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The 2030 Agenda for Sustainable Development and the future of technology

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Note by the secretariat

Summary

As the fourth industrial revolution begins – a revolution defined by frontier technological breakthroughs such as artificial intelligence, robotics, 3D printing and the Internet of things – it will be critical for frontier technologies to work for society and the environment as well as the economy if the ambitions of the 2030 Agenda for Sustainable Development are to be achieved.

Frontier technologies offer a multitude of opportunities. From an economic viewpoint, the adoption of technologies and innovations in production processes could increase overall productivity and expand production possibilities. In terms of social impact, frontier technologies could transform public service delivery, reduce inequality and support inclusion. From an environmental perspective, they can be used to address evolving environmental changes pre-emptively. Notably, the expanding array of tools and services offered by big geospatial data sets is strengthening evidence-based and real-time decision-making.

However, there are challenges with respect to the impact of frontier technologies on jobs and the future of work, ethical issues, regulatory considerations, and the key challenge of the current and potentially widening digital divide leading to further disparities.

Asia and the Pacific is a leading region in the development of frontier technologies and is forecast to be a prominent market of the future. Governments in the region have also been at the forefront of innovative policymaking on this agenda. This prominent position means that Governments in the region have the opportunity to shape the role and scope of frontier technologies.

The present document contains an overview of the development of frontier technologies in Asia and the Pacific. Key opportunities and challenges presented by frontier technologies across the three dimensions of sustainable development – economic, social and environmental – are highlighted. A number of key policy priorities are proposed with a view to: (a) forming the basis of a next-generation technology policy framework for the future as influenced by the fourth industrial revolution; (b) ensuring that frontier technologies are more deliberately aligned with the ambitions of the Sustainable Development Goals; and (c) addressing the digital divide and associated frontier technology divide so that no one is left behind.

The Committee may wish to discuss issues raised in the document, share experiences and lessons learned, and identify policy priorities and areas for cooperation to ensure that the future of technology is aligned with the 2030 Agenda.

* ESCAP/CICTSTI/2018/L.1.

I. Setting the scene

A. Introduction

1. In 2015, when the world signed up to the 2030 Agenda for Sustainable Development – the most ambitious agenda ever agreed – technology was heralded as a key means of implementation. Indeed, technologies are already playing a part in improving health, providing economic opportunities and addressing climate change. Digital technologies such as mobile phones and the Internet have created an era in which ideas, knowledge and data flow more freely than ever before.

2. However, as the fourth industrial revolution begins – a revolution defined by frontier technological breakthroughs such as artificial intelligence, robotics, 3D printing and the Internet of things – the wave of optimism surrounding the transformative potential of technology has been tempered by increasing concerns about the potential negative impacts.

3. While the frontier technologies that are defining the fourth industrial revolution offer a multitude of opportunities to reimagine the economy, society and the environment, there are also significant challenges, which could fuel increased inequality.

4. In the present document, the key opportunities and challenges presented by frontier technologies across the three dimensions of sustainable development – economic, social and environmental – are identified. A number of key policy priorities are proposed with a view to: (a) forming the basis of a next-generation technology policy framework for the future as influenced by the fourth industrial revolution; (b) ensuring that frontier technologies are more deliberately aligned with the ambitions of the Sustainable Development Goals; and (c) addressing the digital divide and associated frontier technology divide so that no one is left behind.

B. Defining frontier technologies

5. There is no universally agreed definition of frontier technology. However, there is a recurring common feature across the different technological advances in that they all have the potential to disrupt the status quo, alter the way people live and work, rearrange value pools and lead to entirely new products and services.

6. What is deemed to be "frontier" depends on context. Although some frontier technologies are new, in other cases they may be a different application or bundling of more established technologies.

7. For these reasons, a multitude of different technologies have been identified as frontier by several studies. The technologies most commonly identified as frontier in these studies are artificial intelligence, robotics, the Internet of things and 3D printing.[1] Given the absence of a universally agreed definition of frontier technology and the multitude of technologies that have been defined as frontier, this document mainly covers these four technologies to provide focus.

[1] Economic and Social Commission for Asia and the Pacific (ESCAP), *Frontier Technologies for Sustainable Development in Asia and the Pacific* (Bangkok, 2018).

II. Opportunities and challenges for sustainable development

A. Opportunities

8. In this section, the potential economic, social and environmental benefits of frontier technologies in the context of the 2030 Agenda are discussed.

1. Economic development

9. Technology is fundamental to sustaining economic growth. History has shown that technology and successive industrial revolutions have had huge impacts on economic growth. Each new wave of technologies – such as steam engines, electricity, telephones, computers and the Internet – has propelled productivity and economic growth and given rise to new types of businesses.

10. Technologies and, more broadly, innovation are central to long-term growth because of their impact on productivity. The adoption of technologies and innovation in production processes increases overall productivity and expands production possibilities. Technological capabilities are thus fundamental to maintaining broad economic growth.[2] Indeed, sustained economic growth is directly linked to a country's capacity to acquire, absorb, disseminate and apply modern technologies.[3]

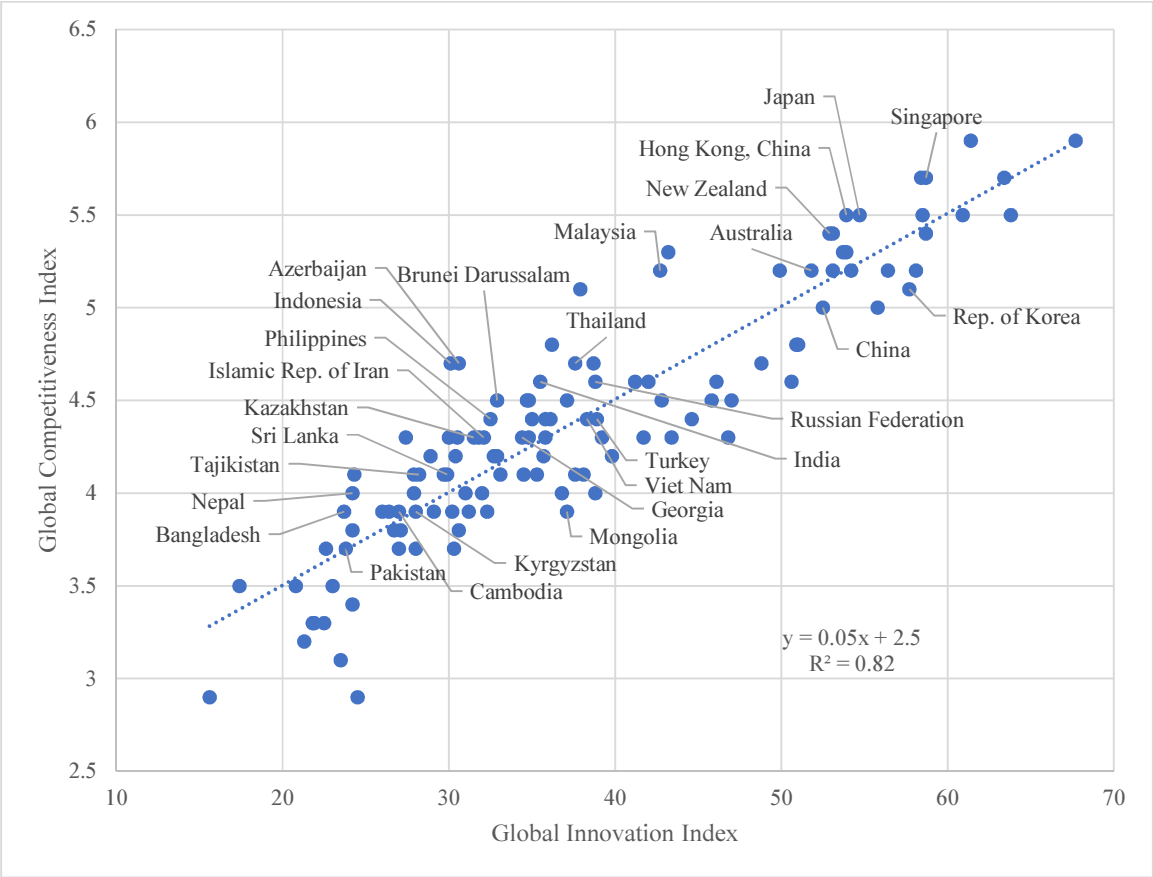
11. From an economic perspective, a nation's competitiveness depends on the capacity of its industry to innovate and upgrade.[4] As shown in figure I, national competitiveness is highly correlated with national innovation capability. Frontier technology could potentially accelerate the pace of innovation, enhance the productivity of a country and strengthen national competitiveness.

[2] Sanjaya Lall, "Technological capabilities and industrialization", *World Development*, vol. 20, No. 2 (February 1992), pp. 165–186.

[3] Stan Metcalfe and Ronnie Ramlogan, "Innovation systems and the competitive process in developing economies", *Quarterly Review of Economics and Finance*, vol. 48, No. 2 (May 2008), pp. 433–446.

[4] Michael E. Porter, "The competitive advantage of nations", *Harvard Business Review*, March–April 1990, pp. 73–91.

Figure I
Correlation between national competitiveness and innovation capability



Source: ESCAP, based on data derived from World Economic Forum, *The Global Competitiveness Report 2016–2017* (Geneva, 2016); and Cornell University, European Institute of Business Administration (INSEAD) and World Intellectual Property Organization (WIPO), *The Global Innovation Index 2017: Innovation Feeding the World* (Ithaca, New York; Fontainebleau, France; and Geneva; 2017).

Notes: The sample covers 120 countries worldwide. The scores of Asia-Pacific countries that are covered in the samples are labelled. The Global Competitiveness Index uses a scale of 1–7, while the Global Innovation Index uses a scale of 0–100; a higher average score means a higher degree of competitiveness or innovation.

2. Social impact

(a) Transforming public service delivery

12. The advent of the Internet in the mid-1990s triggered the rapid diffusion of e-government systems to automate core administrative tasks, improve the delivery of public services and promote transparency and accountability. By 2014, all 193 Member States of the United Nations had national websites: 101 States enabled citizens to create personal online accounts, 73 to file income taxes online and 60 to register a business. In all, 190 countries had automated government financial management, 179 had automated customs and 159 had automated tax systems. In addition, 148 countries had digital identification

schemes, although only 20 had multipurpose digital identification for such services as voting, finance, health care, transportation and social security.[5]

13. Some Governments in the region have been taking innovative policy action to utilize frontier technologies in the delivery of public services. As an example, in Singapore, the Government recently set up a new agency, GovTech, to create an enabling environment for frontier technologies. GovTech's objective is to drive digital transformation across government. It will work with public sector organizations, the information and communications technology (ICT) industry and citizens to apply technologies such as artificial intelligence and machine learning to government services.[6] Setting up such agencies should support the evolution of next-generation public services. Moreover, by hiring staff with technology skills, the Government is supporting the development of a new wave of civil servants fit for the twenty-first century.

(b) Reducing inequality and supporting inclusion

14. The relationship between technology and inequality is multifaceted.[7] Technology has brought equality dividends by enabling productive transformation and rapid economic growth in the region. Technologies, notably ICT, have brought improved access to basic services such as finance.

15. As an example, Aadhaar technology has enabled the financial inclusion of 1.2 billion people in India. The Aadhaar programme in India is a Government-led, technology-based financial inclusion system. The system includes a unique identification number (based on biometric and demographic data) linked to a mobile phone number, a low-cost bank account and an open mobile platform. The combination of those elements enabled public and private banks to establish an open and interoperable low-cost payment system that is accessible to everyone with a bank account and a mobile phone. More than 338.6 million beneficiaries have now received direct benefit transfers, saving the Government $7.51 billion over three years.[8]

3. Environmental protection

16. Frontier technologies have the potential to be applied for environmental protection. Governments in Asia and the Pacific have promoted the adoption of state-of-the-art technologies to address environmental impacts. For instance, in the Republic of Korea, the entire smart city of Songdo is built around the Internet of things. Among other benefits, smart cities reduce traffic pollution, save energy and water and create a cleaner environment.

17. Advanced technologies, such as space technology applications, are also helping to anticipate and respond to climate risks. For example, the national land-use and land cover map uses multitemporal satellite data launched by the Indian Space Research Organization in 2004–2005 to allow experts to analyse

[5] World Bank, *World Development Report 2016: Digital Dividends* (Washington, D.C., 2016).

[6] Karl Flinders, "Singapore launches department to drive digital public services", *ComputerWeekly.com*, 7 October 2016.

[7] *Inequality in Asia and the Pacific in the Era of the 2030 Agenda for Sustainable Development* (United Nations publication, Sales No. E.18.II.F.13).

[8] India, "New innovation approaches to support the implementation of Sustainable Development Goals", statement to the Commission on Science and Technology for Development of the United Nations, twentieth session, Geneva, 10 May 2017.

spatial data, along with data from geographic information systems, to clearly identify the changes in land use over time.[9] This is essential for environmental monitoring, the mitigation of climate change and natural resources management.

B. Challenges

18. The challenges associated with effectively developing and implementing frontier technologies for sustainable development vary depending on the context of a country or industry. This section, however, covers three common areas where frontier technologies may not necessarily result in sustainable development, namely: (a) the impact of frontier technologies on jobs; (b) a new frontier technology divide; and (c) ethical issues.

1. Impact of frontier technologies on jobs

19. In considering only 15 major developed and emerging economies, the World Economic Forum predicts that frontier technological trends will lead to a net loss of over five million jobs by 2020.[10] The World Bank estimates that up to two thirds of all jobs are susceptible to automation in the developing world in the coming decades from a purely technological standpoint.[11] McKinsey Global Institute predicts that, technically, about half of jobs globally can be automated, and that in Asia-Pacific economies, the figure stands at 785 million workers' jobs or 51.5 per cent of total employment in the region.[12] Similarly, results from a firm-level survey suggest that automation may have a significant impact on the job security of 60 to 89 per cent of salaried workers – depending on the country and the sector – in the following five major sectors of the economies of the Association of Southeast Asian Nations (ASEAN): automotive and auto parts; electrical and electronics; textiles, clothing and footwear; business process outsourcing; and retail.[13]

20. It is important to note that the estimates vary according to the sampling and analytical methodologies. For instance, different studies show that anywhere between 7 and 55 per cent of jobs in Japan could be lost to automation. The results of existing studies therefore need to be interpreted with caution (see figure II).

[9] India, Department of Space, *Annual Report 2017–2018* (Bengaluru, 2018). Available at www.isro.gov.in/annual-report-2017-18-english.

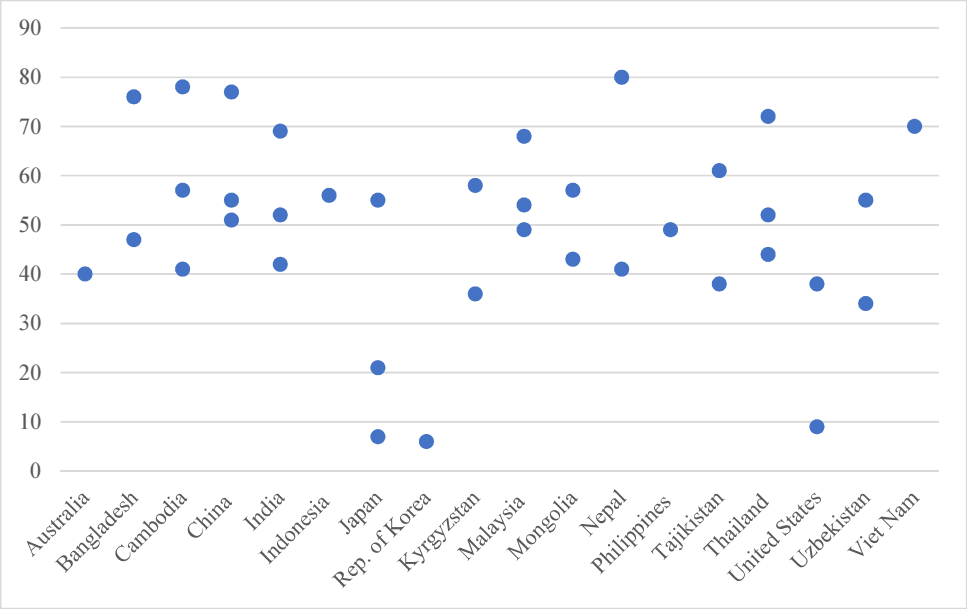
[10] Klaus Schwab, "The Fourth Industrial Revolution: what it means, how to respond", World Economic Forum, 14 January 2016.

[11] World Bank, *World Development Report 2016*.

[12] McKinsey Global Institute, "China's digital economy: a leading global force", (McKinsey and Company, 2017).

[13] International Labour Organization (ILO), *ASEAN in Transformation: How Technology is Changing Jobs and Enterprises* (Geneva, 2016). Available at www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/publication/wcms_579553.pdf.

Figure II
Estimates of the share of jobs that are at risk of being lost to automation, by country
(Percentage)



Source: Based on ESCAP, *Frontier Technologies for Sustainable Development* (see footnote 1).

Note: Each point in the figure represents an estimate reached by a single study; when one country is included in different studies, more than one estimate for that country is shown in the figure.

21. However, it is important to note that what is technically feasible is not always economically viable, and that the current low adoption of artificial intelligence is reflective of the fact that the industry is still at the nascent or pilot stage of development. In addition, it is often the case that decisions on the adoption of automation technologies ultimately hinge on cost-benefit analysis.

22. In short, the nature of technological displacement of labour is such that it is a question of how fast rather than whether it will happen. Market mechanisms will dictate that start-ups, small and medium-sized enterprises, corporations and industries choose the most cost-effective method of production. Governments need to be proactive in analysing the pace and scale of automation, and introduce responsive and adaptive policies.

23. Although the prevailing narrative is that more and more jobs will be lost to machines, it is also a distinct possibility that, in the future, humans and machines work together. As demonstrated by history, the industries of the future and the new jobs that economies will demand may not yet have been envisaged. At the dawn of the digital revolution, it would have been impossible to have imagined how the likes of Facebook, Uber, Alibaba and Airbnb would create new industries and fundamentally reshape existing ones.

2. A new frontier technology divide

24. Despite the rapid penetration of the Internet globally, several billion people have been left behind. As ICT infrastructure is the backbone of many frontier technologies, there is a risk of a new frontier technology divide on the back of the already existing digital divide. For example, the number of fixed-

broadband subscriptions per 100 inhabitants in the Asia-Pacific region is still far lower than in Europe and North America, and remains below the world's average of 11.2 in 2016. In particular, ESCAP member countries with special needs continue to have fewer than two broadband subscriptions for the same indicator.[14]

25. This is a particularly worrying trend, as artificial intelligence and other frontier technologies consist of digital technologies and connectivity, such as the Internet of things, big data, cloud computing and broadband connectivity.[15] Any deficit in these digital components will hamper any meaningful development and usage of frontier technologies.[16]

26. Another perspective for assessing the frontier technology divide is by considering gross domestic expenditure in research and development as a percentage of gross domestic product (GDP). Of the 28 countries for which data are available, only five countries in the region – Australia, China, Japan, the Republic of Korea and Singapore – spend 2 per cent or more of GDP on research and development. At the other end of the spectrum, half of the countries spend 0.25 per cent or less.[17]

27. Technology diffusion rarely happens automatically. Among other reasons, some technologies, despite their technical superiority, may not be commercially viable or affordable for some groups of people or communities. Also, the technology life cycle – often depicted as an S-curve and divided into several stages, covering development, market introduction, growth, maturity and sometimes decline – means that new technologies are often only accessible to a small group of people or sectors before mainstream adoption. One of the most prominent examples of this theory is that it took 30 years for electricity and 25 years for telephones to reach an adoption rate of 10 per cent in the United States of America.[18]

28. On the other hand, evidence has shown that technology adoption has been accelerating. It took decades for the telephone to reach 50 per cent of households, beginning before 1900. However, it took five years or less for mobile phones to accomplish the same penetration in 1990. Similarly, technologies, especially digital technologies, have been spreading more rapidly than before in developing countries. Nearly 70 per cent of the bottom fifth of the population in developing countries own a mobile phone.[19] In addition, the

[14] E/ESCAP/CICTSTI(1)/2.

[15] ESCAP, *Artificial Intelligence and Broadband Divide: State of ICT Connectivity in Asia and the Pacific – 2017* (Bangkok, 2017).

[16] Raúl Zambrano, *Blockchain: Unpacking the Disruptive Potential of Blockchain Technology for Human Development – White Paper* (Ottawa, International Development Research Centre, 2017). Available at https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/56662/IDL-56662.pdf?sequence=2&isAllowed=y.

[17] Based on data from United Nations Educational, Scientific and Cultural Organization, "Science, technology and innovation: gross domestic expenditure on R&D (GERD), GERD as a percentage of GDP, GERD per capita and GERD per researcher", UIS.Stat database. Available at http://data.uis.unesco.org/Index.aspx?queryid=74 (accessed January 2018).

[18] "How Americans spend their money", *New York Times*, 10 February 2008. Available at https://archive.nytimes.com/www.nytimes.com/imagepages/2008/02/10/opinion/10op.graphic.ready.html.

[19] World Bank, *World Development Report 2016*.

number of Internet users has more than tripled in a decade, from 1 billion in 2005 to an estimated 3.2 billion at the end of 2015.[20]

29. The Sustainable Development Goals are aiming to leave no one behind. If market forces dominate, poor people may be the last group to benefit from frontier technologies. If the ambitions of the 2030 Agenda are to be achieved, policy intervention should guide the use of frontier technologies so that they serve and benefit those who generally cannot afford them.

3. Ethical issues

30. The frontier technologies discussed in this report are associated with various ethical issues. For robotics, there are concerns about the impact of automation on jobs. For the Internet of things, as the information is shared among devices connected to the Internet, there are concerns relating to data security and privacy. Also, ownership and management of data can be problematic. For instance, the owner of an Internet-connected device may not clearly understand what data are collected by service providers and how the data are used.[21]

31. 3D printing may bring ethical issues relating to responsibility and accountability. If a 3D-printed product causes damage, it may not be clear from laws and regulations who is responsible: the owner of the printer, the manufacturer of the printer or the person who printed the device. In the context of bioprinting, the moral, ethical and legal issues can be a challenge for many countries, especially in terms of readiness of the legal system.

32. Ethical issues related to artificial intelligence have also attracted much debate, covering such topics as the following:

(a) **The existential risk for mankind.** The late physicist Stephen Hawking warned of the importance of regulating artificial intelligence, stating that the development of full artificial intelligence could spell the end of the human race;[22]

(b) **Bias.** Experts have highlighted that bias could be the real danger of artificial intelligence: John Giannandrea, the former artificial intelligence chief at Google, commented that the real safety question was that if such systems are given biased data, they will be biased;[23]

(c) **Unpredictable and inscrutable nature of artificial intelligence.** In some situations, sophisticated artificial intelligence algorithms are such that their designers or engineers cannot explain how the artificial intelligence system makes decisions. This certainly carries risks: for instance, what decisions will a driverless car make when there is an emergency?

33. Balancing privacy and openness of data is a common ethical dilemma for all the frontier technologies discussed in the present document. The availability of data through the open data and big data movements has combined with advances in computing, machine learning and behavioural

[20] ILO, *ASEAN in Transformation.*

[21] Joshua A.T. Fairfield, "The 'internet of things' is sending us back to the Middle Ages", *The Conversation*, 6 September 2017.

[22] BBC News, "Stephen Hawking warns artificial intelligence could end mankind", 2 December 2014.

[23] MIT Technology Review, "Forget killer robots – bias is the real AI danger", 3 October 2017.

economics to fuel the growth of several frontier technologies. The way in which Governments manage data, now and in the future, will be important. Striking the right balance between privacy, ownership and transparency is a difficult task.

III. Policy priorities

34. While there are question marks over the scale and pace of the frontier technological transition, it would be prudent for Governments to be prepared and to put effective policies in place. Asia and the Pacific is a leading region in the development of frontier technologies and is forecast to be a prominent market of the future.[24] The region is also at the forefront of innovative policymaking on this agenda.

35. Countries in the region are exploring options for policy response. In China, President Xi Jinping called for efforts to turn China into a nation of innovators.[25] In 2017, the Government of China published a comprehensive artificial intelligence development policy with the overarching goal of making the country the front runner and global innovation centre in artificial intelligence by 2030;[26] the Republic of Korea has developed what has been coined the world's first robot tax;[27] and Japan has proposed setting up an international set of basic rules for developing artificial intelligence.[28]

36. While these policies and strategies are very much technology-specific, this section – as an initial step towards understanding the policy response to the opportunities and challenges that frontier technologies present more broadly – covers six key policy areas that could form the backbone of a next-generation technology policy that focuses on creating an enabling environment for frontier technologies and is aligned with sustainable development objectives:[29]

(a) Ensuring inclusive ICT infrastructure;

(b) Developing a workforce that is fit for the future as influenced by the fourth industrial revolution;

(c) Developing innovative regulatory frameworks;

(d) Incentivizing responsible development of frontier technologies in the private sector;

(e) Identifying the role of the Government in the development of frontier technologies;

(f) Creating a platform for multi-stakeholder and regional cooperation.

[24] ESCAP, *Frontier Technologies for Sustainable Development*.

[25] *China Daily*, "Xi calls for making China into a country of innovators", 18 October 2017.

[26] China, State Council, Development plan on the new generation of artificial intelligence (2017) (in Chinese only). Available at http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm.

[27] "South Korea introduces world's first 'robot tax'", *Telegraph*, 9 August 2017.

[28] "Japan to propose basic rules for AI research at G-7 meeting", *Japan Times*, 15 April 2016.

[29] As such, these policy areas do not address specific frontier technologies or sectors.

A. Ensuring inclusive ICT infrastructure

37. A prerequisite for the development and application of frontier technologies is the availability of reliable, resilient and affordable broadband networks and enabling ecosystems, including policy, regulatory and legal frameworks, cybersecurity measures, financing and investment, and linkage to academia and research and development. Addressing the digital divide and building broadband infrastructure are therefore development imperatives.

38. Even if middle-income and, to some extent, low-income countries are not at the forefront of developing frontier technologies, the chance to equalize opportunities that is embedded in the possibility of buying such technology or adapting parts of it to local circumstances could be lost if digital infrastructure deficits persist. In this regard, a continued focus on bridging the digital divide – particularly last-mile connectivity – should be a policy priority so as not to fuel a new frontier technology divide.

B. Developing a workforce that is fit for the future as influenced by the fourth industrial revolution

39. While the scale and pace of frontier technological adoption and diffusion are still unclear, it would be prudent for Governments to develop a workforce that is fit for the future as influenced by the fourth industrial revolution. Some directions to consider include a greater emphasis on entrepreneurship training to develop job creators as well as job seekers, adult education, lifelong learning and reskilling to deal with current and future technological transitions. Education must also instil new expectations about work and the marketplace for jobs, which will require innovative education policies such as those promoted by the Government of Singapore. One such policy offers adults personal accounts that they can use to buy training, and another uses tax incentives to encourage firms to invest more in their lower-paid workers.[30] In addition, Governments could strengthen social protection systems to protect the workers that are vulnerable to losing their jobs. Such forward-thinking policies could support a strategy to facilitate redeployment, rather than unemployment.

C. Developing innovative regulatory frameworks

1. Responsive and adaptive regulation

40. To avoid hindering the application of frontier technologies for sustainable development, regulatory processes need to become responsive and adaptive. However, enabling regulation for innovation is difficult to formulate and, as such, innovation in regulation processes are urgently required. The Fintech Supervisory Sandbox, launched by the Hong Kong Monetary Authority in 2016, is an example of this, allowing banks and their partnering technology firms to conduct pilot trials of their fintech initiatives without the need to achieve full compliance with supervisory requirements in early-stage development. This arrangement enables banks and technology firms to gather data and user feedback so that they can refine their new initiatives, thereby expediting the launch of new technology products and reducing development costs.

[30] Geoff Mulgan, "Anticipatory regulation: 10 ways governments can better keep up with fast-changing industries", Nesta, 15 May 2017.

41. Effective regulation should allow innovation to flourish while still safeguarding society and the environment. Balancing these demands will be an important government agenda as frontier technologies evolve, and one that will require the sharing of effective practices and innovative approaches between Governments. Responsive and adaptive regulation may provide a solution, as it emphasizes that policy needs to support the development of frontier technologies while also allowing for faster responses to ensure that the public are not exploited and that new dangers are averted.[31]

2. Setting standards and principles on ethics

42. Governments have already begun to tackle the ethical issues highlighted in this document. For example, in Germany, the Federal Government has proposed rules for decision-making to promote ethical behaviour by systems that guide crash scenarios for driverless cars. These rules prioritize human life above property damage and do not discriminate between human lives. Although industry is driving advances in artificial intelligence technology, Governments must play a key role in ethical and governance considerations. Consensus among member States on standards and ethical principles for technological advancements will be critical to ensure that technological transitions are well managed.

D. Incentivizing responsible development of frontier technologies in the private sector

1. Shared value

43. As the predominant investor in frontier technologies, the private sector will shape how they impact the economy, society and the environment. However, to create a positive impact on these three dimensions of sustainable development, corporations need to move beyond the concept of corporate social responsibility and redefine their objective, and associated measures of success, to create shared value.[32] Shared value is not corporate social responsibility, but rather measures value across the three dimensions of sustainable development at the core of business strategy. To further promote shared value, policymakers need to create the right incentives, so that these values move from corporate social responsibility departments to boardrooms.

44. Typical measures include subsidies or tax incentives for the development of products by the private sector that bring substantial societal or environmental benefits, especially those related to the Sustainable Development Goals.

2. Engaging the technology giants

45. Leading technology companies could be important partners in addressing the Sustainable Development Goals. For instance, Microsoft's *A Cloud for Global Good: A Policy Roadmap for a Trusted, Responsible and Inclusive Cloud* has brought tangible benefits to developing countries.[33] Efforts

[31] Ibid.

[32] Michael E. Porter and Mark R. Kramer, "Creating shared value", *Harvard Business Review* (January–February 2011), pp. 62–77.

[33] For instance, to respond a 7.8-magnitude earthquake in Nepal in 2015, Microsoft and the United Nations Development Programme built a cloud-based application that allowed reconstruction crews to record precise coordinates and measurements for each building prior to demolition. The application was also used to manage daily cash payments to thousands of local workers, many of whom were clearing debris.

by leading global technology companies to make frontier technologies publicly available and transparent would enable developing countries to learn about the latest developments and identify solutions to social and environmental issues. An important example in this respect is the Partnership on Artificial Intelligence to Benefit People and Society (Partnership on AI) founded by Amazon, Facebook, Google (through its subsidiary DeepMind), IBM and Microsoft in 2016. The partnership's stated goals are to study and formulate best practices on the development, testing and fielding of artificial intelligence technologies, to advance the public's understanding of artificial intelligence, to provide an open platform for discussion and engagement about artificial intelligence and its influences on people and society, and to identify and foster aspirational efforts in artificial intelligence for socially beneficial purposes.[34] In Asia, Huawei published its first report dedicated to the use of technology for sustainable development in 2016, and stated that it took seriously its responsibility to support the United Nations in its pursuit of the Sustainable Development Goals.[35]

46. On the other hand, many technology companies dominate their respective sectors. This may restrain effective market competition and lead to winner-takes-all market outcomes. While the private sector does have an important role in sustainable development, Governments need to introduce effective policies to manage any potential conflicts between corporate objectives of maximizing shareholder wealth and the potentially negative social and environmental impact.

E. Identifying the role of the Government in the development of frontier technologies

1. Public sector innovation skills

47. It will be critical for government and public sector workers to develop innovation skills if countries are to meet the diverse Sustainable Development Goals.[36] Governments will need to support an agile, forward-thinking and technologically skilled civil service to respond to a rapidly changing world and the opportunities that frontier technologies present. While caricatures of public servants that depict them as hostile to innovation are out of date, public organizations continue to need skills and better processes if they are to resist the tendency of inertia.[37] In Singapore, the Government Digital Services team provides an example of an initiative by a Government that has focused on bringing in non-traditional civil service skills. The team of software developers, user-experience designers and architects build digital services using an agile method of project management method that emphasizes small changes to services based on feedback from user testing and research.

[34] See www.partnershiponai.org/about. The United Nations Children's Fund (UNICEF) joined the partnership in 2017 (see www.unicef.org/media/media_95995.html).

[35] Huawei Investment and Holding Co., Ltd., *Connecting the Future: 2016 Sustainability Report* (Shenzhen, China, August 2016).

[36] *Harnessing Science, Technology and Innovation for Inclusive and Sustainable Development in Asia and the Pacific* (United Nations publication, Sales No. E.16.II.F.12).

[37] Geoff Mulgan, "Design in public and social innovation: what works and what could work better", Nesta, January 2014. Available at https://media.nesta.org.uk/documents/design_in_public_and_social_innovation.pdf.

2. Government as a market maker and shaper

48. As highlighted above, the private sector has been the prime investor in frontier technologies. However, increasingly, Governments in the Asia-Pacific region are establishing dedicated agencies to help realize the transformative potential of frontier technologies. One such agency is SGInnovate in Singapore, which was launched in November 2016, building on its heritage of being the investment arm of the former Infocomm Development Authority of Singapore.[38] This Government-owned company specializes in supporting frontier technology initiatives and start-ups in Singapore, with a focus on artificial intelligence, robotics and blockchain.[39] The creation of SGInnovate complements the Government's strategy to boost the country's frontier technology capabilities, through its Government-wide partnership and national programme on artificial intelligence.[40] The National Research Foundation will invest up to 150 million Singapore dollars over the next five years under the programme, in order to create a supportive ecosystem for artificial intelligence start-ups and companies developing artificial intelligence products. The initiative builds on the country's vision of becoming a smart nation, as well the recommendations of its Committee on Future Economy to realize the growth opportunities of the digital economy and build stronger digital capabilities.[41]

F. Creating a platform for multi-stakeholder and regional cooperation

49. Cross-government cooperation, intergovernmental knowledge-sharing and consensus-building, and honest, open and regular discussion with civil society and the private sector – specifically technology developers – will be critical to ensure that frontier technologies have a positive impact on sustainable development.

50. As a first step, the development of a set of overarching principles governing the development of frontier technologies should be a first-order priority. Globally, leadership on such an endeavour has been suboptimal; however, given the prominent position of Asia and the Pacific in several frontier technologies, the region is well placed to lead on governance globally, in order to build trust and ensure effective deployment in alignment with the Sustainable Development Goals.

51. As an example, during the Japanese presidency of the Group of Seven in 2016, the then Minister of Internal Affairs and Communications proposed some basic principles that could guide artificial intelligence research and development. The principles, which were presented during the Group of Seven meeting of ICT ministers in Takamatsu, Japan, in April 2016, were an outcome of ongoing studies into the benefits and impact of artificial intelligence networking on society and the economy in Japan (see box 1).

[38] See www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=21766070.

[39] See www.crunchbase.com/organization/sginnovate.

[40] Organizations that are part of the Artificial Intelligence Singapore partnership include the National Research Foundation, the Smart Nation and Digital Government Office, the Economic Development Board, the Infocomm Media Development Authority, SGInnovate and Integrated Health Information Systems.

[41] See www.nrf.gov.sg.

Box 1
Draft artificial intelligence research and development principles and guidelines proposed by Japan to the Group of Seven

The intention of the guidelines is to enhance the benefits and minimize the potential risk of artificial intelligence, in order to ensure that artificial intelligence research and development is human-centred and protects the interests of users. Given the rapidly developing nature of artificial intelligence technology, the guidelines should not to be perceived as regulations, but rather as proposed guidance to be shared internationally as non-regulatory, non-binding soft law. The draft artificial intelligence research and development guidelines include the following principles:

1. Principle of collaboration: developers should pay attention to the interconnectivity and interoperability of artificial intelligence systems.

2. Principle of transparency: developers should pay attention to the extent to which inputs/outputs of artificial intelligence systems are verifiable and their judgments explainable.

3. Principle of controllability: developers should pay attention to the controllability of artificial intelligence systems.

4. Principle of safety: developers should ensure that artificial intelligence systems do not harm the life, body or property of users or third parties, through actuators or through other devices.

5. Principle of security: developers should pay attention to the security of artificial intelligence systems.

6. Principle of privacy: developers should ensure that artificial intelligence systems do not infringe the privacy of users or third parties.

7. Principle of ethics: developers should respect human dignity and individual autonomy in research and development on artificial intelligence systems.

8. Principle of user assistance: developers should ensure that artificial intelligence systems support users and give them appropriate choices.

9. Principle of accountability: developers should fulfil their accountability to stakeholders, including users of artificial intelligence systems.

Source: Japan, Ministry of Internal Affairs and Communications, "Draft AI R&D guidelines for international discussions (tentative translation): Conference toward AI Network Society, 28 July 2017". Available at www.soumu.go.jp/main_content/000507517.pdf.

IV. Conclusion

52. In this document, policy areas are proposed that could form the basis of a next-generation technology policy framework that is fit for the future as influenced by the fourth industrial revolution. The creation of an enabling environment for frontier technologies, in order to positively impact the economy, society and the environment and to reduce current and potential inequality, should also be a fundamental principle of future technology policy if it is to effectively support the Sustainable Development Goals. The broad contours of such a framework could include the following:

(a) Ensuring inclusive ICT infrastructure;

(b) Developing a workforce that is fit for the future as influenced by the fourth industrial revolution;

(c) Developing innovative regulatory frameworks;

(d) Incentivizing responsible development of frontier technologies in the private sector;

(e) Identifying the role of the Government in the development of frontier technologies;

(f) Creating a platform for multi-stakeholder and regional cooperation.

53. The impacts of frontier technologies are far from preordained. However, frontier technological breakthroughs require different thinking about the formulation of technology policy.

54. When developing policy on this agenda, it is important to note that concerns regarding the economic implications of emerging technologies are not new. Textile workers destroying looms in the nineteenth century for fear of losing their jobs and robots displacing workers on assembly lines are just two examples from past industrial revolutions. In this regard, it is necessary to listen to historians, not just futurists. It will be critical to learn from the past in shaping the future of frontier technologies.

55. Many countries are developing specific frontier technology policies and strategies for the fourth industrial revolution, but they are in their infancy. To support countries' preparations, the evaluation of the impact of these experimental strategies should be a policy priority to establish what works and, equally importantly, what does not. Through these activities, best-practice next-generation technology frameworks can be developed.

56. Lastly, cross-government cooperation, intergovernmental knowledge-sharing and consensus-building, and honest, open and regular discussion with civil society and the private sector – specifically technology developers – will be critical to ensure that frontier technologies have a positive impact on sustainable development.

V. Issues for consideration by the Committee

57. The Committee may wish to discuss the issues raised in the document, and share experiences and lessons learned with regard to frontier technologies.

58. To guide the work of the secretariat, the Committee is invited to make recommendations on the following:

(a) The policy priorities that should underpin a next-generation technology and innovation policy framework that is relevant to the future as influenced by the fourth industrial revolution;

(b) Areas of regional cooperation on frontier technology that could support shared prosperity and reduce current and potential future inequality.