and affects virtually all development issue areas. Undoubtedly, the development, use and dissemination of digital technologies has become even more important in the context of the COVID-19 pandemic, as they become indispensable when educational, professional and healthcare activities cannot be carried out in person. Crucially, these technologies can also make important contributions to monitoring and evaluation of South-South Cooperation in all sectors and modalities by providing feedback channels readily available to stakeholders.

Digitalization in the global South presents considerable challenges as well as opportunities. While the digital divide between developing and developed countries regarding internet service connectivity and quality is significant, remarkable expansion and improvement of digital infrastructure has taken place in the South. A digital gap is also observed between Southern countries, however, which makes digital South-South Cooperation all the more necessary. Finally, challenges also exist related to inequalities within developing countries themselves, which are evident in divides between genders and between rural and urban areas.

Given their importance and their novelty, digital technologies can and should be the focus of South-South Cooperation. Leapfrogging offers opportunities for rapid catching up and should be fundamentally demand-driven, one of the key principles of SSC. As Southern countries share many development needs and challenges, they are well equipped for digital cooperation and for sharing information, experiences and best practices as well as digital innovations that address these needs and challenges. The numerous examples and cases of local, homegrown digital solutions provided by this chapter illustrate the diversity of development issues, technologies and stakeholders involved in digitalization: ranging from finance to agriculture to education; from computers to tablets to mobile phones; from farmers to voters to e-commerce entrepreneurs. In many, if not most, cases the examples can be replicated elsewhere with similar results.

South-South Digital Cooperation fundamentally involves the expansion and upgrade of digital infrastructures in partner countries, skills transfer and capacity building, the provision of funding and, finally, policy support to create a suitable environment for investment in digitalization, including regulatory frameworks. While many instances of each of these pillars can already be identified and were described in this chapter, a great need and potential for expanding SSC in digitalization exists. Regional initiatives are key and may provide the best opportunities for this purpose. Examples of Triangular Digital Cooperation are still few, but this modality should also be expanded, as it may complement fruitfully the more advanced technologies and the larger financial resources of developed countries with the innovations and local know-how of developing countries in promoting digitalization in third countries.

Chapter 9

Concluding remarks: Agenda beyond 2020

This report has put forward a range of evidence-based cases and examined fresh impetus and new approaches to South-South and Triangular Cooperation within the digital world to inform and help chart the way ahead to sustainable development in the global South. It has shown that key issues in the global South, such as agricultural productivity, food security, financial services for low-income communities, health services and climate change, can be effectively addressed through South-South Digital Cooperation and Triangular Cooperation, despite many new challenges. The report offered specific strategies and actions that can be adopted at global, regional, sub-regional and national levels to share the digital dividends.

1. Key findings

Several conclusions can be made from examining the papers presented in this report. As illustrated in the introduction chapter, the scope of SSC has gone far beyond technical cooperation and knowledge exchange and has expanded to include trade, investment, infrastructure and connectivity. South-South and Triangular Cooperation have become important means of cooperation as well as financing channels for the realization of the 2030 Agenda. Meanwhile, digital cooperation is becoming an important part of SS&TrC, facilitating investments in digital infrastructure, cross-border e-commerce and applications of digital technology in agriculture, climate change, health and financial services and so on. South-South Digital Cooperation has been incorporated into some exemplary cooperation frameworks in the global South, such as Africa 2063, the China-Africa Digital Silk Road and the Global Observatory for eHealth. Innovative South-South Digital Cooperation mechanisms are gaining traction in the global South and are having important implications on economic development, especially in the face of the COVID-19 pandemic.

As discussed in Chapter 2, fresh impetus and new approaches have emerged in South-South Cooperation, as described below.

- → ***Evolving types of partnerships: Triangular Cooperation.*** TrC links fragmented North-South assistance with South-South Cooperation and forms emerging cooperative relationships among global South countries, international organizations and donors in the North. This more inclusive cooperation framework transcends traditional North-South Cooperation. TrC expands financial resources and knowledge, in addition to offering official development assistance.

- → ***New financing platforms for Southern countries.*** The creation of the AIIB in 2016 and new financial modes at other Southern banks, such as the African Development Bank, are examples of South-South initiatives designed to address the needs of Southern developing countries and to move away from a Northern-dominated, conditionality-attached financing order, influenced by economic orthodoxy and insufficient country ownership at the recipient end. The move toward a financial architecture with enhanced Southern participation and even leadership, anchored around a set of common principles for development effectiveness, and putting the national interests of recipients and their needs for broad-based sustainable development at its heart, deserves to gain further momentum.

- → ***Emerging cooperation approaches based on platforms: South-South Digital Cooperation***. Spurred on by global South digital innovations in technology and platform business models, SSC based on digital technology, such as Big Data, the Internet of Things and artificial intelligence, is sprouting and expanding. South-South Digital Cooperation has provided fresh impetus and new approaches for helping to realize the 2030 Agenda for Sustainable Development and even longer-term development prospects. In response to the global COVID-19 pandemic, South-South Digital Cooperation is becoming increasingly important to secure digital health solutions, such as sharing epidemic-related experiences and lessons through Cloud meetings, dispatching epidemic prevention materials and equipment on e-commerce platforms and conducting remote expert consultations with regard to treatment.

Chapter 3 indicates that promising digital technologies are being locally developed in the global South and proving to be successful. Initiatives such as the Belt and Road Initiative and the Digital Silk Road are helping global South economies to develop ICT infrastructures and digital services (and create opportunities to further enhancing SSC). Innovative firms from global South economies, such as Argentina, Indonesia and Kenya, are leading strategic initiatives to capitalize on big opportunities presented by the 4IR. All Southern economies need to prepare for and embrace 4IR-related changes, which will be the key to their economic success.

By looking at case studies and literature on using digital technologies to boost agricultural productivity and food security in Chapter 4, public-private partnerships have shown to be a potential solution for meeting the demand for technological integration in the agricultural sector. Examples include technology that has increased farmer access to credit, inputs and markets, smart city technologies that improve safety and AI that has improved the speed and accuracy of planting and crop management techniques, to name a few.

Chapter 5 shows that evidence of success with FinTech in the global South exist. Specifically, the first case explored a smart payment platform that transformed from a social networking site; the second case unveiled efforts of the Chengdu Branch of the People's Bank of China to promote inclusive basic payment services to remote ethnic minority areas; the third case shed light on a social enterprise engaged in rural financial services; and finally, the fourth case illuminated an online microcredit service available for micro and small enterprises based on e-commerce. It is clear there has been tremendous growth of digital finance in the global South. However, FinTech's role in development strategies is unexplored and untheorized.

Chapter 6 analyzed the key opportunities digital health holds to advance health-related Sustainable Development Goals (SDG3) along with commitments to Universal Health Coverage (UHC) which is a major goal for health reform in many Southern countries. By weighing the opportunities and challenges and the potential of South-South and Trilateral Cooperation through numerous examples, the report concludes that if digital health is to effectively advance sustainable health development, it is crucial for countries to formulate national digital health strategies integrated into current health policies organize training programmes and capacity building specifically for the global South and increase financing of digital health in the global South.

Chapter 7 detailed the potential role of SSC in mitigating the negative impacts of digitization and advancing the potential of SSC to help combat climate change. Specifically, it examined digital technologies, such as block chain, remote sensing and geographic information science technology, and the role of SSC in mitigation and adaption to climate change in addition to sustainable energy generation and storage. By presenting a range of successful examples of SSC, including in LDCs to upper-middle-income countries, the report evidenced the successful efforts of SSC beyond BRICS countries.

Chapter 8 analyzed the driving forces and mechanisms of South-South Digital Cooperation. It was argued that many digital innovations are focused on local experiences, hence these innovations are limited in scale, rather than looking at digitization for promoting sustainable development by sector. The chapter called for broader-based initiatives that can be scaled up through collaborative efforts using South-South and Triangular Digital Cooperation.

2. Recommendations

The findings of this report suggest an increasingly significant need for refreshed approaches to the complex digital development challenges faced by the global South in today's economic climate. It is imperative to ground innovative digital solution strategies in the spirit of SSC and TrC to support relevant and interlinking frameworks for successful digital transformation. In the wake of an unmistakably more globalized world, in which economic uncertainty has given rise to protectionist policies, it is important to promote and facilitate Southern digital development in a cooperative manner. Overarching actions needed to achieve this are listed below.

- → Multi-stakeholder partnerships in SSDC should be formed and public-private partnerships encouraged.
- → The United Nations should continue to play a crucial role in resource coordination and mobilization and put forth specific guidelines to implement and scale up digital programmes in Southern countries.
- → Sharing of knowledge should take place between Southern countries and between the North and the South to scale up best practices of digitization in Southern countries.
- → Regional agreements and mechanisms should be formulated that can help Southern countries navigate digital issues.
- → Northern countries should share digital development strategies to foster mutual benefits for Southern countries.
- → Innovation with digital technology in SSTrC should be encouraged and emphasized.
- → Attention must be paid to gender equality and inclusiveness in SSDC.
- → Digital technologies should be used to promote monitoring and evaluation initiatives across all sectors to improve the quality and impact of SSC.

More specific recommendations arising from the report include these below.

- → Triangular Cooperation in the ICT field, through various forms of support, such as funding, training and technological systems, needs to be institutionalized so that donor countries and multilateral organizations better facilitate South-South initiatives and thereby promote long-term sustainable development outcomes.
- → To improve agricultural productivity to meet global food security challenges, countries are advised to formulate frameworks based on five pillars (policy, institutions, technology, capacity and governance) with an increased and sustained focus on digital innovations.
- → Global South governments (as well as their Northern partners) need to identify and foresee the significance of FinTech and enter into unmapped policy territory. FinTech is an area ripe for expansion and SSC and TrC can support efforts to identify the technical elements and best practices that can be shared between and among countries and adapt these to suit the needs of developing countries.

In addition, digital connectivity and the facilitation of technology transfer must be complimented by regulatory and governance structures that prioritize digital efficiency for economic development. When formulating and implementing policies related to financial technologies, governments must advocate for FinTech as a potential area for expansion and support the technical elements and best practices of cooperative development, including through South-South and Triangular Cooperation. While many leading emerging economies from the global South have been addressing these challenges, a demand exists for greater efforts, especially in least developed and vulnerable economies that have considerable economic and political limitations.

→ In terms of tackling climate change-related challenges, TrC can be used to fill gaps to address the potential limitations of SSC. For instance, SSTrC can be leveraged to overcome the limitations of blockchain in Southern countries due to insufficient legislative frameworks and data privacy by calling for a collaborative, harmonized and standardized climate governance framework. Furthermore, SSC practices ought to be revisited, as many digital innovations are led by the BRIC countries that form part of the upper-socioeconomic status in Southern countries. Alternative ways to ensure more equitable participation by those Southern countries with fewer resources must be found via SSC to take the fullest advantage of digital technology in all corners of the global South.

→ As noted in the report, cross-border e-commerce has become an important tool for South-South trade cooperation. For many developing countries, capacity building is needed regarding the objectives, principles, legislation, implementation strategies, monitoring and other aspects of cross-border e-commerce. In particular, electronic data collection, data analysis and risk management of cross-border e-commerce should work with relevant government agencies and e-commerce stakeholders.

Implementing collaborative and cross-sectoral strategies rooted in cross-border digital access and innovation is encouraged. This calls for policy support to create an enabling environment for local digital enterprises in Southern countries so that these countries can thrive and share innovative solutions to development challenges. Building a collaborative regulatory framework for sustainable development that caters to the needs of Southern economies is critical to increasing cooperation among developing countries. Ultimately, new perspectives and approaches are necessary given the rapidly changing global digital economy and, as such, should be viewed as a supplementing, refreshed lens to the way digital economic development is currently analyzed.

3. Agenda for future research

This report has explored a diverse range of cases, from the applications of digital technologies in agriculture, health care, finance, disasters and climate change to policy implications. It noted new internet-based cooperation models and digital advances emerging as a result of the COVID-19 pandemic. The report illustrates that digital technologies and platform business models are the new driving forces of South-South and Triangular Cooperation. However, the question of how to promote pro-poor and inclusive development in South-South Digital Cooperation, both in terms of cooperation methods in digital technologies and business models, requires further study.

Four potential priorities for further research are suggested. These are: (1) How do fresh impetus and new approaches of SSTrC influence sustainable development in the global South? (2) How can in-depth case studies of SSDC be improved? (3) How can SSDC be promoted for post-COVID recovery and to address similar emergencies in the future?

1. Impetus and new approaches of South-South and Triangular Cooperation

The variety of cases of SSTrC in a digital world reviewed in this report — from FinTech to digital uses for agriculture and health — are recent and it can only be projected that such uses will have a positive influence on the future development of Southern countries. However, their true impact on sustainable development in the global South remains to be seen. These and other cases will need to be studied further to adequately gauge their benefits and better understand the challenges and opportunities that arise over time. Future studies may also be able to generate more specific and concrete policy recommendations.

2. In-depth case studies of South-South Digital Cooperation

Africa's E-Commerce Agenda: Roadmap for Action has identified eight areas for consideration, ranging from refreshing policies to expanding connectivity and upgrading logistics to managing data. Each area comes with a goal and recommended steps (ITC and WEF, 2019). These eight areas can also be key themes for further research on SSDC and sustainable development. Important questions that can be explored further through in-depth case studies include which problems to address regarding implementation of the rules of the World Customs Organization and the Africa E-Commerce Agenda: Roadmap for Action and how to solve these problems, among others.

3. Creating a path toward post-COVID recovery through South-South Digital Cooperation

Several research areas should be prioritized in regard to the use of SSDC for recovering from COVID-19 and similar global health challenges and other emergencies. To support a post-COVID-19 economic recovery, it is worth exploring how to strengthen SSDC to create jobs and facilitate industrial recovery and trade. Case studies should be conducted to summarize the lessons learned. This research can be evaluated quickly and shared via expert networks.

Research can be conducted on the application of digital technology to speed up and expand the diagnosis, quarantine and treatment of COVID-19, which would also be instructive for future health crises. Relying on digital technology and Big Data, several Southern countries have used a color-based health coding system to curb the spread of the coronavirus. It has been proven in practice that these health color codes have played a key role in epidemic prevention. The question of how to speed up the spread of health codes to more countries in the global South for prevention of this and futures pandemics or other global crises through SSDC is of great importance regarding further research.

4. Conclusion

This report underscores the importance of the digital economy and what it means for the current and future development status of the global South. The report traces the beginning of the current wave of digital technologies in global South countries and their implications in further strengthening Southern economies. The immense opportunities that digitalization creates by fostering entrepreneurship, raising worker productivity and helping to deepen accountable governance make it compelling for countries in the global South to deepen and strengthen collaboration both between and among countries in the region and sub-regions. This report engages with the universe of the diverse ways in which digital technology is shaping the global economy and the role of SSTrC in ensuring that countries in the global South become more and better prepared to productively benefit from global value chains and to achieve the Sustainable Development Goals for 2030.

A crucial thesis of the report is that the digital economy holds the capacity to unlock many development prospects for the global South. In an attempt to build a digital economy, Southern economies must make conscious efforts to invest in it to remain relevant in the fast-growing digital milieu. Conscious policies geared toward boosting the contributions of digital technology to national growth and competitiveness must be included in national growth strategies and broader development strategies. Southern economies can learn invaluable lessons by drawing from each other's digital experiences. Developing economies can leverage SSTrC as part of their national strategies to create a concrete plan that quite pointedly takes advantage of the rising digital economy.

The report underlined the value of fresh impetus and new approaches of SSTrC in a digital world, and how SSTrC can facilitate digital economic development for Southern actors. Based on compelling case studies and examples of successful digitization programmes and practices from several global South economies, key policy recommendations have been made in the various chapters. The hope is that the report will further propel dialogue on these recommendations and the various sub-topics examined throughout the report.

A great opportunity exists to expand on specific aspects and prospects of digital advancements and their role in development cooperation in the twenty-first century. Much room for improvement can be driven by research on these topics to investigate how they are taking shape in the global South and to help inform policymaking. More specifically, this report calls for continued engagement and cooperation among Southern actors across every industry to support development agendas related to digitalization.

While challenges indeed exist to sustainable and equitable digital development cooperation, the excitement and optimism that prevails can be explored to bring innovative solutions that can only become more effectual through discussions, such as those laid out in this report.

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