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Fourth industrial revolution technologies for sustainable development

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Note by the secretariat

Summary

Governments in the Asia-Pacific region are fast embracing fourth industrial revolution technologies leading to large-scale digital transformation across the world. Fourth industrial revolution technologies are rapidly becoming mainstream, enabling the digital transformation of production, manufacturing systems and service delivery. These technologies have played a vital role in combating the coronavirus disease (COVID-19) through innovative applications for strengthening health-care systems.

With rapid adoption and diffusion of fourth industrial revolution technologies, Governments in the region are realizing the range of opportunities to meet their economic, social and environmental needs in an efficient manner. Development, deployment and diffusion of these technologies are also associated with potential challenges. To effectively harness fourth industrial revolution technologies for sustainable development, it is important to have enabling ecosystems with conducive policy and regulatory frameworks, adequate capacities and skills to absorb, adapt and deploy the technologies, adequate technology access and know-how, appropriate finance and investment, and cooperation at all levels. Regional cooperation can play a critical role and facilitate faster development and cross border transfer of fourth industrial revolution technologies for sustainable development.

The present document contains an overview of the opportunities and challenges related to fourth industrial revolution technologies for sustainable development and the key strategies to accelerate their adoption and diffusion in the Asia-Pacific region. Members and associate members may wish to share national experiences and discuss strategies for strengthening regional cooperation to promote fourth industrial revolution technologies for sustainable development. The Committee on Information and Communications Technology, Science, Technology and Innovation may wish to provide guidance on the future direction of work.

* ESCAP/CICTSTI/2022/L.1.

I. Introduction

1. Advancements in science, technology and innovation over the past decades have led to large-scale digital transformation of industrial manufacturing and service delivery across the world. In recent years, this transformation has been driven largely by fourth industrial revolution technologies, such as artificial intelligence, the Internet of things, high-performance computing, 3D printing, machine learning, blockchain, big data, robotics, fifth generation (5G) wireless systems networks, cloud computing, nanotechnology and additive manufacturing, among others.

2. The unprecedented speed of development and increased usage of fourth industrial revolution technologies is corroborated by the growth of the market for such technologies. Globally the fourth industrial revolution market is expected to have a compound annual growth rate of 20.6 per cent from 2021 to 2026.¹ The contribution of artificial intelligence to the global economy is expected to reach \$15.7 trillion by 2030.² The market for blockchain in Asia and the Pacific is predicted to grow at a compound annual rate of 54.4 per cent from 2021 to 2027.³ The market for the Internet of things in the region is forecasted to reach \$436.77 billion by 2026, with one third of the market comprising expenditure on smart cities.⁴ The region has two of the world's top producers of robotic systems (Japan and the Republic of Korea), with global market shares of 52 per cent and 12 per cent, respectively.⁵ The members of the Association of Southeast Asian Nations are expected to gain a 35–40 per cent increase in manufacturing value added by embracing fourth industrial revolution technologies.⁶

3. Fourth industrial revolution technologies and related innovations have triggered the growth of start-ups and e-commerce. A number of technology-based companies are headquartered in the region, with the majority being in China, India, Japan and the Republic of Korea. The region has vibrant start-up ecosystems with many new start-up hubs emerging in countries such as Indonesia, the Philippines and Viet Nam.⁷

¹ Markets and Markets, *Industry 4.0 Market by Technology (Industrial Robots, Blockchain, Industrial Sensors, Industrial 3D Printing, Machine Vision, HMI, AI in Manufacturing, Digital Twin, AGV's, Machine Condition Monitoring) and Geography - Global Forecast to 2026* (n.p., 2021). Available at www.marketsandmarkets.com/Market-Reports/industry-4-market-102536746.html (accessed on 1 June 2022).

² PwC, "Sizing the prize: what's the real value of AI for your business and how can you capitalise?" (n.p., 2017).

³ Markets and Markets, *Industry 4.0 Market*.

⁴ Kate Birch, "Frost & Sullivan: smart cities to fuel APAC's IoT market", *Business Chief*, 24 April 2021.

⁵ John Karr, Katherine Loh and Emmanuel A. San Andreas, "COVID-19, 4IR and the future of work", Asia-Pacific Economic Cooperation (APEC) Policy Brief, No. 34 (Singapore, 2020).

⁶ A.T. Kearney, "Accelerating 4IR in ASEAN: an action plan for manufacturers" (Chicago, 2018).

⁷ Arpita Mukherjee and Angana Parashar Sarma, "Innovation, transfer and diffusion of fourth industrial revolution (4IR) technologies to catalyze sustainable development in Asia-Pacific", Asian and Pacific Centre for Transfer of Technology (APCTT) Working Paper Series (New Delhi, APCTT, 2022).

4. Fourth industrial revolution technologies are increasingly becoming mainstream, enabling digital transformation of production, manufacturing and delivery systems. Such technologies, encompassing digital, physical and biological spheres, are transforming the ways people live and work. Faster and further diffusion of fourth industrial revolution technologies requires an understanding of how these technologies could be harnessed for environmental, economic and social benefits. In this regard, the present document contains an overview of the opportunities and relevance of fourth industrial revolution technologies for sustainable development, associated challenges and key strategies to accelerate their adoption through national and regional efforts in the Asia-Pacific region.

II. Why fourth industrial revolution technologies matter for sustainable development

5. The Asia-Pacific region hosts some of the fastest growing economies in the world. The *Asia and the Pacific SDG Progress Report 2022* of the Economic and Social Commission for Asia and the Pacific (ESCAP), however, indicates slow progress towards the Sustainable Development Goals in the region. Progress towards the Goals has slowed as the coronavirus disease (COVID-19) pandemic and climate change have exacerbated development challenges. At the current pace, the Asia-Pacific region will achieve none of the 17 Goals by 2030. To accelerate the pace of progress towards sustainable development, fourth industrial revolution technologies can play a crucial and catalysing role. Fourth industrial revolution technologies have the potential to improve productivity and efficiency, raise income and improve quality of life.

6. Fourth industrial revolution technologies provide significant opportunities to support inclusive growth and sustainable development. According to a study by the World Economic Forum, 70 per cent of the 169 targets of the Sustainable Development Goals could be enabled by the application of existing fourth industrial revolution technologies. Such applications are playing an important role in 10 of the Goals, in particular Goal 3 (Good health and well-being), Goal 7 (Affordable and clean energy) and Goal 9 (Industry, innovation and infrastructure).⁸

A. Potential applications and opportunities

7. With increased diffusion and adoption of fourth industrial revolution technologies, Governments are realizing there are a range of opportunities to redefine their economies and meet social and environmental needs through innovative applications of such technologies. The following examples from the Asia-Pacific region serve to highlight innovative applications of fourth industrial revolution technologies to address the current pressing challenges pertaining to health care and climate change in particular.

8. In the context of innovation in production processes and enhanced productivity, fourth industrial revolution technologies, together with data analytics, are driving innovation in integrated manufacturing across the entire range of product development and manufacturing activities. Innovation in integrated manufacturing is responsive, self-adjusting and meets mass customization needs.

9. Applications of fourth industrial revolution technologies are leading to efficient and continued delivery of public services, including cash transfers.

⁸ World Economic Forum, “Unlocking technology for the global goals” (Geneva, 2020).

E-government services that use fourth industrial revolution technologies and platforms have become increasingly prevalent over the past two years. This was highlighted during the COVID-19 pandemic in the health care and education sectors in particular.

10. In terms of conservation of resources, technologies such as artificial intelligence, big data and the Internet of things are enabling precision agriculture by optimizing inputs and water use, and thus helping to reduce the impact of agriculture on water use by 2–5 per cent.

11. Monitoring can help to address the challenges of harsh working environments and reduce the number of safety incidents in factories and at industrial sites. Digital twin technologies and open-source ecosystem are contributing to the development of intelligent unmanned aerial and ground vehicles for worksite monitoring and contactless operations.

12. Additional examples include using fourth industrial revolution technologies to improve processes in waste management, using additive manufacturing to fabricate building components, using drone-based solutions to improve agricultural yields, using smart sensors to improve the efficiency of post-combustion carbon capture, using devices connected to the Internet of things for efficient conversion of waste into clean fuel and using big data for early prediction of extreme weather events, among others.

1. Strengthening health-care systems and recovering from the pandemic

13. While the COVID-19 pandemic has caused unprecedented economic and social damage in the Asia-Pacific region, the crisis has presented an opportunity to build resilience and sustainability. The pandemic highlighted the need for strengthening health-care systems, and fourth industrial revolution technologies have played an important role in these efforts. In health-care systems, fourth industrial revolution technologies are introducing new methods of treatment; introducing new methods of monitoring the health of individuals and the extent and spread of the pandemic; improving access to health care; reducing the distance between patients and service providers; and improving the management of health-care systems by Governments and the private sector.

14. Fourth industrial revolution technologies have been used in groundbreaking ways in developing vaccines and designing targeted responses, such as population screening, tracking infections, contact tracing and prioritizing the allocation of resources, among others. In the fight against COVID-19, for instance, artificial intelligence and big data have been used in a range of measures, such as fast-tracking vaccine development, repurposing drugs to treat patients, detecting and containing COVID-19 clusters, and diagnosing and treating patients. Robotic operating systems and high-performance computing have shown their potential through the high-speed development of COVID-19 drugs.

15. The application of fourth industrial revolution technologies in health care was exemplified in the Republic of Korea where a COVID-19 test kit was developed in approximately two weeks' time using artificial intelligence-based algorithms. A governance structure in the form of a presidential committee on fourth industrial revolution technologies helped to promote these technologies by preparing the groundwork for regulatory and institutional reforms in support of public-private partnerships.

16. Another key example from India is the Electronic Vaccine Intelligence Network that leverages the Internet of things and provides a real-time track-and-

trace system to monitor the movement and storage of vaccines. The Network stimulated the development of the COVID Vaccine Intelligence Network, which was instrumental in ramping up COVID-19 vaccination efforts in an effective and transparent manner.⁹

17. Smart sensing, embedded systems, wireless communication technologies, nanomaterials and miniaturization are being used to develop intelligent medical systems that continuously monitor human activities and physiological parameters, and detect symptoms.¹⁰ Artificial intelligence are one of the many tools that are now driving personalized medicine in which treatments are tailored to each person's unique genomic and biological profile.

18. Deploying fourth industrial revolution technologies in health care requires addressing questions of data privacy, safety and liability, medical ethics, standards, laws and regulations, and it requires new platforms for sharing medical, molecular and scientific data.¹¹

2. Climate change mitigation

19. Asia and the Pacific is one of the most vulnerable regions to climate change, with wide-ranging impacts across countries. According to *Asia and the Pacific SDG Progress Report 2022*, every Asia-Pacific subregion has regressed on Sustainable Development Goal 13 (Climate action). Achieving the long-term goals of the Paris Agreement to tackle climate change would require novel business models and markets for the successful use of fourth industrial revolution technologies.

20. Innovative applications of fourth industrial revolution technologies in the energy sector aim to improve efficiency, reduce emissions, enhance reliability and optimize costs. Examples include artificial intelligence-enabled smart solar energy systems, intelligent motors and using big data to locate harmful emissions. Smart grids and fifth-generation (5G) wireless systems networks are being used across long distances to connect numerous data points, ranging from wind turbines to rooftop solar panels to electric vehicle batteries, to optimize the management of energy supply and demand. Innovations such as virtual power plants, which pool distributed energy resources have a cloud-based control centre that uses the Internet of things and other digital technologies.

21. Fourth industrial revolution technologies are being used as enablers of mitigative and adaptive mechanisms. For instance, in the Republic of Korea, the smart city of Songdo has used applications of the Internet of things to generate benefits such as reducing traffic pollution, saving energy and water, and preserving the environment. Machine learning techniques are being used to obtain accurate rainfall and climatic projections. Big data are being used to locate harmful emissions along the supply chain, and advanced 3D printing helps to reduce carbon emissions and minimize waste in manufacturing. Additional examples include drone-based solutions for sustainable agriculture, smart sensors to improve efficiency of post-combustion carbon capture and devices connected to the Internet of things for efficient conversion of waste into clean

⁹ Anuradha Gupta, "The equity agenda in fourth industrial revolution healthcare technology", *Asia-Pacific Tech Monitor*, vol. 38, No. 4 (October–December 2021).

¹⁰ Subhas Chandra Mukhopadhyay and Krishanthi P. Jayasundera, "Harnessing power of IoT for healthcare", *Asia-Pacific Tech Monitor*, vol. 38, No. 4 (October–December 2021), pp. 16–26.

¹¹ Ibid.

fuel. In Indonesia, big data and artificial intelligence are being used to address deforestation.

22. In the adoption of fourth industrial revolution technologies to respond to climate change, Governments in the region need to consider formulating strong policies, supporting the private sector and fostering collaboration. Cost-effective, culturally compatible and socially acceptable technologies, together with a focus on establishing innovative business models, training and capacity-building, and innovative financing may be needed. Governments need increased support in the areas of clean energy, clean finance, carbon markets and value chains for wider adoption of digital technologies in the energy sector.

3. Business models

23. The impact of fourth industrial revolution technologies on sustainable development will depend on business models that make use of such technologies to support environmental sustainability, economic growth and inclusive development. Technologies in themselves are not a silver bullet. They must be designed to address economic and environmental challenges, and they must be relevant to different types of users.

24. For instance, the use of digital and precision technologies in agriculture requires business models that make effective use of digital platforms to connect farmers to sellers and consumers, and that provide value added services – from access to credit to knowledge insights – that are relevant to smallholder farmers. It requires the design and marketing of affordable precision technologies that poorer farmers can use. For example, while blockchain technology can improve the traceability of spices and the income of growers, business models for blockchain applications help to bring together smallholder farmers and train them on cultivation practices and food safety.

III. Strategies to harness fourth industrial revolution technologies for sustainable development

25. The benefits of fourth industrial revolution technologies for sustainable development are significant. However, challenges to the deployment of such technologies include the digital divide between regions and between socioeconomic groups, issues related to data capture and use, and the potential impact on employment. The development and diffusion of such technologies are limited by challenges such as inadequate research and development spending, digital infrastructure and access gaps, policy and regulatory limitations, and skills and education gaps.

26. Fourth industrial revolution technologies may have challenging impacts, in particular on employment and the digital divide, that disrupt sustainable development within and across countries. Addressing those challenges may require measures at national and international levels to ensure technologies are used in an effective manner. The technological advancements, enabling environment and actions of different stakeholders will determine how the challenges are addressed and the ways technologies are used to achieve the Sustainable Development Goals.

27. In particular, the accelerating digital transformation is a key driver of the fourth industrial revolution across the Asia-Pacific region. The digital transformation has brought about many deliberate and planned changes, but other changes are spontaneous or out of control. It is important for stakeholders to understand the implications of these developments to foster innovations and enterprises and to take decisions and actions to steer the fourth industrial

revolution in the most efficient and productive directions, ensuring that everyone is included, in particular the poorest and most vulnerable groups.

28. Gaps in technology access and regulation are wider for developing countries and least developed countries, and there are concerns that some of them may be left behind as the benefits of fourth industrial revolution technologies are harnessed. At the same time, it is now more important than ever before for Governments to use fourth industrial revolution technologies to emerge from the COVID-19 pandemic on a path of inclusive growth and sustainable development.

A. Enabling ecosystems

29. To effectively harness fourth industrial revolution technologies for sustainable development, it is important to have enabling ecosystems with conducive policy and regulatory frameworks, adequate capacities and skills to absorb, adapt and deploy the technologies, adequate technology access and know-how, appropriate finance and investment, and cooperation at all levels. As new applications of fourth industrial revolution technologies are developed, it is important to consider their social and environmental feasibility along with their economic benefits.

30. Governments have a vital role in providing an enabling environment for the development and diffusion of fourth industrial revolution technologies through policy frameworks, institutional support programmes and investment mechanisms. Owing to the fast growth rate of fourth industrial revolution technologies, the governance and regulation structure must be developed and strengthened accordingly. Fostering collaboration between stakeholders in government, industry and academia for successful development and commercialization of fourth industrial revolution technologies will also be needed. The following are key actions to consider:

- (a) Putting in place adequate digital infrastructure;
- (b) Establishing incentive mechanisms and financial models, including support for breakthrough innovations and commercialization;
- (c) Fostering innovation in fourth industrial revolution technologies through capacity-building, collaboration and interdisciplinary research by universities, research institutes and the private sector;
- (d) Empowering the workforce through knowledge, skills development and entrepreneurship.

B. Regional considerations and cooperation

31. The role of regional cooperation is critical for faster development and diffusion of fourth industrial revolution technologies for sustainable development. The priorities at the regional level include enhancing access and know-how related to fourth industrial revolution technologies and increasing stakeholder engagement and collaboration across countries and regions, including South-South cooperation and triangular cooperation, to ensure easy and even adoption of fourth industrial revolution technologies. The urgent and collaborative approach, as exemplified by the development of vaccines during the pandemic within a short time of one year, is key to the rapid development of innovative applications of fourth industrial revolution technologies.

32. There is a need for guidelines related to producing and sharing reliable data, and public safety and security concerns with regard to personal information and data. Regional collaboration would be required to establish guidelines and

protocols regarding collecting, sharing and monitoring data. A data protocol may also be relevant for sector-specific applications.

33. Facilitating regional research and development cooperation and strengthening collaborative networks can support faster innovation and diffusion of fourth industrial revolution technologies. Sharing experiences with regard to national strategies and good practices for collaborative research and development, innovation, cross-border technology transfer and diffusion can be vital in promoting fourth industrial revolution technologies.

34. The key considerations for members and associate members of the Commission will be to determine how to do the following: (a) jointly enhance understanding and harness the benefits of the fourth industrial revolution; (b) work together to address common concerns and build the enabling environment; (c) learn from each other's good practices; (d) work together to reduce the digital divide and achieve the Sustainable Development Goals; and (e) use South-South cooperation and triangular cooperation to accelerate the adoption of fourth industrial revolution technologies.

IV. Work of the secretariat on fourth industrial revolution technologies for sustainable development

35. Recognizing the critical importance of fourth industrial revolution technologies for sustainable development, ESCAP has been engaged in activities to promote the development, adoption and diffusion of these technologies. The ESCAP divisions and the Asian and Pacific Centre for Transfer of Technology planned a series of international capacity-building events for 2021 and 2022 to deliberate on the opportunities and challenges related to fourth industrial revolution technologies and to identify priorities and the potential for regional cooperation. The series included the following events:

(a) International Conference on Innovation, Transfer and Diffusion of Fourth Industrial Revolution Technologies, 30 June 2022, Guangzhou, China;

(b) Strategic Priorities for Adoption of Emerging Technologies in the Energy Sector for Climate Change Mitigation (side event at the seventy-eighth session of the Commission), 24 May 2022, Bangkok;

(c) International Conference on Fourth Industrial Revolution Technologies for Sustainable Development, 30 November 2021, New Delhi;

(d) Regional workshop on emerging technologies to respond to climate change, 14 September 2021, Kunming, China;

(e) Asia Pacific Digital Transformation Forum, 9 November 2022, Seoul, and the Asia-Pacific Digital Ministerial Conference 2022 in collaboration with the Ministry of Science and Information and Communications Technology of the Republic of Korea, 10 November 2022, Seoul;

(f) Thematic working group on innovation and technology for sustainable development of the United Nations Special Programme for the Economies of Central Asia, 20 July 2022, Almaty, Kazakhstan.

36. Deliberations at those events held so far resulted in takeaways for promoting fourth industrial revolution technologies for sustainable development. The takeaways are focused on the role of knowledge-sharing, capacity-building, collaboration and partnerships for regional cooperation. Key recommendations from the events held so far are as follows:

(a) There is a need to enhance awareness and strengthen the capabilities of relevant stakeholders to develop and adopt fourth industrial revolution technologies;

(b) Fourth industrial revolution technologies may be considered part of the open systems of innovation framework;

(c) It is important to reshape the educational curriculum (from the grassroots level) in the light of skills required for fourth industrial revolution technologies; academia should be involved in the initiative and it should include reskilling and upskilling the workforce for the adoption of fourth industrial revolution technologies;

(d) Academia and the private sector require support to forge strategic partnerships for collaborative research and development, and accelerated commercialization of fourth industrial revolution technologies;

(e) Incubation centres have an essential role in driving innovations and connecting innovators to the market to enhance the uptake and upscaling of fourth industrial revolution technologies;

(f) The private sector can play a vital role in regional cooperation by exploring and promoting cross-border public-private partnership models to increase the adoption and use of fourth industrial revolution technologies, and by providing opportunities for collaboration and partnership to small and medium-sized enterprises, innovators and start-ups in Asia-Pacific countries to scale up and commercialize their technological innovations across national boundaries;

(g) The adoption and transfer of fourth industrial revolution technologies should take into consideration the socioeconomic conditions of countries and sector-specific circumstances and requirements;

(h) New models of intellectual property management and policies can help to enhance access to fourth industrial revolution technologies in developing countries;

(i) It may be useful to explore the development of regional technology banks that can be repositories of technological breakthroughs and developments related to fourth industrial revolution technologies;

(j) Regional institutions such as the Asian and Pacific Centre for Transfer of Technology may work towards fostering agreements between Governments to promote the sharing of fourth industrial revolution technologies and related knowledge;

(k) Collaborative platforms for innovation, transfer and diffusion of fourth industrial revolution technologies may be established, and innovators and incubators may be encouraged to share innovative applications of fourth industrial revolution technologies through technology transfer platforms of the Asian and Pacific Centre for Transfer of Technology.

37. ESCAP has supported Governments in the design of policies and regulatory frameworks to support the effective adoption of fourth industrial revolution technologies. In collaboration with Google and the Association of Pacific Rim Universities, ESCAP is supporting the development of country-specific artificial intelligence governance frameworks and national capabilities to empower transparent ecosystems to develop artificial intelligence solutions that tackle socioeconomic challenges. Following the lessons learned from the Hunga Tonga–Hunga Ha’apai eruption and tsunami in January 2022, ESCAP contributed to the Association of Pacific Rim Universities multi-hazards programme by holding a webinar on emerging risks in a complex world. The

focus was on emerging applications of fourth industrial revolution technologies to manage compound and cascading risks.

38. ESCAP is working with government agencies in Bangladesh and Thailand to identify policy challenges to the use of artificial intelligence for social good and to conduct research that can help to inform the design of such policies. In 2022, four research teams were established to identify how government agencies can use artificial intelligence to support the monitoring women's health during pregnancy (in Bangladesh) and to support the design of poverty alleviation programmes and advance health care (in Thailand).

V. Issues for consideration by the Committee

39. The Commission adopted resolution 78/1 of 27 May 2022, entitled "Bangkok Declaration Commemorating the Seventy-fifth Anniversary of the Economic and Social Commission for Asia and the Pacific: a Common Agenda to Advance Sustainable Development in Asia and the Pacific", in which it recognized that science, technology and innovation are critical in the pursuit of sustainable development and are among the key driving forces of implementation of the 2030 Agenda for Sustainable Development. The fourth industrial revolution, driven by the impact of digital technology and data processing and the development of artificial intelligence, offers unprecedented opportunities and new challenges, and it has tremendous potential to accelerate the implementation of the 2030 Agenda.

40. In the light of the opportunities and challenges related to fourth industrial revolution technologies for sustainable development, members of the Committee on Information and Communications Technology, Science, Technology and Innovation may wish to share national experiences, including effective practices, partnerships and lessons learned.

41. The Committee may wish to take the following actions:

(a) Indicate the types of support that may be required from the secretariat to promote the development, adoption and diffusion of fourth industrial revolution technologies and their innovative applications for sustainable development;

(b) Make recommendations to advance the promotion of fourth industrial revolution technologies for sustainable development in the region;

(c) Identify new and priority policy issues related to fourth industrial revolution technologies for sustainable development that may be addressed through regional cooperation.
